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The State of Sunscreens in the US: *Caveat Emptor*

Lisa Akintilo MD MPH,[a] Ellen Gendler MD[b]
[a]The Ronald O. Perelman Department of Dermatology, New York University Grossman School of Medicine, New York, NY
[b]Gendler Dermatology, New York, NY

INTRODUCTION

Why write another review about sunscreens?

The sunscreen market is complex, competitive and confusing to consumers and healthcare providers alike. Because dermatologic patients look to their providers for expert advice about sun protection, it behooves us to offer accurate information and practical guidelines for obtaining the best products, especially because many of the private label offerings many dermatologists dispense in their offices are inferior in their efficacy.

UV Radiation, simplified

The majority of ultraviolet radiation (UV) reaching the surface of the earth is UVA (320-400nm), which consists of UVA2 (320–340nm) and UVA1 (340–400nm). UVA, which penetrates most deeply into the skin, is widely believed to be the primary cause of photoaging, including melasma and other dyschromias. It also causes the immediate pigment darkening seen during and immediately after sun exposure and are the predominant rays used in tanning booths. UVA also suppresses the immune system and has been shown to be correlated with the development of melanoma.[1]

UVB (290–320 nm), with its increased risk of sunburn compared to UVA, is associated with the delayed tanning that peaks about 3 days after sun exposure, usually after a sunburn, and appears to contribute to the development of actinic keratoses and skin cancers such as squamous cell carcinoma, basal cell carcinoma, and melanoma.[2]

While UVC (200–290nm), with the highest energy of the ultraviolet spectrum, would theoretically carry the highest risk of sunburn, it penetrates the least into skin and is mostly absorbed by the ozone layer, so this is not a big concern.

Visible light, encompassing wavelengths from 380–740nm, is frequently overlooked as a significant contributor to dyspigmentation, and should be a consideration for patients with this issue.

Infrared light (heat) includes longer wavelengths than visible light, from 700nm to 1mm.[2,3] Some studies show infrared can have beneficial effects on skin texture and wrinkles by stimulating fibroblasts to produce collagen and elastin.[4] Light-emitting diodes (LED) produce light in the ultraviolet, visible, and near-infrared ranges of the electromagnetic spectrum and have been found to have some photomodulatory effects on the skin.[5]

How should we explain SPF to our patients?

One of the biggest hurdles to making informed choices in sunscreen selection is correcting misconceptions about what SPF actually stands for. SPF, or sun protective factor, is a relative measure of how long a product protects one from UVB only; it makes no reference to protection from other light wavelengths. This in part explains why patients who use high SPF products don't burn, but do tan; they are often inadequately protected from UVA. Products with high SPF does not lead to protection from deeper-penetrating wavelengths such as UVA. To add to the confusion, in the US, sunscreens containing only a modicum of UVA protection are permitted to be categorized as broad-spectrum. Unfortunately, given the lack of significant UVA protection in these "broad spectrum" sunscreens, fair-skinned individuals using such products for a few hours at the beach may protect themselves from UVB (and thus sunburn) but could get as much UVA exposure as if they had done several sessions at a tanning salon.[6]

Many sunscreens manufactured outside the US include a secondary notation system for persistent pigment darkening (PPD) in addition to SPF. The key difference between the two systems is that PPD pertains to UVA, while as previously mentioned, SPF refers to UVB. Furthermore, a new category of UVA protection called PA (Protection Grade of UVA) has simplified the older PPD scheme by rating products with the use of plus signs—the more plus signs present, the more UVA protection afforded. The use of PPD and PA scoring, combined with SPF, will allow more intelligent choices in sun protection.

What is the difference between sunscreen and sunblock?

Another key distinction is that between sunscreens and sunblocks, given that "sunscreen" has become a colloquialism for any sun protective product. Sunscreen refers to chemical sun protectants that absorb UV photons, while sunblock refers to physical blockers that actually scatter UV photons.

What are the commonly used ingredients in chemical sunscreens in the US?

The primary chemicals used in American sunscreens to protect against UVB by means of absorption include cinnamates, salicylates, benzophenones (including oxybenzone and dioxybenzone), octocrylene, ensulizole, and camphor derivatives. (Use of aminobenzoates, the most potent UVB absorbers, has almost entirely disappeared as the FDA has shown that aminobenzoic acid (PABA) and trolamine salicylate

are not safe or effective for use as sunscreens.[7]) While benzophenones have the added ability to minimally absorb UVA in the 320-340nm spectrum, they also are a well-known contact allergen and photosensitizer.[2,3,8,9] Of note, oxybenzone has been under scrutiny due to studies showing significant skin absorption and potential endocrine system disruption.[3,10] Furthermore, oxybenzone and octinoxate (also as octyl methoxycinnamate) may be harmful to coral reefs; bills have been signed in both Hawaii and Key West banning the sale of sunscreens containing either of these starting in 2021.[11,12]

Avobenzone is the sole chemical approved by the FDA to afford UVA protection. Unfortunately, it is a highly unstable compound that shields only a small fraction of UVA. To mitigate this, stabilizers are frequently added in an attempt to retard its degradation by UV, and these combinations are often afforded proprietary names, such as "Helioplex" or "Cell-Ox Shield," to name a few. Stabilizers may include ingredients like octocrylene or anti-oxidants/anti-inflammatories such as vitamin C, vitamin E, and botanical extracts.[2,13,14]

Which chemical sunscreen ingredients can be used in products manufactured outside the US, and how do they differ from Avobenzone?

A variety of sunscreen ingredients are used outside the US which are not FDA-approved and differ from US products in that they offer significantly increased UVA protection. The four primary ingredients targeting UVA in these sunscreen products include: Mexoryl SX (terephthalylidene dicamphor sulfonic acid), Mexoryl XL (drometrizole trisiloxane or ecamsule), Tinosorb S (also known as bemotrizinol or bis-ethylhexyloxyphenol methoxyphenyl triazine), and Tinosorb M (also known as bisoctrizole or methylene bis-benzotriazolyl tetramethylbutylphenol). These compounds offer better protection from UVA and free radicals than avobenzone and are frequently found in Asian, European, and South American sunscreens. Of note, the only two commercially available Mexoryl SX-containing products in the US are LaRoche-Posay Anthelios SX SPF 15 and Anthelios SPF 40, which were approved by the FDA in 2006 as complete products; the individual ingredient Mexoryl SX has not yet been approved.

According to the FDA in 2015, companies pursuing FDA approval for the four aforementioned sun-filtering chemicals have not yet provided enough evidence regarding their efficacy and safety,[8] in spite of many years of safe use abroad. As such, it is unfortunate that these ingredients can't be incorporated into US-manufactured sunscreen products because, according to a 2015 study, US sunscreens allow three times as much UVA penetration as do European sunscreens.[15] In 2016, the Environmental Working Group estimated that 49% of US beach and body sunscreens could pass the FDA broad spectrum test but not the European UVA test.[16] A 2017 study found that of a small sample of US sunscreen brands targeting UVA rays, nearly half did not pass the standards set by the European Union for assessing UVA protection.[17]

It has become much easier for the US consumer to access superior sunscreen products as the internet and international travel (currently limited by the COVID-19 pandemic) have flourished in recent years. As such, dermatologists well-versed in the subject should consider recommending those previously elusive Asian or European products to their patients as a way to better counter the harmful effects of UVA. Consumers must be careful to review ingredient lists when they are purchasing products online or in foreign pharmacies and to be aware that European and Asian products do not uniformly contain these ingredients, often using the same basic ingredient list as US-manufactured products. Some companies produce disparate products for each market, which means that the European version made by one company is generally entirely different from its US counterpart, in spite of very similar packaging.

How do physical sunblocks compare to chemical sunscreens?

Physical sunblock ingredients include titanium dioxide and zinc oxide. Both offer protection to some degree against UVA, UVB, and visible light by reflecting and refracting UV photons. However, it is important to counsel patients that zinc oxide has been shown to be far superior to titanium dioxide in UVA protection because of larger particle size, though possibly slightly less effective against UVB.[2] The increased effectiveness of zinc oxide against UVA must be balanced against its chalky white appearance , which sometimes makes it less cosmetically appealing than titanium dioxide, which is frequently used as a makeup "primer" when combined with silicones. However, recent developments in manufacturing have led to more elegant formulations, using decreased particle size and even nanoparticles. The use of tinted products has become increasingly popular, particularly among patients with skin of color.

Why is an awareness of sunscreens and sunblocks important for dermatologists?

It should be expected that dermatologists understand the fundamentals of chemical sunscreens and physical sunblocks since we manage conditions strongly affected by UV radiation. For example, one of the mainstays of melasma treatment is effective sun protection by minimizing exposure to UVB as well as the pigment darkening effects of UVA. Furthermore, melasma patients also need to avoid UVC and visible light; as such, iron oxide in sunscreen or cosmetic products can be quite important in their treatment regimen.

What about antioxidants in sun protective agents?

Antioxidants can also be part of the toolbox to treat pigmentary disorders such as melasma, as they can help target the reactive

TABLE 1.

UVA-Protecting Ingredients to Look For in Sunscreen Products	
Ingredient	**Availability**
Mexoryl SX (terephthalylidene dicamphor sulfonic acid)	Asia, Europe, South America
Mexoryl XL (drometrizole trisiloxane or ecamsule)	Asia, Europe, South America
Tinosorb S (bemotrizinol or bis-ethylhexyloxyphenol meth-oxyphenyl triazine)	Asia, Europe, South America
Tinosorb M (bisoctrizole or methylene bis-benzotriazolyl tetramethylbutylphenol)	Asia, Europe, South America
Avobenzone	USA

TABLE 2.

UVB-Protecting Ingredients to Avoid in Sunscreen Products	
Ingredient	**Reason**
Aminobenzoates	PABA sensitivity, contact/ photo allergen
Trolamine salicylate	FDA showed not safe/effective
Benzophenones	Contact/photo allergen
Oxybenzone	Significant skin absorption, harmful to coral reefs
Octinoxate (octyl methoxycinnamate)	Harmful to coral reefs

oxygen species (ROS) created by UV rays. Vitamin C, vitamin E, silymarin, and green tea polyphenols have all been utilized in sun protective products,[3,19] as have botanical extracts which function as anti-inflammatories in sunscreen products such as licorice, aloe, and chamomile.[14] While some of these anti-inflammatories may decrease skin redness by targeting ROS, they have no impact on the amount of UV radiation hitting the skin, and we should make patients aware of this.

CONCLUSIONS

In conclusion, American sunscreens remain effective at minimizing sunburn but are more limited in their protection against UVA mediated skin disorders such as photoaging and non-melanoma skin cancers compared to certain international products. Fortunately, mineral blockers which protect against both UVA and UVB are becoming more widely used as formulations have been improved. The time has come in this complex, confusing, and competitive sunscreen market for dermatologists to take the lead in providing a framework by which our patients can make informed choices. We provide this summary as an aid to ensure that we provide our patients with clear, concise, and helpful information regarding sun protection.

DISCLOSURES

The authors have no conflict of interest.

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AUTHOR CORRESPONDENCE

Ellen Gendler MD
E-mail:..... ellengendlermd@gmail.com