Advanced Functional Coatings for the Active Control of Particle Adhesion and Wettability

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To produce TiO_2 as the final-finished product, inorganic particles are surface modified to improve compatibility and performance in paint and ink formulations. During its formation, inorganic particles go through a series of size enlargement and size reduction steps, and in the final-step of processing, surface modified aggregates are milled to break-up particle aggregates to improve particle wetting and dispersion in solvents. With the need for milling and mixing, these last two-steps are very energy intensive. As such, this project will explore the design and development of active surface coatings to enhance de-aggregation and dispersion of particles in aqueous solvents with little energy input.

The research will focus on synthesizing novel polymer coatings that change their volume and surface topology in a reversible, dynamic fashion when exposed to an external stimulus. In the final application of the polymer coatings, pH and temperature are two adjustable parameters, with one polymer-type initially being studied to understand the effects of polymer molecular weight, cross-linking density, and polymer orientation on the topographical changes of the polymer coatings. The external stimulus should expand the polymer coating, with the expanded layer being sufficiently hydrophilic to disperse the pigment particles in an aqueous solvent.

The project brings together expertise in polymer chemistry and surface science. Prof. Rimmer is a world-expert in stimuli-responsive polymers, developing novel synthesis routes for organic-inorganic responsive polymers, controllable-branching of polyNIPAM polymers, and terminal-group chemistries of these polymers. The research team at ULEEDS (Harbottle and Hunter) lead an established surface science characterization laboratory with atomic force microscopy, optical reflectometry, quartz crystal microbalance (QCM), pendant/sessile drop tensiometer (and pressure cell), and dynamic light scattering, and many in-house built techniques that will be of use in the proposed project including: dynamic dispersion analyzer, high T/P QCM, and shear-resistant coatings tester.

The conformational behavior of the polymer coating under increasing confinement will be studied using the high pressure quartz crystal microbalance. These conditions will simulate the geometrical confinement experienced by the polymer coating in particle aggregates/clusters, and better represent the polymer performance in bulk processing. The effect of confining stress on polymer conformation, and its response to an external stimulus is largely unexplored, hence this is an exciting route for the project to develop and will provide opportunity to work with the Webber group and co-workers at the University of Newcastle, Australia, who have recently published a paper in Macromolecules on the effects of geometrical confinement on the thermoresponse of pNIPAM.

The project seeks to develop a novel solution to mitigate the need for milling and high-energy mixing in the production and formulation of pigment-based products.

References:

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