

44b Modeling and Optimization of Fluid-Wall Aerosol Reactors for Solar Thermochemical Hydrogen Production

Christopher Perkins, Paul Lichty, Carl Bingham, and Alan W. Weimer

Critical to the industrial feasibility of solar thermochemical hydrogen production is the construction of solar reactors that can withstand rapid temperature cycling to ultra-high temperatures (1600 °C to 2100 °C). A “fluid-wall” diffusion barrier can protect materials that have the necessary thermal resilience (e.g., graphite or SiC) from combustion with oxygen reaction products. Experimental studies with various inert gases (N₂, Ar, He) were conducted to determine the permeability of three such candidate materials (Saint-Gobain Crystar® SiC, SGL 33G and 31G porous graphite) to these gases at ultra-high temperatures. The resulting Darcy permeability functions were used in Brinkman/Navier-Stokes computational fluid dynamics models to determine the inert gas flow distribution and reactor geometry that gave minimum oxygen concentrations at the reactor walls. This model was validated experimentally with existing fluid wall solar reactors at the National Renewable Energy Laboratory, and application of these models to the design of next-generation solar aerosol reactors is discussed.