Dynamics of a colloidal particle near a transparent tin oxide electrode

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Transparent thin film electrodes are being used to investigate mechanisms of self assembly of layers of colloidal particles. These investigations usually record the motion and behavior of particles parallel to the plane of the electrode. We take advantage of the transparency to study the nanometric out of plane motion of colloidal particles.

The vertical motion of a levitated colloidal particle immersed in aqueous solution, located near a transparent tin oxide electrode, and subjected to an alternating electric field normal to the electrode was recorded using total internal reflection microscopy. The particle's height was sinusoidal in time during the portion of the cycle above its average height; during the remainder of the cycle, however, hydrodynamic hindrance arising from the particle's proximity to the electrode did not allow it to descend below the average height with the same amplitude as above. The particle's height averaged over a full cycle exhibited a minimum in its frequency and voltage dependences in potassium hydroxide but increased monotonically with frequency in sodium bicarbonate. The phase between the response of the particle and the applied electric field varied significantly with frequency. Both the profoundly different response in potassium hydroxide and sodium bicarbonate and the significant variation in phase angle with frequency are not expected on the basis of colloidal and electrophoretic forces alone; another force is suggested. An electrohydrodynamic model based on faradaic charge transfer at the electrode is qualitatively consistent with these observations.