Resonance and coalescence of sessile droplets in a rotating electric field

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***Abstract*— This paper reports the 3-D oscillations and coalescence of water droplets deposited on a dielectric substrate under the effect of a rotating electric field, taking into account the effect of frequency of the applied AC voltage and the value of the contact angle. Motion of the fluid is governed by the Navier-Stokes equations, which are solved both inside and outside the droplet (ensuring the conservation of volume of the droplets). The time variation of the shape of a perfectly conducting droplet placed between two pairs of orthogonal parallel electrodes with two phase voltage excitation demonstrates that a water droplet vibrates strongly at certain frequencies. It was found that the resonance frequency and the magnitude of the deformation strongly depend on the surface properties. This paper also presents a new design of an electrowetting mixer using the rotating electric field and offers a new method to effectively mix two droplets over a different range of AC frequencies. Two regimes were observed for droplet mixing: 1) mixing due to the high droplet deformation, 2) mixing due to the interaction of electrically induced dipoles. Numerical simulations confirm that by increasing the electric capillary number, the first mixing mechanism starts at lower frequencies.**