Investigation of the Nanomechanical Properties of the Surface Layers of Hair Fibers

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A project led by Ella Hudson, Ph.D. Researchers at the University of Sheffield are attempting to determine the contribution of the hair cuticle to the mechanical properties of the entire fiber.

The aim of this work was to determine whether a novel hair care treatment can restore the nanomechanical properties of the cuticle of hair fibers after a damaging treatment, and also to investigate the effect of hair type (ethnicity). To achieve this, the cuticular nanomechanical properties of hair in three states were studied with samples from two different hair types: African and Caucasian, which is typical of the literature in this field:

– Untreated (healthy) hair,

– Damaged hair and

– Damaged hair treated with the novel treatment.

The contribution of the cuticle (surface layer) to the mechanical properties of a whole fiber was investigated. However, the techniques typically used to study the mechanical properties of hair produce data that are representative of the entire fiber (Yu et al. 2017). Nanoindentation allows localized measurement of hardness properties of only the surface of samples.

Hair fibers are organized hierarchically and consist of three basic structural units: i) a protective outer layer called the cuticle, ii) a central core called the cortex, and in some cases iii) a porous canal called the medulla.

The nanoindentation data showed no significant differences between the African or Caucasian hair treatment groups. These results differ from whole-fiber mechanical tests, which show clear treatment differences, strongly suggesting that the internal structures of the hair fibers (cortex and medulla) respond most strongly to the damaging and restorative treatments, and not the cuticle.

The comparison between African and Caucasian hair types for all three treatment groups (untreated, damaged and restored) showed that the cuticle layer of the African hair sample had higher reduced elastic modulus and hardness values than the Caucasian sample, showing the innate cuticle differences depending on the hair type.

Previous work by Ella on the mechanical properties of hair fibers focused on analyzing population variation and how this can change after different treatments, which was reinforced by the nanoindentation data. In general, damaging treatments reduce variation compared to untreated hair. The novel restorative hair care treatment appears to restore this population variance towards the pre-damaged state, consistent with mechanical property data collected on whole fibers.

The interesting phenomenon to note in the data was that after application of the novel treatment to damaged hair, a bimodal distribution occurred that was not seen in the untreated or damaged hair groups. There is currently no definitive explanation for this, but it may be due to innate differences between individual hair fibers, for example the presence of a marrow.

Ella intends to continue to characterize hair in various states of damage and study the effectiveness of restorative treatments.

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