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Recommended Citation
Ivancic, Willian and Schmitt, Richard, "Processing Conditions for Ultrastable Surfactant-Free Nanoparticle Stabilized Foams" (2015). *Undergraduate Research Posters 2015*. 45.
https://engagedscholarship.csuohio.edu/u_poster_2015/45

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Processing Conditions for Ultrastable Surfactant-Free Nanoparticle Stabilized Foams

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Abstract

Foams, which are mixtures of gas and either a liquid or solid, are important to many applications, from consumer products to industrial processes. Stabilizing the liquid/gas interface against coalescence is key to the performance of foams. Typically, molecular surfactants (surface active agents) are used for interfacial stability, but adsorption/desorption of surfactant can diminish foam performance. We investigated the use of solid nanoparticles, rather than surfactants, as stabilizers. Fumed silica nanoparticles of varying surface chemistry, ranging from hydrophobic to hydrophilic, were suspended at 1% (w/w) and agitated in solutions of water and ethanol. Foam (gas in liquid), suspensions, and inverse foam ("liquid marbles") structures formed during agitation; these materials were classified into a structure map as a function of processing conditions. We found the agitation intensity, solution chemistry, and surface chemistry of the fumed silica nanoparticles had a profound effect on the final structure and that there was an envelope of optimal processing conditions for producing foam. Coalescence was mitigated for 49 days as of writing this abstract. Superior stability arises from the large energy necessary to remove particles with suitable chemistry from an interface. Thus, both the energy input and system chemistry are central to designing ultrastable foams.