Solution Electrostatic Levitator for Complex Nucleation Studies

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I. INTRODUCTION

Containerless processing methods such as electrostatic and electromagnetic levitation have been widely used to process highly reactive materials and undercooled melts [1-2]. They enable access to metastable states by getting rid of container walls. In this paper, we describe an electrostatic levitation setup that can levitate solutions of electrolytes, proteins and colloids, and is coupled with in-situ Raman spectroscopy and neutron scattering to investigate structural changes in aqueous electrolyte solutions to study multi-step and multi-pathway nucleation.

II. SOLUTION ELECTROSTATIC LEVITATOR

A. Sample Levitation and Control

The Solution Electrostatic Levitator (SEL) (Figure 1), developed at Iowa State University in collaboration with Korea Research Institute of Standards and Science, levitates a solution droplet of size 2.3-3.5 mm in diameter between a pair of vertical electrodes that are 10 mm apart. The top electrode is negatively charged by a high-voltage amplifier, while the bottom one is grounded. A solution droplet is injected with a needle moving along the center of in the bottom electrode. A 632 nm HeNe laser is incident on the droplet and casts a shadow on a position sensitive detector (PSD). The PSD sends the information about the sample's position to the control computer, which in turn sends feedback signals to the high-voltage amplifier at the rate of 1 kHz in order to maintain the sample's position. The entire assembly is placed on an optics table with pneumatic isolation to absorb vibrations that could destabilize the levitated droplet.

B. Droplet Size and Solution Concentration

Once launched, the solution droplet shrinks in size due to evaporation of water, thereby increasing the concentration. A monochrome camera collects images of the droplet every 10 seconds. From these images, the radius of the droplet is determined by fitting the 6th order Legendre polynomials. With the size of the droplet and the initial concentration of the solution known, the temporal concentration change can thus be obtained. More details on SEL can be found elsewhere [3].

C. In situ Raman Spectroscopy

In situ Raman spectroscopy is used to detect changes in molecular structure as a function of solution concentration. A 532 nm laser is shone on the levitating droplet, and scattered light is focused on the input slit of a spectrometer. A notch filter is placed at the input slit to filter the signal from Rayleigh scattering. Inside the spectrometer, the light is dispersed by a diffraction grating and focused on the detector, which records Raman spectra of the solution.

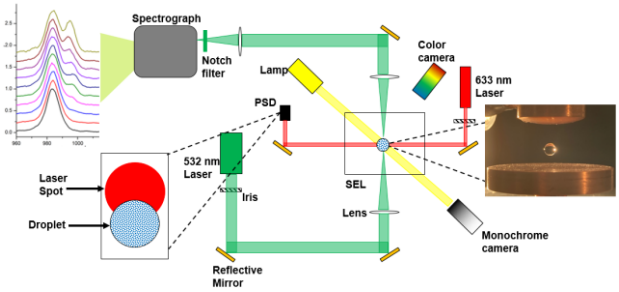

Figure 1: Schematic diagram of the SEL with in-situ Raman spectroscopy

III. FUTURE WORK

Structural analysis in the atomic scale is essential to comprehend the multi-step nucleation pathways in aqueous electrolyte solutions. The SEL is portable and will be integrated to a beamline in Oak Ridge National Laboratory for both in situ wide-angle (WAND^2) and in situ small-angle (GP-SANS) neutron scattering experiments.

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