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An ESEM study of the Influence of Humidity on the Integrity of Mascara Films

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One of the most common methods to embellish eyes is to apply mascara. For any new mascara being developed, it is important to understand its interaction with the substrate (eyelash) and the impact of atmospheric conditions on mascara films. These studies are used to establish the efficacy of mascara in enhancing the appearance of the eyelashes and its durability. In this study, ESEM was used to determine the microscopic features of mascara coatings and their dynamic behavior under varying humidity conditions. Due to their limited number, eyelashes are not readily available for testing, thus a suitable-more-abundant substrate needs to be used. Having the same biochemical composition, hair constitutes a logical substrate to be used for extensive mascara characterization. A comparative analysis of hair vs eyelash behavior was performed to validate the use of hair particularly in humidity cycling studies since morphological differences could affect the swelling of the substrate and therefore the stress that is transferred to the mascara film. Total swelling and swelling rate of hair depends on the ethnic origin and integrity of the specimens [1, 2] thus we have included two ethnic groups in this study (African-American and Hispanic).

The experiments reported here were performed on an FEI Quanta 400 FEG ESEM. Secondary electron images were taken with a 20kV or 10kV electron beam, at the corresponding pressure-temperature combinations (RH from 15% to 100%). Contrast enhancement and dimension measurements were performed with ImageJ [3]. The fibers were mounted side by side on aluminum stubs using ultra-smooth carbon discs and placed in a Peltier cooling stage. The initial diameters were recorded at either 15% RH (swelling of uncoated fibers) or 33% RH (mascara studies). During the humidity experiments the fibers were equilibrated at each RH until no apparent change in diameter was observed (10-80 min). The swelling validation experiment consisted of simultaneously imaging three fibers (one African-American eyelash, one Hispanic eyelash and one Hispanic hair section) through an entire humidity cycle (hydration 15%-30%-60%-90%, dehydration: 90%-60%-30%-15%). To study the behavior of two mascara films (volumizing and lengthening) two fibers coated with each mascara were imaged at each RH during the hydration process (30%-60%-90% RH); after imaging at 90%, the humidity was further increased to induce water condensation. The dehydration process was videotaped to capture dynamic effects.

The swelling properties of eyelashes and hair were determined from the images taken along a humidity cycle. Figure 1a shows that hair experiences a higher increase in diameter than eyelashes (8.5% vs 4.2% for hair vs eyelash from the same ethnic group). Figure 1b shows plotted values for the swelling-shrinking process in one humidity cycle. These plots reveal an almost ideally reversible behavior characterized by narrow hysteresis loops. The eyelashes show a linear hydration path while hair shows more of an exponential curve along both paths. These differences between hair and eyelash swelling behavior may be attributed to the structure of the cuticle. Having a denser cuticle, eyelashes may be less prone to swell than hair under similar humidity conditions and thus exhibit less swelling and fully reversible loops. The higher sensitivity to humidity makes hair a suitable substrate for humidity studies of mascara, since it transfers higher stress to the mascara films.

Hair fibers were thus used to study the properties of mascara films. Figure 2a shows a fiber coated with volumizing mascara, for this kind of mascara the film is rougher than for a lengthening (Figure 2b). In order to compare their permeability (measured indirectly from substrate swelling), coatings with the same thickness were produced. It was observed that both mascaras considerably reduced swelling of the substrate and presented high flexibility and remained continuous even when the fibers changed diameter.

References

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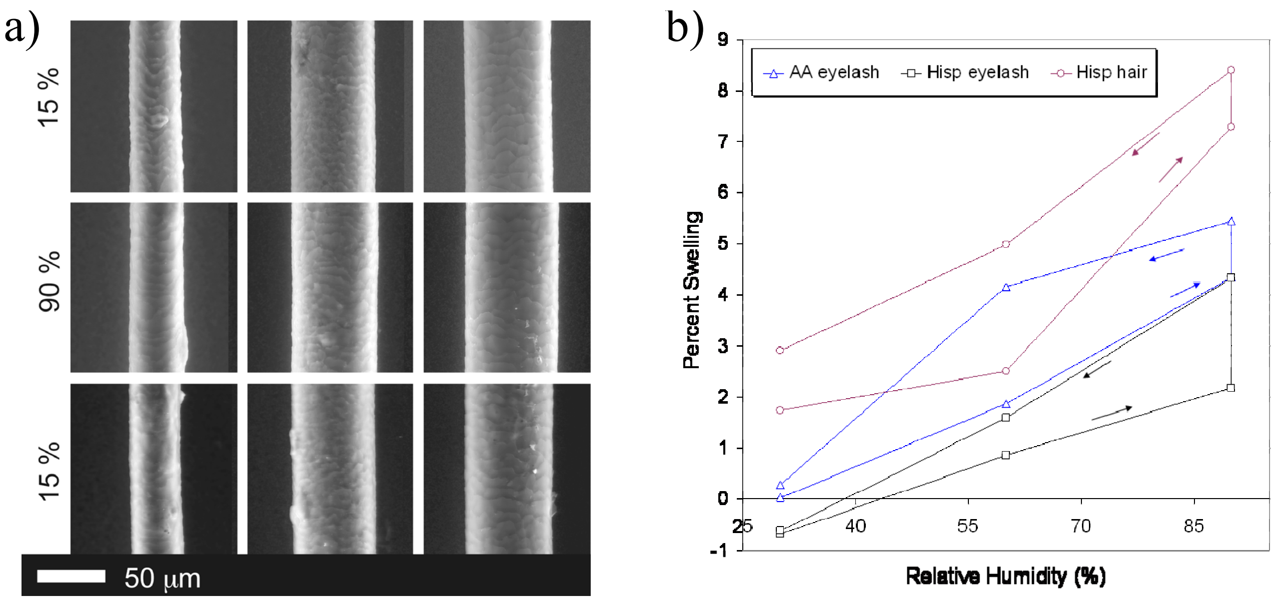

FIG. 1. a) SEM micrographs of hair and eyelash fibers at different RH's. AA eyelash (left), Hisp eyelash (center), Hisp hair (right). b) Hysteresis loops of diameter vs humidity for the three fibers.

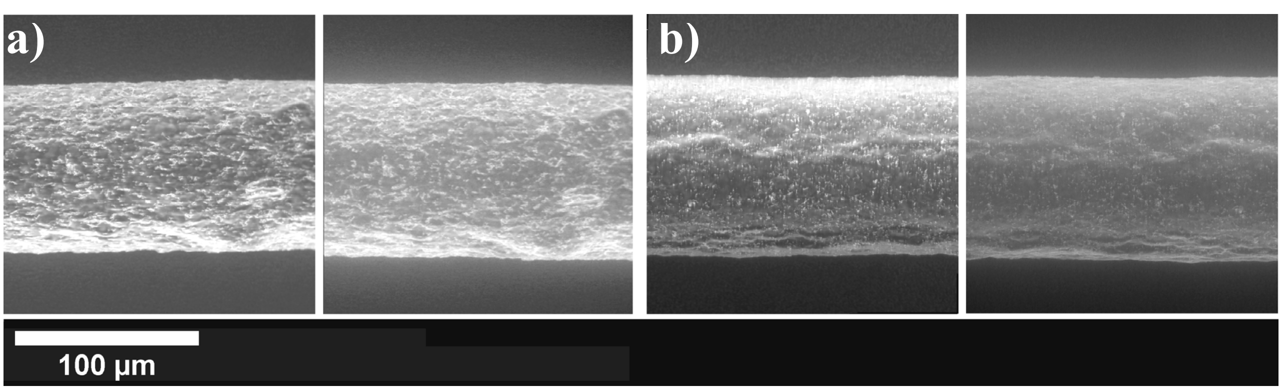

FIG. 2. SEM micrographs of mascara coated fibers. a) Volumizing mascara (33% RH left, 90% right). b) Lengthening mascara (33% RH left, 90% right)

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