

Comparative Studies of Deposition and Formation of Complex Coacervates in Conditioning Shampoos

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Introduction:

This work aims to evaluate the performance of shampoos regarding the formation of complex coacervates in formulations containing the quaternary polymers Quaternized Guar Gum and Polyquaternium-10, combined with Dimethiconol (and) TEA-Dodecylbenzenesulfonate, an anionic emulsion of a high molecular weight hydroxyl-terminated siloxane. Cationic polymers are widely used as conditioning and damage repair agents for hair.



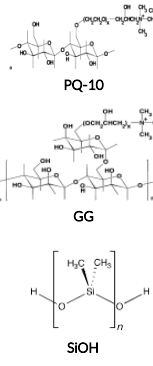
Polyquaternium-10 (PQ-10) and Quaternized Guar Gum (GG) exist in shampoo and liquid soap formulations along with surfactants in a single phase. Upon dilution the cationic polymers become poorly soluble in the medium, generating a liquid-liquid phase separation due to the formation of a gel-polycation-surfactant complex, or coacervate. During the coacervation process, the polymer and surfactant undergo a series of association and microstructure changes. The coacervate is then a phase that contains a high level of cationic charge and its main function is to deposit the polymer on negatively charged substrates, forming a film. In addition, coacervates help in the deposition of insoluble actives, such as silicones.

Materials & Methods:

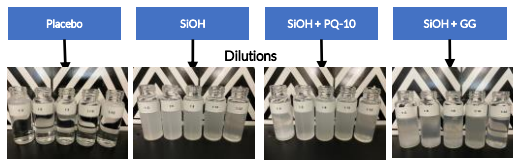
Cationic polymers and silicone emulsion were added to a placebo shampoo formulation at 0.25% and 1.20%, respectively. Concentrations are in active levels. A third shampoo with silicone emulsion unassociated with cationic polymers was also included as an important reference point. Hair tresses were treated with 0.40g of shampoo per gram of hair, rinsed and left to dry overnight.

DOE – SHAMPOO FORMULATIONS

Ingredients	Placebo Shampoo	Shampoo with SiOH	Shampoo with PQ-10 + SiOH	Shampoo with GG + SiOH
Potassium chloride	0,7	0,7	0,7	0,7
Aqua (water)	75,6	73,6	73,35	73,35
Lactic acid	qsp	qsp	qsp	qsp
Methylchlorosothiazolino ne/methylsithiazolinone	0,1	0,1	0,1	0,1
Disodium EDTA	0,1	0,1	0,1	0,1
Sodium hydroxide	qsp	qsp	qsp	qsp
Parfum (fragrance)	0,5	0,5	0,5	0,5
Dimethiconol; TEA-dodecylbenzenesulfonate (60% active levels)	-	2	2	2
Polyquaternium-10	-	-	0,25	-
Guar hydroxypropyltrimonium chloride	-	-	-	0,25
Sodium laureth sulfate; cocamidopropyl betaine	23	23	23	23
Total	100	100	100	100

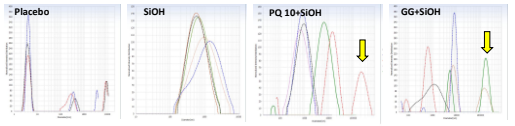


Results & Discussion:



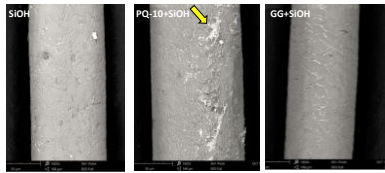
No precipitates observed in dilutions of Placebo and SiOH. Meanwhile, phase separation is observed in the presence of both cationic polymers (PQ-10 and GG) associated with the anionic emulsion of the hydroxyl-terminated siloxane (SiOH).

Coacervation (DLS)



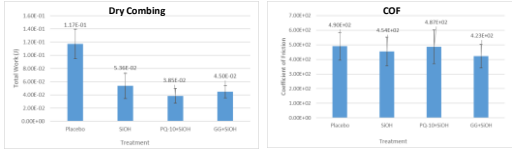
Coacervates generated distribution modes at ~100 µm and ~200 µm for shampoos containing GG and PQ-10, respectively, which are absent in Placebo and SiOH shampoos.

Deposition (SEM)



Clusters, assigned to the coacervate, can be easily observed on fibers washed with the shampoo PQ-10+SiOH. Deposition from shampoo GG+SiOH is directed at the edges of the cuticles, to a lesser extent compared to PQ-10+SiOH.

Performance (Dry Combing and Coefficient of Friction (COF))



Reduction in combing work was observed for all silicone-containing shampoos compared to placebo. Only PQ-10 was significantly different to SiOH at 98.6% confidence level. There is no statistically significant differences among treatments for COF reduction.

Conclusions:

Dilution studies demonstrated the formation of poorly soluble complexes from shampoos containing cationic polymers, which are associated with the increase in the deposition of an anionic silicone emulsion on hair tresses. PQ-10 has a narrower coacervate window compared to GG, however, the coacervate is significantly larger, resulting in more deposition and a larger decrease in combing work. No benefits were identified for reducing the coefficient of friction. This study reinforces the importance of choosing and associating ingredients that form complex coacervates to create minimalist and effective shampoos, leading to cost-effective products with superior performance to consumers.

Acknowledgements:

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