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Chemistry 2019: Short range order, crystal nucleation and crystal growth in liquid colloidal suspensions- Dieter M Herlach-Germany

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Abstract

Colloidal suspensions are model systems to study phase transformations of first order as crystallization of a liquid system. The particles of colloidal suspensions are in size of several hundred nanometres and the carrier fluid is transparent in the spectrum of visual light. These characteristic features make colloidal suspensions easily accessible for optical investigations. The structural transformations are very sluggish and can be monitored in-situ. In the present work, light scattering experiments are performed to investigate homogeneous nucleation in the interior and heterogeneous nucleation on the container walls of silica colloidal suspensions and to measure the growth velocity of the crystal. Since nucleation processes require shortrange ordering as precursor of their formation, we conduct ultra-small-angle scattering of X-rays of synchrotron radiation at DESY Hamburg to determine the topological short-range order of monodisperse colloidal suspensions in liquid phase far away from thermodynamic equilibrium. In such a way, the entire pathway of crystallization from the stable liquid to the metastable liquid state, the formation of short-range ordering over crystal nucleation and eventually crystal growth is quantitatively investigated. The experimental results are analysed within current models of formation of aggregates of different structure, classical nucleation theory and the Wilson-Frenkel theory of crystal growth. From measurements of crystal growth and its analysis within the Wilson-Frenkel theory, the deviation from thermodynamic equilibrium of a shear melted crystal is inferred as defined by the difference of chemical potential between the metastable liquid and the stable solid. The in-situ investigations of homogeneous crystal nucleation are used to determine the solid-liquid interface which is very difficult to measure by other methods. The measurement of the growth of a planar liquid-solid interface allows for detailed information of the particle attachment kinetics of particles from the liquid to the crystal

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