Sunscreens
A Review of Health Benefits, Regulations, and Controversies

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KEYWORDS

• Photoprotection • Skin cancer prevention • Sunscreen controversies • Sunscreen regulations

KEY POINTS

- Regular sunscreen use prevents the development of actinic keratosis (AK), squamous cell carcinoma (SCC), melanoma, and photoaging associated with sun exposure.
- Food and Drug Administration (FDA) final ruling on labeling and effectiveness testing adopted the critical wavelength (CW) test to assess ultraviolet (UV)-A filtering capacity; only products with CW greater than or equal to 370 nm can claim broad-spectrum status.
- Safety profiles of sunscreens have been called into question, but current studies show that sunscreens are safe and effective.
- Appropriate application and improved compliance remain the major challenges that limit the effectiveness of sunscreen use.

INTRODUCTION

Skin cancer is the most common cancer in the United States. Over the past decades, both the incidence and the mortality of skin cancer have been rising. Current estimates of nonmelanoma skin cancer suggest that more than 2 million Americans are affected annually and 1 in 5 Americans will be affected in their lifetime.[1,2] UV light plays a major role in the development of skin cancer.[3] Exposure to sunlight has been attributed to nearly 90% of nonmelanoma and 65% of melanoma skin cancers.[4,5] Therefore, protecting from UV light is a major strategy in the prevention of skin cancer.

UV light is classified into different wavelengths: UV-C (270–290 nm), UV-B (290–320 nm), UV-A2 (320–340 nm), and UV-A1 (340–400 nm).[6] UV-C is filtered by the ozone layer and does not reach the surface of the earth. Compared to UV-B radiation, UV-A penetrates deeper into the skin and reaches the dermis. The intensity of UV radiation that reaches the skin depends on several environmental factors including latitude, altitude, season, cloudiness, and time of day.[7] As UV radiation travels through the skin, DNA, lipids, and proteins absorb UV energy causing direct and indirect damage to nearby structures.[8,9] High-energy UV-B rays cause direct damage to DNA by creating covalent bonds between pyrimidine bases.[10,11] These bonds have a high mutagenic potential and need to be corrected by DNA repair mechanisms. Indirect damage is caused by both UV-A and UV-B light, resulting in the formation of reactive oxygen species, oxidative DNA damage, and activation of inflammatory cytokines.[12–14] Ultimately, these molecular insults result in sunburns, pigment darkening, suppression of cellular immunity, premature aging, and photocarcinogenesis.[15–17]

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Over the past decades, there has been an increased effort by the health care community to promote healthy sun-related attitudes and behaviors. Comprehensive sun protection includes minimizing sun exposure by using photoprotective gear such as long-sleeved shirts, wide-brimmed hats, and sunglasses and by applying sunscreen regularly (**Box 1**). Among these measures, sunscreens are one of the most popular protective methods used by the public.[18] This review discusses the health benefits afforded by sunscreen use, reviews the impact of the 2011 FDA ruling on sunscreen labeling and effectiveness testing, and addresses the controversies and limitations associated with sunscreen use.

MECHANISM OF ACTION

Sunscreens provide temporary protection against UV radiation. The active ingredients are classified into organic and inorganic UV filters based on chemical composition and mechanism of action. Organic filters are aromatic compounds that work by absorbing UV light, and inorganic filters are minerals that can absorb, reflect, and scatter UV light (**Fig. 1**). There are advantages and disadvantages associated with both kinds of filters, and it is not infrequent to see both types of filters present in commercially available formulations.

Organic UV filters exert their protective effects by absorbing high-energy photons from UV radiation. The energy absorbed is transmitted to electrons, which jump to an excited state, and on return to ground state, release their energy in the form of heat or light in longer wavelength.[19–21] *p*-Aminobenzoic acid was the first UV filter available in the United States but had many undesirable properties. It was known for its potential to cause photoallergic, contact dermatitis and stain clothes.[22] Newer generations of organic filters have improved safety and sensory profiles and extended coverage to the UV-A range.

Box 1
Patient recommendations for comprehensive photoprotection

- Seek shade and minimize sun exposure, especially between 10 AM and 2 PM
- Wear photoprotective clothing, including a wide-brimmed hat, long-sleeve shirt, pants, and sunglasses
- Use a broad-spectrum sunscreen with an SPF of 15 or more daily
- For extended outdoor activity, use a water-resistant, broad-spectrum sunscreen with an SPF of 30 or more
- Apply 1 oz of sunscreen to the entire body 15 minutes before going outside
- When outdoor, reapply sunscreen at least every 2 hours, or immediately after swimming or excessive sweating

At present, there are 15 organic UV filters approved for use in the United States (**Table 1**). At this time, avobenzone is the only organic filter approved by the FDA that has long-range UV-A (340–400 nm) protection. Its absorption profile ranges from 310 nm to 400 nm, with an absorption peak around 360 nm.[23] Avobenzone is known for being intrinsically unstable and degrades after 1 hour of UV exposure.[24] To maintain its efficacy, it must be combined with a photostabilizer, which facilitates the transition from an excited state back to ground state.[25] Without the presence of a photostabilizer, the avobenzone molecule in its excited state can isomerize and fragment into compounds that are less effective at filtering UV light.[26]

Zinc oxide (ZnO) and titanium dioxide (TiO_2) are the only inorganic UV filters approved for use in the United States (see **Table 1**). Early generations of these products lacked popularity because of inherent flaws in their sensory profiles. These early-generation products contained larger particles with higher refractive indices resulting in a thick, white coat that had poor particle dispersion and comedogenic potential.[27] Over the past few decades, manufacturers have modified formulations to include microsized and nanosized ZnO and TiO_2, which scatter less visible light and create more transparent films that provide improved cosmetic appearance.[28] The reduction in particle size has also led to changes in the absorption profile. Nanosized TiO_2 has an enhanced ability to absorb UV light in the UV-B range (ie, 290–320 nm).[29] However, this increase in UV-B absorption may result in decreased protection from UV-A radiation and potential loss of broad-spectrum coverage.[30] Compared to organic filters, these filters are less susceptible to degradation from UV exposure and have a lower potential of causing allergic reactions.[27]

HEALTH BENEFITS OF USING SUNSCREEN

Sunscreen use has been shown to impart many health benefits. Studies have demonstrated that using sunscreen on a daily basis can prevent the development of AK, SCC, and melanoma.[31–33] Furthermore, there is evidence suggesting that sunscreens can diminish the appearance of premature aging and prevent exacerbations of photodermatoses.[34,35] Much of the information