

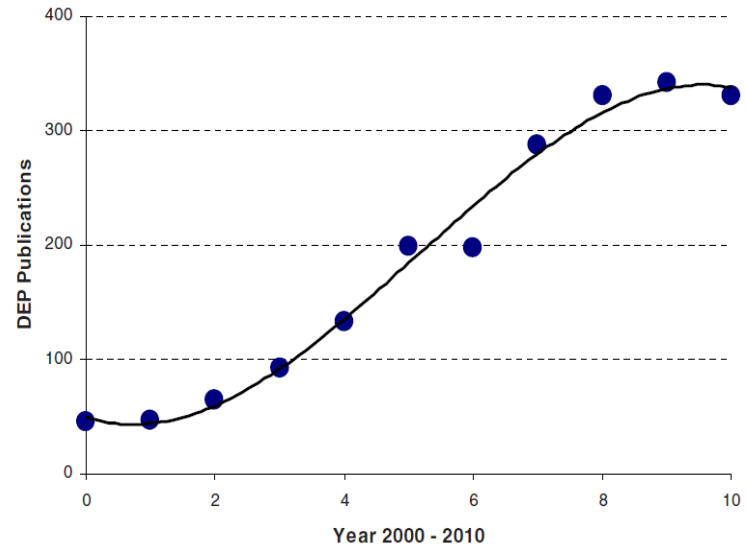
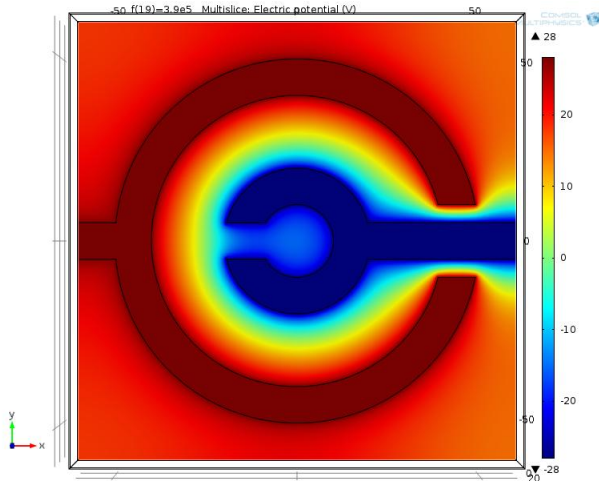
Some Commonly Neglected Issues That Affect the DEP Applications

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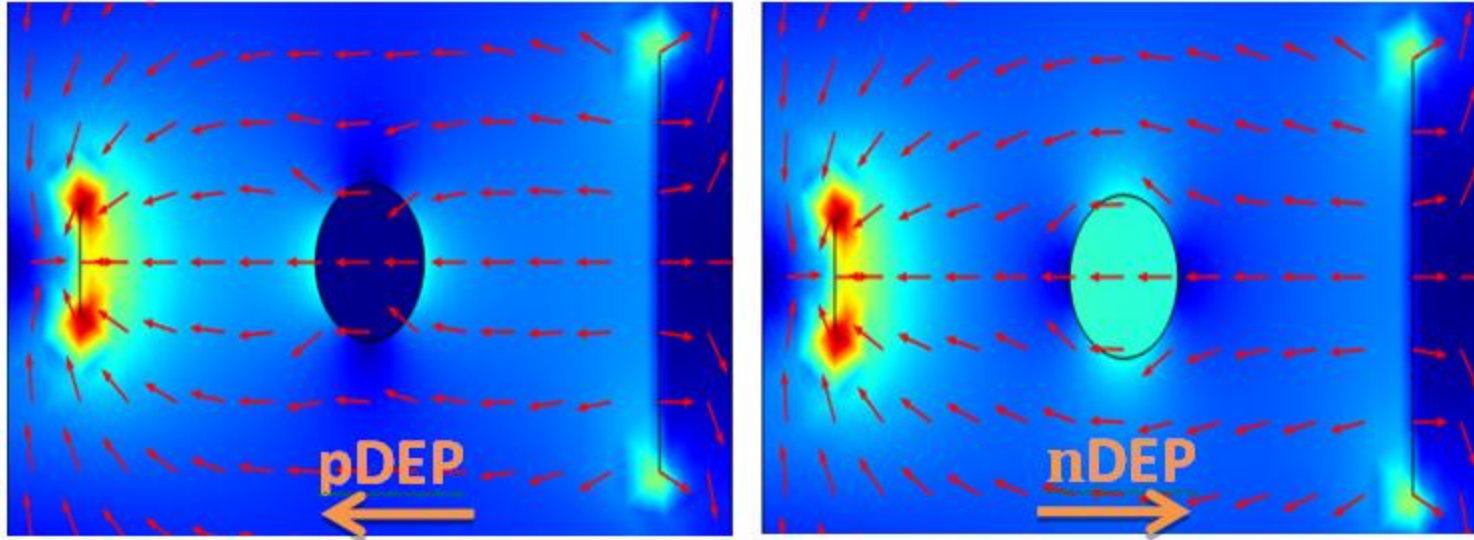
Outline

- Dielectrophoresis - Problems in literature
 - Effect of particle radius on particle conductivity
 - Double layer effect
 - Nonhomogeneous particles - shell model
- Applications of DEP



Dielectrophoresis

- Experienced by dielectric particles in a non-uniform electric field
 - Does not require particles to be charged
 - DEP occurs in both AC and DC electric fields



Research Objective

- To identify and demonstrate the consequences of some common misconceptions, discrepancies and problems in the literature in the application of DEP.

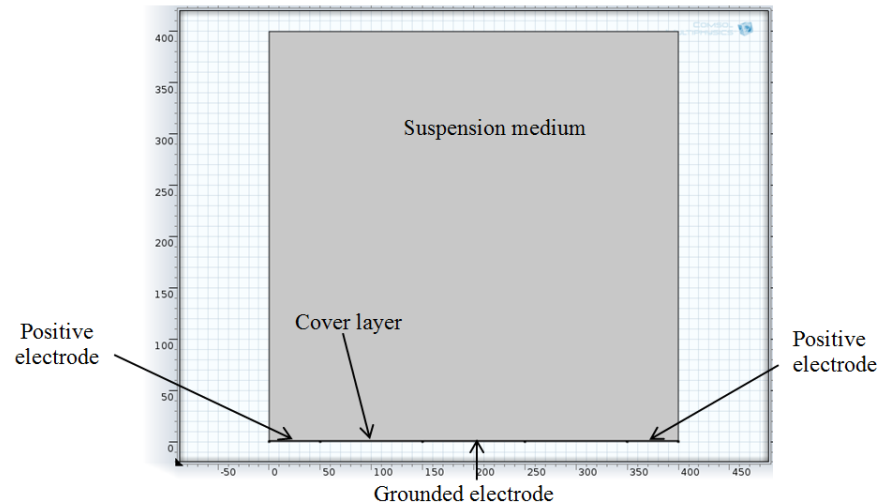
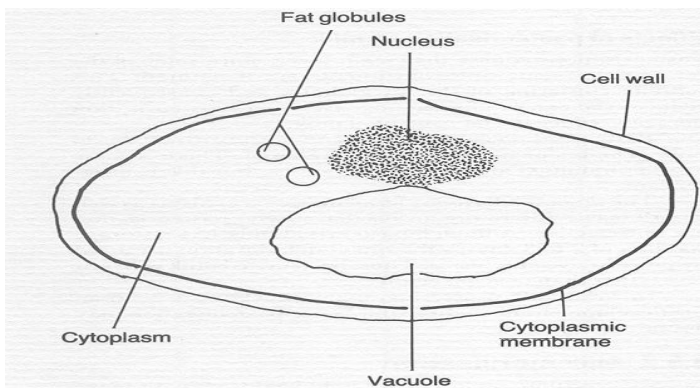
$$\pi \varepsilon_f a^3 \operatorname{Re}[f_{cm}] E \cdot \nabla E$$

$$\operatorname{Re}[f_{cm}] = \frac{\omega^2 (\varepsilon_p - \varepsilon_f) (\varepsilon_p + 2\varepsilon_f) + (\sigma_p - \sigma_f) (\sigma_p + 2\sigma_f)}{\omega^2 (\varepsilon_p + 2\varepsilon_f)^2 + (\sigma_p + 2\sigma_f)^2}$$

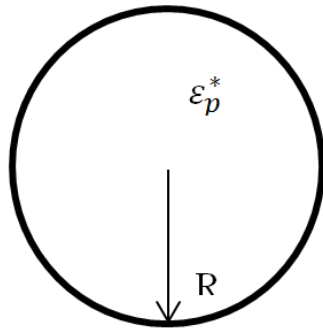
Common Problems

- Effect of particle radius on particle conductivity $\sigma_p = \sigma_b + \frac{2\lambda}{r}$
- Effect of double layer $\sigma_p = \sigma_b + \frac{2(k_s + k_d)}{r}$
- Nonhomogeneous particles (shell model)

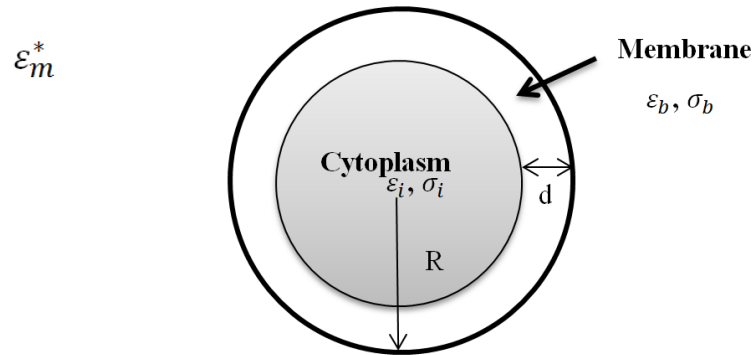
$$\varepsilon_p^* = \varepsilon_m^* \frac{2\varepsilon_m^* + \varepsilon_i^* - 2\nu(\varepsilon_m^* - \varepsilon_i^*)}{2\varepsilon_m^* + \varepsilon_i^* - \nu(\varepsilon_m^* - \varepsilon_i^*)}$$



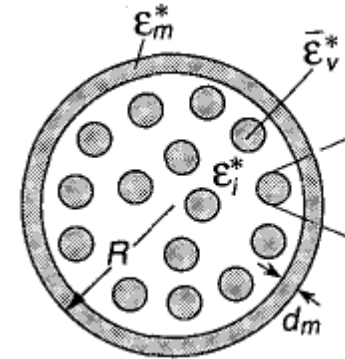
Shell Model



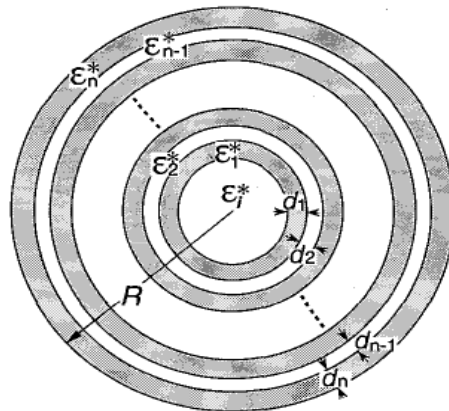
Zero shell model



Single shell model



Single shell model with vesicle inclusion

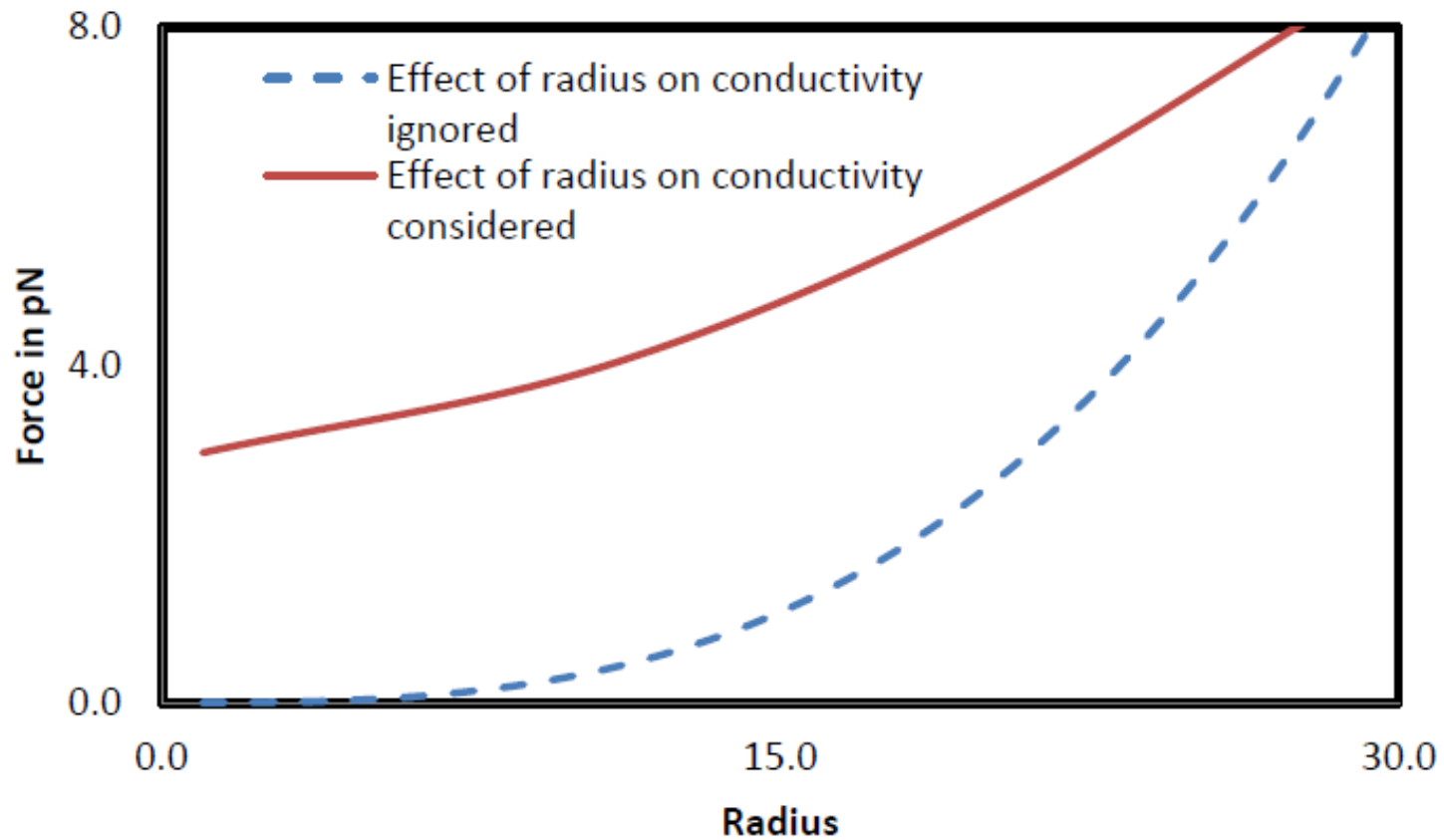


Multi-shell model

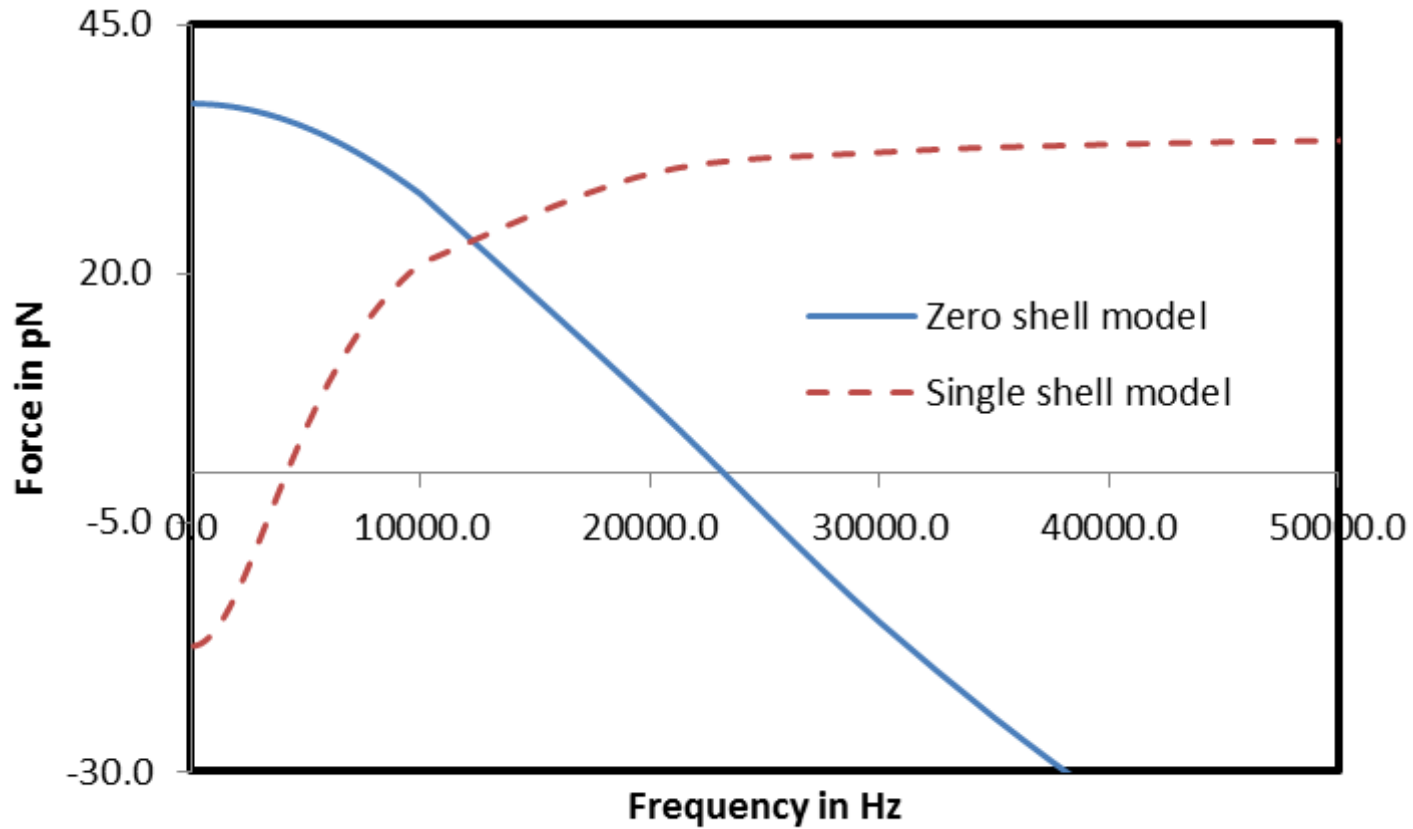
$$\epsilon_p^* = \epsilon_m^* \frac{2\epsilon_m^* + \epsilon_i^* - 2v(\epsilon_m^* - \epsilon_i^*)}{2\epsilon_m^* + \epsilon_i^* - v(\epsilon_m^* - \epsilon_i^*)}$$

$$v = \left(1 - \frac{d}{R}\right)^2$$

Size Effect

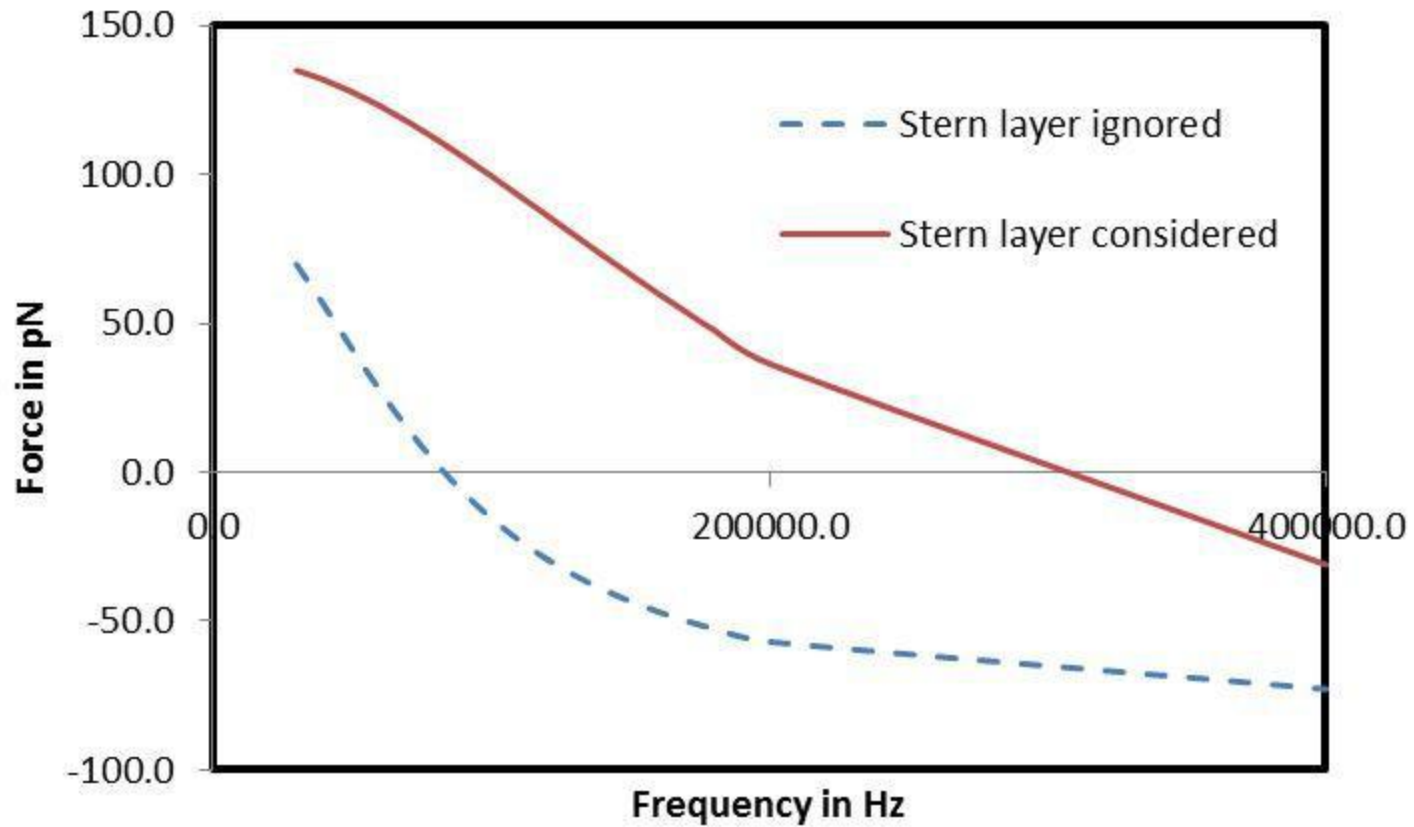


Shell Model

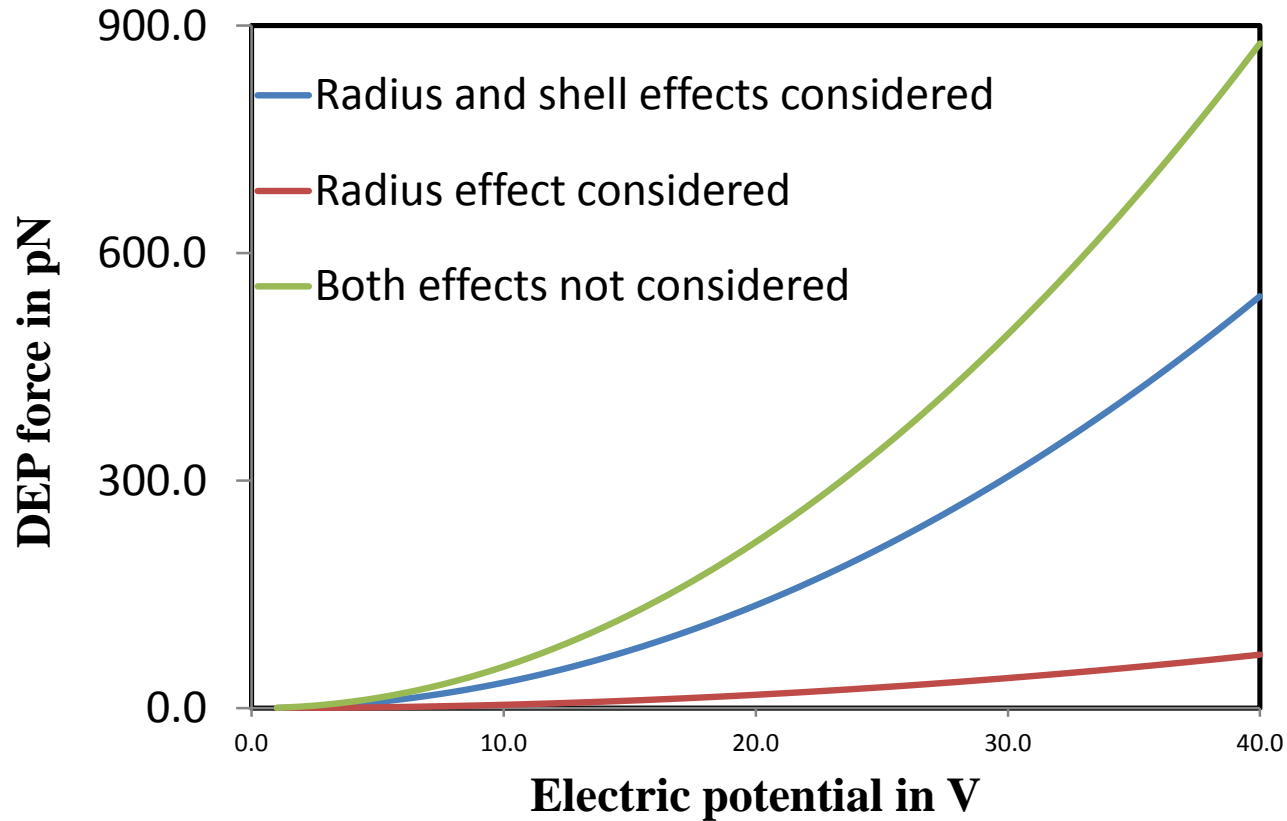


Variation of DEP force with electric potential in three different cases

Double Layer

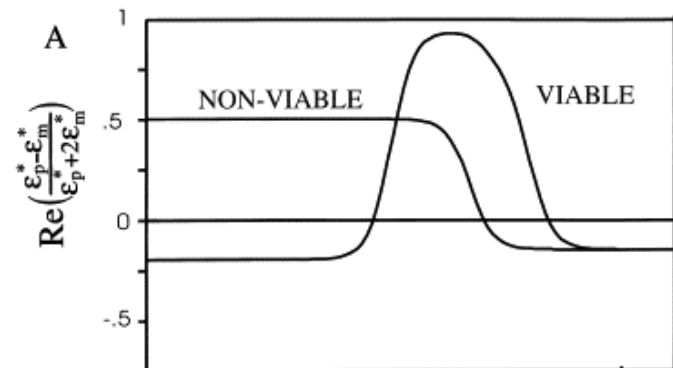
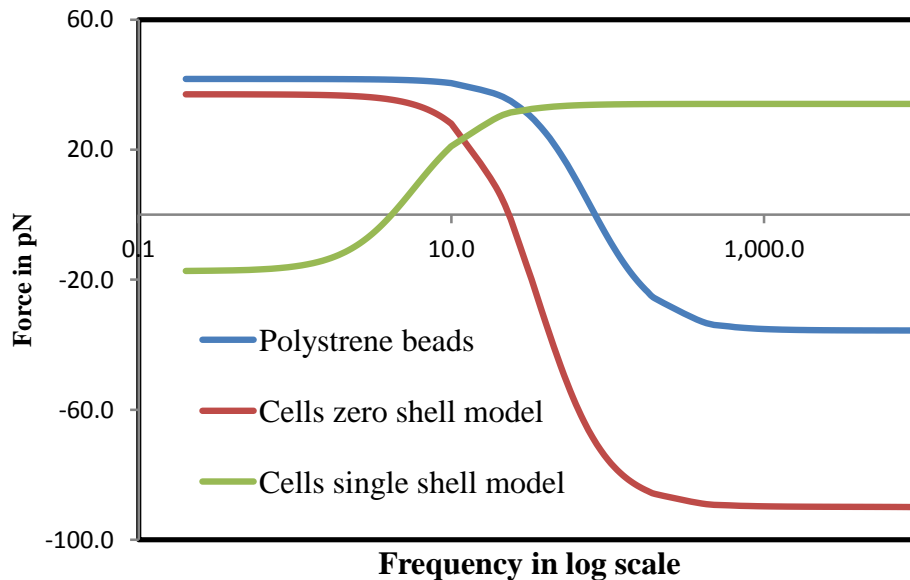


Combined Effect



Particle Properties

- Cells do not have uniform dielectric properties like synthetic particles
- Different cross-over frequency observed when shell model is ignored
- Can be used to separate cancer cell and healthy cell



Comparing the crossover frequency curve for polystyrene beads and *E.coli* cells

Summary

- Magnitude of the DEP force is found to be quite different when the radius-conductivity effects is ignored compared with when it is considered
- Ignoring the shell model for non-homogeneous particle could lead to a shift in the crossover frequency.
- It is necessary and important to correct the problems identified.

Acknowledgement

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