DAVID Y. IGE
GOVERNOR OF HAWAII

ELIZABETH A. CHAR, M.D.
DIRECTOR OF HEALTH

**STATE OF HAWAII**
**DEPARTMENT OF HEALTH**
P. O. Box 3378
Honolulu, HI 96801-3378
doh.testimony@doh.hawaii.gov

**Testimony COMMENTING on SB0132**
**RELATING TO WATER POLLUTION**

SENATOR MIKE GABBARD, CHAIR
SENATOR CLARENCE K. NISHIHARA, VICE CHAIR
SENATE COMMITTEE ON AGRICULTURE & ENVIRONMENT
Hearing Date: 2/17/2021 Room Number: Videoconference

**Fiscal Implications:** This measure may impact the priorities identified in the Governor's Executive Budget Request for the Department of Health's (Department) appropriations and personnel priorities.

**Department Testimony:** SB 0132 seeks to add homosalate, octocrylene and octisalate to the list of active ingredients restricted from sale or distribution in Hawaii in non-prescription sunscreens. The Department has the following comments.

The Department recognizes the benefits of the 2018 Act 104 prohibiting the sale of oxybenzone and octinoxate containing sunscreen products in Hawaii. It is heartening to see the dramatic increase in availability, variety and consumer acceptance of oxybenzone and octinoxate-free options and mineral sunscreen products that have entered the consumer market in the past few years. Use of these products meets standards for public health protection and offers the public a concrete choice to help protect Hawaii's coral reefs and marine environment when enjoying our beaches. However, the risk of skin cancer from sun exposure remains a hazard for the people of Hawaii and visitors and it is imperative to consider the potential public health consequences of additional prohibition on sunscreen ingredients.

The Department strongly supports public education efforts and outreach strategies to inform Hawaii beachgoers about steps they can take to reduce the unintended impacts of sunscreen use while safely enjoying our tropical marine waters and sunny beaches. The Department also supports academic and applied research efforts further investigating the fate and environmental effects of homosalate, octocrylene, octisalate and other sunscreen compounds in the nearshore marine environment.

**Offered Amendments:** None

Thank you for the opportunity to testify on this measure.

DAVID Y. IGE
GOVERNOR OF HAWAII

SUZANNE D. CASE
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

ROBERT K. MASUDA
FIRST DEPUTY

M. KALEO MANUEL
DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND COASTAL LANDS
CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

**STATE OF HAWAII**
**DEPARTMENT OF LAND AND NATURAL RESOURCES**

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

**Testimony of**
**SUZANNE D. CASE**
**Chairperson**

**Before the Senate Committee on**
**AGRICULTURE AND ENVIRONMENT**

**Wednesday, February 17, 2021**
**1:00 PM**
**State Capitol, Via Videoconference**

**In consideration of**
**SENATE BILL 132**
**RELATING TO WATER POLLUTION**

Senate Bill 132 proposes to add the chemicals homosalate, octocrylene, and octisalate to the sale and distribution sunscreen ban beginning 1/1/23. **The Department of Land and Natural Resources (Department) supports this measure and offers the following comments.**

The Department recognizes the concerns about the presence of homosalate, octocrylene, and octisalate in the nearshore marine environment. There is growing body of science that suggests these chemicals may have negative effects on corals and other marine life.

Octocrylene is now the dominant UV-sunscreen contaminant in coastal waters.[1] Recent scientific studies suggest that octocrylene may have negative impacts in aquatic environments equivalent to oxybenzone (already banned from Hawaii sunscreens). Octocrylene functions as an endocrine disruptor, a metabolism disruptor, and a reproductive disruptor. It has also been shown to reduce the ability of coral symbionts to photosynthesize. Scientific evidence suggests that it can have toxic impacts to a variety of aquatic organisms from corals, to fish, to mammals, to plants.[2]

Octisalate has displayed multiple hormonal disrupting activities with in vitro lab studies. In addition, disruption of mitochondrial membrane function, and possible apoptosis (programed cell death) was found. No coral toxicity studies were found for homosalate, but this chemical has been readily found in reef waters. Lab based studies have shown hormone-receptor disrupting activities in in vitro assays. Lethal and sublethal effects were found when the marine algae

[1] Downs, Craig A., personal communication (2021)
[2] Fel et al. (2019), Lozano et al. (2020), Giraldo et al. (2017), Boyd et al. (2021), Yan et al. (2020), Zhang et al (2016), Campos et al (2017), Gago-Ferrero et al. (2013), Cocci et al. (2020),Bluthgen et al. (2014)

(*Tetraselmis* sp.) was exposed to homosalate, indicating potential impacts to phytoplankton communities. This highlights concerns that it could affect corals and suggests the need for testing for these potential the effects. Both homosalate and octisalate are teratogens, which are known to cause embryonic development defects in mammals, fish, and larvae.

As a result of these recent scientific findings, we feel that prohibiting the sale of products containing homosalate, octocrylene, and octisalate would likely benefit the health and resiliency of Hawai‘i’s coral reef ecosystems. At the very least, the Department would recommend support for increased monitoring of various sunscreen chemicals at high-use swimming areas and further research examining the effects of these chemicals on the nearshore marine environment in Hawai‘i.

The Department supports the use of sunscreens that do not contain chemicals that are harmful to marine life, as well as sun protective clothing, as alternatives. The Department continues to conduct outreach efforts to help the public understand the issues regarding using oxybenzone and similar chemicals in the ocean so they can be better informed and make better choices regarding sun protection. These efforts include information on the Department’s Division of Aquatic Resources website, focused one-on-one outreach, news releases, videos, interaction with partner organizations, and meetings with boat tour operators and vendors who sell sunscreen. The Department continues to explore other ways to inform the public on this issue.

It should be noted that, although it is important to address all potential coral reef ecosystem stressors, the primary concerns with Hawaii’s coral reefs continue to be related to land-based source pollution, unsustainable fishing practices, invasive species, and climate change. Continued legislative support to reduce these main stressors will have the largest impact on coral reef resilience and recovery.

Thank you for the opportunity to comment on this measure.

**SB-132**
Submitted on: 2/16/2021 12:57:30 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| David Sakoda | Testifying for DLNR | Support | No |

Comments:

I am available for questions. Please allow me Zoom access. Thank you.

Testimony on behalf of the
**Hawai‘i State Youth Commission**

IN SUPPORT OF SB132
February 17, 2021

To: The Honorable Mike Gabbard, Chair
The Honorable Clarence Nishihara, Vice Chair
Members of the Agriculture and Environment Senate Committee

From: Shwe Win
And Commissioners of the Hawai‘i State Youth Commission

I speak on behalf of the Hawai‘i State Youth Commission (HiYC) in expressing my support for SB132. HiYC was formed to “advise the governor and legislature on the effects of legislative policies, needs, assessments, priorities, programs, and budges concerning the youth” [§352D-11]. The 15 Youth Commission members (ages 14 – 24) are appointed by the Governor, the Senate President, and the Speaker of the House.

SB132 would greatly strengthen our state’s existing sunscreen ban—setting a strong precedent and reaffirming Hawai‘i’s commitment to protecting and preserving the environment. Speaking as a youth that grew up snorkeling along the coasts of Hilo, I hope that succeeding generations are given the same chance to experience the beauty and grandeur of our marine ecosystems. A majority of my community’s livelihoods depend on that intact state of our saltwater bodies—the foundation of which rests on healthy coral, algae, and other aquatic life.

Octocrylene, one of the three chemicals accounted for in this new amendment, poses a grave threat to marine ecosystems. The chemical is vulnerable to bioaccumulation—able to impair developmental gene expression and cause adverse reproductive effects in aquatic species. Recently, the U.S. Virgin Islands recognized octocrylene, along with oxybenzone and octinoxate (the two chemicals included in our existing ban), as carcinogens and hormone disrupters capable of devastating marine life. Hawai‘i should follow suit.

HiYC strongly urges the committee to pass SB132. Thank you for the opportunity to testify on this critical measure.

Mahalo nui loa,
Shwe Win

HAWAII FOOD INDUSTRY ASSOCIATION

1050 Bishop St. PMB 235 | Honolulu, HI 96813
P: 808-533-1292 | e: info@hawaiifood.com



TO:
Committee on Agriculture and Environment
Senator Mike Gabbard, Chair
Senator Clarence K. Nishihara, Vice Chair

FROM: HAWAII FOOD INDUSTRY ASSOCIATION
Lauren Zirbel, Executive Director

DATE: February 17, 2021
TIME: 1pm
PLACE: Via Videoconference

RE: SB132 Relating to Water Pollution

Position: Oppose

The Hawaii Food Industry Association is comprised of two hundred member companies representing retailers, suppliers, producers, and distributors of food and beverage related products in the State of Hawaii.

HFIA proposes that since this bill would ban many products that are used to prevent skin cancer, that a higher standard of review should be conducted to ensure that taking this action would indeed improve outcomes for reefs. The primary causes of damage to reefs are increased water temperatures, run-off, sewage, and overfishing.

It's important to understand that it's nearly impossible to enforce a State specific ban of products that can be bought online, including skin protecting moisturizers and sunscreens. Functionally this law will just make it harder for Hawaii consumers to buy products they use to prevent skin cancer, and force them to buy from online sellers rather than local stores.

In Hawaii where skin cancer is a major health concern[1] we believe it's important for people to have access to products that have been proven to offer effective sun protection for daily use.

[1] http://www.staradvertiser.com/2018/02/28/editorial/island-voices/heathy-people-healthy-places-include-sunscreen/

Many products that have sun protection factor, such as lotions, tinted moisturizers, and anti-aging products are intended for daily use in small amounts. These products are not used in large quantities anywhere near the ocean. However, all of these products would be unnecessarily banned under this bill, as would other federally approved and regulated healthcare products.

Given that this ban would not do anything to alleviate the known primary causes of coral bleaching, and that it would try to deprive people of products they use to prevent possibly life threatening skin cancers, we do not think the potential benefit is worth the risk and we ask that this measure be held.

Thank you for the opportunity to testify.

P.O. Box 437462 | Kamuela, Hawai'i 96743 | +1 808 887-6411 | Fax +1 808 885-6707 | kohalacenter.org

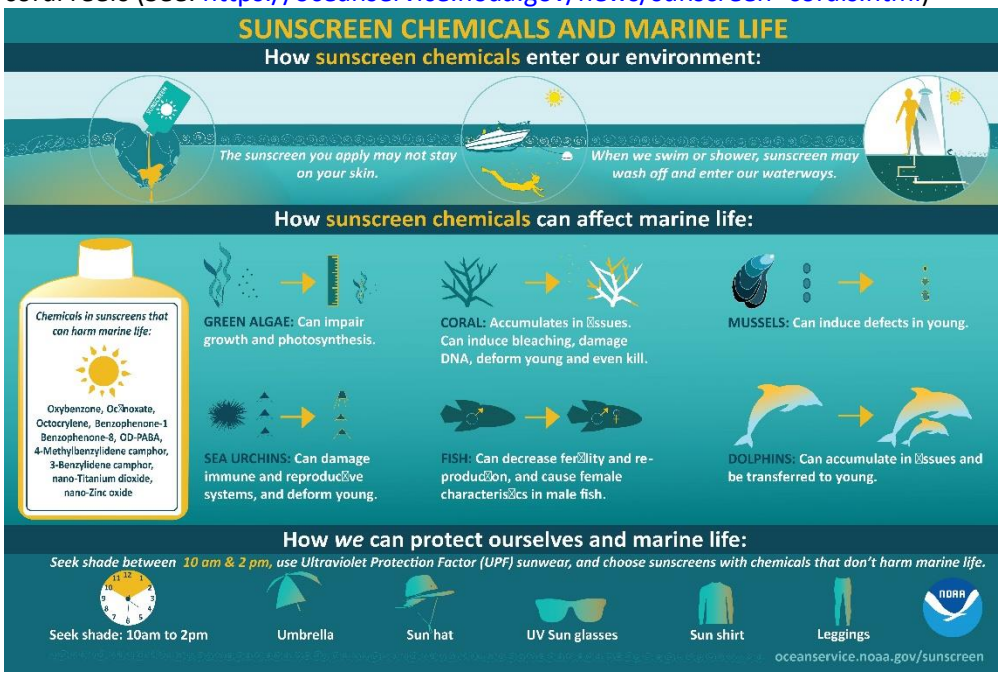
THE KOHALA CENTER®

**To: The Senate Committee on Agriculture and Environment (AEN)**
**Re: SB 132 RELATING TO WATER POLLUTION**
**Position: STRONG SUPPORT**
**Hearing Date: Thursday, February 17, 2021, 1:00 am, videoconference**

Aloha Chair Gabbard, Vice Chair Nishihara, and Agriculture and Environment Committee members

Coral reefs are intrinsic to Hawaiian culture and provide critical natural protection against coastal erosion and sea level rise. Further our coral reefs underpin our vibrant tourism industry, Hawai'i's primary and vital economic engine. Currently, these reefs we depend on are at risk. Where people use marine environments as recreational resources, there is sunscreen pollution. Swimmers put on sunscreen products before they get into the water and over a period of an hour much of that sunscreen will slough off, potentially contaminating the surrounding water. This is a grave concern because it has been reported in the scientific literature that specific chemicals in sunscreen can have irreversibly detrimental effects on marine life, including changes in fish behavior, damage to coral DNA and larvae, and the health of algae, fish, shellfish, urchins, and marine mammals.

The National Oceanic and Atmospheric Administration has already recognized this existential threat to our coral reefs (See: https://oceanservice.noaa.gov/news/sunscreen- corals.html)

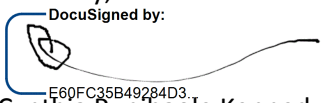



On February 26, 2019, the FDA removed all but two sunscreen ingredients from their GRASE (Generally Recognized As Safe and Effective) Category 1 list. Those two ingredients remaining on the category 1 list are Zinc Oxide and Titanium Dioxide. All other chemical sunscreen ingredients have been placed on the GRASE

category 3 “insufficient data for use in sunscreens” list. Included among those chemical ingredients on the category 3 list are oxybenzone, octinoxate, octisalate, octocrylene and avobenzone.
(See https://www.fda.gov/media/124655/download ).

We ask your support for SB 132 restricting the use of sunscreen chemicals that have questionable effects on the health of humans and marine life in alignment with the precautionary principle, affording us the opportunity to protect our environment and communities for future generations.

Sincerely,




Cynthia Punihaole Kennedy, Director
Kahalu‘u Bay Education Center
a program of The Kohala Center

**SB-132**
Submitted on: 2/15/2021 10:46:29 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Kaitlyn Jacobs | Testifying for Surfrider Foundation O'ahu Chapter | Support | No |

Comments:

Research supports the dangers of these chemicals to both humans and the environment, and it is a no brainer to support the state moving away from the sale of these products. We want to protect the residents and natural resources that bring in tourists, and their billions of dollars annually, so that we can support tourism sustainably and protect residents.

**SB-132**
Submitted on: 2/15/2021 6:48:40 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Charlie Quesnel | Testifying for Surfrider Maui Chapter | Support | No |

Comments:

I support this bill.

**SB-132**
Submitted on: 2/15/2021 8:51:11 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Robyn Fukumoto | Testifying for Lani & Kai | Support | No |

Comments:

Senators, thank you for your consideration with this essential bill.

As a state, we have made massive strides in leading the way in groundbreaking ocean regulation. We made it clear that our people stand for the preservation of our land and will go to great lengths to protect it.

The regulation of reef harming sunscreen is urgent, and preservation is unfortunuately not something that can be taken halfway. Reefs are in grave peril due to the ocean temperature fluctuations from global warming. We know from extensive scientific backing that, even in the smallest amount, avobenzone and octocrylene stress coral to the point of death. We've done our part to ban oxybenzone and octinoxate, but we cannot stop there if we want to make an impact.

Beyond balancing our ocean's biodiversity and producing the majority of the world's oxygen, the coral reefs are the backbone to our economy. They protect our coastline real estate from devastation, they sustain our island fish and fuel the jobs of our island fisherman, and fuel our tourist economy. The decision to oppose this bill would do irreprecable damage to our already fragile island economy.

I highly encourage your support for HB102 on behalf of myself and other concerned residents.

Personal Care Products Council
Committed to Safety, Quality & Innovation

February 16, 2021

Senator Mike Gabbard, Chair
Senator Clarence K. Nishihara, Vice Chair
Hawaii Senate Committee on Agriculture and Environment

**RE: Oppose Senate Bill 132**

Chair Gabbard and Vice Chair Nishihara:

On behalf of the members of the Personal Care Products Council (PCPC),[1] I am writing to express our opposition to Senate Bill 132, banning the sale, offer for sale or distribution in the State of any sunscreen that contains octocrylene, octisalate or homosalate.

Senate Bill 132 lacks the necessary scientific evidence to demonstrate that sunscreen ingredients are responsible for Hawaii's coral bleaching. There are well-recognized causes of coral reef decline in Hawaii and the rest of the world, including climate change, land-based pollution and other human activities, such as physical damage to corals from recreational activities. There is scientific consensus that these well-recognized causes are the primary reasons for coral bleaching, not sunscreens. Making environmental management decisions on sunscreens based on insufficient scientific data may lead to unintended health consequences, such as fewer available sunscreens and an increase in the prevalence of skin cancer. Ensuring that consumers have access to products containing a broad variety of sunscreen active ingredients is critical to public health.

We remain concerned that sunscreen ingredients continue to be depicted as unquestionably harming coral reefs and other marine life. Available scientific evidence on the environmental impact of sunscreen active ingredients is limited and indicates organic UV filters are unlikely to threaten coral reefs. There are also major knowledge gaps and data reliability issues with published coral toxicity studies that have been used to justify recent state sunscreen/UV filter restrictions. A recent scientific review of published coral toxicity and environmental occurrence data supports our concern and makes recommendations for additional research that would allow the scientific community to reach a consensus.[2] PCPC continues to work with leading environmental and coral experts to address open research questions by evaluating the risk of sunscreen active ingredients to U.S. corals.

Homosalate, octocrylene and octisalate, approved for use by the U.S. Food and Drug Administration (FDA), are three critical ingredients in sunscreen products, a crucial and well-recognized step in the fight

[1] Based in Washington, D.C., the Personal Care Products Council (PCPC) is the leading national trade association representing global cosmetics and personal care products companies. Founded in 1894, PCPC's 600 member companies manufacture, distribute and supply the vast majority of finished personal care products marketed in the U.S. As the makers of a diverse range of products millions of consumers rely on and trust every day – from sunscreens, toothpaste, and shampoo to moisturizer, makeup and fragrance – personal care products companies are global leaders committed to product safety, quality and innovation.

[2] Mitchelmore CL, Burns, EB, Conway A, Heyes, A, Davies IA. 2021. A critical Review of Organic Ultraviolet Filter Exposure, Hazard, and Risk to Corals. Environ Toxicol Chem. DOI: 10.1002/etc.4948.

against skin cancer and premature skin aging. The U.S. has a limited number of approved organic sunscreen ingredients – particularly those that protect against UVA rays, which penetrate more deeply into the skin and have been scientifically proven to contribute to skin cancer – to make products that protect consumers from the harmful effects of solar radiation. FDA previously proposed that all sunscreens with a SPF (sun protection factor) higher than 15 should be broad-spectrum sunscreens. Only sunscreen products with ingredients protecting against both UVB and UVA rays may be labeled as "broad-spectrum protection," preventing premature aging and skin cancer. With Hawaii's previous ban on some sunscreen active ingredients, further limiting access to products that can help prevent skin cancer is contrary to protecting public health.

Sunscreens are a key factor in preventing and reducing the risk of skin cancer and UV damage. Nonprofit health organizations, including the American Cancer Society, American Academy of Dermatology, the Mayo Clinic and the Skin Cancer Foundation, recommend using sunscreen as part of a safe sun regimen to prevent skin cancer. The Centers for Disease Control and Prevention's Sun Safety recommendations note the importance of daily sunscreen use, including on cloudy and overcast days, to help prevent most skin cancers.

For all of the above reasons, we respectfully ask that you vote NO on Senate Bill 132. Thank you for your consideration and for the opportunity to comment.

Sincerely,

Iain Davies, Ph.D.
Director, Environmental Science Programs
Personal Care Products Council

# Supporting Science

The following report outlines the state of the science pertaining to the risk UV filters pose to coral and these risks are put in the context of proven local and global stressors of coral reef decline. The risk UV filters pose to corals is important to investigate and manage; however, current data to assess this risk is limited. A roadmap to assessing risk is presented along with the knowledge gaps that industry, academia, and third-party experts are currently working to fill.

# Local and Global Causes of Coral Reef Decline

Coral reefs are immensely valuable ecosystems and an essential habitat for numerous threatened and endemic species. They provide not only a buffer against coastal erosion, a wide variety of food resources, pharmaceutical materials, but also facilitate tourism and recreation.[3] Therefore, the degradation of coral reefs is a serious concern for Hawaii and reef ecosystems globally. Significant efforts to determine and address the causes of reef decline are critical for protecting these ecologically and economically important ecosystems. Much work has been conducted to investigate the role of various stressors on reef decline, including local stressors such as land-based pollution (e.g., nutrients), coastal development, sedimentation (e.g. land runoff and dredging), and human recreation; while global stressors such as increased sea temperatures and ocean acidification as a result of climate change.

Many studies have examined the impact of local stressors on corals. Sedimentation, resulting from dredging or land-based runoff, has been studied in 89 coral species.[4] Sensitivity to sedimentation is species-dependent, but it can cause adult coral mortality and reduce the successful recruitment and survival of coral larvae. For example, Ricardo et al.[5] determined that a very thin (< 150 µm, similar to the thickness of paper) layer of sediment inhibited successful settlement and therefore the successful recruitment of *Acropora millepora* larvae. Increased nutrient loads from land-based runoff can trigger algal blooms which can kill corals, reduce coral growth, and also inhibit larval recruitment.[6,7] The threat of nutrient-based pollution is particularly pronounced in Hawaii as large-scale cesspools and septic systems are utilized for waste management. These large-capacity cesspools have been found to violate the Safe Drinking Water Act by U.S. Environmental Protection Agency (EPA),[8] and are a significant source of land-based pollution to coastal Hawaiian waters.[9] Human recreation such as snorkeling has also been identified as a mechanism to cause physical damage to corals (due to fragmentation and breakage).[10]

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[3] Weijerman, M. *et al.* Managing local stressors for coral reef condition and ecosystem services delivery under climate scenarios. *Front. Mar. Sci.* **5**, 1–16 (2018).

[4] Erftemeijer, P. L. A., Riegl, B., Hoeksema, B. W. & Todd, P. A. Environmental impacts of dredging and other sediment disturbances on corals: A review. *Mar. Pollut. Bull.* **64**, 1737–1765 (2012).

[5] Ricardo, G. F., Jones, R. J., Nordborg, M. & Negri, A. P. Settlement patterns of the coral *Acropora millepora* on sediment-laden surfaces. *Sci. Total Environ.* **609**, 277–288 (2017).

[6] Weijerman, M. *et al.* Managing local stressors for coral reef condition and ecosystem services delivery under climate scenarios. *Front. Mar. Sci.* **5**, 1–16 (2018).

[7] Wedding, L. M. *et al.* Advancing the integration of spatial data to map human and natural drivers on coral reefs. *PLoS One* **13**, 1–29 (2018).

[8] US EPA News Release. July 22, 2020. https://www.epa.gov/newsreleases/epa-fines-hawaii-local-and-state-governments-requires-three-cesspool-closures-effort.

[9] Mezzacapo, M. *et al.* Hawai'i's Cesspool Problem: Review and Recommendations for Water Resources and Human Health. J. Contemp. Water Res. Educ. **170**, 35-75 (2020).

[10] Hannak, J. S., Kompatscher, S., Stachowitsch, M. & Herler, J. Snorkelling and trampling in shallow-water fringing reefs: Risk assessment and proposed management strategy. *J. Environ. Manage.* **92**, 2723–2733 (2011).

An extensive review by Brainard et al.[11] identified both an increase in sea temperatures and ocean acidification (resulting from climate change) as major threats to coral reefs. Ocean acidification leads to reduced calcification rates, indicating that the overall growth of calciferous reef structure is inhibited.[12] Meanwhile a clear connection between increased ocean temperatures and coral bleaching has also been established. In a landmark 2017 study, the cause of mass coral bleaching events in Australia's Great Barrier Reef in 1998, 2002 and 2015-2016 was examined.[13] The authors concluded that sea temperature increases resulting from climate change was responsible for the bleaching events and that local pressures (water quality and fishing) were of minimal effect comparatively. The authors concluded that interventions targeting local pressures would provide little or no protection from the effects of climate change. In a follow-up study, Hughes et al.[14] demonstrated that the mass coral mortality stemming from the 2015-2016 Great Barrier Reef bleaching events reduced coral recruitment (settlement and subsequent growth of sexually produced coral larvae) by 89%. This reduction in coral recruitment severely hampers coral recovery from the impacts of global warming. A 2017 University of Hawaii study by Rodgers et al.[15] examined the causes of coral bleaching in Hawaii and considered visitor numbers, water currents and elevated sea temperatures. The authors concluded that climate change (increased sea temperatures) was the dominant factor driving coral bleaching in comparison to the other factors studied.

Taken together, there is a clear scientific consensus that both global and local stressors contribute to the degradation of coral reefs through a variety of mechanisms. It has been postulated that resilience to global stressors can be enhanced by addressing local stressors. A key 2018 modelling study conducted for Maui Nui, Hawaii, by Weijerman et al. evaluated how different local management approaches (sedimentation mitigation and the designation of marine protected areas) could improve coral reef conditions under various climate change scenarios.[16] Multiple pressures were included in the model such as fishing; sedimentation from river mouths and dredging; land-based nutrient release from cesspools septic systems; and fertilizers, and hurricane damage. The comprehensive study identified that strict sedimentation mitigation could reduce coral cover decline; however, the benefit of these local management scenarios was lost when accounting for climate change impacts, a similar conclusion to that for the Great Barrier Reef.[17] This is aligned with the position of multiple national and international governmental and environmental organizations including the National Oceanic and Atmospheric Administration (NOAA), the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the U.S. Coral Reef Task Force, all of which have identified rising sea temperatures from global warming as the primary cause of coral bleaching. It is critical that the findings from studies like those presented by Weijerman et al., which integrate proven local and global stressors on coral reef decline to optimize coral ecosystem management, are utilized to give the best chance of protecting threatened reef ecosystems.

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[11] Brainard, R. E. *et al.* Incorporating Climate and Ocean Change into Extinction Risk Assessments for 82 Coral Species. *Conserv. Biol.* **27**, 1169–1178 (2013).

[12] Weijerman, M. *et al.* Managing local stressors for coral reef condition and ecosystem services delivery under climate scenarios. *Front. Mar. Sci.* **5**, 1–16 (2018).

[13] Hughes, T. P. *et al*. Global warming and recurrent mass bleaching of corals. *Nature* **543**, 373–377 (2017).

[14] Hughes, T. P. *et al.* Global warming impairs stock–recruitment dynamics of corals. *Nature* **568**, 387–390 (2019).

[15] Rodgers, K. S., Bahr, K. D., Jokiel, P. L. & Donà, A. R. Patterns of bleaching and mortality following widespread warming events in 2014 and 2015 at the Hanauma Bay Nature Preserve, Hawai'i. *PeerJ* **5**, e3355 (2017).

[16] Weijerman, M. *et al.* Managing local stressors for coral reef condition and ecosystem services delivery under climate scenarios. *Front. Mar. Sci.* **5**, 1–16 (2018).

[17] Hughes, T. P. *et al.* Global warming and recurrent mass bleaching of corals. *Nature* **543**, 373–377 (2017)

# Coral Toxicity to UV Filters

Considering coral reefs are expected to be exposed to UV filters through wash-off during recreational activity, evaluating their impact as a local stressor is important. An environmental risk assessment (ERA) should be conducted to fully assess the environmental impact of UV filters on coral. The ERA considers the level at which UV filters are found near coral reefs and whether these levels exceed the concentration that is expected to cause harm to corals. If safe levels are exceeded, then risks can be managed through mitigation measures. This is the fundamental approach used for chemical management in the U.S. and around the world.

A recent review by Mitchelmore et al. critically analyzed existing near reef UV filter concentrations and coral toxicity data.[18] As this is the only comprehensive review of all relevant science thus far, the work reported in the review is discussed herein. A total of 12 studies have measured organic UV filters in the water near coral reefs. Generally, average concentrations of each organic UV filter were very low, below 0.1 microgram per liter (µg/L). Of the 12 studies, only two presented data relevant to the Hawaiian reef environment. Mitchelmore et al.[19] measured all organic UV filters permitted for use in the U.S. at 19 sites in Hawaii, while Downs et al.[20] measured oxybenzone at 15 sites in Hawaii. The organic UV filter concentrations in Hawaii reported by Mitchelmore et al. were either similar to or less than concentrations reported for other regions. The review by Mitchelmore et al. highlighted significant analytical problems with the oxybenzone monitoring data reported by Downs et al., thereby limiting the usefulness of that data for ERA. For example, Downs et al. reported extraordinarily high limits of quantification, 0.5 µg/L, over 5000 times greater than the other studies. Furthermore, the values reported by Downs et al. are extraordinarily high, 1-3 orders of magnitude greater than any other study. For example, the average and maximum oxybenzone concentrations reported by Mitchelmore et al. (2019) were 0.02 and 0.14 µg/L, respectively, compared to 145 and 1395 µg/L reported by Downs et al. (2016). The exceptionally high oxybenzone values reported by Downs et al. exceed the total dissolved organic carbon (TDOC) concentrations typical in seawater near coral reefs. This would mean that a TDOC concentration would be double the typical ranges in Hawaii due to the presence of oxybenzone alone. Taken together, the Downs et al.'s data are a clear outlier, and the methodological issues identified indicate the data is not reliable for ERA and will not be considered further.

In terms of organic UV filter toxicity to coral, Mitchelmore et al. reported that only nine studies have been published to date. Of these nine studies, only four attempted to demonstrate a dose-response relationship where toxic effects increase as UV filter concentrations increase.[21,22,23,24] Observation of a dose-response

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[18] Mitchelmore, C. L., Burns, E. E., Conway, A., Heyes, A. & Davies, I. A. A critical review of organic ultraviolet filter exposure, hazard, and risk to corals. *Environ. Toxicol. Chem.* 1-22 (2021). 10.2002/etc.4948.

[19] Mitchelmore, C. L. *et al.* Occurrence and distribution of UV-filters and other anthropogenic contaminants in coastal surface water, sediment, and coral tissue from Hawaii. *Sci. Total Environ.* **670**, 398–410 (2019).

[20] Downs, C. A. *et al.* Toxicopathological Effects of the Sunscreen UV Filter, Oxybenzone (Benzophenone-3), on Coral Planulae and Cultured Primary Cells and Its Environmental Contamination in Hawaii and the U.S. Virgin Islands. *Arch. Environ. Contam. Toxicol.* **70**, 265–288 (2016).

[21] He, T. *et al.* Toxicological effects of two organic ultraviolet filters and a related commercial sunscreen product in adult corals. *Environ. Pollut.* **245**, 462–471 (2019a).

[22] He, T. *et al.* Comparative toxicities of four benzophenone ultraviolet filters to two life stages of two coral species. *Sci. Total Environ.* **651**, 2391–2399 (2019b).

[23] Fel, J. P. *et al.* Photochemical response of the scleractinian coral Stylophora pistillata to some sunscreen ingredients. *Coral Reefs* **38**, 109–122 (2019).

[24] Downs, C. A. *et al.* Toxicopathological Effects of the Sunscreen UV Filter, Oxybenzone (Benzophenone-3), on Coral Planulae and Cultured Primary Cells and Its Environmental Contamination in Hawaii and the U.S. Virgin Islands. *Arch. Environ. Contam. Toxicol.* **70**, 265–288 (2016).

relationship is a cornerstone of ecotoxicology, as it enables toxicity results to be translated into an environmental context.[25] If a study is not designed to observe a dose-response, it is of no value for ERA or decision-making. Therefore, only these four studies are relevant for determining toxicological thresholds or the safe levels of UV filters that coral can be exposed to before exhibiting toxic effects.

Avobenzone has only been included in a single ecotoxicity study.[26] Danovaro et al. included it in their preliminary study,[27] but that study is not acceptable for determining toxicological thresholds for multiple reasons reported in the Mitchelmore et al. review. Fel et al. monitored photosynthetic yield, which is thought to be a precursor for coral bleaching. [28] If the UV filter suppresses photosystem II in the coral symbiont algae, photosynthetic yield will be reduced. The lowest concentration of avobenzone that caused a significant reduction in photosynthetic yield was 516 µg/L. To put this value in an environmental risk context, it needs to be compared to relevant exposure data. Tsui et al. have reported the highest near-reef avobenzone concentration globally as 0.7 µg/L.[29] This level is **700 times less than the lowest level needed to cause an effect** based on the only coral toxicological data available to date. Furthermore, Mitchelmore et al. did not even detect avobenzone in Hawaiian waters above their limit of detection, indicating that less than 0.003 µg/L was present, **over 170 000 times less than the level that causes an effect (516 µg/L).**

Octocrylene was also included in the Fel et al. study.[30] The concentration required to significantly reduce photosynthetic yield was even higher than avobenzone, 1318 µg/L. Additionally, octocrylene was included in a toxicity study carried out on two adult coral species by He et al. (2019). [31] A range of effects were studied and the lowest concentration that caused an effect was 1000 µg/L. At this concentration, a significant reduction in the symbiotic algae within the coral host was observed and the coral condition was impacted as evidenced by polyp retraction. Importantly, He et al. did not observe any coral bleaching, even at the highest concentration studied (1000 µg/L). Therefore, the lowest toxicity concentration for octocrylene reported to date is 1000 µg/L, **over 13 000 times higher than average octocrylene levels measured in near-reef environments near reefs**, as reported by Mitchelmore et al. [32] The highest near-reef concentration of octocrylene reported in Hawaii to date is 0.027 µg/L, [33] indicating that based on current data environmental concentrations of octocrylene near reefs are far too low to cause an effect on coral.

Similarly to avobenzone, octinoxate has appeared only in a single coral ecotoxicity study. He et al. (2019) exposed adult corals and monitored a range of toxic effects. [34] Polyp retraction was the lowest observed

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[25] Harris, C. A. *et al.* Principles of Sound Ecotoxicology. *Environ. Sci. Technol.* **48**, 3100–3111 (2014).

[26] Fel, J. P. *et al.* Photochemical response of the scleractinian coral Stylophora pistillata to some sunscreen ingredients. *Coral Reefs* **38**, 109–122 (2019).

[27] Danovaro, R. *et al.* Sunscreens cause coral bleaching by promoting viral infections. *Environ. Health Perspect.* **116**, 441–447 (2008).

[28] Fel, J. P. *et al.* Photochemical response of the scleractinian coral Stylophora pistillata to some sunscreen ingredients. *Coral Reefs* **38**, 109–122 (2019).

[29] Tsui, M. M. P. *et al.* Occurrence, distribution and ecological risk assessment of multiple classes of UV filters in surface waters from different countries. *Water Res.* **67**, 55–65 (2014).

[30] Fel, J. P. *et al.* Photochemical response of the scleractinian coral Stylophora pistillata to some sunscreen ingredients. *Coral Reefs* **38**, 109–122 (2019).

[31] He, T. *et al.* Toxicological effects of two organic ultraviolet filters and a related commercial sunscreen product in adult corals. *Environ. Pollut.* **245**, 462–471 (2019a).

[32] Mitchelmore, C. L., Burns, E. E., Conway, A., Heyes, A. & Davies, I. A. A critical review of organic ultraviolet filter exposure, hazard, and risk to corals. *Environ. Toxicol. Chem.* 1-22 (2021). 10.2002/etc.4948.

[33] Mitchelmore, C. L. *et al.* Occurrence and distribution of UV-filters and other anthropogenic contaminants in coastal surface water, sediment, and coral tissue from Hawaii. *Sci. Total Environ.* **670**, 398–410 (2019).

[34] He, T. *et al.* Toxicological effects of two organic ultraviolet filters and a related commercial sunscreen product in adult corals. *Environ. Pollut.* **245**, 462–471 (2019a).

effect at 10 µg/L, while the lowest concentration to cause bleaching was 100 µg/L. The maximum concentration of octinoxate reported in near reef environments globally was observed by Tsui et al. (2014) at 4 µg/L, while the average concentration across seven monitoring studies as reviewed by Mitchelmore et al. was 0.1 µg/L. [35] Mitchelmore et al. were unable to detect octinoxate in near-reef Hawaiian waters, meaning levels were below 0.002 µg/L[36]. Therefore, the most sensitive coral toxicological response to octinoxate, polyp retraction, would not be expected to occur in Hawaii as **environmental concentrations are over 5000 times lower than the effect concentration (10 µg/L).**

Two studies have conducted coral toxicological investigations of oxybenzone. Downs et al. exposed coral planulae (fertilized larvae) and determined a median lethal concentration (LC50) and median effect concentration (EC50) for planulae deformity under light and dark conditions. [37] Downs et al. also included a coral cell line assay, but this was not correlated with effects in whole organisms and is therefore not suitable for risk assessment, as discussed in the Mitchelmore et al. review. [38] The LC50 was reported as 139 µg/L, while the deformity EC50 was lower, 49 µg/L. In Hawaii specifically, Mitchelmore et al. recorded an average near-reef oxybenzone concentration of 0.02 µg/L and a maximum concentration of 0.14 µg/L. [39] This means the average concentration of oxybenzone in near reef environments in Hawaii **is over 2000 times less** than the concentration required to cause an effect, according to the toxicity data reported by Downs et al. for coral larvae. [40] He et al. also studied the impacts of oxybenzone on two coral species in both larval and adult life stages. [41] In adults, polyp retraction was observed at the lowest concentration, 10 µg/L, while bleaching was observed at 1000 µg/L of oxybenzone. He et al. concluded that coral larvae were not as sensitive to oxybenzone exposure as adults. Therefore, the lowest effect concentration for oxybenzone was observed by He et al. at 10 µg/L for polyp retraction. This effect concentration is still below far the average concentration of oxybenzone in Hawaiian waters reported by Mitchelmore et al. (0.02 µg/L) and below the global near-reef maximal values reported in the environment by Bargar et al.[42] and Tsui et al.[43] of 6.2 and 5.4 µg/L globally.

Octisalate and homosalate were not included in any suitable ecotoxicological coral study to date. Therefore, there is **no ecotoxicological evidence** these UV filters harm coral. Octisalate is included in the Danovaro

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[35] Mitchelmore, C. L., Burns, E. E., Conway, A., Heyes, A. & Davies, I. A. A critical review of organic ultraviolet filter exposure, hazard, and risk to corals. *Environ. Toxicol. Chem.* 1-22 (2021). 10.2002/etc.4948.

[36] Mitchelmore, C. L. *et al.* Occurrence and distribution of UV-filters and other anthropogenic contaminants in coastal surface water, sediment, and coral tissue from Hawaii. *Sci. Total Environ.* **670**, 398–410 (2019).

[37] Downs, C. A. *et al.* Toxicopathological Effects of the Sunscreen UV Filter, Oxybenzone (Benzophenone-3), on Coral Planulae and Cultured Primary Cells and Its Environmental Contamination in Hawaii and the U.S. Virgin Islands. *Arch. Environ. Contam. Toxicol.* **70**, 265–288 (2016).

[38] Mitchelmore, C. L., Burns, E. E., Conway, A., Heyes, A. & Davies, I. A. A critical review of organic ultraviolet filter exposure, hazard, and risk to corals. *Environ. Toxicol. Chem.* 1-22 (2021). 10.2002/etc.4948.

[39] Mitchelmore, C. L. *et al.* Occurrence and distribution of UV-filters and other anthropogenic contaminants in coastal surface water, sediment, and coral tissue from Hawaii. *Sci. Total Environ.* **670**, 398–410 (2019).

[40] Downs, C. A. *et al.* Toxicopathological Effects of the Sunscreen UV Filter, Oxybenzone (Benzophenone-3), on Coral Planulae and Cultured Primary Cells and Its Environmental Contamination in Hawaii and the U.S. Virgin Islands. *Arch. Environ. Contam. Toxicol.* **70**, 265–288 (2016).

[41] He, T. *et al.* Comparative toxicities of four benzophenone ultraviolet filters to two life stages of two coral species. *Sci. Total Environ.* **651**, 2391–2399 (2019b).

[42] Bargar, T. A., Alvarez, D. A. & Garrison, V. H. Synthetic ultraviolet light filtering chemical contamination of coastal waters of Virgin Islands national park, St. John, U.S. Virgin Islands. *Mar. Pollut. Bull.* **101**, 193–199 (2015).

[43] Tsui, M. M. P. *et al.* Occurrence, distribution and ecological risk assessment of multiple classes of UV filters in surface waters from different countries. *Water Res.* **67**, 55–65 (2014).

et al. study (in addition to avobenzone, oxybenzone, octocrylene and octinoxate) but as mentioned the study was conducted so poorly that it is not possible to draw any conclusion from it as discussed in the Mitchelmore et al. review. [44]

# Quality of Published UV Filter Coral Toxicity Studies

Major scientific flaws have been found for all published UV filter coral toxicity studies. These issues reduce the confidence we can have in their findings, which ultimately makes them unsuitable for environmental risk assessment. For ERA to be successful and protective, high quality data need to be used. There are several methods to assess the reliability of a study, and these approaches are routinely applied by regulatory bodies (such as the U.S. Environmental Protection Agency and Environmental and Climate Change Canada) to ensure that data used to inform decision-making is suitable. These coral studies are not the first ecotoxicity studies to be criticized for failing to meet basic requirements for conducting reliable experiments.[45] To improve the usefulness of ecotoxicity studies published in the peer-reviewed literature for ERA, data reliability assessments have been established, such as the CRED method.[46] These methods evaluate the quality of five key areas of a study: test setup, test compound, test organism, test design/conditions, and results and statistics. This covers aspects such as whether adequate controls were used, whether the test medium suitable for the test animal, and whether the concentration of the test compound was measured and maintained throughout the test.

Applying the CRED method to the four coral toxicity studies extensively discussed, no study is 'reliable without restriction,' which is considered the scientific gold standard, and use of those data in an ERA would be suitable. The two He et al. studies contained the fewest reliability issues; however, the test concentrations they used meant they were not able to observe statistically important effects (for example EC50s or LC50s). They also demonstrated that the UV filters degraded (broke-down) so much so that by the end of their tests oxybenzone, octocrylene and octinoxate were no longer detectable. Therefore, we cannot say what level of UV filter the coral were actually exposed to and this can lead to an under or overestimate of toxicity.[47] A similar problem was observed with the Downs et al. study; no concentrations were measured throughout the whole test. [48] Turner and Renegar observed similar issues in a review of coral toxicity studies with petroleum hydrocarbons, where test concentrations were either not measured or measured too infrequently to determine an average exposure.[49] The purpose of a toxicity study is to determine a threshold concentration that can be compared with concentrations observed in the environment to inform chemical management. If this threshold concentration is not measured, then the study is of little value. On the other hand, Fel et al. [50] did monitor the concentration of UV filters throughout the test; significant UV filter

[44] Mitchelmore, C. L., Burns, E. E., Conway, A., Heyes, A. & Davies, I. A. A critical review of organic ultraviolet filter exposure, hazard, and risk to corals. *Environ. Toxicol. Chem.* 1-22 (2021). 10.2002/etc.4948.

[45] Harris, C. A. & Sumpter, J. P. Could the Quality of Published Ecotoxicological Research Be Better? *Environ. Sci. Technol.* **49**, 9495–9496 (2015).

[46] Moermond, C. T. A., Kase, R., Korkaric, M. & Ågerstrand, M. CRED: Criteria for reporting and evaluating ecotoxicity data. *Environ. Toxicol. Chem.* **35**, 1297–1309 (2016).

[47] Harris, C. A. *et al.* Principles of Sound Ecotoxicology. *Environ. Sci. Technol.* **48**, 3100–3111 (2014).

[48] Downs, C. A. *et al.* Toxicopathological Effects of the Sunscreen UV Filter, Oxybenzone (Benzophenone-3), on Coral Planulae and Cultured Primary Cells and Its Environmental Contamination in Hawaii and the U.S. Virgin Islands. *Arch. Environ. Contam. Toxicol.* **70**, 265–288 (2016).

[49] Turner, N. R. & Renegar, D. A. Petroleum hydrocarbon toxicity to corals: A review. *Mar. Pollut. Bull.* **119**, 1–16 (2017).

[50] Fel, J. P. *et al.* Photochemical response of the scleractinian coral Stylophora pistillata to some sunscreen ingredients. *Coral Reefs* **38**, 109–122 (2019).

degradation was also identified, but due to the frequency of measurement, a mean exposure concentration could be calculated.

Using the CRED method, the Fel et al. and Downs et al. studies are considered unreliable due to the number and severity of studies' flaws (and the remaining six UV filter toxicity studies that were not discussed). For the Fel et al. study specifically, a significant dose-response relationship was not observed, and the experiment was not adequately replicated. For the Downs et al. study, test concentrations were not analytically verified; the test chemical was incorrectly identified; a reference toxicant was not included (which was required as part of the guideline the authors cited); too little data provided to assess basic study acceptability criteria including control mortality and effects; the exposure conditions were not suitable for the coral larvae; and the use of a solvent, dimethyl sulfoxide, which is not considered acceptable by the US EPA. Together, these flaws limit the usefulness of these studies for drawing any conclusions about the harm UV filters may cause coral and **would not** be suitable for any ERA conducted by regulatory authorities such as the U.S. EPA, European Chemicals Agency or Environment and Climate Change Canada.

# Critical Knowledge Gaps for the Impacts of UV Filters on Coral

At this time, we cannot conclusively determine that UV filters do not harm coral; however, the presented synthesis of existing data demonstrate that based on current environmental levels, UV filters are not suspected of harming coral. This is because there is currently limited or no ecotoxicological data for some UV filters and much of the existing data are considered unreliable based on the results of systematic data quality evaluation approaches. These ecotoxicological knowledge gaps need to be addressed with robust ecotoxicological tests that are repeatable and reliable for all UV filters. The design of these studies should provide comparable toxicological thresholds that are suitable for ERA and can therefore support evidence-based decision making. Conducting an ERA for UV filters is also a priority of the U.S. EPA as recently they tasked the U.S. National Academy of Sciences (NAS) with determining data gaps and/or risks UV filters pose to both the freshwater and marine environment and to assess the impact on public health of potential changes in sunscreen use.[51]

A significant barrier exists for generating reliable coral toxicological data. There is no standardized coral toxicity test system, which describes basic acceptability criteria, water quality thresholds, replication, animal husbandry, and endpoints to observe. This is likely a significant reason why most of the toxicity studies to date are unreliable; there is no core method or suitable modified guideline method to follow. In response to this need, PCPC is working to develop a standardized coral ecotoxicological test system. This work is in conjunction with scientists at the University of Maryland Center for Environmental Science and the Nova Southeastern University and can be used to generate reliable, comparable and consistent data for ERA purposes. Development of a coral toxicity test system will be critical for filling knowledge gaps with reliable coral toxicity data for UV filters so that an ERA with appropriate data can be conducted.

More broadly, PCPC published the first comprehensive review on the UV filter occurrence, effects and risks to coral reefs.[52] The review identified a series of actions that need to be taken in order to effectively assess the environmental risk of UV filters to coral environments. This includes the prediction of UV filter

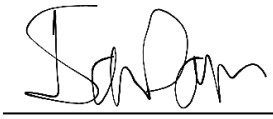
[51] NASEM [NASEM] National Academies of Sciences, Engineering, and Medicine. 2020. Environmental impact of currently marketed sunscreens and potential human impacts of changes in sunscreen use. https://www.nationalacademies.org/our-work/environmental-impact-of-currently-marketed-sunscreens-and-potential-human-impacts-of-changes-in-sunscreen-usage.

[52] Mitchelmore, C. L., Burns, E. E., Conway, A., Heyes, A. & Davies, I. A. A critical review of organic ultraviolet filter exposure, hazard, and risk to corals. *Environ. Toxicol. Chem.* 1-22 (2021). 10.2002/etc.4948.

concentrations in marine environments due to recreational and down-the-drain use. A scoping exercise to determine appropriate models for this purpose has already been initiated by a coalition of industry and non-industry scientists. Predicted environmental concentrations are better suited to ERA as they don't reflect a snapshot in time and can incorporate spatial variability within a probabilistic framework. The review also identified the use of an eco-epidemiological approach which could be a useful strategy for evaluating combinations of physical, chemical and environmental conditions over time to identify dominant stressors. A feasibility assessment for the eco-epidemiological approach has already been commissioned by PCPC. This approach is similar to Weijerman et al.'s modelling study (discussed previously) that evaluated the effectiveness for different local management approaches to improve coral reef conditions under various climate change scenarios in Hawaii.[53]

There is currently limited evidence to suggest that corals are adversely impacted by environmental exposure to UV filters; however, these major knowledge gaps need to be addressed with high-quality UV filter toxicity and environmental occurrence data. Together these studies can be used to appropriately quantify the risk of UV filters to coral, thus enabling assessors to make informed, evidence-based decisions that will truly be of benefit for coral health.

Emily Burns, Ph.D.
Environmental Scientist
Personal Care Products Council



Iain Davies, Ph.D.
Director, Environmental Science Programs
Personal Care Products Council

[53] Weijerman, M. *et al.* Managing local stressors for coral reef condition and ecosystem services delivery under climate scenarios. *Front. Mar. Sci.* **5**, 1–16 (2018).

February 16, 2021

The Honorable Gerald Michael Gabbard
Chair, Senate Committee on Agriculture and Environment
415 South Beretania Street Room 201
Honolulu, HI 96813

Dear Chairman Gabbard:

On behalf of the Hawaii Dermatological Society and the over 13,800 U.S. members of the American Academy of Dermatology Association (AADA), we write concerning SB 132, legislation that would prohibit for sale or distribution sunscreens containing homosalate, octocrylene, and octisalate. As dermatologists, we dedicate our lives to promoting habits in our patients that ensure healthy skin. UV radiation damages the skin's DNA, which is the beginning stage of skin cancer. We urge you and the members of the Committee on Agriculture and Environment to strongly consider the broad implications of banning sunscreens containing certain ingredients, and bear in mind the dangers of sun exposure without adequate protection that the residents and visitors of Hawaii face.

UV light exposure is a risk factor for all types of skin cancer and sunscreen use is one photoprotection method to protect against it. UVA damages deeper layers of the skin and contributes to the development of melanoma, the deadliest form of skin cancer. UVB is the primary cause of sunburn and plays a key role in the development of skin cancer in the skin's

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more superficial layers. In addition, both types of rays can cause suppression of the immune system.[1] Unprotected sun exposure is the most preventable risk factor for skin cancer. According to current estimates, at least one in five Americans will develop skin cancer in their lifetime.[2,3] Melanoma, the deadliest form of skin cancer, is now the second most common form of cancer for females aged 15-29 years old, and Caucasian men over 50 years of age are at a higher risk of developing melanoma than the general population. [4,5,6] In 2021, 460 new cases of melanoma are expected to be diagnosed in Hawaii.[7] Further, the annual cost of treating nonmelanoma skin cancer in the U.S. is estimated at $4.8 billion, while the average annual cost of treating melanoma is estimated at $3.3 billion.[8]

To help prevent skin cancer, the AADA recommends a comprehensive sun protection plan that includes seeking shade; wearing protective clothing, including hats and sunglasses; and generously applying a broad-spectrum, water-resistant sunscreen with an SPF of 30 or higher to exposed skin. Those who are concerned about the reported effects of chemical sunscreen ingredients can opt for a physical sunscreen containing the active ingredients zinc oxide or titanium dioxide.

Dermatologists have an interest in patient and public access to safe and effective sunscreen ingredients. The FDA is currently working with industry on safety testing for currently marketed sunscreen ingredients. The FDA is also considering several time-and-extent applications (TEAs) for new sunscreen ingredients to be added to the FDA over-the-counter (OTC) sunscreen monograph. The FDA's conclusion from recent studies on sunscreen ingredient absorption "supports the need for further studies to determine the clinical significance of these findings." FDA further stated that "these findings do not indicate that individuals should refrain from the use of sunscreen."[9] It should be noted that sunscreen ingredients have been used since

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[1] Lim HW, James WD, Rigel DS, Maloney ME, Spencer JM, Bhushan R. Adverse effects of ultraviolet radiation from the use of indoor tanning equipment: time to ban the tan. Journal of the American Academy of Dermatology. 2011 Apr 30;64(4):e51-60.
[2] Stern RS. Prevalence of a history of skin cancer in 2007: results of an incidence-based model. Arch Dermatol. 2010 Mar;146(3):279-82.
[3] Robinson JK. Sun Exposure, Sun Protection, and Vitamin D. JAMA 2005; 294: 1541-43.
[4] Siegel RL, Miller KD, Jemal A. Cancer statistics, 2017. CA Cancer J Clin. 2017; 67:7-30.
[5] Little EG, Eide MJ. Update on the current state of melanoma incidence. Dermatol Clin. 2012:30(3):355-61.
[6] NAACCR Fast Stats: An interactive quick tool for quick access to key NAACCR cancer statistics. North American Association of Central Cancer Registries. http://www.naaccr.org/. (Accessed on 3-10-2016).
[7] American Cancer Society. Cancer Facts and Figures 2021. https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/annual-cancer-facts-and-figures/2021/cancer-facts-and-figures-2021.pdf
[8] Guy GP, Machlin S, Ekwueme DU, Yabroff KR. Prevalence and costs of skin cancer treatment in the US, 2002–2006 and 2007–2011. Am J Prev Med. 2015;48:183–7
[9] Matta, MK, Florian, J, Zusterzeel, R, Nageswara RP, Patel, V, Volpe, DAPhD, et al. Effect of Sunscreen Application on Plasma Concentration of Sunscreen Active Ingredients: A Randomized Clinical Trial. Journal of the American Medical Association 323, No. 3 (2020). 267.

the 1970s without any reported systemic adverse side effects. This issue highlights the urgent need for new safe and effective ingredients to be introduced in the United States. With the approval of ingredients that utilize alternative UV filters available to sunscreen product manufacturers, the public's health will be increasingly protected. The AADA will continue to take part in the discussion with the FDA and manufacturers regarding availability of current and new ingredients.

We are aware of and concerned about the potential environmental impact of UV-filters. However, the potential adverse effects, if any, related to the levels of UV-filters in the water supply and marine life (as well as humans) is an emerging science. In a recent review of this topic, 12 studies evaluating up to 14 different organic UV filters in seawater near coral reefs were critically analyzed. The authors concluded that the majority of concentrations found in seawater were in the nanograms per liter range. Nine papers report toxicological findings from no response to a variety of biological effects, however, these effects were detected in the micrograms per liter to milligrams per liter range, namely, at least 1000-fold higher that those reported in seawater in real life.[10] The review concludes "there is currently limited evidence to suggest that corals are adversely impacted by environmental exposure to UV filters."

Our organizations advocated for the enactment of the Further Consolidated Appropriations Act, 2020, under which the U.S. Congress directed the Environmental Protection Agency (EPA) to contract with the National Academy of Sciences (NAS) to conduct a scientific literature review of current sunscreens' potential risk to the marine environment. The study will also consider scientific literature on the potential public health implications as a result of reduced use of sunscreens. This type of further research is required in order to definitively understand how UV-filters may affect the environment. We encourage you to consider these ongoing efforts before taking any action to remove a product that has been proven effective to protect humans from skin cancer. Based on current data, removing specific sunscreen active ingredients and products from the market would be premature, and would deprive the public an integral component of photoprotection to decrease the risk of skin cancer.

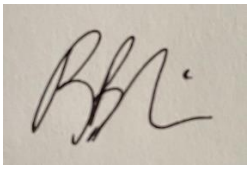
Please consider the public health consequences of removing access or attaching stigma to sunscreens containing certain ingredients. We request that Hawaii give the FDA more time to add new sunscreens for public use and for the NAS to conduct its review and publish a report. We appreciate the opportunity to provide written comments on this important public health

[10] Mitchelmore CS, Burns, EE, Conway A, Heyes A, Davies IA. A critical review of organic ultraviolet filter exposure, hazard, and risk to corals. Environ Toxicol Chem. 2020 (00);00:1-21. Online 2 February 2021 in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/etc.4948

issue. For further information, please contact Lisa Albany, director of state policy for the AADA, at **LAlbany@aad.org** or (202) 712-2615.

Sincerely,

Bruce H. Thiers MD, FAAD
President
American Academy of Dermatology Association



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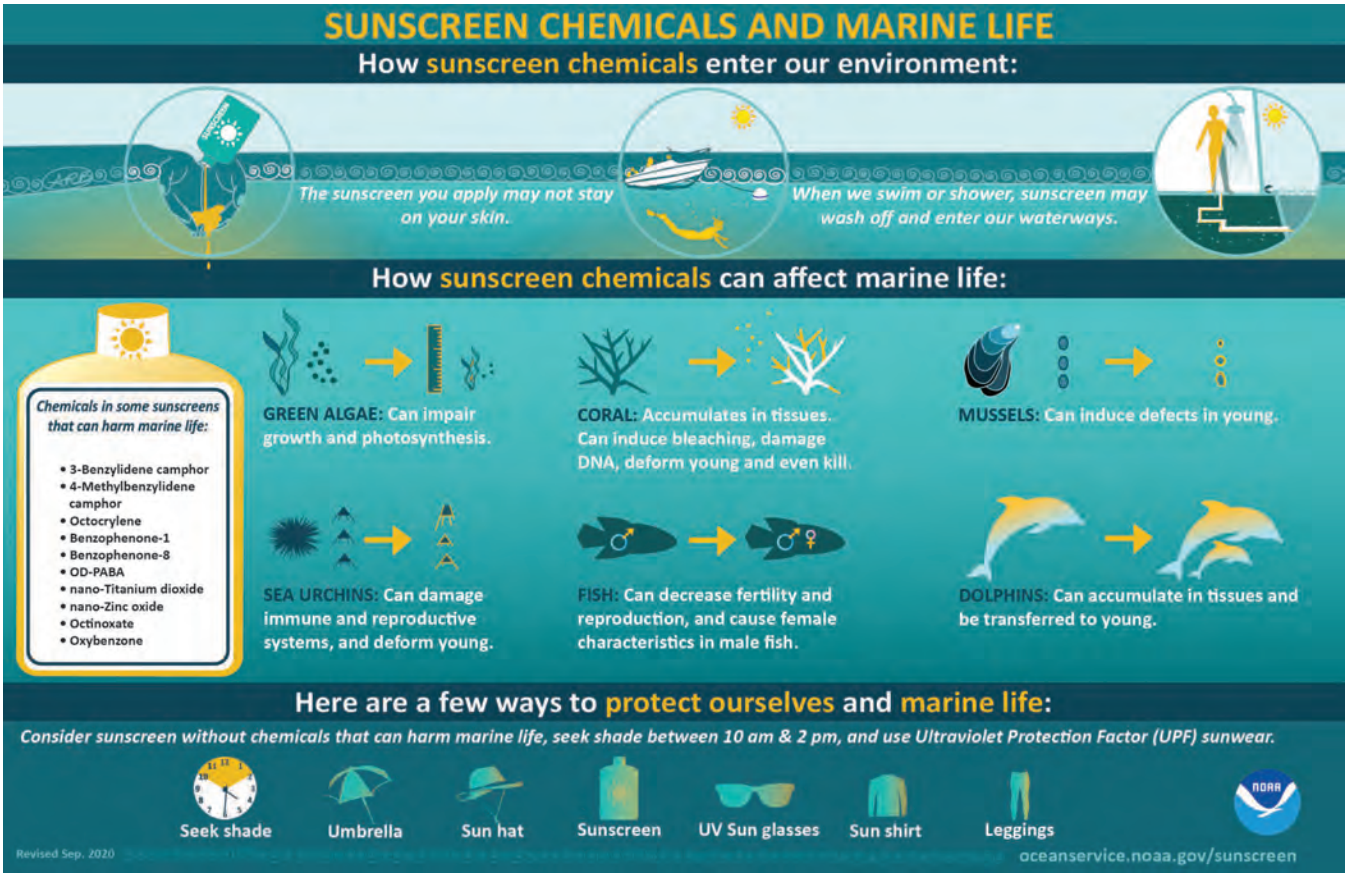
Aloha Hawaii Legislature,

This letter is testimony for our support of Senate Bills 132 & 366 and House Bill 102.

The inclusion of avobenzone, homosalate, octisalate and especially octocrylene, as amendments to 2018 Hawaii Act 104 is an important step in coral reef and marine conservation against the threat of localized plumes of sunscreen pollution. Hawaii's leadership in banning oxybenzone and octinoxate inspired the rest of the world to pass their own regulations, but also inspired millions of tourists to consider their impact to the places they love to visit.

These chemicals pose a potential threat to coral reefs and other marine life. I would like to point out that even U.S. NOAA recognizes their capacity to afflict harm to a variety of marine life, from corals to marine mammals.



Many in the product-protection lobby (including those in academia who have been "captured" by industry) will say that there is no proof that these chemicals are a threat to marine life. They pose a twisted and corrupt narrative – by Federal law, the onus is on industry to provide to the public the scientific validated data of the potential harm that these chemicals can afflict onto wildlife. Industry has not provided any data regarding their ecotoxicity or relevant and authentic environmental contamination. All of the data has been generated by academic, government, or non-profit organizations. This is a grievous short-coming, and industry should be required to provide objective information that is reviewed by a consensus of non-conflict of interest experts. Until such assurances can be provided by industry, these chemicals should not be allowed to be used in such massive commercial quantities. The threat is too great!

Octocrylene is ubiquitous in coastal environments. Octocrylene can be found in the fish we eat (Cunha et al. 2018), in the shellfish that we consume (Picot-Groz et al. 2018), and it has been found in coral reefs and marine environments in many places around the world, including Hawaii's (Tsui et al. 2017; Mitchelmore et al. 2019). Its environmental pollution stems from the fact that it is found in most of the sunscreen products and anti-aging creams throughout the world, and often at a concentration of 10% octocrylene (v/v) per product.

The ecotoxicity of octocrylene has been known to be a threat to wildlife since 2014, when it was shown that fish exposed to octocrylene exhibited endocrine disruption action, as well as inducing developmental deformities in the brain and testes of larval fish (Blüthgen et al. 2014). Recently, the danger of octocrylene has been further discovered to cause reproductive tissue deformities in developing fish larvae (Zhang et al. 2016). Just this past year, scientists documented that environmentally relevant concentrations of octocrylene acted as estrogenic endocrine disruptors and caused reproductive toxicity in fish – essentially threatening the continuity of populations (Yan et al. 2020). What are the impacts of octocrylene pollution to Hawaii's reef fish? And if our fish are contaminated with octocrylene, what does that mean for people eating these fish, especially pregnant women and keiki?

The ecotoxicity of octocrylene to aquatic invertebrates is just as alarming. Octocrylene induced toxic metabolic effects in coral that could have implications in reducing their resiliency to climate change (Stien et al. 2019; Stien et al. 2020). Octocrylene causes an ecdysone endocrine disruption and an induction of the protein stress response (Ozaez et al. 2016; Muniz-Gonzalez & Martinez-Guitarte, 2018). Furthermore, studies indicate that octocrylene exhibited an ecological threat at environmental concentrations to marine organisms, such as algae, sea urchins, mussels, and an arthropod critical in marine food webs (Giraldo et al. 2017).

Avobenzone is a suspected metabolic-disrupting obesogen – a toxicant that can either cause an animal to inappropriately store fat, or inappropriately cause it to "burn up" its fat reserves (Ahn et al. 2019). Additional evidence indicates that avobenzone may act as metabolic obesogen by causing a dysfunction with the cell's mitochondria (the power-house of the cell), which may lead to cell death and accelerated aging (Yang et al. 2018).

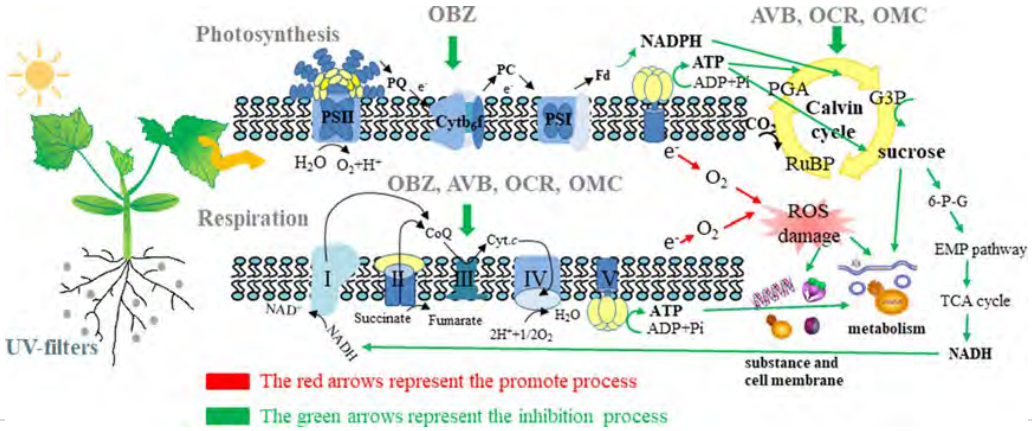
A study published this year showed that the combination of avobenzone and octocrylene cause an aquatic invertebrate to die 7-days after it was initially exposed (Boyd et al. 2021). Avobenzone

exposure cause a change in both reproductive and metabolic outputs in this aquatic invertebrate. This study concluded that "…that the most well-studied UV filter, oxybenzone, may not be the most toxic to *Daphnia* (an aquatic invertebrate), as both avobenzone and octocrylene induced behavioural and physiological disruption at environmentally realistic concentrations." This study was very alarming because this aquatic invertebrate is a key component of the food web, and the loss of this species threatens ecological integrity.

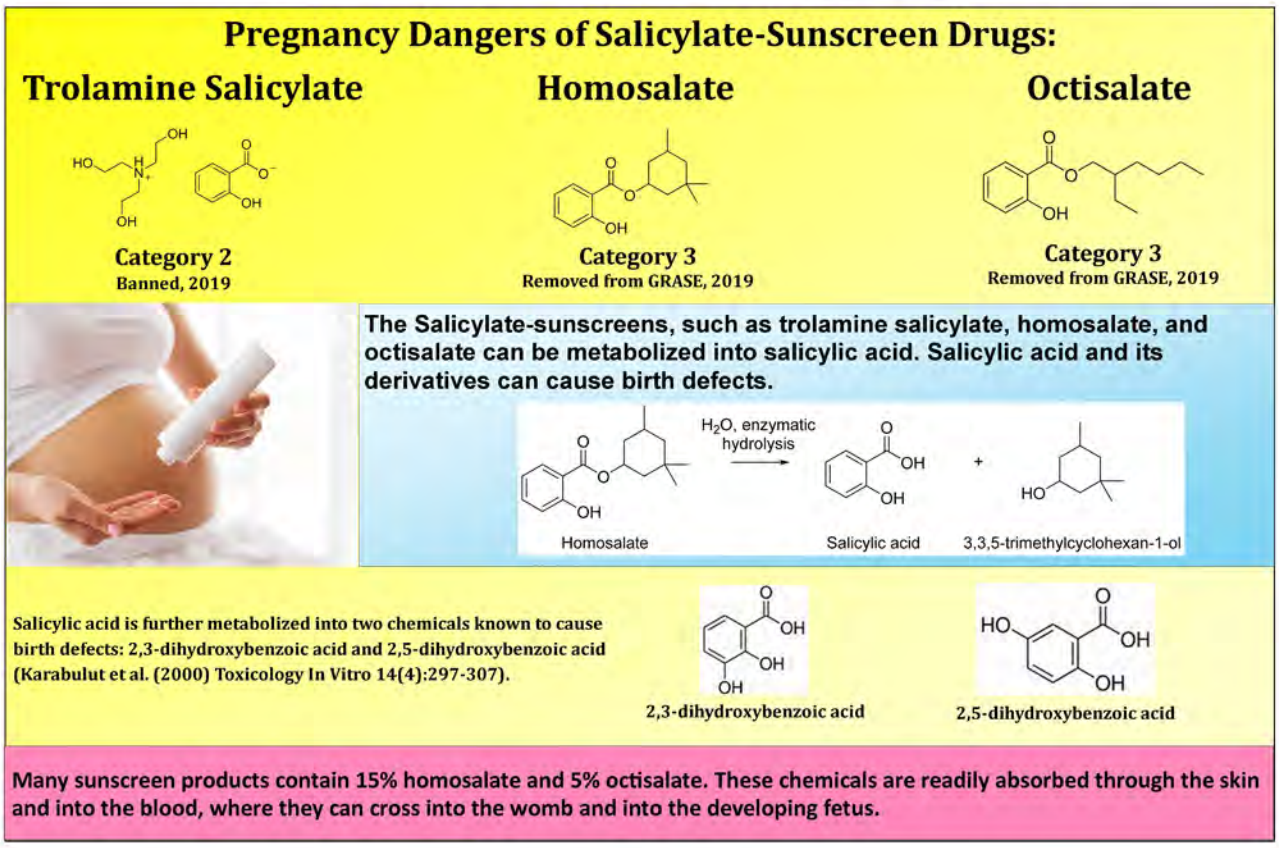
Avobenzone can also pose a threat to plants (sea grasses) and algae, including coral. Colleagues from China and I published work on how avobenzone is toxic to photosynthesis and mitochondrial metabolism in plants (Zhong et al. 2020).


**AVB = Avobenzone exposed plants**

Could this toxicity occur in corals and causing a bleaching? A single industry-funded study says no, but their experimental design has a number of significant flaws, and its questionable any of the corals were actually exposed to avobenzone (its not very water soluble).



Octisalate and homosalate can be metabolized by mammals (e.g., humans, monk seals, humpback whales, dolphins) and animals into metabolites that are known teratogens and fetogens. Teratogens and fetogens are poisons that cause birth defects and may result in miscarriages.




Please consider this legislation as an important conservation tool in the judicious and effective management to mitigate the toxic effects of sunscreen pollution.

Respectfully submitted,

Craig A. Downs, Ph.D.
Executive Director

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COLLEGE of CHARLESTON
1770
Department of Biology
February 3, 2021

Hawaii State Legislature
Dear Members,

I write in support of two bills that will come before you (SB366/HB102) that ban the use of sunscreens containing oxybenzone and avobenzone. These sunscreens are found in all the world's coastal waters principally due to human application to prevent UV skin damage. However, it is also found in seafood and marine organisms that humans consume (oysters, fish, crabs, shrimp). The toxicity of these compounds has been shown to be alarming including being toxic to reef corals and fish. I support legislative Senate Bill 366 and House Bill 102 because it will mitigate pollution that threatens the conservation and restoration of coral reefs and the overall health of the oceans.

My 50 years as a coral reef ecologist put me in the witness box to the global collapse of coral reef ecosystems from human stress. Science is now demonstrating that decreased local stress improves resiliency to global stressors like thermal bleaching. The continued use of toxic chemicals is unnecessary and can only push reefs closer to the brink of extinction.

Sincerely,

Phillip Dustan

Phillip Dustan PhD FLS
Professor of Biology

66 GEORGE ST. | CHARLESTON, SC 29424-0001

Hawaii State Legislature February 6, 2020

Dear Committee Members,

I am writing in support of two bills, Senate Bill 366, Senate Bill 132, and House Bill 102, that will soon be coming before you to ban the use of sunscreens containing avobenzone and octocrylene in Hawaii. In 2019 alone, about 10.5 million tourists visited Hawaii. Most visitors use sunscreens containing the above chemicals. I implore you to pass these bills for the long-term sustainability of Hawaii's marine environment and the tourism economy that relies on Hawaii's beautiful ecosystems.

Sunscreen chemicals cause damage to the marine life and environment at multiple levels. Many research studies have reported that these chemicals are toxic to fish, shellfish, coral and microplants (Tsui et al, 2014). Small fish depend on microplants for food. When the sunscreen chemicals destroy microplants, small fish are the first to go, followed by bigger fish. The loss of microplants can impact the entire food chain. Large fish and shellfish can store these chemicals to a very high concentration (Fent et al., 2010). In a study in Switzerland rivers, high levels of octocrylene were detected in brown trout (Poiger et al., 2004). In another study, high levels of octocrylene were detected in mussels (Bachelot et al. 2012). When people eat seafood with high levels of sunscreen chemicals, they are unwittingly exposed to the toxicity of these chemicals. Many of these chemicals penetrate coral cells and kill them by causing coral bleach. Fifty percent of the world's coral reefs have already died because of physical and chemical pollution. Coral reefs support 25% of all aquatic life in our oceans (Boyce et al, 2010). The loss of reefs would have direct impact on millions of people around the globe including all of Hawaii's residents. In addition to killing fish and corals, sunscreen chemicals can also change the water chemistry by destroying the chemical balance of sea water. Change in marine chemistry will have long-term implications on the whole marine ecosystem. US Food and Drug Administration (FDA) is seriously considering banning several chemicals in the sunscreens (Matta et al., 2020). Additional information on the toxicity of sunscreen compounds on the environment and human health can be found in the following research papers (Downs et al., 2016; Goikaas et al, 2007; Laffoley et al., 2019; Song, 2020).

From my experience as an environmental toxicologist with 24 years of research experience in drinking water, wastewater treatment, and environmental toxicology, I strongly support Senate Bill 366, Senate Bill 132 and House Bill 102. Banning sunscreens containing toxic chemicals such as oxybenzone and avobenzone in Hawaii is the right decision for the environment and for Hawaii's economic sustainability long term. It will protect Hawaii's marine life and protect people's health in Hawaii and the tourists who visit Hawaii to be able to enjoy the pristine beaches and oceans for generations to come.

Respectfully submitted,

Achal Garg, Ph.D.
Board of Directors at Chemists Without Borders
Adjunct Professor, Miami University, Oxford, Ohio
Research and Development Manager, Wastewater Division, City of Cincinnati (Retd.)
Fulbright Scholar, Namibia, 2012
Fulbright Scholar, Peru, 2019
achalkgarg@gmail.com
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אוניברסיטת בן-גוריון בנגב
Ben-Gurion University of the Negev

**February 3, 2021**

**Re: Letter of support for ban of Octocrylene**

To whom it may concern
I support legislative Senate Bill 366 and House Bill 102 that will help to mitigate pollution that threatens the conservation and restoration of coral reefs in Hawaii. There is increasing scientific evidence that traces of chemicals such as octocrylene originating in cosmetics and sunscreens can be found in aquatic environments with high swimmer pressure. In these studies various effects of these chemicals and their derivatives were reported to have deleterious affects on marine life including corals. Studies by our group further showed that the active ingredients found in these common sunscreens and cosmetics affect coral larval viability and is toxic to coral cells *in vitro*. We demonstrated that these chemicals can cause disruption of coral physiology and may even cause their death. It was found that these chemicals accumulate in coral tissues and causes dysfunction of the coral cells' mitochondria (Stein et al 2019, 2020). These effects occur at concentrations that are found in the environment. The information published in these papers is significant and should hopefully be taken into account by legislators in Hawaii
In light of these deleterious effects and the large number of swimmers in areas where corals are found, we call for the prevention of further harm to our marine life from this chemical. This is especially important in light of possible additive effects of these chemicals with additional pollutants and with the deleterious effect of climate change. We therefore call for a ban of this chemical and its derivatives in sunscreens used in Hawaii in order to maintain healthy reefs and marine environment in the wonderful Hawaiian Islands.

Sincerely

E. Kramarsky - Winter

Dr Esti Kramarsky Winter
Dept of Biotechnology Engineering
Ben Gurion University
Beersheva Israel

Institute of Geophysics
University of Tehran

No. .....
Date.....

In The Name of God

**Date: For the 2021 Hawaii Legislative Season**
**To: The State of Hawaii Legislature, its Committees and Chairpersons, and Governor Ige**

Re: Restriction of the Sale of Octocrylene & Avobenzone SPF products
DANGER of UV chemicals to climate change and its carbon footprint.

I am an environmental scientist and oceanographer at the Institute of Geophysics within the University of Tehran, Tehran, Iran. I am one of the foremost experts in my country that studies the impact of human activities on the marine environment.

To the point, I want to express my support for HB102 and SB366. These bills were written with the broad input of a number of independent scientists that strikes a wise and effective balance to diminish Oxybenzone/Octinoxate environmental pollution to coral reefs and other marine habitats, while NOT impacting tourism.

I am sure there will be a number of scientists worldwide who will provide scientific testimony to the toxicology and pollution of these two dangerous chemical that impacts all matter of marine life, but also the integrity of human health.

Carbon footprint - I would like to point out something that my other scientific colleagues may not. The CARBON FOOTPRINT of hydrocarbon-based sunscreens is considerable. If Hawaii DLNR is correct, that over 55 gallons of sunscreen pollutes the coast line of Maui per day, then we can calculate that the input of octocrylene alone is contributing to 4,444lbs (2.02 metric tons) of CO2 per year. If you include avobenzone into the calculation, that is almost 1.5 metric tons of CO2 per year. For Hanauma Bay, assuming that 6,025 pounds of octocrylene pollutes the bay per year, that is equivalent to more than 8.5 metric tons of CO2 per year.

Sunscreen pollution is not just the direct toxic impact it has to nearshore and mesophotic reef habitats, and migrating cetaceans. The use of these chemicals in Hawaii has a direct contribution of the CO2 load to atmospheric and oceanic condition. The State of Hawaii government has made a promise to recognize and mitigate the overall size of their carbon footprint. Sunscreen pollution and its impact to climate change is an issue that Hawaii can show leadership and responsibility.

Your efforts in legislative conservation have been noted around the world, and we applaud your effort and leadership.

Respectfully submitted,

S. A. Haghshenas

**S. Abbas Haghshenas**, PhD
Assistant Professor in Physical Oceanography
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山東農業大學

SHANDONG AGRICULTURAL UNIVERSITY

February 12, 2021

Dear Members of the Hawaii Legislature,

We appreciate very much the legislative Senate Bill 366 and House Bill 102 which intend to ban the use of toxic chemicals such as octocrylene and, avobenzone in personal care products.

Our research team has recently found that all avobenzone and octocrylene, as well as oxybenzone and octinoxate have severe damaging effect on plants (including algae and terrestrial plants). These chemicals are readily absorbed by plants, and may instantly inhibit photosynthesis and respiration processes; the two most important processes in plants. This inhibition further interferes with a wide variety of metabolic activities, leading to the over-accumulation of Reactive Oxygen Species (leading to oxidative stress) and causing a deficiency of ATP (the fundamental energy units of all cells), resulting in adversely effecting disease in all affected plants.

The application of these chemicals has severely led to pollution of marine and freshwaters, potentially inhibiting the growth of plants in those habitats, and damaging the ecosystems. In addition, the concentrations of damaging effect of these UV-filters have been proven to be extremely low. And the damaging effect of these chemicals will be aggravated when other stresses also exist.

Thus, limiting the use of these chemicals will greatly protect the marine and terrestrial ecosystems, which will finally benefit mankind.

Sincerely,

Prof. Dr. Huiyuang Gao

Gao Huiyuan

State Key Lab. of Crop Biology
College of Life Sciences
Shandong Agricultural University

Sincerely,

Xin Zhong

Zhong Xin

State Key Lab. of Crop Biology
College of Horticulture Science and Engineering
Shandong Agricultural University

TEL AVIV UNIVERSITY
אוניברסיטת תל אביב

Re: Letter of support Feb. 04, 2021

To whom it may concern
I would like to support legislative Senate Bill 366 and House Bill 102 that will help to mitigate chemical pollution that threatens the conservation of coral reefs in Hawaii.
I would like to stress that there is increasing scientific evidence that traces of the octocrylene, a chemical found in many sunscreens and personal care products can be found in aquatic environments at various concentrations. In these studies the effects of these chemicals and their derivatives have been reported to have deleterious effects on marine life including corals. This is based on a number of published studies showing that the active ingredients found in some common sunscreens and cosmetics affect coral health. These chemicals can cause disruption of coral physiology and may even cause their death. Recent studies showed that octocrylene accumulates in coral tissues and causes dysfunction of the coral cells' mitochondria. Indeed these effects occur at concentrations that are found in the environment. The information published in these papers is significant and should hopefully be taken into account by legislators in Hawaii
In light of these effects on corals we call for the prevention of further harm to the reefs of Hawaii by this chemical. This is important in light of possible additive effects of these chemicals with effects of climate change. We therefore call for a ban of this chemical and its derivatives in sunscreens used in the Hawaiian Islands.

Yossi Loya, PhD
Professor Emeritus of Marine Ecology
School of Zoology, Tel Aviv University
Tel Aviv, 69978 Israel

אוניברסיטת בן-גוריון בנגב
Ben-Gurion University of the Negev

Re: Letter of support Feb. 4, 2021

To whom it may concern

I support legislative Senate Bill 366 and House Bill 102 that will help to mitigate pollution that threatens the conservation and restoration of coral reefs in Hawaii. There is increasing scientific evidence that traces of the chemical **octocrylene** found in many sunscreens can be found in aquatic environments. Studies demonstrated various deleterious effects of these chemicals and their derivatives on marine life ranging from corals to fish. In addition to that studies by a number of researchers further showed that the active ingredients found in some common sunscreens and cosmetics affect coral larval viability and is toxic to coral cells *in vitro*. These chemicals can cause disruption of coral physiology and may even cause their death. It was found that these chemicals accumulate in coral tissues and causes dysfunction of the coral cells' mitochondria (Stein et al 2019, 2020). It is important to note that these effects occur at concentrations that are found in the environment. The information published in these papers is significant and should hopefully be taken into account by legislators in Hawaii.
In light of these deleterious effects, we call for the prevention of further harm to our marine life from this chemical. This is especially important in light of possible additive effects of these chemicals with additional pollutants and climate change. I therefore call for a ban of this chemical and its derivatives in cosmetics used in Hawaii in order to maintain healthy reefs and marine environment in the Hawaiian Islands.

Thank you

Professor Ariel Kushmaro


*Prof. Ariel Kushmaro, John A. Ungar Chair in Biotechnology, Head of Environmental Biotechnology Lab, Department of Biotechnology Engineering, The Ilse Katz Center for Meso and Nanoscale Science and Technology, Ben Gurion University, Beer Sheva, 84105, Israel.*
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*Google scholar: https://scholar.google.com/citations?user=E6U8wkAAAAAJ&hl=en*

325 Lysander Place,
Ottawa, ON K1K 3X8,
CANADA.
FEB 5, 2021.

To: Honourable Members, Senate and House of Representatives, 31st Legislature 2021, and Governor Inge, State of Hawaii.

**Re: Soluble Organic UV filters and the Parallels between Human and Wildlife Toxicity. A Common Precautionary Approach for Humans and The Marine Eco-system.**

The Government of Hawaii is considering extending the ban of ***soluble*** organic UV filters to include octocrylene and avobenzone in addition to oxybenzone and octinoxate, the filters restricted in 2018. We strongly support SB 366 and HB 102 as physicians who cherish the first dictum or the sacred trust in medicine - First Do No Harm. All four belong to the group of twelve ***soluble*** organic UV filters watchlisted by the US-FDA in February 2019 and classified as Category III or insufficient data to be designated Generally Regarded As Safe or Effective (GRASE). Only two ***insoluble*** inorganic UV filters were placed in Category I or classified as GRASE [1]. The FDA merely affirmed over two decades of peer-reviewed literature that these 12 ***soluble*** organic UV filters were bioavailable and were associated with diverse toxic effects in humans and wildlife [1]. More alarmingly, they do not appear to prevent skin cancer [1]. The FDA also re-confirmed 25 years of science that permeation (percutaneous absorption) through human skin leads to systemic bioavailability. The six ***soluble*** organic filters in the FDA Maximum use Studies Trial (MuST) were avobenzone, oxybenzone, octinoxate, homosalate, octocrylene and octisalate. All attained blood levels after only one application > the threshold for non-clinical toxicology testing [2].

**Bioavailability**

There appears to be a common pathway for toxicity to humans and the marine eco-system. It is established that human toxicity begins with permeation then bioavailability resulting in binding to various cell receptors, causing hormone disruption, DNA mutation, and damage to enzymes that methylate genes leading to the alarming consequence of epigenetic changes or transgenerational effects, in the progeny of exposed individuals. The pathogenetic pathway in humans – first permeation – then endocrine disruption, DNA mutation or genotoxicity – is also likely to occur in the marine environment, given the similar properties of human skin to coral epidermis and the external membranes of many marine organisms. Oxybenzone at relatively low concentrations degraded coral acting as a skeletal endocrine disruptor in planula of *Stylophora pistillata* [3]. *Coral has an epidermis similar to human skin but less complex, and an unintended consequence of human use of* ***soluble*** *organic UV filters may be the degradation of the marine habitat* [3,4].

A 1997 study warned about the human danger posed by cutaneous absorption of oxybenzone from sunscreens. Basic physiology instructs that any substance with a molecular weight (MW) < 500 Daltons applied to skin will enter human blood [5]. Bioavailability in humans is a fact established by many studies over 25 years. Only a few can be cited here in the interest of brevity. The CDC confirmed 96.8% of Americans had oxybenzone contamination from its pervasive use in sunscreens and cosmetics [6]. International studies proved bioavailability to the fetus and newborn - 85.2% of nursing mothers in the EU had at least one UV filter in breast milk [7], and another CDC study found oxybenzone in the urine (99%) and amniotic fluid (61%) of pregnant patients [8]. The lipophilic (fat soluble) nature of soluble organic UV filters ensure widespread contamination of humans literally bathing every cell in the human body and brain. They are found in blood, urine, amniotic fluid, placenta, fetal and cord blood, semen, ovarian follicular fluid, and adipose tissue [9].

**A Benefit Risk Assessment of Sunscreens using Soluble organic UV Filters**

Benefit Risk Assessment (BRA) is a compulsory precept in medicine, drug research, and a prudent practice for life in general. A "net risks test" or similar has never been applied to the use of sunscreens, now allowed to make therapeutic label claims in some regulatory jurisdictions. These label claims are largely based on the assumption that sunscreens could prevent sunburn and by extrapolation skin cancer and sun damage. They were never preceded by

the mandatory rigorous clinical research trials required for any medication making a serious claim like preventing skin cancer.

For over 60 years, applying sunscreen to UV exposed skin is promoted to prevent sunburn, skin cancer, and other effects of sun damage like photoaging and immune suppression. Most sunscreens deliver some degree of sunburn protection, largely by reducing the effects of UVB and UVA2 radiation, but there is little or no evidence in published literature that they prevent skin cancer to a significant degree. Prior to 2010 some studies suggested that sunscreens caused skin cancer, particularly melanoma [10-15]. These early studies detail the uncertainty that sunscreens actually prevent skin cancer, and more recently, the two most encyclopedic and exhaustive reviews DO NOT show that sunscreens prevent skin cancer to any useful degree [16,17]. Not surprising, as early sunscreens were designed to prevent sunburn, not skin cancer.

Early and current sunscreens use combinations of soluble organic UV filters providing UVB and UVA2 attenuation but with minimal or no UVA1 extinction, resulting in 10X more UVA than UVB passing through the sunscreen to reach the skin [18].This asymmetric UV or UVB-BIASED protection over the past 6-7 decades parallels the global rise in skin cancer. Non- Melanoma Skin Cancer (NMSC ) continues to rise in the USA and worldwide at an average annual rate of 1-2% [19,20]. The National Cancer Institute reports that melanoma rates in the United States tripled between 1975 and 2014 [21]. Skin cancer is now the most common cancer in the USA and in N. America, and accounts for more than 50% of all human cancers i.e. skin cancer cases outnumber all other cancers combined [19,21]. The rate of new melanoma cases among American adults has tripled from 7.9 per 100,000 people in 1975 to 25.2 per 100,000 in 2014 [21]. Melanoma is the leading cause of cancer death in women ages 25-30, the second leading cause of cancer death in women ages 30-35, and melanoma is the second most commonly diagnosed cancer age 15-29 [21]. From 1970 to 2009, the incidence of melanoma increased by 8-fold among young women and 4-fold among young men, and in the USA, one person dies of melanoma every 54 minutes, and an estimated 9,730 people will die of melanoma in 2017 [19,21]. The Global Burden of Disease Study (2015) reported that from 2005 to 2015 there was a 27.2% and 42.9% increase in the global death rate from melanoma and NMSC respectively [22].

The detailed review above explaining the global rise in all skin cancers is necessary to refute the misconception fostered by stakeholders that sunscreens using combinations of soluble UV filters actually prevent skin cancer. It establishes along with the studies cited [10-17] that there is no measurable BENEFIT from using these sunscreens. There is a logical and intellectual explanation for the parallel rise in global skin cancer provided by understanding the concept of UVB-BIASED protection [18]. If there is **NO BENEFIT** in using these petrochemical UV filters, any level of risk, however minimal becomes significant and arguably unacceptable, particularly for the most vulnerable to toxic effects – expectant or nursing mothers, young or adolescent children, and couples trying to conceive. Definitive fetal toxicity studies to identify mutagenic, and epigenetic effects, or to assess the NOAEL (No Observed Adverse Effect Level) in a fetus are either unethical or methodically impractical. It would require exposing women in pregnancy to chemicals thought to be harmful and could require observation and data collection involving their progeny for at least two generations. For sunscreens using petrochemical organic filters, the Benefit Risk Assessment (BRA) equation has only **risk to the fetus and the environment** (terrestrial and marine) and **no intended benefit.** This fact strongly resonates with the authors, one of whom was a former obstetrician.

The **first** precept in medicine 'first do no harm' (primum non nocere) - taken from the writings of Hippocrates), and the Precautionary Principle [23] are more stringent standards than 'not generally regarded as safe'. The Precautionary Principle is applied variably, but fundamentally asserts "that the burden of proof for potentially harmful actions by industry or government rests on the assurance of safety and that when there are threats of serious damage, scientific uncertainty must be resolved in favor of prevention". This approach supports the physician's **first rule** and is long overdue for soluble organic sunscreens

These ***soluble*** organic filters share functional properties along with their structural analogues that include human estrogen, pesticides like DDT (an organochlorine), organophosphate pesticides like malathion or diazinon, dioxin, and other hormone disruptors like BPA and phthalates. The risks to humans and wildlife have been well described for almost 3 decades [24,25]. In humans they represent ***a primary exposure*** to hormone disruptors in a first world modern society where sunscreen use is highest - now more likely than DDT, dioxin, BPA, and others.

**Human Risks**

The 12 watchlisted FDA Category III soluble organic filters are similar in chemical structure and are all potential or proven hormone disruptors, sharing these properties with BPA, DDT, and other persistent organo-phosphates. ***The human and wildlife effects are numerous and diverse, described by several hundred publications, too numerous to be referenced here.*** There is another instructive often forgotten first principle from basic endocrinology – ***isoform function*** – chemicals with the same structure will act at a cellular level in a similar manner, and bind to the same receptors [24]. Hence if oxybenzone exhibits endocrine disrupting properties, then all soluble organic UV filters are suspect, and the Precautionary Principle should be applied. This principle should also apply to the marine eco-system.

The peer-reviewed literature implicates oxybenzone, octinoxate, octocrylene, homosalate, and 4-methyl benzilidene camphor as hormone disruptors in humans and animal models, and suggest generally that reproductive organs and the central nervous system represent sensitive targets for developmental effects of endocrine active xenobiotics [24,26]. Contemporary studies document widespread effects in human and wildlife from soluble organic UV filters and their structural analogues like DDT, BPA, and other hormone disruptors. A review of 85 scientific papers in humans and lower species concluded that aromatic hydrocarbon UV filters are generally involved in the disruption of the hypothalamic–pituitary–gonadal system [26].

Oxybenzone, homosalate, avobenzone and 4-methyl benzylidene camphor (4-MBC, not used in the USA) show variable interaction with estrogen, androgen, and progesterone receptors using Reporter Gene Assays [27], and reports showed that octinoxate and 4-MBC had equal effects to 17 β-estradiol on gene induction, reproductive, and skeletal systems in mammalian, amphibian, and other animal models cells [28]. A change in a hormone level is arguably evidence of Hormone Disruption. In one of several recent studies in healthy premenopausal women, various phenols, including oxybenzone and parabens, changed the levels of key reproductive hormones - FSH (Follicle Stimulating Hormone), (LH) Luteinising Hormone, estradiol, and progesterone [29]. Contemporary reviews show the disruption of endocrine, reproductive, metabolic systems, leading to a variety of human disorders and cancers [29,30,31]. Some effects from fetal exposure are seen in newborns – spina bifida [32] and Hirschsprung's Disease [33,34], others in adolescents – delayed puberty [35,36], and others delayed until adult life – endometriosis [37,38] and infertility [39], usually serious and often irreversible.

**Environmental/Wildlife/Marine Eco-System Risks**

Soluble organic UV filters contaminate every link in the land-based aquifer leading to the oceans. Most of the twelve watchlisted by the FDA are found in Waste Water Treatment Plant (WWTP) influents and effluents, since most WWTP do not remove the traditional soluble aromatic hydrocarbon sunscreen filters [40]. As of 2015, thirty-three scientific publications confirmed these UV filters polluting not only WWTP inflow and outflow, but swimming pools, tap-water, urban groundwater, freshwater (rivers and lakes), estuaries, and seawater [41]. The ubiquitous contamination by soluble organic UV filters of the entire global environment from industrial, lifestyle, and recreational activities is supported by their presence in the open waters of the Pacific Ocean, the surface waters of China, Japan, the USA, Thailand, the Arctic [41], and every global coral reef system [42]. Fifteen studies confirmed significant concentrations of these filters in sediments from rivers and lakes, beach sand, soils and sludge [4].

The contamination of the entire global water supply is intimidating [4,41,42]. No other chemical, drug, pesticide or agent is apparently a contaminant on this scale. With the toxicity in wildlife and the eco-system these petrochemical UV filters have arguably become the world's number one POLLUTANT. Recent reviews confirmed significant concentrations of organic UV filters in sediments from rivers and lakes, beach sand, soils and sludge, ultimately reaching land-based and marine wildlife [4,41]. Reviews describe their biomagnification in mussels, corals, crabs, shrimps, prawns, squids, fish, dolphins, cormorants, and in unhatched eggs of bird's species, where the same effects of hormone disruption in marine species and aquatic biota are observed [4,43]as in humans [25]. Reports spanning a decade focused global attention on their effects on coral and ocean reefs [4,42,44]. Contamination of the marine food supply is a secondary source of human exposure. The hormone disrupting and other effects on marine species have also been consistent for 20 years [45,46,47,48,49].

**A Solution based on a Precautionary Approach**

The most persuasive argument for adopting a precautionary approach to UV filters and human/environmental safety – whatever the level of risk – is the mere possibility for congenital, teratogenic, hormone disruption, and carcinogenic effects in the exposed individual – human or wildlife - and the risk for transgenerational and multigenerational sequelae. Human safety may be ***the pre-emptive consideration*** when looking at the marine eco-system and sunscreens. The toxic petrochemical filters have a low MW < 500 Daltons that enable bioavailability leading to systemic toxicity. They are benzyl chemicals with properties to cause photocontact or irritant dermatitis. They are consistently in the top 30 contact allergens, although the prevalence is low.

The approach is simple – avoiding bioavailable UV filters eliminates any human risks and the unintended consequences to the environment and wildlife. Larger filters with MW > 500 Daltons are not bioavailable through intact human skin and are less likely to harm wildlife. Mineral oxides, new organic agents like bemotrizinol, bisoctrizole, and drometrizole trisiloxane meet this objective and satisfy the safety first concept of the Precautionary Principle. These insoluble filters provide the best UVA protection and have a better chance of preventing skin cancer and sun damage, since modern science now confirms that UVA is the primary driver of skin cancer [18]. The authors prefer 25% zinc oxide as a safe and effective sunscreen. It does not permeate human skin and even if it did zinc is a normal and important mineral in human physiology, as a co-factor in over 200 enzyme reactions. There is no evidence that zinc is accumulating in the marine environment and it is a small component in sea water. Industry and their consultants argue that banning the toxic UV filters will discourage sunscreen use, particularly in people of colour who disliked old goopy-white mineral sunscreens. Products with soluble UV filters have no benefit anyway, and contaminate our bodies and the world we live in. Modern zinc oxide sunscreens are no longer white or chalky on even dark skin. They are available in 25% zinc oxide dispersions that apply clear on any skin colour. Safe, esthetic, and effective. A former First Lady, Venus Williams (tennis icon), and others with coloured or dark skin now use transparent 25% zinc oxide sunscreens.

The worry that nanoparticles from mineral sunscreens are marine contaminants is overstated, since most modern mineral products with either zinc oxide or titanium dioxide particles are no longer nanoscale but are in the micron range. They are insoluble particles that mostly fall to the ocean floor and do not travel on surface ocean currents for thousands of miles like soluble petrochemical UV filters. Marine contamination from mineral sunscreens is a valid environmental concern requiring thoughtful investigation. At this time it is theoretical rather than empirical, as there is little or no present evidence that mineral oxide particles - nano or larger - from sunscreen use are accumulating in the ocean environment.

Eventually, the FDA and others will develop a regulatory framework from valid evidence of safety and efficacy. While it evolves, a good place to start would be with a WARNING Label on BIOAVAILABILITY and a CAUTION to pregnant or nursing mothers and the most vulnerable among us – young or adolescent children, and couples trying to conceive. This occurs for almost everything that is bioavailable to vulnerable groups, particularly the fetus, including low dose aspirin and many other OTC non-prescription items, such as vitamins, cigarettes, and alcohol. A Warning Label is justified based on the absolute proof of bioavailability, and allows the consumer to make their own informed choice.

Thoughtful and strategic future marine research on sunscreen ingredients and finished products may confirm that large insoluble UV filters, which avoid human permeation, bioavailability, and any systemic toxicity are also better for the entire environment. This research must transcend borders, financial and political interests, and involve a global team of multidisciplinary scientists. Meanwhile, a simple solution is to apply the Precautionary Principle to sunscreen use. Label warnings of permeation and bioavailability should convince expectant and nursing mothers, and prudent parents to avoid soluble filters. A ban on ineffective sunscreens that are toxic to humans and the environment is one simple measure, compared to other initiatives to protect the reefs. warming. Wearing highly effective UV protective clothing outdoors, reduces the amount of sunscreen used on exposed skin and lowers the amount available to reach terrestrial and marine water. Applying a sunscreen using insoluble large MW UV filters in conjunction with UV protective clothing is very effective photoprotection for humans. Both measures will support reef and marine conservation. This precautionary approach for humans is in harmony with a precautionary measure for coral and all wildlife, land- based and marine. Banning these 4 soluble organic UV filters in Hawaii leads by example, but only a partial solution. As these four toxic petrochemicals are removed from your marine environment, the others in the group of twelve FDA Category III are still toxic to humans. Others like homosalate or ecamsule may

begin to emerge as environmental toxins with effects on marine life as they are used in greater relative frequency. Banning all 12 of the FDA Category III filters is best for the human condition, and will likely be better for the coral and remove these non biodegradable petrochemicals from your streams and ocean. A definite precautionary measure for the health of your citizens, your millions of visitors, and their progeny.

**SUBMITTED BY**


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**February 7, 2021.**

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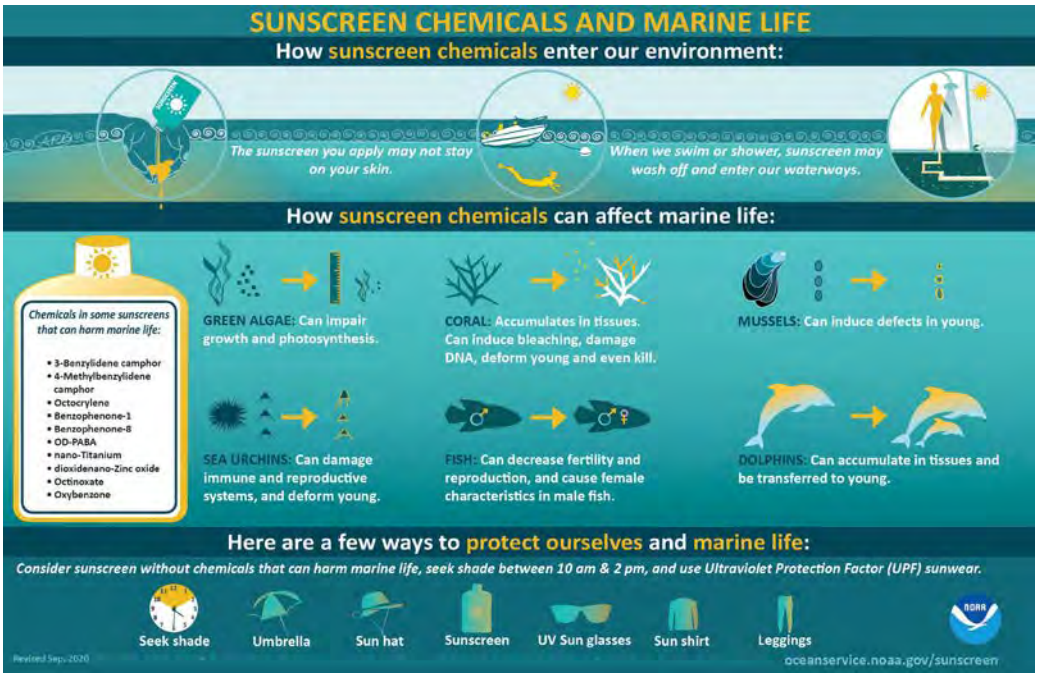
NAPILI
Bay and Beach Foundation

February 8, 2021

Aloha Members of Hawaii State Legislature:

Napili Bay and Beach Foundation, Inc. supported the 2018 legislative efforts which resulted in the ban of sales of sunscreens containing octinoxate and oxybenzone in the new Hawaiian law. Likewise we are in support of Senate Bill 366 and House Bill 102, amending 2018 House Act 104 by including avobenzone, and especially octocrylene, as an important step in coral reef and marine conservation against the threat of localized plumes of sunscreen pollution.

We have recently become aware of increasing scientific evidence that traces of the chemical octocrylene found in many sunscreens can be found in aquatic environments. Multiple recent (2014 – 2020) studies have demonstrated various deleterious effects of octocrylene and octinoxate and their derivatives on marine life ranging from corals to fish. NOAA has recently updated their public information on sunscreen chemicals that harm the marine environment, and added octocrylene to the list of ingredients known to be harmful to marine life.




Respectfully ,

Pat B. Lindquist

*We are a non-profit organization formed to protect and improve the health of Napili beach and bay.*

**Gregg Nelson, GM Napili Kai Resort & VP**
**Nane Aluli, GM The Mauian, & Secretary**
**Norm Runyan, GM Napili Shores Resort & Dir.**
**Jamie Lung-Ke'o, GM Hale Napili Resort & Dir.**
**Tano Taitano, GM Napili Surf Resort & Dir.**

SAFE SUNSCREEN COUNCIL

**February 11, 2021**
**RE: In Support of Senate Bill 366 and House Bill 102 - Amending Act 104**

TO: Hawai'i Legislature

We are the Safe Sunscreen Council, a coalition of companies working to raise public awareness about the impact sunscreen ingredients may have on people and planet. As such, we believe it is our responsibility to offer alternatives to harmful ingredients and we would like to show our **support of Senate Bill 366 and House Bill 102, amending Act 104**.

We request that the State of Hawai'i continue its global leadership role in protecting coral ecosystems by amending Act 104 to include two other toxic ingredients: Octocrylene and Avobenzone.

Emerging scientific studies indicate that ingredients found in many chemical sunscreens may cause damage to coral reefs and oceanic ecosystems. We know that these chemical sunscreen pollutants impact not just coral larvae and recruitment, but they also impact other important species such as algae, sea urchins, mussels, and an arthropod critical in marine food webs.

There are better ways - safer ways - to protect from UV rays without putting the health of our oceans at risk. Safer ingredients, like the ones found in mineral sunscreens made by members of the Safe Sunscreen Council and many other companies, all comply with U.S. Food & Drug Administration's regulations on SPF values and UV protection and are cost-competitive to products made with harmful chemical ingredients.

Please consider this legislation as a way to combat aquatic contamination within the State of Hawai'i and beyond. Thank you for your consideration.

With Gratitude,

Caroline Duell, Spokesperson & Members of the
Safe Sunscreen Council

**In Favor of HB102/SB366** Banning the sale, offer of sale, or distribution in Hawaii of sunscreen products that contain Avobenzone and/or Octocrylene. Joe DiNardo (Retired Toxicologist/Hawaiian tourist) **January 30, 2021**:

Dear Senators and Representatives, based on Hawaii's lead in the environmental impact of oxybenzone and octinoxate the world has turned its eyes to evaluating the impact of other organic sunscreen actives that impact the environment and human health. Although the coronavirus has slowed us all down, scientists for all over the world continue to conduct research on these chemicals. With that said, below are a dozen scientific references, recently published, relating to the negative impact to the aquatic environment focusing solely on avobenzone and octocrylene (Note: other chemicals of concern may have also been tested concurrently in the papers referenced below).

1) Irrigation with water containing avobenzone and octocrylene significantly inhibit the aboveground growth of cucumber plants by interfering with photosynthesis. (Zhong et al Sci Total Environ. **2020 Apr 20**;714:136879). These findings should cause great concern since aquatic plants (currently growing in sunscreen contaminated waters) also use photosynthesis to grow that feed a variety of aquatic species.

2) Octocrylene was the most toxic UV filter tested in brine shrimp followed by avobenzone (Thorel et al Toxics. **2020 Apr 10**;8(2):29).

3) Octocrylene was considered to be a great threat to Japanese medaka (Oryzias latipes) based on its reproductive toxicity (Yan Environ Pollut. **2020 Jun**;261:114104)

4) Both avobenzone and octocrylene induced behavioral and physiological disruption at environmentally realistic concentrations in Daphnia magna (Boyd et al Sci Total Environ. **2021 Jan 1**;750:141707).

5) Long-term exposure to avobenzone and octocrylene was lethal for some organisms living in freshwater environments and were considered dangerous for freshwater ecosystems (University of Alberta – **Sept 1,2020** https://www.enn.com/articles/65243-common-sunscreen-ingredients-dangerous-for-freshwater-ecosystems).

6) Octocrylene was reported to alter in a negative manner mitochondrial function of hexacoral *Pocillopora damicornis* (Stien et al Sci Rep. **2020 Jun 15**;10(1):9601).

7) Octocrylene accumulates in Pocillopora damicornis tissues as fatty acid conjugates and triggers coral cell mitochondrial dysfunction (Stien et al Anal Chem. **2019 Jan 2**;91(1):990-995).

8) Octocrylene and avobenzone were found in multiple species of fish from markets in the Canary Islands and Catalonia (Spain) with Thunnus thynnus being the most heavily polluted species (Gimeno-Monforte et al Foods. **2020 Dec 9**;9(12):1827). This finding continues to demonstrate the growing concern of bioaccumulation/biomagnification of organic sunscreen actives in the contamination of our food chain.

9) Octocrylene may pose high risk to aquatic organisms in the riverine and estuarine environment in Thailand (Juksu et al Ecotoxicol Environ Saf. **2020 Nov**;204:110952).

10) In the Enoggera Reservoir (Australia), seven UV filters were detected, of which the most prevalent were octocrylene and avobenzone (O'Malley et al Sci Total Environ. **2021 Feb 1**;754:142373).

11) Octocrylene was one of three chemicals mixed together that modified genes related to the endocrine system, detoxification mechanisms, and the stress response in Chironomus riparius (Muñiz-González Ecotoxicol Environ Saf. **2020 Dec 15**;206:111199).

12) Over 60 disinfection by-products were identified as transformation products of avobenzone in different disinfection reactions of chlorination and bromination of fresh or seawater … increasing its toxicity (Lebedev et al Environment International Volume 137, **April 2020**, 105495).

Lastly, the toxicity associated with organic sunscreens and the role that these chemicals are thought to play in preventing skin cancer is of concern, therefore, I will let the researchers and medical professional who have evaluated this perspective over the last 6 decades answer this question using their own statements:

**Published Research Reviewing the Skin Cancer Prevention of Sunscreens**

| Statement | Citation |
|---|---|
| "The preparations are all designed to protect against the acute effects of ultraviolet, namely sunburn. Because of their effectiveness in this regard, they are often assumed to protect against ultraviolet carcinogenesis. In most cases, however, there is little or no published evidence that they do so and the relationship is inferential." | Emmett. Ultraviolet radiation as a cause of skin tumors. CRC Crit Rev Toxicol. **1973**;2(2):211-55. |
| "In summary, the results of this study indicate that inflammation and enhanced melanoma growth are different effects of UV radiation involving different mechanisms and have different sensitivities for sunscreen protection. Furthermore, protection against sunburn does not necessarily imply prevention of other possible UV radiation effects, such as enhanced melanoma growth. In fact, sunscreen protection against UV radiation-induced inflammation may actually encourage prolonged exposure to UV radiation and thereby increase the risk of development of cutaneous melanoma." | Wolf et al. Effect of sunscreens on UV radiation-induced enhancement of melanoma growth in mice. J Natl Cancer Inst. **1994**;86(2):99-105. |
| "… the topical use of sunscreens reduces the risk of sunburn in humans and that sunscreens probably prevent squamous-cell carcinoma of the skin when used mainly during unintentional sun exposure. No conclusion can be drawn about the cancer-preventive activity of topical use of sunscreens against basal-cell carcinoma and cutaneous melanoma | World Health Organization - Vainio et al. An international evaluation of the cancer-preventive potential of sunscreens. Int J Cancer. **2000**;88(5):838-42. |
| "Although a sunscreen with an SPF of 15 or higher offers protection from sunburn, it does not block all of the sun's damaging rays. In fact, there is no evidence that sunscreens protect you from malignant melanoma, the deadliest form of skin cancer, even though sunburns have been linked with the development of melanoma." | Environmental Protection Agency: Sunscreen the burning facts **2006**. Is sunscreen fail-safe (pg6). www.epa.gov |
| "Despite the availability and promotion of sunscreen for decades, the incidence of CMM (cutaneous malignant melanoma) continues to increase in the U.S. at a rate of 3% per year. There currently is little evidence that sunscreens are protective against CMM." | Planta. Sunscreen and melanoma: is our prevention message correct? J Am Board Fam Med. **2011**;24(6):735-9. |
| "The strength of the association between risk of skin cancer and sunscreen use has constantly decreased since the early 1980s, and the association was no longer statistically significant from the early 1990s. While the current evidence suggests no increased risk of skin cancer related to sunscreen use, this systematic review does not confirm the expected protective benefits of sunscreen against skin cancer in the general population." | Saes da Silva et al. Use of sunscreen and risk of melanoma and non-melanoma skin cancer: a systematic review and meta-analysis. Eur J Dermatol. **2018**;28:186–201. |
| "Could it be that the nearly universal recommendation of dermatologists and professional societies to use sunscreen to prevent skin cancer is unfounded?" | Waldman et al. The role of sunscreen in the prevention of cutaneous melanoma and nonmelanoma skin cancer. J Am Acad Dermatol. **2019** Feb;80(2):574-576. |

**Note: Everyone should practice sun avoidance measure when possible, especially during peak hours of UV exposure (10 AM – 2 PM); wear protective clothing include a broad-brimmed hat and sunglasses and/or use a beach umbrella/cabana when at the beach or pool; if sunscreen is desired, use a mineral based zinc oxide or titanium dioxide sunscreen - which are considered safe and effective for human use according to the FDA.**

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Dear Hawaii Legislature,

This letter is testimony for my support of Senate Bill 132.

The inclusion of octocrylene in the context of the Hawaii Law 104 Amendment of 2018 is an important step in the conservation of coral reefs against the threat of localized haloes of sunscreen pollution in areas frequented by swimmers.[1]

Our group has used an innovative method to evaluate and quantify the impact on UV filters on reef building coral *Pocillopora damicornis*.[2–4] We have been able to demonstrate that the effect of octocrylene is of particular concern. On the one hand, this compound alters mitochondrial function in coral, whereas mitochondria are the source of energy for the animal cell. By way of illustration, in humans, many conditions including Alzheimer's disease, muscular dystrophy, and cancer can induce mitochondrial dysfunction.

On the other hand, we also established that octocrylene accumulates in coral by "hiding" into it. Indeed, where octocrylene itself is present in relatively small quantities, larger amounts of octocrylene derivatives have also been found. These derivatives result from the transformation of octocrylene by coral enzymes. They can be 10 to 100 times more concentrated than octocrylene. As a result, the concentrations of octocrylene measured in the coral in Hawaii are likely very largely underestimated because octocrylene derivatives concentrations were never measured.[5] This is all the more worrying since these derivatives are very closely related to octocrylene itself and are expected to be just as toxic for coral.

Another concern is that similar compounds have also been found in human urine after topical (on the skin) application of sunscreens containing octocrylene.[6,7] This highlights the fact that (1) octocrylene does penetrate animal membranes, including human skin, and (2) these biological mechanisms of octocrylene transformation are possibly ubiquitous, and therefore these derivatives should be systematically considered in octocrylene concentration measurements. It should be mentioned that we have found these same analogues in other marine animals in a work that has not been published yet.

Our second article demonstrated that octocrylene was the most toxic of all the 10 UV filters tested on coral. Ethylhexyl salicylate comes second, and benzophenone-3 third. In another work, we also demonstrated that octocrylene was somewhat toxic towards the brine shrimp *Artemia*

*salina* and the microalgae *Tetraselmis* sp..[8] In an unpublished work, we have found huge localized concentration of octocrylene in beach sand and water column, and I am convinced owing to our work and literature data on this compound that it represents one of the major threat for coral reef in bathing areas.

Respectfully submitted,

Dr. Didier Stien.

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REVIEW ARTICLE

BJD British Journal of Dermatology

# Sunscreen abuse for intentional sun exposure

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## Summary

Skin cancer is caused by exposure to ultraviolet radiation (UV) and the sun is the main source of this radiation. Sunscreens were initially formulated to prevent sunburns; laboratory studies later revealed that in rodents they could reduce UV-induced skin cancer which resembles human squamous cell carcinoma. Three randomized trials in older adults showed the ability of sunscreens to moderately reduce the occurrence of solar keratoses and of squamous cell carcinoma. However, no effect was observed for basal cell carcinoma. There is no animal model for human melanoma and observational studies often found sunscreen use associated with a higher risk of nevus, melanoma and basal cell carcinoma. These higher risks were found when sun exposure appeared to be intentional, that is, with the desire to acquire a tan, a healthy look or simply to spend as long as possible in the sun with as much skin exposed as possible. Three randomized trials showed that sunscreen use by sun sensitive subjects engaging in intentional sun exposure could increase the duration of exposure without decreasing sunburn occurrence. This increased duration could be the reason why melanoma risk is increased when sunscreen is used. Hence, sunscreen abuse may extend sun exposure duration thus allowing sun exposure behaviours that would not be possible otherwise. Advertising for sunscreens and labeling of sunscreen bottles should inform consumers of the carcinogenic hazards associated with sunscreen abuse. It would be good to use a personal UV dosimeter which would give an alert when one's individual sunburn threshold in the absence of sunscreen use is nearing. The combination of sunscreen and a UV dosimeter may be an option for reducing the melanoma risk among sun worshippers.

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The advent of sunscreens paralleled the tanning fashion that spread in light skinned populations starting in the 1930s.[1] Their initial formulation was designed to block ultraviolet (UV) B radiation (UVB, 280–320 nm), which causes most sunburns. Epidemiological studies in the 1980s found a strong link between sunburn history and skin cancer, including melanoma. At the same time many laboratory experiments showed that besides delaying the erythemal reaction, sunscreens could reduce a variety of other UV-induced skin lesions, including squamous cell cancer. As a result, these products have been advocated for the prevention of skin cancers, including melanoma despite the absence of a good animal model mimicking human skin melanoma. Until recently, it was generally assumed that the greater the ability of a sunscreen to delay sunburn (i.e., its sun protection factor – SPF), the higher the protection against deleterious effects of the sun. In the 1990s the carcinogenic properties of ultraviolet A radiation (UVA, 320–400 nm) began to be suspected, and a new generation of broad-band sunscreens has emerged, having high SPF (30 and more) and containing agents specifically blocking the UVA.

However, contrary to the expectations based on laboratory experiments, population-based case-control studies often found an increased risk of melanoma associated with sunscreen use (revised in ref. 2). Prospective and retrospective cohort studies found sunscreen use to be associated with increased risk of basal cell cancer in adult women,[3] and higher numbers of acquired melanocytic nevi among school children and adolescents.[4,5] Concerns raised by epidemiological studies were emphasized by laboratory experiments showing that sunscreens could enhance the stimulation of melanoma growth by UV radiation.[6]

After 1995, epidemiological studies and randomized trials found that the most probable reason why sunscreen use increased the risk of melanoma was that by delaying sunburn occurrence, these products extended the time spent in the sun.[7] In this paper, we review the evidence backing this finding and propose a model for explaining why sunscreen extended sun exposure may increase melanoma risk. Based on this model, we propose a way to control time spent in the sun when a sunscreen is used.

## Sunscreens and intentional or non-intentional patterns of sun-exposure

Understanding the sunscreen-melanoma association requires distinguishing between two different types of sun exposure patterns.

The non-intentional sun exposure (NISE) pattern represents sun exposure during daily life activities, without a special willingness to acquire a tan or to be able to spend a long time in the sun. The so-called chronic sun exposure pattern usually equates to NISE. Examples of NISE are outdoor activities such as walking, hiking, gardening, skiing, or construction and farming work. Lifetime accumulated NISE is mainly associated with solar keratoses and squamous cell carcinoma.

The intentional sun exposure (ISE) pattern is sun exposure with an intention to stay in the sun with large uncovered skin areas, or/and to acquire a tan. ISE is characteristic of light-skinned subjects who spend most of their daily life indoors but enjoy intense sun exposure during holidays. The usually called intermittent sun exposure pattern is often intentional as subjects look for a biological effect. Sunbathing is the most typical ISE behaviour. Melanoma is commonly found on the usually covered sites such as the trunk, and this clinical evidence fits with the ISE patterns being the cause of most melanoma.

## Reasons for the increased melanoma risk associated with sunscreen use

It was first hypothesized that the increased risk of melanoma or high nevi numbers was found in populations not using modern high SPF, anti-UVA broad-band sunscreens. However, many of these studies are quite recent and included people who already used the broad-band type of sunscreens.[2]

Secondly, it was argued that because sunscreen users were generally more sun sensitive than non-users, the increased risk of melanoma observed in sunscreen users merely reflected their inherently greater risk of melanoma. The epidemiological literature describes this phenomenon as 'bias by indication'. However, this bias can likely be excluded because of the 'sunscreen-clothes paradox' found in many studies: sunscreen use and wearing of clothes when in the sun are more prevalent in sun sensitive subjects.[2,8] The study on nevi in European schoolchildren showed that during sunny holidays, an inverse correlation existed between sunscreen use and sun protection through the wearing of clothes (Fig. 1): the more sunscreens were used, the fewer clothes protected the skin against the sun. This and other studies found that while sunscreen use was associated with higher nevus counts, wearing clothing was associated with decreasing numbers of nevi.[4,5] Only one population-based case-control study examined the risk of melanoma with sunscreen use and wearing of clothes, and found a melanoma risk reduced by 52% ($P < 0{\cdot}001$) when the primary site of the tumour was usually covered with clothes during outdoor work in the summer.[9] In contrast, the melanoma risk associated with sunscreen use was 1·15 (95% CI 0·78–1·68) in subjects who used sunscreens for 10 years or more.

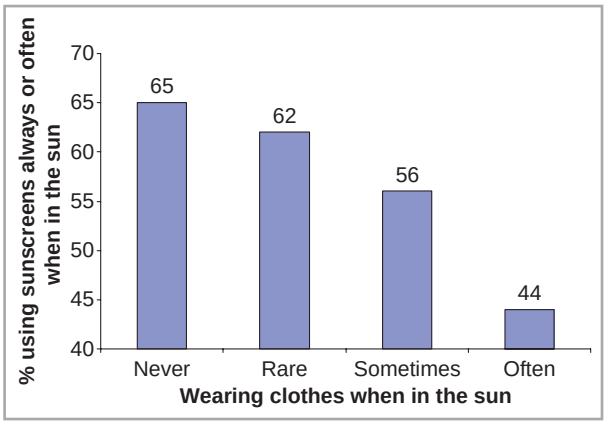


**Fig 1.** Correlation between sunscreen use and wearing clothes in 623 5- to 7-year-old European schoolchildren (R-square = 0·92, $P < 0{\cdot}0001$) (Ref. 4).

If wearing clothing and using sunscreen represent real barriers against the transmission of UV to the skin, then why does the former actually protect against melanoma and nevus formation, while the latter seems unable to protect against melanoma and rather increases nevus development. This paradox made credible the hypothesis that sunscreen use could be involved in nevus and melanoma occurrence.

The third hypothesis was that due to their ability to delay sunburns, sunscreen use would encourage sun exposures of longer duration; this would be especially true when sun exposure is motivated by a desire to tan or to remain in the sun for longer periods. This hypothesis was supported by the common observation that in NISE situations, sunscreen use can reduce sunburn occurrence. In contrast, in ISE situations, sunscreen use did not change the risk of sunburn.[2,8]

## Sunscreen use and duration of sun exposure

Three randomized trials demonstrated that during ISE, use of relatively small amounts of sunscreen (i.e., amounts 3–4 times smaller that those used for measuring the SPF) was able to increase time spent in the sun. Two trials were conducted in France, Switzerland and Belgium with sun-sensitive volunteers 18–24 going to sunny areas for summer holidays.[10,11] These volunteers were randomized in a double blind design to receive SPF 10 or SPF 30 sunscreen. These trials showed that high SPF sunscreen extended sunbathing time by 19–25%, while there was no difference in sunburn experience and no difference in quantity of sunscreen used. Another key finding of these two trials was that as their holiday progressed, subjects using the SPF 30 sunscreen usually started sunbathing around noon, whereas those using the SPF 10 sunscreen tended to start sunbathing steadily later in the day. Hence, sun exposure duration of sun sensitive subjects engaged in ISE is limited by sunburn acquisition, and delaying sunburn occurrence leads to profound changes in sun behaviours.

 

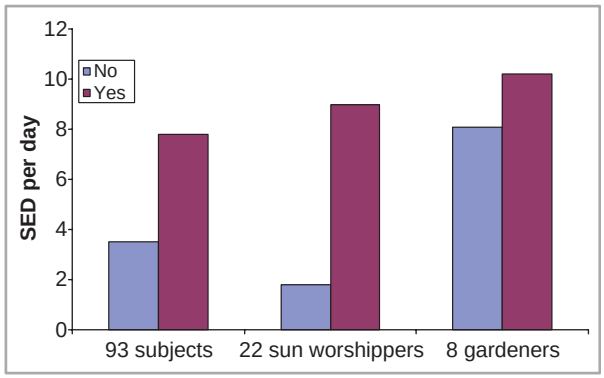


**Fig 2.** UV doses [in standard erythemal dose (SED) per day] received by volunteers wearing personal UV dosimeters, Denmark (Ref. 14).

The third trial took place in 2003 in a French holiday village and randomized 308 adults 18–78 years of age into three groups using sunscreen of different SPF and having different labelling.[12] Results of this trial indicated that after 1 week of use, higher SPF was associated with longer ISE duration.[7]

What about sunscreen use and sun exposure duration during NISE? The few available data suggest that in NISE situations, there is no increased duration of sun exposure associated with sunscreen use. The Australian randomized trials for prevention of squamous and basal cell carcinoma found no evidence for increased duration of time spent in the sun when high SPF sunscreen was used.[13] A Danish group with great experience in individual UV dosimetry monitored time spent in the sun and UV doses experienced during various types of outdoor activities (Fig. 2).[14] Although samples were relatively small, sunscreen use during a NISE activity like gardening did not increase the UV dose received, while among sun worshippers sunscreen use was associated with a considerable increase in UV dose received.

## ISE, NISE, sunscreens and skin cancer

Three randomized controlled trials (two in Australia and one in the U.S.A.) in subjects over 50 years old, many of whom had a history of actinic skin lesions, have shown that when used during NISE, sunscreen use (moderately) decreases the incidence of squamous cell carcinoma and of solar keratoses, but not of basal cell carcinoma.[15–17]

Essentially because of intractable practical and ethical difficulties, no randomized trial has ever tested the ability of sunscreen use to protect against skin cancer and melanoma in particular during ISE situations. The trial in Vancouver, Canada tested the ability of a broad-band sunscreen to limit nevi numbers in schoolchildren.[18] It is not clear whether the Vancouver trial was representative of ISE situations. Results of this trial are difficult to interpret, as, for yet unknown reasons, all the effect of sunscreens was confined to children with high freckling. Furthermore, the statistical analysis did not adjust for nevi counts at baseline.

Epidemiological data relevant to the associations found between sunscreen use and skin cancer is summarized in the Table 1. Studies conducted during NISE situations were close to conditions encountered in laboratory experiments that demonstrated the cancer prevention properties of sunscreens, e.g., application of high doses of sunscreens, subjects eager to protect themselves from harmful effects of the sun and not attracted by tan acquisition. These laboratory experiments did not at all reflect sunscreen use during ISE situations.

These data led a Working Group convened by the IARC in 2000 to conclude that:[2]

1 Sunscreen use may decrease occurrence of SCC.
2 Sunscreen use has no demonstrated influence on BCC.
3 In ISE situations, sunscreen use may increase the risk of melanoma.

## The traditional and alternative view on the biological effects of sunscreen use in humans

The traditional view is that the greater the SPF of the sunscreen actually applied onto the skin (usually 2–4 times lower than doses used for measuring the SPF), the greater the sun protection. This view schematized in Figure 3a suggests that the application of a potent sunscreen will decrease the UV

**Table 1** Likely effects of sunscreen use in sun sensitive subjects during non-intentional and intentional sun exposure

| | Non-intentional sun exposure | Intentional sun exposure |
|---|---|---|
| Examples | Outdoor professional activities, gardening, skiing, walking | Sunbathing, outdoor sport with naked trunk |
| Type of subjects in studies | Old adults or elderlies not sun to tan attracted, often with history of actinic skin damage | Young adults, suntan seekers |
| Sunburn occurence | Decrease | No difference[a] |
| Time spent in the sun | No change | Increase |
| Influence on risk of | | |
| Squamous cell carcinoma | Decrease | No data |
| Basal cell carcinoma | No change | No difference or increase |
| Cutaneous melanoma | No data | No difference or increase |

[a]The increase reported in some studies was probably due to lack of control for sun-sensitivity (ref. 7).

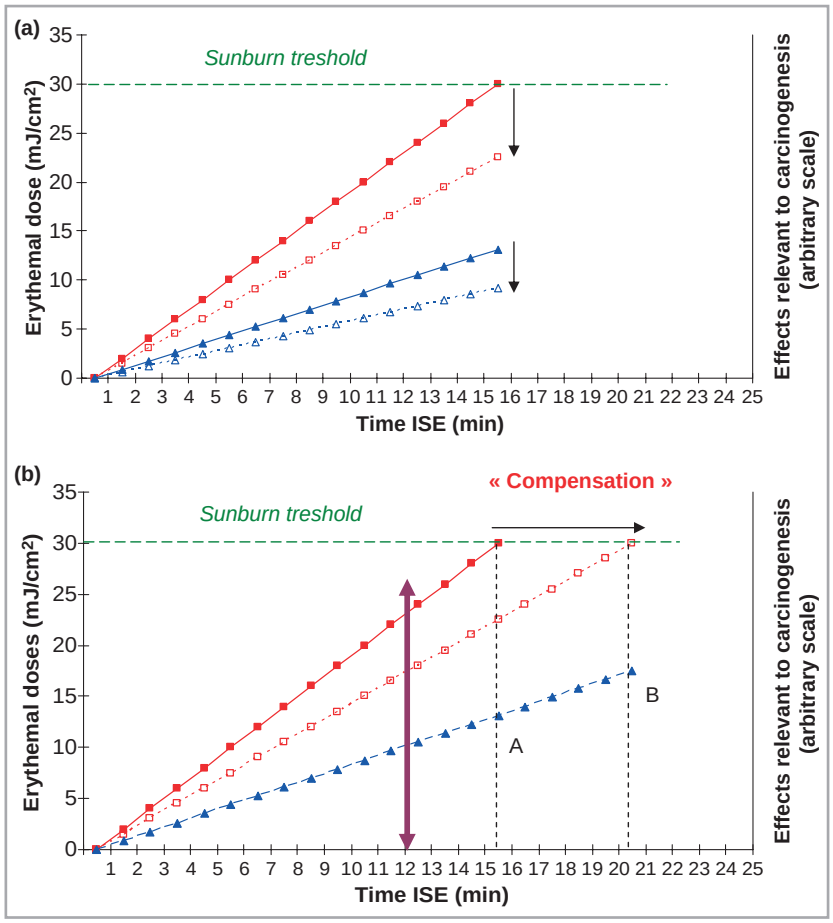


**Fig 3.** Schematic representation of traditional and alternative views on effects of use (continuous lines, plain squares and triangles) or no use (doted lines, open squares and triangles) of sunscreens in humans. Squares refer to sunburn occurrence according to UV dose received in mJ $cm^{-2}$ on the left Y-axis. Triangles refer to carcinogenic effects, with an arbitrary scale of Y-axis on the right. For simplification, sunburn occurrence and carcinogenic effects are assumed to linearly increase with time spent in the sun. In this example, a sunburn threshold of 30 mJ $cm^{-2}$ was chosen, but this threshold varies from subject to subject according to skin complexion and phototype. Black arrows indicate effects of sunscreens, and the large double arrow indicates the threshold for the alert displayed by an individual UV dosimeter.

dose delivered to the skin. The immediate consequence is the prevention of sunburn. In this case, the decrease in erythemal effect is paralleled by a proportional decrease in carcinogenic effects. This view assumes that the duration of sun exposure remains equivalent with or without sunscreen use. This traditional view mirrors the results from laboratory studies during which exposure duration parameters are controlled.

The assumption that duration of sun exposure remains equivalent with or without sunscreen use is not tenable as nothing indicates to sunscreen users that without the sunscreen, they would already be sunburned. So, the alternative view schematized in Figure 3b is based on evidence that sunscreen use will just delay sunburn occurrence but not prevent it, and lead to increased duration of sun exposure. This increased duration is sometimes labelled 'compensatory behaviour'.[2] Also, the alternative view assumes that the ability to prevent sunburns (as measured by the SPF) probably does not imply the ability to prevent melanoma or basal cell carcinoma. This view agrees with results of randomized trials on sunscreen use and sun exposure duration during ISE and also agrees with laboratory data suggesting that wavelengths other than the UVB may be involved in melanoma initiation and growth.[6,19] Extension of sun exposure duration induced by sunscreen use will result in the increase from point A to point B of the carcinogenic effects.

So, the traditional view would apply to typically UVB-induced skin lesions, including squamous cell cancer and solar keratoses. The alternative view would apply to cutaneous melanoma, mainly for melanoma occurring on usually sun protected sites such as the trunk.

Adding specific UVA filters to sunscreens is now common, and is deemed to improve their anti-cancer properties. But there is still disagreement on the standard test for evaluating their anti-UVA properties.[20] Indeed, filtering out some of the UVA may affect biological pathways other than those involved in erythema but possibly involved in skin carcinogenesis. However, because the quantity of sunscreen typically applied to the skin is small and sunlight is very rich in UVA, it is quite possible that the anti-carcinogenic defences provided by UVA filters might be overwhelmed during sunbathing in the midday sun, especially if exposure time is increased due to a high SPF. We thus do not think that the schematic view we outlined would be fundamentally different if sunscreens did or did not contain specific UVA filters. Our reasoning is supported by studies in volunteers using sunscreen of the same SPF formulated with essentially UVB filters or with essentially UVA filters.[21] No difference between the two types of sunscreens was found in their capacity to decrease UV induced DNA damage or erythema.

## Sunscreen abuse

Sunscreen abuse has two complementary facets. The first is that most subjects engaging in ISE use a sunscreen in order to best take advantage of their sun exposure without, do they believe, incurring side effects, mainly sunburns. The second, less obvious facet is that sunscreen use during ISE allows sun exposure behaviors that would not be possible otherwise. The recommendation to re-apply sunscreen after a certain length of sun exposure probably represents a form of abuse.

Many studies and prevention campaigns have been conducted with the belief that recreational sun exposure, specially sunbathing, is safer when a sunscreen is used. When there is no control of sun exposure duration, that belief is questionable. So, the basic question is, 'what is most dangerous: sunbathing with or without using a sunscreen?' Until a method is found to prevent subjects unable to refrain from ISE from extending the time they spend in the sun, they should be advised not to use sunscreen but rather to let their skin adapt and set strict limits on the time they spend in the sun. This may be somewhat shocking but it follows the logic outlined in the alternative view in Figure 3b, because not using a sunscreen would prevent the stimulation of carcinogenic processes induced by unfiltered radiation.

Sunscreen abuse is encouraged by the false sense of security promoted by sunscreen advertisements, claiming or suggesting that these products protect against carcinogenic processes when used during ISE, and especially during tan acquisition. Such advertising encourages sunscreen abuse during ISE and thus contributes to increasing the risk of melanoma. This raises consumer protection issues. One day, melanoma patients could sue sunscreen makers because they were not warned against excessive sun exposure induced by sunscreen use and rather lulled by messages promoting sunscreen use during sunbathing as a way to safely acquire a nice, deep tan. This is not science fiction as in 2006 in the U.S.A., a class action suit was filed at the Los Angeles Superior Court for misleading advertising and fraudulent misrepresentation in the labelling of sunscreen bottles that, according to the plaintiffs, did not correctly indicate the hazards associated with the absence or low UVA blocking capacity of sunscreens.[22]

## How to avoid sunscreen abuse and its deleterious consequences?

Trying to discourage tan acquisition and deliberate sun exposure during the holidays is not very cost effective, especially among teenagers and young adults.

Consumer information on sunscreens should better reflect current knowledge of potential health hazards associated with their use during ISE. Cosmetic companies should not pretend that 'safe tanning' exists when using sunscreen.

Sunscreen bottles could bear messages on the hazards associated with ISE, mainly the longer stay in the sun that may end up in sunburn and the possibility of higher melanoma risk. However, such labelling of sunscreen products is not likely to be well understood, especially if on the other hand, it is rightly claimed that sunscreen use during non-intentional sun exposure may decrease skin cancer risk. Sunburns would remain frequent and no one would understand why lotions preventing sunburns during NISE would be discouraged during ISE.

A wiser approach would be to avoid excess sun exposure thanks to information on individual UV exposure. Referring back to Figure 3b, if a subject engaged in ISE is informed after say 12 min that he or she is nearing his or her specific sunburn threshold in the absence of sunscreen use, and if that subject covers up or moves to a shaded area, then the erythemogenic UV dose and the carcinogenic effect would be lower than if no information was provided.

Practically speaking, UV dosimeters could inform sunscreen users engaged in ISE. The dosimeter could be worn as a watch [22] or inlayed in the caps of the sunscreen bottle. Indeed, dosimeters should be calibrated according to individual sun sensitivity in the absence of sunscreen use. The technology for cheap individual UV dosimeters already exists that could be adapted for controlling sun exposure duration.[23–25]

This approach would reconcile sunscreen and educational efforts. If feasible such a method would transform an ISE situation into a NISE situation and sunscreen use could then decrease skin cancer risk, and probably also melanoma.

Users of dosimeters and sunscreens will surely complain that tan acquisition is longer, and that they would like to stay longer in the bright sunshine than allowed by the dosimeter, but at the end of the day, subjects complying with the method will understand their health benefit.

Testing this approach may first be done though randomized trials on sunburn occurrence comparing sunscreen users vs. sunscreen and dosimeter users. Normally, the latter group should experience fewer sunburn episodes. A second, test would be the assessment of changes in nevi count and shape on the trunk of young adults spending holidays in sunny areas, again with randomization of sunscreen alone vs. sunscreen combined with dosimeters.

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ACCOUNTS
of chemical research

# Benzophenone Photosensitized DNA Damage

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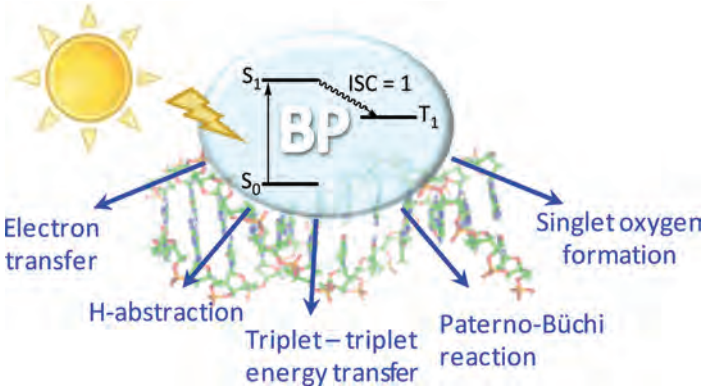
## CONSPECTUS




Although the carcinogenic potential of ultraviolet radiation is well-known, UV light may interact with DNA by direct absorption or through photosensitization by endogenous or exogenous chromophores. These chromophores can extend the "active" fraction of the solar spectrum to the UVA region and beyond, which means that photosensitizers increase the probability of developing skin cancer upon exposure to sunlight. Therefore researchers would like to understand the mechanisms involved in photosensitized DNA damage both to anticipate possible photobiological risks and to design tailor-made photoprotection strategies. In this context, photosensitized DNA damage can occur through a variety of processes including electron transfer, hydrogen abstraction, triplet–triplet energy transfer, or generation of reactive oxygen species.

In this Account, we have chosen benzophenone (BP) as a classical and paradigmatic chromophore to illustrate the different lesions that photosensitization may prompt in nucleosides, in oligonucleotides, or in DNA. Thus, we discuss in detail the accumulated mechanistic evidence of the BP-photosensitized reactions of DNA or its building blocks obtained by our group and others. We also include ketoprofen (KP), a BP-derivative that possesses a chiral center, to highlight the stereodifferentiation in the key photochemical events, revealed through the dynamics of the reactive triplet excited state ($^3$KP*). Our results show that irradiation of the BP chromophore in the presence of DNA or its components leads to nucleobase oxidations, cyclobutane pyrimidine dimer formation, single strand breaks, DNA–protein cross-links, or abasic sites. We attribute the manifold photoreactivity of BP to its well established photophysical properties: (i) it absorbs UV light, up to 360 nm; (ii) its intersystem crossing quantum yield ($\phi_{ISC}$) is almost 1; (iii) the energy of its n$\pi^*$ lowest triplet excited state ($E_T$) is ca. 290 kJ mol$^{-1}$; (iv) it produces singlet oxygen ($^1O_2$) with a quantum yield ($\phi_\Delta$) of ca. 0.3.

For electron transfer and singlet oxygen reactions, we focused on guanine, the nucleobase with the lowest oxidation potential. Among the possible oxidative processes, electron transfer predominates. Conversely, triplet–triplet energy transfer occurs mainly from $^3$BP* to thymine, the base with the lowest lying triplet state in DNA. This process results in the formation of cyclobutane pyrimidine dimers, but it also competes with the Paternò–Büchi reaction in nucleobases or nucleosides, giving rise to oxetanes as a result of crossed cycloadditions. Interestingly, we have found significant stereodifferentiation in the quenching of the KP triplet excited state by both 2′-deoxyguanosine and thymidine. Based on these results, this chromophore shows potential as a (chiral) probe for the investigation of electron and triplet energy transport in DNA.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## 1. Introduction

Photochemical DNA damage is currently a matter of public health concern.[1,2] This adverse effect can be induced by direct absorption of UV light or through indirect light absorption by endogenous or exogenous chromophores near the biomacromolecule. By extending the "active" fraction of solar radiation to the UVA and beyond, photosensitizers increase the risk of developing skin cancer upon exposure to sunlight. For this reason, it is of paramount importance to understand the mechanisms involved in photosensitized formation of DNA damage, in order to develop efficient photoprotection strategies.

Benzophenone (BP) is a classical and paradigmatic sensitizer in photochemical studies. Irradiation of this chromophore in the presence of DNA leads to formation of nucleobase modifications, cyclobutane pyrimidine dimers (CPDs), DNA−protein cross-links, single strand breaks (ssb), or abasic sites. The photophysical properties of BP have been intensively studied and are well established (Figure 1): (i) it absorbs UV light, up to 360 nm, (ii) its intersystem crossing quantum yield ($\phi_{ISC}$) is near 1, (iii) the energy of its n$\pi^*$ lowest triplet excited state ($E_T$) is ca. 290 kJ mol$^{-1}$, and (iv) it produces singlet oxygen ($^1O_2$) with a quantum yield ($\phi_\Delta$) of ca. 0.3.[3,4]

In this Account, we use BP to illustrate the advances in the investigation of the reaction mechanisms involved in photosensitized DNA damage, paying special attention to stereodifferentiation. Detailed information is provided on the main photoinduced reactions of DNA mediated by BP and related derivatives like ketoprofen (KP), a 2-arylpropionic acid with a BP chromophore that possesses a chiral center.[5,6] These reactions include triplet−triplet energy transfer (TTET) to nucleobases, together with both type I (hydrogen atom or electron transfer) and type II (singlet oxygen) processes.[7]

## 2. Benzophenone Photosensitized Reaction of Pyrimidine (Pyr) Bases: Triplet−Triplet Energy Transfer (TTET)

Photosensitized TTET may occur from BP to the nucleobases, especially to thymine (Thy), which is the DNA base with the lowest $E_T$ (310 kJ mol$^{-1}$).[8] Subsequent reaction of $^3$Thy* with another Thy or a cytosine (Cyt) in their ground states, gives rise to CPDs through a [2 + 2] photocycloaddition (Figure 2). As a result, a number of regio- and diastereoisomers can be obtained in solution with free 2′-deoxyribonucleosides, although there is certain prevalence of the *trans−anti* forms.[9]

In complex systems like oligonucleotides or DNA itself, the scenario is different. Thus, photosensitization of

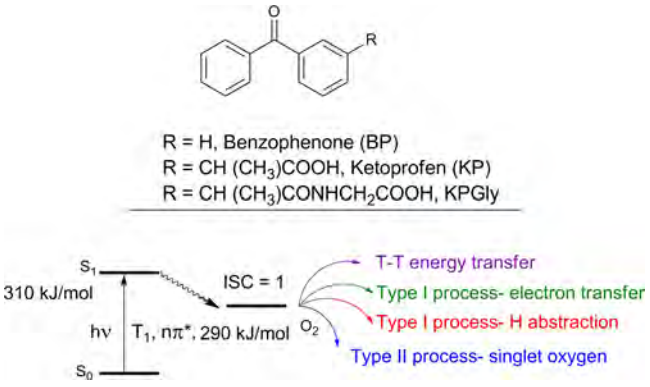


**FIGURE 1.** Photophysical properties and photoreactions of the benzophenone chromophore.

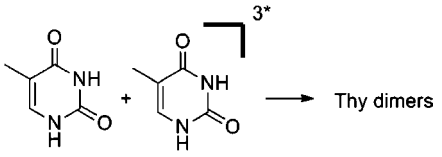


**FIGURE 2.** Thymine base dimerization.

oligonucleotides and ss-DNA gives mainly rise to *cis−syn* and *trans−anti* cyclobutane thymine dimers (Thy<>Thy), while in ds-DNA *cis−syn* CPDs clearly predominate[10] due to orientation restrictions imposed by the double strand.

Analysis of CPD formation photoinduced by BP in calf thymus DNA reveals a relative distribution of Thy<>Thy, 5′-Cyt<>Thy-3′ and 5′-Thy<>Cyt-3′ of 1, 0.23, and 0.25, respectively.[11] Cyclobutane cytosine dimers (Cyt<>Cyt) are not detected likely because $^3$BP* is not energetic enough to populate $^3$Cyt* (334 kJ mol$^{-1}$).[9] Absolute photodimerization quantum yields ($\phi_D$) are difficult to obtain experimentally given that it has to be ensured that light is absorbed *exclusively* by the photosensitizer. For this reason, there are only a few $\phi_D$ values in the literature, one of them corresponding to ketoprofen; specifically, $\phi_D$ (KP) in supercoiled DNA has been determined to be 0.0002.[12]

According to their relative triplet energies, TTET between $^3$BP* and Thy is a slightly disfavored process, yet it is still observed in solution due to thermal population of upper vibrational states of $^3$BP*.[8,9,13] Notably, this process is more feasible in DNA, where $\pi$-stacking and base pairing result in a shift of the $E_T$ of Thy down to 267 kJ mol$^{-1}$ (Figure 3).[9,12,14,15]

We have determined the triplet energy of Thy in DNA by photosensitization experiments, in which supercoiled DNA is irradiated in the presence of a family of fluoroquinolones. The known $E_T$ values of these drugs are within a narrow

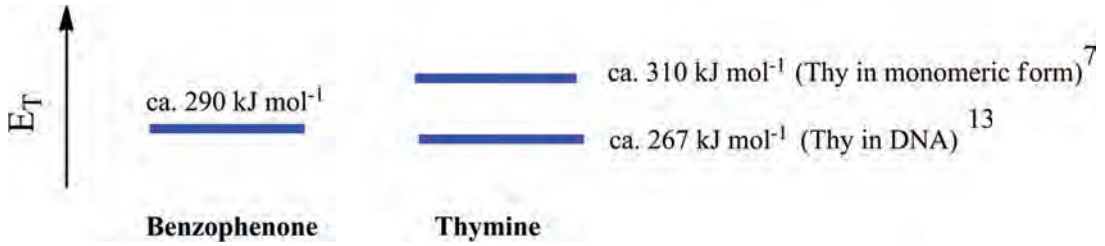


**FIGURE 3.** Benzophenone and thymine triplet energy levels.

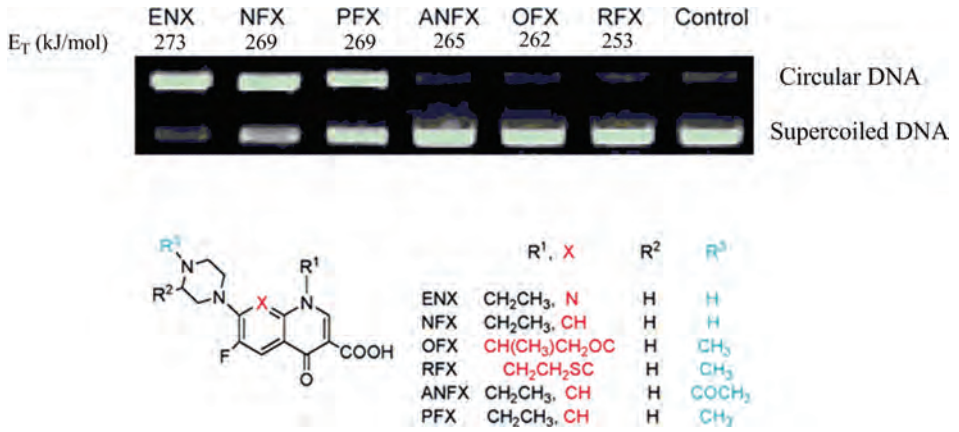


**FIGURE 4.** Photomixtures of fluoroquinolones of known $E_T$ and plasmid pBR322 DNA after treatment with T4 endo V enzyme and gel electrophoresis.

range (from 273 to 253 kJ mol$^{-1}$), close to the expected $E_T$ of Thy in the biomacromolecule. Following UVA irradiation, the samples are digested with T4 endonuclease V, which cleaves the double helix at those points where Thy<>Thy are formed, converting supercoiled DNA into its circular form. Subsequently, Thy<>Thy are revealed by electrophoresis, based on the different mobility of supercoiled and circular DNA (Figure 4). In this way, we have clearly shown that those drugs with $E_T > 269$ kJ mol$^{-1}$ photoinduce Thy<>Thy, while those with $E_T < 265$ kJ mol$^{-1}$ do not. Hence, any compound with $E_T > 267$ kJ mol$^{-1}$ should be considered as a potential photosensitizer via Thy dimerization. This value is higher than the $E_T$ of other well-known DNA photosensitizers, such as riboflavin (ca. 200 kJ mol$^{-1}$).[16]

Furthermore, studies performed on oligonucleotides have demonstrated that CPD formation is sequence-dependent.[12,17−20] In particular, the amount of these lesions increases when an additional Pyr base is located in the 5′ side of two consecutive Thy as shown by irradiation of 5′-TGA GCG TTA GTT TAA GTC GGC TAT C-3′ in the presence of BP, which leads to the highest CPD formation yields at the TTT sites.[12]

Competing with TTET, the contribution of the type I mechanism to photoinduce DNA damage has been

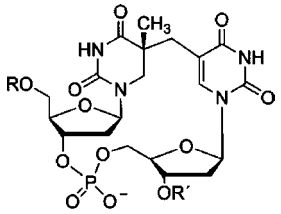


**FIGURE 5.** Structure of the spore photoproduct.

evaluated by irradiating BP in the presence of the dinucleotide thymidylyl-(3′→5′)-thymidine (TpT) under aerobic conditions.[10] By quantification of Thy<>Thy dimers, we have shown that the energy transfer mechanism clearly predominates over Thy oxidation (17:1 ratio).

Another structurally interesting type of Pyr dimer, found in the dry environment of bacterial spores, is the 5-thyminyl-5,6-dihydrothymine adduct, commonly known as spore photoproduct (SP, Figure 5).[9,11,21,22] The formation of this bipyrimidine lesion can be photosensitized by BP in dry films.[22] The photosensitized formation of SP in DNA gives rise uniquely to the 5*R* diastereomeric form and is conditioned by the presence of $\alpha/\beta$ acid soluble protein, which converts $\beta$-DNA into $\alpha$-DNA. In the spores, dipicolinic acid seems to play the role of a natural photosensitizer.

After generation of $^3$Thy* by TTET, we have proposed two alternative mechanisms of SP formation: (i) C−C coupling of a radical pair generated by H-abstraction from a ground state Thy and, less likely, (ii) a concerted mechanism.[22,23]

## 3. Benzophenone Photoreaction with Pyrimidine Bases: The Paternò−Büchi Reaction

Carbonyl compounds may react with olefins through a [2 + 2] photocycloaddition giving rise to oxetanes through a Paternò−Büchi reaction (Figure 6). This competes with TTET and is favored for n$\pi$* triplets when the $E_T$ of the alkene is comparable to or higher than that of the carbonyl compound. Because this is the case for the BP/Thy system, oxetane formation is possible.[3,13,24]

Actually, upon irradiation of BP in the presence of thymidine (Thd), we have isolated two stereoisomeric oxetanes (Figure 7).[24]

To gain a deeper insight into the reaction mechanism, we have performed time-resolved laser flash photolysis (LFP) experiments to study the interaction between the triplet excited states of BP or KP and Thd. Because both $^3$BP* and $^3$KP* are n$\pi$* in nature, a fast triplet−triplet quenching by Thd is observed, (ca. $5.0 \times 10^8$ M$^{-1}$ s$^{-1}$). This supports a Paternò−Büchi photoreaction,[24] in view of the endergonic nature of TTET. Accordingly, oxetanes prevail over CPDs after steady-state irradiation of Thy in the presence of BP.[8,10,24] Indeed, BP-photosensitized Thy dimerization is concentration dependent, and CPDs are only detected when the nucleobase is present in a large excess.

It is worth noting that this scenario may vary in DNA, where the contribution of TTET would be higher, due to the lower $E_T$ of Thy in the biomacromolecule. Thus, the double helix would prevent the Paternò−Büchi photoreaction from taking place but at the same time would enhance the prospects for Thy dimerization.

**3.1. Chiral Discrimination.** Direct photophysical evidence for chiral discrimination in the triplet excited state has only been found in a few cases;[13,25−29] this includes the interaction between $^3$KP* and Thd, which we have studied by LFP in aqueous acetonitrile, monitoring the kinetics of KP n$\pi$* triplet state decay upon addition of increasing amounts of Thd.[13] Plotting the reciprocal lifetimes of (*S*)- and (*R*)-$^3$KP* vs Thd concentration, we obtained quenching rate constants of $k_S = 3.6 \times 10^8$ M$^{-1}$ s$^{-1}$ and $k_R = 5.1 \times 10^8$ M$^{-1}$ s$^{-1}$ for (*S*)- and (*R*)-KP, respectively (Figure 8).

We have investigated the intramolecular version of this reaction in the *cisoid* (5′-KP-Thd) or *transoid* (3′-KP-Thd) dyads (Figure 9) where KP is attached to positions 5′ or 3′ of the 2-deoxyribose moiety.[30]

Long wavelength irradiation of the *transoid* form leads to polymerization. Conversely, a mixture of photoproducts is obtained from the *cisoid* isomer, where the oxetanes arising from a Paternò−Büchi reaction (Figure 10) are clearly predominating (combined yield of ca. 52%). In addition, minor

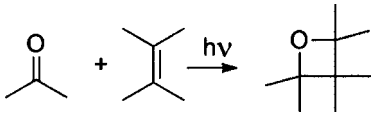


**FIGURE 6.** The Paternò−Büchi reaction.

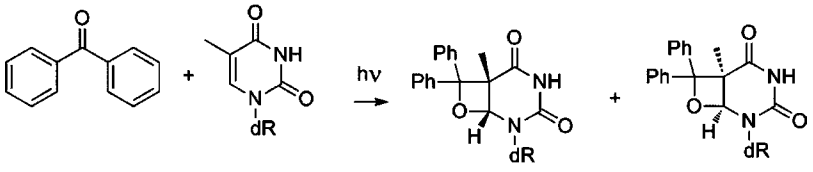


**FIGURE 7.** Oxetane formation upon irradiation of BP and Thd.

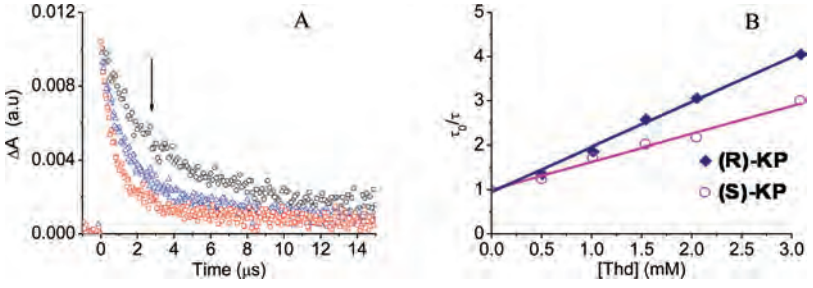


**FIGURE 8.** (A) Ketoprofen triplet excited state decay upon addition of increasing amounts of Thd using MeCN/$H_2O$ (4:1, v/v) as solvent and (B) Stern−Volmer plots for quenching of (*R*)- and (*S*)-$^3$KP* by Thd.

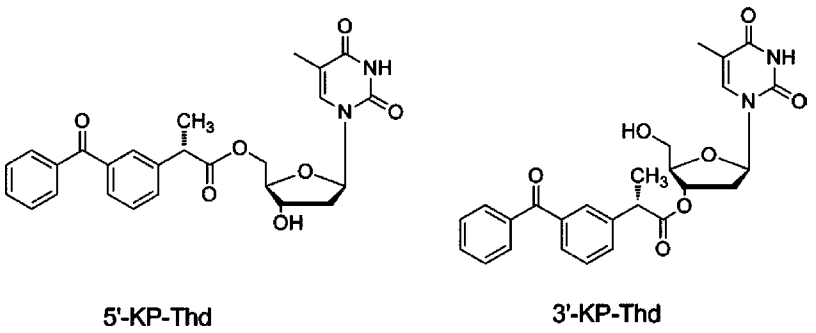


**FIGURE 9.** Ketoprofen–thymidine dyads.

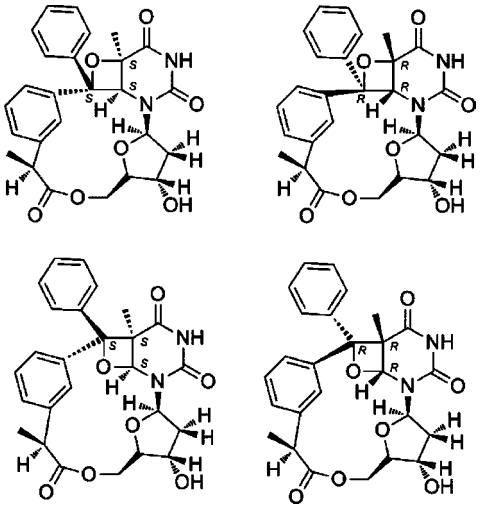

**FIGURE 10.** Photoproducts isolated from irradiation of the *cisoid* 5′-KP-Thd dyad.

amounts of products resulting from initial hydrogen abstraction by the excited ketone from the 5-methyl group of Thy are also detected.

Our results showed a good correlation between the photoproduct yields and the LFP measurements. Thus, the transient absorption spectra of the dyads essentially coincide with the TT bands of (*S*)-KP, displaying two maxima centered at 330 and 530 nm (Figure 11). However, the triplet lifetimes of the reference compound, $\tau_T$((*S*)-KP) = 1.3 $\mu$s, and the dyads are strikingly different. This is particularly noteworthy in the case of the *cisoid* form whose $\tau_T$ is 20 ns, much shorter than the value obtained for the *transoid* isomer ($\tau_T$ = 300 ns, Figure 11).

## 4. Benzophenone-Photosensitized Type I Oxidation

In addition to its above-mentioned capability to photosensitize the formation of Thy lesions by TTET and Paternò–Büchi reaction, BP is also able to oxidize DNA. The ability of BP to photosensitize oxidatively generated DNA damage is extensively reported in the literature.[31−38] Most of the published work deals with an electron transfer mechanism triggered by BP in its triplet excited state. Indeed, the Rehm–Weller equation allows determination of free energy changes of −70 and −30 kJ mol$^{-1}$ for the reaction with 2′-deoxyguanosine (dGuo) and Thd, respectively.[12] Nonetheless, although $^3$BP* is in principle able to oxidize all nucleobases, a particular emphasis has been placed on dGuo, the nucleoside with the lowest oxidation potential. When BP is compared with a typical DNA type I photosensitizer, such as riboflavin, the latter exhibits a lower oxidizing ability, with free energy changes ca. 30 kJ mol$^{-1}$ more positive than BP.[16] Thus, both compounds mediate one-electron oxidation of guanine (and to a lesser extent adenine) in double-stranded DNA; however, thymine oxidation has only been reported for BP.[39]

**4.1. Reaction with Purine Bases: An Electron Transfer Mechanism.** Information on the primary processes involved in the interaction between excited BP and dGuo is provided by LFP studies. Thus, the decay kinetics of $^3$BP* (or its derivatives KP and KPGly, Figure 1) in the presence of dGuo demonstrates a high reactivity, with a bimolecular rate constant close to diffusion ($k_q > 10^9$ M$^{-1}$ s$^{-1}$).[13,40,41] Moreover, we have confirmed the electron transfer nature of the process by detection of ketyl radical (KPGly(H$^•$)), obtained by protonation of the initially formed KP radical anion, together with the neutral dGuo(−H)$^•$ radical (Figure 12).[40]

Our results revealed a stereodifferentiating interaction between enantiopure (*S*)- or (*R*)-KP triplet excited state and dGuo, for which we determined quenching rate constants of $k_S$(dGuo) = 1.00 × 10$^9$ M$^{-1}$ s$^{-1}$ and $k_R$(dGuo) = 1.23 × 10$^9$ M$^{-1}$ s$^{-1}$ in aqueous acetonitrile. This agrees well with the relative amounts of (*R*)- and (*S*)-KP ketyl radical formation (Figure 13).

Steady-state irradiation studies also point to a type I mechanism. As a first clue, the hallmark of an electron transfer process is observed in double-stranded oligonucleotides

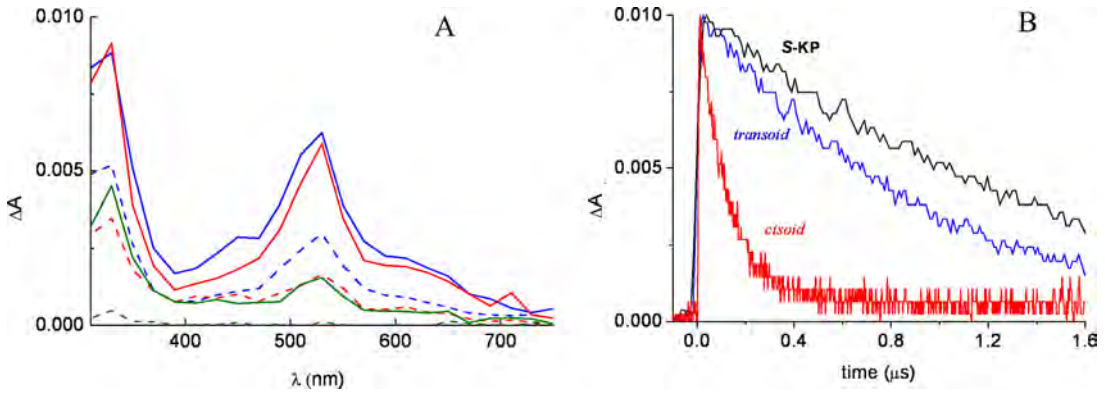


**FIGURE 11.** (A) Transient absorption spectra of the dyads and (*S*)-KP in acetonitrile, 35 ns (full line) and 2 $\mu$s (dashed line) after laser excitation and (B) triplet excited states of (*S*)-KP and the *cisoid* (3′-KP-Thd) and *transoid* (5′-KP-Thd) dyads.

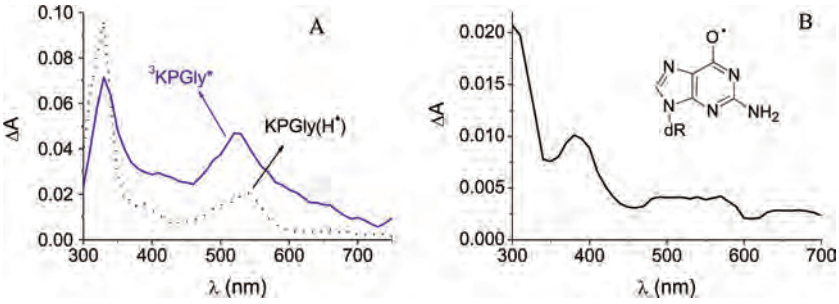


**FIGURE 12.** (A) Benzophenone-like triplet excited state (full line) and ketyl radical (dotted line) together with (B) dGuo(−H)• radical obtained by laser flash photolysis of KPGly/dGuo mixture in neutral aqueous medium (phosphate buffer).

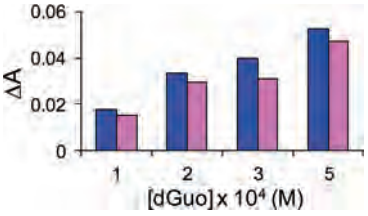


**FIGURE 13.** Comparison of the amount of ketyl radical formed after flash excitation of a solution of enantiopure (*S*)-KP (pink) or (*R*)-KP (blue) in the presence of dGuo, using MeCN/$H_2O$ (4:1, v/v) as solvent.

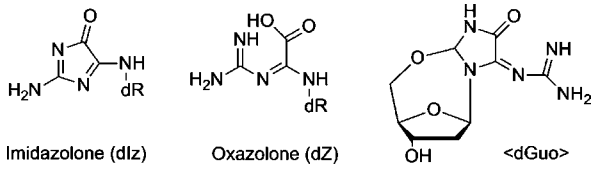


**FIGURE 14.** Structures of imidazolone and oxazolone, the typical product for BP-photosensitized type I oxidation of dGuo, together with the intrabase product <dGuo>.

irradiated in the presence of BP. Gel sequencing experiments show a highly specific alkali-labile site at the hot spot 5′-G of -GG- and in the middle G of -GGG- sequences.[12,36,42] Moreover, prolonged irradiation leads to degradation of all G residues, with efficiency decreasing in the order 5′-GG > 5′-GA > 5′-GC > 5′-GT, in good agreement with the calculated ionization potentials of stacked nucleobase models.[12] The capability of BP to act as a strong electron acceptor has been exploited to attach covalently this chromophore to predetermined sites of oligodeoxynucleotides, without perturbing the base stack, in order to investigate hole migration to remote sites.[42] This principle can be applied to the development of new probes for the study of electron transport in DNA.

In the case of isolated dGuo, typical photoproducts derived from electron transfer from the nucleobase to $^3$BP* are mainly obtained. They correspond to the unstable 2-amino-5-[(2-deoxy-$\beta$-D-*erythro*-pentofuranosyl)amino]-4*H*-imidazol-4-one (dIz), which is further hydrolyzed to 2,2-diamino-4-[(2-deoxy-$\beta$-D-*erythro*-pentofuranosyl)amino]-5(2*H*)-oxazolone (dZ) (Figure 14).[41,43−46] Interestingly, we also obtained photoproduct <dGuo> based on an intrabase link as a result of a primary electron transfer, followed by nucleophilic attack by the 5′ hydroxyl group to the C8 position of the nucleobase (Figure 14).[47]

In similar studies on the dinucleotide thymidylyl-(3′→5′)-2′-deoxyguanosine (TpdG), we described the corresponding oxazolone product (TpdZ) as the main photoproduct,

together with a 2-deoxy-D-ribono-1,4-lactone derivative TpdL.[48] This sugar oxidation, also reported in the case of dGuo, is of special interest because it leads to the formation of an oxidized abasic site. The proposed mechanism is based on electron transfer oxidation of the nucleobase, followed by deprotonation at C1′ of the guanine radical cation giving rise to a neutral radical, which after oxygen trapping, release of superoxide radical anion, and hydration of the resulting 2-deoxyribose cation gives rise to 2-deoxy-D-ribono-1,4-lactone (dL) (Figure 15).[49] However, direct hydrogen abstraction cannot be totally discarded as initial step. Mechanistic confirmation has been provided by combining photoproduct characterization and time-resolved experiments with appropriate model systems.

Thus, the KP−purine dyads shown in Figure 16 have been first considered.[50] Their structural variations have allowed us to evaluate the different factors influencing the electron transfer mechanism. In this way, changes associated with the *cisoid* versus *transoid* spatial arrangement have been investigated with dyads 5′-KP-dAdo and 3′-KP-dAdo respectively, while compounds 5′-KP-dGuo, 5′-KP-dAdo, and 5′-KP-8-oxodAdo have been chosen to obtain information on the relative base reactivity. In addition, the length of the spacer has also been considered by comparing 5′-KP-dAdo with 5′-KPGly-dAdo. The experimental results fulfilled our expectations for an electron transfer from the purine to $^3$KP*. As a first piece of evidence, only *cisoid* 5′-KP-purines lead to the formation of a 2-deoxyribonolactone (5′-KP-dL, Figure 16) as major photoproduct. Accordingly, while triplet lifetime of the *transoid* 3′-KP-dAdo is similar to that of isolated KP, used as standard, a much faster decay is observed for 5′-KP-dAdo. In general, we determined lifetimes in submicrosecond range for all the 5′-KP-purines in agreement with an efficient interaction between the excited KP and the nucleobase. As a matter of fact, the intramolecular quenching rate constants, ranging from $3.3 \times 10^7$ s$^{-1}$ for 5′-KP-dAdo to $1.1 \times 10^8$ s$^{-1}$ for 5′-KP-dGuo, correlate well with the one-electron oxidation potentials of nucleobases. Additional evidence is provided by the influence of the spacer length, which results in a markedly lower reaction rate constant for 5′-KPGly-dAdo (ca. $2.2 \times 10^6$ s$^{-1}$) than for 5′-KP-dAdo.

The behavior of diastereoisomeric (*S*,*S*)- and (*S*,*R*)-KP-THF conjugates bearing tetrahydrofuran as a base-free model of the 2-deoxyribose moiety (Figure 17) allowed us to rule out the possibility of a direct H-abstraction from the sugar at C1′.[51] Kinetic analysis of the transient absorption spectra reveals that the (*S*,*S*)-KP-THF triplet signal decays

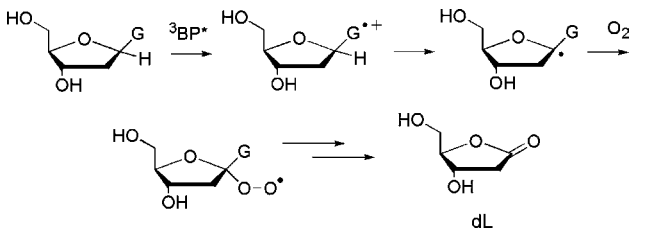


**FIGURE 15.** Mechanism of 2-deoxyribonolactone (dL) formation.

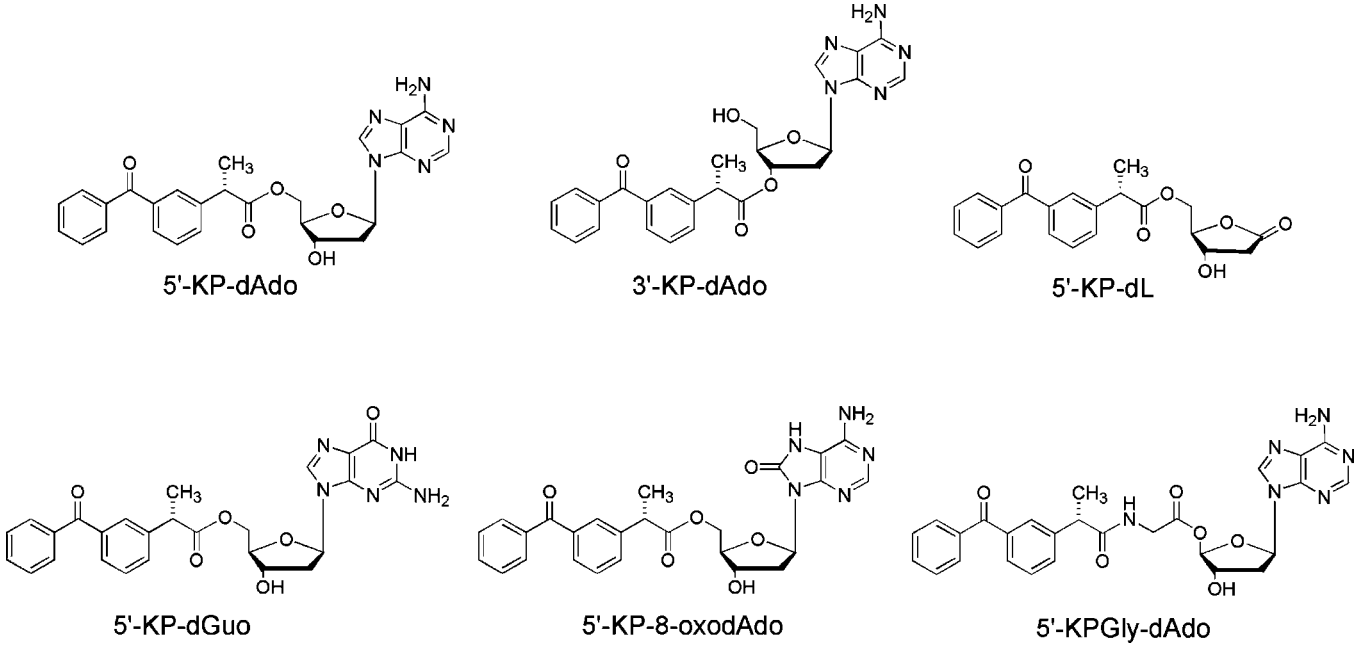


**FIGURE 16.** Structure of KP−purine dyads and 5′-KP-dL.

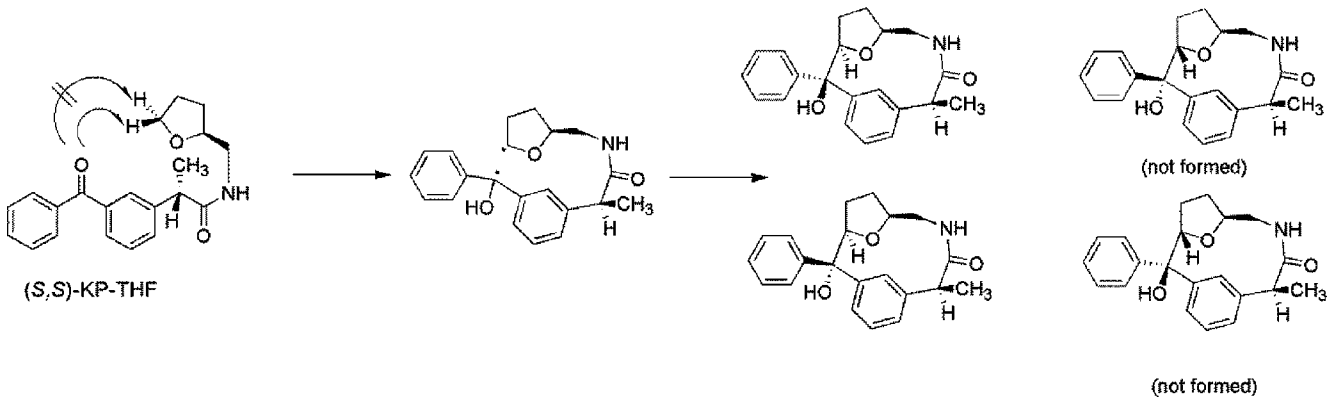


**FIGURE 17.** Structure and reactivity of the (*S,S*)-KP-THF.

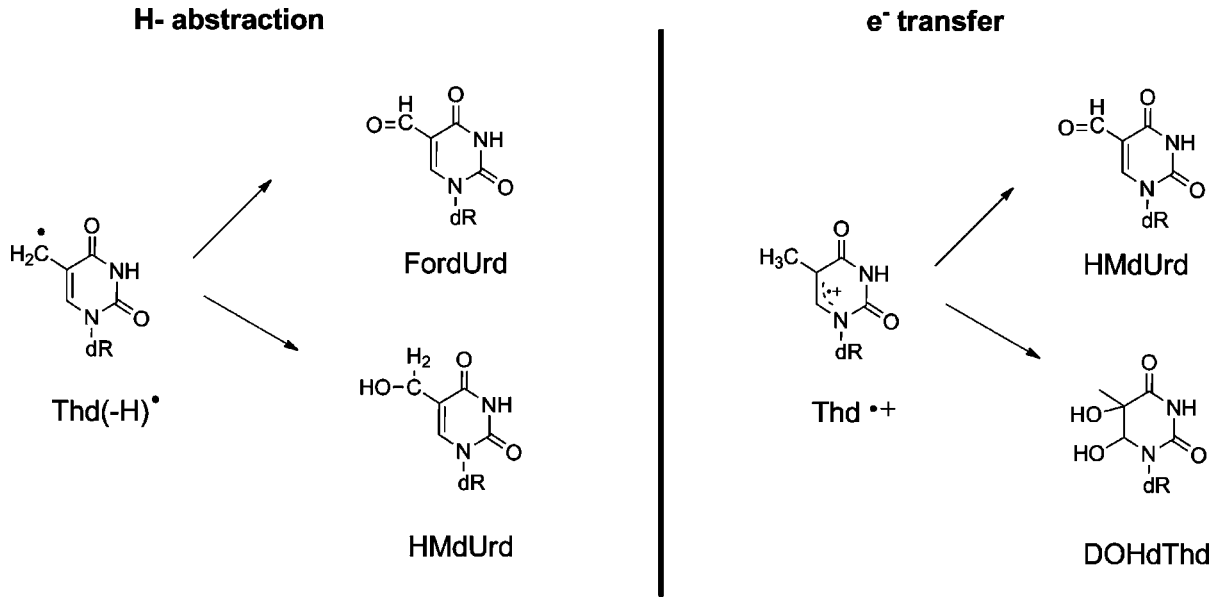


**FIGURE 18.** Photooxidation of Thd by BP.

significantly faster than that of the (*S,R*)-isomer. Moreover, the reaction rate constants of 5.9 and 3.2 $\times$ $10^5$ $s^{-1}$ are at least 2 orders of magnitude lower than for the 5′-KP−purine dyads. This demonstrates that a different primary process is involved in the photochemistry of these two types of systems. We have obtained the same conclusion from photoproduct studies, where biradicals initially formed via remote hydrogen abstraction undergo intramolecular recombination to macrocyclic ring systems with high regio- and stereoselectivity (Figure 17). In all cases, the products with *cisoid* ring junction are preferentially or even exclusively obtained, in agreement with their smaller ring strain.

Altogether our results are consistent with the predominance of an electron transfer mechanism during the BP-photosensitized oxidation of purine nucleosides to dL as detailed in Figure 15.

**4.2. Reaction with Pyrimidine Bases: One-Electron Oxidation, H-Abstraction and Intrabase Cross-Link.** In addition to the Paternò−Büchi photoreaction and the TTET between $^3$BP* and Thd, oxidation of Thd may occur as a secondary reaction, given the ability of the chromophore to abstract hydrogen or to participate in electron transfer processes.[10,45] We have studied this photoreaction in aerated medium and identified the products as 5,6-dihydroxy-5,6-dihydrothymidine diastereomers (DOHdThd), 5-(hydroxymethyl)-2′-uridine (HMdUrd) and 5-formyl-2′-deoxyuridine (FordUrd) (Figure 18). Formation of a neutral radical centered on the 5-methyl of Thd after a formal H-abstraction by the excited ketone or deprotonation of thymine radical

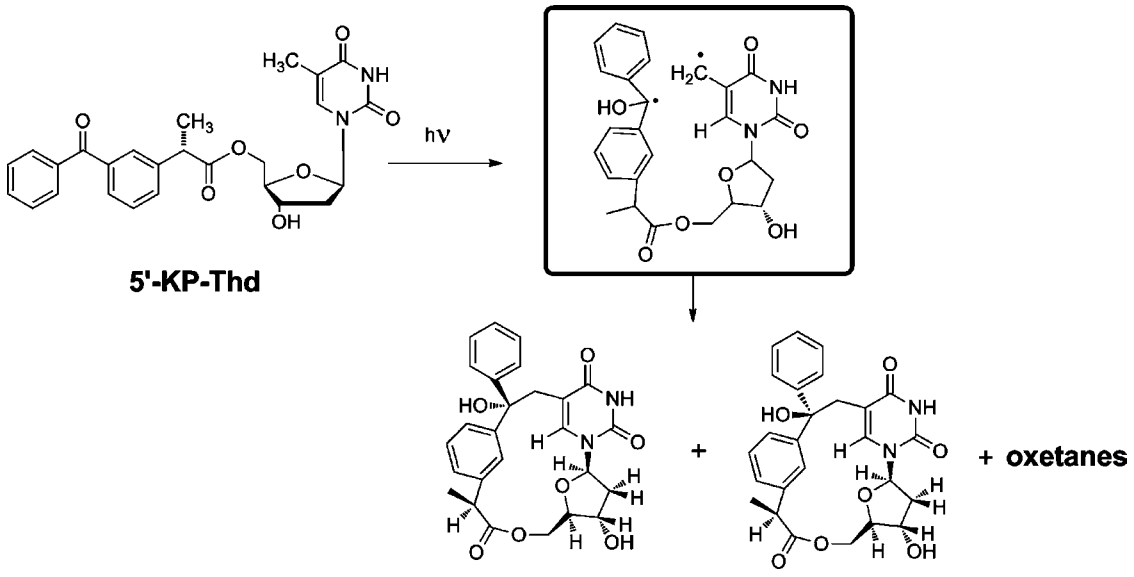


**FIGURE 19.** Hydrogen abstraction in the photoreaction of the *cisoid* 5′-KP-ThdKP-BP dyad.

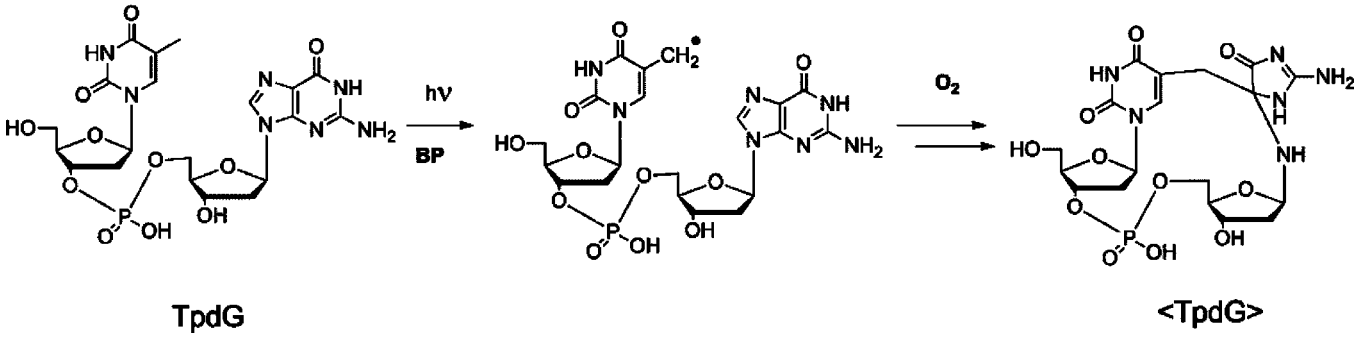


**FIGURE 20.** Photosensitization of TpdG by BP under aerated conditions.

cation at the methyl group leads to FordUrd and HMdUrd, while DOHdThd arises from hydration of Thd radical cation. The former pathway is in agreement with LFP results, while the presence of the four DOHdThd diastereomers in the reaction mixture supports the formation of Thd radical cation.

We have observed hydrogen abstraction at the C-5 of the base by $^3$BP* upon irradiation of the *cisoid* KP-Thd dyad presented in the TTET (section 3.1), which leads to a couple of minor products (14% combined yield, Figure 19) arising from recombination of a primary biradical.[30]

Type I reactions induced by BP have also been assessed in TpdG dinucleotides.[45] In our hands, photosensitization of TpdG in the presence of BP leads to formation of an adduct (<TpdG>, Figure 20) resulting from formal hydrogen abstraction at the C-5 of the Thy base by $^3$BP*. Generation of a carbon-centered radical would be the first step in a sequence of reactions ultimately producing a covalent linkage to the C-4 of the guanine.

**4.3. Modeling DNA−Protein Cross-Links.** In eukaryotic cells, DNA−protein cross-links are important contributors to the deleterious effects of solar radiation, because of the close contact between DNA and proteins such as histones. Thus, the role of type I oxidation in the formation of these adducts has been investigated using BP as photosensitizer and dGuo as a simple unit of the DNA biomolecule.

In this context, BP-photosensitized reaction between dGuo and the methyl ester of acetylated lysine leads to the spiroiminodihydantoin derivative 8-Lys-Sp as the main photoproduct, together with small amounts of 5,8-Lys-Sp (Figure 21A).[52] These compounds are the result of an electron transfer process leading to covalent adduct formation between the $\varepsilon$-amino group of lysine and the C8 position of the nucleobase, which further undergoes rearrangement to give the spirocyclic adducts. We have also used methanol as a mimic of the hydroxyl group of tyrosine, threonine, or serine side chain. In this case, two 4,5-imidazolidinedione diastereoisomers are obtained as

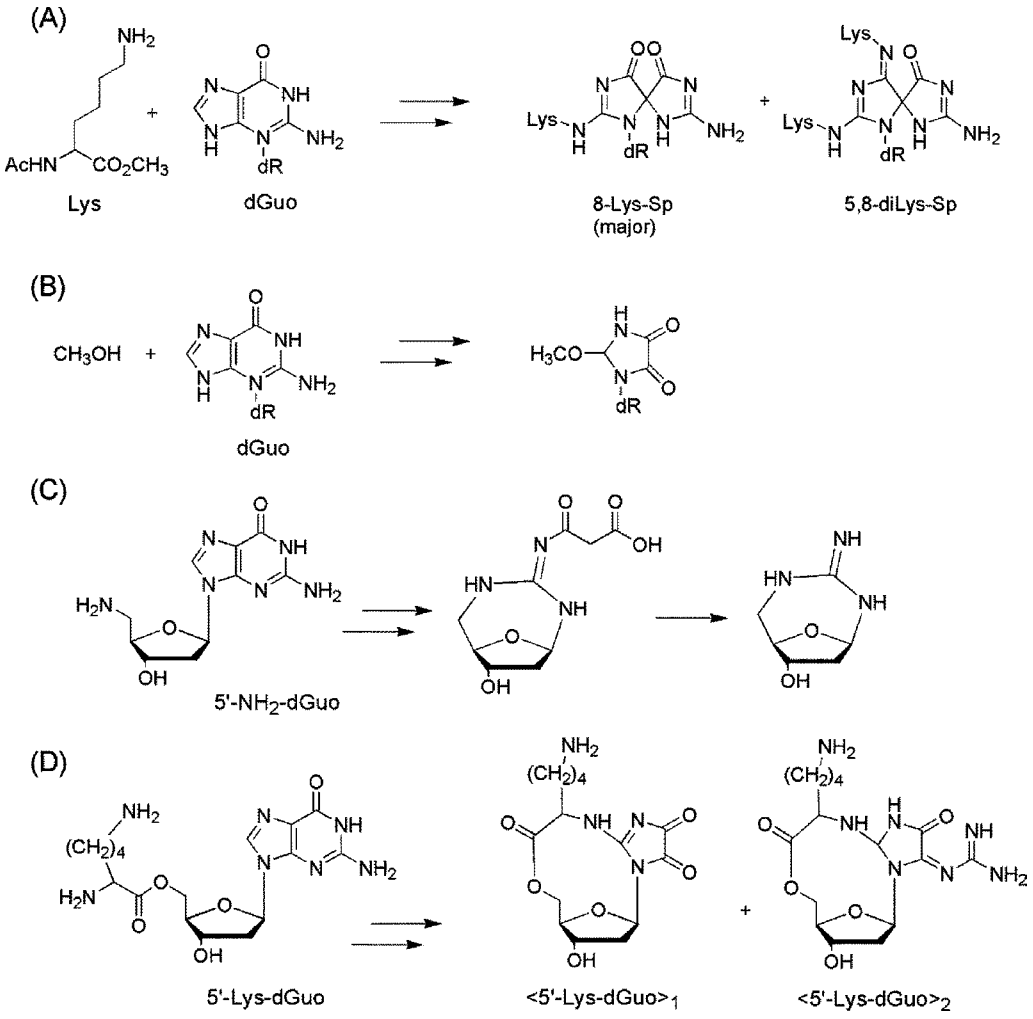


**FIGURE 21.** Model photoreactions for the BP-sensitized DNA–protein cross-links.

products of the nucleophilic addition of methanol to the guanine base (Figure 21B).[44]

Furthermore, we have modeled the intimate association between DNA and histones using different systems containing an amino group or a lysine residue tethered at the C5′ of dGuo. Thus, BP mediated oxidation of 2′-amino-2′,5′-dideoxyguanosine (5′-$NH_2$-dGuo, Figure 21C)[53] in aerated aqueous solution leads to the formation of two cyclic nucleosides, where the heterocyclic guanine ring is missing (Figure 21C). In the case of a lysine residue linked at C5′ of dGuo (5′-Lys-dGuo, Figure 21D), two intramolecular adducts are formed in low yield (ca. 2%).[54] Although both compounds derive from a reaction between the α-$NH_2$ of lysine and the C8 position of electron transfer oxidized guanine, <5′-Lys-dGuo>$_1$ would be formed by a nucleophilic attack to the guanine radical cation, whereas <5′-Lys-dGuo>$_2$ can be explained by addition of the α-$NH_2$ group to the 7,8-double bond of the neutral dGuo radical.

## 5. Type II Processes: Singlet Oxygen

A photosensitizer in its triplet excited state may interact with molecular oxygen, generating $^1O_2$, which is a very potent oxidizing agent. This is the case for BP and KP; they produce $^1O_2$, which in turn reacts with guanine yielding spiroiminodihydantoin diastereoisomers or 8-oxodGuo, in double stranded DNA (Figure 22). The ability of this reactive species to photoinduce DNA lesions through a type II mechanism has been examined in aqueous solutions, in the presence of single-stranded oligonucleotides. When $D_2O$ is used instead of $H_2O$, the BP-photosensitized DNA damage increases, indicating that, to a certain extent, a type II mechanism is involved.[12]

Nevertheless, dGuo sensitization studies indicate that BP-mediated photooxidation is dominated by the type I mechanism.[41,45] Consistently, dGuo conversion upon UVA irradiation in the presence of BP is not affected by the presence of $D_2O$ and is lower in aerated solution.

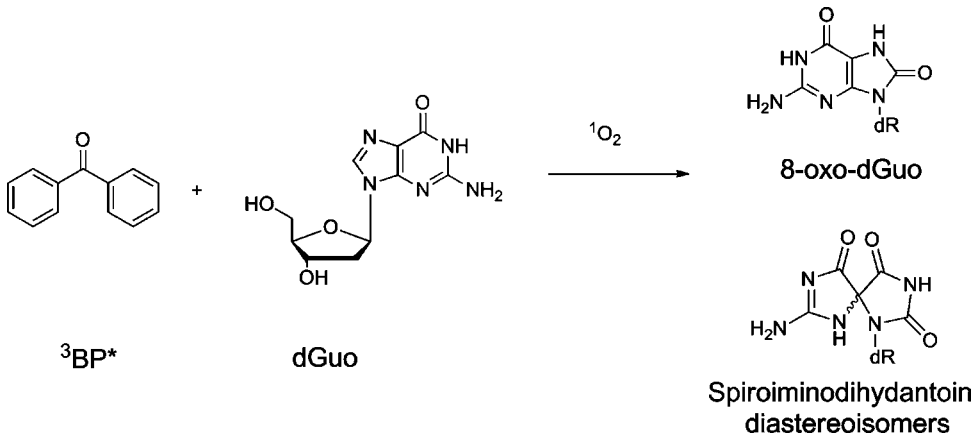


**FIGURE 22.** Type II photooxidation of dGuo by BP.

## 6. Summary and Outlook

Light is a potentially carcinogenic agent. For this reason, it is of paramount importance to understand the mechanisms involved in photoinduced DNA damage, in order to develop efficient photoprotection strategies. Ultraviolet radiation can interact with the biomacromolecule by direct light absorption or through photosensitization by endogenous or exogeneous chromophores, which extend the "active" fraction of the solar spectrum to the UVA and beyond. As a consequence, photosensitizers increase the risk of developing skin cancer upon exposure to sunlight. Photosensitized DNA damage may occur through processes comprising electron transfer, hydrogen abstraction, triplet–triplet energy transfer, or reactive oxygen species generation.

Here, we have chosen benzophenone (BP) as a classical and paradigmatic chromophore to illustrate the different lesions that photosensitizers may provoke in systems of increasing complexity: nucleosides, oligonucleotides, or DNA itself. Thus, we provide detailed mechanistic information on the main photoinduced reactions of DNA mediated by BP. Related derivatives like ketoprofen (KP), a BP-like compound that possesses a chiral center, have been included to highlight the possibility of stereodifferentiation. In this context, irradiation of the BP chromophore in the presence of DNA or its building blocks leads to nucleobase oxidations, cyclobutane pyrimidine dimers formation, single strand breaks, DNA–protein cross-links or abasic sites. The manifold photoreactivity of BP is attributed to its well established photophysical properties: (i) it absorbs UV light, up to 360 nm, (ii) its intersystem crossing quantum yield ($\phi_{ISC}$) is near 1, (iii) the energy of its n$\pi^*$ lowest triplet excited state ($E_T$) is ca. 290 kJ mol$^{-1}$, and (iv) it produces singlet oxygen ($^1O_2$) with a quantum yield ($\phi_\Delta$) of ca. 0.3. When these properties of BP are compared with those of riboflavin, a well-known DNA photosensitizer, the main difference is related to the much lower triplet energy value of the latter (ca. 200 kJ mol$^{-1}$). Accordingly, excited riboflavin is a markedly weaker oxidizing agent and is unable to act as donor in triplet–triplet energy transfer to thymine.

Electron transfer, hydrogen abstraction, and singlet oxygen reactions have been discussed centering attention on guanine, since this is the nucleobase with the lowest oxidation potential. Among oxidative processes, electron transfer is the predominating pathway. Conversely, triplet–triplet energy transfer occurs mainly from $^3$BP* to thymine, the base with the lowest lying triplet state in DNA. This process results in the formation of cyclobutane pyrimidine dimers, although it competes with the Paternò–Büchi reaction in nucleobases or nucleosides, giving rise to oxetanes as a result of crossed cycloadditions.

In summary, we have presented key insight into the diverse mechanistic pathways of the biologically relevant DNA modifications photosensitized by BP. On the basis of the accumulated experimental data, this chromophore shows potential as a probe for the investigation of electron and triplet energy transport in DNA. The introduction of a chiral center, as in KP, provides a useful tool to examine stereochemical aspects of the involved processes.

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BIOGRAPHICAL INFORMATION

**M. Consuelo Cuquerella** obtained her Ph.D. from the Technical University of Valencia at the Institute of Chemical Technology

(UPV-CSIC) studying the oxidative DNA damage induced by fluoroquinolones. In June 2004, she moved to the Department of Physics of the University of Liverpool as a postdoctoral fellow. Back to Spain in 2007, she was granted a Juan de la Cierva contract at the University of Valencia. Since 2009, she has been a member of Prof. Miranda's group as a JAE-Doc researcher and her work is mainly focused in the investigation of photoinduced damage to DNA.

**Virginie Lhiaubet-Vallet** graduated in 1997 and obtained her PhD degree in 2001 from the University Paul Sabatier (France), working on DNA damage photoinduced by nonsteroidal anti-inflammatory drugs. She then joined the group of Prof. M. A. Miranda at the Institute of Chemical Technology (UPV-CSIC) as a postdoctoral researcher benefiting from an Individual Marie Curie European Fellowship. Virginie Lhiaubet-Vallet received the Young Investigator Award from the European Society for Photobiology in 2007. Since 2008, she has been a "Ramón y Cajal" Researcher from Spanish National Research Council at the Institute of Chemical Technology.

**Jean Cadet** received his Ph.D. in chemistry from the University of Grenoble in 1973 and has been the Head of Laboratory of "Lésions des Acides Nucléiques" at the French Atomic Energy Commission, CEA/Grenoble, until 2001. He is currently Scientific Adviser at CEA/Grenoble and Adjunct Professor at University of Sherbrooke. He is involved in research activities on various aspects of the chemistry and biochemistry of oxidatively generated and photoinduced damage to DNA (mechanisms of reactions, measurement in cells, assessment of biological features, such as substrate specificity of DNA repair enzymes, and mutagenesis of base lesions). He has received several awards including Research Award from American Society for Photobiology, the medal of Excellence from European Society for Photobiology, the Charles Dhéré Award, and Berthelot Medal from the French Academy of Sciences.

**Miguel A. Miranda** is Professor of Organic Chemistry at the Polytechnical University of Valencia and Head of the Institute of Chemical Technology (UPV-CSIC). He was Associate Professor at the University of Valencia before accepting his present position in 1990. His research interests are mainly focused on photochemistry and photobiology. Miguel A. Miranda has received the Honda-Fujishima Award of the Japanese Photochemistry Association, the Organic Chemistry Award of the Spanish Royal Society of Chemistry, and the Theodor Förster Award of the German Chemical Society and the Bunsen Society of Physical Chemistry. He has been the President of the European Society for Photobiology from 2009 to 2011.

## FOOTNOTES

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The authors declare no competing financial interest.

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Re: Letter of support

Aloha Hawaii State Legislature,

Hanauma Bay Snorkel Adventures and Koko Beach Rentals support Bill 366 and House Bill 102, amending Act 104 to stop using avobenzone, and especially octocrylene in sunscreen.

We believe that , Hawaii State Legislature and Hawaii's leadership can take an important step to marine conservation and coral reef preservation by banning this toxic chemicals from sunscreen products. The studies in the effects of these toxic chemicals to marine life including corals has been shown to be alarming, threatens the conservation and restoration of coral reefs.

We all need to do our part to preserve and protect our Hawaii's ocean and the marine life, and we strongly support the need for HB102 and SB366

Mahalo for the opportunity to testify on behalf of Hawaii's coral reefs!

Sincerely

Florin Moisan Nica
President
Hanauma Bay Snorkel Adventures
Co-Founder
Koko Beach Rentals

P.O. BOX 25354 • HONOLULU, HI 96825
PHONE: (808) 306-3393 • EMAIL: ADMIN@HANAUMABAYSNORKEL.COM
WWW.HANAUMABAYSNORKEL.COM


**To: The Committee on Agriculture and the Environment (AEN)**

Senator Mike Gabbard, Chair
Senator Clarence Nishihara, Vice Chair

**Re: SB132 RELATING TO WATER POLLUTION**

**Position: STRONG SUPPORT WITH AMENDMENT**

**Hearing Date: Wednesday, February 17, 2021 1 p.m. Via Videoconference**

Aloha Chair Gabbard, Vice Chair Nishihara, and Committee members,

The noted members of the Hawaii Coral Reef Stakeholders Hui, which includes eminent scientists from around the world, strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, but please retain the effective date of 1 January 2023.

We thank the Legislature for passing Act 104 in 2018 which provides for the world's first ban on sale or distribution for sale of sunscreens containing oxybenzone and octinoxate, effective January 2021. Oxybenzone and octinoxate are two of the most ubiquitous and harmful chemicals that threaten marine life around the world. The amended SB132 would build directly on Act 104 by adding two more ecotoxic petrochemicals to the list: octocrylene and avobenzone. In the interim since the passage of Act 104, we have learned that octocrylene and avobenzone are also harmful to marine life and human health and should also be kept out of our marine environment. As of February 2021, the U.S. Federal Drug Administration's database lists 2,223 sunscreen products containing octocrylene, and 2,329 containing avobenzone. Evolving science around the world clearly demonstrates that these ubiquitous and pervasive reef toxins irreversibly interfere with the life-cycles of Hawaii's foundational and endemic marine life including corals, algae, fish, shellfish, sea urchins and marine mammals.

Furthermore, long-term exposure to avobenzone and octocrylene has been found to be lethal for some organisms living in freshwater environments, and are considered dangerous for freshwater ecosystems. Avobenzone is the leading active ingredient in chemical sunscreens and can cause hormone disruptions. Octocrylene is also quickly metabolized into a mutagen called benzophenone which is regulated by the FDA and included in California's Prop 65 list of chemicals known to cause cancer or reproductive toxicity. And in February 2019, the U.S. Food and Drug Administration declared that it does not have sufficient scientific evidence that any of the organic UV filters in sunscreens including oxybenzone, octinoxate, octocrylene, and avobenzone are safe and effective for human use - never mind our marine ecosystems.

Additionally, the attached letters of support from eminent scientists from around the world urging the Hawai'i State Legislature to ban the sale of sunscreens containing octocrylene and avobenzone attest to the global dangers of these two chemicals, and

acknowledge Hawaii's ongoing leadership in prohibiting the sale of chemicals in sunscreen that have been known to be reef toxins for years.

It has been argued that banning sunscreens containing petrochemicals like avobenzone and octocrylene from the market would lead to additional skin cancers, because people therefore won't use any sunscreen. This false argument ignores the fact that there are ample safer alternatives available on the market containing the active ingredient minerals zinc oxide or titanium dioxide.

Sunscreen preparations were designed to protect against sunburn and because of this they are assumed to protect against skin cancer, but unfortunately this relationship is inferential only[1]. There are no definitive studies that demonstrate that sunscreens protect against skin cancers as evidenced by research published by the World Health Organization, US Environmental Protection Agency and dermatologist alike[2-4].

The argument also ignores what the World Health Organization has called "sunscreen abuse." Petrochemical sunscreens are often not applied sufficiently or frequently enough, and wash off in water, so may not actually protect as much as people are led to believe. A false sense of protection against both UVB and UVA pathologies[5] may cause people to spend more time in the sun. This additional exposure to the sun, or "sunscreen abuse," increases the risk of melanoma and may cause MORE skin cancers.

The best course is to avoid the mid-day sun, but if you will be in the sun, wear a protective hat and clothing and sunscreens with zinc oxide or titanium dioxide. This is much better course for both public health and our fragile marine environments than using a petrochemical sunscreen that washes off in water and kills corals and other marine life, gets absorbed into your bloodstream, and may disrupt your hormones, potentially causing more cancers.

Approximately one-fourth of the plants, fish, and invertebrates found in Hawaiian coral reefs are endemic to Hawaii. Coral reefs are intrinsic to Hawaiian culture, and fundamental to the fabric of our local communities. They provide critical habitat for near shore marine life, and natural protection against coastal erosion and sea level rise - ecosystem services worth billions of dollars. Further, our coral reefs underpin tourism, Hawaii's primary economic engine. It is therefore critical to eliminate as many existential threats to our marine ecosystems as possible, like these additional reef-toxic chemicals, to ensure our reefs can both survive and thrive for future generations.

The need for an amended SB132 is obvious and critical, and we strongly urge you to support its passage.

Mahalo for the opportunity to testify on behalf of Hawaii's coral reefs!

Sincerely,

Coral Reef Stakeholders Hui:

Melodie R. Aduja
Alan B. Burdick
Co-chairs
Environmental Caucus of the
Democratic Party of Hawaii

Ted Bohlen
Hawaii Reef and Ocean Coalition

Cindi Punihaole
Director Kahalu`u Bay Education Center
The Kohala Center

Mendy Dant
Executive Vice President
Fair Wind Cruises

Lisa Bishop
President
Friends of Hanauma Bay

Craig Downs, Ph.D.
Executive Director
Haereticus Environmental Laboratory

Maxx Phillips
Hawai'i Director
Center for Biological Diversity

William T. White, III
President, Wailea Property Owners
Association

Bill Coney
Dr. Susanne Otero
Co-Founders
Legacy Reef Foundation

Pat B. Lindquist
President
Napili Bay and Beach Foundation

Rene Umberger
Executive Director
For the Fishes

Jamie Lung Ka'eo
General Manager
Hale Napili

Ken Staples
Director of Hawai'i Operations
Ocean Defenders Alliance

Ka`imi Kaupiko
Executive Director
Kalanihale

Mike Nakachi
President
Moana Ohana

Caren Loebel-Fried
Artist, Illustrator, Author

Sue Aronson
Owner
Kona Coast Realty Corp.

Kealoha Pisciotta
Founder
Kai Palaoa

Ryan Scalf and Christy Johnson
Co-Owners
Nudi Wear

Ray Hollowell
Founder
Sea Inspiration

Christine Zalewski, Ph.D.
Founder
Silver Spiral Seas, LLC

Matt Zimmerman
Owner
Island Divers Hawaii and Honolulu Scuba Company

Jeannie Jewell
President
Destination Kona Coast
Owner, Kona Glass Bottom Boat

Scott Head
Vice President of Resort Operations
Waikoloa Beach Resort

Marcio Lira
Florin Mosanica
Co-Founders
Koko Beach Rentals

Marcio Lira
Owner
Kaimana Tours

Caroline Duell
CEO
All Good

Brian A. Guadagno
Founder
Raw Elements USA

Elizabeth Reilly
Founder/President
Livable Hawaii Kai Hui

Wilkie McClaren
Safe Sunscreen Coalition

Lauren Blickley
Hawai‘i Regional Manager
Surfrider Foundation

Rick Gaffney
President
Hawaii Fishing & Boating Association

Florin Nica
Owner
Hanauma Bay Snorkel Adventures

Iris Kahaulelio
Aloha Surfing Ohana

Michael Koenigs
Founder
Little Hands Hawai’i

| Reference | Conclusion |
|---|---|
| 1) Emmett. Ultraviolet radiation as a cause of skin tumors. CRC Crit Rev Toxicol. **1973**;2(2):211-55. | "The preparations are all designed to protect against the acute effects of ultraviolet, namely sunburn. Because of their effectiveness in this regard, they are often assumed to protect against ultraviolet carcinogenesis. In most cases, however, there is little or no published evidence that they do so and the relationship is inferential." |
| 2) World Health Organization - Vainio et al. An international evaluation of the cancer-preventive potential of sunscreens. Int J Cancer. **2000**;88(5):838-42. | "… the topical use of sunscreens reduces the risk of sunburn in humans and that sunscreens probably prevent squamous-cell carcinoma of the skin when used mainly during unintentional sun exposure. No conclusion can be drawn about the cancer-preventive activity of topical use of sunscreens against basal-cell carcinoma and cutaneous melanoma |
| 3) Environmental Protection Agency: Sunscreen the burning facts **2006**. Is sunscreen fail-safe (pg6). www.epa.gov | "Although a sunscreen with an SPF of 15 or higher offers protection from sunburn, it does not block all of the sun's damaging rays. In fact, there is no evidence that sunscreens protect you from malignant melanoma, the deadliest form of skin cancer, even though sunburns have been linked with the development of melanoma." |
| 4) Waldman et al. The role of sunscreen in the prevention of cutaneous melanoma and nonmelanoma skin cancer. J Am Acad Dermatol. **2019** Feb;80(2):574-576. | "Could it be that the nearly universal recommendation of dermatologists and professional societies to use sunscreen to prevent skin cancer is unfounded?" |
| 5) World Health Organization - Autier P. Sunscreen abuse for intentional sun exposure. British Journal of Dermatology 2009 161 (Suppl. 3), pp40–45 | "The increased duration could be the reason why melanoma risk is increased when sunscreen is used. Hence, sunscreen abuse may extend sun exposure duration thus allowing sun exposure behaviours that would not be possible otherwise." |

Chamber of Commerce HAWAII
*The Voice of Business*

**Testimony to the Senate Committee on Agriculture and Environment**
**Wednesday, February 17, 2021 at 1:00 P.M.**
**Via Videoconference**

**RE: SB 132, RELATING TO WATER POLLUTION**

Chair Gabbard, Vice-Chair Nishihara, and Members of the Committee:

The Chamber of Commerce Hawaii ("The Chamber") **opposes** SB 132 which bans the sale, offer of sale, or distribution in the State of any sunscreen that contains homosalate, octocrylene, or octisalate without a prescription issued by a licensed healthcare provider.

The Chamber is Hawaii's leading statewide business advocacy organization, representing about 2,000+ businesses. Approximately 80% of our members are small businesses with less than 20 employees. As the "Voice of Business" in Hawaii, the organization works on behalf of members and the entire business community to improve the state's economic climate and to foster positive action on issues of common concern.

This measure is too premature to impose a ban on ingredients used in day-to-day sunscreen products already approved by the FDA. The ban of certain ingredients will eliminate the sale of up to 64% of FDA approved sunscreen products already out in the market which will unnecessarily place the risk of public health by way of increased health related costs to treat skin cancer, UV damage, and melanoma.

One unintended consequence, amongst others, is that people often will not take time off from work, pay a co-payment to see a doctor and then wait in the pharmacy to a get a prescription filled for "sunscreen."

Thank you for this opportunity to provide testimony and ask that the committee hold this measure.

733 Bishop Street, Suite 1200 • Honolulu, Hawaii 96813 • Phone: (808) 545-4300 • Facsimile: (808) 545-4369

TO:
Senate Committee on Agriculture and Environment
Senator Mike Gabbard, Chair
Senator Clarence K. Nishihara, Vice Chair

FROM:
Lynn Miyahira representing Public Access to SunScreens (PASS) Coalition

DATE: Wednesday, February 17, 2021
TIME: 1:00 PM
PLACE: Via Videoconference

Re: SB 132 - Relating to Water Pollution

Position: Opposed

The Public Access to SunScreens (PASS) Coalition is a multi-stakeholder coalition composed of public health groups, dermatologists, sunscreen manufacturers, and leading advocates for skin cancer patients. The PASS Coalition opposes this measure as it will create additional barriers for consumers to access their choice of safe, effective and FDA-approved sunscreens as a skin cancer prevention tool.

**We ask that the legislature hold off on passing SB 132 or any other legislation on sunscreen ingredients, until more data on environmental and public health impacts are available.**

The use of sunscreen is an important evidence-based sun-safe practice. It is well known that utilizing comprehensive sun-safe practices is one of the most effective ways to reduce the risk of skin cancer, including the regular use of sunscreen, wearing sun protective clothing, hats and sunglasses, and seeking shade. Skin cancer prevention tools, such as broad-spectrum sunscreens that protect against both UVA and UVB rays, must be combined with comprehensive educational tools to ensure consumer awareness of the risks of skin cancer due to excessive sun exposure.

**Hawaii Residents Are at Higher Risk for Skin Cancer**

Some notable skin cancer and sun safety behavioral statistics include:

- Native Hawaiians and other Pacific Islanders suffer from double the melanoma mortality rate than the State average[i]
- In 2018, more than one in three Hawaii residents surveyed reported having a sunburn in the last 12 months, nearly double from the previous year[ii] – and having just five or more sunburns in your lifetime is known to double your risk for melanoma[iii]

- Researchers have found that just *one* blistering sunburn in childhood or adolescence more than doubles a person's chance of developing melanoma later in life[iv]
- Hawaii has one of the highest daily UV index averages in the nation[v] making protecting residents from sun exposure a crucial public health issue

**Science Touted by Sunscreen Ban Advocates Is Flawed**

Despite the known risk of skin cancer, Hawaii and a handful of other jurisdictions have placed restrictions on the sale of sunscreens based on limited laboratory testing that led policymakers to believe banning sunscreen would improve coral reef health. The early studies, however, did not fully consider the complexity of a coral reef system and had scientific limitations. Importantly, findings from a 2019 study by Dr. Carys Mitchelmore of the University of Maryland contradicts an earlier study by Dr. Craig Downs that has been widely promoted by advocates of the sunscreen ban. Dr. Mitchelmore's study uses rigorous methodology and shows actual levels of oxybenzone sampled from sea water in Hawaii to be 141 times lower than previously stated by Dr. Downs, and 1,020 times below levels considered toxic to coral.[vi]

The limited studies that purported to show a link between sunscreen exposure and coral toxicity are methodologically flawed and should not be used for evidence-based policy making based on EPA data reliability standards. Subsequent follow-up studies with more rigorous analyses have not replicated the work by Dr. Downs, and do not support the conclusions.

**Congress Has Directed the National Academy of Sciences to Conduct a Comprehensive Study**

For that reason, banning sunscreen will have little impact on protecting coral reef. The overwhelming consensus amongst the scientific community is that coral decline is primarily caused by rising ocean temperature, ocean acidification, invasive species, land-based source pollution, water quality issues due to poor wastewater management and other causes. As a result, the United States Congress directed the National Academy of Sciences (NAS) to evaluate the latest science available on the correlation between coral reefs and sunscreens and the potential public health impact of limiting access to sunscreen.

This NAS study, titled "Environmental Impact of Currently Marketed Sunscreens and Potential Human Impact of Changes in Sunscreen Usage," will conduct an objective review of these issues by leading scientific experts. The project description is as follows:

> "Concerns have been raised about the potential toxicity of sunscreens to a variety of marine and freshwater aquatic organisms, particularly corals. At the same time, there are concerns that people will use less sunscreen rather than substituting sunscreens with UV filters that are considered environmentally safe. This study will review the state of science on use of currently marketed sunscreen ingredients, their fate and effects in aquatic environments, and the potential public health implications associated with changes in sunscreen usage."[vii]

This study, sponsored by the U.S. Environmental Protection Agency, will examine research concerning both the environmental and human health impacts of access to sunscreen. This independent study will evaluate the scientific merit of current science and identify gaps in our

current understanding of coral reef environmental health and human health risks of skin cancer. All NAS studies involve multiple strategies to reduce bias and to synthesize the best available science.

**NAS Study Should be Completed Before Legislators Make Further Decisions on Consumer Sunscreen Choice**

The conclusion of this NAS study – expected in 2022 – will inform future decisions of policymakers to ensure access to sunscreens while also protecting the coral reefs. Until this study is completed, legislation like SB 132 should be suspended as there are currently insufficient data to inform a risk/benefit analysis between protecting the marine environment and protecting the public's health. It is important that the legislature wait for unbiased scientific analysis and consensus.

**FDA Advises Continued Use of Sunscreens**

In addition to the lack of peer-reviewed evidence on the environmental impact of sunscreens, the impact on human health is also still being researched. The Food and Drug Administration (FDA), which regulates sunscreens as over-the-counter (OTC) drugs for the prevention of sunburn and skin cancer, recently posted an article titled, "Shedding More Light on Sunscreen Absorption" that explained that while the FDA is continuing to seek more information on the absorption levels of sunscreen ingredients, including avobenzone, oxybenzone, octocrylene, homosalate, octisalate, and octinoxate, it still advises their continued use. The FDA clearly stated, "Absorption does NOT equal risk – the FDA advises continued use of sunscreens" and noted that:

> "The findings in these studies do not mean that the FDA has concluded that any of the ingredients tested are unsafe for use in sunscreens, nor does the FDA seeking further information indicate such. The agency's proposed rule requested additional safety studies to fill in the current data gaps for these ingredients. The rule also proposed that two active ingredients (zinc oxide and titanium dioxide) are generally recognized as safe and effective for use in sunscreens, and additional data was not requested for them.
>
> Given the recognized public health benefits of sunscreen use, the FDA strongly advises all Americans to continue to use sunscreens in conjunction with other sun protective measures (such as protective clothing) as this important rulemaking effort moves forward."[viii]

The Hawaii state law signed in July 2018 already eliminated the OTC sale of the ingredients oxybenzone and octinoxate. **SB 132 would expand this ban to include the most utilized alternative sunscreen ingredients and could potentially remove approximately 64% of the sunscreens currently available in the United States from being sold in Hawaii.**

The proposed legislation could significantly reduce consumer choice of and access to sunscreen in Hawaii, where sunscreen is often used not only in the ocean, but whenever people are outdoors doing activities such as hiking, golfing, walking, running, cycling or working outside.

This puts Hawaii residents at greater risk for skin cancer with only limited peer-reviewed scientific evidence on sunscreen ingredients and its impact on environmental and human health.

**Again, we ask that the legislature hold off on passing SB 132, or any other legislation on sunscreen ingredients, until more data on environmental and public health impacts are available.**

If you have any questions about the PASS Coalition or the content of this testimony, please feel free to contact me at lmiyahira@iq360inc.com.

Mahalo you for the opportunity to testify.

Sincerely,

Lynn Miyahira
Public Access to SunScreens (PASS) Coalition

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[i] http://www.hawaiihealthmatters.org/indicators/index/view?indicatorId=2389&localeId=14&localeChartIdxs=1%7C2%7C4
[ii] http://www.hawaiihealthmatters.org/indicators/index/view?indicatorId=3029&localeId=14
[iii] https://www.skincancer.org/skin-cancer-information/skin-cancer-facts/
[iv] https://www.skincancer.org/skin-cancer-information/skin-cancer-facts/
[v] https://www.epa.gov/sunsafety/sun-safety-monthly-average-uv-index
[vi] https://www.sciencedirect.com/science/article/pii/S0048969719310125?via%3Dihub
[vii] https://www.nationalacademies.org/our-work/environmental-impact-of-currently-marketed-sunscreens-and-potential-human-impacts-of-changes-in-sunscreen-usage
[viii] https://www.fda.gov/news-events/fda-voices/shedding-more-light-sunscreen-absorption

CHPA® | CONSUMER HEALTHCARE PRODUCTS ASSOCIATION

Taking healthcare personally.

February 16, 2021

To: Committee on Agriculture and Environment
Chair Mike Gabbard
Vice Chair Clarence K. Nishihara

Re: **SB 132 Related to Sunscreens - OPPOSE**

On behalf of the Consumer Healthcare Products Association (CHPA), the national trade association representing the leading manufacturers of over-the-counter (OTC) medications, dietary supplements, and consumer medical devices, I'm writing to express strong opposition to SB 132 – legislation seeking to ban the sale, offer of sale, or distribution in the State of any sunscreen that contains octocrylene, octisalate, or homosalate without a prescription.

Octocrylene, octisalate, and homosalate are Food and Drug Administration (FDA) approved ingredients found in many common sunscreens sold on the market today. They are commonly used in broad spectrum sunscreens to block the full range of ultraviolet rays that are linked to skin cancer – one of the most common, yet preventable forms of cancer in the world according to the World Health Organization.[1] Eliminating sunscreen options for consumers needlessly increases the risk of skin cancer for residents and visitors to the State of Hawai'i and will provide no benefit to the health of the native coral reef population. In fact, the American Cancer Society estimates that melanoma will be one of the leading causes of new cancer cases in Hawai'i in 2021.[2]

The State of Hawai'i remains the only American state to have banned the sale of sunscreens containing oxybenzone and octinoxate. Expanding this ban to also include octocrylene, octisalate, or homosalate is based on an inaccurate assumption that sunscreen ingredients are unquestionably harmful to coral reefs and other marine life. This notion is contrary to the scientific consensus that global warming, land pollution, and other human activities are the primary cause of coral bleaching around the world.[3] Rising sea temperatures as a result of global warming are the primary cause of coral decline.

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[1] https://www.who.int/news-room/q-a-detail/radiation-protecting-against-skin-cancer
[2] American Cancer Society, Cancer Facts & Figures 2021; available at https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/annual-cancer-facts-and-figures/2021/cancer-facts-and-figures-2021.pdf
[3] e.g., see Hughes *et al.*, 2017 Global warming and recurrent mass bleaching of corals. Nature, 543(7645):373-377; Rodgers *et al.*, 2017 Patterns of bleaching and mortality following widespread warming events in 2014 and 2015 at the Hanauma Bay Nature Preserve, Hawai'i. PeerJ, DOI 10.7717/peerj.3355

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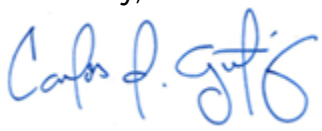
Given the lack of convincing scientific evidence that sunscreens are responsible for coral degradation, we strongly oppose the elimination of sunscreen ingredients like octocrylene, octisalate, or homosalate. Consumer access to sunscreen products containing a broad variety of ingredients, especially in a state with the highest rate of melanoma cases attributed to UV exposure, is a matter of public health and sunscreen use has been proven to reduce the risk of skin cancer.[4] For these reasons, we oppose passage of SB 132.

Thank you for taking the time to consider our concerns and feel free to contact me or our local representative, Lauren Zirbel, directly with any follow up questions you may have.

Sincerely,



Carlos I. Gutiérrez
Vice President, State & Local Government Affairs
Consumer Healthcare Products Association
Washington, D.C.
202.429.3521
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[4] Watts *et al*., 2018 Sunscreen Use and Melanoma Risk Among Young Australian Adults. JAMA Dermatol, 154(9):1001-1009.

**SB-132**
Submitted on: 2/16/2021 10:31:30 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Rhiannon Chandler-'Iao | Testifying for Waiwai Ola Waterkeepers Hawaiian Islands | Support | No |

Comments:

**Aloha,**

**We strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023. There was a time when we allowed these products because we did not understand their impact. Today, we know the harm caused to the marine life that our people and visitors cherish, and there are other alternatives. It is time to act for the best interest of our waters and our long-term economy which is supported by a beautiful marine environment. Mahalo for your leadership.**

**SB-132**
Submitted on: 2/16/2021 11:35:54 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Hawaii Reef and Ocean Coalition | Testifying for Hawaii Reef and Ocean Coalition | Support | No |

Comments:

To: The Honorable Michael Gabbard, Chair, The Honorable Clarence Nishihara, Vice Chair, and Members of the Senate Committee on Agriculture and Environment

From: Hawaii Reef and Ocean Coalition (by Ted Bohlen)

Re: Hearing SB132 RELATING TO SUNSCREENS.

Wednesday February 17, 2021, 1:00 p.m., by videoconference

Position: **Strongly Support SB132 with amendments**!

The HAWAIʻI REEF AND OCEAN COALITION – HIROC – **STRONGLY SUPPORTS SB 132 with amendments. HIROC proposes amending SB132 by substituting "avobenzone" for "homosalate and octisalate" wherever they appear in the bill. In addition, the definitions of homosalate and octisalate should be deleted and the definition of avobenzone in HB 102 HD1 inserted.**

HIROC was formed in 2017 by coral reef scientists, educators, local Hawaii environmental organizations, elected officials, and others to address the crisis facing Hawaii's coral reefs and other marine life. Coral reefs are already being severely harmed by ocean waters that are warming and becoming more acidic as a result of greenhouse gas emissions worldwide. Coral reefs are also being harmed in Hawaii by sediment runoff from the land, by overfishing (especially of reef-cleaning herbivores), by nutrients from cesspools and failing individual wastewater systems, and by sunscreen petrochemicals.

HIROC thanks the Legislature for passing Act 104 in 2018, which provided for the world's first ban on sale or distribution for sale of sunscreens containing oxybenzone and octinoxate, effective January 1, 2021. HIROC recommends amending SB132 in order to align it with the latest science (and HB102 HD1, but please retain the effective date of 1 January 2023.) The amended SB132 would build directly on Act 104 by adding two more ecotoxic petrochemicals to the list: **octocrylene and avobenzone.** In the interim since the passage of Act 104, we have learned that octocrylene and

avobenzone are also harmful to marine life and human health and should also be kept out of our marine environment. As of February 2021, the U.S. Federal Drug Administration's database lists 2,223 sunscreen products containing octocrylene, and 2,329 containing avobenzone. Evolving science around the world clearly demonstrates that these ubiquitous and pervasive reef toxins irreversibly interfere with the life-cycles ofHawaii's foundational and endemic marine life including corals, algae, fish, shellfish, sea urchins and marine mammals.

Furthermore, long-term exposure to avobenzone and octocrylene has been found to be lethal for some organisms living in freshwater environments, and are considered dangerous for freshwater ecosystems. Avobenzone is the leading active ingredient in chemical sunscreens and can cause hormone disruptions. Octocrylene is also quickly metabolized into a mutagen called benzophenone which is regulated by the FDA and included in California's Prop 65 list of chemicals known to cause cancer or reproductive toxicity. And in February 2019, the U.S. Food and Drug Administration declared that it does not have sufficient scientific evidence that any of the organic UV filters in sunscreens, including oxybenzone, octinoxate, octocrylene, and avobenzone, are safe and effective for human use - never mind our marine ecosystems.

It has been argued that banning sunscreens containing petrochemicals like avobenzone and octocrylene from the market would lead to additional skin cancers, because people therefore won't use any sunscreen. This false argument ignores the fact that there are ample safer alternatives available on the market containing the active ingredient minerals zinc oxide or titanium dioxide.

Sunscreen preparations were designed to protect against sunburn and because of this they are assumed to protect against skin cancer, but unfortunately this relationship is inferential only. There are no definitive studies that demonstrate that sunscreens protect against skin cancers as evidenced by research published by the World Health Organization, US Environmental Protection Agency and dermatologist alike.

The argument also ignores what the World Health Organization has called "sunscreen abuse." Petrochemical sunscreens are often not applied sufficiently or frequently enough, and wash off in water, so may not actually protect as much as people are led to believe. A false sense of protection against both UVB and UVA pathologies may cause people to spend more time in the sun. This additional exposure to the sun, or "sunscreen abuse," increases the risk of melanoma and may cause MORE skin cancers.

The best course is to avoid the mid-day sun, but if you will be in the sun, wear a protective hat and clothing and sunscreens with zinc oxide or titanium dioxide. This is much better course for both public health and our fragile marine environments than using a petrochemical sunscreen that washes off in water and kills corals and other marine life, gets absorbed into your bloodstream, and may disrupt your hormones, potentially causing more cancers.

Approximately one-fourth of the plants, fish, and invertebrates found in Hawaiian coral reefs are endemic to Hawaii. Coral reefs are intrinsic to Hawaiian culture, and fundamental to the fabric of our local communities. They provide critical habitat for near shore marine life, and natural protection against coastal erosion and sea level rise - ecosystem services worth billions of dollars. Further, our coral reefs underpin tourism, Hawaii's primary economic engine. It is therefore critical to eliminate as many existential threats to our marine ecosystems as possible, like these additional reef-toxic chemicals, to ensure our reefs can both survive and thrive for future generations.

Mahalo for the opportunity to testify in **STRONG SUPPORT for SB132 with proposed amendments!**

Hawaii Reef and Ocean Coalition (by Ted Bohlen)

February 17, 2021

To: The Honorable Mike Gabbard, Chair
Members, Senate Committee on Agriculture and Environment

From: Tim Shestek
American Chemistry Council

Re: **SB 132 – OPPOSE**

On behalf of the American Chemistry Council (ACC), I am writing to express our concern with SB 132, legislation that would ban non-prescription sunscreens containing octocrylene, octisalate or homosalate. If passed, this bill would eliminate many of the U.S. Food and Drug Administration (FDA) approved sunscreen active ingredients that protect skin against the damaging effects of ultraviolet light. In addition to these comments, ACC supports the comments submitted by the Personal Care Products Council (PCPC) and the Consumer Healthcare Products Association (CHPA).

The FDA, the Centers for Disease Control and Prevention (CDC), the U.S. Surgeon General, the American Academy of Dermatology (AAD), the Skin Cancer Foundation, and health care professionals worldwide emphasize that using sunscreens is a critical part of a safe sun regimen. The dangers of sun exposure are clear and universally recognized by public health professionals and dermatologists. The National Institutes of Health Report on Carcinogens identifies solar UV radiation as a "known human carcinogen." A single bad burn in childhood doubles the risk of developing skin cancer later in life.

ACC shares the concerns regarding the threat to the world's coral reefs. Climate change and ocean warming are the most notable culprits for reef bleaching. According to the U.S. National Oceanic and Atmospheric Administration's (NOAA) Coral Reef Conservation Program, coral reefs are impacted by an increasing array of hazards, primarily from global climate change, ocean acidification, and unsustainable fishing practices.

Thank you for the opportunity to share these comments. Should you have any questions, please do not hesitate to contact me at 916-448-2581 or tim_shestek@americanchemistry.com. You may also contact ACC's Hawai'i based representative Ross Yamasaki at 808-531-4551 or ryamasaki@808cch.com

**SB-132**
Submitted on: 2/16/2021 12:31:05 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| James B. Gordon, Ph.D. | Testifying for Kawaihae Canoe Club | Support | No |

Comments:

As an ex-member of the Kawaihae Canoe Club, I strongly support SB132 with the following amendments:

Please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing Octocrylene and Avobenzone to protect the State's marine ecosystems to align with HB102, and

Please retain the Effective Date of 1 January 2023.

James B. Gordon, Ph.D.



**Aloha State Legislature,**

**Science has provided ample evidence that long-term exposure to avobenzone, homosalate, octisalate, and particularly octocrylene** commonly found in sunscreens (including those labelled "reef safe") have been found to have detrimental impacts on people and marine life. The intention was always to include these dangerous UV filters to the original sunscreen bill, as we waited for the released studies to be published. Now there is more than enough solid science to back up the urgency to update our sunscreen laws.

**Octocrylene accumulates in fatty tissues of aquatic life (and humans)**, can alter mitochondrial function and is linked to developmental and reproductive toxicity. It can contribute as a "deciding factor" of whether coral survives or dies a bleaching event. It's one of the more inefficient UV filters and one of the most toxic to corals. **Avobenzone degrades when exposed to the sun causing the release of free radicals**, which can increase the risk of cancers. It must be used with other chemicals because it breaks down so quickly and is not waterproof. It shows endocrine disruption and decrease sperm viability. Octocrylene and avobenzone typically go together in formulations, making them even more dangerous. **Octisalate and homosalate** are absorded into the blood, cross into the womb & can cause birth defects and miscarriages.

**The hypothesis that if you prevent a sunburn with chemical sunscreens you prevent skin cancer has never been proven**. By preventing a burn you certainly miss the body's natural warning you're being exposed to too much sun. There's no need to trade the health of marine life in order to protect from sun exposure. People can utilize UV protective hats / sunglasses / clothing, shade, avoid direct sun mid-day… *then choose a safe sunscreen*. **There are a multitude of non-nano mineral sunscreens on the market**, easily available across Hawai'i, offering more efficient broad spectrum protection. It's embarassing to continue making the excuse that there are no safe, effective options to chemical UV filters.

**Covid has given Hawai'i a time-out from extreme tourism.** We need to step back, reevaluate human impact, and consider the negative effects these chemicals have been having on our environment, food supply (these UV filters are being found in Hawaii-caught fish we eat), in coastal waters we swim, in the air we breathe (via aerosols sprayed constantly at beaches, parks, hotels… which are impossible to avoid inhaling), in the sand honu lay their eggs…. Are we truly working to be an eco-destination or is that simply green-washing used year after year at Hawaii's tourism conventions.

**Coral reefs are fundamental to our sustainability.** They provide critical habitat for near shore marine life and natural protection against coastal erosion. Their health also provides for our tourism economy. It's vital we eliminate as many existential threats to our marine ecosystems as possible, including reef-toxic chemicals, to ensure they can survive and thrive for future generations.

**We urge your support for HB102 and SB132. Mahalo.**

**SB-132**
Submitted on: 2/17/2021 9:17:54 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Heather Howard | Testifying for Coral Reef Education Institute | Support | No |

Comments:

Surrounded by the ocean, the Hawaiian Archipelago stretches 1500 miles NW to SE and includes 132 islands, atolls, reefs, and shoals. Hawaii has a unique marine ecosystem; 25% of our marine species are endemic, meaning they are only found in Hawaii, and nowhere else in the world. Hawaii is home to 80% of all coral reefs in the United States. The main Hawaiian islands are surrounded by almost 410,000 acres of coral reefs. Hawaii's ocean industry, including ocean recreation, generates over $3 billion annually in gross revenues to Hawaii's economy. Source: DLNR

From larger, populated islands like Oahu to small, remote islands like Jarvis, the reefs surrounding islands and atolls in the Pacific are impacted by changes in the surrounding ocean and terrestrial watersheds. Everything that starts on land or in the air can impact the health of the coral reefs. Source: NOAA

Over recent decades, worldwide, over 50% of living coral has been lost on coral reefs due to a combination of local factors and global climate change. In 2016-17 bleaching alone caused the loss of half the shallow water corals on the northern 700 km of the Great Barrier Reef and substantial damage elsewhere. Recovery from such events is a decades-long process. With bleaching now frequent, reefs have little time to rebuild.

In 2015 Hawaii experienced one of its worst bleaching events on record. for 18 consecutive weeks during our summer months, the ocean temperature surrounding the Hawaiian Islands increased by 3 degrees Fahrenheit. During this time we lost 95% of our Cauliflower Corals and 50% of our corals overall. Since the last major bleaching event that lasted from 2015-2017 globally, Cauliflower Coral (Pocillopora Meandrina) has been petitioned by the National Marine Fisheries Service (NMFS) and the National Oceanic and Atmospheric Administration (NOAA) to be added to the Endangered Species Act.

It's now commonly known that many chemicals found in sunscreen are harmful to coral reefs. With coral reefs experiencing high rates of mortality and having little time to recover, it is imperative we do all we can to protect and restore them. Including banning the sale of all chemicals harmful to their survival. Healthy coral reefs provide goods and services worth at least US$11.9 trillion per year and support (through such activities as fisheries and tourism) at least 500 million people worldwide.

- **How sunscreen chemicals enter our environment:** The sunscreen you apply may not stay on your skin. When we swim or shower, sunscreen may wash off and enter our waterways.
- **How sunscreen chemicals can affect marine life:**
    - **Green Algae:** Can impair growth and photosynthesis.
    - **Coral:** Accumulates in tissues. Can induce bleaching, damage DNA, deform young, and even kill.
    - **Mussels:** Can induce defects in young.
    - **Sea Urchins:** Can damage immune and reproductive systems, and deform young.
    - **Fish:** Can decrease fertility and reproduction, and cause female characteristics in male fish.
    - **Dolphins:** Can accumulate in the tissue and be transferred to young.

Source: NOAA

By passing this bill not only are we benefiting the ocean ecosystem, but we are also protecting the cultural history of the Hawaiian people. As stated in the Kumulipo, the coral polyp is the beginning of all life born from the darkness. The coral was the first stone in the foundation of the earth mentioned in the ancient chant. In this text, the selection of hard-coated creatures as the first forms of life on earth harmonizes with the idea of reproductive power inherent in a stone into which a god enters, an idea fundamental to Polynesian thought about the structure of the world.

We support SB132 and the ban of harmful chemicals for sale in sunscreen or other beauty products on all Hawaiian islands.

Heather Howard

**SB-132**
Submitted on: 2/9/2021 2:01:28 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Douglas Fenner | Individual | Oppose | No |

Comments:

I wish to state following regarding the proposal to ban certain sunscreen chemicals in Hawaii:

1) that climate change is the main threat to corals,

2) that sunscreen is unlikely to be a major player,

3) that UV is a known carcinogen and sunscreen provides protection (& oxybenzone happens to be a major player because it's one of the only filters that is broad-spectrum), and

4) that more study is needed before making policy changes that could impact human health without some certainty that it could help the coral.

In particular, while there are a very wide range of threats to corals known, the number one threat currently and projected into the future is global warming. In fact, one paper (Brainard et al, 2013) published in a peer-reviewed journal has a list of stressors for corals from the strongest (global warming) to the weakest. Sunscreens are not even on that list. The list was for stressors of the world's corals. However, in a small, enclosed body of water with little or no circulation and very large numbers of tourists applying sunscreen it is conceivable that it might at least make the bottom of a list of stressors. However, I know of no scientific study that has documented a single wild coral dying from sunscreen while living in the ocean. On the other hand, the studies documenting coral death from high water temperatures are too numerous to count, and the numbers of corals that were documented to have died in those studies are basically uncountable, clearly in the billions or more.

The fact that ultraviolet rays from the sun cause skin cancer is well known, there are huge numbers of people who die from it, and there can be no doubt that if effective sunscreens are denied to people who want to get in the water and look at your coral, it would be an appropriate public health measure to ban people from getting into the water there. Perhaps they could wear full sets of clothes, but likely that won't be popular with the tourists which drive your economy. The American Academy of Dermatology asks you NOT to ban sunscreens (http://www.kplctv.com/2019/02/21/dermatologists-raise-concerns-over-movement-ban-sunscreen-environmental-reasons/).

I often point out to people that if you work in an emergency room and a patient comes in with a gunshot wound to the chest and a small scratch on the hand, and you work to treat the scratch but don't treat the bullet wound, you will lose your patient and be sued and lose your right to practice medicine. So far, sunscreen has not really even been shown to be the equivalent of a scratch on the hand for corals. But global warming has been shown to be the equivalent for corals of a gunshot wound to the chest. Scientists now estimate that if we continue business as usual, over 90% of the world's corals are likely to die from high temperatures, probably within 30 years, perhaps less. There are places in the world where 90% of the corals have already been killed by hot water from global warming. If you don't want to lose your coral reef tourism business, global warming is the real threat to that business. Even fishing does more damage to your coral reef ecosystem than sunscreen, unless you have completely banned fishing from your coral reefs.

The last scientific article I knew about on this topic tested the organic ingredients used in European sunscreens, and found that none of them, NONE, had effects on corals or larvae right up to as much of it as you can get dissolved into water.

I was just sent a new scientific article that reviews this subject, all of the scientific papers published so far on this subject. It says in the discussion, and I quote, "Organic UV filters do occur in the environment, but according to our analysis, there is limited evidence to suggest that their presence is causing significant harm to coral reefs." And "These toxicological thresholds exceed 98 and 100%, respectively, of environmental concentrations observed thus far near coral reefs." In other words, the concentrations needed to harm corals are almost always greater than those chemicals are at in the actual water corals live in, which have been tested.
https://setac.onlinelibrary.wiley.com/doi/10.1002/etc.4948

Banning sunscreens is a feel-good exercise that will be highly ineffective at protecting corals, and will threaten human health and have high public health costs..

Sincerely,

Douglas Fenner, Ph.D.

Coral reef expert with over 35 years of experience working on coral reefs around the world, and about 50 peer-reviewed scientific publications and book chapters, most on coral reefs, and one book on the corals of Hawaii. Resume available on request.

Coral Reef Consulting, American Samoa

Brainard, R.E., Weijerman, M., Eakin, C.M., McElhany, P., Miller, M.W., Patterson, M., Piniak, G.A., Dunlap, M.J., and Birkeland, C. 2013. Incorporating climate and ocean change into extinction risk assessments for 82 coral species. Conservation Biology 27: 1169-1178.

**In Favor of SB132:** Banning the sale and distribution of sunscreen containing Octocrylene, Octisalate or Homosalate. Joe DiNardo (Toxicologist/Hawaiian tourist). February 14, 2021

Dear Senators, based on Hawaii's lead in the environmental impact of oxybenzone and octinoxate the world has turned its eyes to evaluating other petrochemical (organic) sunscreen actives that impact the environment and human health. Although the coronavirus has slowed us all down, scientists for all over the world continue to conduct research on these chemicals. With that said, below are a dozen scientific references, recently published, relating to the negative impact to the aquatic environment focusing solely on avobenzone and octocrylene (Note: other chemicals of concern may have also been tested concurrently in the papers referenced below).

1) Irrigation with water containing avobenzone and **Octocrylene** significantly inhibit the aboveground growth of cucumber plants by interfering with photosynthesis. (Zhong et al Sci Total Environ. **2020 Apr 20**;714:136879). These findings should cause great concern since aquatic plants (currently growing in sunscreen contaminated waters) also use photosynthesis to grow that feed a variety of aquatic species.

**2)** Results show that both **Homosalate** and **Octocrylene** was the most toxic UV filter tested in brine shrimp followed by avobenzone (Thorel et al Toxics. **2020 Apr 10**;8(2):29).

3) **Octocrylene** was considered to be a great threat to Japanese medaka (Oryzias latipes) based on its reproductive toxicity (Yan Environ Pollut. **2020 Jun**;261:114104)

4) Both avobenzone and **Octocrylene** induced behavioral and physiological disruption at environmentally realistic concentrations in Daphnia magna (Boyd et al Sci Total Environ. **2021 Jan 1**;750:141707).

5) Long-term exposure to avobenzone and **Octocrylene** was lethal for some organisms living in freshwater environments and were considered dangerous for freshwater ecosystems (University of Alberta – **Sept 1,2020** https://www.ualberta.ca/folio/2020/09/common-sunscreen-ingredients-dangerous-for-freshwater-ecosystems-study.html

6) **Octocrylene** was reported to alter in a negative manner mitochondrial function of hexacoral *Pocillopora damicornis* (Stien et al Sci Rep. **2020 Jun 15**;10(1):9601).

7) **Octocrylene** accumulates in Pocillopora damicornis tissues as fatty acid conjugates and triggers coral cell mitochondrial dysfunction (Stien et al Anal Chem. **2019 Jan 2**;91(1):990-995).

8) **Octocrylene** and avobenzone were found in multiple species of fish from markets in the Canary Islands and Catalonia (Spain) with Thunnus thynnus being the most heavily polluted species (Gimeno-Monforte et al Foods. **2020 Dec 9**;9(12):1827). This finding continues to demonstrate the growing concern of bioaccumulation/biomagnification of organic sunscreen actives in the contamination of our food chain.

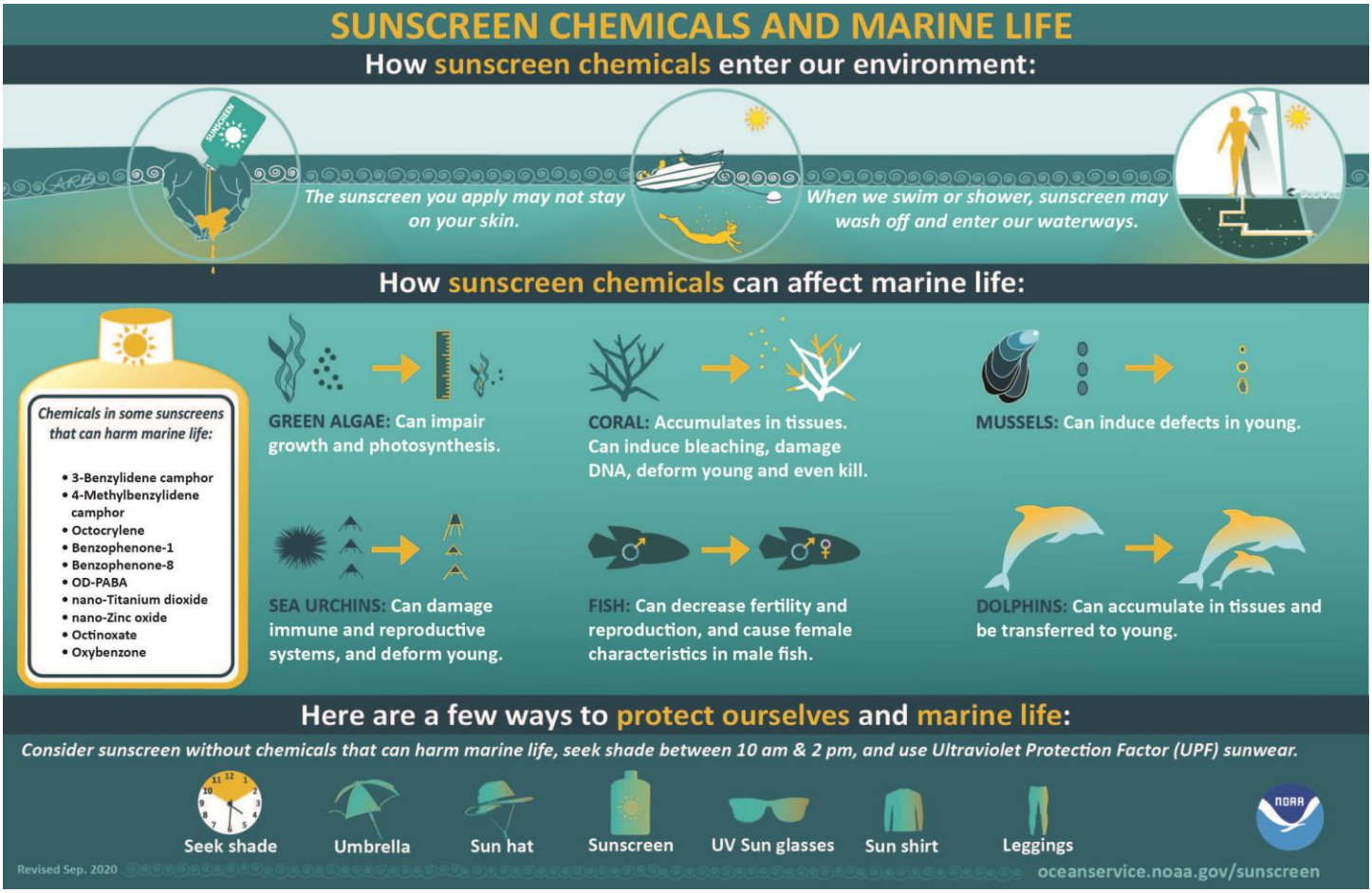
**9) Octocrylene** may pose high risk to aquatic organisms in the riverine and estuarine environment in Thailand UV-filters concentration including **Homosalate** were higher than those reports from other regions … the occurrence of UV-filters compare to some other famous sea and beach tourism regions, the UV-filters concentrations levels in Thailand were higher than Hawaii, Spain, Norway, USA and Japan. (Juksu et al Ecotoxicol Environ Saf. **2020 Nov**;204:110952).

10) In the Enoggera Reservoir (Australia), seven UV filters were detected, of which the most prevalent were **Octocrylene** and avobenzone (O'Malley et al Sci Total Environ. **2021 Feb 1**;754:142373).

11) **Octocrylene** was one of three chemicals mixed together that modified genes related to the endocrine system, detoxification mechanisms, and the stress response in Chironomus riparius (Muñiz-González Ecotoxicol Environ Saf. **2020 Dec 15**;206:111199).

12) The uptake and transformation of sunscreen ingredients in duckweed was evaluated with the maximum concentration found in the plant material was in the range of 2 µg (**Octisalate** in duckweed) to 10 µg (avobenzone in duckweed) per gram plant material (Seyer et al Journal of Chromatography A **2021)**.

Additionally, the National Oceanic and Atmospheric Administration (NOAA) recently released this infographic clearly communicating that sunscreen chemicals affect marine life including green algae, coral, mussels, sea urchins, fish and dolphins.




Lastly, the role that these chemicals are thought to play in preventing skin cancer is of concern, therefore, I will let the researchers and medical professional who have evaluated this perspective over the last 6 decades answer this question using their own statements:

**Published Research Reviewing the Skin Cancer Prevention of Sunscreens**

| Statement | Citation |
|---|---|
| "The preparations are all designed to protect against the acute effects of ultraviolet, namely sunburn. Because of their effectiveness in this regard, they are often assumed to protect against ultraviolet carcinogenesis. In most cases, however, there is little or no published evidence that they do so and the relationship is inferential." | Emmett. Ultraviolet radiation as a cause of skin tumors. CRC Crit Rev Toxicol. **1973**;2(2):211-55. |
| "In summary, the results of this study indicate that inflammation and enhanced melanoma growth are different effects of UV radiation involving different mechanisms and have different sensitivities for sunscreen protection. Furthermore, protection against sunburn does not necessarily imply prevention of other possible UV radiation effects, such as enhanced melanoma growth. In fact, sunscreen protection against UV radiation-induced inflammation may actually encourage prolonged exposure to UV radiation and thereby increase the risk of development of cutaneous melanoma." | Wolf et al. Effect of sunscreens on UV radiation-induced enhancement of melanoma growth in mice. J Natl Cancer Inst. **1994**;86(2):99-105. |

| | |
|---|---|
| "… the topical use of sunscreens reduces the risk of sunburn in humans and that sunscreens probably prevent squamous-cell carcinoma of the skin when used mainly during unintentional sun exposure. No conclusion can be drawn about the cancer-preventive activity of topical use of sunscreens against basal-cell carcinoma and cutaneous melanoma | World Health Organization - Vainio et al. An international evaluation of the cancer-preventive potential of sunscreens. Int J Cancer. **2000**;88(5):838-42. |
| "Although a sunscreen with an SPF of 15 or higher offers protection from sunburn, it does not block all of the sun's damaging rays. In fact, there is no evidence that sunscreens protect you from malignant melanoma, the deadliest form of skin cancer, even though sunburns have been linked with the development of melanoma." | Environmental Protection Agency: Sunscreen the burning facts **2006**. Is sunscreen fail-safe (pg6). www.epa.gov |
| "Despite the availability and promotion of sunscreen for decades, the incidence of CMM (cutaneous malignant melanoma) continues to increase in the U.S. at a rate of 3% per year. There currently is little evidence that sunscreens are protective against CMM." | Planta. Sunscreen and melanoma: is our prevention message correct? J Am Board Fam Med. **2011**;24(6):735-9. |
| "The strength of the association between risk of skin cancer and sunscreen use has constantly decreased since the early 1980s, and the association was no longer statistically significant from the early 1990s. While the current evidence suggests no increased risk of skin cancer related to sunscreen use, this systematic review does not confirm the expected protective benefits of sunscreen against skin cancer in the general population." | Saes da Silva et al. Use of sunscreen and risk of melanoma and non-melanoma skin cancer: a systematic review and meta-analysis. Eur J Dermatol. **2018**;28:186–201. |
| "Could it be that the nearly universal recommendation of dermatologists and professional societies to use sunscreen to prevent skin cancer is unfounded?" | Waldman et al. The role of sunscreen in the prevention of cutaneous melanoma and nonmelanoma skin cancer. J Am Acad Dermatol. **2019** Feb;80(2):574-576. |

**Note: Everyone should practice sun avoidance measure when possible, especially during peak hours of UV exposure (10 AM – 2 PM); wear protective clothing include a broad-brimmed hat and sunglasses and/or use a beach umbrella/cabana when at the beach or pool; if sunscreen is desired, use a mineral based zinc oxide or titanium dioxide sunscreen - which are considered safe and effective for human use according to the FDA.**

**SB-132**
Submitted on: 2/15/2021 3:20:09 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Maui OFR | Individual | Support | No |

Comments:

We need to regulate what harmful chemicals are leaking into the ocean and destroying our reef!

**SB-132**
Submitted on: 2/15/2021 3:52:21 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Michael McGuire | Individual | Support | No |

Comments:

***Our family strongly supports SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to also include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems and to align with HB102, but please retain the effective date of 1 January 2023 or sooner. Our oceans. its creatures and our coral cannot wait another 29 years for protection!***

**SB-132**
Submitted on: 2/15/2021 4:14:06 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Dorothy Norris | Individual | Support | No |

Comments:

***I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to also include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems and to align with HB102, but please retain the effective date of 1 January 2023".***

**SB-132**
Submitted on: 2/15/2021 4:32:52 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Donna G Spence | Individual | Support | No |

Comments:

1. ***strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to also include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems and to align with HB102, but please retain the effective date of 1 January 2023". Even sooner would be better!***

**SB-132**
Submitted on: 2/15/2021 4:50:37 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Maureen Datta | Individual | Support | No |

Comments:

I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023. Mahalo from all our fishy friends.

**SB-132**
Submitted on: 2/15/2021 4:56:24 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| George Fry | Individual | Support | No |

Comments:

**I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023".**

**SB-132**
Submitted on: 2/15/2021 5:18:39 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Emi Harase | Individual | Support | No |

Comments:

The sunscreens that are sold in stores now are misleading. It is painful to see thousands of visitors come in thinking that they are doing the right thing by purchasing sunscreen that is labeled "reef friendly" when it is not. Marshall Islands banned 28 chemicals while the State of Hawaii only banned 2! Banning these harmful chemicals will not only help the coral reef, but the limu, fish, Honu and continue to provide economy to the state for tourism. We have to take preventative measures by banning these harmful chemicals before losing our precious resource.

**SB-132**
Submitted on: 2/15/2021 5:25:14 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Zach Taylor | Individual | Support | No |

Comments:

**I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023". This is a very time sensitive subject, please do not delay any further protection of our fragile ecosystems.**

**SB-132**
Submitted on: 2/15/2021 5:57:00 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Ebby Pinson | Individual | Support | No |

Comments:

**Aloha kakou**

**I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023.**
Please protect Hawaii's biggest asset and think about the future of our island.
Thank you for your consideration.

**SB-132**
Submitted on: 2/15/2021 6:18:17 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Rosanne Shank | Individual | Support | No |

Comments:

I **strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023".**

**SB-132**
Submitted on: 2/15/2021 6:19:13 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Marly Isler | Individual | Support | No |

Comments:

I request that the Hawaiian government expand Act 104, Sessions Laws of Hawaii 2018 to ban the sale and distribution of sunscreens containing ingredients that damage marine ecosystems. Octocrylene and avobenzone have been proven to irrevocably lead to the destruction of coral infrastructure. This ban needs to occur as soon as possible to prevent irreparable damage to Hawaiian marine life.

**SB-132**
Submitted on: 2/15/2021 6:53:58 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Adam Maire | Individual | Support | No |

Comments:

***I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to also include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems and to align with HB102, but please retain the effective date of 1 January 2023. We need to protect the ocean ecosystems as soon as possible. Any delay may do damage beyond repair.***

***Thank you.***

***Adam Maire***

**SB-132**
Submitted on: 2/15/2021 6:57:23 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Paul Montague | Individual | Support | No |

Comments:

**I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023.**

**SB-132**
Submitted on: 2/15/2021 7:24:33 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Audrey Newman | Individual | Support | No |

Comments:

I strongly support SB132 to protect our ocean and reefs from harmful chemicals in sunscreens. Please strengthen this bill by adding two more chemicals - octocrylene and avobtenzone - to the state's existing ban on sale or distribution for sale of sunscreens. These chemicals are included in HB102.

I also strongly support the effective date of 1 January 2023. It is important to take action as quickly as possible, and this will allow businesses and government agencies enough time to implement the expanded law.

Mahalo a nui loa,

Audrey Newman

**SB-132**
Submitted on: 2/15/2021 7:45:20 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| E A Pinson | Individual | Support | No |

Comments:

**I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023".**

**SB-132**
Submitted on: 2/15/2021 9:12:31 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Elizabeth Winternitz | Individual | Support | No |

Comments:

**I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023".**

**SB-132**
Submitted on: 2/15/2021 9:57:45 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Cynthia Urry | Individual | Support | No |

Comments:

"I/We strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to also include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems and to align with HB102, but please retain the effective date of 1 January 2023".

**SB-132**
Submitted on: 2/15/2021 10:31:43 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Hillary Hendrickson | Individual | Support | No |

Comments:

Science has provided ample evidence that long-term exposure to avobenzone & octocrylene commonly found in sunscreens (including sunscreens labelled “reef safe”) have been found to have detrimental impact on people & marine life.

Octocrylene accumulates in fatty tissues of aquatic life (and humans), can alter mitochondrial function and is linked to developmental & reproductive toxicity. It can contribute as a “deciding factor” of whether coral survives or dies a bleaching event. It’s one of the more inefficient UV filters AND one of the most toxic to corals.

Avobenzone degrades when exposed to the sun causing the release of free radicals, which can increase the risk of cancers. It must be used with other chemicals because it breaks down so quickly and is not waterproof. Combined with other UV filters it shows endocrine disruption and decreases sperm viability.

The hypothesis that if you prevent a sunburn with chemical sunscreens you prevent skin cancer has never been proven. There’s no need to trade the health of marine life in order to protect ourselves from the sun. We should utilize UV protective clothing, shade, & avoid direct sun mid-day… then choose sunscreen.

There are endless efficient mineral sunscreens on the market, available in thousands of stores across Hawaii. In fact, out of all approved UV filters non-nano zinc oxide is the most efficient, offering the best broad spectrum protection.

Coral reefs are fundamental to our sustainability. They provide critical habitat for near shore marine life and natural protection against coastal erosion. It’s vital we eliminate as many existential threats to our marine ecosystems as possible, including reef-toxic chemicals, to ensure they can survive & thrive for future generations.

We urge your support for SB132

**SB-132**
Submitted on: 2/15/2021 10:34:41 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Dee Fulton | Individual | Support | No |

Comments:

**I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023".**

**Mahalo.**

**SB-132**
Submitted on: 2/16/2021 5:53:37 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Elizabeth Cole | Individual | Support | No |

Comments:

I want to express my strong support for SB132. These bills were written with knowledge of the mounting scientific literature as to the negative effects of Oxybenzone/Octinoxate on Hawaii's precious coral reefs and other marine habitats. Asking residents and visitors to take necessary precautions such as using reef-friendly sunscreen is a proactive way to balance the need to protect our environment with the ability for everyone to enjoy our shoreline ecosystems.

**SB-132**
Submitted on: 2/16/2021 6:18:50 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Ron Jarvis | Individual | Support | No |

Comments:

I strongly support SB132 with the following amendments:  please expand Act 104, Sessions Laws of Hawaii 2018, to also include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems and to align with HB102, but please retain the effective date of January 1, 2023.

**SB-132**
Submitted on: 2/16/2021 7:12:46 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| curt shaw | Individual | Support | No |

Comments:

**I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023.**

**SB-132**
Submitted on: 2/16/2021 7:59:37 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Jane Fettter | Individual | Support | No |

Comments:

**We strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023".**

**My family owns Hale Kai on Keauhou Bay. The Bay is a treasured heritage of the island. It desperately needs protection. Thank you**

**SB-132**
Submitted on: 2/16/2021 8:32:46 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Suzanne Marie Ager | Individual | Support | No |

Comments:

***"I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to also include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems and to align with HB102, but please retain the effective date of 1 January 2023".***

**SB-132**
Submitted on: 2/16/2021 8:42:37 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Claire Gallinghouse | Individual | Support | No |

Comments:

I **strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023".**

**SB-132**
Submitted on: 2/16/2021 8:52:19 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Jessica Kuzmier | Individual | Support | No |

Comments:

I believe these sunscreen chemicals should be banned.

GREG K. SAKAMOTO, M.D.
DERMATOLOGY

QUEENS PHYSICIANS OFFICE BLDG III
550 N BERETANIA ST, STE 603
HONOLULU, HI 96813
PH: (808) 447-7454 FAX: (808) 447-7456
WWW.SAKAMOTODERMATOLOGY.COM

February 16, 2021

To Whom It May Concern:

I am writing in opposition of House Bill 102. As dermatologists**,** we know that 80% of skin cancer can be prevented by following sun safe practices, yet we see patients with skin cancer on a daily basis. Many of these patients present with multiple skin cancers, with a vast majority of cases related to excessive sun exposure. This proposed ban on more sunscreen ingredients could potentially eliminate about 64% of the sunscreens currently on the shelf. The only sunscreens that will be left are the ones that cause a white cast and feel sticky on the skin, which will deter people from using sunscreen altogether. This bill will severely limit consumer choice. Sun damage is real and it can affect anyone, and is even more critical here in Hawaii where we have one of the highest average UV indexes in the nation. The benefits of sunscreen for reducing skin damage and preventing skin cancer have been well documented and has been proven to reduce your risk of developing melanoma by up to 50%. We know that sunscreen saves lives.

I understand the intention behind this bill is to protect our coral reefs and I believe that is a worthy cause. However, I am not a reef expert, but according to NOAA's website about sunscreen and coral damage, it did **not** list avobenzone, homosalate or octisalate as being harmful to marine life. Given the fact that sunscreen prevents skin cancer, there should be solid, overwhelming evidence that banning it will actually help improve coral health. Think about all the other ingredients that enter the ocean, including insecticides, cleaning chemicals, gasoline, oils etc. Are we planning on banning those as well?

Please consider the public health impacts that such a sweeping ban on sunscreens will have on the people of Hawaii.

If you have any questions, please feel free to call me.

Sincerely,

GREG K. SAKAMOTO, M.D.
*DERMATOLOGY*

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Greg K. Sakamoto M.D., Dermatologist

**SB-132**
Submitted on: 2/16/2021 10:10:52 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Kirstin Kahaloa | Individual | Support | No |

Comments:

Aloha! I support SB132.

**SB-132**
Submitted on: 2/16/2021 10:37:36 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Dennis Solberg | Individual | Comments | No |

Comments:

***"I/We strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to also include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems and to align with HB102, but please retain the effective date of 1 January 2023".***

***Dennis R. Solberg***

**SB-132**
Submitted on: 2/16/2021 11:38:45 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| marjorie erway | Individual | Comments | No |

Comments:

**I strongly support SB132 with the following amendments:**

**-please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102,**

**-please retain the effective date of 1 January 2023.**

**Mahalo for your consideration.**

**SB-132**
Submitted on: 2/16/2021 11:42:12 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Mary Ellen Jaske | Individual | Support | No |

Comments:

***I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to also include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems and to align with HB102, but please retain the effective date of 1 January 2023.***

***I volunteer as a Reef Teacher at Kahalulu Bay on the Big Island. We have seen a dramatic impact in the improvement of the health of the ecosystem when harmful substances are banned. Waiting until 2050 is nearly like doing nothing at all. Please change the date on implementation. Mahalo.***

**SB-132**
Submitted on: 2/16/2021 1:47:11 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Paul Herring | Individual | Support | No |

Comments:

I would like to submit testimony in favor of SB132, the bill aimed at adding additional chemicals to the list that are banned for use in sunscreens sold or distributed in Hawaii. I find it appalling that Hawaii allows the sale of suncreens that are harmful to coral reefs, which are such an important part of the ecosystem of the islands. Not only are coral reefs vital for the health of the fish and oceans that suround our islands but these natural wonders are also a huge draw for tourists. This last year of the COVID pandemic has highlighted the importance of tourism on the Hawaii‘s economy. Why then would we not do everything in our power to help maintain the health of our oceans and coral reefs, which help to bring hundreds of thousands of tourists to the islands each year? In talking with both local residents and numerous out-of-state tourists over the last year or two it is apparent that most people try their best to use sunscreens that will not harm the coral reefs and fish which are dependent on them. Unfortunately the misleading if not outright false labeling of many sunscreens as “reef friendly” greatly impead these efforts. Many out of state tourists that I have talked to specifically waited until they got to Hawaii to buy sunscreen as they assume that whatever they bought here would have to be safe for the reefs. It is very embarrassing to have to tell them that unfortunately this is not true. Clearly this kind of attitude displayed by the tourists should alleviate fears of lost sales due to banning harmfull chemicals from sunscreens, as the visitors will buy whatever sunscreens are available in the local stores. So if local stores stock only true ‘reef friendly‘ sunscreens they should have no trouble selling them. I would also suggest ammending this bill to include Avobenzone as a prohibited chemical to better align with HB102, but please retain the current effective date of January 2023.

RICHARD W. VARLEY
511 Hahaione Street, Apt. 18-A
Honolulu, HI 96825
(808) 265-3610 | rvarley@hawaii.edu

February 16, 2021

**Re: SB 132 – oppose**

Dear Chair Gabbard and Vice Chair Nishihara,

As a skin cancer survivor and avid outdoorsman, I oppose SB 132 that would ban more sunscreen ingredients from being sold in Hawaii.

Now that oxybenzone and octinoxate are banned, sunscreens have to be formulated with alternatives ingredients. My understanding is that some of the most common alternatives are homosalate, octocrylene, and octisalate, but this bill is trying to remove these alternatives. If we remove these alternative ingredients, it could potentially take off about 64% of the sunscreens currently on the shelf in Hawaii, basically making mineral sunscreens some of the only ones available for purchase.

Mineral sunscreens are great for use in the ocean, but sunscreen isn't only for the beach – sunscreen should be used anytime you are outside. I use it when I'm running, cycling, hiking, golfing, or just working outside. My dermatologist has told me over and over again that I need to use sunscreen as part of my daily routine and limiting sunscreens to only those that are "reef-safe" doesn't take into account that there are many other situations that require sun protection. I'm sure the thick, white haze of mineral sunscreens will discourage a lot people from using them on a daily basis and that puts a lot of people at risk for sun damage – especially in a place like Hawaii that has year-round sunny weather.

For those of us who have survived skin cancer, it seems completely insane to take away sunscreens that have decades of proven evidence to prevent skin cancer, for something that is just beginning to be studied. I've seen articles that have raised skepticism on the insufficient evidence that sunscreen is a major cause for coral damage (https://theconversation.com/theres-insufficient-evidence-your-sunscreen-harms-coral-reefs-109567).

We all know that sunscreen is a vital part of sun safety and skin cancer prevention. Please wait until there is more peer-reviewed scientific evidence on the environmental and human impacts of sunscreen before banning any more sunscreens.

Thank you for the opportunity to submit testimony.

Respectfully,

Richard Varley
Triathlete & skin cancer survivor

**SB-132**
Submitted on: 2/16/2021 3:32:52 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Jennifer Johansen | Individual | Support | No |

Comments:

**Aloha,**

**I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023.**

**Sincerely,**

**Jen Johansen**

**SB-132**
Submitted on: 2/16/2021 4:39:28 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Craig O Matkin | Individual | Support | No |

Comments:

**I paddle with the Kawaihae Canoe Club on the Big Island. I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023**

**SB-132**
Submitted on: 2/16/2021 8:19:52 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| John Paszalek | Individual | Comments | No |

Comments:

Hello,

I do not wish to explain things that you already know but if you think that we can wait until 2050 to reduce stressors on coral then maybe you don't know.

A quick look at the state of coral reefs in Hawaii, especially the massive bleaching events in 2014 and 2015, and predictions of future bleaching events will tell you that we must do everything we can to mitigate stressors on our corals. Bleaching is caused by stress which comes from a number of factors all of which contribute. Chemical sunscreens are one of these stressors.

NOAA predicts yearly bleaching events by 2055. If we wait till 2050 it will be far to late.

I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to also include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems and to align with HB102, but please retain the effective date of 1 January 2023.

Thank you for reading (and hopefully doing the right thing),

John Paszalek

https://www.coris.noaa.gov/monitoring/status_report/docs/Hawaii_status_report_forweb.pdf

https://www.fisheries.noaa.gov/feature-story/tracking-and-managing-predicted-massive-coral-bleaching-hawaii

**SB-132**
Submitted on: 2/16/2021 9:11:43 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Lisa Bunge | Individual | Support | No |

Comments:

***I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to also include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems and to align with HB102, but please retain the effective date of 1 January 2023. It is so important to protect our coral reefs, do not delay.***

**SB-132**
Submitted on: 2/16/2021 9:51:25 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Mitch Stauffer | Individual | Support | No |

Comments:

***Dear Hawaii legislators, Any person that fails to protect Hawaiian reefs by stopping or delaying this act or any other act or law or similar means of ecosystem protection will NEVER get my vote or support in the future. "I strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to also include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems and to align with HB102, but please retain the effective date of 1 January 2023". The date of 1 January 2023 is not soon enough! Please chose the health of the environment and all living things over profit and coruption. It is your duty to take action and get this done now.***

**SB-132**
Submitted on: 2/17/2021 12:48:43 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Daniel Amato | Individual | Support | No |

Comments:

Please support SB132!

**SB-132**
Submitted on: 2/17/2021 7:07:17 AM
Testimony for AEN on 2/17/2021 1:00:00 PM

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Liz Lees | Individual | Support | No |

Comments:

Please ban the use of harmful chemicals to our oceans and reefs as soon as possible!

**SB-132**
Submitted on: 2/17/2021 12:56:50 PM
Testimony for AEN on 2/17/2021 1:00:00 PM

LATE

| Submitted By | Organization | Testifier Position | Present at Hearing |
|---|---|---|---|
| Candee Laine Ellsworth | Individual | Support | No |

Comments:

**We strongly support SB132 with the following amendments: please expand Act 104, Sessions Laws of Hawaii 2018, to include the ban on sale or distribution for sale of sunscreens containing octocrylene and avobenzone to protect the State's marine ecosystems to align with HB102, and please retain the effective date of 1 January 2023".**

**Candee Ellsworth**

**Executive Director**

**Keahole Center for Sustainability/ Friends of NELHA**