application note

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Atomic Force Microscopy - Human Hair

Measurements on different human hair
Human hair is composed of three elements. The cuticule is the outer surface of the hair shaft, it is a very hard keratinous substance. The next element is the cortex which is a more fiberous keratin. The third element is the medulla, a soft keratin-rich material. To investigate the reaction of the hair surface to chemical or cosmetic treatment, a tool is needed to image the surface with high resolution. Offering easy sample preparation and high resolution imaging possibilities, the alpha300 A is a well suited instrument for such studies. The integrated scientific-grade optical microscope provides superior optical access, easy cantilever alignment, and high resolution cantilever survey. An integrated video camera supports precise positioning of the cantilever on the sample area of interest, as shown in Fig. 1. The cantilever be can easily placed on the hair. The diameter of the hair is approximately 50 µm and the width of the cantilever is 25 µm. The aim of these studies is to show, the surface structure of different coloured hair. The difference between untreated and bleached blonde hair should also be demonstrated, which will be very interesting as it shows how the different hair will respond to cosmetic treatments.

Different human hair were fixed to microscopic slides coated with double-sided adhesive tape. Fig. 2 shows a brown untreated hair with crenelated cuticule borders (scan range: 30 µm x 30 µm). Fig. 3 shows a natural white hair (scan range: 40 µm x 40 µm). Clearly visible are the platelets of the keratin, which are wrapped around the hair shaft in several layers.

Fig. 4 shows an untreated blonde hair (scan range: 35 µm x 35 µm), Fig. 5 a bleached one (scan range: 15 µm x 15 µm). Clearly visible is the complete loss of the scale-like structure after the bleaching process.

The thickness of the cuticle cells varies with the different colours: 300 nm to 400 nm for the brown hair, between 300 nm and 500 nm for the blonde hair, while the cuticle cells of the white hair are appoximately 700 nm thick. Chemical treatment (bleaching) or the preparation of the hair with hair care products lead to significant differences in the surface topography.

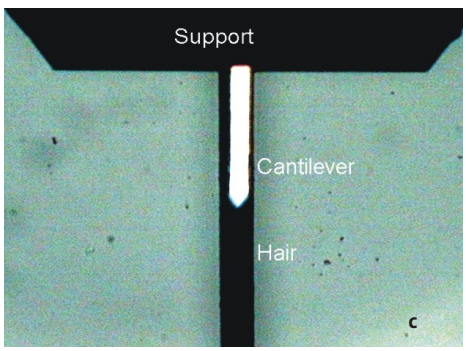

Fig. 1

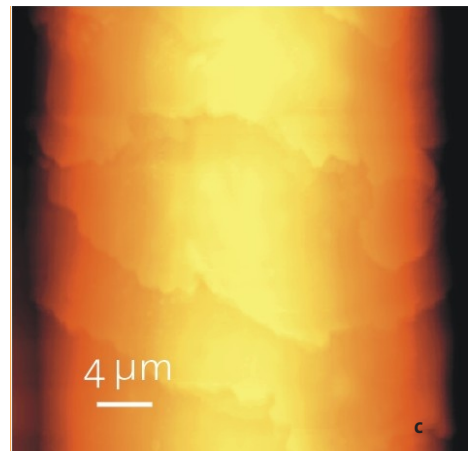

Fig. 2: Brown Hair

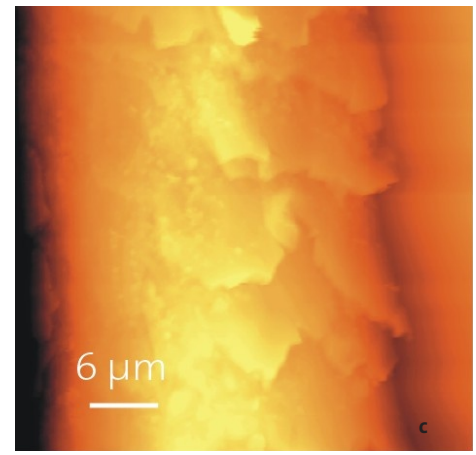

Fig. 3: White Hair

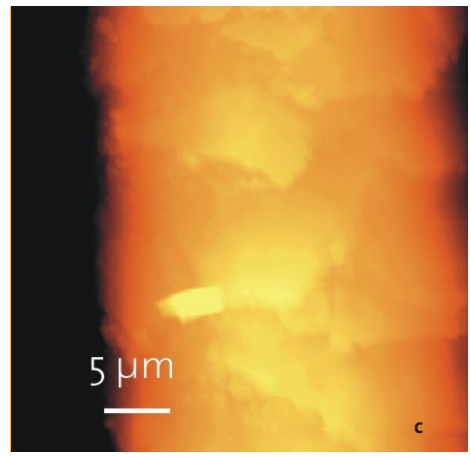

Fig. 4: Blond Hair

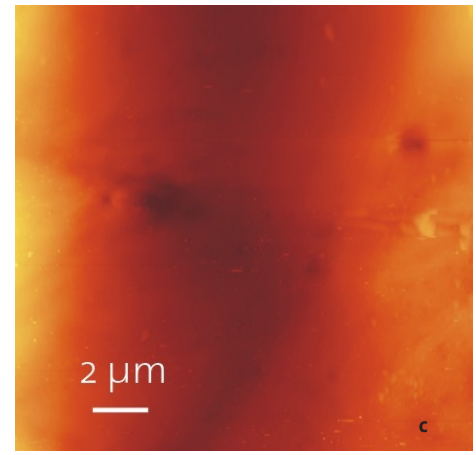

Fig. 5: Bleached Blond Hair

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Hair Treatment

Combining the alpha300 A with the Digital Pulsed Force Mode provides additional information about the sample surface such as adhesion, stiffness or viscosity (Fig. 6). Line A shows completely untreated hair. Line B shows hair after shampooing and line C after being treated with conditioner.

In the topography of the unwashed hair, the borders of the cuticule seem to be frayed and some particles are visible. The washed hair shows a smoother result but the hair treated with conditioner is even more so and the platelets of keratin are wrapped closely around the hair shaft.

There is a remarkable change in adhesion. The untreated hair shows different areas with more adhesion (bright) and less adhesion. These are the regions with the accumulation of contaminants.

In the washed hair, only the regions at the borders of the crenelated follicle show more adhesion. The hair treated with conditioner shows a nearly uniform surface. Differences in stiffness are only visible on the untreated hair in contaminated areas.

Only the untreated hair shows significant differences in viscosity. The brighter areas which also show particles are more viscous. The washed hair and the hair with conditioner seem to show nearly the same results with respect to viscosity.

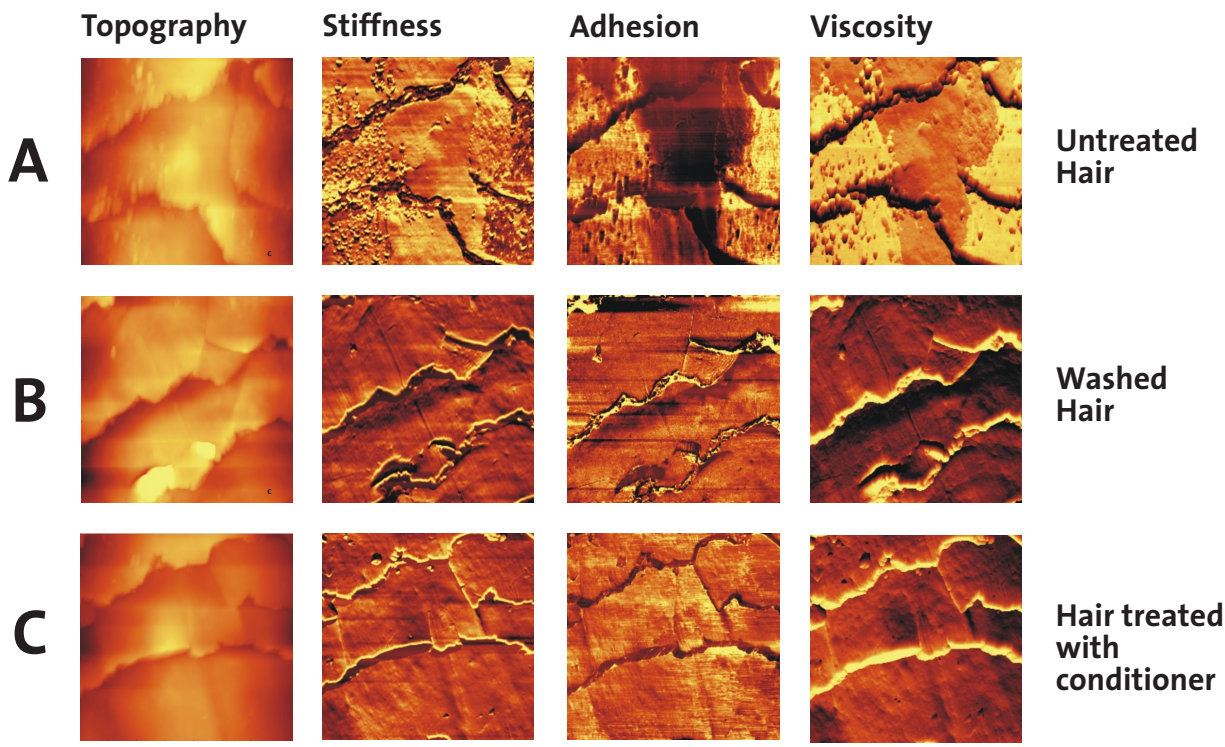

Fig. 6: Nanoscale surface properties of human hair. Scan range 15 x 15 µm