Cryogenic-Temperature Electron Microscopy
A Tutorial

Yeshayahu (Ishi) Talmon
Department of Chemical Engineering
and
The Russell Berrie Nanotechnology Institute (RBNI)
Technion-Israel Institute of Technology, Haifa 3200003, Israel

Full nanostrucutral characterization of any material system requires direct imaging, in addition to non-imaging techniques, such as x-ray or neutron scattering. To image nanometric domains at supramolecular resolution one should use electron microscopy, either transmission electron microscopy (TEM) or scanning electron microscopy (SEM). To study nanostructured liquid systems of considerable vapor pressure, they must be made compatible with the high vacuum of the microscope, and all motion on the supramolecular level must be stopped. To meet those requirements we ultra-fast cool the liquid, and maintain the specimen in the microscope at cryogenic temperatures. That is the basis of cryogenic temperature electron microscopy, or cryo-EM. For cryo-TEM we need a thin enough specimen. In cryo-SEM we must ensure electrical neutrality of the cryo-specimen. As in all forms of microscopy we should have sufficient contrast in the prepared specimens. Also, almost all complex liquids are very sensitive to electron radiation-damage, that is, ionization and destruction of the specimen by the electron beam even at very short electron exposures.

In my two-hour tutorial I will describe the basic principles of TEM and SEM, cryo-TEM and cryo-SEM. The topics to be covered include the hardware used for cryogenic temperature electron microscopy (cryo-EM), cryo-EM specimen preparation, and electron-beam specimen interaction, including imaging, beam damage, and signal generation. Examples of cryo-EM of several liquid systems will be presented to illustrate the various subjects described. No background in electron microscopy is needed to follow the tutorial.