LIQUID CRYSTALS FOR SURFACE MODIFICATION OF COLORED HAIR

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INTRODUCTION

Over 60% of western women use hair colorants, however, the chemistry involved in the oxidative hair color process changes the structure of the hair fiber. The protective layer of 18-methyleicosanoic acid (18-MEA) found on virgin hair gives it a natural hydrophobic barrier, which limits the penetration of water into the hair's internal structure. After a single coloring, up to 70% of the 18-MEA layer is removed, leaving color-treated hair with a more hydrophilic character which hinders the deposition of hydrophobic hair conditioning ingredients and leaves it more prone to damage[1].

OBJECTIVE

Given the right ratio of ingredients, lyotropic liquid crystal structures can be present in a neat shampoo formula that contains poly(diallyldimethyl ammonium chloride) or poly(DADMAC)[2,3]. The objective of this study was to investigate poly(DADMAC)-containing liquid crystal technology:

- To decrease bleached hair's surface energy and impart a hydrophobic character to bleached hair
- To improve the deposition efficiency of traditional, hydrophobic conditioning ingredients onto bleached hair

METHODS

Virgin hair and bleached hair switches, from International Hair Importers & Products, Inc, were treated with the control shampoo, containing 1.0% dimethicone and no cationic polymer, or the liquid crystal shampoo (the control shampoo with 0.25% poly(DADMAC), also 1.0% dimethicone). Hair switches were washed with their respective shampoos and rinsed 5 times each before each analysis.

A home built Dynamic Contact Angle and Absorption Tester was used to measure surface energy of the hair samples before and after treatment. Contact angles were determined using image analysis and Fowkes equation was used to convert contact angles to surface energies[4]. Samples were run in triplicate.

Positive ion secondary ion images of hair fibers were acquired using an ION-TOF IV time-of-flight secondary ion mass spectrometer equipped with a 25 keV Bi^{3+} primary ion source and operated under static SIMS conditions. The primary ion beam was operated in the single crossover mode resulting in a primary ion beam diameter of ~0.5 µm.

Inductively coupled plasma optical emission spectroscopy (ICP-OES) was used to measure silicone deposition. Silicone was extracted from bleached hair samples with 50:50 toluene:methylisobutyl ketone and the extracted samples were compared to ICP calibration standards of known silicone concentration. Samples were prepared in quadruplicate.

RESULTS

Surface energy measurements

Surface analysis measurements indicated that the poly(DADMAC)/liquid crystal shampoo increased the hydrophobicity of bleached hair, similar to that of virgin, which is hair that has never been oxidatively damaged. Dyanmic absorbency testing (DAT) showed a marked reduction in the polar component of surface energy for the liquid crystal-treated hair as compared to bleached hair, indicating a significantly more hydrophobic character. The polar component of liquid crystal-treated hair was comparable to virgin hair.

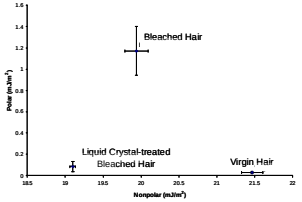
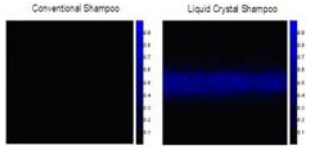


Figure 1. Surface energies of bleached hair, virgin hair, and bleached hair treated with the liquid crystal shampoo, as determined by DAT.

Visual analysis of poly(DADMAC) and silicone deposition

ToF-SIMS (time-of-flight secondary ion mass spectrometry) analysis was used to visually analyze the deposition of materials onto the surface of bleached hair. For both analyses, the images represent a 100 µm x 100 µm field of view.

- The poly(DADMAC) polymer was seen to deposit from the liquid crystal-containing shampoo and coat the surface of the hair fiber fairly uniformly, as seen in the secondary ion image of $C_3H_8N^+$, generated by the poly(DADMAC) polymer, shown in Figure 2:



- Dimethicone, a commonly used silicone conditioning ingredient, was seen to deposit more on the bleached hair from the liquid crystal-containing shampoo than from the control shampoo (Figure 3). The total ion images are shown for reference of where the hair fiber is located within the image field of view.

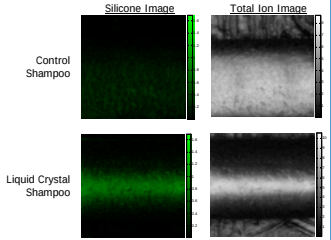


Figure 3. Tof-SIMS images of silicone (dimethicone) conditioning ingredients (green) deposited onto bleached hair from the control and liquid crystal shampoos.

Silicone Deposition measurements

Deposition of silicone, in the form of dimethicone, onto bleached hair from the control and liquid crystal-containing shampoos was measured with ICP-OES. The liquid crystal-containing shampoo was shown to significantly enhance silicone deposition onto bleached hair, which is in part due to the very low deposition levels seen on bleached hair from the control shampoo. Results are shown in the table below:

	Silicone Deposition (ppm) Mean (SD)
Control Shampoo	0* (NA)
Liquid Crystal Shampoo	353 (30)

Below detection limit of method, <10ppm

CONCLUSIONS

Oxidatively-damaged hair, above others, needs effective conditioning to protect the hair from environmental and mechanical damage as the oxidative process has left it more prone to damage. However, the surface characteristics of bleached hair make formulating a conditioning shampoo a challenge.

It has been found that having a poly(DADMAC)-containing liquid crystal colloidal structure in a shampoo formulation can significantly enhance the deposition of silicone conditioning ingredients onto the surface of bleached hair.

- The poly(DADMAC)-containing liquid crystal structure increases the hydrophobicity of bleached hair.
- As a result of the renewed hydrophobic surface on the bleached hair, a liquid crystal–containing shampoo was able to deposit significantly more dimethicone onto bleached hair than a conventional shampoo.

References

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2. US Patent Appln No. 12/131057, "Method for treating damaged hair"
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4. F.M. Fowkes. *Ind. Eng. Chem.* 56 (1964) 40.

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