Analysis of the Internal Configurations of Droplets of Liquid Crystal Using Flow Cytometry

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Micrometer-sized droplets of thermotropic liquid crystals (LCs) offer the basis of promising methods for detection of bacterial endotoxin and membrane-derived microvesicles that are shed by cells. To enable the use of LCs in this context, in this presentation, we will describe the use of flow cytometry to identify the internal ordering (director configurations) of micrometer-sized droplets of thermotropic liquid crystals (LCs) dispersed in aqueous solutions of adsorbates (surfactants and phospholipids) [1]. We reveal that changes in the configurations of the LC droplets induced by the adsorbates generate distinct changes in light scattering plots (side versus forward scattering; Figure 1). Specifically, when compared to bipolar droplets, radial droplets generate a narrower distribution of side scattering intensities (SSC, large angle light scattering) for a given intensity of forward scattering (FSC, small angle light scattering). This difference is shown to arise from the rotational symmetry of a radial LC droplet which is absent for the bipolar configuration of the LC droplet. In addition, the scatter plots for radial droplets possess a characteristic “S-shape”, with two or more SSC intensities observed for each intensity of FSC. The origin of the experimentally observed S-shape is investigated via calculation of form factors and established to be due to size-dependent interference effects that differ for the forward and side scattered light. Finally, by analyzing emulsions composed of mixtures of bipolar and radial droplets at rates of up to 10,000 droplets per second, we demonstrate that flow cytometry permits precise determination of the percentage of radial droplets within the mixture with a coefficient of determination of 0.98 (as validated by optical microscopy). Overall, the results presented in this presentation demonstrate that flow cytometry provides a promising approach for high throughput quantification of the internal configurations of LC emulsion microdroplets. The methodology also appears promising for quantification of chemical and biological assays based on adsorbate induced ordering transitions within LC droplets.

Figure 1. (A and B) Flow cytometry light scatter plots of side (SSC) vs. forward (FSC) light scattering measured for LC emulsions that contained bipolar (A) or radial (B) droplets. Insets show polarized light micrographs of the droplets in each respective configuration. (C) Percentage of radial LC droplets calculated from flow cytometry ($\Phi_{DPPC}^{FC}$) plotted against the percentage of radial LC droplets determined from polarized light micrographs of the same emulsions ($\Phi_{DPPC}^{PM}$).

References:

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