Forces on a pair of parallel plates in an electrolyte solution: the effects of charge regulation

Dora Izzo[1], Yan Levin[2]

[1] Instituto de Física, Universidade Federal do Rio de Janeiro,
[2] Instituto de Física, Universidade Federal do Rio Grande do Sul

We consider an example from biology: vesicles with double membranes, which we model as a pair of parallel plates in an electrolyte solution or lyotropic liquid crystals in a lamellar phase. We picture the membrane walls or the lamellar sheets as colloidal plates. The charge of the colloidal particles (plates) immersed in an electrolyte solution is not constant: it depends on the pH and on the electrolyte concentration inside the suspension[1, 2]. The process of charging the colloidal particles is denoted by charge regulation. We search for the repulsive force on each plate as charge regulation is achieved. The effective charge on the plates is obtained by integrating a Poisson-Boltzmann equation using a Runge-Kutta fourth-order algorithm combined with a Newton-Raphson root-find ing routine. The repulsive force on each plate at a given separation (gap) can be obtained using the Gouy-Chapman model of the diffuse layer and the additional electric stress local stress (in the case of plates carrying unequal charges). The dependence of the repulsive force on the gap width is obtained numerically. Of course the stability of the plates (vesicles) is guaranteed by equilibrating the electrostatic force on each plate and the surrounding suspension net hydrostatic force.

References

[1] Y. Avni, T. Markovich, R. Podgornik and D. Andelman, Soft Matter 14, 6058-6069 (2018).

[2] A. Bakhshandeh, D. Frydel and Y. Levin, Langmuir 38, 13963-13971 (2022).

Type

ORAL