

# Impact of surfactant on diffusiophoresis of a charged liquid droplet

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**Abstract.** We study the effect of surfactant distribution on the diffusiophoresis of a charged dielectric as well as conducting droplet in an electrolyte medium. The drop is assumed to remain spherical. The numerical solution is obtained by solving the full non-linear coupled Navier-Stokes-Nernst-Planck-Poisson equations with prescribed boundary conditions with finite volume method. We find that the presence of surfactant at the drop interface has a huge impact on the motion of the droplet. A unique effect is observed that mobility may increase in the presence of surfactant distribution in the context of diffusiophoresis of a droplet. Presence of Marangoni stress has the ability to reverse the direction of the droplet motion.

## Introduction

Diffusiophoresis is an electrokinetic phenomena which describes the motion of particles immersed in electrolyte and non-electrolyte solution under the impact of an applied ion concentration gradient. Due to the non-uniform distribution of ion concentration, a pressure driven osmotic flow is generated and hence diffusiophoresis has two parts, electrophoresis, which arises due to the induced electric field and chemiophoresis, due to the pressure driven osmotic flow. Diffusiophoresis has potential application in colloid chemistry and bio-medical fields. Motion of droplets and bubbles is found to be extremely useful in the context of targeted drug delivery, colloid separation, water purification, bone-fracture detection and food products dispersion. Theoretical analysis of the droplet diffusiophoresis based on Debye–Hückel approximation is made by Tsai *et al.* [1], at thin Debye layer is made Yang *et al.*[2] and numerical solution based on perturbation approximation is studied by Fan *et al.*[3]. All those studies is for surfactant free droplet. But in the context of diffusiophoresis of droplets, the surfactant effect is relevant. We study numerically the effect of non-uniform surfactant distribution on the diffusiophoresis of a charged dielectric as well as conducting droplet. Presence of surfactant lowers the interfacial tension at the droplet surface, which creates the Marangoni stress. The Governing equation are the Navier-Stokes equation for fluid flow, the Nernst-Planck equation for ion concentration and the Poisson equation for electric potential, which are solved numerically in a coupled manner through a finite volume method with staggered grid arrangement.

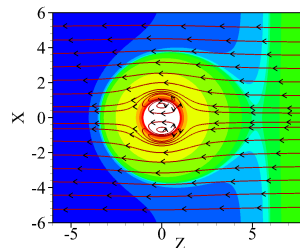


Figure 1: Streamlines patterns and counterion distribution in and around the droplet.

## Results and discussion

In diffusiophoresis, velocity of a dielectric droplet may increase with the increase of viscosity ratio because of the creation of the vortex at the equator of the droplet. The repulsive force on the drop due to the double layer polarization (DLP-II effect) arises in the context of dielectric droplet diffusiophoresis at moderate to thin Debye length, which drives the drop to the lower concentration gradient no matter the surface charge density around the drop is positive and negative. Marangoni stress which is created due to the interfacial tension at the droplet surface has a dramatical effect on the droplet motion in the context of diffusiophoresis. We present the relation of surfactant distribution and internal circulation of the droplet and that the Marangoni stress increases with the decrease of viscosity ratio. We establish here that the presence of surfactant reduced the DLP-II effects. For a conducting droplet, the mobility reduces when it is positive and the mobility increases when it is negative in the presence of Marangoni stress. But in the case of dielectric droplet, the mobility may increase even it is positive and may reduce even it is negative due to the Marangoni stress.

## References

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