

4ah Flow-Induced Microstructure of Nanoparticles in Multiphase Systems: Processing, Characterization, and Applications

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During the past decade, nanoparticles (1-100 nm) and nanocomposites have become the focus of many studies, due to the unique properties of nanostructured materials that make them attractive for various applications. Due to their atomic and molecular interactions, nanomaterials have unique and often favorable catalytic, mechanical, optical, and/or electronic properties. For instance, nanocrystalline copper is up to 5 times harder than conventional micron-sized copper particles. Nanocomposites, such as a homogenous mixture of different nanoparticles, can also exhibit improved properties. Other examples include coating and reacting nanoparticles with a second nanostructured phase. These processes are ideally suited to a fluidization process. However, in order to successfully use these applications, it is necessary to understand how nanoparticles can be fluidized. Understanding their hydrodynamic behavior, for example, will have repercussions in other fields such as their application in shear thickening fluid technology where fumed silica particles, at much lower particle loadings, have shown discontinuous shear thickening characteristics for possible military use in body armor.

This poster will highlight the author's graduate work under the guidance of Dr. Robert Pfeffer at the New Jersey Institute of Technology and postdoctoral work under the guidance of Dr. Norman Wagner at the University of Delaware. Her graduate work demonstrated that the fluidization of nanoparticles is indeed possible and in fact, significantly improvable with the addition of external forces or changes in certain conditions. Silica (among others, such as alumina and titania) nanoparticles, whose sizes range from 7 to 21 nm in diameter, were fluidized in a conventional gravity-driven bed, a vibrated bed, a magnetically assisted bed, a rotating bed, and a bed under supercritical conditions. The key parameters affecting fluidization quality were examined in each fluidized bed system. An advanced laser and CCD camera system was used to view agglomerates as they were being fluidized. A novel method for estimating fluidized agglomerate size and microstructure structure from liquid-fluidization theory and fractal analysis was shown to be in very good agreement with experimental data. Exciting applications in mixing and filtration were also presented.

The author's current postdoctoral work consists of using very similar silica nanoparticles but instead of researching their properties in a gas-solid system, she has investigated their dispersion properties in various polymeric matrices for other applications such as their possible military use for body armor. Her postdoctoral experience has allowed her to extend her particle technology knowledge from processing work (fluidization) and subsequent modeling (modified fractal analysis) to deeper characterization work through several tools: rheology, neutron & light scattering techniques, and detailed microscopy techniques. Part of her current work involves a close examination of the rheology of polymeric suspensions of fumed silica particles, which are often described as aggregated, fractal-like structures, of varying volume fraction, sizes, and surface modifications. These suspensions are shown to exhibit discontinuous shear thickening at much lower particle loadings than suspensions of hard, spherical particles. For example, discontinuous shear thickening was observed for a suspension with a particle loading of only 7% by volume as opposed to 52%, a typical loading needed to achieve discontinuous shear thickening behavior of larger particle suspensions. A portion of this poster will present the work exploring the mechanism and underlying shear-dependent structure of fumed silica particle dispersions. Thixotropy of the suspensions is also explored and compared to results reported in the literature. The results are compared to previous results for shear thickening in near hard sphere suspensions to establish the mechanisms of shear thickening.