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Lithium extraction from seawater

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Introduction:

Within today's world, lithium has become as one of the most significant elements, especially with the growing global demand for batteries and electric vehicles. However, the limited supply of lithium resources may become an issue with the rapid growth of lithium consumption. Seawater contains around 230 billion tons of lithium, nearly 5,000 times more than land-based reserves, but at low concentrations (~0.2 ppm) and significant amounts of competing ions. Our research develops covalent organic frameworks (COFs), which are highly porous and tunable materials, to selectively adsorb lithium ions from challenging water sources such as seawater and oilfield brine.

Objectives:

- Develop COFs for efficient lithium extraction from seawater.
- Compare the performance of TpPa-COF and TpPa-SO3H in lithium uptake.
- Enhance selectivity and capacity for lithium over other ions.

Methodology:

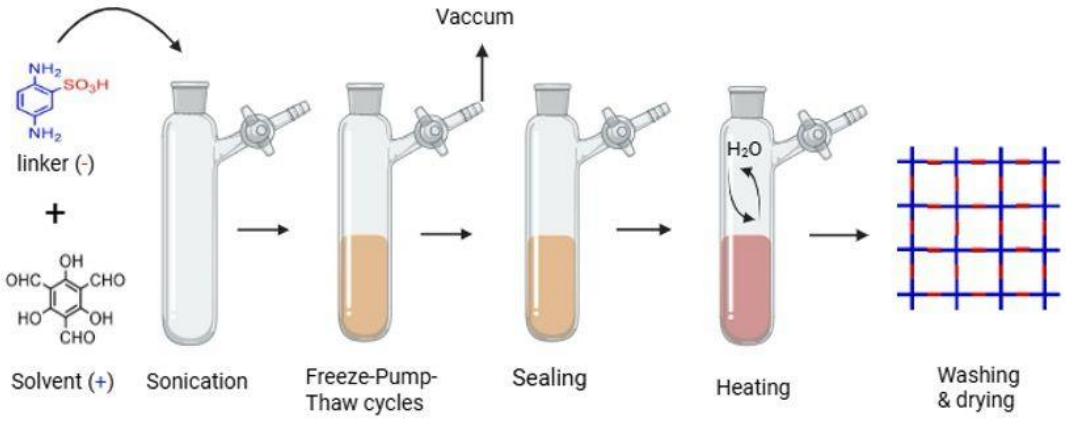


Fig.1 Synthesis of COFs

Results:

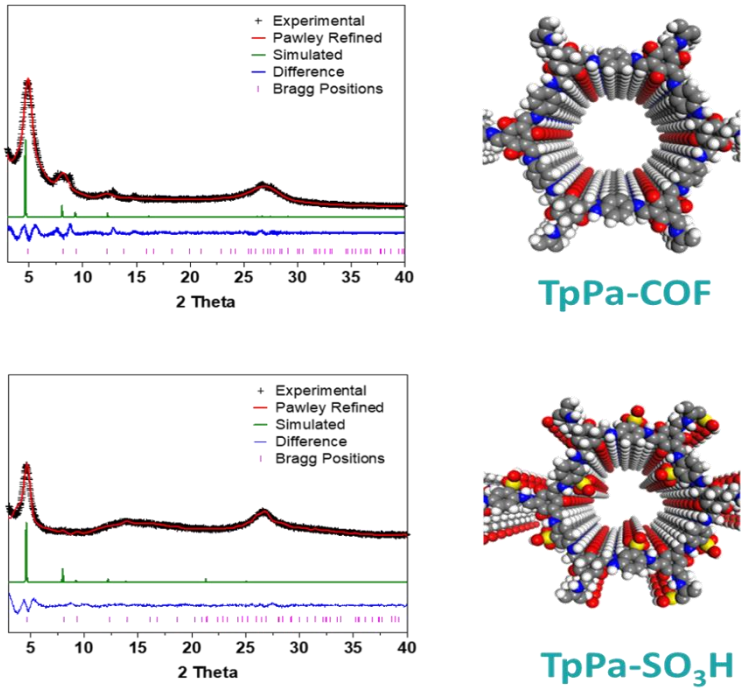
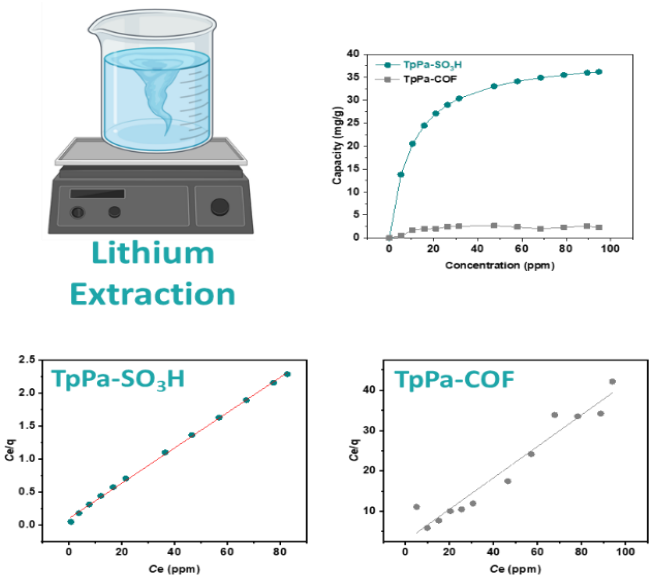


Fig.2 PXRD For Structural Define

The crystallinity and structure of TpPa-COF, TpPa-SO_3H were determined by the powder X-ray diffraction (PXRD). The PXRD pattern of TpPa-COF presents an intense peak at around 4.8° and a relatively weak peak at around 27.3°. This indicates the successful synthesis of well-crystallized TpPa-COF. After being functionalized with -SO_3H group, there is a certain degree of decline for the diffraction peak intensity of TpPa-SO_3H, but still maintain highly crystalline 2D frameworks. TpPa-SO_3H exhibits similar diffraction peaks as TpPa-COF.



COF	Langmuir model		
	Q_m (mg/g)	K_L	R_L^2
TpPa-SO_3H	37.5	0.258	0.998
TpPa-COF	2.56	0.145	0.94

Fig.3 Langmuir model for lithium extraction

The adsorption behavior of TpPa–COF and TpPa–SO_3H toward lithium ions was analyzed using the Langmuir model. TpPa–SO_3H exhibited a maximum adsorption capacity (Qm) of 37.5 mg/g, which is nearly 18 times higher than that of TpPa–COF (2.56 mg/g). This significant increase confirms that the introduction of –SO_3H groups greatly enhances the affinity of the framework toward Li^+ ions. In addition, TpPa–SO_3H showed a higher Langmuir constant (K_l = 0.258) compared to TpPa–COF (K_l = 0.145), indicating stronger binding interactions. The adsorption data for TpPa–SO_3H also displayed an excellent model fit (R^2 = 0.998), suggesting uniform adsorption sites and monolayer coverage, whereas TpPa–COF showed a weaker fit (R^2 = 0.94). Overall, these results demonstrate that sulfonation substantially improves both the capacity and selectivity of COFs for lithium extraction.

Conclusions:

- Covalent Organic Frameworks (COFs) offer a promising platform for lithium extraction from challenging brine sources.

- The designed TpPa-COF and sulfonated TpPa-SO3H demonstrated high porosity and tunable chemistry for selective lithium adsorption. The results indicate that TpPa-SO3H exhibits superior lithium uptake (~40 mg/g), while control materials show negligible capacity (~2–3 mg/g).

- Future work will focus on device integration and real-brine testing.

Reference:

1- Huang, N., Wang, P., & Jiang, D. (2016). Covalent organic frameworks: a materials platform for structural and functional designs. Nature Reviews Materials, 1(10), 1-19.

2- Christmann, P., Gloaguen, E., Labbé, J. F., Melleton, J., & Piantone, P. (2015). Global lithium resources and sustainability issues. In Lithium process chemistry (pp. 1-40). Elsevier.

3- Tan, K. T., Ghosh, S., Wang, Z., Wen, F., Rodríguez-San-Miguel, D., Feng, J., ... & Jiang, D. (2023). Covalent organic frameworks. Nature Reviews Methods Primers, 3(1), 1.