CONDUCTIVE NANOTHICK GOLD ON HYDROPHILIC POLYMERIC NANOMEMBRANES

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Key Words: Nanomembranes, Nanopores, Surface, Functionalization, Sensing

The properties of separation membranes have been predicted and proven to be outstanding when their thickness approaches the dimensions of the molecules being separated. Ultrafast diffusion and high selectivity of such nanomembranes promise significant economic benefits by fewer and shorter processes with lower pressures. However, their widespread and industrial application is commonly impaired by poor biocompatibility and laborious, costly fabrication of currently used materials. Here we present the fabrication of self-supporting, hydrophilic, permeable nanomembranes from a thermosetting resin. A facile spin-coating procedure is employed which can be altered to yield two different kinds of porosity: (i) diffusion channels intrinsic to the covalently crosslinked resin network allowing small molecule permeation and (ii) perforations of defined geometric shape and size suitable for biomacromolecule separations. We show that the permeability of type (i) can be tuned by adjusting the resin component concentrations whereas perforations in type (ii) are introduced by a phase separation approach. Their remarkable features make nanomembranes, in particular biocompatible ones, very attractive materials for fast (bio-)sensing or functional bio-composite materials. In this respect, we furthermore show that small molecule separation nanomembranes can be rendered electrically conductive by coating with a thin gold layer whilst permeability is preserved.

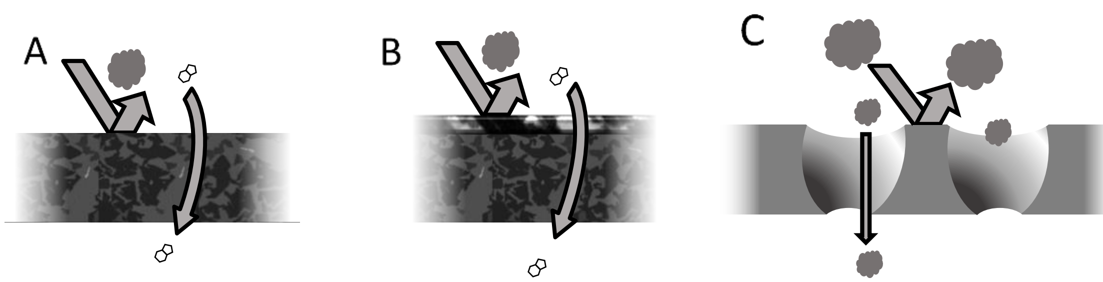

Figure 1 – Three types of nanomembranes are presented: (A) Intrinsically porous epoxy polymer network. Nanomembrane permeable for small molecules. (B) Metal covered, porous nanomembranes still permeable for small molecules and (C) Dense epoxy network with geometrically defined perforations suited for macromolecule separation.

The nanothick gold coating exhibits electrical conductivity from ~10 nm gold mass thickness onwards and this functionalization with gold is accompanied by a distinctive change in stress-strain behavior. Fast and selective separation of (macro-)molecules is assessed with a simple photometric setup where we simultaneously evidence the structural integrity by rejection of larger particles (50 – 150 nm). Nanomembranes can be freely suspended over several tens of mm² during filtration experiments and bulging tests on the cm scale reveal their outstanding mechanical features.

In conclusion, we adapted and developed procedures to fabricate hydrophilic separation nanomembranes of different sieving behavior and large lateral dimensions. Their potential use in sensing and functional materials will be facilitated by the availability of conductive surfaces and free reactive residues for functionalization.