A REVIEW: SUN PROTECTING FACTOR

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ABSTRACT: Since now a day the degradation of ozone layer caused by chlorofluorocarbon, sulphur, and nitrogen etc which are generated by human, leads to the excessive exposure to the UVA, UVB and UVC radiation of the sun which can cause skin cancer and other skin diseases.UVB (290–320 nm) and UVA (320–400 nm) are both responsible for skin aging and the skin alterations caused by UV radiation depend upon the phenotype of photo exposed skin.UVB induces changes mainly at the epidermal level, where the bulk of UVB is absorbed. UVB damages the DNA in epidermal cells, and induces production of the soluble epidermal factor (ESF) and proteolytic enzymes, which can be found in the dermis after UV exposure. After UVB exposure, a strong covalent bond between two thymidine occurs. With aging, this bond is difficult to be dissolved quickly, and accumulation of mutations occurs and the affected cells appear as sunburn cells 8 to 12 hours after exposure.UVA penetrates even more deeply into the dermis and damages both the epidermis and dermis. The amount of UVA in ambient light is 10 to 100 times more than the UVB, but UVB has biological effects 1,000 times stronger than UVA.UVA radiation plays an important role in the pathogenesis of photoaging. This level of destruction caused by sunray leads to the aim of this article which compile all the information related to sun protecting factor, need to use protection (sunscreen), evaluation method for sunscreen and its dosages, natural Products used as sunscreen, and application too. This article reduced the knowledge gap of by including the recent technology developed in the field of SPF and protection related to sun's harmful rays. This article will help researcher to get the knowledge about everything related to SPF in a single article.

Key Word: SPF, UV radiation, Sunscreen, Evaluation

INTRODUCTION:

Throughout human history, people have protected their skin from sunburn by wearing clothing and accessories or by limiting their exposure to the sun[1] .

During World War II, the need for adequate photoprotection of American soldiers in battle fronts in the tropics led to the use of red petrolatum as a standard protective substance[1]. In 1943, para-aminobenzoic acid (PABA) was patented as the first established sunscreen, marking a new stage of photoprotection[2]. However, it was not until the 1970s that sunscreens gained popularity with the incorporation of different UVB filters in creams and lotions[3]. While the use of UVA filters began in 1979, it was only with the introduction of

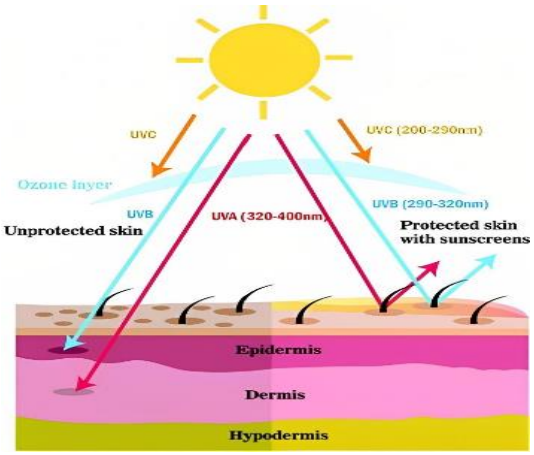
inorganic particles of titanium dioxide in 1989 and of zinc oxide in 1992 that more effective protection in the UVA range was achieved[2]. According to Pathak, the classic definition of a sunscreen is a product designed to block the sun and protect or shelter viable skin cells against the potentially harmful effects of ultraviolet radiation, such as sunburn and skin cancer[4].

US Filter's can be classified into inorganic (physical) or organic (chemical) filters, depending on their physio-chemical properties. Inorganic filters are metal oxide particles that can reflect or disperse incident radiation through an optical mechanism. Zinc oxide (ZnO) and titanium dioxide (TiO2) are the main representatives of inorganic filters, which are usually used in combination with organic filters. Inorganic filters have low skin permeability and high photostability, meaning they can maintain photoprotection even after prolonged periods of exposure to sunlight[5]. On the other hand, organic filters are molecules that interfere with incident radiation through absorption. When the filter absorbs a photon of energy, it evolves to the excited state of the molecule, acting as an exogenous chromophore. Upon returning to the stable state (unexcited), the release of energy occurs at a longer wavelength, either in the range of visible light (as fluorescence) or in the range of infrared radiation (as heat). This process can be repeated numerous times by a mechanism called resonance. Depending on their capacity to absorb shorter or longer wavelengths, organic filters can be subcategorized into UVA filters, UVB filters, and filters for broad-spectrum protection (UVA and UVB)[6].

Fig1: Mechanisms of interaction of sunscreens with sun radiation adapted [7]

What is SPF?

Sun Protection Factor is referred to as SPF. When compared to the period without sunscreen,



the number indicates how long it would take the sun's UVB radiation to cause your skin to get red. Therefore, if you correctly apply an SPF 30 product, it would take 30 times longer for you to burn than if you did not use any sunscreen [8].

Need to use Sunscreen: Sunscreen lowers your chances of skin cancer and sun damage while also reducing your overall UV exposure.Other things to consider-

- **Your skin cancer risk factor**: Your level of protection will depend on your skin type and family history.

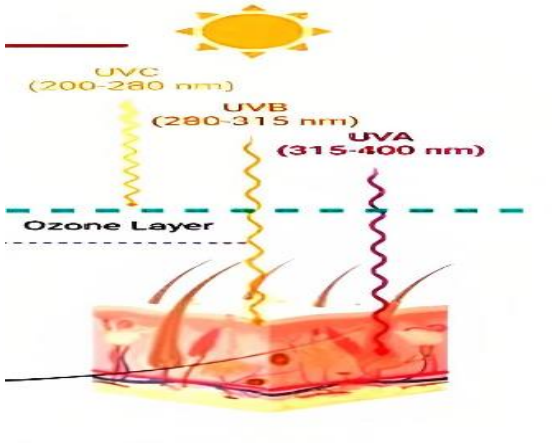
- **Photosensitivity**: Regardless of your skin type, certain drugs and medical conditions can make you extremely sensitive to the sun, necessitating greater sun protection.
- **Skin conditions**: There are sunscreens available for dry skin, oily skin, sensitive skin, and skin prone to acne[8].

Harm from Sun rays: In addition to visible light that you can see, the sun also emits infrared radiation that you can feel as heat and ultraviolet radiation that you cannot see or feel. Fortunately, the atmosphere of the Earth shields humans from the majority of UV radiation. While some sun exposure is necessary for our bodies to produce vitamin D, too much UV radiation is harmful.

There are three types of UV rays:

- **Ultraviolet A rays (UVA)**
  - The majority of UVA radiation reaches the Earth's surface, with the atmosphere doing little to block it.
  - UVA rays can weaken your body's immune system and speed up the ageing process for your skin and eyes. UVA radiation also increase the chance of developing skin cancer.

    Fig2: Penetration of UVA, UVB and UVC in the skin[9]



- **Ultraviolet B rays (UVB)**
  - Most UVB rays are blocked by the Earth's atmosphere, but the amount that reaches the surface of the planet depends on latitude, altitude, season, and other variables.
  - Sunburns, skin cancer, ageing skin, and snow blindness (a corneal sunburn that results in a temporary loss of vision) are all brought on by UVB rays, which can also weaken your body's immune system.
- **Ultraviolet C rays (UCB)**
  - Because the atmosphere totally absorbs UVC rays, they never reach the surface of the Earth.
  - There is very little risk from UVC rays [10].

Types of Sunscreens: There are mainly two types of sunscreens:

- Chemical Sunscreen
- Physical Sunscreen

- **Chemical Sunscreen**- Chemical sunscreens, such as PABA, PABA esters, benzophenone, salicylates, and anthranilates, can prevent UVA rays that cause direct tanning, damage to elastin cells, actinic skin damage, and the development of skin cancer while absorbing about 95% of UVB light that can induce sunburn (erythema). Additionally, there are physical sunscreens that can reflect, deflect, and block sunlight, such as kaolin, zinc oxide, titanium dioxide, and magnesium silicate.

- **Physical Sunscreen**-Both UV-A and UV-B rays can be absorbed by physical sunscreens. A broad-spectrum sunscreen that protects against UV-A and UV-B rays is the best kind to use in order to avoid skin conditions like erythema, sunburn, early ageing, and skin cancer. Chemical and physical sunscreens are frequently mixed, and some cosmetic preparations even incorporate multiple types of sunscreens to maximise their effectiveness [11][12].

Evaluation Method:

Friedrich Ellinger evaluated the effectiveness of sunscreens in protecting against mercury lamp radiation on both forearms in 1934, determining the minimal erythemal dose (MED) from protected and unprotected skin. Ellinger also expressed a coefficient of protection that decreased in value as protection increased. The "Schulze Factor," developed by Rudolf Schulze in 1956, has been a standard for assessing sunscreens in European nations for many years. The Schulze Factor is the amount of time that must pass before incremental doses of sunlight or radiation from lamps cause erythema to appear on skin that has been treated with sunscreen and skin that has not. Reiter coined the term Sun Protection Factor (SPF) in 1974 to replace "Schulze factor." SPF has now become a common word in the assessment of sunscreens[13].The FDA, a North American regulatory body, put forward the first normalization for calculating the Sun Protection Factor (SPF) in 1978. The methods listed below are now acceptable and used to evaluate sunscreens:

1. **Invitro Method-** A correctly prepared sample's diffuse transmittance in the UV spectrum can be used to calculate an in-vitro SPF value. An effective sample preparation technique has two goals. The initial step is to mimic the applied amount and sub- strata interaction circumstances utilised for in-vivo testing. This would result in a trustworthy in-vitro SPF value that might accurately predict the outcome of an additional in-vivo test. The method's ability to produce repeatable findings for the same sunscreen formulation from sample to sample is the second goal [14].The in-vivo substrate for in-vitro SPF should mimic the porosity and texture of human skin and be relatively transparent to UV light. Human and mouse epidermis, as well as sausage casings and natural lamb condoms, are suitable in-vitro substrates. Transport,

Vitro-Skin, Roughened Quartz Plate, Polymethyl-methacrylate (PMMA) plates, and PTFE (Teflon) are examples of common substrates [15].

a) **In-Vitro SPF Determination (absorbance measurement) by UV-Spectrophotometer**[13]**:** All samples should be weighed at 1 g, transferred to a 100 mL volumetric flask, diluted to volume with ethanol, ultrasonically processed for five minutes, and then filtered through cotton, with the first ten mL being discarded. A 5.0 mL sample should be transferred to a 50 mL volumetric flask and diluted with ethanol to volume. After that, pour an aliquot of 5.0 mL into a 25 mL volumetric flask and top it up with ethanol. Using a 1 cm quartz cell and ethanol as a blank, measure the absorptions of samples in solution in the range of 290 to 450 nm in 5 nm increments. Calculate the SPF using the Mansur equation and the average of the three variables. The values of EE **λ calculated by following formula** and are listed in Table 1.

$$\mathbf{SPF_{spectrophotometric} = CF \times \sum_{290}^{320} EE(\lambda) \times I(\lambda) \times Abs(\lambda)}$$

Where ,

EE(*λ*)-erythemal effect spectrum;

I(*λ*)- solar intensity spectrum;

Abs(*λ*)-absorbance of sunscreen product ;

CF-correction factor(10)

Wavelength(λ) in nm	EE x I (normalized)
290	0.015
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0839
320	0.018
	Total= 1

Tab.1: Normalized product function used in the calculation of SPF [16]

b) **In- vitro Determination of SPF by UV 2000S Ultraviolet Transmittance Analyzer(Labsphere):**The theory is based on the measurement of sample transmittance, where transmittance is the proportion of light passing through a sample to light impinging on it. Procedure: As instructed in the UV-2000S Ultraviolet Transmittance Analyzer's operation handbook for sample preparation and application procedure, weigh 100 mg of the investigational sample and distribute it over a 56 cm2 area to create a sample even film

thickness of 2 l/cm2. To determine the Sun Protection Factor, expose the prepared sample to a Xenon flash light as follows:[17][15]

$$SPF = \frac{\int_{290}^{400} E\lambda S\lambda \, d\lambda}{\int_{290}^{400} E\lambda S\lambda \, d\lambda}$$

Where,

E (λ) is the erythema action spectrum,
S(λ) is the solar spectral irradiance,
T(λ) is the spectral transmittance of the sample.

- **Critical wavelength method\Broad spectrum rating method United States(FDA):**Critical wavelength is the wavelength at which 90% of the area under the extinction curve between 290 and 400 nm are obtained, or simply a measurement of the 'breadth' of UVA protection using a test method called 'critical wavelength'. The greater the UVA extinction, the greater the increase in c. This is a suggested replacement for the Boots Star System. This assesses how consistent the absorption spectrum of a sunscreen product is. The outcome is based on a value known as the crucial wavelength, which can be calculated spectrophotometrically from the absorption spectra. Since the technique only relies on the relative values of spectrum absorbance and not the absolute values, it is less susceptible to sample preparation than in-vitro SPF or Boots Star measurements. In this test concept, the absorbance of the sunscreen's thin film is integrated (summed) starting at 290 nm across the UV spectrum and continuing until the sum reaches 90% of the sunscreen's overall absorbance in the ultraviolet region (290–400 nm). The 'critical wavelength', which is regarded as a gauge of the depth of sunscreen protection, is the wavelength at which the sum of the absorbance approaches 90% of the total absorbance. When the crucial wavelength is longer than 370 nm, filters are then categorised as "broad spectrum," having a large portion of their absorption in the UVA. The following equation determines the crucial wavelength for the 290–400 nm spectrum:[17][15]

$$\lambda \quad \mathbf{C = Min(}\ \lambda'\mathbf{)}\ \ \mathbf{0.9}\frac{\sum_{\lambda}^{\lambda'=290} A_\lambda}{\sum_{\lambda=2}^{400} A_\lambda}$$

Where,

A (λ) is the absorbance at wavelength, the following outcomes of the United States' broad spectrum rating technique should be predicted:[16]

Λc	**Level of Protection**
340nm ≤λX < 370nm	Some (UVA/UVB)
λc>370nm	More (broad-spectrum)

- **UVA/UVB ratio:** The fact that the SPF rating system for sunscreens uses erythema as an endpoint has recently raised some questions. As a result, active compounds that primarily function as UVB blockers significantly raise a product's SPF. In addition to the SPF, a mechanism for product labelling that details the UVA protection provided is required. The spectrum absorbance values A=-log (T λ) are created from the spectral transmittance values Tλ. The ratio of the total amount of UVA absorption to UVB absorption is known as the UVA ratio [17][15].

  Another need for adopting this approach is to first assess a sunscreen formula's photo-stability if it contains UVA absorbers. Prior to measuring the spectral transmittance, the samples must be pre-irradiated with a solar simulator light source. The pre-irradiation exposure dosage is expressed as a percentage of the SPF value for the specific formulation being tested and is expressed in units of MED (minimum erythemal dose), or one third of it. The use of a flashlamp in the Labsphere UV-1000S is supported by concerns about photostability for specific sunscreen formulations.Samples must be pre-irradiated using a continuous source whose spectra and dose are carefully monitored. The analysing spectrophotometer's light source should not be utilised to illuminate samples. The UV absorption spectrum's structure alone—not its amplitude—is all that the Broad-Spectrum Rating technique is based on. The test's drawback is its weak connection with in-vivo outcomes[14][17].

2. **In – Vivo Methods:**The techniques listed below are frequently employed in-vivo for SPF determination. Apart from their endpoints and manner of expression, all three techniques follow a relatively similar pattern. These are the steps and endpoints:

   Procedure: A UVA light source (320–400 nm) is used to irradiate human volunteers. Skin changes, such as an instantaneous or persistent pigment darkening, erythema, or tanning, are seen after the radiation has stopped for the required amount of time.

   Observation: The irradiated sites were assessed for pigmentation response and erythema under bright "warm while" illumination (roughly 1000 Lux at 6000 K) within 60 seconds of each exposure (IPD test), again roughly 2 hours later (PPD test), and between 16 and 24 hours later (PFA), using the following scales:[16]

Pigmentation	**Erythema**
0=No response	0=No response
0.5-Equivocal response	0.5-Equivocal response
1.0-Unambiguous dark grey or brown pigmentation	1.0-Unambiguous erythema
1.5-Well define dark gray or brown pigmentation with sharp borders	2.0-Bright erythema
2.0-Deep pigmentation	

- IPD (Immediate Pigment Darkening): Where UVA protection factor is calculated from the ratio of the minimal immediate pigment darkening dose protected by sunscreen to the minimal immediate pigment darkening dose unprotected during 60 seconds of each exposure. The pigmentation yielding a grade 1 within 1 minute of each UVA exposure is the method's endpoint [18].

- PPD (Persistent Pigment Darkening): Where UVA protection factor is calculated from the ratio of the minimal immediate pigment darkening dose protected by sunscreen to the minimal persistent pigment darkening dosage unprotected, tested about two hours after UVA exposure. The pigmentation yielding a grade of 1, 2 hours after UVA exposure serves as the method's endpoint. When compared to IPD, the PPD approach has the benefit that the residual colour that has formed from radiation exposure is stabilised and permits more accurate readings [19].
- PFA (Protection Factor in UVA): Where UVA protection factor is determined roughly 24 hours after UVA exposures by comparing the ratio of the minimal reaction dosage (eryhema or tanning) protected by sunscreen to the minimal response dose unprotected by sunscreen [20].
- PPF (Phototoxic Protection Factor): where the lowest phototoxic dosage, assessed 72 hours after UVA exposure, was protected by sunscreen ratio. This technique employs 8-methoxypsoralen to make UV light more sensitive. Erythema or tanning resulting in a grade 1 during 16–24 hours of UVA radiation is the method's endpoint [17].

Terminologies Associated with Sunscreen: Technologies associated with sunscreen are-

- **In vitro sun burns protection factor**- We defined as the sun protection factor, as given by FDA in 1978, As if numerical ratio between the MED (minimal erythemal dose) of sunscreen protection ,used in the quantity of 2 mg/cm2 and MED of unprotected skin , calculation related than can be denoted by equation:[21]

SPF = MED (protected skin/med (unprotected skin)

- **In vitro UVA protection factor (UVAPE)-** The complete execution of a sun protect product, determine from the deliberate in vitro transmitted after irradiation and weighted by the PPD professional spectrum and with the 'standard' out turn spectrum of AUVA filtered solar pattern[22].
- **Critical wavelength value (λC)-**The C.W value for the experiment product is determined as for the irradiated product, from 290 nm to delta C is 20% of the undivided of the absorbance spectrum from 290 nm to 400 nm[14].
- **In vitro UV a protection factor before UV exposure UVAPF-**The In-vitro UV a protection factor identified before model UV exposure it is secured from the transmitted curve of the covered sample, weighted with the PPD function spectrum and with the 'standard' out- turn spectrum of a UV filtered solar aggravation, after integration to labelledSPF[15].

Dosages and Application: It has been discovered that inadequate application of the recommended amount or a lack of practise in reapplying sunscreen after simple cleaning, perspiring, swimming, or severe activity cause sunscreen efficacy to fail. FDA sunscreen testing uses a dosage of 2 mg/cm2 of exposed skin. Applying around 30 g (or 30 ml, or about 1 oz) equally to the exposed body region is recommended for adults wearing bathing suits that cover the groyne area, assuming an "average" adult build of height 5 ft 4 in (163 cm), weight 150 lb (68 kg), and a 32-inch (82-cm) waist. These quantities should be scaled for larger or smaller people. When only the face is considered; this is around 1/4 to 1/3 of a

teaspoon for the typical adult face. Before exposure to the sun, sunscreen should be adequately administered in a dosage of 2 mg/cm2 to all sun-exposed regions. Every two hours, after swimming, intense activity, or exercise, as well as after each wipe, it should be reapplied [23][24][25].

Labelling: The crucial wavelength of a sunscreen must be equal to or higher than 370 nm in order to be deemed "broad spectrum," and only "broad spectrum" sunscreens with an SPF of at least 15 may make the claims made in the monograph on advantages against skin cancer and skin ageing. Sunscreens that once met the criteria for water resistance now bear the designation "water resistant (40 min)." Formerly classified as extremely water resistant, these items are now marked as "water resistant (80 min)." Terms like "waterproof," "sweatproof," and "sunblock" are prohibited and are not authorised [26][27].

Natural Products used as Sunscreen

- **Aloe-vera**: Aloe barbadense and aloe vera the main source of aloe vera gel .The constituent are used of that natural product(aloe vera) are leaves .Aloe barbadense or aloe vera gel is broadly used in cosmetic for its moisturising , soothing and refreshing etc. It prevents both UVA and UVB rays and preserve skin's natural moisture moderation. The enzyme bredykinase in aloe prevent the sun burn and promote immune system interference. The study was communicated out to define the photo protective activity of aloe vera juice [28][29][30][31].
- **Tomato:** Tomato or Lycopersicon fruits are the general source of lycopene and well - read for its antioxidant activity in cosmetic and medical field. Tomato is wealthy in lycopene ,a broadly studied strong antioxidant and anti-carcinogenic carotenoid with energetic reducing capacity. Lycopene may decrease the damaging influence which UV light can have on the skin and can promote safety adverse or against both little term (sun burn) and accumulative influence of sun exposure (cancer)[32][33][34].
- **Grapes:** Grape’s fruit or Vitis vinifera are the prosperous source of polyphenols (65-70%). The skin and seeds of grapes also carry the polyphenolic phytoalexin namely resveratrol (trans -3,5,4'-trihydroxystilbene). It is also used as antioxidant as well as contains strong anti-inflammatory activity [35].
- **Cucumber**: Cucumber or Cucumissativus draw out has strong moisturising capacity and slightly astringent influence. It also helping to remove out dead skin cells and clamp skin. Cucumber also carries vitamin-C (ascorbic acid) and caffeic acid ,these both of which quite skin irritations. These two-acid compounds inhibit water maintenance or support. Cucumber is generally applied topically because they support for expand eyes, burn and dermatitis [36][37].
- **Soybean Oil:** Soybean or Glycine Max are nutritious and cost-effective combination to Sunscreen. Soybean fundamentally originate from China and are widely source of essential fatty acid iron, protein, and calcium in diet .If soybean used topically on the skin, act as moisturizer compare to natural SPF and other oils[38].

Recent Technology Developed:

- **Tinted Mineral-Based Formulas-** There is an increasing need for mineral-based sunscreens that contain zinc oxide and/or titanium dioxide. The FDA decided in 2019 that these two sunscreen chemicals are generally accepted as safe and effective (GRASE) in the United States. Because they remain on the skin's surface and primarily block UV radiation, they are also frequently referred to as "physical blockers." Researchers prefer the phrase "inorganic UV filters."
  These substances were once infamous for being white and pasty, difficult to blend in, and giving off a pale, ashy appearance, especially on dark skin tones. Now that most products have been "micronized" into smaller particles, they apply more smoothly and readily, remain securely on the skin's surface, and appear better on most skin tones. Iron oxides are typically used to colour products, which can improve their appearance as well as perhaps other aspects.
- **Antioxidants-**According to research, several wavelengths of the light spectrum may damage the skin by producing free radicals. These erratic oxygen molecules cause inflammation, damage DNA in your skin, and impair cell function. Skin cancer-causing mutations may result from the injury. According to studies, antioxidants aid in the battle against free radicals and stop the harm that they may do, including the development of skin cancer.
  In addition to advising you to consume a diet rich in antioxidant-rich fruits and vegetables, many physicians also advise using sunscreens and cosmetics formulated with antioxidants to help fight free radicals and partially heal damage from pollution.
- **Anti-aging Ingredients-**The sunscreen business has been paying close attention to consumers who want multifunctional products, or those that offer moisturising, anti-aging, or cosmetic advantages in addition to protecting against skin cancer, sunburns, dark spots, and wrinkles. Enzymes for DNA repair may be one of these to lessen damage. Other products could make claims like moisturising, removing dark spots, or enhancing your skin's general look. Women and men now spend money for Botox, fillers, and laser treatments, according to Dr. Sarnoff. To assist them safeguard their investment, people are becoming more aware of what to look for on the label and using high-quality multipurpose sunscreens every day.
- **Probiotics-** Like how beneficial bacteria outnumber harmful bacteria in the stomach, there are methods in the beauty business for treating the skin. For the purpose of preserving a healthy micro-biome, scientists are examining sunscreen formulation options. Changes to the pH level, addition of probiotic living cultures, substances that support the moisture barrier, or alternative preservatives that will not harm the beneficial bacteria are some examples[39].

Conclusion: This article gives a reader a complete knowledge about SPF and differ ingredient used by the people when there was less knowledge and change in the protection from harmful rays from sun now a days. Including all the knowledge about SPF and filling the Knowledge gap will answer every question om the topic of SPF. The conclusion of this article is too aware the peoples about the harmful effect of UVA, UVB, and UVC and help to

be protected from the harm of sun rays by using sunscreen. The protection from sun rays is important and the field to develop the agent that can protect from it is vast and will never end until the sun is shining.

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