Towards Rigorous Measurements and Modeling of Supercritical Carbon Dioxide Drying of Aerogels

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In manufacturing silica aerogels, an alcohol solvent is often extracted from a wet gel via supercritical carbon dioxide ($SCCO_2$) drying to avoid crossing the liquid-vapor boundary and thus prevent capillary forces from collapsing the delicate mesoporous structure. This process is not fully understood due to a lack of available thermophysical properties of the working fluids and properties of silica aerogels at $SCCO_2$ conditions. A rigorous model of the drying kinetics is essential to capture its transport phenomena and further reduce the manufacturing costs. We modified an existing apparatus, described by Griffin et al. [1], to continuously measure alcohol extraction rates via an IR sensor and redundantly via density and mass flow rate measurements from a Coriolis flow meter. The studied geometry is a silica aerogel annulus surrounded by a concentric $SCCO_2$ annulus. This paper presents a three-dimensional transient numerical model and simulation of density-driven natural convection, due to variation in fluid density as its concentration changes from pure alcohol to CO_2. We solve the compressible forms of momentum, continuity and species equations governing and coupling the transport in the open region (free flow outside of the gel) and the porous region (inside the gel). We vary the gel thickness and $SCCO_2$ mass flow rate to investigate their influence on drying time.

[1] J. Griffin, D. Mills, M. Cleary, R. Nelson, V. Manno, and M. Hodes. Continuous extraction rate measurements during supercritical CO_2 drying of silica alcogel. *The Journal of Supercritical Fluids*, 94:38-47, 2014.