Cryogenic Electron Microscopy (Cryo-EM) Studies: Structure and Formation of Self-assembled Nanostructures in Solution

Hanseung Lee

1. Characterization Facility, University of Minnesota, 312 Church St SE, Minneapolis, 55455 Minnesota, USA

Relation between structure and property is central for optimization of materials performance. Therefore, a major goal in materials science is to analyze structure of materials and understand their properties. Based on these fundamental understandings in materials, we can control both intra-molecular and inter-molecular forces at the interfaces of the system and therefore elucidate the mechanism governing nanostructure development in self-assembled liquid system.

Cryogenic electron microscopy (Cryo-EM) is very unique among various characterization techniques. It provides a direct visualization of nanosized soft materials at the nanometer scale without any need for implicit models or assumptions about the structure. We can even visualize structure under dynamic conditions, capturing each stage of development. Complementary electron microscopy such as cryogenic temperature transmissions electron microscopy (cryo-TEM), cryogenic temperature scanning electron microscopy (cryo-SEM), and free-fracture electron microscopy enable to elucidate the structure at all length scale.

In this work, cryo-EM is used to investigate the formation and structure of several self-assembling soft materials: 1) micelle structure transition using cryo-TEM and small angle X-ray scattering (SAXS) [1], 2) microstructure of engineered nanoparticles and its release with cryo-TEM [2], and 3) formation of oil-in-water nanoemulsions with cryo-TEM and cryo-SEM [3]. Visualization is complemented by SAXS, dynamic light scattering, and conductivity measurements. In each case, cryo-EM provides new insights, not otherwise available, into the nanostructure development.

Reference:


Figure 1. Schematic of cryo-TEM specimen preparation, example micrograph, and contrast mechanism of TEM.
Figure 2. Schematic of cryo-SEM specimen preparation, example micrograph, and signal mechanism