Nanoemulsions composed of sub-100 nm droplets are being used in many different applications, such as drug delivery, food products, and agricultural treatments. In many cases, nanoemulsions offer distinct advantages over standard microscale emulsions, including improved bioavailability, increased shelf life, optical clarity, and desirable elastic rheological properties at lower droplet volume fractions. While nanoemulsions have become increasingly important in many different industrial areas over the past decade, highly controlled nanoemulsions can also be useful for fundamental scientific studies.

Here, we take advantage of the much higher surface area-to-volume ratio of nanoemulsions as compared to standard emulsions, in order to study surfactant adsorption onto oil-water interfaces. Interfacial tension experiments are commonly used to measure surface concentrations of adsorbed surfactants on macroscopic flat liquid-liquid interfaces. In recent years other techniques, which involve small angle neutron scattering or optical spectroscopy, have been developed to measure such surface concentrations using unfractionated emulsions. However, the neutron scattering method can only be performed at a beam line, and the optical spectroscopy method is not very accurate and requires correction by more than a factor of 40. By contrast, we have designed a method of measuring interfacial tension of ionic surfactants that involves size-fractionated monodisperse nanoemulsions and can be readily performed using low-cost standard lab equipment through a combination of electrical conductivity and gravimetric analysis. With this approach, we measure the adsorbed surface concentration of sodium dodecyl sulfate (SDS) on interfaces of polydimethylsiloxane oil-in-water nanoemulsions as a function of bulk SDS concentration, thereby obtaining the adsorption isotherm. We show that this adsorption isotherm can be described by a Langmuir model. In addition we have developed predictions for the relative partitioning between interfacially adsorbed and bulk surfactant for high surface-area-to-volume ratio nanoemulsions as a function of droplet radius and volume fraction.

Moreover, we have developed monodisperse size-fractionated nanoemulsions that have enabled other scientific studies, including diffusing wave spectroscopy (DWS) of ionic nanoemulsions in the presence of salt as well as x-ray photon correlation spectroscopy (XPCS) under oscillatory shear. These studies highlight the versatility of highly controlled nanoemulsions in answering key questions surrounding the physical behavior of soft matter.

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