

Evaluation of Sunscreen Agents

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Synopsis—A new method for the evaluation of sunscreen agents is presented. The method is based on Urbach's chemical ultraviolet exposure-meter system (1). For the sake of comparison, ultraviolet absorption values of the compounds tested are also reported.

INTRODUCTION

It is known that ultraviolet solar rays with a wavelength of from about 2900 to 3000 Å cause severe burning of human skin upon over-exposure. To diminish the burning and protect human skin, ultraviolet light absorbing compounds are added to lotions, aerosols, and creams that are applied to the human body. A list of various ultraviolet light-absorbing compounds has been tabulated by Giese *et al.* (2). Subsequent research dealing with sunscreen products has been directed toward the studies of sunscreen agents themselves, their vehicles, and the development of methods for their evaluation. New formulations are appearing on the market regularly, and, in many instances, superior sunscreen properties are claimed. Thus, the development of an *in vitro* method for testing the efficiency of these products in their final form would enable one to make comparisons.

Giese *et al.* (3) used the skin of the arm or abdomen of human subjects for evaluation of sunscreen agents. They reported that the minimal erythema dosage varies from individual to individual, depending upon previous exposure and the type of skin. Knox (4) used the abdomen of the albino rabbits in his studies but noted the same disadvantage of nonuniformity of response. The inherent variations encountered when employing human subjects or rabbits render tests on

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living subjects difficult to evaluate. Admittedly, fairly good data can be obtained through large scale field testing of human subjects. However, this is an expensive and time consuming procedure.

Parke and Sperandio (5) published a photographic method of evaluation which is too complicated for routine use in the laboratory; Riegelman (6) reported that the absorption spectrum can vary with the solvent used. In the final form of the formulation, a common solvent for spectrophotometric testing may not be easy to find. Thus, the need for a simpler and reliable method for the evaluation of sunscreens would appear to be welcome.

EXPERIMENTAL

Materials and Equipment

1. *Urbach's System*: A mixture of 62 mg methyl yellow, 120 mg hexachlorocyclopentadiene, 10 mg dibenzylamine, and 447 g Aloe's wax paraplax* is prepared as follows:

The wax is melted and the other ingredients are added. The melt is poured into Petri dishes and allowed to cool before use. These dishes should be kept away from direct light. Upon exposure of this system to uv light, a free halogen radical is liberated from hexachlorocyclopentadiene which then combines with hydrogen to form an acid. The pH indicator, methyl yellow, then responds to changes in the acidity by turning from yellow to red. Thus, the amount of color change (from yellow to red) is a measure of incidental ultraviolet radiant energy absorbed by the system (7).

2. *Brass Plate*: This plate is slightly shorter than the size of the Petri dish and is about 167 μ thick. A circular hole is cut in the center, and eight more holes surround the central one (hole radius approximately 6 mm). The outside holes are numbered from one through eight.

3. *Westinghouse Fluorescent Sunlamp*†: This 20-watt lamp has an approximate range of 2900 to 3500 A, with a peak at approximately 3100 A. Minimum energy output is 47 μ w/cm² at 1 m. Erythema is produced by this lamp in 140 seconds, whereas average sun produces it in 762 seconds.

4. *Beckman DB Spectrophotometer with Sargent Recorder*: All spectral curves were obtained with this instrument. Concentration of each compound was 0.0015% in methanol. Red Veterinary Petrolatum was

* Available from Aloe's Scientific Co., 1831 Olive St., St. Louis, Mo.

† Westinghouse lamp number S.S.20.

used at 0.015% because Veterinary Petrolatum is used *per se* for protection, whereas 10% concentrations of other absorbers, like *p*-aminobenzoic acid, are commonly employed. Red Veterinary Petrolatum is not soluble in methanol; therefore, the solution was made in chloroform. A curve for red veterinary petrolatum with vitamin B-2 could not be made because of the nonavailability of a common solvent. Results, the average of three readings at 2900, 3100, and 3300 Å, appear in Table I. The results were calculated on the basis of the same solution strengths as those used in Urbach's system.

5. *Polyethylene Glycol 1500 (Carbowax 1500*)*: This was found to be the best vehicle for all the sunscreen agents because, in itself, it does not absorb any uv radiant energy from the sunlamp. The prepared concentrations of sunscreen agents were the same as those conventionally available on the market. Red Veterinary Petrolatum and Red Veterinary Petrolatum with vitamin B-2 were not mixed or diluted with polyethylene glycol 1500. All the other sunscreen agents were prepared by thorough mixing with the melted polyethylene glycol 1500 at the indicated percentages. They were cooled to room temperature before testing.

(a) 2-Ethyl hexyl salicylate	5%
(b) 2-Ethoxy- <i>p</i> -methoxy cinnamate	1.5%
(c) Homomenthyl salicylate	3%
(d) Isobutyl- <i>p</i> -aminobenzoate	5%
(e) <i>p</i> -Aminobenzoic acid	10%
(f) 2-Hydroxy-4-methoxy benzophenone-5-sulfonic acid	10%

Table I
Average Absorption Values Between 2900-3300 Å

Agent	Absorption ^a	Rating ^b
Red Veterinary Petrolatum	3.0	Fair
Red Veterinary Petrolatum with B-2 (No common solvent available)
2-Ethyl hexyl salicylate	0.85	Poor
2-Ethoxy- <i>p</i> -methoxy cinnamate	0.59	Poor
Homomenthyl salicylate	0.54	Poor
Isobutyl- <i>p</i> -aminobenzoate	2.25	Fair
<i>p</i> -Aminobenzoic acid	3.5	Good
2-Hydroxy-4-methoxy benzophenone-5-sulfonic acid	4.5	Good

^a Calculated on the basis of the percentage solution as used in the Urbach system.

^b Assigned on the basis of light absorbed.

* Trade mark of Union Carbide Corp., 270 Park Ave., New York, N. Y. 10017.

Table II
Ratings According to Urbach's System Testing

Name of the Agent	Rating
Red Veterinary Petrolatum	Good
Red Veterinary Petrolatum with B-2	Good
2-Ethyl hexyl salicylate	Fair
2-Ethoxy- <i>p</i> -methoxy cinnamate	Poor
Homomenthyl salicylate	Poor
Isobutyl- <i>p</i> -aminobenzoate	Poor
<i>p</i> -Aminobenzoic acid	Fair
2-Hydroxy-4-methoxy benzophenone-5-sulfonic acid	Fair

Method

The brass plate was superimposed on Urbach's system in the Petri dish and held firm with the help of two small pins. Fifty mg of each sunscreen formula was first daubed in the numbered holes and rubbed in to form what appeared to be an even layer. This technique is a source of error in this procedure. Similarly, 50 mg of the polyethylene glycol 1500 was rubbed in the central hole. The dish was then exposed to the Westinghouse sunlamp for 20 minutes at a distance of 25.5 cm. The degree of change in color was recorded at the central hole since polyethylene glycol 1500 allows all the radiant energy to pass and be absorbed by the system. This experiment was repeated five times, and the results were reproducible. On the basis of change in color of the substrate, the sunscreen agents were classified as good, fair, and poor. Results appear in Table II.

DISCUSSION AND CONCLUSION

It can be readily seen that the results obtained by the new method do not confirm those obtained by the spectral absorption method. For example, 2-hydroxy-4-methoxy benzophenone-5-sulfonic acid has a good ultraviolet absorption value but proved to be less absorbant by the new method, and 2-ethyl hexyl salicylate proved to be more absorbant by this method than by ultraviolet spectrum. Red Veterinary Petrolatum, although it did not absorb well during spectrophotometric test, nevertheless, proved to absorb very well in the proposed method. For absolute surety, actual testing on a fairly large number of human subjects may be the only way. The advantages of the proposed method are: (a) product can be tested in its final form, (b) simplicity, and (c) low cost.

With further work, a quantitative method for measuring the color change can be developed, thus making this test more precise.

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