Portfolio Hy Dinh

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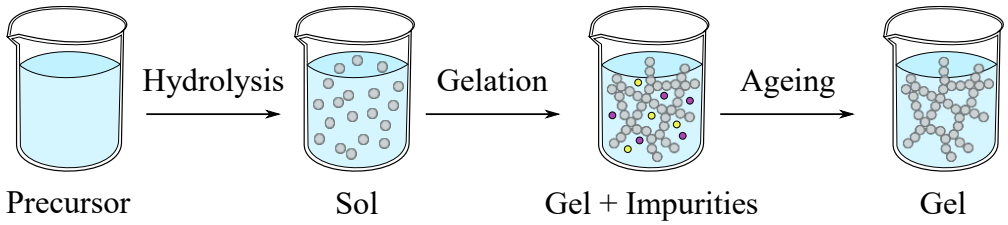
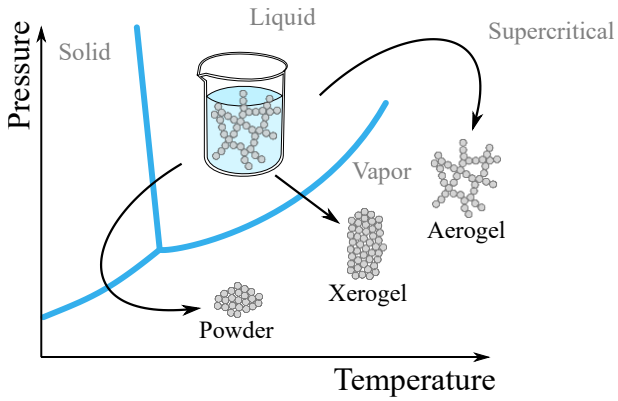
Silica Aerogel

Aerogel is a versatile class of low-density, high surface area, adjustable surface chemistry, nanoporous material attractive for a wide range of applications, including thermal insulation, light-weighting of transportation, catalyst and use as an adsorption medium in environmental remediation.

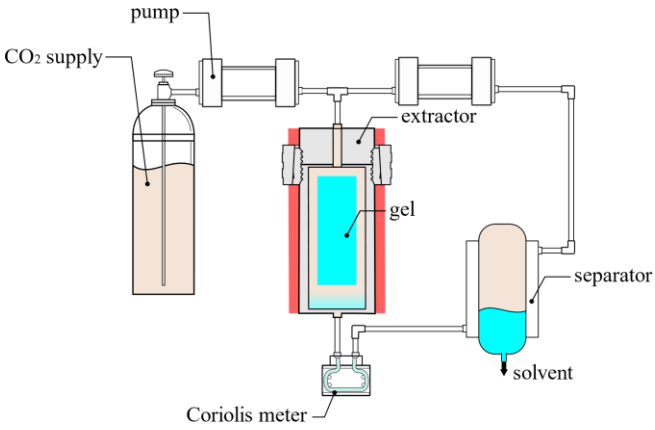


Aerogel synthesis: sol-gel method

- Gelation: React silicon alkoxide, say, with water to form solid silica skeleton with alcohol-filled pores (alcogel).
- Aging: Increase alcogel strength by soaking at elevated temperature – continued hydrolysis and condensation, Ostwalt ripening and syneresis.
- Drying: Replace pore liquid with gas without damaging the silica structure.



Aerogel drying methods



Simplified schematic of a representative SCCO2 extraction rig

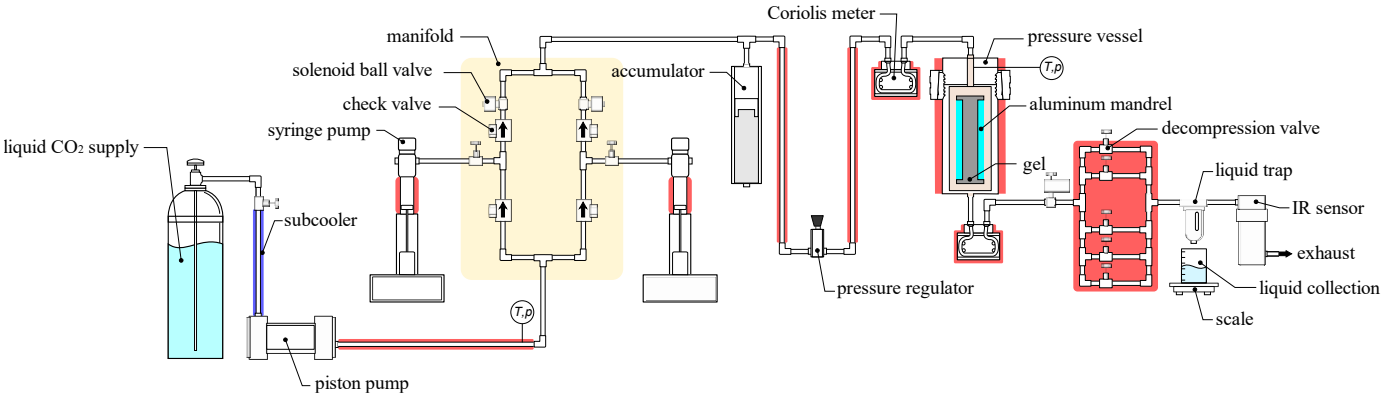
Gel mold and silica aerogels of various thicknesses

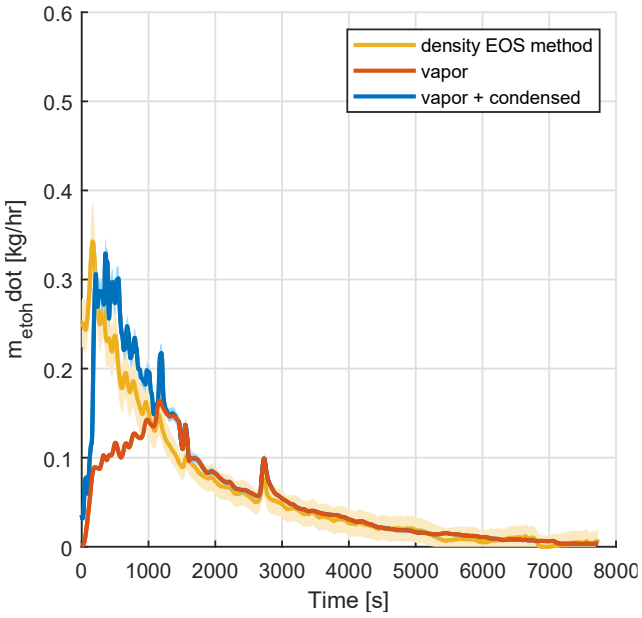
During aerogel manufacture, first, an alcogel, i.e., porous nanoskeleton filled with alcohol, is synthesized via a sol-gel process. The alcohol must be removed (i.e., the aerogel must be “dried”) without damaging its delicate porous nanoskeleton via capillary forces to convert it into an aerogel. Slow, diffusion-limited mass transfer during drying is a key barrier to aerogel’s widespread adoption. Development of cost- and energy-efficient aerogel manufacture requires an in-depth understanding of the underlying drying mechanisms.

Supercritical CO2 Drying

Designed and constructed an experimental apparatus to measure continuous rates of alcohol extraction from SCCO2 drying of aerogels using 2 independent methods:

- Total mass flow rate of (CO_2 + EtOH) effluent ($\dot{m}$) measured by downstream Coriolis meter and, after decompression, liquid-component of two-phase mixture is continuously weighed on a scale and mass fraction of EtOH in vapor measured by infrared hydrocarbon sensor.
- Measure total effluent mass flow rate and mixture density (ρ) with downstream Coriolis meter and based on known equation-of-state $\rho(m_{\mathrm{EtOH}}, T, p)$ and measured T and p, compute m_{EtOH} in effluent. Then, $\dot{m}_{\mathrm{EtOH}} = m_{\mathrm{EtOH}}\dot{m}$.





Extraction rates for 7.5 mm-thick annular gel at 4kg/h SCCO2 mass flow rate.