CAPILLARY IMBIBITION IN A DIVERGING FLEXIBLE CHANNEL

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ABSTRACT

We study the imbibition of a wetting liquid between flexible sheets that are fixed on both ends. Assuming a narrow gap between the sheets, we solve the lubrication equation coupled with slender body deformation. When the sheets are parallel, we find that the deformation speeds up the flow, as shown in previous studies, but only up to the middle of the channel. The channel then contracts, increases the hydrodynamic resistance and slows down the filling process. Below a threshold stiffness, the sheets collapse and imbibition stops. We propose a scaling of the filling duration near this threshold. Next we show that if the sheets are initially tilted with a minimal angle, the channel avoids collapse. The liquid front pulls the diverging sheets and spreads in nearly parallel portions, which maintains the capillary propulsion and enhances the wicking. Therefore, while it is established that diverging rigid plates imbibe liquids slower than parallel ones, we show that elasticity reverses this principle: diverging flexible sheets imbibe liquids faster than parallel ones. We find an optimal tilt angle that gives the shortest filling time.