SIZE-DEPENDENT DIELECTROPHORETIC CROSSOVER FREQUENCY OF SHPERICAL MICROPARTICLES VARIES WITH DIFFERENT MEDIUM CONDUCTIVITY

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Dielectrophoresis (DEP) has been extensively used in lab-on-a-chip systems for trapping, separating and manipulating micro particles suspended in liquid medium. In this paper, we report the size-dependent dielectrophoretic crossover frequency of spherical micro polystyrene (PS) particles in Distilled Deionized water (DD-water) and solutions of different conductivity. We apply several methods to obtain the relationship between crossover frequency and medium conductivity. Then, from these results, we provide a better understanding of DEP phenomenon, and explain what factors contribute to the precipitous drop of crossover frequency for increasing medium conductivity.

Our prior study on size-dependent dielectrophoretic crossover frequency was published in BIOMICROFLUDICS [1], which mainly compared the crossover frequency obtained from dipole model theorem and Maxwell stress tensor (MST), and concluded that, for larger particle size (D > 4.6μm), the dipole model cannot provide accurate prediction. Green [2] and Wei [3], among others, conducted experiments and observed the relationship between crossover frequency and particle size. However, the mechanism that affect the variation of crossover frequency, as a function of particle size and medium conductivity, is not well understood. Here, we conduct systematical study on DEP properties using analytical dipole model, finite element simulations based on MST, and optical tweezers apparatus. From these methods, we obtain an overall understanding of DEP properties from different view, and build a model by PI theorem to predict the result well.

In Fig. 1, we compare the crossover frequency over medium conductivity obtained from dipole model, MST, and experiment. We observe that, in specified particle size, both MST and experiment have the same trend. From our previous paper, we have known dipole model does not provide accurate prediction for larger particle size, and now we find out, while varying medium conductivity, the result of dipole model also deviate from experiment and simulation. From the simulations using MST, we calculate the surface charge distribution of different medium conductivity (Fig. 2), and notice that, for higher medium conductivity, the surface charge distribution differs much from an ideal dipole, which violates the basic assumption of dipole model theorem. In addition, from experiment result (Fig. 3), we observe that, for higher medium conductivity, the effect of particle size on crossover frequency becomes weaker. We deduce that as medium conductivity increases, charge screening effect becomes dominant [4], which increases the dependence of the crossover frequency on medium conductivity and decrease its dependence on the particle diameter.

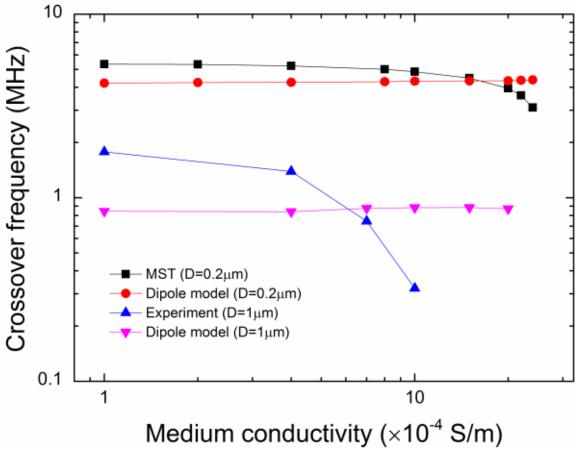

Fig.1 for specified particle size, the relation between crossover frequency and medium conductivity obtained by finite element simulation (MST), dipole model, and experiment

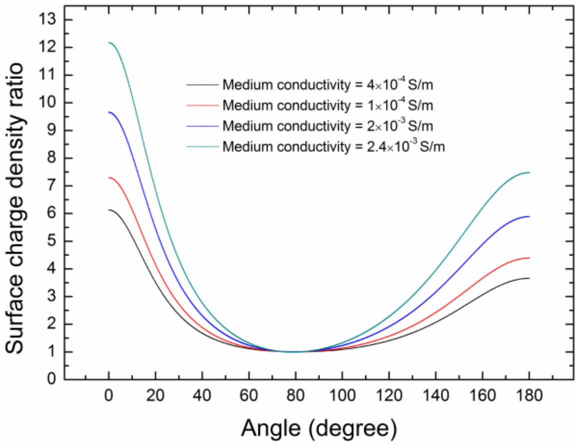

Fig.2 the surface charge distribution of PS particle in different medium conductivity cases obtained by finite element simulation

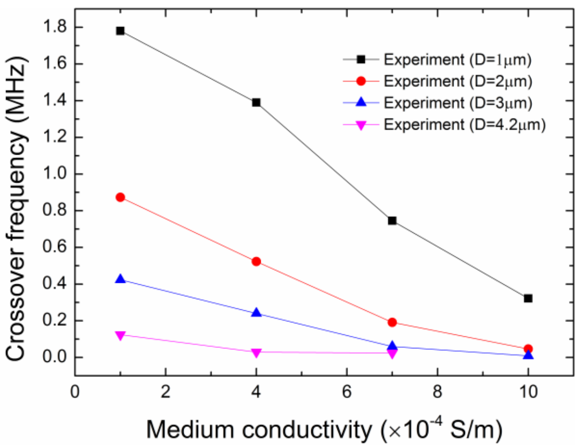

Fig.3 Effect of different medium conductivity and diameters on DEP crossover frequency measurement

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