Viscous fingering instability triggered by a pH chemical reaction

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A pH-changing chemical reaction is used to induce changes in a pH-sensitive polymer and induce a fingering instability in a liquid system otherwise stable. The formaldehyde-sulfite (FS) reaction is an example of a complex chemical reaction where pH varies according to the reaction parameters. On the other hand, poly(acrylic acid) is an organic polymer which exhibit large viscosity changes in aqueous solutions when the pH increases from acidic to basic. Results on the coupling between the FS reaction and the poly(acrylic acid) show that it is possible to obtain changes in both pH and viscosity that are strongly modulated by the reaction kinetics. We exhaustively analyzed the influence of the involved species by using rheological techniques and optimized the reaction initial conditions in order to maximize the differences between the initial and final pH/viscosity values [1].

Once obtained suitable conditions, we adapted the described system in order to study the occurrence of fingering instability driven by the chemistry in a radial Hele-Shaw cell experimental arrangement. The reaction reagents were separated into two independent solutions with different viscosities that only react where in contact. However, even if the liquids were injected in an initially stable configuration, fingering instability was obtained due to changes in the pH that strongly modified the local viscosity. At the interface the FS reaction occurs increasing the viscosity. The instability was also characterized and numerically modeled. Both experimental and numerical results show a very good agreement [2].

[1] D. M. Escala, A. P. Muñuzuri, A. De Wit, and J. Carballido-Landeira, Temporal viscosity modulations driven by a pH sensitive polymer coupled to a pH-shifting chemical reaction, Phys. Chem. Chem. Phys. **19**, 11914-11919 (2017).

[2] D. M. Escala, J. Carballido-Landeira, A. De Wit, and A. P. Muñuzuri, pH induced viscous fingering instability, (in preparation).