Supporting Information

Controlled Electro-coalescence / non-coalescence on Lubricating Fluid Infused Slippery Surfaces

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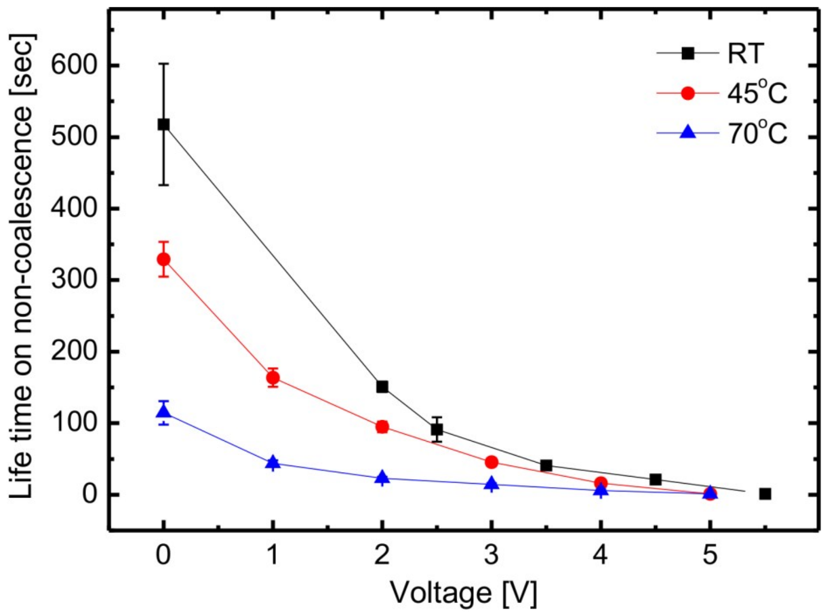

Figure S1: Life time of non-coalescence of two aqueous drops as a function of applied ac voltage three different temperatures.

Assumptions to derive model for electric field induced drainage of oil film between two aqueous drops:

i. Lubricating fluid is a Newtonian fluid in isothermal condition.

ii. Aqueous drops are semi spherical with identical radii, R i.e. (R_1=R_2=R)

iii. Thickness of the oil film between aqueous drops is constant at any given time, *T(t)*, and does not vary along the radial axis.

iv. Radius of the oil film between aqueous drops (a) does not vary during oil drainage and only its thickness decreases.

v. Viscous force dominate during oil drainage the inertial terms can be neglected in the governing flow equation.

vi. Oil film thickness $T(t) << a$, therefore within the lubrication approximation only radial velocity $u_r(z,t)$ of draining oil is considered.

vii. Laminar (Poiseuille) flow is assumed such that $\frac{\partial P}{\partial r} = -\frac{\Delta P(t)}{a}$

Navier-Stokes equation for the incompressible flow for Newtonian fluids is

$$\rho\left(\frac{\partial u}{\partial t} + u.\nabla u\right) = -\nabla p + \eta\nabla^2 u + f \quad (1)$$

where, ρ is the density of fluid, u is flow velocity, η is the viscosity of the fluid, f is the body force on the fluid.

Simplified Navier-Stokes equation using the above assumptions results as:

$$\frac{\Delta P}{a} = \eta\frac{\partial^2 u_r(z,t)}{\partial z^2} \quad (2)$$

No slip boundary condition: $u_r\left(\frac{T}{2},t\right) = u_r\left(-\frac{T}{2},t\right) = 0$

Integrating Eq.2 twice with respect to z and using the above boundary conditions, we get

$$u_r(z,t) = \frac{\Delta P}{2a\eta}\left(z^2 - \left(\frac{T(t)}{2}\right)^2\right) \quad (3)$$

Volumetric flow rate of the oil drainage around the outer radius of the film is given by

$$Q(t) = 2\pi a\int_{-T/2}^{T/2} u_r(z,t)dz$$

or

$$Q(t) = -\frac{\pi\,\Delta P(t)}{6\eta}T^3(t) \quad (4)$$

Change in the film thickness with time can be written as:

$$\frac{dT}{dt} = \frac{Q(t)}{\pi a^2} \tag{5}$$

Total pressure difference between the two aqueous drops can be written as:

$$\Delta P = \left(\frac{2\gamma_{wa}}{R} + \frac{A_H}{6\pi T(r,t)^3} + \frac{\in_r \in_0 V^2}{2T(r,t)^2} \right) \tag{6}$$

where the 1st term corresponds to the Laplace pressure, 2nd term corresponds to the long range molecular interaction i.e van der waals interaction where A_H is Hamakar constant and the 3rd term is electrostatic pressure due to the applied voltage between the two aqueous drops. $\in_r$ is the dielectric constant of the oil, $\in_0 = 8.85 \times 10^{-12}$ F/m is the vacuum permittivity, V is the applied ac voltage.

Combining Eq. 4, 5 and 6 results in the rate of change of oil film thickness as:

$$\frac{dT}{dt} = - \frac{1}{3\eta a^2} \left(\frac{\gamma_{wa} T(t)^3}{R} + \frac{A_H}{12\pi} + \frac{\in_r \in_0 V^2 T(t)}{4} \right) \tag{7}$$