AgriCos e-Newsletter
ISSN: 2582-7049
Volume: 02 Issue: 08 August 2021 Article No: 35

Sunscreen- A Protection for Humans, But a Threat to Corals

Sudarshan S[1], Karthik R[2], S. Aanand[3] and Jeyaprakashsabari, S[3]
[1]Dr. MGR Fisheries College and Research Institute, Thalainayeru, Nagapattinam.
[2]Senior Technician, CP Aquaculture (India) Private Limited, Andra Pradesh.
[3]Erode Centre for Sustainable Aquaculture, Bhavanisagar, Erode.

SUMMARY

Healthy coral reefs are amongst the valuable ecosystems on Earth. They provide billions of dollars in economic and environmental services, such as food, coastal protection, and tourism. However, coral ecosystems around the world face serious threats from several sources, including climate change, unsustainable fishing, land-based pollution, coastal development, disease, and invasive species. Surprisingly enough, scientists have discovered that chemicals found in sunscreen and other personal health products are threatening coral reef health.

INTRODUCTION

Ultraviolet radiation (UVR) in the sunlight, interact with living tissue and cause biochemical and physiological changes in exposed tissue. Unprotected exposure to UVR can cause sunburn, premature ageing and increased risk of skin cancers. UVR has been subdivided into three wavelength ranges: UVA (320-400 nm), UVB (290-320 nm) and UVC (200-290 nm). The UVA range (longer wavelengths) is associated with the lowest energies, the UVB range (intermediate wavelengths) with intermediate energies and the UVC range (shorter wavelengths) with the highest energies. On average 80%-90% of UVA, 1%-10% of UVB reaches the earth surface, while the UVC radiation is completely screened out by the earth's atmosphere and does not reach the surface. All three forms of UVR have been shown to cause various types of tissue damage (Raffa et al., 2018). UVA causes the formation of reactive oxygen species, which can damage DNA by creating breaks in the tertiary structure. UVB is absorbed by DNA and causes structural damage. In addition, UVR exposure causes mutations in p53 tumour suppressor genes which play an important role in DNA repair and cellular death (apoptosis) in cells that have sustained DNA damage. Analysis of p53 gene mutations induced by UVR shows a positive correlation between UVR exposure, DNA damage and skin carcinogenesis (Raffa et al., 2018**)**. Sunscreen ointments and applications have been designed to prevent such damage and have been in use since long back. With increasing awareness regarding the risks of sunburn, photo-ageing, and skin cancer, the demand for better-improved sunscreens has increased. This has led to the development of industry on its right.

Types of Sunscreen Filters

Organic and inorganic filters are used in sunscreen products worldwide. Sunscreens have been traditionally divided into chemical absorbers and physical blockers, based on their mechanism of action. Chemical sunscreens are generally aromatic compounds conjugated with a carbonyl group. These chemicals absorb high-intensity UV rays, producing excitation to a higher-energy state. Physical blockers reflect or scatter UVR. Microsized forms of physical blockers, also designated as inorganic particulates, also function in part by absorption. The commonest absorbents are para-aminobenzoic acid (PABA) and its derivatives, cinnamates, benzophenones, and salicylates, none of which offers significant protection against UVA. Dibenzoylmethane derivatives and anthranilates, which also work by absorbing radiation, are more effective UVA filters. Reflection inorganic components, such as zinc oxide and titanium dioxide, provide significant UVA protection, as well as good UVB protection. However, they are opaque and can leave a visible white film, despite the use of "microfine" particles in most products, and some users find them cosmetically less acceptable. There are 55 UV filters approved for sunscreen products globally, but only 16 have been approved in the United States (Shoko Mori, Steven Q. Wang, 2021).

Chemicals in Sunscreens that can Harm Marine Life:

Benzophenone-1, Oxybenzone, Benzophenone-8, OD-PABA, 4-Methylbenzylidene camphor, 3-Benzylidene camphor, nano-Titanium dioxide, nano-Zinc oxide, Octinoxate (ethylhexyl methoxycinnamate), Octocrylene are various chemicals used in popular sunscreens which can harm marine life (NOAA).

Effects of Benzophenone-2:

Benzophenone (BP) ultraviolet (UV) filters are one class of organic UV filters that are used in products to prevent burning of the skin by both UVA (320–400 nm) and UVB (280–320 nm) radiation. Sunscreen chemicals commonly used in many soaps, cosmetics, and body fragrances are highly toxic to corals **(Weisbrod et al., 2007)**. Even very low concentrations of benzophenone-2, or BP-2, can quickly kill juvenile corals.

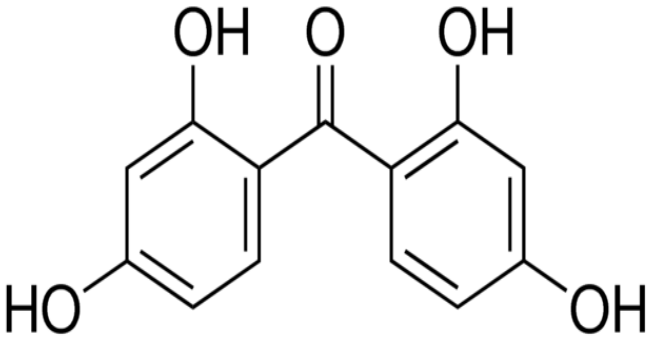

Fig 1. Chemical structures of Benzophenone-2

(Source : https://www.sigmaaldrich.com/)

BP-2 is an additive used in personal-care products since the 1960s to protect against the damaging effects of ultraviolet light. BP-2 causes bleaching of colourful corals, and potentially increase mutation in corals by DNA damage. Existing municipal wastewater treatment facilities do not remove BP-2, and discharges directly released in coastal waters of the Caribbean and the Indo-Pacific, are threatening near-shore coral reefs.

Effects of Oxybenzone (Benzophenone-3)

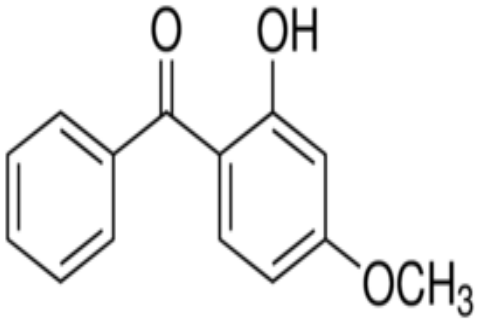

Fig 2. Chemical structures of Oxybenzone

(Source : https://www.sigmaaldrich.com/)

Oxybenzone (BP-3; benzophenone-3) often is used as an active ingredient in sunscreen lotions and personal-care products that protects against the damaging effects of ultraviolet light, such as body fragrances, hair-styling products, shampoos and conditioners, anti-ageing creams, lip balms, mascaras, insect repellants, as well as dishwasher soaps, dish soaps, hand soaps, and bath oils/ salts. BP-3 and other benzophenone derivatives often are found as contaminants in boating, residential, and municipal wastewater effluents and are considered ‘‘emerging environmental contaminants of concern’’ by the U.S. Environmental Protection Agency. In a 2016 study, a team of international scientists found that a common chemical in many sunscreen lotions and cosmetics is highly toxic to juvenile corals and other marine life. Oxybenzone, or BP-3, is found in more than 3,500 skincare products worldwide for protection against the sun's harmful effects. The compound has been found entering the environment both through wastewater effluent and directly from swimmers wearing sunscreens. It has been estimated that as much as 14,000 tons of sunscreen, some containing as much as 10% oxybenzone, is released into coral reef areas annually (Downs et al., 2016). Ninety per cent of snorkelling and diving sites occur on 10% of the world’s reefs, which puts approximately 10% of global reefs and up to 40% of coastal reefs at risk of coral bleaching. Four major toxic effects in early, developing coral is reported as, increased susceptibility to bleaching; DNA damage, skeletal endocrine disruptor (abnormal skeleton growth) and gross deformities of baby coral.

Effects of Octinoxate

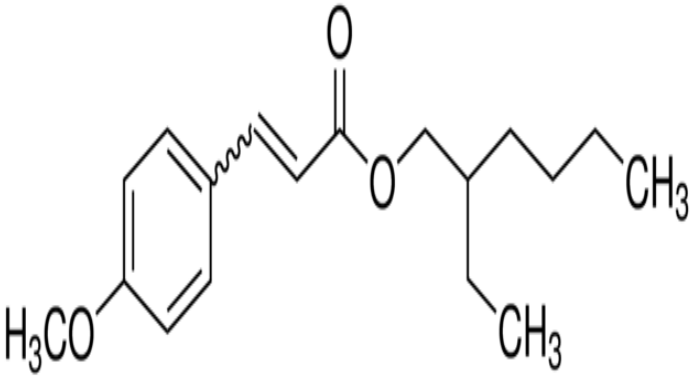

Fig 3. Chemical structures of Octinoxate

(Source : https://www.sigmaaldrich.com/)

Octinoxate is a cinnamate ester and a common ingredient in sunscreen and other skincare products to minimize DNA photodamage. It was originally developed in the 1950s as an organic UV-B filter that absorbs UV-B rays from the sun. It is often combined with nanoparticles or other water-resistant liposomes in formulations to increase the localization at the epidermis and decrease the risk of percutaneous absorption. Its use in pharmaceutical and cosmetic formulations is approved by FDA. It tends to work well in sunscreen formulas because it dissolves easily in oil. Octinoxate is a ubiquitous environmental contaminant – it is found in streams, rivers, lakes and marine environments from the Arctic Circle (Barrow, Alaska) to the beaches and coral reefs along the equator. It is considered an environmental hazard in many locations, and that may pose a significant risk to the aquatic environment. Octinoxate can be found in both municipal treated and desalinated drinking water. Sewage sludge can be heavily contaminated by Octinoxate and other Personal Care Product Chemical, further expanding the types of sources contaminating the environment (e.g., biosolids). Swimmers directly contaminate water sources, but point and non-point sewage and treated waste-water effluent discharge may be the largest source of contamination. Octinoxate is linked to endocrine disruption by an abundance of data, as well as to reproductive toxicity.

Effects of Octocrylene:

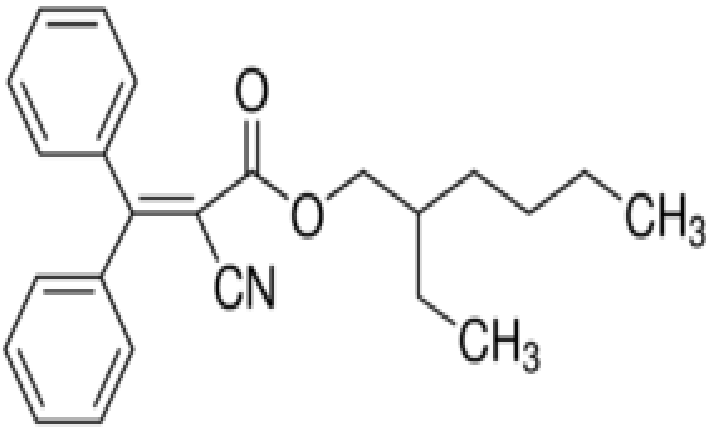

Fig 4. Chemical structures of Octocrylene

(Source : https://www.sigmaaldrich.com/)

Octocrylene (OC) is an ingredient used in many sunscreens and other cosmetics such as hair sprays, tannin oils, blemish balm creams, and conditioners. Hence, OC is continuously released into marine and freshwater environments from wastewater treatment plants and through more direct sources, namely, people bathing in these environments. OC also concentrates in the lipophilic tissues of aquatic organisms at various trophic levels, ranging from filtering organisms, such as mussels, to dolphins. oxybenzone, octinoxate, and octocrylene were identified in raw and treated water from wastewater treatment plants (Stien et al., 2018).

Effects of Sunscreen Threaten Corals and Other Marine Life

Sunscreen chemicals can affect marine life and the nature of the effect varies with type (NOAA).

- Green Algae: It impairs growth and photosynthesis.
- Mussels: It induces defects in the young.
- Sea Urchins: It damages immune and reproductive systems, and deform young.
- Fish: It decreases fertility and causes feminisation of male fishes.
- Dolphins: It can bio-accumulate and be transferred to young by vertical transmission.
- Coral: It induces bleaching, damages DNA, causes deformities on the young, and mortality

Reef Friendly Sunscreen Products

Fortunately, some sunscreens are still considered safe for coral reefs, such as zinc oxide, titanium dioxide and several others are currently available, and new substances are being investigated. Titanium dioxide (TiO2) and zinc oxide (ZnO) are the two most common physical UV filters used, working as a shield to the UV rays. As an alternative to sunscreen made with chemicals toxic to fish, corals and other marine life, mineral-based sunscreen is often used as a "reef friendly" option. While mineral-based sunscreens are better for the marine environment than sunscreens with toxic chemicals, such as oxybenzone, octinoxate and octocrylene, there are still risks associated with their use. Nowadays, these two compounds usually appear in nanoparticle (NP) sizes to improve the texture and spreadability of the sunscreen, making these products more appealing cosmetically. Moreover, the combination of both types of UV filters (organic and inorganic) is more effective and more frequently used in sunscreen composition, since it increases the protection factor.

Titanium Dioxide:

Fig 5. Commercially available sunscreen with titanium dioxide particles

The ideal sun screening agent would be chemically inert, safe, and absorb or reflect through the full UV spectrum. This UV filter can be safe in mineral sunscreen if it's used and processed under certain conditions. But, titanium dioxide is considered possibly carcinogenic when inhaled. So it's best to avoid this ingredient is aerosol spray sunscreens, dry powder sunscreens, and SPF powder cosmetics. TiO_2 meets these criteria, limited only by aesthetics. By reducing the particle size of this chemical to a microsize or ultrafine grade and making it less visible on the skin surface, some of these advantages could be used. Changing the form of these particles results in their functioning by absorption and not simply blocking (reflecting and scattering) UVR, making TiO_2 less effective in the UVA range than an opaque physical blocker. Even with this limitation, this ingredient can be classified as a broad-spectrum agent (Shoko Mori, Steven Q. Wang, 2021).

Zinc Oxide

Fig 6. porphyria cutanea tarda

(Source: https://www.healthline.com/health/porphyria-cutanea-tarda)

Fig 7. Some of commercially available sunscreens contain zinc oxide particles

(Source : https://www.travelandleisure.com/style/beauty/reef-safe-sunscreen)

Protection against UVA-1 is superior for zinc oxide (340–380 nm) than for TiO2, thereby providing more full-spectrum protection. Both organic and inorganic particulate microsized sunscreens are not very effective in the short-wavelength visible range—the Soret band—necessary for optimal protection of patients with porphyria cutanea tarda (PCT) or other porphyrias. Protective clothing and sun avoidance remain the mainstays of PCT UV exposure protective measures. Opaque physical blockers would be of some value for localized regions in these patients with PCT (Shoko Mori, Steven Q. Wang, 2021).

CONCLUSION

Even with government bans, certain types of sunscreen can be used to guard against burns and skin cancer. Use these tips on sunscreen and other ways to help you protect yourself and the corals.

- Use of reef-safe sunscreen free of harmful chmeicals. Choose mineral-based sunblocks that use zinc oxide or titanium dioxide of “non-nano” size particles that can’t be ingested by corals.
- Use of naturally available plant extracts with sunscreen property such as aloe vera.
- Avoiding sun exposure during peak sun hours (10 AM – 2 PM)
- Avoid usage of aerosol sunscreen sprayers. A part of aerosols from sunscreen sprayers lost during application process and fall to the sand, where it can easily wash into the ocean.

- Wearing hats, full sleve shirts, and other apparel incorporating UV protection can reduce the amount of sunscreen you need by up to 90 percent, and these items will likely last longer than a bottle of sunscreen.

REFERENCES

Downs, C.A., Kramarsky-Winter, E., Segal, R., Fauth, J., Knutson, S., Bronstein, O., Ciner, F.R., Jeger, R., Lichtenfeld, Y., Woodley, C.M. and Pennington, P., 2016. 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 US Virgin Islands. *Archives of environmental contamination and toxicology*, *70*(2), pp.265-288.

NOAA. Skincare Chemicals and Coral Reefs. National Ocean Service website, https://oceanservice.noaa.gov/news/sunscreen-corals.html, 10/07/2021.

Raffa, R.B., Pergolizzi Jr, J.V., Taylor Jr, R., Kitzen, J.M. and NEMA Research Group, 2019. Sunscreen bans: Coral reefs and skin cancer. *Journal of clinical pharmacy and therapeutics*, *44*(1), pp.134-139.

Schneider, S.L. and Lim, H.W., 2019. Review of environmental effects of oxybenzone and other sunscreen active ingredients. *Journal of the American Academy of Dermatology*, *80*(1), pp.266-271.

Shoko Mori, Steven Q. Wang, 50 - Sunscreens. In: Wolverton SE, editor. *Comprehensive Dermatologic Drug Therapy (Fourth Edition)*. Elsevier; 2021:565–575.e2.

Stien, D., Clergeaud, F., Rodrigues, A.M., Lebaron, K., Pillot, R., Romans, P., Fagervold, S. and Lebaron, P., 2018. Metabolomics reveal that octocrylene accumulates in Pocillopora damicornis tissues as fatty acid conjugates and triggers coral cell mitochondrial dysfunction. *Analytical chemistry*, *91*(1), pp.990-995.

Weisbrod, C.J., Kunz, P.Y., Zenker, A.K. and Fent, K., 2007. Effects of the UV filter benzophenone-2 on reproduction in fish. *Toxicology and applied pharmacology*, *225*(3), pp.255-266.