Active Viscous Fingering

Harold Auradou*[1], Akash Ganesh[1], and Carine Douarche[1]

[1]Fluides, automatique, systèmes thermiques – Université Paris-Saclay, Centre National de la Recherche Scientifique, Centre National de la Recherche Scientifique : UMR7608 – France

Résumé

Adding swimming bacteria to a liquid lowers its viscosity (1, 2, 3, 4, 5). We study how this phenomenon can lead to the formation of viscous Saffman–Taylor fingers which occurs when a less viscous fluid is injected into a more viscous fluid (6). To do this, we injected bacterial suspensions into a HeleShaw cell containing the suspending fluid to prove that active fluids can induce this instability. The role of the flow velocity, and bacterial volume fraction was then systematically studied. The Saffman-Taylor fingers (See Fig. 1(a,b,c) observed are identical to those obtained with a pair of Newtonian fluids with different viscosities (See Fig. 1(e)). Quater five spots experiments were also performed (See Fig. 1(f,g,h)). They demonstrate that the addition of bacteria in the suspension reduces the breakthrough time. These results reproduce what is observed with pairs of Newtonian fluids of different viscosities. Our study determines the flow conditions and the bacterial volume fraction to observe the SaffmanTaylor instability from an active fluid. For For run-and-tumble E.Coli bacteria, it requires a flow characterized by a low shear rate ($<$ 1s –1) and a suspension of volume fraction ($\Phi >$ 0.8%) greater than the volume fraction for which the zero viscosity regime is observed. In the conclusion, we will examine the implications of this new instability for flow applications in porous media.

*Intervenant