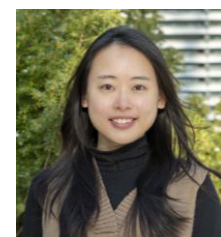


MOF-derived Synthetic Carbon Anode Materials for Sodium-Ion Batteries



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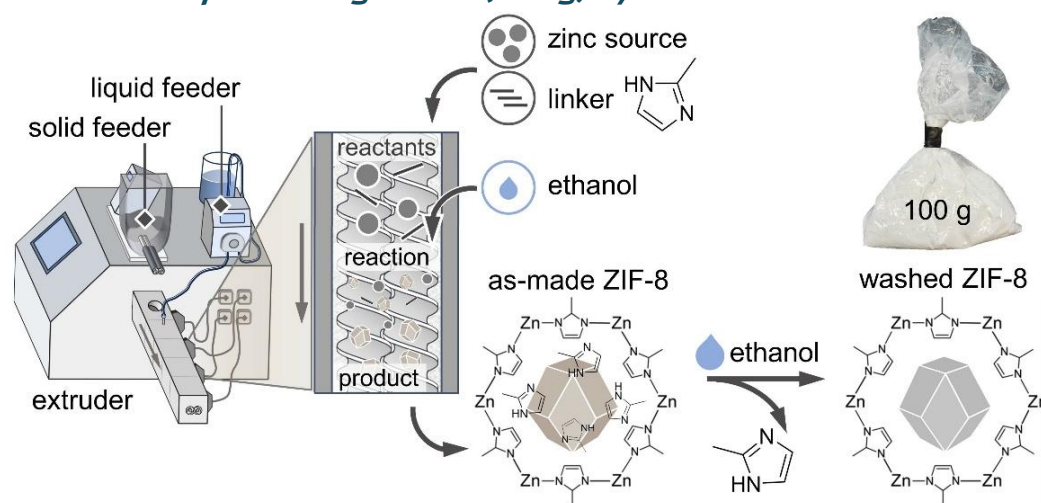
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Abstract

Metal-organic frameworks (MOFs), particularly the zeolitic imidazolate framework (ZIF) family, are attractive precursors for advanced energy-storage materials. Upon pyrolysis, ZIFs can be transformed into electrically conductive carbon materials while preserving their original particle morphology, which is crucial for achieving high-performance sodium-ion battery anodes. Despite these advantages, large-scale implementation remains challenging due to the need for synthesis routes that balance performance, cost, and sustainability. The present study addresses these challenges by developing environmentally benign and economically feasible strategies for the scalable production of ZIF-8-derived carbon anodes suitable for industrial applications.^[1]

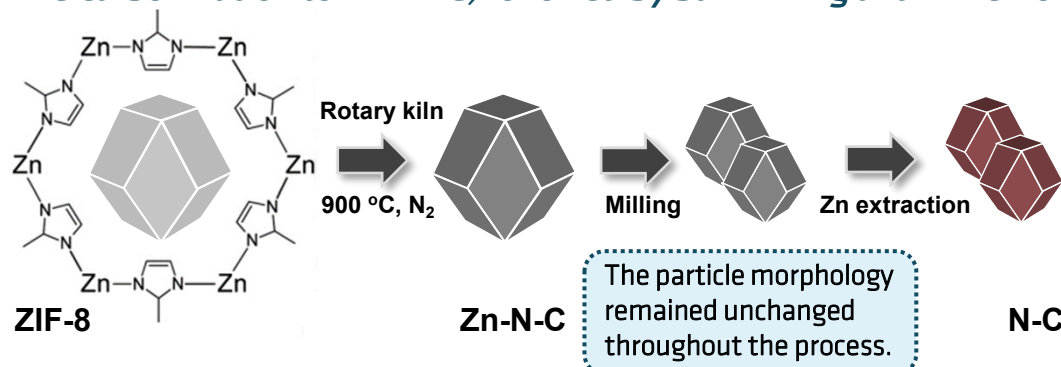
Scaled-up laboratory synthesis of MOF "ZIF-8"

Extruder set up^[2] for large scale (100 g) synthesis of ZIF-8



MOF "ZIF-8" pyrolysis

ZIF-8 carbonization to Zn-N-C, followed by ball milling and Zn removal

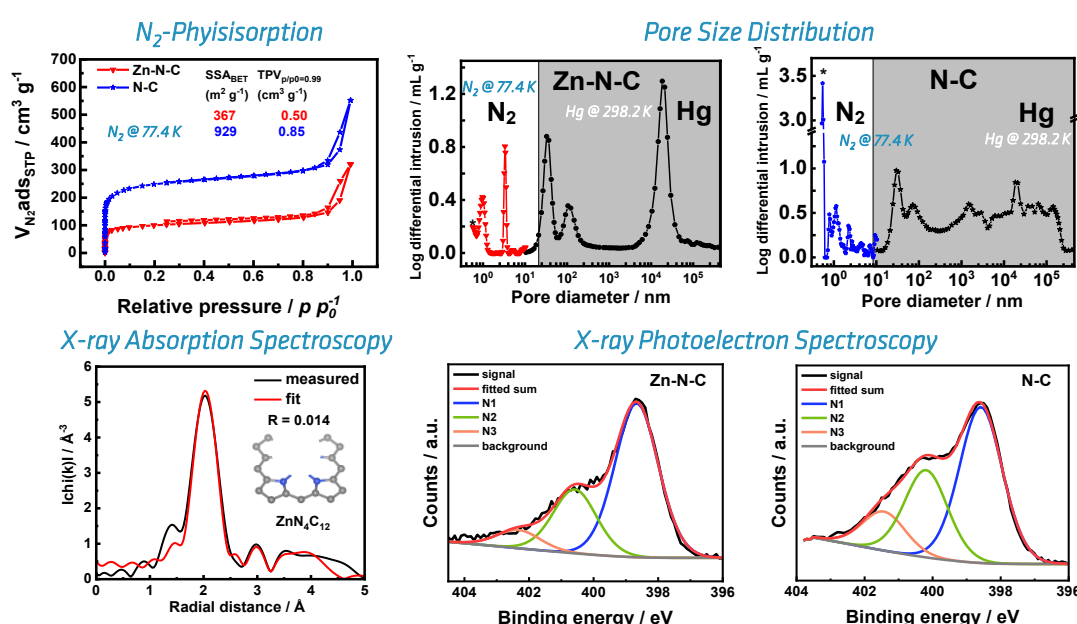


Rotary kiln before and after ZIF-8 carbonization



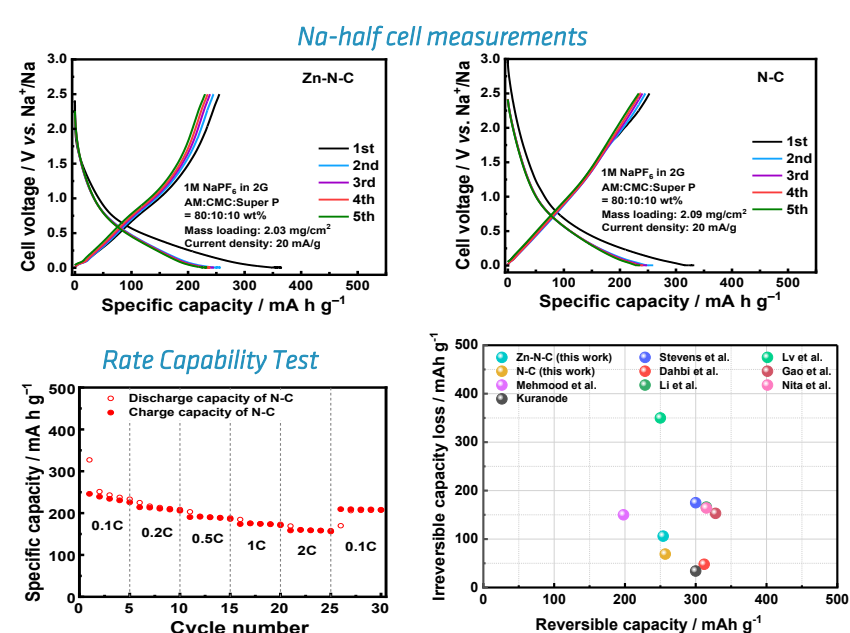
Result and discussion

Porosity and chemical analyses of Zn-N-C and N-C materials



- Zn removal increases the surface area from 350 to 900 m² g⁻¹.
- The narrow peak at 0.55 nm was shown to be an artefact (indicated with an asterisks) of specific adsorption sites.^[3]

Performance of Zn-N-C and N-C materials



- Irreversible capacity loss is not straightforwardly correlated with surface area of N₂-accessible porosity.

Conclusion

This work presents a joint BAM effort to develop sustainable and scalable synthetic carbon anodes for sodium-ion batteries. ZIF-8 was produced as a carbon precursor using a fast, solvent-efficient, quasi-solid-state extrusion method scalable to 100 g. The carbonized (Zn-N-C) and processed (N-C) materials were studied to understand their sodium storage behavior. Despite major differences in surface area and porosity, both showed similar reversible capacities and irreversible losses, suggesting that pore structure, surface chemistry, and particle connectivity play a key role in SEI stability.

References:

- [1] S.-H. Wu, A. Mehmood, N. Gugin, C. Prinz, P. Piehl, A. Guilherme Buzanich, S. Dietzmann, J. L. Low, B. Mieller, J. Radnik, J. Krug von Nidda, D. Al-Sabbagh, F. Lindemann, T. Lange, C. Adam, V.-D. Hodoroaba, J. Günster, F. Emmerling, T.-P. Fellerger, „Sodium-ion battery research@ BAM (III): Eco-Friendly Large-Scale Synthesis of Carbon Anode Materials from Metal-Organic Frameworks for Sodium-Ion Batteries“, *in preparation*.
- [2] N. Y. Gugin, J. A. Villajos, O. Dautain, M. Maiwald and F. Emmerling, *ACS Sustainable Chemistry & Engineering*, 2023, 11, 5175-5183.
- [3] S. W. J. Dietzmann, A. Mehmood, J. L. Low, S.-H. Wu, C. Prinz, A. Guilherme Buzanich, J. Radnik, P. A. Appel, T.-P. Fellerger, „A Pore or Not a Pore? Understanding Pore Size Distributions of Non-Graphitic Carbon and Atomically-Dispersed M-N-C Materials“, *submitted*.

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