Synthesis of Ceria Coatings on Soda-Lime Glass via Solution-Gel Process: The Role of Cerium Citrate Precursor Species

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The solution-gel coating approach offers versatility in tailoring material composition and properties, allowing for the creation of uniform, homogeneous coatings on various substrates.[1, 2] The research presented can be related to the spray coating of spherically curved glass beads with ceria from a solution-gel precursor solution.

While significant research exists in sol-gel chemistry mechanisms, there remains a need for a more detailed understanding of how the specific chemical species in the precursor solution might influence the properties of the resulting coatings. This would enable a precise prediction and tailoring of the microstructure, morphology, and functional characteristics of ceria coatings obtained from these precursors by spray coating.

Citric acid is highly valued in solution-gel precursors as it chelates with metal ions, stabilizing them and enhancing the homogeneity of the coating. It can also form oxides at low temperatures.[3] However, the complexes formed are highly pH-dependent. A speciation plot was created to understand this and relate it to the coating characteristics, such as smoothness and homogeneity. Relevant species were determined by combining experimental potentiometry data with the speciation program Hyperquad2013. As the pH increases, the citrate ligands are deprotonated. Above pH 7 hydroxyl ions replace citrate ligands. ESI-MS data were obtained in addition to the speciation simulations to confirm the presence of simulated species in precursor solutions at a specific pH.

We speculate that the coating process and the resultant film properties are influenced by the cerium citrate species due to the variable chemical and physical properties of the species present at different pH levels. For example, we hypothesize that the coating uniformity and adherence are enhanced with increasing pH as a result of the increased number of hydroxyl ions in a species that reacts with surface hydroxyl functionalities by the formation of Ce-O-Si bonds.[2]

References

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