Study on Sequential Measurement of Diffusion Coefficient of Samples in Picoliter Droplets Using Laser-Induced Dielectrophoresis

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In recent years, microfluidics has grown dramatically in many fields such as clinical applications. In microfluidics, the rapid analysis and minute sample sensing can be achieved due to the superior characteristics of the device. These features are expected to have potential in cancer cell research, drug screening, and drug delivery systems. In particular, the Lab-in-a-droplet, a type of microfluidics using droplets, can encapsulate extremely small amounts of nanomaterials in a micro space, enabling efficient and automated analysis, and has the advantage of reducing the sample volume to the order of a picoliter (pL). In this study, a Lab-in-a-droplet device based on Laser-Induced Dielectrophoresis (LIDEP) has been developed to handle the droplets and to measure the diffusion coefficient of nanomaterial in a droplet. Although several diffusion coefficient measurement methods such as dynamic light scattering (DLS) and nanoparticle tracking (NTA) have already been established, it is difficult to realize a method that simultaneously achieves (1) measurement of small amounts on the order of a pL, (2) measurement in a short time of a few seconds, and (3) measurement without the need for sample pretreatment. In our method, the droplet can be optically manipulated with a high degree of freedom using LIDEP. Furthermore, LIDEP enables not only measurement, but also other multifunctional operations such as purification and concentration. The nanomaterial encapsulated in a droplet is also manipulated by LIDEP in a lattice shape, and the first-order diffracted beam is detected to observe the quick mass transport in the droplet. In this paper, the validity of our optical manipulation method of droplets and samples in a droplet is discussed.