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The Saffman-Taylor Instability Without Walls SANDRA TROIAN, California Institute of Technology, 1200 E California Blvd, MC 128-95, Pasadena, CA 91125, STEFFEN BERG, Shell International BV, Rijswijk, Netherlands — The Saffman-Taylor problem represents the unstable displacement of a more viscous fluid by a less viscous fluid under the action of an external pressure gradient. Small sinusoidal deformation of the separation front gives way to repeated fingering and tip-splitting. This repetitive process causes the transformation of an initially featureless front to a highly ramified curve whose fractal dimension is roughly 1.7. This instability requires that the fluids be confined by two substrates, such as in a Hele-Shaw cell, in order to enforce the pressure gradient which drives the flow. In this talk we describe experiments in which this instability is observed for the first time in nanofilms freely suspended in air for which there are no confining walls. The nanofilms consist of an aqueous surfactant solution containing hydrosoluble polymer. The fractal dimension D_F ranges from $1 < D_F < 2$ and increases with the viscosity of the bulk solution. The expanding front appears to delineate between a surfactant-rich mobile phase and a polymer-rich less mobile phase. We describe a phenomenological model for linearly unstable flow in which the mobility contrast incorporates both modulation in film thickness from disjoining pressure variation as well as the viscosity contrast from phase segregation. This extension generalizes our understanding of this well known phenomenon.

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