Abstract

For NAMS 2016 Annual Meeting

May 21-25, Seattle, Washington

Oral Session: Membrane Formation

Macro-porous α-Al_2O_3 support tubes for thin defect-free membranes, made by centrifugal colloidal casting

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Thin membranes are considered for applications, in water purification, gas separation and as components in thin supported fuel cells and oxygen pumps. The compositions of such membranes are typically inorganic to achieve high selectivities. For reasons of energy efficiency their thickness is preferably less than 1 μm and possibly as small as 50 nm. The membranes are made by colloidal deposition of homogeneous nano-particle dispersions on a porous support, followed by thermal consolidation. For applications that require high temperatures and pressures, the support must be fully ceramic. It is typically made by compaction and thermal consolidation of α-Al_2O_3. α-Al_2O_3 is chemically inert, hard and strong and has an excellent thermal conductivity. High quality powders to make ceramic porous α-Al_2O_3 are readily available and affordable. Since a membrane thickness of 50 nm…1 μm greatly increases the risk of defect formation, the support structure must have a surface roughness of <25 nm, and no surface defects with dimensions of >50 nm. These requirements cannot be met with state-of-the-art forming techniques for porous ceramic support structure.

Centrifugal colloidal casting (CCC) is a known ceramic forming method that we used to make supports that meet the requirements for thin membrane deposition. A purified, stable dispersion of 300 nm α-Al_2O_3 particles was introduced into a cylindrical mold. Centrifugal consolidation of homogeneous dense tubular structure took place by rotation the mold at 20,000 rpm. The structure was dried inside the mold, released and sintered to the target strength and gas permeance by heating at 950°C. By careful optimization of the dispersion formulation, the centrifuge's stability, the drying and release procedure, we have been able to make, for the first time by CCC, high quality membrane support tubes with an outer diameter of <10 mm. One first application of such tubes will be the deposition of fully selective thin dense O_2 membranes for operation at temperatures of <500°C.