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Know Your Sunscreen

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Abstract:
Ultraviolet(UV) radiation from the sun has significant adverse effects on the skin, including sunburns, premature aging (photoaging), tanning, and many skin cancers. Sunscreens protect from harmful UV radiation. This article delves into the fundamentals of solar radiation, focusing on the UV spectrum, its effect on the skin, various types of sunscreens, and their mechanism of action to offer protection from harmful rays.
UV exposure depends on factors like geographic location, altitude, time of day, season, and surface reflectivity. Sunscreen efficacy is measured by the Sun Protection Factor (SPF), which indicates how well a sunscreen can protect against UVB-induced sunburn. SPF ratings of 15, 30, and 50+ correspond to 93%, 96%, and 98% UVB blockage, respectively. In contrast, UVA protection lacks a standardized measure, with various in vitro and in vivo indices used globally.
Sunscreens are categorized as organic (chemical) or inorganic (physical), each with distinct mechanisms and properties. Proper application of sunscreen, involving adequate coverage and reapplication, maximizes its protective benefits, significantly reducing the risk of UV-induced skin damage and cancers. Despite minor side effects like potential allergies, the advantages of sunscreen use, including prevention of sunburn, tanning, premature aging, and skin cancers, far outweigh the drawbacks.
UV radiation from the sun poses significant risks to skin health. Understanding the nature and effects of UV radiation is crucial in appreciating the importance of protective measures such as sunscreen. The role of sunscreens in providing comprehensive protection cannot be overstated.

Introduction

Ultraviolet (UV) radiation has a detrimental effect on the skin. Prolonged exposure to UV radiation is associated with early aging, tanning, sunburns, and a few skin cancers.[1] The purpose of applying sunscreen is to block the absorption of solar UV radiation. Before understanding sunscreen it is prudent to get into the basics of solar radiation. The sun is the source of electromagnetic radiation. It is transmitted as waves of different wavelengths and frequencies. This spectrum is broadly classified into seven categories: radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma-rays. It is based on decreasing wavelengths and increasing energy.[2]

Methods: Scientific material was collected from various sources including journals, literature, internet searches, product labels, and information brochures about sunscreen. This material was studied in depth and analyzed to compile it that covers the basics to the salient features. It will help to have a better understanding of sunscreens.

Results:

UV radiation: UV radiation has the wavelengths of 380nm to 10nm.[3] It has been classified into three sub-bands UVA, UVB, and UVC. UVA forms about 95% of the radiation reaching the earth, while UVB forms

the remaining. Almost all of the UVC is absorbed by the atmosphere and does not reach us. Following are a few salient comparative features of UVA and UVB sub-bands:[4,5]

Table 1: Comparison of UVA and UVB

S No	Property	UV A	UV B
1	Wavelength	315-400 nm	280-315nm
2	% of Sea level solar UV radiation	95-98%	2-5%
3	Skin penetration	Penetrates deeper than UVB reaching up to subdermal levels.	Superficial penetration.
4	Effects	It produces free reactive oxygen species by tissue interaction.	Direct impact on cell DNA and Proteins
5	Immunosuppression	Produces profound immunosuppression	No significant immunosuppression
6	Responsible for	Tanning, photoaging, cancer,	Sunburn and cancers

UV exposure is dependent on many factors which are:

Distance from Equator: Places close to equators have the maximum exposure to UV radiations because at equators distance traveled by the sunlight is minimal.

Altitude: The higher the altitude, the higher the exposure due to the rarefication of the atmosphere.

Time of day: At the noontime sun is directly above, hence UV exposure is maximum from 10 am to 2 pm.

Season: UV exposure is higher in summers in comparison to the rainy season.

Surface: Snow, sand, and water reflect more sunlight so the UV exposure is more.

Skin color: Very fair skin burns easily while tans rarely. As the skin color goes darker chances of skin burns go lesser while that of tanning go higher.

UV Index: The UV index is the measure of harmful UV radiation reaching the earth. It is measured on a scale of 1 to 11. 1-2, 3-5, and 6-7 scores signify mild, moderate, and severe UV index respectively. If the index is less than 2, there is no problem in staying out. If the index is 3 to 7 then additional protections are required like using sunscreen, working in shades, and protective clothing. If the index is more than 7 then going out at noon is not advisable and the use of protection from UV rays is a must. The higher the index more damaging will be the UV radiation.[6]

Effects of UV radiation:[7,8] UV radiation forms only 10% of the electromagnetic radiation received from the sun. It gets absorbed by the skin and can lead to the following reactions:

Sunburn: It is mainly due to UVB radiation which can penetrate the superficial layer (epidermis) of the skin and burn it.

Tanning: It is caused by UVA radiation which can penetrate deeper than the skin. It stimulates the Melanocytes (melanin-forming cells) to produce more melanin. Melanin is a black color pigment that tans the skin. Melanin absorbs the UV radiation and dissipates the heat to the environment. Melanin production is a natural defense mechanism to deal with UV radiation.

Melanoma: It is a type of skin cancer that may occur due to prolonged exposure to UV radiation. It can lead to cell damage and mutations in the cells. As discussed above, UVA radiation penetrates deeper and damages the defense mechanism of the body. The above factors can lead to a type of cancer arising from the melanocytes called Melanoma.

Other Skin Cancers: Prolonged UV radiation exposure is also associated with other skin cancers like Basal cell cancer and Squamous cell cancer.

Sun Protection Factor (SPF)[9]: This is an important concept to understand. SPF denotes the time taken by the UV radiation to produce sunburn (redden the skin patch) when covered with sunscreen divided by the time taken to produce sunburn on unprotected skin. It is denoted by the following formula

SPF= Duration to produce sunburn on protected skin in seconds Duration to produce sunburn on unprotected skin in seconds. .

For example, if sunscreen is applied and it produces sunburn after 500 seconds while sunburn occurs in un-protected skin after 10 seconds then the SPF would be, 500/10 i.e. 50. It assesses the efficacy of UVB blockage.

SPF15,30,50 or more: SPF 15 sunscreen blocks 93% of UVB radiation while SPF 30+ and 50+ sunscreens effectively block 96% and 98% of UVB radiation respectively.

UVA Protection indices:[10] Unlike SPF which assesses UVB radiation blockage, there is no single method to assess the efficacy of UVA blockage. There are several in vitro and in vivo indices that are being used, for example, the Australia-New Zealand standards in which transmission of UVA is assessed after the application of 8 and 20 micrometers thin layer of sunscreen. It must block 90% and 99% of UVA radiation respectively. The boot star rating is commonly used in the UK.

Broad Spectrum Sunscreen: A broad-spectrum sunscreen should block both UVA and UVB radiations.

Sunscreen:[11,12] Sunscreen when properly applied should protect against the absorption of UV radiation. Sunscreens are classified as Organic and Inorganic.

Organic Sunscreen: [11,12] Organic sunscreens, previously known as chemical sunscreens, absorb UV radiation based on their structure, involving an aromatic compound conjugated with a carbonyl group. This structure allows high-energy UV rays to be absorbed. Once UV radiation is absorbed, the molecule moves from the ground state to the excited state. Further reaction is based on its chemical properties which could be:

Photo-stability: The absorbed energy is transferred to the atmosphere and molecule comes back to the ground state to absorb UV radiation again.

Photo-instability: The molecule undergoes a chemical change in the structure and cannot reabsorb the UV radiation.

Photo-reactivity: In an excited state it reacts with the other ingredients of the sunscreen or skin proteins.

Commonly used ingredients and their important properties are shown in the following table

Table 2: Various UV filters and their features

UV filters			
S No	Name	Properties	Special features
1	Benzophenones oxybenzone	Absorbs mostly UVB Broad spectrum Photo unstable	High incidences of photoallergy and dermatitis. Few animal studies suggest

	sulisobenzone dioxybenzone		endocrine and carcinogenic effects. Not proven in human beings.
2	Anthranilates	Weak UVA and UVB blockers	Rarely used in sunscreen
3	Avobenzones	Very effective and Broad spectrum Photo unstable	Used with other UV filters
4	Ecamsule (Terephthalyidene dicamphor sulfonic acid)	Broad spectrum Photostable Water-resistant	Not approved by FDA
5	Aminobenzoates PABA (Para aminobenzoic acid) Padimate O	Most potent UVB filters but do not absorb UVA radiations Very potent UVB filter Photoallergen Contact dermatitis Potent UVB filter Less allergic	 So out of favor now
6	Cinnamates Octinoxate	Less potent than PABA Most commonly used in the USA Not very photostable	 Used in combination with other filters
7	Salicylates	Weak UVB filters photostable	Used in combination with photo-unstable ingredients
8	Octocrylene	UVB filter Less allergic reactions	Used in combination

Inorganic Sunscreen:[11,12] They are also known as physical or metallic sunscreen. It acts by reflecting the UV light. The reflection of light is dependent on the reflective index, size, and quantity applied. Nanoparticle size increases the efficacy but also increases the chances of systemic absorption. It needs to be applied as a thick coat which may not be very aesthetically pleasing. Zinc oxide(ZnO) and Titanium oxide (TiO_2) are the most commonly used compounds. Their properties are shown in the following table:

Table 3: Inorganic filters

S No	Name	Properties	Special features
1	Zinc Oxide	Active against UVA Photostable Doesn't react with other filters	It is not effective against UVB
2	Titanium Oxide	Active against UVA	

		Smaller particle size and high refractive index Looks white on application hence aesthetically less appealing	

Antioxidants: Many commercially available sunscreens contain a combination of UV filters and antioxidants such as Vitamin C, Vitamin E, and green tea polyphenols. These antioxidants are claimed to protect the skin from erythema, photoaging, and skin cancers.

Ingredients of sunscreen:[13] In a commercially available sunscreen there is a combination of UV filters that enhance the SPF and quality of sunscreen by complementing properties of each other. This forms about 20% of the contents. Formulation stabilizers like solvents, emulsifiers, preservatives, and thickeners contribute about 55% of the contents. Sensory enhancers such as fragrance, moisturizers, and emollients which improve the feel of the formulation contribute about 23%. Extra added contents like aloe extracts, vitamin C, or antioxidants contribute 2%.

Advantages of using sunscreen: Sunscreen protects from the ill effects of UV radiation. If properly applied, it prevents sunburn, tanning, premature skin aging, and skin cancers. There are so many studies to prove the beneficial role of sunscreen.

Proper application of sunscreen:[14,15] To get the maximum benefits from the sunscreen, it should be applied properly. The following points are stressed:

It should be a broad-spectrum sunscreen with SPF 30 or more.

Read the instructions from the manufacturer.

It should be applied 15 minutes before expected sun exposure.

Reapply as per the instructions on the label. Frequent reapplications are required in cases of higher exposure to UV radiation and also in cases of swimming and sweating.

There is UV radiation on a cloudy day also, hence should be applied judiciously.

A thick coat should be applied. The recommended dose is $2mg/cm^2$. This means 3 ml is sufficient for the face while 6 ml is for the legs, chest, arms, and back. This is also known as the teaspoon rule. 3ml and 6ml are just more than half a teaspoon and a full teaspoon respectively.

Side effects of sunscreen application:[16] The benefits of sunscreen application outweigh the side effects. The common side effects are allergy to sunscreen leading to redness and itching over the involved area. The safety profile has not been established for infants hence it should not be used for infants. For them, physical methods are recommended like covering the body with protective clothing and avoiding sun exposure between 10 am to 3 pm. Theoretically, there is a possibility of Vitamin D deficiency which is formed by the sun-exposed skin. But to date, no study has proved that the use of sunscreen is associated with Vitamin D deficiency.

Conclusion

Ultraviolet radiation forms only 10% of the solar electromagnetic radiation reaching the earth. However, it has harmful effects too. It can cause skin burns, tanning, early aging changes, and skin cancers. Sunscreens if applied properly protect against the harmful effects of UV exposure. It is vital to know the sunscreen being used so that it can be used effectively to mitigate the negative impact of these radiations on our skin.

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