

BALANCE-OF-FORCE SELECTIVE ACCUMULATION OF TRACE IONIC SPECIES IN HIERARCHICAL SUB-NANO-/NANO-/MICRO-POROUS STRUCTURES

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Separation of species of close electrochemical mobilities (peptides, isotopes) is of interest for a number of applications. In this presentation, we will explore selective accumulation of ionic species in current-polarized hierarchical sub-nano-/nano-/micro-porous structures.

The selective accumulation of trace ions near micro-/nano-porous interfaces arises from the electric field profile created by transport of the dominant (high-concentration) salt. The dominant-salt counterions (ions with a charge opposite to the immobile charge in the nanoporous membrane) carry a larger fraction of the current in the nanoporous membrane than in the micropores due to exclusion of coions from the nanopores.

Consequently, a salt depletion zone appears next to the membrane (Fig. 1b, black curve) [1], and this depletion

gives rise to low electrical conductivity and, hence, a high local electric field (Fig. 1b, red curve). The concentration profile for trace coions is very different than that for the dominant salt and can give remarkable concentration factors that are very sensitive to the trace-coion diffusion coefficient. In Fig. 1, these trace ions (anions in this case) move to the right via electroosmosis-induced convective flow and to the left via Electro-Migration (EM). However, EM of the trace ions increases with the increasing electric field in the dominant-salt depletion region. Thus, if the coion electrical mobility is in the right range, at some position the convective and EM flux components for the trace coions are equal in magnitude and opposite in direction (**balance of forces**). Near this position trace coions accumulate (Fig. 1b, blue curve) to maintain a steady-state flux that is a combination of convection, EM, and diffusion components [2].

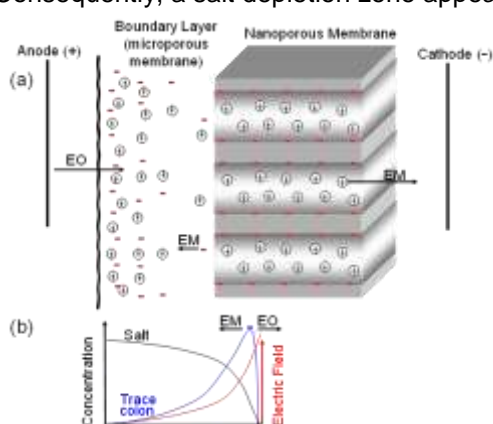


Figure 1 – Schematics of current-induced depletion of micro-/nano-interface and selective accumulation of coions

Qualitatively similar phenomena can occur in composite materials comprising an ion-exchange (sub-nanoporous) layer having scarce micro-perforations and juxtaposed with a nanoporous layer as schematically shown in Fig.2 [3]. Current-induced depletion of dominant salt occurs at the interface between non-perforated zones of ion-exchange layer and the nanoporous material. The micro-perforations allow for electroosmotic flow through the system and transport of lower-mobility coions towards the interface.

The accumulation occurs close to the latter. In such systems, the effect does not require the use of dilute dominant salts (and, consequently, very dilute trace ions) so its productivity can be higher than in systems sketched in Fig.1. However, the accumulation is less selective. The choice of system will depend on the application and its priorities.



Figure 2 – Schematics of sandwiched nanoporous and micro-perforated ion-exchange layers

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