A Strategy for Underground Hydrogen Containment based on Time-Dependent Yield Stress Materials

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A brief Summary

Current and emerging approaches to subsurface storage suffer from geographical limitations and in some cases insufficient seal integrity or lateral containment.

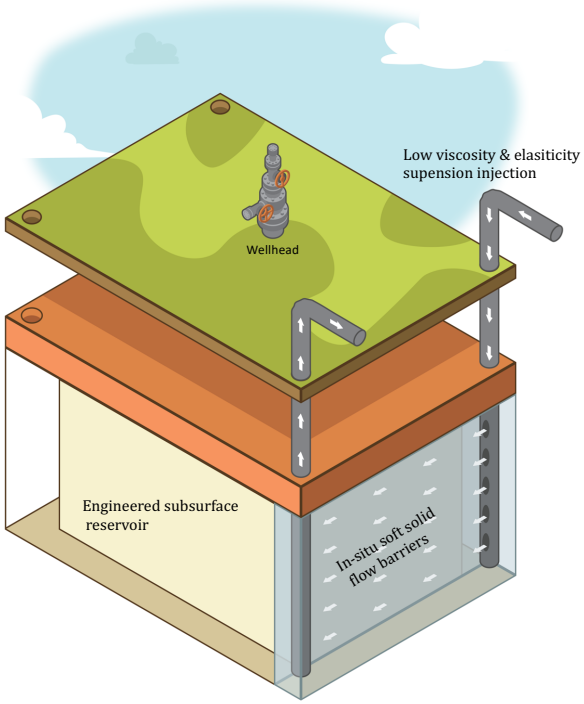
We propose an innovative containment strategy based on time-dependent yield stress materials, namely Smectite clay suspensions, to address these challenges and make subsurface storage reliable and geographically agnostic.

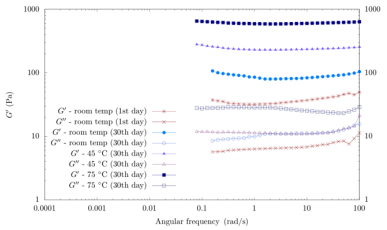
We outline a containment strategy designed to reinforce natural subsurface seals and engineer flow barriers.

As a high-risk, high-reward approach, suspension can be injected at its initial low viscosity and elasticity into a porous medium, allowing for easy pumping and targeted delivery, once inside the target zone, it matures into a soft solid with much higher viscosity and elasticity, acting as a flow barrier.

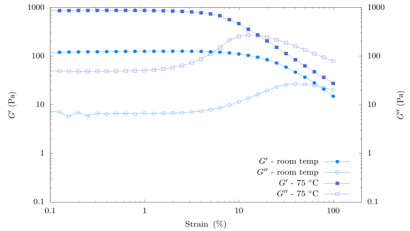
We introduce and discuss the exceptional properties of this Smectite suspensions that we believe can revolutionize subsurface containment and storage to move in tandem with the energy transition.

There are no adverse effects from higher temperatures on its long-term stability, unlike most polymer aqueous dispersions used in the industry. Moreover, its thixotropic microstructure offers many advantages in operations, such as handling sudden pump shutdowns.

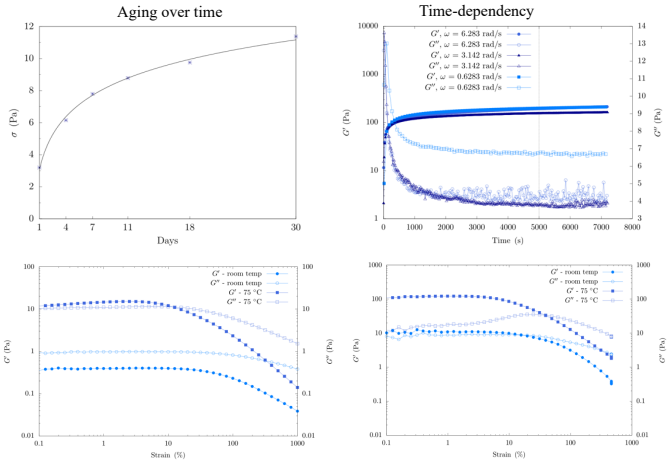




Soft solid with long-term stability



Soft solid with high elasticity



Aging over time & under high temperatures – 1st & 4th day after preparation of suspension

Final remarks

Our proposed strategy complements existing solutions, such as salt caverns and depleted reservoirs, particularly when they are constrained by size and seal integrity, making previously unsuitable geologic structures viable for geologic storage.

References

Abedi, B., Mendes, R., & de Souza Mendes, P. R. (2019). Startup flow of yield-stress non-thixotropic and thixotropic materials in a tube. *Journal of Petroleum Science and Engineering*, *174*, 437-445.

Abedi, B., Marín Castaño, E. P., C. Rodrigues, E., Thompson, R. L., & de Souza Mendes, P. R. (2023). Obtaining test-independent values of the dynamic and static yield stresses for time-dependent materials. *Rheologica Acta*, 1-21.

Abedi, B., Orujov, A., & Aryana, S. (2023). Containment strategy for subsurface H_2 and CO_2 storage based on time-dependent soft solids. *Energy* (*Under review*).

Acknowledgments

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