Safer Sun

A White Paper on Sunscreen Ingredients, Labels, and Sun Protection

A hazard-based evaluation of sunscreen ingredients and formulations
Final Report - October 29, 2026

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Intelligence

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Executive Summary

Sunscreen selection should consider both sun-protection capacity and product chemistry. Yet the range of active ingredients, formulations, and marketing claims can make it difficult for consumers to know where to begin. Ultraviolet (UV) radiation contributes to sunburn, premature skin aging, and skin cancer. Broad-spectrum sunscreen helps protect against both ultraviolet A (UVA) and ultraviolet B (UVB) radiation, while sun protection factor (SPF) primarily describes protection against UVB.[1] Sunscreen is most effective as part of a layered strategy that also includes protective clothing, hats, UV-blocking sunglasses, shade, and attention to time of day. Shade alone may not provide complete protection because UV radiation can be diffused or reflected from nearby surfaces.

Consumers should look for a broad-spectrum, non-spray sunscreen containing non-nanomaterial zinc oxide and/or titanium dioxide, review the complete ingredient list, apply an adequate amount, and reapply as directed. Sun exposure also plays a role in vitamin D production, as vitamin D is synthesized in the skin in response to UVB radiation, and nearly one in four people in the United States have vitamin D levels considered too low or inadequate.[2]

High-Level Findings

- SPF alone does not measure full sun protection. SPF mainly describes protection against UVB, the main cause of sunburn, while UVA contributes to premature skin aging and skin cancer.[3] A “broad-spectrum” label is what signals UVA protection. Protection also doesn’t rise in step with the SPF number: SPF 15 filters about 93% of UVB, SPF 30 about 97%, and SPF 50 about 98%.[4]
- Several widely used chemical filters still have outstanding safety questions. The US Food and Drug Administration (FDA) requested additional data before it can classify avobenzone, homosalate, octinoxate, or oxybenzone as generally recognized as safe and effective. However, that request does not by itself mean they are unsafe.[5] Laboratory and animal studies have reported endocrine-related activity for several of these filters,[6] and UV filters including octinoxate have been detected in human urine, blood, and breast milk.[7]
- Oxybenzone and octinoxate are linked to coral harm, but “reef safe” is not a reliable guide. Oxybenzone has been shown to harm coral larvae and cells and to turn phototoxic inside corals and sea anemones,[8] and Hawaii has restricted sunscreens containing oxybenzone or octinoxate since 2021.[9] “Reef safe” has no standardized definition, and other active and inactive ingredients can also be toxic to aquatic life. California now restricts these claims.[10]
- Newer is not automatically better. Bemotrizinol, added by the FDA in 2026 as the first new US sunscreen active ingredient in more than 20 years, offers UVA and UVB protection with low systemic absorption.[11] However, it dissolves poorly in water, is expected to settle into soil and sediment, and resists degradation, leaving its long-term environmental behavior uncertain.[12]

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- Non-nanomaterial mineral filters are the preferred choice. The FDA has proposed classifying zinc oxide and titanium dioxide as “generally recognized as safe and effective”, or GRASE, at concentrations up to 25%.[13] Nanoscale particles can behave differently in the body and the environment, and some have caused coral stress in laboratory studies.[14] Lotions, creams, and sticks avoid the inhalation concerns of sprays and loose powders, and many spray sunscreens are also flammable.[15]
- Sunscreen works best as one layer of protection. A typical beach umbrella may provide only about SPF 3–7 in real-life conditions,[16] and in a randomized trial, umbrella shade alone did not prevent sunburn as reliably as high-SPF sunscreen.[17] Car side windows block far less UVA than windshields.[18] Clothing, hats, sunglasses, shade, and timing all add protection.

In simple terms: choose a broad-spectrum, non-aerosol spray, non-nanomaterial mineral product you will actually apply generously and reapply, used alongside clothing, shade, and good timing rather than in place of them.

Purpose and Scope

This report evaluates common sunscreen active ingredients and the broader formulation features that may affect human health or ecosystems. It focuses on ingredients and claims that consumers can realistically identify on a label, while acknowledging that ingredient lists do not always reveal particle size, manufacturing residues, proprietary mixtures, or the environmental fate of the finished formulation.

A hazard-based approach asks whether a substance has inherent properties that warrant concern, such as endocrine activity, reproductive toxicity, sensitization, aquatic toxicity, persistence, bioaccumulation, or major data gaps. A hazard identified in this report is not automatically a demonstrated risk in every product or use.

Sun Protection in Context

UVA and UVB Radiation

Ultraviolet (UV) radiation is invisible to the naked eye. UVA has a longer wavelength and penetrates more deeply into the skin. It contributes to premature skin aging and also plays a role in skin cancer. UVB has a shorter wavelength, is the main cause of sunburn and direct skin damage, and also contributes to skin cancer. Effective sun protection addresses both. The SPF value indicates protection against UVB, while “broad-spectrum” on the label means UVA is covered too, so the best choice is a product that lists both.[19]

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Choosing the Right SPF

SPF stands for sun protection factor. It is based primarily on protection against UVB-induced sunburn under laboratory test conditions. The relationship is not linear: increasing from SPF 30 to SPF 50 provides a relatively modest increase in UVB protection. Higher SPF can still provide a useful margin, especially because most people apply less sunscreen than the amount used in laboratory testing, but no SPF blocks all UV radiation.

Labeled SPF	Approximate UVB Filtered	Interpretation
15	93%	Provides meaningful protection, but less margin for under-application.
30	97%	Is the common minimum recommendation for routine outdoor use.
50	98%	Provides slightly more UVB filtering and greater margin for under-application.

Table 1. Approximate UVB filtering under test conditions; actual protection depends on amount applied, coverage, water exposure, friction, and reapplication.[20]

Remember: Broad-Spectrum Matters

Choose a product labeled “broad-spectrum” so that UVA protection accompanies the labeled UVB/SPF protection. Sunscreen should be applied generously and reapplied according to the label, especially after swimming, sweating, or toweling off.[21]

What’s Inside Conventional Sunscreen

Conventional sunscreens may contain active UV filters, nanoscale particles, and numerous inactive ingredients. The full formulation determines spreadability, water resistance, stability, scent, skin feel, and shelf life. It also determines the product’s complete human health and environmental profile.

Active UV Filters

UV filters reduce the amount of ultraviolet radiation reaching the skin. The familiar distinction between “chemical” filters and “physical” or “mineral” filters is useful for shopping, but is often oversimplified. Both organic and mineral filters primarily absorb UV energy. Zinc oxide and

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titanium dioxide can also scatter and reflect a portion of incoming light. Coverage differs by ingredient and formulation.

Inactive Ingredients and the Rest of the Formula

Sunscreens also contain ingredients serving other functions, including preservatives, emulsifiers, emollients, moisturizers, solvents, alcohols, film formers, thickeners, fragrance ingredients, colorants, and photostabilizers. Some can be associated with irritation, sensitization, persistence, aquatic toxicity, or contamination concerns. A safer active ingredient does not automatically make the entire product preferable.

Sunscreen use may enhance the penetration of pesticides, such as ingredients in some bug sprays, or other substances present in or used alongside the formulation. Some sunscreen formulations have increased dermal absorption of pesticides, and occupational pesticide exposure can be affected by the protective measures used.[22]

Nanomaterials and Delivery Format

Nanoparticles are generally measured in billionths of a meter and can be roughly 1,000 times smaller than the width of a human hair. In sunscreens, nanoscale forms are most commonly associated with titanium dioxide and zinc oxide. Their potential human health and environmental effects have not been fully characterized across all particle types and use conditions. Small particle size can reduce the visible white cast of a mineral sunscreen, but it can also alter chemical reactivity, mobility, bioavailability (the amount available to enter or interact with the body), and environmental behavior.

Particle-size questions cannot be separated from the route of exposure. Evidence for an intact-skin lotion does not automatically establish safety for an aerosol, powder, or product likely to be inhaled. Researchers still have important data gaps about how different nanoparticles behave in people and ecosystems. Laboratory studies have also reported coral stress or adverse effects from some nanoscale zinc oxide and titanium dioxide materials, although results vary by coating, concentration, species, and test conditions. [23]MADE WISE Certified™ and MADE SAFE® Certified products therefore require non-nanomaterial documentation for mineral filters and do not permit inhalable titanium dioxide applications. For consumers, creams, lotions, and sticks are generally easier to control than loose powders or aerosol sprays.

Ingredient Profiles

The sections below summarize each active filter's UV coverage, human health considerations, and environmental considerations. Avobenzone, homosalate, octinoxate, and oxybenzone are among the ingredients for which the FDA has requested additional data. That request does not, by itself, mean that an ingredient has been found unsafe.[24]

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Avobenzone

Avobenzone is widely used because it provides broad UVA protection. Experimental research has reported endocrine-related and metabolic effects, while aquatic studies have identified behavioral, physiological, and endocrine-related effects in organisms such as Daphnia and zebrafish, including effects associated with mixtures of avobenzone and other UV filters.[25]

The FDA's proposed sunscreen order listed avobenzone among the active ingredients for which additional data were needed to support a positive GRASE determination. A positive GRASE determination means the FDA has sufficient evidence to conclude that an over-the-counter sunscreen active ingredient is safe and effective when used as directed. The FDA has emphasized that this status is not the same as a conclusion that avobenzone-containing sunscreens are unsafe.[26]

Homosalate

Homosalate is a very commonly used UVB absorber. A European scientific review found that some studies suggest possible endocrine activity, although it judged the evidence inconclusive and supported tighter concentration limits than were historically used in some products.[27] Aquatic studies have also examined homosalate alone and in mixtures with other UV filters.[28]

Homosalate also warrants environmental scrutiny because aquatic effects have been reported and its environmental fate remains relevant to repeated releases.

Octinoxate

Octinoxate is a widely used UVB filter that may appear on labels as octinoxate, octyl methoxycinnamate, ethylhexyl methoxycinnamate, methoxycinnamate, or OMC. Animal studies and reviews have reported endocrine activity and reproductive or developmental effects.[29] Biomonitoring studies have detected UV filters, including octinoxate, in human samples such as urine, blood, and breast milk, demonstrating exposure but not establishing a health outcome on its own.[30]

Octinoxate is toxic to aquatic life and has been implicated in coral-related effects. Hawaii enacted legislation in 2018 that prohibited the sale and distribution of nonprescription sunscreens containing octinoxate or oxybenzone beginning in 2021.[31]

Oxybenzone

Oxybenzone, also called benzophenone-3 or BP-3, was historically one of the most commonly used sunscreen filters, although its use has declined in recent years. It absorbs both UVB and some UVA. It is distinct from benzophenone, another chemical name that may appear in sunscreen-related discussions. Oxybenzone has been associated with skin and eye irritation, contact allergy, photoallergy (an allergic response that is triggered when chemical exposure is followed by light), and endocrine-related activity, meaning potential interference with normal hormone signaling.[32]

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Environmental concerns are especially prominent. Laboratory and field research has reported toxicity to coral larvae and cells, phototoxic transformation in coral and sea anemone systems, and contamination in heavily visited marine environments.[33] Reflecting these environmental concerns, Hawaii's 2021 restriction covered oxybenzone.[34]

Bemotrizinol: A Newer US Option with a Different Tradeoff

On June 9, 2026, the FDA announced a final order adding bemotrizinol as the first new active sunscreen ingredient in the US in more than 20 years; the order took effect on August 9, 2026. Bemotrizinol is photostable, protects against both UVA and UVB, and has low systemic absorption. The FDA concluded that it is GRASE at concentrations up to 6% under the conditions in the final order, including use by adults and children 6 months and older.[35]

The action followed federal efforts to modernize the US process for evaluating over-the-counter sunscreen ingredients, including sunscreen-review provisions enacted in 2025 as part of Public Law 119-37. Bemotrizinol has a longer history of use and regulatory review in other markets, including the European Union and Canada.[36]

The review for MADE SAFE® Certification, however, extends beyond direct human health endpoints. Bemotrizinol is very poorly soluble in water, is expected to partition into soil and sediment, and has been characterized as resistant to degradation, leaving uncertainty about long-term environmental behavior.[37]

Mineral Filters and Nanomaterials

Zinc Oxide

Zinc oxide is a naturally occurring mineral UV filter that can provide broad-spectrum protection across UVA and UVB. The FDA has proposed classifying zinc oxide as GRASE for sunscreen use at concentrations up to 25%, based in part on evidence of minimal penetration below the outermost skin layer.[38]

MADE WISE Certified™ and MADE SAFE permit zinc oxide in non-nanomaterial form. Its key strength is its ability to provide broad-spectrum coverage as a single active filter, though it can leave a white cast on the skin. Its environmental effects depend on particle size and the full formulation, and further research is still needed to understand how nanoscale zinc oxide behaves across formulations and environmental compartments. A label that says "mineral" does not necessarily disclose particle size, so certification provides stronger verification.

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Titanium Dioxide

Titanium dioxide is a naturally occurring mineral that provides strong UVB protection and some UVA protection. Still, it may not provide complete UVA coverage on its own, so it is often paired with zinc oxide or another UVA filter. The FDA has proposed classifying titanium dioxide as GRASE for sunscreen use at concentrations up to 25%.[39]

MADE WISE Certified™ and MADE SAFE® allow non-nanomaterial titanium dioxide in defined topical applications where inhalation is not expected. Aerosols, loose powders, and other applications that can create respirable particles are not permitted. Particle size also affects the environmental profile, and aquatic data for nanoscale forms remain limited. Consumers should choose non-spray mineral products and avoid inhaling any sunscreen powder or mist.

MADE WISE Certified and MADE SAFE documentation must demonstrate that the material's primary particle size is greater than 100 nanometers. This threshold is used to distinguish non-nanomaterial forms for certification review.

Environmental Considerations

Why Coral Reefs Matter

Coral reefs support extraordinary biodiversity, fisheries, and tourism economies. They also reduce wave energy and help protect coastlines from storms and erosion. Reefs also take part in carbon and nutrient cycling.[40]

Sunscreen is only one of many stressors affecting coral ecosystems; climate change, warming seas, ocean acidification, pollution, sedimentation, and overfishing are also major drivers. Even so, avoiding unnecessary releases of biologically active or persistent UV filters is a practical way to reduce one local source of chemical pressure.

Aquatic Toxicity and Environmental Fate

Some organic UV filters have demonstrated acute or chronic toxicity to fish, invertebrates, algae, or coral-related organisms. Environmental fate matters too. A substance that does not dissolve easily in water may settle into sediment or soil and accumulate there instead of being transported away. Persistence can extend exposure over time, while bioaccumulation potential can increase concern across organisms and food webs.
Oxybenzone and octinoxate have the strongest public association with coral concerns, but "reef safety" cannot be reduced to a two-ingredient checklist. Other active filters and inactive ingredients can also have aquatic toxicity, persistence, or data-gap concerns. The complete formulation, particle size, use pattern, wastewater pathway, and local ecosystem conditions all influence environmental impact.

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Understanding “Reef Safe” Claims

There is no standardized authoritative definition or certification protocol for the term “reef safe.” A sunscreen may use the phrase while containing ingredients that are restricted in some jurisdictions or remain poorly characterized with respect to their environmental impacts. Read the Drug Facts panel and ingredient list rather than relying on front-label imagery or marketing language.

States have begun responding to these claims. In September 2026, California enacted a law that restricts the use of “reef safe,” “reef friendly,” “ocean safe,” and similar claims on sunscreens unless the product is free of certain chemical UV filters.[41] The regulatory landscape may continue to change, so ingredient-level review remains more durable than a marketing claim.

Choosing and Using Sunscreen

- Choose broad-spectrum. This confirms that the product has been tested for proportional UVA protection in addition to its UVB/SPF claim.
- Look for non-nanomaterial zinc oxide and/or titanium dioxide as the active ingredient. Zinc oxide is the most straightforward single-filter option for broad-spectrum mineral coverage.
- Prefer lotions, creams, and sticks over aerosol sprays or loose powders. These formats reduce inhalation concerns and make coverage easier to see and control.
- Review the entire ingredient list. Fragrances, preservatives, alcohols, film formers, and other inactive ingredients can affect irritation, sensitization, and environmental impact.
- Choose a product you will apply consistently. Texture, skin tone compatibility, water resistance, and comfort matter because an unused “ideal” sunscreen provides no protection.
- Look for third-party certification. MADE WISE Certified™ and MADE SAFE® seals verify more than the front-label active ingredient and screen intentionally added substances through a human health and ecosystem framework.

Spray Sunscreen Considerations

Spray sunscreens can be difficult to apply evenly and can leave missed areas. Aerosol and propellant-containing products also raise inhalation and flammability concerns, while alcohol-rich formulas may sting or dry out sensitive skin. Avoid inhaling the spray and apply it in a well-ventilated area. The FDA warns that many spray sunscreens contain alcohol and can catch fire, so keep them away from open flames.[42]

When a spray is the only available option, do not spray directly onto the face.[43] Spray onto the hands first, then apply to the face, and follow the label closely. For children, mineral lotions or sticks are generally easier for a parent to apply.

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Application Is Part of Performance

- Apply enough product to cover all exposed skin. Thin or patchy application lowers protection.
- Reapply as directed, especially after swimming, sweating, toweling, or prolonged outdoor exposure.
- No sunscreen, regardless of SPF, provides unlimited sun protection. Limit time in the sun, especially when rays are most intense.
- Check the expiration date and store the product as directed. Heat and age can affect efficacy and performance.
- Use a separate lip product with SPF when lips are exposed, and avoid inhaling or ingesting loose mineral particles.

Layered Sun Protection

Cover Up and Find Shade

Clothing and hats provide an additional physical barrier. Color, fabric, material, and weave all affect protection. In general, a tighter weave and greater coverage provide more protection. Purpose-made UPF (ultraviolet protection factor) clothing can simplify the choice. Seek shade and reduce time in the strongest direct sun when practical. The FDA advises limiting time in the sun, especially between 10 a.m. and 2 p.m.,[44] so choose earlier in the morning or later in the afternoon for lower-intensity outdoor time. Local UV intensity still varies by season, latitude, altitude, cloud cover, and reflection, so time of day should be combined with the local UV index and other protection.

Protect the Eyes

Wear UV-blocking sunglasses and consider a hat with a brim. Eye protection matters because UV exposure affects not only the skin, but also ocular tissues.

Beach Umbrellas: Useful, but Not Complete

Umbrellas reduce direct overhead sunlight, but diffuse UV and radiation reflected from sand or water can still reach the skin. Modeling and field research estimated that a typical umbrella may provide only about SPF 3–7 in real-life conditions, and a randomized beach trial found that umbrella shade alone did not prevent sunburn as reliably as high-SPF sunscreen.[45] Use an umbrella as one layer, not as a substitute for sunscreen and protective clothing.

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Sun Exposure Inside Vehicles

Vehicle glass generally blocks UVB more consistently than UVA. Front windshields tend to provide high UVA protection, while side-window protection is lower and more variable. One US study found an average UVA blockage of 96% for windshields, with side windows providing substantially less protection.[46] On long drives or during frequent commuting, cover exposed skin and use broad-spectrum sunscreen as needed.

Vitamin D Without Oversimplifying Sun Exposure

UVB exposure triggers vitamin D synthesis in the skin. Vitamin D is not absorbed directly from sunlight. Very few foods naturally contain substantial vitamin D, although fortified foods and supplements can contribute. Nearly one in four people in the US have vitamin D levels considered low or inadequate.[47]

Vitamin D needs vary with age, skin pigmentation, geography, season, diet, health conditions, and other factors. Intentionally seeking unprotected sun exposure is not risk-free. People concerned about vitamin D should discuss diet, testing, and supplementation with a qualified health professional rather than overexposing skin.

Conclusion

Sunscreen is an essential tool, but not all sunscreens are equal, and sunscreen alone is not complete sun protection. SPF describes only part of a product's protection; active ingredients differ in their human health and environmental profiles; and marketing terms such as "reef safe" do not reliably reflect what is in the bottle.

For most people, the simplest path is a broad-spectrum lotion, cream, or stick made with non-nanomaterial zinc oxide and/or titanium dioxide, applied generously and reapplied as directed. Reading the full ingredient list, not just the front label, helps avoid inactive ingredients of concern, and third-party certification can verify details a label leaves out, such as particle size.

No sunscreen blocks all UV radiation. Pairing it with protective clothing, a brimmed hat, UV-blocking sunglasses, shade, and attention to the time of day offers the most dependable protection, while still allowing families to enjoy time outdoors.

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About MADEWORKS Intelligence

MADEWORKS Intelligence (formerly MadeSafe.org) has been driving marketplace change since 2015. We are building a bridge to a safer, more sustainable future for all. Using the MADE Ecosystem Approach, MADEWORKS Intelligence generates insights that support better product development and advance systemic change. By bringing together science, industry leadership, and informed consumer choice, we help turn meaningful information into action, transforming the marketplace for a healthier world.

MADEWORKS Intelligence is a project of Nontoxic Certified Inc., a registered 501(c)(3) nonprofit organization.

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