Experimental and Computational Studies in Porous Media to Assist the Global Energy Transition Strategy

Sala Torres Quevedo. Monday 25 September @ 11:30 a.m.

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Abstract: One of the most significant obstacles toward a sustainable energy transition, away from a critical reliance on fossil fuels, is the need for clean energy storage capacity. Subsurface hydrogen storage has a big role to play in that transition. Despite the large potential and need for hydrogen storage in geologic formations, limited laboratory experiments and high-fidelity simulations are available in the literature. As such, the interactions between H_2 gas and the surrounding medium remain poorly understood. Our research group at Penn State University has conducted one-of-a-kind gas invasion experiments in conjunction with X-ray microCT imaging in ultra-low permeability rock cores to improve predictability of their effective storage capacity. Results show evidence of storage capacity significantly exceeding traditional adsorption models, with varying degrees of gas densification across different rocks and gases used. We have also investigated the role of gas diffusion and sorption kinetics through numerical simulations and demonstrated that sorption and surface diffusion contribute significantly to total mass transport through nanopores. These findings lay the foundation to evaluate transport, storage capacity, and gas-rock interactions relevant to underground hydrogen storage potential, although many questions remain underexplored. For example: What are the relevant multiphase flow properties (relative permeability, capillary pressure-saturation relations) applicable to hydrogen-gas mixtures flowing in porous media?; What is the effect of markedly different thermodynamic properties of hydrogen compared to typical hydrocarbon fluids on storage performance? What is the relative contribution of advection, diffusion, and dispersion of the injected hydrogen in the heterogeneous host medium? What type of dissolution, mixing, or trapping of the hydrogen phase should be expected, and how does it impact hydrogen storage and recovery? How can this information be used to optimize design and operation? This presentation seeks to invite a collaborative approach to investigate these research questions, borrowing from a suite of experimental and numerical techniques developed for multiphase flow in porous media.