DRYFOAM – Super-stabilised opaque foam coatings for architectural applications

Titanium dioxide (TiO_2) is an engineered pigment commonly used to create whiteness and opacity in architectural paints and coatings. The high refractive index of this pigment ($\eta \approx 2.8$) relative to the refractive index of a polymer matrix ($\eta \approx 1.5$) results in a high light scattering efficiency, which is desirable for high performance coatings products. The TiO_2 content of architectural coatings is typically in the range of 5-15% by weight and accounts for about 20-40% of the total raw material cost. Recent shortages in the supply of TiO_2 have led to challenges in pigment availability and increasing costs. Alongside these pressures, there has been a growing awareness that TiO_2 is a significant contributor to the carbon footprint of coatings. These concerns have driven coatings developers to consider alternative strategies for product formulation.

DRYFOAM was a two year research project funded through the Seventh Framework Programme (FP7) of the European Commission. The primary objective of the research was to develop opaque paints that were completely free of titanium dioxide without sacrificing coating performance. This was to be accomplished using an innovative stabilized foam structure, leveraging developments in polymerization, surface modification, and formulation. The foam structure was stabilized to create air voids (refractive index $\eta = 1.0$) in the dried paint film, thereby serving as the source of light scattering. The partners in this development project were:

- Lankem Ltd. (UK)
- Resiquímica - Resinas Químicas, S.A. (Portugal)
- Danske Malermestre (Denmark)
- Le Comptoir de Minéraux et Matières Premières (France)
- Ronseal Ltd. (UK)
- SP Sveriges Tekniska Forskningsinstitut (Sweden)
- PRA Trading Ltd. (UK)

Initial work focused on preparing polymer latices and surface modified inorganic particles that were evaluated for the stabilization of aqueous foam structures. Styrene acrylate, vinyl acetate, and core/shell latices were prepared by emulsion polymerization having varying monomer compositions, surfactant stabilization systems, particle sizes, morphologies, and surface polarities. Submicron inorganic particles (e.g. silica, clay, mica) were also prepared having differing hydrophilic-lipophilic balance (HLB) surface modification, particle sizes, and either film-forming or non-film forming character. The latex particles and inorganic particles were screened as prepared and/or in surfactant solutions for their ability to stabilize foam. Strongly adsorbing particles at the air bubble / water interface were expected to create a steric barrier to inhibit foam collapse.

Paint formulations free of titanium dioxide were prepared. Several methods to introduce air into the waterbased paints were evaluated, including chemical blowing and gas expansion. Paints were dried and characterized for film appearance, opacity, and wet scrub resistance (durability). Although the ideal model of foam structure having a bubble size of 700 nm diameter was not achieved, promising systems were found that demonstrated excellent whiteness (> 75 units per ASTM E313) and scrub resistance. Two prototype formulations were optimized and successfully scaled up to 10 L to complete professional user application and performance validation trials. DRYFOAM paints were applied to pre-painted and non-primed plasterboard and were visually rated. The opacity of the coatings looked good and was comparable to a standard TiO_2-based paint.

Three notable accomplishments resulted from this project. A novel Lankem emulsifier system (Kemsurf ESD and Lanspec HSR) was identified which helped to improve the durability of latex films by remaining within the polymer matrix. Two new Resiquimica vinyl acetate based emulsion polymers were synthesized using the novel emulsifier system, which offered up to 150% increase in scrub resistance relative to standard emulsifier systems. Finally, a paint formulation and method of application was developed that maintained air voids in the matrix during film formation and drying, resulting in a coating that demonstrated comparable performance to a conventional architectural coating.