EDUCATION science

modern SUN PROTECTION

The sun is the culprit in sunburn, skin cancer and photo-ageing. The solar spectrum ranges in wavelength from 290 nm to 3000 nm. Although the sun emits the wavelength shorter than 290 nm, this radiation is referred to as short wave ultraviolet or UVC and is absorbed by the ozone layer of the earth's atmosphere and does not reach the surface.

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The solar spectrum is generally divided into three categories: ultraviolet (290 - 400 nm), references visible (400 - 760 nm) and infrared (760 - 3000 nm). The ultraviolet category of the solar spectrum is further subdivided into middle wave ultraviolet (UVB: 290 - 320 nm) and long wave ultraviolet (UVA 320 - 400 nm). Recently UVA has been subdivided into UVA I (340 - 400 nm) and UVA II (320 - 340 nm). The composition of the solar spectrum at the earth's surface (sea level) is approximately 49% visible, 45% infrared and 6% ultraviolet. Among ultraviolet, UVB is about 0.5%. Although composing only about 0.5% of the total solar spectrum, it is UVB, which is responsible for producing sunburn and associated skin cancer.

All traditional sun protection products mainly focus on the skin protection against sunburn. The sun protection capability of a product is expressed as SPF (Sun Protection Factor). The SPF is defined as the ratio of the time needed to produce the equal sunburn with and without a sunscreen product. This can simply be expressed as the following equation;

$$SPF = \frac{\text{Average time length for producing skin burn with sunscreen}}{\text{Average time length for producing skin burn without sunscreen}}$$

Assuming the skin gets burned after 1 hour without any sunscreen and the skin gets the same burn after 10 hours with a sun protection product, the SPF value of the sun protection product would be 10/1 ie: SPF 10. The SPF ranges from 10 to 25 for most sunscreen products on the market. A sunscreen called oxybenzone (benzophenone - 3) is commonly added into sun protection products to shield UVA. However, the UVA protection is quite limited because it does not shield UVA (I). Most other UVA absorbers either do not shield the entire UVA spectrum or have poor shielding efficiency. There is a newly approved UVA sunscreen in the USA which is called Avobenzone (butyl methoxy dibenzoyl methane) providing good UVA protection.

figure 1 : comparison of particle sizes in sun lotion

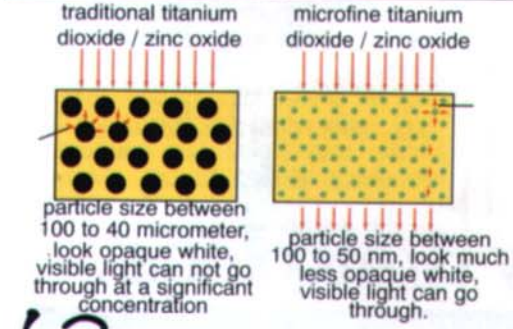
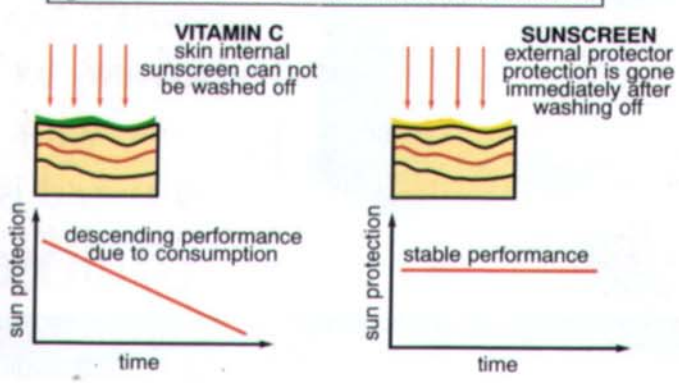


figure 2 : difference between vitamin C and sunscreen



Toxicological studies clearly indicate that all traditional absorbers have skin irritation, eye irritation, possible phototoxicity and skin sensitisation. Modern research reveals that all traditional sunscreens have skin penetration problems due to their small molecular size and chemical structure (molecular weight between 200 - 400). The higher the SPF value, the more skin penetration of the sunscreens. The penetration may cause skin discomfort, irritation and even skin cancer particularly with long term use. Many dermatologists are concerned about this potential side effect of the sunscreen products. There is contradiction between sunscreen's benefits and drawbacks.

Traditionally titanium dioxide and zinc oxide are used as white pigments for paint, paper, synthetic fibre and facial masks. Their particle size is between 100 - 20 micrometer. Titanium dioxide and zinc oxide can block ultraviolet light and are called physical sunscreens because they are not soluble in water or organic solvents and ultraviolet is not absorbed by their molecules. However, titanium dioxide and zinc oxide also block visible light and show white opaque colour. Therefore, they are not suitable for cosmetic use. Nobody will wear a white mask for working and social activity.

Modern technology is able to reduce titanium dioxide and zinc oxide to microfine size - 100 to 50 nm(1nm is 1/1000 micrometer or 10-9 meter) Microfine titanium dioxide and zinc oxide have been found to block UVB and UVA more efficiently in their microfine particle sizes. Extensive studies have demonstrated the microfine titanium dioxide with particle size 50 nm and microfine zinc oxide with particle size 100 nm is the optimum for physical sunscreens. On the other hand microfine titanium dioxide and zinc oxide do not block visible light so much . This means the microfine titanium dioxide and zinc oxide do not look so white and are compatible to cosmetic application. Why do microfine titanium dioxide and zinc oxide become cosmetically transparent ? A microfine particle has far less light scattering and scatters light in all directions. Some of the scattered visible light goes forward becoming transmittance. Therefore microfine particles allow the visible light to go through (see through) and appear somewhat transparent. This is illustrated in Figure 1 .

Actually the blocking efficiency of UV and visible light varies with particle sizes of microfine titanium dioxide and zinc oxide . The relationship is somewhat complicated . The details of this subject is beyond the scope of this article .

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Being well known , titanium dioxide and zinc oxide are very inert and non - toxic to skin . Although microfine titanium dioxide and zinc oxide have very small particle size , they are still one hundred times bigger than traditional sunscreens and do not dissolve in water or most organic solvents. Therefore , they have no skin penetration. As a result , these physical sunscreens are absolutely safe for skin application . It is a very important benefit compared with all traditional organic sunscreens .

There is some difference between microfine titanium dioxide and zinc oxide . Microfine titanium dioxide has superior blocking effects on UVB and a good blocking effect on UVA (II) but a poor effect on UVA (I) . In contrast , microfine zinc oxide has a good blocking effect for UVB and UVA (II) and superior effect on UVA (I) .

Modern research reveals UVA penetrates the skin far deeper than UVB due to its longer wavelength . Thus , UVA directly affects all constituents of dermis and is responsible for the skin photo-aging ; wrinkles ; undesirable pigmentation ; immunosuppression and the risk of melanoma . UVA radiation is relatively constant year-round . Therefore , a good sun protection should not only prevent sunburn but also block entire UVA radiation . Microfine titanium dioxide might be used together with microfine zinc oxide to enhance the UVB blocking effect (increase SPF value) .

The recent studies reveal that vitamin C can prevent and repair sun damage to skin . Vitamin C does not absorb UV rays and provides sun protection via a totally different mechanism than sunscreens . Vitamin C has an excellent anti-inflammatory effect , keeps cells from being damaged by oxygen free radicals and helps collagen synthesis . Therefore , Vitamin C 's sun protection is independent from UV wavelength . In other words , vitamin C can protect skin against both UVB and UVA . Vitamin C protects the skin at its own consumption . This is similar to the anti-oxidation process in which an anti-oxidant is oxidised itself first to keep the target from oxidation . By analogy , vitamin C is similar to body guards who fight with the enemy to protect their master. As the fight goes on , the number of body guards may decrease due to sacrifice and the protection capability to master decreases accordingly . The sunscreen particularly the physical sunscreen has a constant protection as long as they stay on the skin (if no rubbing and sweating off) . By analogy , traditional sunscreen is similar to a solid wall which stands constantly if there is no mechanical damage . Once a sunscreen is removed , the protection diminishes immediately . The difference between vitamin C and sunscreen is illustrated in Figure 5. It should be well understood that vitamin C will only provide sun protection after absorption into the skin . In other words , Vitamin C does not provide any sun protection if it remains on the skin because it does not absorb or block UV rays . Vitamin C behaves as an internal sunscreen under the skin and the protection remains until the vitamin C is either consumed by the body or sun radiation . Therefore , it is recommended to apply a concentrated vitamin C (> 8 % in a penetrative vehicle - single aqueous phase) as a first layer on the skin . In contrast , vitamin C added into a sunscreen product is not so effective due to a poor skin penetration (a low concentration in emulsion) . As is well known , a sunscreen can reduce but can't totally eliminate the UV penetration to skin . For instance , exposure to sunlight with a sunscreen of SPF 10 would generally get 10% sun damage compared with no sun protection . With a sunscreen of SPF 20 , the damage would be 5% .

In military practice , a solid wall and guards are often used together to defend a site . Similarly the combination of vitamin C and sunscreen - the concept of dual sun protection is developed .

The application is really simple - apply concentrated vitamin C serum on the skin , allow it to be absorbed thoroughly and then apply an appropriate sunscreen . For a better result , the topical vitamin C may be applied twice . According to some experimental results , Vitamin C at a high concentration (under the skin) can easily reduce 40 - 50 % of UVB damage . The comparison between double sun protection and single sunscreen protection is illustrated in Figure 3 . Obviously the single protection (sunscreen with SPF 20) reduces the sun damage to the 5% of that without any sun protection . In dual protection , vitamin C further cuts down 50% and the ultimate sun damage is 2.5 % . This is equivalent to a sunscreen with SPF 40 , which is difficult to formulate so far . Evidently , dual protection is much more effective than a single sunscreen protection . In addition to blocking UVB (SPF value) , Vitamin C protects the skin against UVA's photo aging very well . This is an important benefit of the double sun protection concept .**In summary , physical sunscreens without or with minimal concentration of chemical sunscreens is good for skin safety , particularly for long term use . A sunscreen with a broad spectrum including UVA should be chosen for complete sun protection . The dual protection can be adopted for enhancing sun protection .**

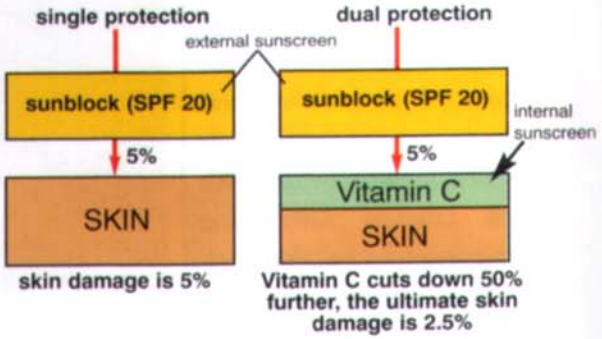

figure 3 : difference between vitamin C and sunscreen