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Experimental study of the influence of chemical reactions on convective dissolution of CO_2 in aqueous solutions.

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Within the global context of climate change, carbon dioxide (CO_2) sequestration into deep saline aquifers is one of the technologies being considered in order to tackle the accumulation of anthropogenic CO_2 in the atmosphere. Upon injection of CO_2 into these porous geological formations, the less dense CO_2 rises above the aqueous phase, spreads laterally under the upper impermeable cap rock and starts to dissolve into the underlying brine. This leads to a buoyantly unstable stratification of denser CO_2-enriched brine on top of less dense brine, which can give rise to density-driven convective fingering in the fluid. This hydrodynamic instability is a favorable process for CO_2 sequestration as it accelerates the mixing of CO_2 into the aqueous phase and therefore enhances the safety of the storage in the saline aquifer (by reducing the risks of leaks of CO_2 to the atmosphere). The influence of chemical reactions and of the physico-chemical characteristics of the geological reservoir on the development of this instability is, however, still not completely understood.

In this context, we study experimentally in a laboratory-scale reactor the influence of chemical reactions on convective fingering occurring during dissolution of CO_2 in reactive aqueous solutions. Experiments are performed in Hele-Shaw cells (constructed of two vertical transparent plates separated by a thin gap) in which gaseous CO_2 at atmospheric pressure flows above aqueous solutions containing chemical reactants. Dynamics occurring within the transparent fluids are visualized by Schlieren techniques, which track dynamical changes in refractive index related to density gradients in the solutions.

We show that in some cases the convection can be enhanced by chemical reactions as they accelerate the development of the fingers, shorten their onset time and increase the number of fingers. In particular, we show that the presence of a color indicator (for instance bromocresol green) in the aqueous solution can affect the fingering dynamics. Color indicators should therefore be used with caution in this kind of study.