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Concentration Profiles in a Cylindrical Cell under Electrophoretic and Electroosmotic Forces

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Due to rising concerns with environmental issues, electroosmosis and electrokinetic techniques are currently being explored in various applications within the field of environmental engineering. Current techniques include desalination and the remediation of soil due to the necessity of non-polluted soil and safe water. Mathematical modeling approaches to electroosmosis and electrokinetic techniques, within these subjects, have been proven to be effective. Unfortunately, these current models are unique to a specific set of circumstances leaving these models without any flexibility to be an effective tool for other situations. This individualistic approach to mathematical modeling fails to allow a singular model to be applied in other fields, such as drug delivery and biomedical engineering as a whole. While still beneficial, these mathematical models do not account for the changing of multiple variables to allow them to be generally applicable. This work introduces an accurate generalized mathematical model for describing the concentration gradient of a molar species within a cylindrical channel that is undergoing electroosmotic and electrokinetic influence. This model coupled electrostatic potential in a cylindrical channel with the velocity profile to obtain accurate concentration predictions. Core to the formulation is established fluid mechanics equations, including the Poisson–Boltzmann equation, the Navier–Stokes equation, and the Molar Species continuity equation. This model also includes factors like a fluid's diffusivity, susceptibility, and electrostatic potential as variable parameters. A distinct aspect of this study is its use of area-averaging techniques to resolve the molar continuity equation. The study continues to provide analysis of the working cylindrical model and to provide highlights of certain discovered patterns within standard parameters. One of which being that if the fluid has a high susceptibility the concentration gradient becomes more uniform from the wall of the cylindrical channel to the center of it. Similar outcomes of the same type and further areas of research are discussed.