# ABSTRACT

**PRESENTER:** Dr. Lyndsay Leal

**COMPANY:** Dow Chemical Company

**JOB TITLE:** Associate Research Scientist

**Podium Title:** *Bio-based Breakthrough in Hair Conditioning*

**Background information (Short introduction)**

The desire for silicone-free products is driving beauty trends in the hair care market to naturally derived alternatives. Cellulose, a natural material, can be modified with functional groups to tune its physical properties. Historically, cationic cellulose polymers have been developed to provide conditioning benefits. We have developed a cationic cellulose ether with long-chain hydrophobic segments (cat-hmHEC) that outperforms the incumbent technology and matches the performance of silicone.

**Objective**

When using a hair conditioner, consumers expect a smooth feel during and after applications. Silicones are able to meet all aspects of the desired sensory profile, but despite their proven sensorial benefits, some customers are seeking naturally-derived alternatives. Leveraging Dow's expertise in cellulose ether chemistry, a cationic, hydrophobe-modified hydroxyethyl cellulose (cat-hmHEC) was developed to match the in-use feel and conditioning benefits of silicones.

**Methodology**

Cat-hmHEC structure-performance relationships were established via optimization of two functional handles through DOE: cationic groups to enhance polymer deposition onto hair fibers and hydrophobic segments to impart softness, smoothness, and hydrophobicity. Polymers were evaluated in rinse-off conditioner, leave-on, and shampoo applications and compared to competitive offerings and a no-polymer control. Friction/combing evaluation was performed, and polymer deposition was quantified.

**Results**

Preliminary results show the cat-hmHEC polymers enable unique and desirable benefits, delivering outstanding performance in wet and dry combing and reduced hair breakage, with additional benefits in styling and hair protection. Enhanced combing, reduced breakage, volume and alignment were measured instrumentally, and panel tests confirmed user-perceivable benefits in smoothness, alignment and combing when compared to silicones or other cationic polymers. Polymer deposition on hair was evaluated using surface analysis (XPS and SIMS) and visualized with FTIR-LUMOS analysis.

**Conclusion**

Varying structural polymer parameters (hydrophobic segments, cationic charge, and molecular weight) significantly impacts the overall performance on hair. A synergistic effect of the hydrophobic and cationic groups was demonstrated to be critical for the deposition of the polymer on hair and the sensorial improvement. Higher levels of cationic charge provide improved substantivity to hair; the addition of long chain hydrophobes were determined to be critical in achieving the sensorial benefits. This study identified a new class of polymer composition with enhanced performance and formulation stability, and unique benefits in sensory benefit/combing, stylability, and thermal protection.

**Why is this important to the industry?**

As consumers are driving the market for natural products, the most significant impact of this work is the development of a cat-hmHEC polymer that provides brand owners a silicone alternative in hair care products without sacrificing performance. This class of polymers can be customized to maximize performance based on hair type and aesthetic preferences. This technology can expand into other industries such as skin care, with the same consideration of the consumer's needs.

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Lyndsay Leal is an Associate Research Scientist in Dow’s Home & Personal Care R&D (HPC), located in Collegeville, PA. Her research efforts focus on the synthesis of functional polysaccharides and sustainable polymers for applications in hair, skin and fabric care. Currently, Lyndsay is leading the HPC Sustainable Chemistry Team focusing on expanding HPC's biosourced and biodegradable polymer offerings. Prior to joining the HPC business, she received a dual B.Sc. in Chemistry and Biology in 2010 at The College of New Jersey and completed her Ph.D. in Organic Chemistry at the University of Pennsylvania in 2015. Her Ph.D. work combined her interest in cell biology and small molecule total synthesis to develop selective transmembrane protein inhibitors that limit cancer cell growth. Recently, as part of the UCARE(TM) Extreme Polymer team, Lyndsay and her coworkers have developed a cationic cellulose polymer that match the in-use feel and conditioning benefits of silicones.