Analyzing the surface wettability of human hair

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The surface of an untreated human hair fiber has been described by Kamath, et al, in a series of excellent papers (see references below). Human hair is by nature a fibrous material with a negatively charged hydrophobic surface. The critical surface tension of untreated human hair has been measured at less than 30 dynes/cm. These properties are a result of the adsorption of a natural, oily secretion (sebum) which is produced by the sebaceous glands in the skin. Human hair is naturally coated with this oily secretion. Increases in inter-fiber adhesion between hair fibers is directly correlatable with an increase in the bulk density of the hair.

Manufacturers of hair care products - shampoos, conditioners, and related cosmetics require a thorough understanding of the surface properties of hair when designing these products. Anionic surfactants are added to a shampoo to clean the hair fibers, and cationic surfactants or polymers form the basis of a conditioner to replace the sebum coating and thus reduce inter-fiber adhesion while protecting the hair from damage and improving the body and manageability of the hair.

Because the amount of residue present on the surface of hair is so small, a sensitive wettability measurement capable of characterizing the surface of a single hair fiber is required. The Thermo Scientific DCA RADIAN 322 system with Fiber-Range sensitivity is ideally suited for this application. In addition to measuring fundamental differences in wettability between treated and untreated fibers, the scanning feature of the DCA permits an evaluation of coating uniformity from base to tip along the length of a hair fiber.

By programming the instrument to perform repeated immersion or hysteresis cycles, the adsorption/desorption characteristics of a hair care product is readily determined.

A typical dynamic contact angle profile of a hair fiber has several interesting and informative characteristics. First, in the advancing cycle during which time the probe liquid (typically water or a buffer solution) is first brought in contact with the fiber, the measured angle is typically non-wettable (greater than 100 degrees). A "stick-slip" phenomenon is also evident in this profile as the probe liquid meniscus jumps from one position to the next. This is representative of an irregular or non-homogenous surface and can be quantified by calculating the average wettability across this region of the fiber. When the direction of the stage is reversed to measure the receding cycle, a roughness factor can be seen in the surface that is representative of the fiber scale orientation and/or the orientation of surface active groups at the fiber-liquid interface.

Temperature-dependent effects on the adsorption of surfactants and polymer formulations to the surface of human hair have also been reported by Kamath, et al. The optional temperature accessory kit for the DCA system permits variations in probe liquid temperature to study these effects.

References:

[1] Kamath, Y.K., et al, „Surface Wettability of Human Hair. I. Effect of Deposition of Polymers and Surfactants", J. of App. Polymer Science, Vol. 29, 1011-1026, 1984.

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[3] Kamath, Y.K., et al, „Surface Wettability of Human Hair. III. Role of Surfactants in the Surface Deposition of Cationic Polymers", J. of App. Polymer Science, Vol. 30, 937-953, 1985.

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