particles. By "free of particles," it is meant that the drops or bubbles are free of particles, or, in recognition that separation process typically are not perfect, substantially or essentially free of particles. Thus, in one non-limiting example in the context of the methods described herein, a drop or bubble is considered to be free of particles where the number of particles and/or particle density on the surface of the drop is reduced by at least 90%, 95%, or 97.5%, and preferably at least 99%, and increments therebetween as compared to the original drop or bubble from which particles are removed. The method also facilitates separation of particles for which the sign of the Clausius-Mossotti factor is different, making particles of one type aggregate at the poles and of the second type aggregate at the equator. The former can be removed from the drop or bubble by increasing the electric field strength, leaving the latter on the surface of the drop or bubble.

The methods can be used for particle assembly and concentration on a drop or bubble's surface, the full removal of particles from the drop or bubble's surface (cleaning or filtration of particles from bulk liquids and then from the drops or bubbles), and further concentration into smaller drops or bubbles containing a high density of particles. The particle manipulation on drops' or bubbles' surfaces could also be used for changing the drops' or bubbles' surface properties (e.g., for adsorption of external agents or the destabilization of foams and emulsions).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**. The dielectrophoresis force induced motion of small particles on the surface of a drop subject to a uniform electric field generated by the electrodes placed at the top and bottom of the device. The figure shows the direction of motion for particles for which the Clausius-Mossotti factor is positive (the direction is the opposite for particles with a negative Clausius-Mossotti factor). The dielectric constant of the drop in the FIG. **1**A is greater than that of the ambient fluid while the dielectric constant of the drop in the FIG. **1**B is less than that of the ambient fluid.

FIG. **2**. The steady deformed shape and the modified electric field around a dielectric drop suspended in a dielectric liquid and subjected to a uniform electric field. In FIG. **2**A, the dielectric constant of the drop is less than that of the ambient liquid. In this case, the electric field is no longer uniform; it is locally maximum at the equator and locally minimum at the poles. In FIG. **2**B, the dielectric constant of the drop is greater than that of the ambient liquid. In this case, the electric field is locally maximum at the poles and locally minimum at the equator.

FIG. **3**. Removal of extendospheres from a water drop immersed in decane. The electrodes were mounted on the left and right side walls of the device, and the distance between them was 6.5 mm. (a) The drop diameter was 933 μm. The initial distribution of extendospheres on the drop's top surface. The voltage applied was zero. (b) The voltage applied was 3000 V at 1 kHz. Particles moved towards the two poles. (c) The voltage applied was 3500 V at 1 kHz. All of the particles accumulated at the two poles and formed particle chains. Notice that the radius of curvature near the poles was smaller, and the deformation is larger than in (b). (d) Shortly after the voltage of 3800 V at 1 kHz was applied, the drop shape near the poles became conical, and all of the particles had already ejected from the drop via tip-streaming (e) After the electric field was switched off, the drop assumed a spherical shape. The drop was clean and its diameter was 833 μm.

FIG. **4**. Removal of extendo spheres from a water drop immersed in corn oil. The distance between the electrodes is 2.65 mm and the voltage applied is 2 kV at 1 kHz. The drop with an initial diameter of 844.2 μm is shown at t=0, 16.6, 16.8667 and 17.1667 s (a-d). Particles remain at the equator while the drop stretches (b) and breaks into two clean drops (c-d), leaving particles in a small detached droplet (of high particle concentration) in the middle (d).

FIG. **5**. Drop placed in an ambient fluid and subjected to a uniform electric field generated by the electrodes placed at the top and bottom of the computational domain. The domain is three dimensional with a rectangular cross-section.

FIG. **6**. Deformation of a water drop suspended in decane and subjected to a uniform electric field. Electrodes are mounted on the side walls of the device, and so the electric field is horizontal. The drop diameter is approximately 885 μm. The distance between the electrodes is 6.5 mm. (a) The applied voltage is 0 volts; the drop is spherical. (It, however, appears to be slightly elongated in the vertical direction due to the optical distortion that arises because the top surface of the ambient liquid is not flat.) (b) The steady shape when the applied voltage is 3700 volts. The longer dimension of the drop is 1157 μm. (c) The applied voltage is increased to 3800 volts. A short time later, just before it breaks up (it breaks in the next frame). The longer dimension of the drop is 1476 μm.

FIG. **7**. Schematic diagram showing the formation of drops containing small particles on their surfaces. (a) The initial state of an injected drop. Particles are present within the drop and not on its surface. (b) The suspended particles are less dense than the drop and so they get accumulated at the top surface of the drop. (c) The suspended particles are denser than the drop and so they get accumulated at the bottom surface of the drop.

FIG. **8**. Top view of the motion of hollow glass spheres on the surface of a silicone oil drop suspended in corn oil and subjected to a uniform electric field. Electrodes are mounted on the bottom and top surfaces of the device. The electric field is normal to the plane of the paper. The drop diameter is approximately 684 μm. The distance between the electrodes is 6.0 mm and the applied voltage is 3000 volts. The density of hollow glass spheres is 0.6 g/cm^3 and their diameter is approximately 18 μm. The Clausius-Mossotti factor is positive and since the electric field is maximal at the equator, after the electric field is switched on, the particles move towards the equator. (a) t=0, (b) t=20 s. (c) t=40 s. (d) t=60 s.

FIG. **9**. Top view of the motion of sodalime glass spheres on the surface of a silicone oil drop suspended in corn oil and subjected to a uniform electric field. Electrodes are mounted on the bottom and top surfaces of the device. The electric field is normal to the plane of the paper. The drop diameter is approximately 940 μm. The distance between the electrodes is 6.0 mm and the applied voltage is 4000 volts. The density of sodalime glass spheres is 2.5 g/cm^3 and their diameter is between 4-10 μm. The Clausius-Mossotti factor is positive and since the electric field is maximal at the equator, after the electric field is switched on, the particles move towards the equator. (a) t=0, (b) t=10 s, (c) t=20 s, (d) t=60 s.

FIG. **10**. Top view of the motion of extendospheres on the surface of a water drop suspended in decane and subjected to a uniform electric field. Electrodes are mounted on the left and right side walls of the device. The electric field is horizontal within the plane of the photographs. The drop diameter is approximately 1547 μm. The distance between the electrodes is 6.5 mm. The density of the extendospheres is 0.75 g/cm3 and their diameter is approximately 55 μm. The Clausius-Mossotti factor is positive and since the electric field maximum is located at the poles, after the electric field is