On-Water Surface Synthesis of Two-Dimensional Polymer Membranes toward Effective Ion Transport

Zhiyong Wang, Xinliang Feng
[a]Max Planck Institute for Microstructure Physics, Halle (Saale), Germany
[b]Center for Advancing Electronics Dresden (cfaed) & Faculty of Chemistry and Food Chemistry, Technische Universität Dresden, Germany
wang.zhiyong@tu-dresden.de

Synthetic two-dimensional polymers (2DPs) are an emerging class of structurally-defined crystalline materials that comprise covalent networks with topologically planar repeat units. Yet, synthesizing 2DP single crystals via irreversible reactions remains challenging. Herein, utilizing the surfactant-monolayer-assisted interfacial synthesis (SMAIS) method, few-layer, large-area, skeleton-charged 2DP (C2DP) single crystals were successfully synthesized through irreversible Katritzky reaction, under pH control. The resultant periodically ordered 2DPs comprise aromatic pyridinium cations and counter BF_4^- anions. The representative C2DP-Por crystals display a tunable thickness of 2-30 nm and a lateral size of up to 120 μm^2. Using imaging and diffraction methods, a highly uniform square-patterned structure with the in-plane lattice of a = b = 30.5 Å was resolved with near-atomic precision. Significantly, the C2DP-Por crystals with cationic polymer skeleton and columnar-like pore arrays offer a high chloride ion selectivity with a coefficient up to 0.9, thus ensuring the integration as the anion-selective membrane for the osmotic energy generation. In addition, as the graphite electrode skin, we demonstrate that C2DP enables to prevent the cation/solvent co-intercalation into the graphite electrode and suppress the consequent structure collapse, leading to enhanced durability of Li battery. Our studies reveal a route to synthesize 2DP single crystals using a kinetically controlled irreversible reaction and will propel the development of membrane-based energy-conversion and storage technologies.

References

[1] Wang, Z.; Zhang, Z.; Qi, H.; Ortega-Guerrero, A.; Wang, L.; Xu, K.; Wang, M.; Park, S.; Hennersdorf, F.; Dianat, A.; Croy, A.; Komber, H.; Cuniberti, G.; Weigand, J. J.; Kaiser, U.; Dong, R.; Feng, X., Nat. Synth. 1 (2022), 69-76.

[2] Wang, Z.; Jia, X.; Zhang, P.; Liu, Y.; Qi, H.; Zhang, P.; Kaiser, U.; Reineke, S.; Dong, R.; Feng, X., Adv. Mater. 34 (2022) 2106073.

[3] Sabaghi, D.; Wang, Z.; Bhauriyal, P.; Lu, Q.; Morag, A.; Mikhailovia, D.; Hashemi, P.; Li, D.; Neumann, C.; Liao, Z.; Dominic, A. M.; Nia, A. S.; Dong, R.; Zschech, E.; Turchanin, A.; Heine, T.; Yu, M.; Feng, X., Ultrathin positively charged electrode skin for durable anion-intercalation battery chemistries. Nat. Commun. 14 (2023) 760.

Figures

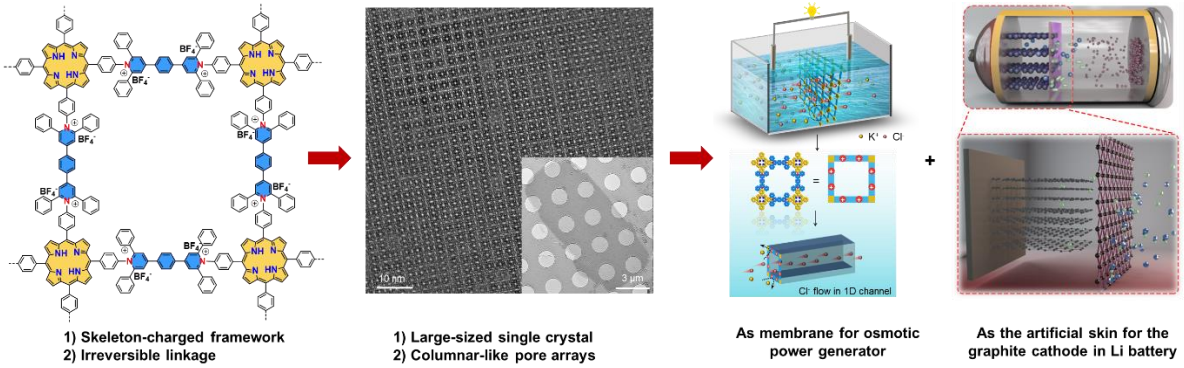

Figure 1: On-water surface synthesis of charged 2DP single crystal as the membrane for osmotic power generation, and electrode skin for Li battery.