

**OSMOLYTE-MODULATED DIFFERENTIAL CAPACITANCE
AND DISJOINING PRESSURE IN NANOCONFINED ELECTROLYTES**

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Electrolytes confined in nanoporous structures are heterogeneous systems in which interfacial phenomena govern electrical properties. The electric double layer (EDL) formed at the electrode–solution interface plays a central role, while nanoconfinement enhances surface interactions through EDL overlap, causing significant deviations from bulk electrolyte behavior [1].

We theoretically investigate the effect of zwitterionic osmolytes on thermodynamic properties of electrolytes confined in charged slit nanopores with conducting walls. The analysis employs a modified Poisson–Boltzmann framework accounting for finite particle size, dipolar solvent and osmolyte molecules, and field-dependent dielectric permittivity, with equilibrium states obtained via grand potential minimization [2].

Increasing osmolyte concentration restructures the EDL and increases differential capacitance due to preferential accumulation and orientation of dipolar molecules near charged surfaces, enhancing local dielectric response and interfacial charge storage. Osmolytes also increase the disjoining pressure between pore walls through reduced ionic screening and an additional osmotic contribution arising from their accumulation in nanopores, strengthening electrostatic repulsion between interfaces.

These results show that zwitterionic osmolytes enable control of interfacial processes in nanoconfined systems. The simultaneous enhancement of differential capacitance and disjoining pressure suggests improved energy storage performance and mechanical stability of nanoporous electrodes without increasing electrolyte concentration, highlighting the key role of dipolar additives in tuning EDL properties and interfacial interactions in heterogeneous nanosystems.

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