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Pore Structure Evaluation of Carbon Nanotube and Inorganic Membranes through Sorption and Permeability Studies

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1. Introduction

Arrays and membranes consisting of carbon nanotube (CNT) pores can enable high flux molecular transport, as indicated by recent molecular dynamic models predicting that transport diffusivities of small molecules through CNT membranes are orders of magnitude higher than in zeolites or any other nanoporous material with comparable pore sizes. This high flux is attributed to the inherent smoothness of the nanotube inner surfaces that provides nearly frictionless molecular transport, as well as to single-file diffusion mechanism of hydrophilic species through the core of small-diameter CNTs. CNT arrays loaded with catalyst particles are also promising as functional reactor elements for catalyzing a variety of reactions of energy and environmental interest.

Internal nanotube configuration plays a crucial role in such applications and a detailed picture of the overall internal characteristics is critically important. Electron microscopy, although it can provide important information for the inside morphology of the structures, its in principle extremely localized nature does not allow for acquiring a representative view of the overall material. There is therefore a need for employing generic "inside-tubes" techniques in order, complementarily to electron microscopy and other on-spot methods, to provide information of the overall internal structure variations of CNTs, and possibly other ordered nanomaterials exhibiting hollow morphology and/or interparticle porosity throughout their dimensions.

2. Scope

CNT membranes were grown inside the ordered channels of anodized alumina (AAO) templates by chemical vapor deposition (CVD) [1,2], and studied by combinations of sorption and permeability techniques including n-hexane, nitrogen, and water adsorption, nitrogen permeability, and relative permeability, the later proceeding through gradual blocking of the nanotube bore space through capillary condensation of a hydrocarbon vapour

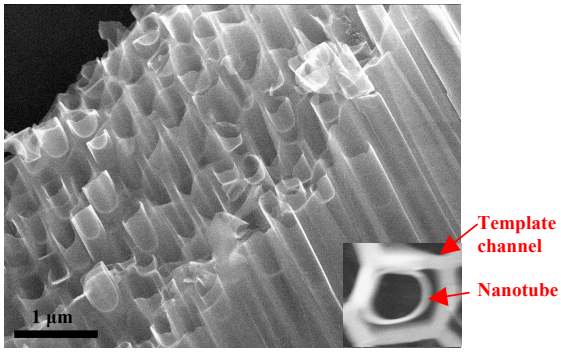

Fig. 1: Aligned CNTs by templated growth in AAO

and measurement of the permeability of a non-condensable gas through the CNTs. The presentation will discuss recent finding obtained from the above methodology concerning CNT internal structure, and expand to other inorganic membranes where interesting inside-pores diffusion phenomena have been observed, including silica membranes that were undergone cyclic CVD post-treatment by TEOS/O_3 [3], ionic liquid-loaded silica membranes [4], and AFI-type aluminophosphate ($AlPO_4$-5) membranes [5,6].

3. Conclusion

Sorption and diffusion studies through the pores of CNT and other inorganic membranes can evaluate overall pore structure and provide useful information concerning pore uniformity, internal constrictions that alter pore diameter, CNT-template adherence, and other localized morphological details of crucial importance in flow-through applications.

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