SUNSCREEN PROTECTION AGAINST VISIBLE LIGHT: IS IT NEEDED?

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ABSTRACT

Ultraviolet radiation and Visible light (VL) have biological effects on the skin. VL causes erythema in light-skinned individuals and pigmentation in dark-skinned individuals. Broad-spectrum sunscreen protects skin against ultraviolet radiation but does not adequately protect against VL. The purpose of this study was to analyze the biological effects of visible light (VL) and the choice of sunscreen that can protect it. The research method used in this study is a qualitative descriptive method. The type of data used in this study is qualitative data, which is categorized into two types, namely primary data and secondary data.The protection provided by organic (mineral) and inorganic sunscreen filters can prevent skin damage due to ultraviolet radiation, but does not provide protection against VL. Only tinted sunscreens that use formulations of concentrated iron oxide and titanium dioxide can provide protection against VL. Various steps have been taken to provide photoprotection against VL. There are many sunscreens available that combine percentages level of iron oxide and titanium dioxide pigment to suit all skin types. This tinted sunscreen is beneficial for melasma and post-inflammatory hyperpigmentation and photodermatosis induced by VL.

Keywords: *Iron Oxide, Photoprotection, Tinted Sunscreen, Titanium Dioxide, Ultraviolet Light, Visible Light*

INTRODUCTION

Exposure to UV-A rays will stimulate the formation of melanin, which functions as a layer protector on the skin. UV radiation close to 300 nm (UV-B) can penetrate both the stratum corneum that causes sufficient burning (erythema) of the epidermis severe, especially on individual skinned white. Radiation with long wave longer than 350 nm start to penetrate the dermis so that stimulate the formation of melanin and produce (tanning) browning on the skin consequence of burnt direct by exposure to ray sun (Alhasaniah et al, 2018). Although UV-A light energy is lower than UV-B rays, however, reality UV-A rays can penetrate farther into the hypodermis, which can cause elastosis and damage skin other so the potential emergence of skin cancer (Brenner and Hearing, 2008).

Avoiding the sun is actually the best way to protect the skin, but it's not practical. Sunscreens are known to cause a number of disorders for some people, including allergic reactions, cosmetic disorders, discomfort, and high costs. Clothing can protect the skin

from sun exposure, even seen as the simplest step in reducing the adverse effects of sunlight on the skin. The color factor in clothes also affects skin protection from sun exposure (Paul, 2019)

LITERATURE REVIEW

Ultraviolet light

Ultraviolet light is a radiation wave of electromagnetic origin from the sun. This ray can not be seen by the eye. However, some animal like bees, birds, and butterflies can see UV light with clear. Not all UV rays coming from the sun can reach the surface of the earth. The ozone layer succeeds prevents certain ultraviolet rays for reach the earth.

Radiation UV rays coming from the sun have three types of rays divided by radiation based on long waves. The more short the wave, the more dangerous it (Maatsumura and Ananthaswamy, 2004). What are just types of ultraviolet light? Type UV rays consist of:

1. UVA rays. UVA rays have long 315-400 nm and have the longest wave among other UV rays. These rays are considered the most powerful ultraviolet rays and are capable penetrate clouds, as well as glass, and are even permanent there at the moment weather is overcast or rain. UVA rays too could absorb more into the dermis layer.
2. UVB rays have long 280-315 nm waves. UVB rays can be absorbed by clouds and no could penetrate glass, however, range the display only could reach the epidermal layer of the skin. UVB can cause skin blush, soreness, and burn.
3. UVC rays. UVC rays. UVC rays have long the shortest wave of 180-280 nm and are the most dangerous ultraviolet rays for the skin. However, UVC rays can't penetrate the layer of ozone, so rays can't reach the surface earth.

Visible light (VL)

Visible light is a spectrum of electromagnetic waves that can be seen with the human eye. Next to visible light is UV or ultraviolet light. The role of visible light in those with skin bright can cause skin becomes more red, whereas for those who are colored like Asian skin, cause pigmentation or to increase bad (Narla et al, 2020).

RESEARCH METHODOLOGY

The research method used in this study is a qualitative descriptive method. The type of data used in this study is qualitative data, which is categorized into two types, namely primary data and secondary data.

Sources of data are obtained through library research techniques (library study) which refers to sources available both online and offline such as scientific journals, books, and news sourced from trusted sources. These sources are collected based on discussion and discussion from one information to another.

Data collection techniques used in this study were observation, interviews and research. This data is analyzed and then conclusions are drawn

DISCUSSION

The sun emits a broad spectrum of electromagnetic radiation, mainly in the visible light (VL) range (400–700 nm). Which reaches the earth's surface and consists of UVB (290–320 nm), UVA2 (320–340 nm), UVA1 (340–400 nm), VL (400–700 nm), and infrared (IR) radiation (700 nm-1 mm).

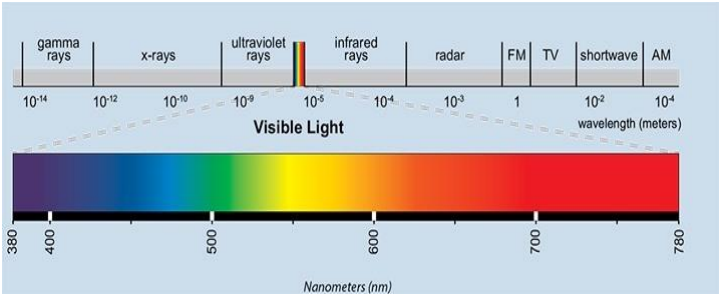

Figure 1. Colours from the entire visible light spectrum. (Source: Mark Whorlow, https://www.quora.com/Can-you-show-me-a-color-Ive-never-seen-before)

Skin photobiological research is mainly carried out on UV rays. While research on VL is still very limited even though VL is 50% of electromagnetic waves that reach the earth's surface. Environmental exposure to VL comes not only from the sun, but also from electronic devices such as smartphones, tablets, and computer screens. However, the cumulative dose of VL, especially the blue light (BL) emitted by the low-intensity source, is not relevant because it does not reach the dose to induce hyperpigmentation (Gasparro et.al, 1998).

The effects of ultraviolet radiation, visible light, and infrared radiation on skin erythema, hyperpigmentation, and delayed tanning are influenced by various factors. These factors include skin penetration of certain wavelengths, individual skin types, and the absorption spectrum of different chromophores in the skin. There is an absorption spectrum of endogenous and exogenous skin chromophore that gives the effect of VL radiation, such as erythema, pigmentation, thermal damage, and free radical production, which induces indirect DNA damage through ROS generation, photodermatosis (Sklar et al, 2013).

UVB is an effective spectrum for inducing erythema, which is followed by delayed tanning. UVA induces hyperpigmentation and delayed tanning. At high doses, UVA (especially UVA2) can cause erythema in individuals with skin types I-II (Pacifico et al, 2019)

Visible light has been shown to induce an erythema and tanning response in dark skin, but not in fair skinned individuals. Infrared radiation produces erythema which may be a thermal effect (Randhawa et al, 2015)

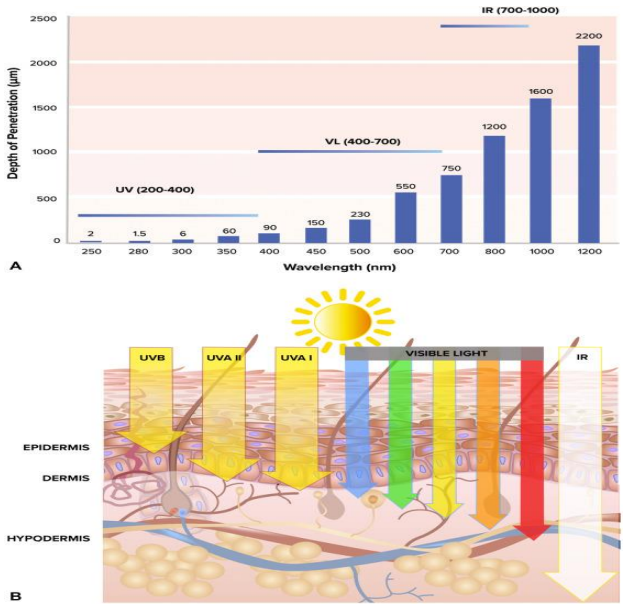

Figure 2.
Visible light: depth of penetration (Anderson and Parish, 1981). Visible light penetration depth: Red light can penetrate until it reaches the subcutaneous adipose layer, while blue light only reaches the dermis, this shows that the wavelength is directly proportional to the depth of penetration, but inversely proportional to the energy.
B. Schematic of penetration depth, electromagnetic spectrum of sunlight.

Beer-Lambert and Planck's law that the wavelength is directly proportional to the depth of penetration but inversely proportional to the energy, As a result, blue light (BL) has higher energy than red light (RL) but has less penetration. Pathological changes in the skin, such as edema, erythema, pigmentation, and fibrosis, can affect light penetration by changing the concentration and density of chromophores. (Kocsis et al, 2006).

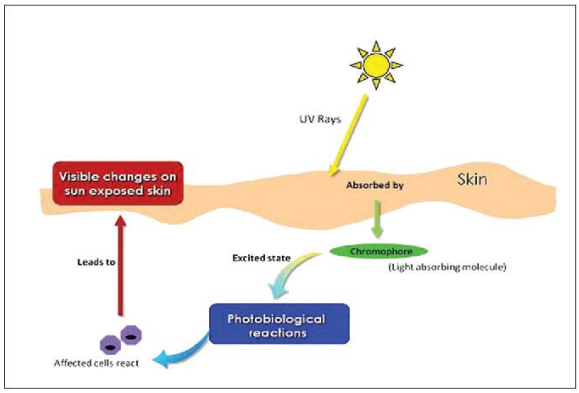

Figure 3. Schematic representation of the photobiological response Sun Protection (Solano, 2020)

a. Photoprotection modalities.

Photoprotection is very important to maintain healthy skin, minimize post-inflammatory hyperpigmentation, and prevent

photoaging and photocarcinogenesis (Martini and Maia, 2018).

Photoprotective measures:

1. avoid the sun,
2. Looking for a shady place,
3. use protective clothing,
4. Wearing a hat and sunglasses,
5. Apply a broad-spectrum sunscreen.

UV filters are used in sunscreens such as organic (chemical) or inorganic (mineral). Organic and inorganic filters are terms recommended by the US Food and Drug Administration (FDA). All UV filters, including mineral filters (Zinc oxide (ZnO) and titanium dioxide (TiO2) are "chemical". Nano-sized inorganic filters (ie, ZnO, TiO2) do not have VL photoprotective properties, but non-nano inorganic filters do. (Mancuso et al, 2017)

Table 1. Ultraviolet filter recommended by the FDA in 1999

light filter	**Maximum Approved Concentration (%)**	**Peak Absorption (nm)**	**Action spectrum**
Organic Filters			
PABA derivatives			
PABA	15%	283	UVB
Padimate O	8%	311	UVB
Benzophenones			
Dioxybenzone	3%	352	UVB, UVA2
Oxybenzone	6%	288, 325	UVB, UVA2
Sulisobenzone	10%	366	UVB, UVA2
Salicylates			
Homosalate	15%	306	UVB
Octisalate	5%	307	UVB
Trolamine salicylate	12%	260–355	UVB
Cinnames			
Cinoxate	3%	289	UVB
Octinoxate	7.5%	311	UVB
Other			
Avobenzone	3%	360	UVA2, UVA1

light filter	Maximum Approved Concentration (%)	Peak Absorption (nm)	Action spectrum
Ensulizole	4%	310	UVB
Meradimate	5%	340	UVA2
Octocrylene	10%	303	UVB, UVA2
Inorganic			
Titanium dioxide	25%		UVB, UVA2, UVA1
zinc oxide	25%		UVB, UVA2, UVA1

Source: Hexsel et al, 2007

b. Organic filters.

The organic filter consists of an aromatic ring and an electron donor and acceptor functional group that delocalizes electrons upon UV irradiation and absorption. There are five main types of organic filters: para-aminobenzoic acid (PABA) derivatives, benzophenone , salicylic, cinnamic and others. Oxybenzone is the most commonly used benzophenone and absorbs short UVB and UVA. UV filters are often combined to improve photostability and spectral performance. The structure of the organic filter allows for the UVR, but not the VL, to be absorbed, resulting in a conformational change of the molecule. As the molecule returns from the excited state to the ground state, energy is released as heat (Figure 4).

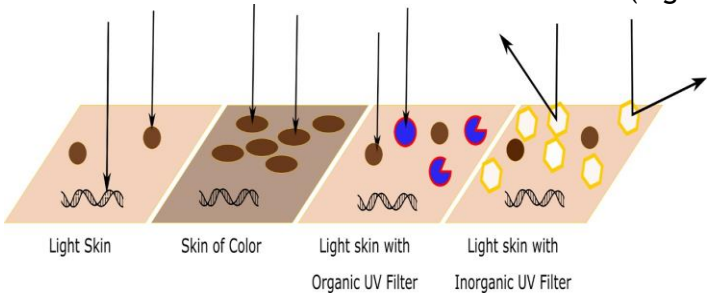

Figure 4. The mechanism of action of organic and inorganic UV filters. Note that as the diameter of the inorganic filters decreases, they do absorb UVB.
Source: Geisler, 2021

c. Inorganic filters.

Two FDA-approved inorganic filters, ZnO and TiO2, are metal oxides that effectively absorb, reflect, or scatter electromagnetic radiation. Inorganic filters are non-toxic, non-allergenic, and largely unaffected by light-induced reactions, unlike organic filters. Products with inorganic filters may make the skin appear chalky white which limits its use due to cosmetics, especially in skin of

color (SOC). The micron formulation makes inorganic filters more cosmetically attractive, but less protective against UVA and VL. The larger opaque pigment provides superior protection against VL-induced photodermatosis, such as erythropoietic protoporphyria (EPP) (Geisler et al, 2021)

d. Colored sunscreen (tinted)

Since neither organic nor inorganic UV filters used in sunscreens protect against VL, tinted (tinted) sunscreens are available to protect against VL. Colored sunscreens consist of a mixture of iron oxide pigments (Fe2O3) and TiO2 which act as VL and UV blockers. Depending on the oxidation state, Fe2O3 may appear yellow, red, or black. Yellow Fe2O3 protects melanocompetent subjects from VL-induced pigmentation. Tinted sunscreen reduces VL transmission by 93-98%. Daily application of tinted sunscreen reduces the appearance of skin hyperchromia after 60 days (Boukari et al, 2014)

Castanedo-Cazares, et al. (2014) compared a combination of Fe2O3 and TiO2 with an SPF 50+ non-tinted mineral sunscreen with ZnO and TiO2 for protection against VL-induced pigmentation. Expert judgment and colorimetry demonstrated that formulations containing Fe2O3 were more protected against VL-induced pigmentation than non-colored mineral sunscreens in Fitzpatrick IV individuals.

Formulations containing Fe2O3 in women's facial products, including foundations, have the dual function of covering pigmentation blemishes and reducing the further development of pigmentation caused by sunlight. The availability of foundations in a variety of shades and tones can offer customized daily protection beyond the UV spectrum for individuals of all skin phototypes. Foundations containing Fe2O3 to even out skin tone and cover blemishes have been proven to protect against blue light (Dumbuya et al, 2020).

Photoprotection against VL is relevant for SOC, as VL can cause melasma and post-inflammatory hyperpigmentation. Colored sunscreens that include mineral pigments increase Melasma Area and Severity Index (MASI) scores. A study compared the use of a broad-spectrum UV protection containing Fe2O3 as a VL-absorbing pigment (UV-VL) and a regular UV-specific broad-spectrum sunscreen in 61 patients with melasma, receiving 4% hydroquinone as a depigmentation treatment at 8 weeks, UV-VL protection showed a 15%, 28%, and 4% greater improvement in MASI, colorimetric values, and melanin assessment, respectively. In addition to improving melasma lesions after 8 weeks, broad-spectrum sunscreens containing Fe2O3 alone or in combination with ZnO and TiO2 prevented recurrence after 6 months (Castanedo-Cazares, et al 2014)

e. sunscreen application.

The effectiveness of sunscreens was measured by a sun protection factor (SPF), an assessment of the minimal erythema dose ratio (MED) UVR on filter-protected skin compared to unprotected skin (MED protected/unprotected). For SPF testing, sunscreen is applied at 2 mg/cm2, which is equivalent to 30 mL (1 oz) for the entire body surface. SPF is a measure of the erythemogenic effect of UVB, and to a lesser extent, UVA. In the US, sunscreens labeled "broad spectrum" must have a critical wavelength (CW) of 370 nm. To meet this criterion, at least 90% of the total absorbance of the product must be at or above this CW value

when measured using UV wavelengths ranging from 290 to 400 nm (Majeed et al. 2020)

Broad spectrum sunscreen with SPF >15 can claim protection from skin cancer and premature skin aging. Theoretically, for someone who burns normally after 10 minutes, wearing SPF 15 will allow them to stay outside 15 times longer (2.5 hours) without burning if exposed to constant sunlight. However, most individuals tend to apply sunscreen less. Therefore, the SPF used is significantly lower than the labeled SPF. In addition, SPF alone does not show protection against UVA or VL (Majeed et al, 2020)

The FDA and the US Preventive Services Task Force recommend using a broad-spectrum filter with an SPF>15, while the American Academy of Dermatology (AAD) recommends an SPF>30. Products with SPF 15, 30, and 60 allowed 6.7%, 3.3%, and 1.7% UVR to be transmitted to the skin surface, based on topical application at 2 mg/cm. However, consumers usually apply 0.5-1.0 mg/cm. While the difference between SPF 30 and 60 (3.3% vs. 1.7% transmittance) is relatively minimal for a single acute exposure, with daily application over time, a more than 2-fold difference can significantly influence the effects of chronic UV on the skin." The Teaspoon Rule of Applying Sunscreen," which suggests 1 teaspoon of sunscreen to the face/head/neck, 1 teaspoon for each upper extremity, 2 teaspoons for the trunk, and 2 teaspoons for each lower extremity, is proposed to help achieve this. density of 2 mg/cm2 (Geisler, 2021)

f. More photoprotective strategy.

Pollutants, clouds and fog can reduce the intensity of UVR, VL, and IR; ozone absorbs UVC (99%), some UVB (90%), but little or no UVA or VL (50%). Calculations of the US National Weather Service's UV index assume that clear skies allow 100% of UV transmission, 89% scattered clouds, 73% broken clouds, and 31% overcast skies. Clear glass allows up to 90% VL (rated from 400–780 nm), 72% UV (from 300–400 nm), and 83% of solar heat to penetrate. Tinted or reflective glass transmits less VL, UV and IR radiation; however, US federal standards mandate at least 70% VL transmission through the windshield. All types of transmitting UVB glass blocks (280–315 nm). Dark sunglasses can block UVA and VL but can cloud vision (Kuallavanijaya and Lim, 2005)

UVB can damage the cornea and lens, while VL can affect the retina. Glasses with blue lenses absorb VL between 400–500nm. Orange and yellow lenses provide the best protection against UV and VL. A wide-brimmed hat can offer an SPF of up to 7.5. UV protection factor (UPF) is a measure of protection against UV through clothing. UPF 15–24 exhibits good protection, 25–39 excellent protection, and 40–50 excellent protection, with tight weave and dark fabrics superior. Pigments in make-up and tanning preparations (eg, dihydroxyacetone) protect against UVA and VL by their oxidizing effect which turns the skin color orange-brown. The color stays attached to the stratum corneum and provides SPF (Geisler, 2021).

CONCLUSION

1. Invisible light: Types of wavelengths in the electromagnetic spectrum that is short or too long to be detected by the human eye (ultraviolet and infrared light)
2. Visible light: Types of wavelengths in the

electromagnetic spectrum that are visible by the human eye

3. Effects of visible light and infrared radiation involving chromophores There is an absorption spectrum of endogenous and exogenous skin chromophores. VL radiation effects can caused erythema, pigmentation, thermal damage and free radical production, indirect DNA damage through ROS generation, and photodermatosis.
4. Photoprotection aims to maintain healthy skin, minimize post-inflammatory hyperpigmentation, prevent photoaging and photocarcinogenesis by: avoid sunlight, looking for a shady place, wear protective clothing, wearing a hat and sunglasses, and apply a broad-spectrum sunscreen.
5. UV filters used in sunscreens can be organic (chemical) or inorganic (mineral) and tinted (tinted) sunscreens are available to protect against VL.
6. To protect against VL radiation, a tinted sunscreen consists of a mixture of iron oxide (Fe2O3) and TiO2 pigments that act as VL and UV blockers

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