ANTIOXIDANTS IN SUNSCREENS

Charlene DeHaven, MD explores the use of antioxidants in sunscreens to provide additional protection against non-UVA/B environmental aggressors

CHARLENE DEHAVEN MD,
Clinical Director, INNOVATIVE SKINCARE®, manufacturer of iS CLINICAL® products

email cdehaven@innovativeskincare.com

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THE NEED FOR BROAD-SPECTRUM PHOTOPROTECTION AGAINST UVA and UVB damage for risk mitigation of photoaging and skin cancer development is well accepted. Broad spectrum photoprotection protects against DNA damage[1] and reduces risks of photo exposure. In addition to sunscreen actives that accomplish this goal, substantial additional work has been published on the advisability of incorporating antioxidants and other ingredients into the skin care regimen. Sunscreen antioxidants providing an extra reserve against non-UVA/B radiation—such as infrared radiation, pollution, and/or blue light—would be beneficial. One requirement, however, would be that these must not be exhausted during UVA/B protection and must maintain enough antioxidant reserve to neutralize these other free radical sources. As explained herein, it is possible to design a sunscreen including extra antioxidants possessing this capacity.

Topical antioxidants can be beneficial in decreasing free radical damage and oxidative stress associated with several conditions. These can, in addition to sunscreen actives, further protect the skin from photoaging and its consequences. 'Human studies have convincingly demonstrated pronounced photoprotective effects of "natural" and synthetic antioxidants when applied prior to UVR exposure.'[2] In addition to the sun, there are several other important sources of radical damage to the skin and its DNA.

Pollution is one of these important sources. According to the World Health Organization, the percentage of people living in urban areas with substandard air quality has increased from WHO's previous estimate of 87 percent several years ago to 92 percent in 2016[3]. The incidence of all skin symptoms, skin diseases, and morbidity from disease in general increases during times of worsening pollution[4,5].

Blue light—also termed HEV or high energy visible light—exposure is much higher now than in pre-industrial times. Due to dramatic increases in personal device use, including laptops and cell phones, individuals worldwide sustain average exposure to

four hours per day of HEV light exposure from personal devices. This is in addition to the HEV blue light exposure humans have always received from the sun[6]. Although blue light may be used therapeutically[7], this radiation is a deeply penetrating form of light that is another source of free radical damage[7] in the non-therapeutic milieu.

Solar infrared radiation is another environmental aggressor[8].

The term 'total sun protection' refers to providing topical protection against the totality of environmental free radical sources[9]. In addition to these external sources, internal cell metabolism is another important source of free radical damage within living cells. This is an ever-present source of oxidative damage since these processes are required for cellular life[10]. The 'exposome' consists of the entirety of external stressors and free radical sources to which the organism is exposed[11].

Protection from solar free radical damage is the primary purpose of sunscreen but additional sunscreen actives can protect against other secondary sources of important cellular damage, including DNA damage. Examples of such actives include antioxidants and DNA repair enzymes[12].

DNA damage is a key component of photoaging and risks for skin cancer development[13]. Furthermore, DNA damage is relatively easy to quantify with CPD (cyclobutane pyrimidine dimer) measurements. CPD formation occurs with both UVA and UVB exposure and is the most commonly found type of DNA damage found in this situation[14]. DNA damage results from the effects of oxidative stress upon the skin cell.

The wisdom of incorporating additional antioxidants into sunscreens has been discussed in the literature[15]. Adding antioxidants to a sunscreen is convenient for the consumer as this requires the use of fewer total products and could improve compliance. This article illustrates that antioxidants and other beneficial actives incorporated adequately into a cosmeceutical product can provide DNA damage protection in excess of that related to UVA and UVB exposure alone.

Key points

- Traditional broad-spectrum sunscreens provide protection against UVA/B damage
- Other damaging free radical skin aggressors include ongoing cellular metabolism/intrinsic ageing, pollution, high energy visible (HEV)/blue light, infrared (IR), and tobacco use/other toxins
- Formulating sunscreens with additional ingredients can protect against these non-UVA/B sources of damage

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Methods

A sunscreen preparation* was evaluated for the ability to prevent CPD/thymine dimer formation in skin equivalents. The utility and validity of using this skin equivalent technology as a research tool has been previously substantiated in the literature[17]. The preparation contained sunscreen actives, antioxidants, and DNA protectants/Extremozymes™. CPDs were measured after UVA/B exposure from a standard solar simulator. The sunscreen was applied 20 minutes prior to solar exposure. Biopsies were evaluated following CPD staining. Quantitative measurements of CPDs were performed.

Results

Positive control tissue—Anti-CPD stain Kamiya MC-062. CPDs are seen in both the basal and suprabasal epidermal layers as brown staining within epidermal cells.

Treated tissue—Anti-CPD stain Kamiya MC-062. Absence of CPDs with no brown staining visible.

Control and treated tissue—Quantitative CPD measurement taken from the tissues in the above biopsies plus negative control (NC). With quantification, small subvisual levels of CPDs become detectable. Standard deviations are shown. Student's t-test was performed; $p<0.05$.

Discussion ▷

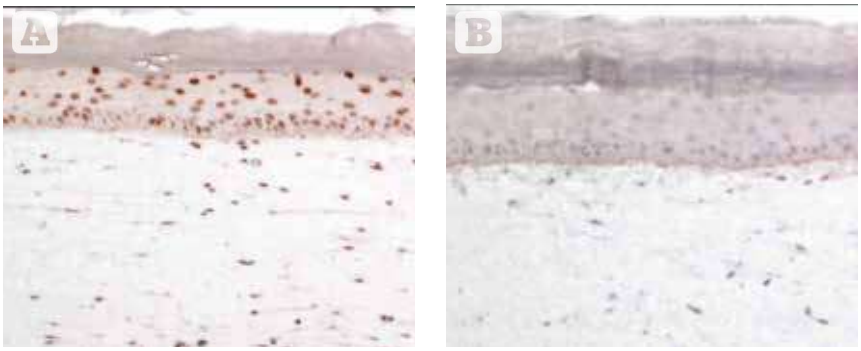
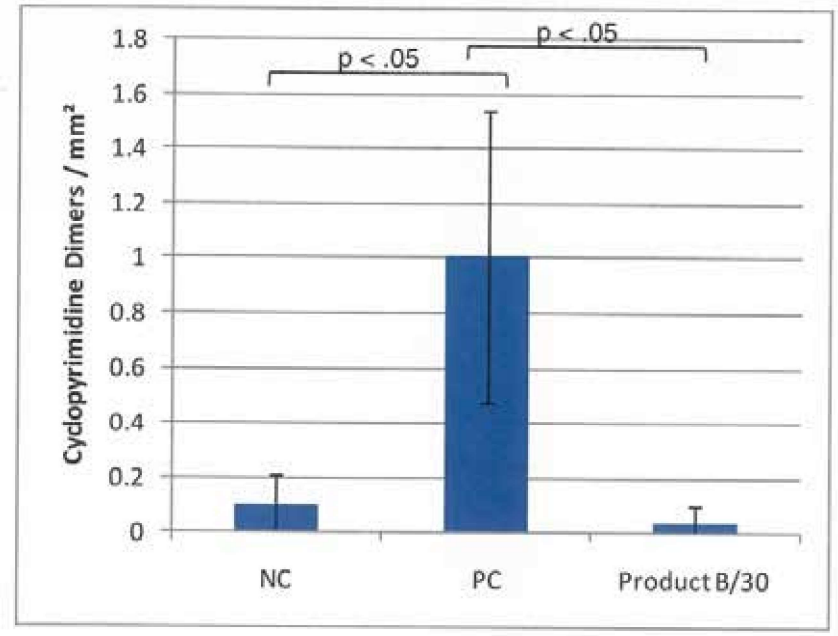


Figure 1 (A) Control Tissue — Anti-CPD stain Kamiya MC-062. CPDs are seen in both the basal and suprabasal epidermal layers as brown staining within epidermal cells. (B) Treate Tissue – Anti-CPD stain Kamiya MC-062. Absence of CPDs with no brown staining visible.



The biopsies with CPD staining exhibit an absence of visible CPDs with sunscreen application and heavy CPD staining without sunscreen. Microscopy appears to indicate effective mitigation of all sources of free radical damage and resultant CPD creation. However, finer assessments are provided with a quantified measurement of CPDs. Here, the amount of free radical protection afforded by the sunscreen is shown to be more comprehensive and extends beyond UVA/B protection alone.

The bar graph illustrates the negative control/NC (skin in the dark), positive control/PC (sunlight-exposed skin without product, and Product (sunlight-exposed skin with product applied 20 minutes before exposure). The bar associated with product indicates more free radical absorption than skin in the dark. The difference between the NC and Product measurements indicates the additional antioxidant protection conveyed for non-UVA/B damage.

Although these measurements are weighted in favour of the oxidative stress secondary to intracellular metabolism, it is not unreasonable to expect that all sources of free radical damage would be similarly mitigated.

Conclusion

Sunscreen formulations containing both sunscreen actives plus additional antioxidants may provide additional protection from environmental aggressors in addition to those of UVA/B origin. These sources of oxidative damage may originate from normal intracellular processes of energy creation and from more recently described additional environmental aggressors including pollution, infrared radiation, and blue/HEV light.

▶ ***Declaration of interest*** *Charlene DeHaven is Clinical Director of INNOVATIVE SKINCARE®, manufacturer of iS CLINICAL® products*

▶ ***Figures 1-2*** *© Dr DeHaven*

▶ **EXTREME PROTECT® SPF30, manufactured by iS CLINICAL®*

References

1. DeHaven C, Hayden P, Armento A, Oldach J. DNA photoprotection conveyed by sunscreen. 2014 Jun. J Cosmetic Dermatol. 13:99-102.
2. Dreher F, Maibach H. Protective effects of topical antioxidants in humans. 2001 Curr Probl Dermatol. 29:157-164.
3. Kennedy M. 92 percent of the world's population breathes substandard air, WHO says. NPR Breaking News. 2016 Sep 27.
4. Leonard J. The effects of pollution on skin. Aesthetics J. 2016
5. Drakaki E, Dessinioti C, Antoniou CV. Air pollution and the skin. 2014 May15. Frontiers Environment Sci. 2(11):1-6
6. Novoseletsky J. Beware: blue light damage on the rise. 2017 Jun 5. Cosmetics Toiletries online.
7. Ammad S, Gonzales M, Edwards C, Finlay AY, Mills C. An assessment of the efficacy of blue light phototherapy in the treatment of acne vulgaris. J Cosmet Dermatol. 2008 Sep. 7(3):180-188.
8. Grether-Beck S, Marini A, Jaenicke T, Krutmann J. Effective photoprotection of human skin against infrared A radiation by topically applied antioxidants: results from a vehicle controlled, double-blind, randomized study. Photochem Photobiol. 2015 Jan-Feb. 91(1):248-250.
9. Schroeder P, Krutmann J. What is needed for a sunscreen to provide complete protection: multipronged approach to complete photoprotection. Skin Therapy Letter. 2010. 15(4):4-5.
10. Cadenas E, Davies KJ. Mitochondrial free radical generation, oxidative stress, and aging. Free radic biol med. 2000 Aug. 29(3-4):222-230.
11. Krutmann J, Bouloc A, Sore G, Bernard BA, Passeron T. The skin aging exposome. J Dermatol Sci. 2017. 85:152-161.
12. Yarosh DB, O'Connor A, Alas L, et. al. Photoprotection by topical DNA repair enzymes: molecular correlates of clinical studies. Photochem photobiol. 1999 Feb. 69(2):136-140.
13. Del'Acqua G, Schweikert K. A DNA repair complex to decrease erythema and UV-induced CPD formation. Cosmetics Toiletries. 2008 May. 69-76.
14. Runger TM, Farahvash B, Hatvani Z, Rees A. Comparison of DNA damage responses following equimutagenic doses of UVA and UVB: a less effective cell cycle arrest with UVA may render UVA-induced pyrimidine dimers more mutagenic than UVB-induced ones. Photochem photobiol sci. 2012 Jan. 11(1):207-215.
15. Hanson KM, Clegg RM. Bioconvertival vitamin antioxidants improve sunscreen photoprotection against UV-induced reactive oxygen species. J Cosmet Sci. 2003 Nov-Dec. 54(6):589-598.
16. Stephens P, Wood EJ, Raxworthy MJ. Development of a multilayered in vitro model for studying events associated with wound healing. Wound Repair Regen. 1996. 4:393-401.