Nanomaterials for Broad Spectrum Sun Protection for the Skin: Microfine Zinc Oxide and Titanium Dioxide

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Introduction

(see references 1 and 2 for this section)

Ultraviolet radiation (UVR) from sunlight is only about 5 percent of the total amount of electromagnetic radiation reaching the earth's surface, however it has been shown to be very harmful to the skin. Electromagnetic radiation is classified according to wavelength (1nm = 10^{-9}m) and shorter wavelengths have higher frequencies and higher energy. Of the solar spectrum, the shortest wavelengths reaching the earth's surface are in the ultraviolet region (Fig. 1).

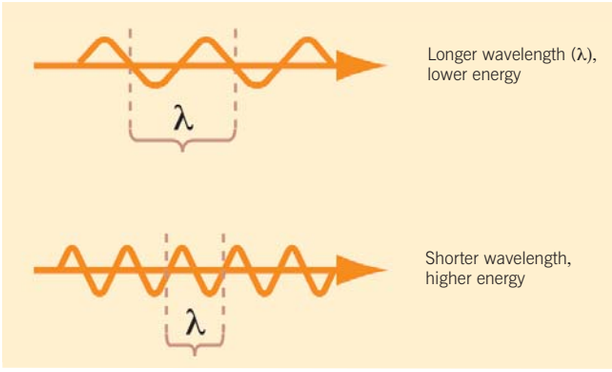

Figure 1. The wavelength (λ) is one full cycle.

The dimensions of the relevant UV wavelengths begin at 290nm and extend through 400nm (Fig. 2) and are classified as UVB (290–320nm) and UVA (320–400nm). Most of the UV radiation reaching the earth's surface is UVA. Radiation between 400 and 700nm is classified as visible (light) and above 700nm is infrared (heat). Radiation below 290nm is UVC and is highly damaging. However, UVC is screened out by the ozone layer of the atmosphere and does not reach the earth's surface. UVB radiation has the highest energy since it has the shortest wavelength and can cause sunburn. UVA has lower energy, but it penetrates deeper into the skin and has a major contribution to photoaging. Excess exposure to both are known to be risk factors for skin cancer as well, so the need for broad-spectrum (UVA and UVB) filters for skin protection has been clearly established. Titanium dioxide and zinc oxide have been long recognized as efficient particulate agents that filter UVA and UVB from solar radiation.

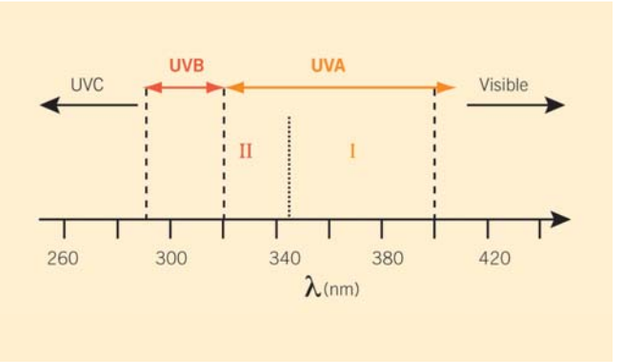

Figure 2. UVB covers λ 290–320nm. UVA extends from 320–340nm (UVA II) and from 340–400nm (UVA I).

Microfine metal oxides provide protection from UVR without whitening the skin

(see references 3, 4, and 5 for this section)

Conventional pigment-grade metal oxides such as zinc oxide (ZnO) and titanium dioxide (TiO_2) do not produce transparent films in sunscreen formulations, that is, when applied in a lotion form on the skin, they cause whitening. This is especially problematic for darker skin tones. The opaque appearance is from the scattering of the radiation within the wavelength range of the visible spectrum (400–700nm). For sunscreen use on the skin, the diameter of the particle of the metal oxides is reduced from greater than 500nm to less than 200nm. These are known as nanoparticles. They are also referred to as ultrafine or microfine particles. Zinc oxide and titanium dioxide particles below this diameter can successfully scatter UVA and UVB radiation from 290nm up to around 370nm while allowing longer wavelengths (visible) to pass through. This gives an aesthetically acceptable transparent film on the skin instead of imparting an undesirable white or blue tint to the skin.