ME 517: Micro- and Nanoscale Processes

Lecture 30: Electrokinetics - I

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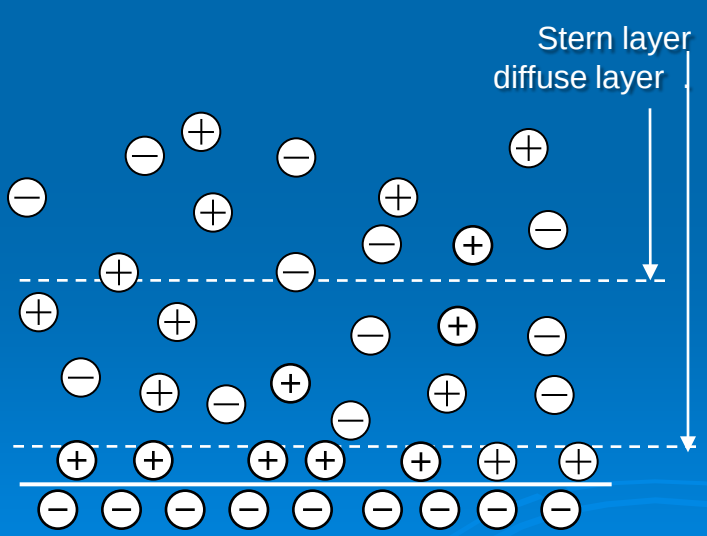
Electrokinetics

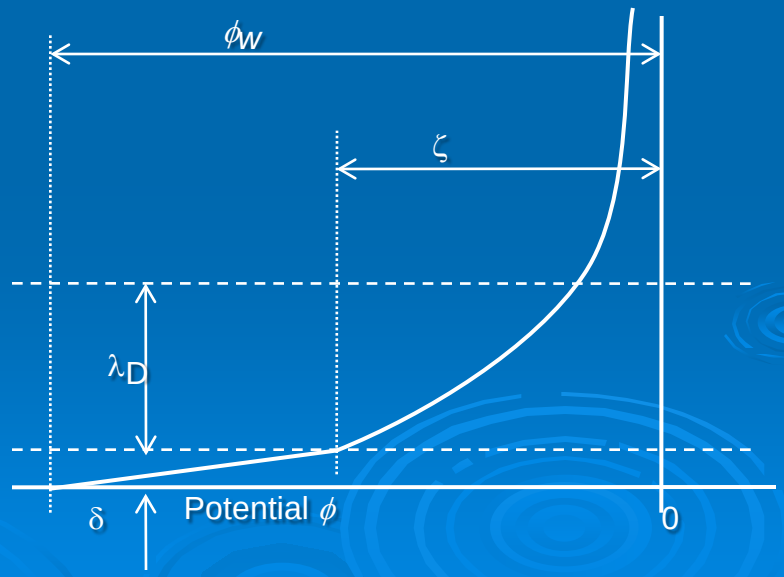
- Charged particles
  - can be manipulated with DC electric field according to Coulomb's law
  - Electrophoresis or Capillary Electrophoresis
- Uncharged particles
  - Spatially varying field
    - Dielectrophoresis
  - Uniform field, i.e. no spatial gradients
- Optically defined electrodes

Electrokinetics Basics

- Most surfaces acquire surface charge in presence of polar liquid
  - e.g. glass-water
  - many polymers and water, too
  - Debye thickness generally order of nm
  - K = 1.3805×10-23 J/K, F = 9.65 × 10^4 C mol^{-1}, z is valency of ion, c_∞ is bulk concentration, ε is permittivity (8.85418×10^{-12} F/m for vacuum)

$$\lambda_D = \sqrt{\frac{\varepsilon KT}{2z^2F^2c_\infty}}$$



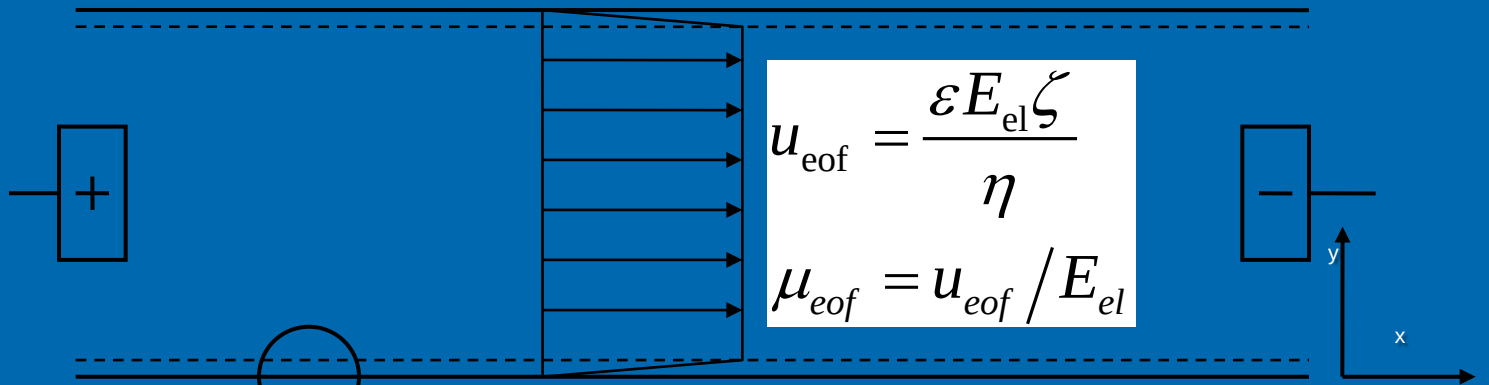


Electrokinetic Flow Classification

Name	Type of Movement	Electrokinetic Coupling
Electrophoresis	Charged surface moves relative to a stationary liquid	Use an applied electric field to induce movement
Electroosmosis	Liquid moves relative to a stationary charged surface	
Streaming Potential	Liquid moves relative to a stationary charged surface	Use movement to create and electric field
Sedimentation Potential	Charged surface moves relative to a stationary liquid	

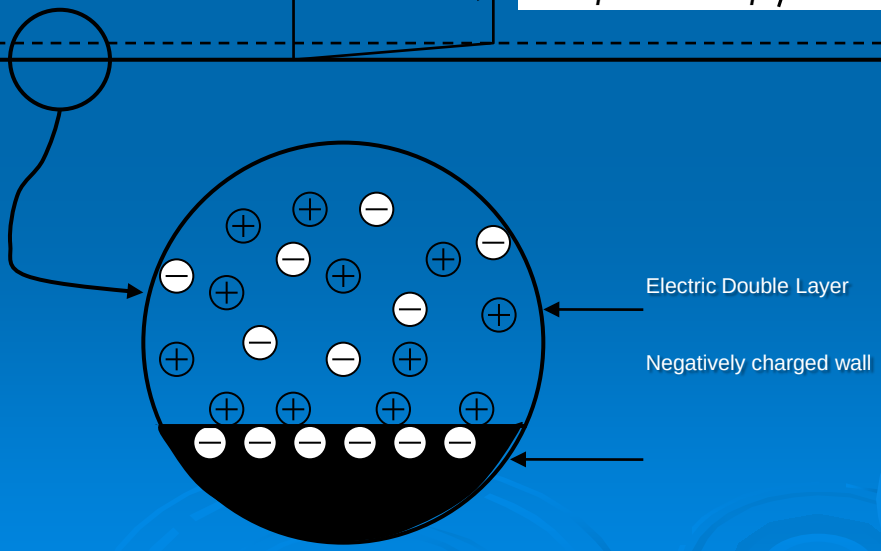
DC Electroosmosis (EOF)

- Apply electrical field across channel
- EDL drawn toward electrode pulling bulk along
- “Plug flow” if no pressure gradient



$$u_{\text{eof}} = \frac{\varepsilon E_{\text{el}} \zeta}{\eta}$$

$$\mu_{eof} = u_{eof} / E_{el}$$



DC Electroosmosis

- Backflow in the presence of pressure gradient
- Zero mean flow in closed channel