Coating Process Regimes in Particulate Film Production by Forced-Convection-Assisted Drag-Out

D. D. Brewer, T. Shibuta, L. F. Francis, S. Kumar, and M. Tsapatsis
Department of Chemical Engineering & Materials Science
University of Minnesota, Minneapolis, MN 55455

Presented at the 16th International Coating Science and Technology Symposium,
September 9-12, 2012, Midtown Atlanta, GA[1]

Operating conditions for the deposition of monolayer and bilayer particulate coatings from aqueous silica dispersions are identified in the context of a drag-out operation assisted by forced convection. Dry film thickness, uniformity, and morphology are assessed within an operating window parameterized by the capillary number and silica dispersion weight fraction. Three film deposition regimes with respect to the capillary number are observed: convective film deposition at low process rates, film entrainment at moderate process rates, and a thin-film transition regime at intermediate process rates. Locally ordered particulate films of variable layering thickness, including (i) a discontinuous submonolayer, (ii) a mixed submonolayer and monolayer, (iii) a mixed monolayer and bilayer, and (iv) multilayers, are dominant under convective deposition conditions. A map of morphologies is presented within the capillary number/weight fraction operating window, where monolayer and mixed monolayer/bilayer films are demonstrated in the thin-film transition regime at intermediate dispersion weight fraction. A complementary map of the morphologies formed by the drag-out of 110 nm silica dispersions reveals a broader applicability to this type of operating diagram. These operating maps are constructed using model silica dispersions, and are therefore relevant to particulate coatings of other inorganic materials.

[1] Unpublished. ISCST shall not be responsible for statements or opinions contained in papers or printed in its publications.