

Force acting on a moving colloidal particle in a polymer solution

Takashi Taniguchi, Yu-ichi Arai, Remco Tuinier; and Tai-Hsi Fan
Kyoto Univ., DSM ChemTech, Utrecht Univ., and Univ. of Connecticut

Introduction: Colloid and polymeric systems has been used in various industrial products, e.g., paints, cosmetics, displays and so forth. In a colloid and polymer dispersion system, it has been well-known that a depletion zone of polymer segment in the vicinity of the surface of a colloidal particle is formed, which yields an attractive interaction among colloidal particles. So far, the equilibrium properties such as the strength of the attractive interaction as a function of distance and phase diagrams of colloid-polymer mixtures has been intensively studied. On the other hand, there are a limited number of studies on the dynamic properties of such systems. Therefore, here we focus on the flow behavior and the change of polymer concentration profile around a moving colloidal particle with a constant velocity. The aim of the present work is to clarify the effect of polymer concentration distortion by the flow on the frictional force acting on the particle.

Results and Discussions: When a single colloidal particle is moving with a constant velocity in a dilute polymer solution, the flow can change the depletion layer and therefore the frictional force acting on the particle and the flow patterns are tightly related each other. We investigated the change of polymer depletion distribution around a particle moving with a constant velocity to a quiescent polymer solution at bulk and the resultant frictional force acting on it. To understand the effect of the spatially dependent viscosity on the frictional force, firstly we investigate the constant viscosity case. I found that the spherically formed depletion in quiescent state is distorted by the effect of hydrodynamic effect. In front of the moving particle, polymer concentration becomes higher than that at bulk. In the rear of it, on the other hand, the depletion is enhanced and becomes wider by the flow effect. The frictional force along the particle moving direction is contributed from two forces, viscous force F_v and osmotic force F_π . One of the control parameters of the present system is the Peclet number Pe . As Pe becomes larger, F_v dominates, while the osmotic one becomes small. At a very high Pe , F_π still gives a finite contribution, but F_v becomes very large ($\propto Pe$). We also investigated the case that the viscosity of polymer solution depends on the local concentration of polymer and therefore varies spatially. We found that the flow behavior around the colloidal particle is quite different from the case where the viscosity is spatially constant. To understand the effect of spatially dependent viscosity on the frictional force, we compare our numerical results with the results obtained by two layer model [1] proposed by Fan et al. As a result, it is found that F_v under taking into account the distortion of concentration profile around the particle is larger than the two layer model and the case without any change of volume fraction profile from the equilibrium state. It is found that the origin of the larger frictional force in the case of the distorted concentration profile by flow comes from a larger shear deformation in the vicinity of the colloidal surface (i.e., the *apparent slippage effect* [2]).

[1] T. H. Fan et al., *Phys. Rev. E*, **75**, 011803 (2003).

[2] Remco Tuinier and Takashi Taniguchi, *J. Phys: Cond. Matt.*, **17**, L9 (2005).