# Determination of Zeta Potential by Microelectrophoresis

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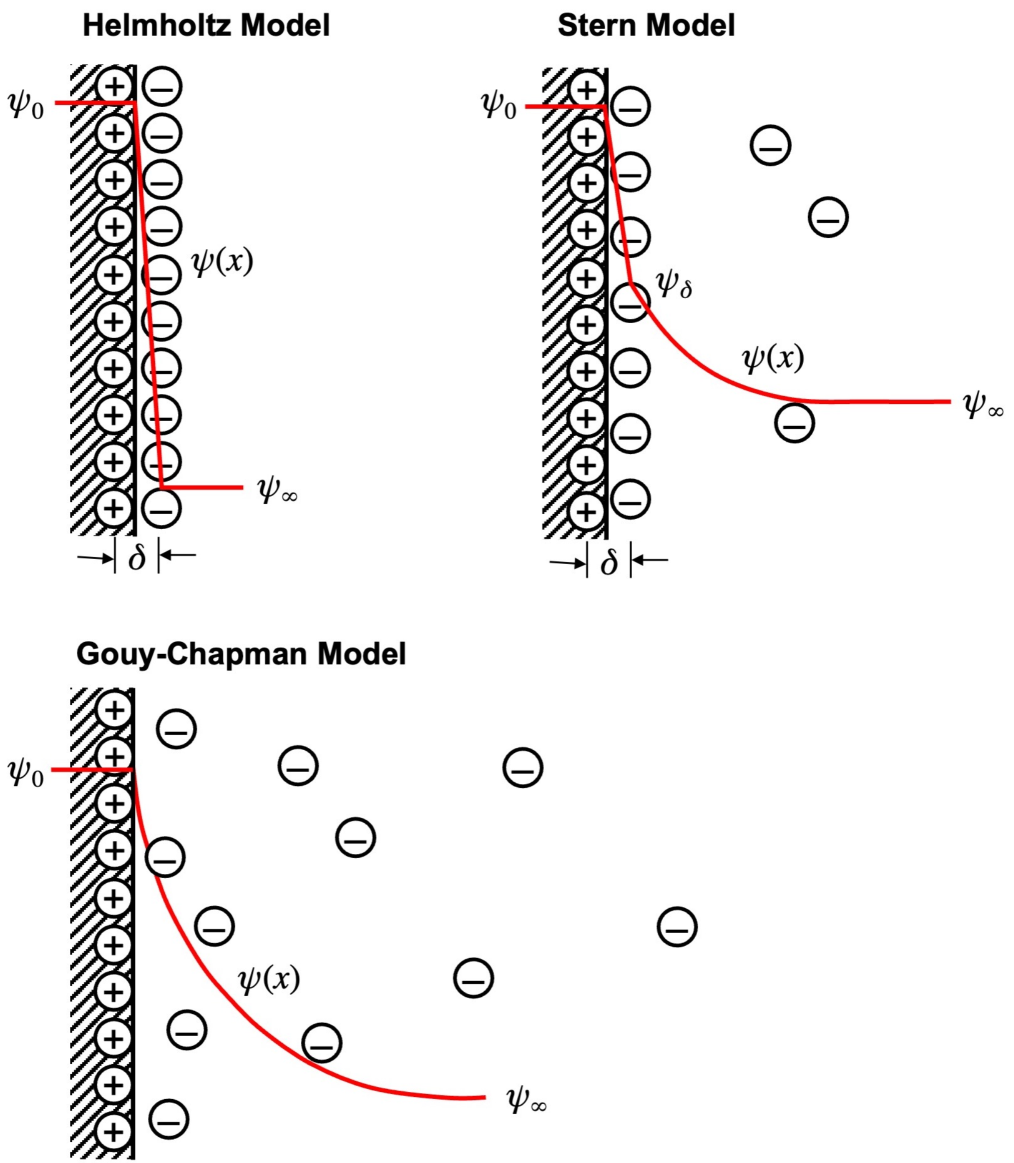
**Surface and Colloid Science**

# Zeta potential is the electrical potential at the slip plane of the electric double layer

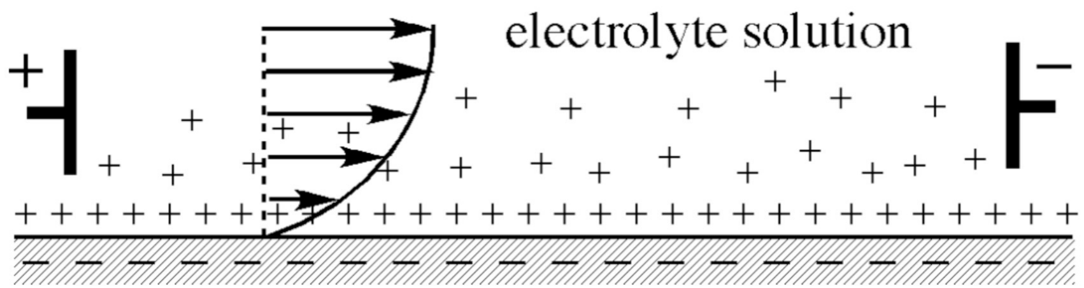
- $\psi$ - electrical potential difference between dispersing medium and ...
  - $\psi_\infty \equiv 0$ - the dispersing medium
  - $\psi_0$ - the surface of colloidal particle
    - True surface potential
  - $\psi_\delta$ - the outer first layer of counterions
    - Effective (Stern) surface potential
  - $\zeta$ - the slip plane (medium velocity = 0)
    - Zeta potential, electrokinetic potential
- The slip plane may be slightly further out into the solution than Stern layer
  - $\psi_\delta \approx \zeta$



# Electro-osmosis and electrophoresis give the same zeta potential

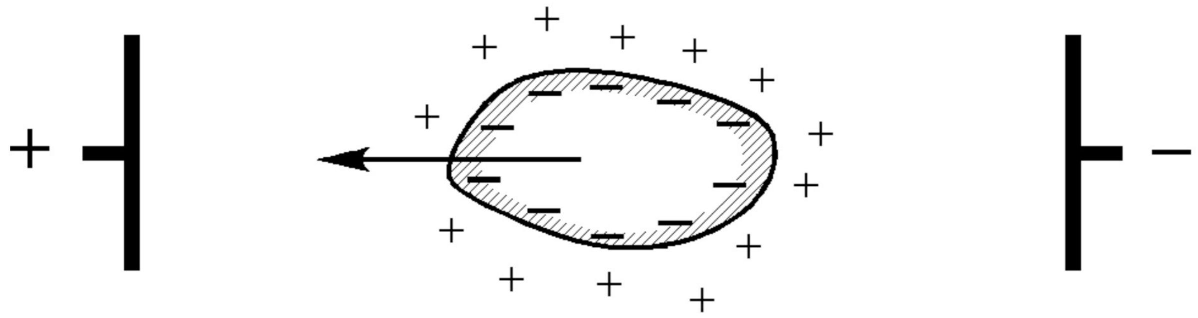
- **Electro-osmosis** - diffuse layer of ions beside a charged immobile surface move under *E* field, which sets the liquid into motion by the action of viscosity
  - *Liquid* moves, *solid* at rest

**Electro-osmosis**




- **Electrophoresis** - diffuse layer of ions beside a charged particle surface move under *E* field, which sets the particle into motion
  - *Solid* moves, *liquid* at rest

**Electrophoresis**



# Electrophoretic mobility allows determination of zeta potential

- **Electrophoretic mobility** - $u_E[(\mathrm{\mu m/s})/(\mathrm{V/cm})]$
  - $u_E = \dfrac{V_p}{E_x} = \begin{cases} \dfrac{\varepsilon\varepsilon_0\zeta}{\mu} & (\kappa a > 200) \\ \dfrac{2}{3}\dfrac{\varepsilon\varepsilon_0\zeta}{\mu} & (\kappa a < 0.1) \end{cases}$

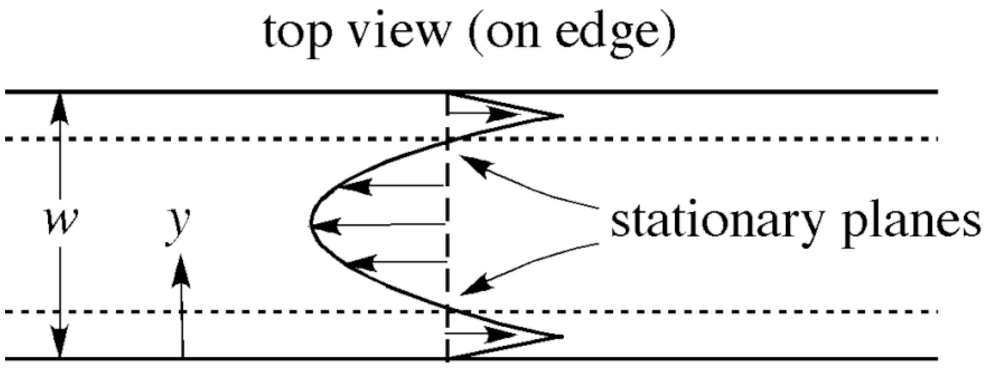
- $u_E$ - Electrophoretic mobility
- $V_p$ - Particle velocity
- $E_x$ - Electric field strength
- $\varepsilon$ - Dielectric constant of the medium
- $\varepsilon_0$ - Permittivity of free space
- $\zeta$ - Zeta potential
- $\mu$ - Viscosity of the medium
- $\kappa$ - Debye length
- $a$ - Particle radius

# Point of zero charge and isoelectric point define pH at which potentials are zero

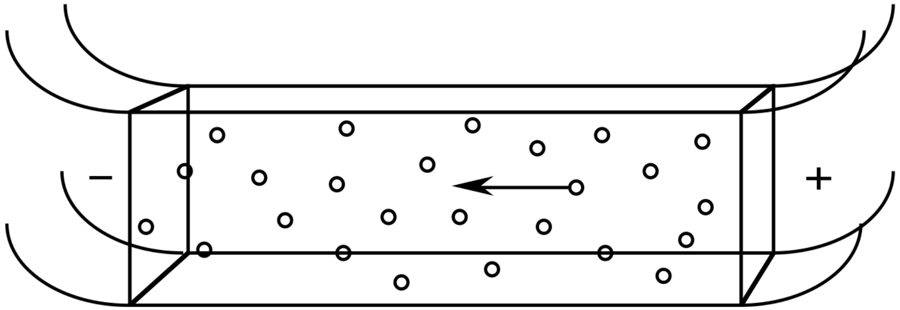
- **Potential determining ions** - ions whose concentration determines surface potential
  - Crystalline solid - lattice ions
  - Oxides - $\mathrm{H_3O^+}$, $\mathrm{OH^-}$ (pH)
- **Point of zero charge (PZC)** - pH at which $\psi_0 = 0$
  - pH < PZC: $\psi_0 > 0$
  - pH > PZC: $\psi_0 < 0$
- **Isoelectric point (IEP, pI)** - pH at which $\zeta \approx \psi_\delta = 0$
  - $u_E = 0 \Rightarrow V_p = 0$

# Darkfield illumination microscopy visualizes colloidal particles under $E$ field

- $u_E = \dfrac{V_p}{E_x} = \dfrac{\varepsilon\varepsilon_0\zeta}{\mu} \qquad (\kappa a > 200)$
  - $\boxed{\zeta = \dfrac{\mu V_p}{\varepsilon\varepsilon_0 E_x}}$
- Electrophoresis has solid particles moving when liquid is at rest ($v_x = 0$)




  - $v_x = 0$ when $y = \begin{cases} 0.205w \\ 0.795w \end{cases}$



# Laser Doppler electrophoresis determines zeta potential with more sensitivity