

ELUCIDATING THE ROLE OF ELECTROPHORETIC MOBILITY FOR INCREASING YIELD IN THE ELECTROPHORETIC DEPOSITION OF NANOMATERIALS

Prabal Tiwari, Department of Materials Science and Engineering, University of Florida, United States
prabal.tiwari93@gmail.com

Noah D. Ferson, Department of Materials Science and Engineering, University of Florida, United States
Jennifer S. Andrew, Department of Materials Science and Engineering, University of Florida, United States

Key Words: electrophoretic deposition, electrophoretic deposition kinetics, particle mobility, scalable nanomanufacturing, materials assembly

Catalysts, chemical, gas, and bio- sensing devices fabricated from porous nanoparticle films show better performance and sensitivity than their bulk material counterparts because of their high specific surface area. Electrophoretic deposition (EPD) technique is a cost-effective, fast, versatile, and easy to perform method to fabricate porous nanoparticle films. However, conventional EPD is currently limited by the fact that the deposition rate decreases with time, resulting in an eventual plateau in the deposit yield. Here, we sought to overcome this limitation by establishing and leveraging the critical role of the particle's electrophoretic mobility in EPD kinetics. To identify the impact of electrophoretic mobility on EPD yield we used positively charged alumina nanoparticles suspended in ethanol and hydrochloric as a model system. Changes in particle mobility during EPD were observed via electrokinetic measurements as well as by monitoring changes in the effective pH (pHe) of the suspension. To establish an apparent connection between particle mobility and EPD yield, we developed a particle replenish EPD in which we maintained the particle concentration and effective electric field nearly constant and allowed only particle mobility (pHe of suspension) to vary with time. Further, we developed a novel suspension replenish EPD approach that allows us to maintain near-constant particle mobility and particle concentration with time, thereby allowing the film mass to keep increasing with time. We observed that in conventional EPD the film mass gradually stopped increasing with increased deposition time, ultimately reaching a plateau. We also showed that the particle mobility of the alumina nanoparticles decreased during EPD as the pHe of suspension shifts towards the isoelectric point of alumina. This shift in pHe is attributed to the electrochemical change of H^+ ions into H_2 gas upon accepting electrons from the negative electrode. Further, using the particle replenish EPD, we showed that this decrease in particle mobility causes the rate of deposition to drop significantly i.e. causes the plateau limitation in EPD. Finally, using the suspension replenish approach, we observed a linear increase in the mass of the deposited film with time, overcoming the plateau limitation of conventional EPD as shown in Figure 1. Since this approach applies to a wide variety of materials which are electrostatically stabilized using pH adjustment, the yield and the thickness of deposits of a number of materials can be improved significantly by using the suspension replenish EPD approach. Thus, this work is of relevance to the following themes of the conference: "Modelling and fundamentals (theory) of EPD" and "Novel experimental setups for EPD".

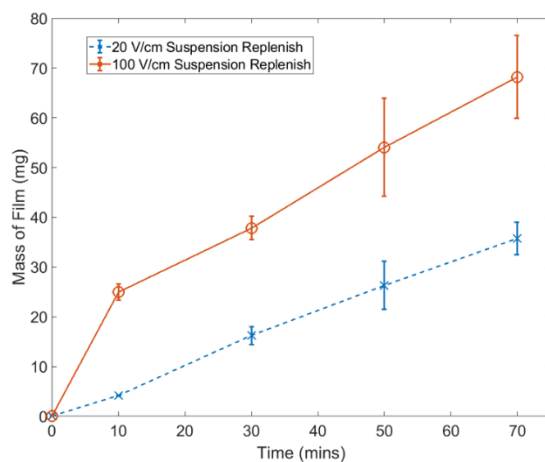


Figure 1 – The mass of the deposited film as a function of the deposition time deposited via suspension replenish EPD by applying 20 V/cm and 100 V/cm fields.