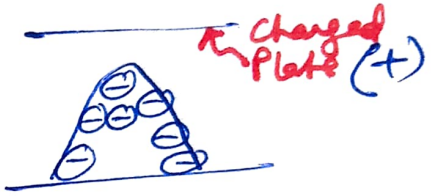
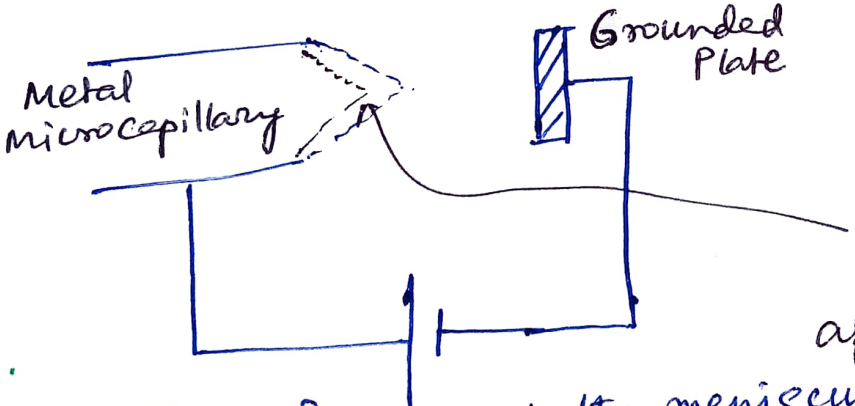
Electrohydrodynamic Atomization

* A hemispherical drop of electrolyte solution on a substrate

* Deformation into a conically shaped meniscus when a charged plate is brought close to the drop

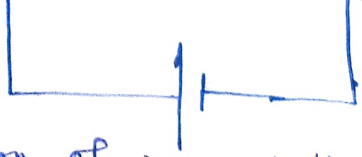


* when the liquid is housed within a metal capillary, and a voltage is applied across the capillary and a grounded plate at a small distance away, **the conical meniscus appears at the orifice.**



Thin polarized layer on the liquid side of the meniscus interface forms on application of the electric field.

* Accumulation of ions at the meniscus tip leading to high charge density.
* when coulombic repulsion exceeds local surface tension, meniscus tip becomes unstable, and the charges in the meniscus are drained through extrusion of liquid jet



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Definition of Critical voltage

(*) Liquid meniscus protruding from the orifice in the shape of a spherical cap $\Rightarrow$ Stress arising from surface tension $= \frac{\sigma}{R}$

where $R \equiv$ principal radius of curvature, which is of same order as the radius of capillary

(*) If V is the applied voltage, and d is the electrode separation, the Maxwell stress $= \epsilon_0 \epsilon_l \frac{V^2}{2d^2} = \epsilon \frac{V^2}{2d^2}$

by which the meniscus will be pulled towards grounding plate due to Coulombic attraction.

When imposed maxwell stress is greater than the stress arising from surface tension (by which the liquid meniscus held to the orifice)

$\Rightarrow$ a thin jet will be pulled out from the tip of the meniscus.

Equating the two stresses, $V_c \sim \sqrt{\frac{\sigma d^2}{\epsilon R}}$ Factor 2 is ignored.

For $\sigma \sim 10^{-2} \frac{N}{m}$

$d \sim 10^{-2}$ m

$R \sim 10^{-3}$ to 10^{-4} m

$\epsilon = \epsilon_0 \epsilon_l \sim 10^{-10} \frac{\text{Coulomb}^2}{J-m}$

$\Rightarrow V_c \sim 10$ kV

One volt is defined as energy consumption of one joule per electric charge of one coulomb.

Break-up of Jet

Jet that comes out from the tip of the meniscus breaks down into droplets.

Rayleigh Capillary Instability

* When charging of jet is not excessive
* Rayleigh Instability theory modified to include charge effect
* Drop diameter ~ 1.9 {Jet diameter}
* Drops are monodisperse

Coulombic Instability

* Applicable for highly charged jets
* Kink instability: jet undergoes lateral whipping and bending motion
* Drops are polydisperse and significantly smaller in size.

Evaporation from the drop ⇒ decrease in size

⇒ increase in charge density

⇒ Further coulombic fission and generation of finer droplets prior to deposition on grounding plate.