A novel strategy to fabricate polymer membranes: superspreading on immersed gel surfaces

Gels are a kind of soft materials that are composed of three-dimensional (3D) crosslinked polymer network and entrapped liquid phase. Unlike solid surfaces, liquid phase entrapped in the gels can be up to 95 wt %. Accordingly, gels can be considered a quasi-liquid phase, while behaving like a solid.

Conventional industrial polymer film preparation is mainly based on casting, inflation and stretching. These strategies are usually energy consuming, narrowly applied and difficult to prepare. To complete liquid spreading, the key question is how to conquer the pinning effect of three-phase contact line (TCL) to form a liquid layer. To realize the superspreading of liquid on the surface of solids, engineered surface topographies or introduced external contaminants such as surfactants have been utilized. In these strategies, however, the pinning effect of three-phase contact line (TCL) was inevitable.

Recently, Professor Mingjie Liu from the School of Chemistry and Environmental Science of Beihang University took advantage of the soft properties of the gel material, and realized the superspreading of liquid on the gel surfaces, thus developing a universal method to fabricate functional polymer membranes (Fig 1). Professor Liu managed to apply the phenomenon under the immiscible liquid. The miscible polymer solution can conquer the pinning effect of three-phase contact line.

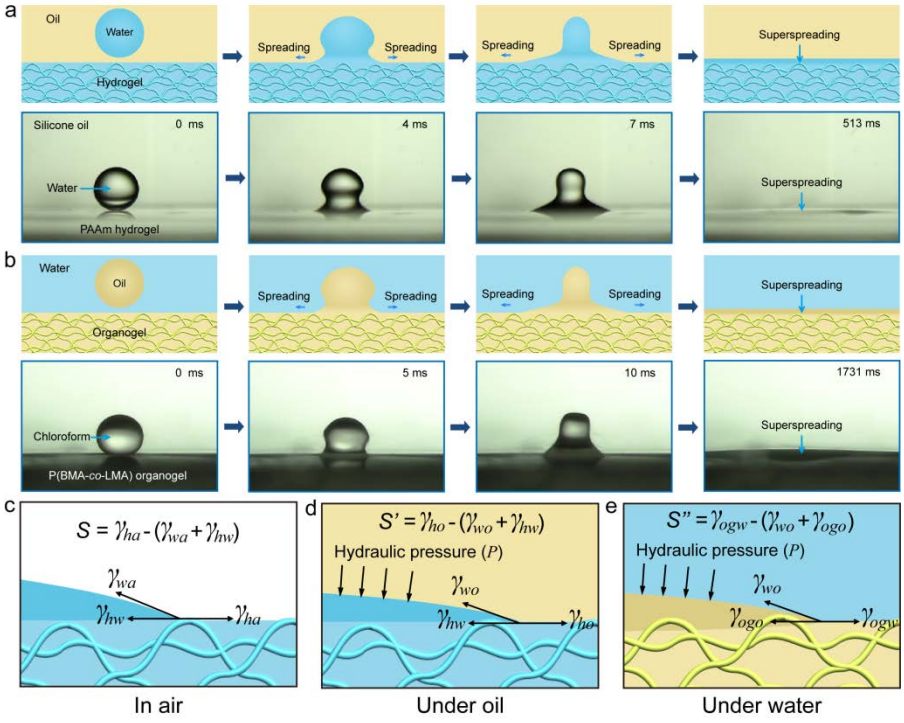

Fig 1. Spontaneous liquid superspreading on gel surfaces in a liquid/liquid/gel tri-phase system. a) Illustration and images of the superspreading processes of a water droplet on hydrogel surfaces. b) Illustration and images of the superspreading processes of a chloroform droplet rapidly and completely spreading and forming an oil layer on organogel surface. Illustrations of the spreading coefficient S of liquid droplets spreading on gels. c) in air, d) under oil, and e) under water.

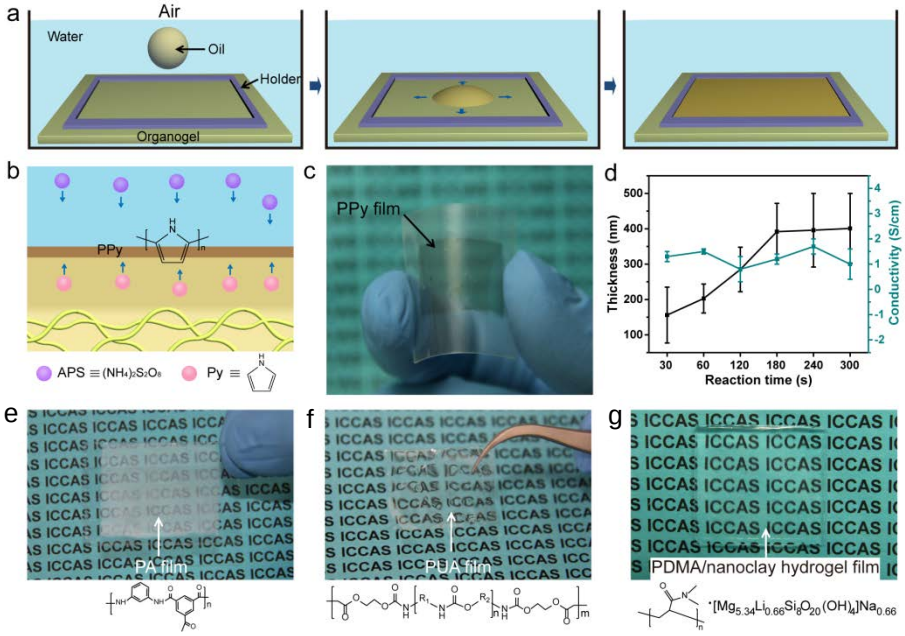

Fig 2. Thin polymer films synthesized by confined liquid layers on gel surfaces in a liquid/liquid/gel system.

It is worth noting that the superspreading of highly viscous liquids can even be realized using this strategy. Furthermore, by introducing the reactants into the superspreading layers of liquids, we can fabricate various functional films such as conductive polymer films, reversed membranes and Janus membranes through one-step polymerization (Fig 2). Compared with traditional methods, this strategy is easy to fabricate polymer films with controlled thicknesses (nm- to mm-scale).

The special wettability space between the gel and the immiscible not only enhanced the superspreading of the polymer solution on the surfaces of the gels, but also induced different configurations of the polymer chains. Professor Mingjie Liu`s team fabricated the asymmetric porous PAA-g-PVDF membranes bewteen the interface of hydrogel and its immiscible silicone oil phase. During the polymerization process, the hydrophobic silicone oil above and the hydrophilic hydrogel below the thin solution layer may induce different configurations of the polymer chains, thus leading to opposite wettability on two sides of the membranes.

The synergistic effect of asymmetric micro/ nanoporous structures and asymmetric wettability endow the asymmetric PAA-g-PVDF membranes with anisotropic critical water breakthrough pressure, leading to the efficient water flow gating ability.

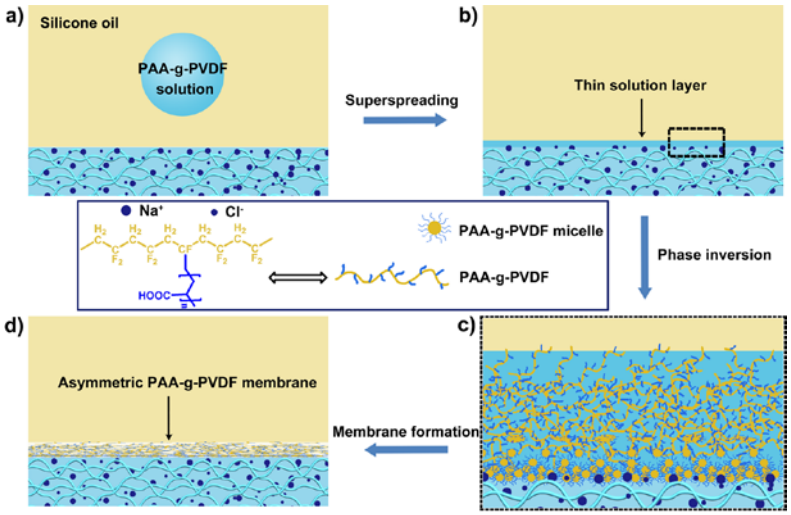

Fig 3. Schematic of the fabrication of asymmetric PAA-g-PVDF membranes by an interfacial confined phase inversion process on immersed PAAm hydrogel surface.

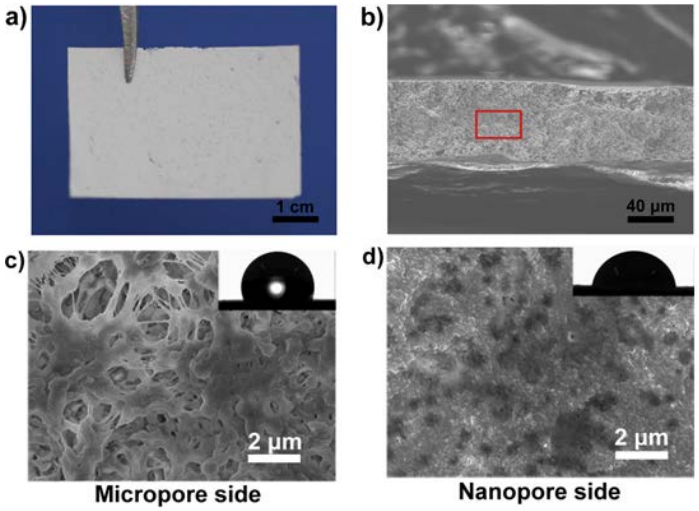

Fig 4. Asymmetric porous structures and wettability of the as-prepared PAA-g-PVDF membranes. a) Photograph of the asymmetric PAA-g-PVDF membrane. SEM images of b) cross section and c) its Micropore side and d) nanopore side of the PAA-g-PVDF membrane. The water CA of the micropore side and nanopores side are 107.2 ± 4.5° (inset of c)and 77.1 ± 2.3°(inset of d), respectively.

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References

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[2] **C. Q. Zhao,** P. C. Zhang, Z. D. Gu, L. Chen, H. Yi, Z.Y. Cao, J. Jin, M. J. Liu and L. Jiang. **Advanced Materials Interfaces**, **(2016)**. DOI: 10.1002/admi.201600615.