4ag Crystal Nucleation in Levitated Polyethylene Oxide

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Polymer crystallization is a first order phase transition that is complicated by severe kinetic frustration, a metastable endpoint, and inclusion of single molecules in multiple crystallites. The conditions under which a polymer crystallizes affect the resulting morphology, and thus the mechanical, optical, and transport properties of the material. An instrument has been developed for inducing phase transitions in polymers by thermal and solvent processing of micron sized particles that are levitated in an electrostatic field. Working with levitated microscopic particles eliminates container surfaces, increases the probability of observing material without solid impurities, and facilitates rapid equilibration of diffusive processes. Our apparatus provides a continuous record of particle mass with picogram resolution, precisely controls temperature and background gas composition, and monitors angular scattering of laser radiation. Nanogram samples of semicrystalline polyethylene oxide are exposed to cycles in relative humidity and temperature. The dynamics associated with melting, dissolution, and crystallization are monitored through changes in sample mass and optical properties. A single particle can be cycled repeatedly through strictly controlled conditions to capture the statistical nature of homogeneous crystal nucleation.

Electrostatic levitation enables unique studies of the chemistry, thermodynamics, optical properties, and transport processes of many classes of materials. In addition to polymer crystallization, we have also investigated cellular thermodynamics and candidate materials for chiral separations. Membrane osmometry is performed on individually levitated pollen cells in studies aimed towards understanding the release of asthma inducing nanoparticles. Differential absorption of chiral organic vapors by stereochemically enriched polyolefins is measured using an instrument with minor modifications.