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Why Particle Dispersions Matter: Product Discovery and Problem Solving in the Hydrocarbon Industry Through Neutron Scattering[1]

HUBERT KING, ExxonMobil Research and Eng. Co.

A surprisingly wide range of matter consists of dispersions of one material in another. In the hydrocarbon industry we often work with mixtures of solid, liquid, and gas as a consequence of the production of hydrocarbons. For example, in deep sea oil production solid phases of wax or gas hydrates can form in pipelines due to low temperatures and high pressures. Dispersions also arise in the products we design; examples include polymers, fuel additives, and lubricants. Hence, understanding such dispersions is a key technology. Size of the dispersed phase (supermolecular) and sensitivity of the structure to the presence of a fluid phase (high-vacuum imaging methods are difficult), makes the small-angle scattering technique, using light, x-rays, and neutrons, a preferred method of structure determination. We focus in this talk on neutron scattering, and this method has several strengths: 1) contrast matching to highlight features is easily achieved through use of various isotopes, for example ^{1}H vs ^{2}H, 2) an unprecedented range of length scales is accessible (several μm to nm) through the combined use of SANS and USANS, and 3) the concentration of scattering entities is precisely determined because scattering is routinely measured on an absolute basis. When one considers small-angle scattering from a dispersion, simple models such as Debye scattering, where the magnitude of the momentum transfer ($q=2\pi\ \mathrm{Sin}(\theta)/\lambda$) is comparable to the size of the dispersed phases ($R^*q\sim1$), is often used to estimate the size of the dispersed phase. However, this simple approach fails in many real-world cases where we must deal with, for example, high concentrations of solids or highly-anisotropic dispersed phases. In this talk we will illustrate how we have utilized combined SANS / USANS data along with contrast matching techniques to understand the structure-property relations governing behavior in several areas of interest, including self-assembly of polymers in fuel additives, polymer-modified gas-hydrate slurries, and organoclay dispersion/exfolation as thickening agents.

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