

# Determination of the in vitro UV A factor of Sunscreen products on the German market

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## Introduction

UV A radiation is the most prevalent component of UV radiation in sun light. It causes the tanning reaction (both the immediate tanning and the delayed tanning reaction). UV A can also evoke the sunburn reaction, but the erythemogenic capacity of UV A is very weak. About 20 to 100 j/cm<sup>2</sup> of UV A dose is required to produce a minimally perceptible redness reaction. UV A induced erythema is seen soon after exposure and the exposed sites may be red up to 24 hours.

The amount of UV A energy reaching the surface of the earth is about 10-20 times greater than that of UV B (5 to 6 mW/cm<sup>2</sup> of UV A versus 0.3 to 0.5 mW/cm<sup>2</sup> of UV B). Therefore, the long-term cumulative effects of UV A radiation may be as dangerous as the effects of UV B radiation. The combined effects of UV A & UV B are usually additive. UV A is usually involved in evoking phototoxic and photoallergic reactions.

Although UV A radiation is less erythemic and less damaging than UV B radiation, it's becoming increasingly clear that this spectrum of sunlight can not be neglected.

UV A radiation has been shown to produce many of the potentially deleterious effects in mammalian skin, including human skin. UV A radiation causes, among others:

- 1) sunburn (endothelial cell damage),
  - 2) damage to melanocytes manifested by proliferation of melanocytes and augmentation of melanin pigmentation
  - (3) edema (swelling of any organ or tissue due to accumulation of excess lymph fluid),
  - (4) DNA damage in the form of cyclobutane pyrimidine dimers and inhibition of DNA synthesis,
  - (5) Depletion of epidermal Langerhans' cells,
- UV A wavelengths are also responsible for inducing certain skin diseases that are manifested in the form of drug induced phototoxic reactions, polymorphous light eruptions (papules, plaques with pruritus) and solar urticaria. Long-term UV A exposures have also resulted in epidermal tumors and augmentation of UV B photocarcinogenesis.

**Aim of Study:** This study was aimed at evaluating the quality of sunscreen products on the German market regarding the UV A protection. All product classes on the German market were analysed. For the determination of the UV A protection factor, the new in vitro method developed by **Wendel et al from Beiersdorf AG (BDF method)** with a routine spectrometer with integration sphere (fig. 1 & 3) was used.

## Method

This method is based on transmission measurements. The transmission measurements were carried out through thin layers of product sample on roughened PMMA-plates (Fig. 2). The amount of sunscreen was adjusted to the roughness of the plates to ensure an optimal distribution of the sample and measurement in the optimal range of the spectrophotometer. The transmission was measured in the UV range (290-400 nm) in steps of 1 nm. Measurements were performed on 3 plates and at 4 different positions per plate. Mathematical normalisation of the absorption spectrum to the labelled (in vivo) SPF makes it possible to predict the level of in vivo UV A protection. (V. Wendel et al, 2001).

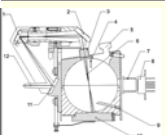


Fig. 1: Path of rays for transmission measurements (integration sphere)(1) mirror 2 (2) mirror 3 (4) baffle 1 (6) not scattered radiation (7) reflector (8) radiation detector (9) baffle 2 (10) PMMA plate (11) mirror 1 (12) path of rays of device



Fig. 2: Picture of PMMA plate with sample



Fig. 3: Integration sphere with PMMA plate, ready for measurement.

## Results and Discussion

76 representative sunscreens from the German market were studied. These market products contained all the common UV filters and UV filter combinations corresponding to a UV B protection performance ranging from SPF 4 to 60. In addition, different Emulsion types were included. These products were chosen from all price categories on the market. Expensive mark and cheap no-name products were studied

Sun milks and sun creams are the most popular forms on the market. The Emulsion type is evenly distributed.

**Generally, there seemed to be no correlation between the SPF and the UV A factor. Many products with the same SPF showed totally different UV A factors. The rampant mixture of colours and numbers in figure 4 is proof of lack of correlation.**

**Products with SPF 4, 6, 8,12,15, 30, 40, 50 fall almost on a straight line which means that these products have almost the same UV A protection factor.**

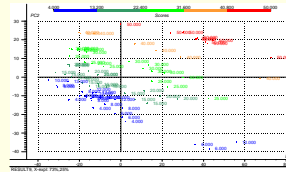


Fig. 4: Interrelation between in vivo SPF and in vitro UV A for all products. The band above the graph (blue, grey, green, orange and red) represent the SPF range and the figures inside stand for the SPF of the various products. Products with SPF between 4 and 13,2 are written with blue ink.

However, some mark products from the same company seemed to show a significant trend.

The interrelation of both parameters was therefore analysed in two groups

**Expensive mark products:** A few products from the category E,M (expensive mark) were chosen and the trend was analysed (see Fig. 5). These products were chosen from the same company since it was obvious that almost the same UV absorbers and method of formulation will be used.

There was a good correlation between the SPF and the UV A factor ( $R^2 = 0.8724$ ).

**Cheap no-name products:** The same way, a few products were chosen from this category. The products were chosen randomly from more than one company because unlike the big companies, the small ones will only have a maximum of 3 products in a series.

As expected, there was a very poor correlation between the parameters in question ( $R^2 = 0.0419$ ), see Fig. 6).

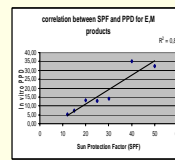


Fig. 5: Correlation between in vivo SPF and in vitro UV A (E,M products)

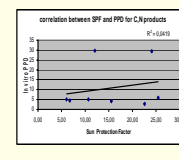


Fig. 6: Correlation between in vivo SPF and in vitro UV A (C,N products)

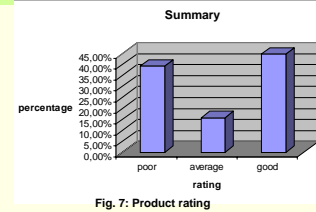


Fig. 7: Product rating

## Rating of products

According to the Guideline 2006 of the European Commission, a good sunscreen product should protect from both UV B and UV A radiation, should have a sun protection factor (SPF) of at least 6 and a critical wavelength of at least 370 nm. The UV A factor should be at least 1/3 of the UV B factor (SPF) which means the UV A/UV B ratio should be at least 0,33.

The summary of all products in this study can be appreciated in Fig.7 above.

The products were classified in 2 categories. Cheap, No-name (C,N)- 23 and Expensive, Mark (E,M)- 53.

The products were rated according to the 3 important parameters: SPF, UV A/UV B ratio and Critical Wavelength. The products with 2 or more inadequate parameters were rated "poor" (p), with 1 inadequate were "average" (av) and the products which fulfilled all conditions were rated "good".

• There is almost an equal distribution of good and poor products on the market. From the 76 samples tested, only 6 of them had the in vivo UV A factor (PPD) on the package and these were products from the same company

• The feature of a particularly well-balanced or equilibrated relationship of UV A and UV B protection - without reference to the Australian standard - was only claimed in a few cases (mostly the E,M products). This led to a large range (in vitro UV A) in the products with the same SPF e.g., the UV A factor for products with SPF 30 in this study ranged from 4,1 to 18,9.

• Among the 34 "good" products, 28 were expensive mark (E,M) products. 6 cheap, no-name (C,N) products also fell under this category..

Most of the products here contained a combination of more than 2 UV B and UV A absorbers each, which was not always the case with the other products.

• 19 out of 53 expensive mark products were considered "poor". 11 out of 23 cheap no-name products also found themselves here.

• There was a peculiar observation with the all natural products (only inorganic UV filters). Though they always had a very low UV A/UV B ratio, the Critical wavelength was always very high. More research should be done to explain whether it really has something to do with the fact that they only contain TiO<sub>2</sub> and/or ZnO or if it's just a coincidence!!

## Further Results:

1. There was no correlation between the AOC and the in vitro UV A factor.
2. A balanced UV A/UV B protection does not only depend on the number of UV absorbers in the product. A product with only 1 UV A absorber can be equally or even more effective than a product with 6 UV A absorbers.
3. There's a relation between the CW, UVA factor and the UV A/UV B ratio. The correlation between the CW and UV A factor is not significant because the UV A factor depends on the SPF (high SPF= high UV A factor).

However the correlation between the UV A/UV B ratio and the critical wavelength was obvious in most cases.

4. This method is not efficient in measuring the in vitro SPF of Sunscreen products.

5. The type of emulsion ( W/O, O/W) has no effect on the in vitro UVA factor.

6. It is important that photo- stable UV filters are used to ensure that the sunscreen products retain their efficacy during sun exposure. Photostability of sunscreens should be part of the quality recommendations for sunscreen products of the European Union.

## Conclusion:

- To enable the consumer to choose the right products from the bulk of products, the declaration of the UV A factor must be standardised like the SPF.
- More research must be done in order that a standardised method (not Australian standard) be used for the determination of the in vitro UV A factor.
- This method proved to be effective.



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