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The effect of the electrical double layer on the membrane charging process MIAO YU, HAO LIN, Rutgers University — The electrical charging process of a lipid membrane immersed in electrolytic solutions is of significance to a variety of applications including electroporation and electrodeformation. In these phenomena, the build-up of a potential difference across the membrane (the so-called transmembrane potential, or TMP) induces pore formation and membrane permeabilization (in electroporation) or deformation (in electrodeformation). The classical model treats the membrane as an equivalent capacitor-resistor system which is valid in the zero-thickness electrical double layer (EDL) limit. In this work, the effects of a finite EDL on the charging dynamics are investigated. Starting from the Nernst-Planck equations governing ionic transport, the membrane charging problem is solved in both planar and spherical geometries, and using both analytical and numerical methods. The results demonstrate that the effects of the EDL become more significant as the electrical conductivity of the electrolytic solution decreases, which is a natural consequence of an increased Debye length. The steric effect, which often arises in the limit of large zeta-potentials, is shown to be insignificant for physiological applications. The effective circuit equivalence of the EDL is calculated and validated. The results are discussed in comparison with experimental data on electroporation from the literature.

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