Assessing UV Damage and Antioxidant Influence on Human Hair Using a Combination of Spectroscopic, Thermal and Physical Measurements

Dr. Yingxia He; Croda

He, Yingxia PhD 1; Park, Kimun 1; Edouard, Farahdia 1; Horn, Alissa PhD 1; Bernard, Laure 2

1 Croda Inc., Plainsboro, New Jersey, United States

2 Sederma, Le Perray en Yvelines, France

Introduction

UV destruction of human hair has been well documented in the literature [1-4]. The impact on hair cuticle and cortex causes surface impairment and protein loss. Methodologies applied to evaluate UV damage of hair include SEM, protein analysis, ESR, Raman, FTIR, color and tensile measurement. Since the level of UV damage is directly linked to exposure dosage, hair type and condition, and preventing treatment, such as utilizing antioxidant, there are still unidentified characteristics remained to be discovered.

The aim of this study is to use a combined approach of Fluorescence Spectroscopy with DCFH probe to detect reactive oxygen species, FTIR to evaluate degree of cystine oxidation of UV exposed hair, DSC to evaluate structural changes within hair cortex, tensile and cyclic fatigue methods to assess the mechanical impact on UV damaged hair with and without antioxidant (Hydrolyzed Cicer Seed Extract) protection.

Experimental Results

To explore oxidative damaging impact on hair, medium brown Caucasian hair treated with aqueous solution or hair conditioner with and without antioxidant (Hydrolyzed Cicer Seed Extract, HCSE) was subjected to different exposure levels of UV or UV/Ozone damage. After 10J/cm2 UVA exposure, DCFH fluorescence intensity of unprotected hair increases 147%, while hair treated with 0.25% and 1.0% antioxidant aqueous solution reduces ~70% vs. unprotected hair, as detailed in Table 1.

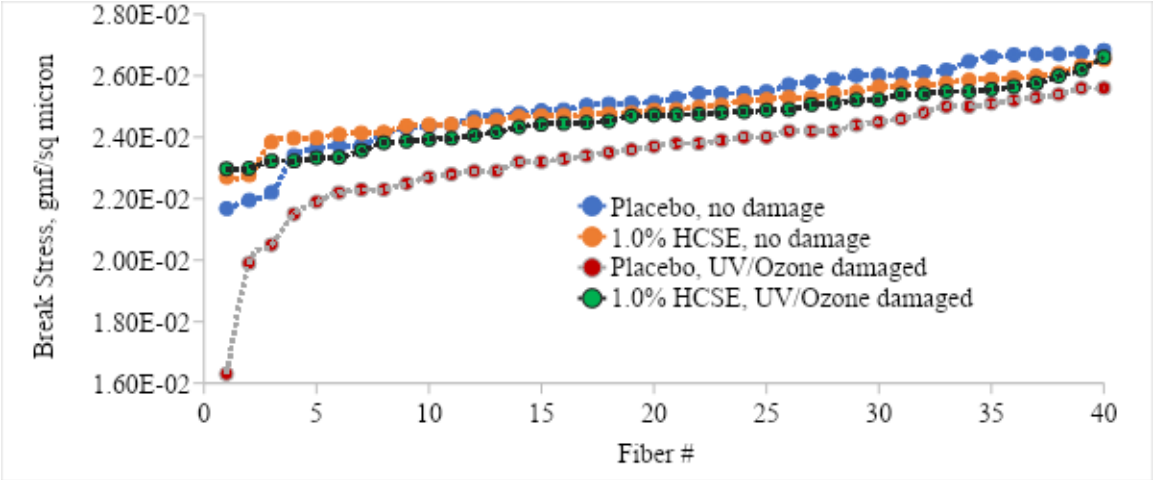
Table 1, DCFH fluorescence intensity of leave-on solution treated hair

Hair treatment	No UVA, Fluorescence*	10J/cm^2 UVA, Fluorescence*	%Fluorescence change vs. no UVA	%Fluorescence reduction
Untreated hair	15402, +/- 1852	38094, +/- 726	147	Reference
0.25% HCSE solution	8511, +/- 371	15069, +/- 1682	77	-70**
1.0% HCSE solution	7514, +/- 31	13152, +/- 773	75	-72**

*: Arbitrary fluorescence units; **: difference is significant.

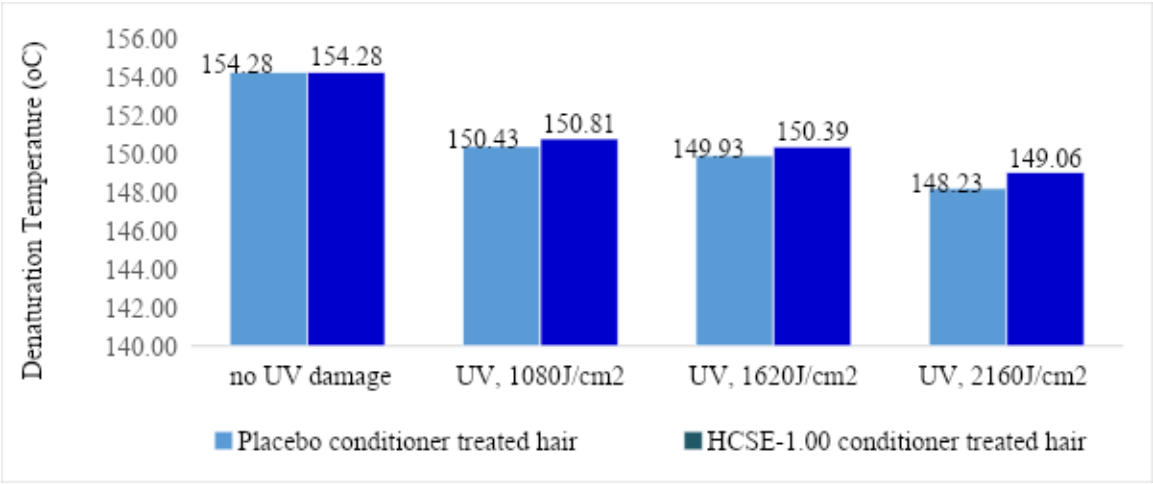
Following 12 cycles of repeated treatment and UV/Ozone pollution, for antioxidant protected hair, FTIR shows 13.57% less cysteic acid peak intensity and 4.18% higher break stress versus unprotected hair. Tensile break stress data of the tested fibers is illustrated in Figure 1; unprotected hair exhibits the lowest break stress cross all sample population due to the weakening effect of UV/Ozone damage.

Figure 1, Break stress of undamaged hair vs. UV/Ozone damaged hair



Denaturation temperature of hair decreases along with the increased UV exposure dosage, as shown in Figure 2. After exposed to 120hr. (2160J/cm2) UV, the denaturation temperature (Td) of antioxidant conditioner protected hair is significantly higher than that of placebo conditioner treated hair, combined with 32% fatigue cycle improvement.

Figure 2, Denaturation temperature (Td, ºC) change vs. UV exposure dose



Conclusions

The study results confirm that different instrumental measurements can provide distinct insight on the damage effect of UV to human hair. The intensity of fluorescence from DCFH-DA assay reflects quantity of reactive oxygen species generated due to photo oxidation of hair proteins; the oxidative damage of hair internal structure can be detected by FTIR using intensity of cysteic acid peak as a marker. Denaturation temperature of DSC measurement indicates that UV exposure decreases cross-link density of hair matrix, denaturation temperature and enthalpy of UV damaged hair decrease as exposed UV dosage increases.

Tensile and cyclic fatigue data are consistent with conclusions of DCFH, FTIR and DSC measurements. The study results suggest that hair internal structure damage weakens its natural strength, the collective impact and antioxidant protection effect of Hydrolyzed Cicer Seed Extract can be best verified with a combined approach of employing various spectroscopic and physical measurement techniques.

References

1) Robbins CR (2002) Chemical and Physical Behavior of Human Hair. Fourth ed. Springer, New York.

2) Nogueira ACS and Joekes I (2004) Hair color changes and protein damage caused by ultraviolet radiation. Journal of Photochemistry and Photobiology B: Biology 74. 109–117.

3) Hoting E, Zimmermann M and Hilterhaus-Bong S (1995) Photochemical alterations in human hair. I: artificial irradiation and investigations of hair proteins. J. Soc. Cosmet. Chem., 46, 85–99.

4) Signori V (2004) Review of the current understanding of the effect of ultraviolet and visible radiation on hair structure and options for photoprotection. Int. J. Cosmet. Sci., 55, 95–113.

About the speaker

Dr. Yingxia He is a Technology Specialist in Product Validation and Claims Substantiation group at Croda Inc., she is responsible for supporting research and development of new technologies on sustainable hair care product. Prior to joining Croda, Dr. He completed her postdoc research work at University of Florida and University of Arkansas for Medical Sciences. On top of product claims expertise from Croda, Dr. He also worked for DuPont, Ciba and Inolex in polymer design and synthesis, pigment research and applications, hair and skin care product applications, and preservatives. Dr. He obtained her B.S. and M.S. in organic chemistry from Heilongjiang University, Harbin, China, and her Ph.D. in inorganic chemistry from Simon Fraser University, Burnaby, BC Canada. Dr. He served as a member of Committee on Scientific Affairs for the Society of Cosmetic Chemists during 2018 - 2020, she has numerous publications and patents, and has been active in cosmetic industry since 2006.