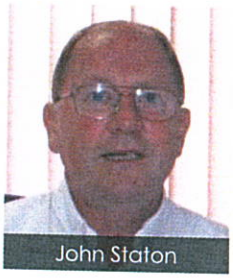
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THE DISCUSSION

What SPF should I expect from my Sunscreen?

SPF Yield is defined as the SPF per percentage of total actives included in the formula. It is of importance in terms of maximising efficiency of formulations, usually with the objectives of minimising cost, reducing the influence of UV absorbing chemicals on the aesthetic properties of the formula and potentially reducing any perceived risks associated with higher levels of actives.
Last year, the manufacturers of SPF actives were asked to give us their expectations and those who replied indicated that a yield of from 1 to 2 should be the expectation.

A review (Figure 1) of the sunscreen raw material suppliers published formulations showed, for those "starting formulas" where *In vivo* SPF testing had been performed, the average SPF yield was 2.3 and the highest was 3.8.

Examples where the true SPF yield is established beyond doubt can be found in the ISO standards (Figure 2). They are...

Formulations published by Raw Material Suppliers			
Supplier	**SPF**	**Actives %**	**Yield**
A	60	25	2.4
A	50	25	2.0
A	35	20	1.8
A	30	15	2.0
B	75	20	3.8
B	89	24	3.7
C	18	13.5	1.3
C	30	23.5	1.3
C	45	22	2.0
D	30	22.5	1.3
E	50	27.5	1.8
F	36	10	3.6
F	28	9	3.1
G	50	23	2.2
G	50	20	2.5
H	30	13	2.3
H	50	20	2.5
		Mean	2.3

Figure 1. Published Supplier Formulas

Formulations published in ISO Standards			
Reference	**SPF**	**Actives %**	**Yield**
P2	16	10%	1.6
P3	15	6%	2.5
P7	4	8%	0.5
S1	20	13%	1.5

Figure 2. ISO Standard Reference Sunscreens

A survey of 77 lotion and cream type Primary sunscreens in the High and Very High Protection TGA categories (1) is shown below (Figure 3).

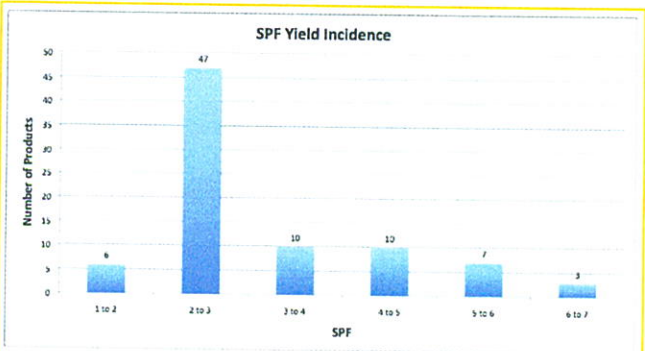

Figure 3. Yield for SPF 50 and SPF 50+ Sunscreens listed with TGA (n=77) in Australia.

This appears to indicate that the testing of most sunscreens results in the certification of yields of 2 to 3 for the majority of products Listed with TGA. There are a few outliers, well in excess of this. Our own testing has not shown high numbers for typical o/w or w/o emulsions or alcoholic sprays. Certainly sticks and other forms of volatiles free sunscreens can exhibit higher SPF yield, as their dried down film thickness will be the same as applied i.e. 2 mg/sq cm = 20 microns, rather than 10 micron for 50/50 emulsions and as low as 4 microns for sprays.

"Synergy" is commonly used as the explanation of higher yields for combinations of actives. However, this must have some maximum! Does a theoretical limit exist? Perhaps an excellent project for a forum!

A clue to SPF can actually be found in the measurement of UVAPF according to the ISO 24443 method (2). Whilst the reliability of In vitro SPF testing is not established, the "c" value ie. correlation of match between In-vivo(3) and In vitro SPF is a reasonable indicator of the SPF range for traditional emulsions, but not reliable for sticks or formulations with high volatiles. Where one active such as Avobenzone is the only

or major contributing UVA absorber (as is often the case), the extinction coefficient is essentially linear around 360 nm and, if apportioned to the UVA/UVB ratio (2), may be used as another comparator to relate In vitro to In vivo SPF. That is to say, if the UVAPF/SPF ratio is one third, as is required, then the UVA absorber would need to show an extinction "contribution" at 360 nm of at least 1 for an SPF 50 sunscreen i.e. at least 3% Avobenzone.

Major international brands seem to typically achieve a yield of 2 to 3. This can be easily surveyed in any pharmacy or supermarket, and is particularly evident in the US market, possibly due to the limitations of choice and permitted levels of UVA absorbers, as this spectral region does impact on SPF performance.

Earlier this year, the Consumer Reports.org published a list of 34 US SPF tests, reported from an independent US test lab. Of these, when compared with label claim, 14 were found to be deficient according to the SPF measured in vivo.
When the actual SPF (as reported) is applied to these 14, all fit within the SPF Yield categories shown below in Figure 4.

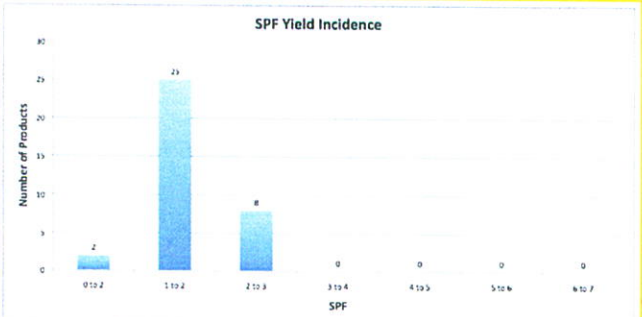

Figure 4. SPF Yield Incidence 34 US Sunscreens.

From Figure 5, it can be seen that the highest SPF Yield determined in this sampling is 3.

Figure 5. SPF Yield sort for 34 US Sunscreens

As observed, even with such a large number of commercial examples, the yield is still less than 3. So, why is it that some products can claim numbers much higher than this? At Dermatest, the highest yield we can identify, for a typical sunscreen emulsion, from our testing over 15 years is almost 4 for a Very High Protection formulation (SPF 60 or above) and this formulation included a very efficient photostabilising excipient. The author would welcome evidence that yield numbers in the order of 7, or above for high SPF formulations are supported by multi-centre test results.

REFERENCES AND NOTES

This article was first published in Dermatest Newsletter July 2015.

1. https://www.ebs.tga.gov.au
2. ISO 24443 - - Cosmetics – Sun protection test methods — In Vitro Determination of Sunscreen UVA Protection (UVA-PF).
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4. http://www.consumerreports.org/cro/sunscreens/buying-guide.html