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Mutual benefits of storing hydrogen at the crest of CO2 or other gas storages

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We examine the benefits of storing H2 in sedimentary reservoirs jointly with another gas serving as a cushion gas, such as the CO2 in a CCS operation or the methane-rich gas of a depleted reservoir or a seasonal gas storage. When H2 occupies the crest of the reservoir, the presence of either gas is beneficial to the other. H2 reinforces the capillary-sealing efficiency of the top seal due to its more favorable interfacial properties with respect to brine and rock-forming minerals. In comparison to conventional storage where the whole column of cushion gas + working gas is made up of H2, the denser cushion (CO2 or methane) alleviates the buoyancy pressure at the top of the column, which increases H2 storage safety and capacity. The potential drawback of this storage scheme is mixing between the two gases, which can however be strongly reduced if, by an appropriate choice of well completion and placement, H2 is positioned in upper zones of the reservoir and its velocity, i.e., its injection rate, is kept below a critical value. This value is that of the incipient fingering instability of the mixing front, which is related in a simple manner to the density vs. viscosity behavior of the mixture of H2 and cushion gas. The critical velocity turns out to have large values, which stems from the strong density contrast between H2 and the cushion gas, whereas viscosities are much less contrasted : as a consequence, dispersive mixing is in practice the dominant cause of front spreading. The mutual benefits outlined in this study are the strongest when the cushion is made up of dense CO2, which suggests that the crest of offshore CO2 storage reservoirs are good candidates for H2 storage.

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