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Geometric confinement stabilizes fluid invasion during imbibition in microfluidic porous media

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We establish a comprehensive description of the invading patterns formed when a wetting liquid displaces a non-wetting fluid in various porous mediums with geometric confinement variation. Building on model microfluidic experiments, we evidence imbibition scenarios yielding different imbibition stability and macroscopic morphologies controlled by geometric confinements and the capillary number. We report a phenomenon whereby no or weak depth variation of microfluidic porous media but with the strong geometric confinement suppresses flow instability during immiscible imbibition, that seemingly ignored or contradicts conventional expectations. Theoretical analytical models and pore-scale numerical simulations were combined for characteristics of imbibition front and final displacement result as a function of geometric confinements. We get a complete dynamic view of the imbibition process over a full range of regimes from the unstable patterns dominated by the snap-off or by-pass phenomenon to the stable state dominated by the cooperative pore filling. The study provides new insights into the role of geometric confinements in suppressing unwanted invasion instabilities in porous media. The finding provides design or prediction principles for engineered porous media, such as rock, exchange columns, fabric, membranes, and microfluidic devices concerning their desired immiscible imbibition behavior.

Participation

In-Person

References

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Energy Transition Focused Abstracts

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