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Perpendicular Separations of a Binary Mixture Under Van Der Waals Confinement

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ABSTRACT

The phase separation of confined polymeric mixtures plays a critical role in the design of advanced materials and nanoscale devices. Over the past decades, extensive studies have highlighted the interplay of wetting dynamics, hydrodynamics, and interfacial forces in governing phase separation under confinement. In this work [1], we employ molecular dynamics simulations to investigate the dynamics of a binary mixture confined by van der Waals (vdW) walls, revealing a novel phenomenon termed Perpendicular Separation of Two Phases (PSTP). In the initial stage, water molecules residing in the central region rapidly diffuse and condense symmetrically along the mid-plane of the confinement, forming a unique liquid interface. Subsequently, as water droplets nucleate and grow, the resin phase undergoes a perpendicular separation, transforming into two distinct films that flank a newly formed hollow nanochannel. Our analysis indicates that the resin concentration in the mid-region decays following a power-law behavior, $C(t,T) \propto a(T)\, t^{1/3}$, highlighting the time-dependent evolution of the phase separation. We propose that dynamic "soft pillars" emerging in the system provide stabilization against Rayleigh-like instabilities. Furthermore, our study provides insights into tuning interfacial dynamics and confinement parameters to design robust and tunable nanostructured devices. These findings hold promising implications for the fabrication of nanofilms and organic nanochannels, with potential applications in bio-detection and energy conversion.

KEYWORDS

Confined binary liquids; phase separation; temporal power; soft pillars; nano-films

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References

1. Lin, K. (2025). Perpendicular phase separation in confined binary liquids: Unveiling novel kinetics and stabilization mechanisms for nanofilms. *Nano Letters, 25(1)*, 470–475.