ABSTRACT

In this paper we provide experimental evidence showing that various types of submicrometer-sized particles (latexes, inorganic, and metallic), suspended in either aqueous or nonaqueous carrier liquids to which a temperature gradient dT/dx is applied, experience a force in the direction opposite to that of dT/dx. This behavior is similar to that of small particles such as soot, aerosols, and small bubbles suspended in stagnant gases across which temperature gradients are applied, a phenomenon known as "thermophoresis in gases." We report the use of a thermal field-flow fractionation (ThFFF) apparatus in two different configurations to establish the direction of particle motion subject to a temperature gradient. The first approach employed the conventional horizontal ThFFF channel orientation. In this case, small electrical potentials were applied across the narrow channel thickness either to augment or to act in opposition to the applied thermal gradient, depending on whether the accumulation wall was maintained at a positive or negative potential relative to the depletion wall. Thus, by observing the changes in the retention behavior of surface-charged latices or silica particles with changes in potential difference across the channel thickness, we were able to ascertain the direction of migration of the particles in the thermal gradient. The second approach involved the use of a ThFFF column oriented vertically in an implementation of a technique known as thermogravitational FFF. In this approach, the convective flow along the channel length (due to density gradients associated with the temperature gradient) couples with the thermal diffusion effect across the channel thickness to result in a combined particle retention mechanism. A retarded upward migration rate is indicative of accumulation of particles at the cold wall, while enhanced upward migration would indicate a hot-wall accumulation. From the results of our investigations, we conclude that submicrometer-sized particles suspended in either aqueous or nonaqueous carrier liquids and subjected to a temperature gradient migrate from the hot wall toward the cold wall of a ThFFF channel.