Rapid Selective Recycling of Spent $LiFePO_4$ Cathodes via a Deep Eutectic Solvent-Assisted Carbothermal Shock Method

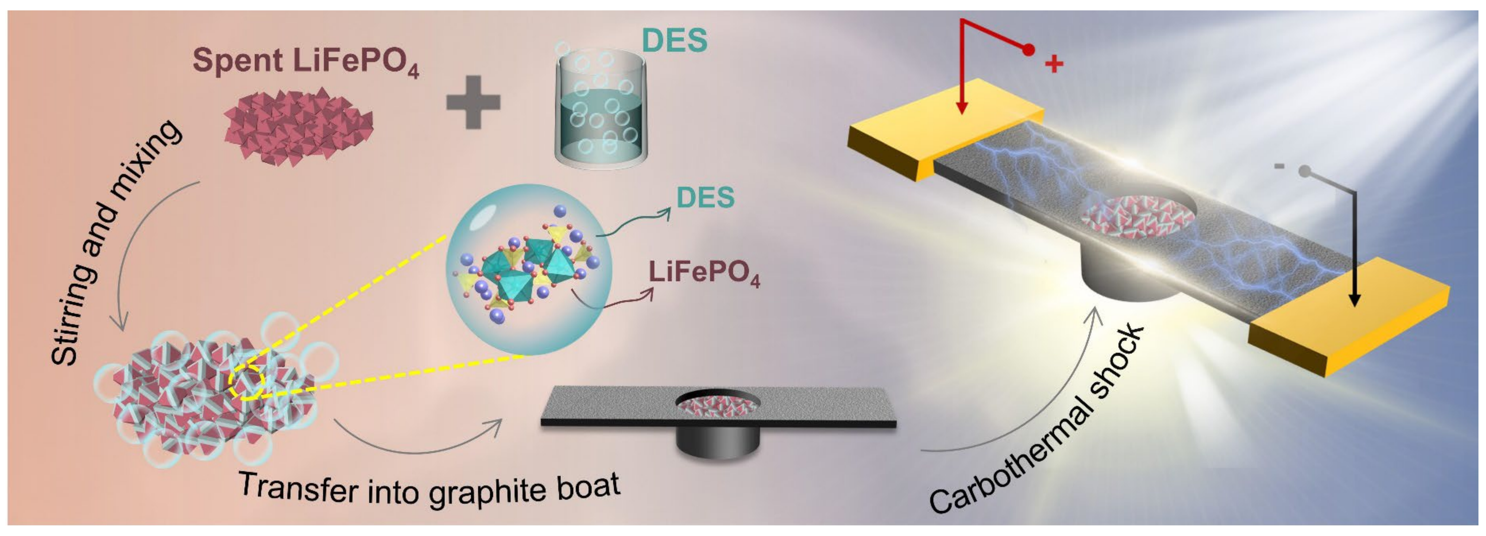
Xuhui Zhu and Dr Helena Wang*
Department of Chemical Engineering, The University of Melbourne
xuhui.zhu@student.unimelb.edu.au

Introduction

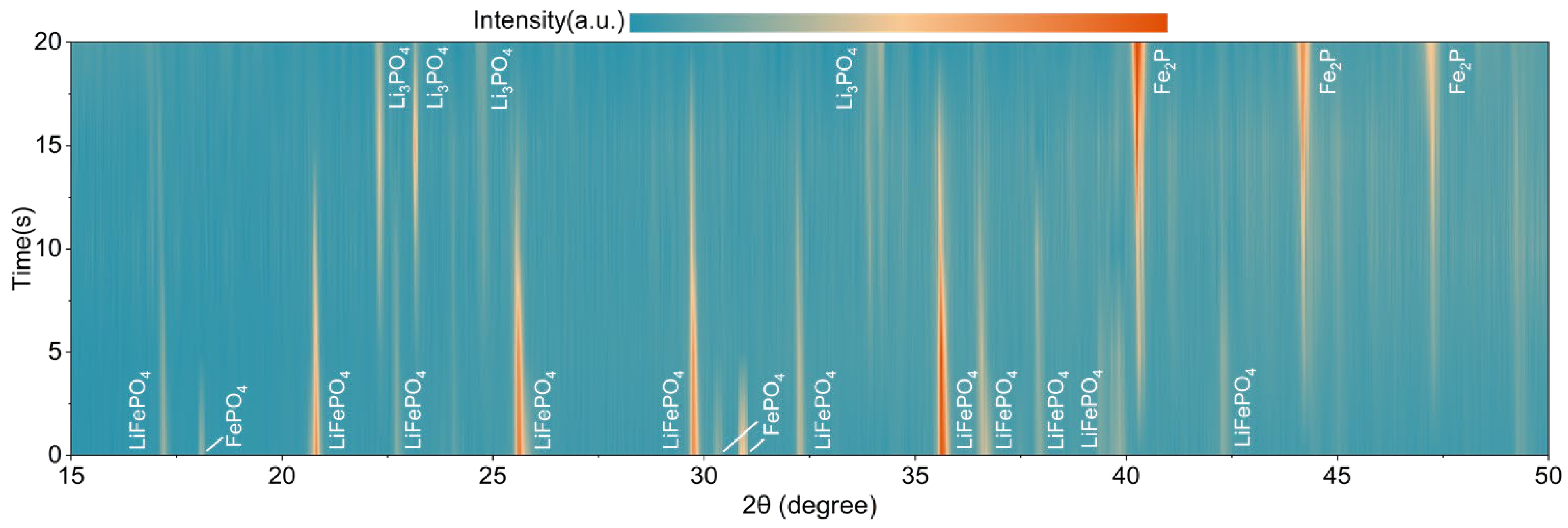
The surge in lithium-ion battery adoption underscores the need for innovative recycling technologies, particularly for **$LiFePO_4$ (LFP)**, whose thermally stable olivine structure leads to high energy consumption, lithium loss, and low economic viability in conventional pyrometallurgical routes. Here, we introduce a **deep-eutectic-solvent-assisted carbothermal shock** process that achieves ultrafast (~20 s) and complete decomposition of spent LFP through uniform ChCl-urea encapsulation, preventing Li volatilization during the short reaction time. The method yields **high-purity Fe_2P and Li_3PO_4** with **excellent Li (97.39%) and Fe (99.17%) recovery**, enables simple magnetic separation, and provides a synergistic valorization pathway through the catalytic performance of recovered Fe_2P in PET alcoholysis.

Methods

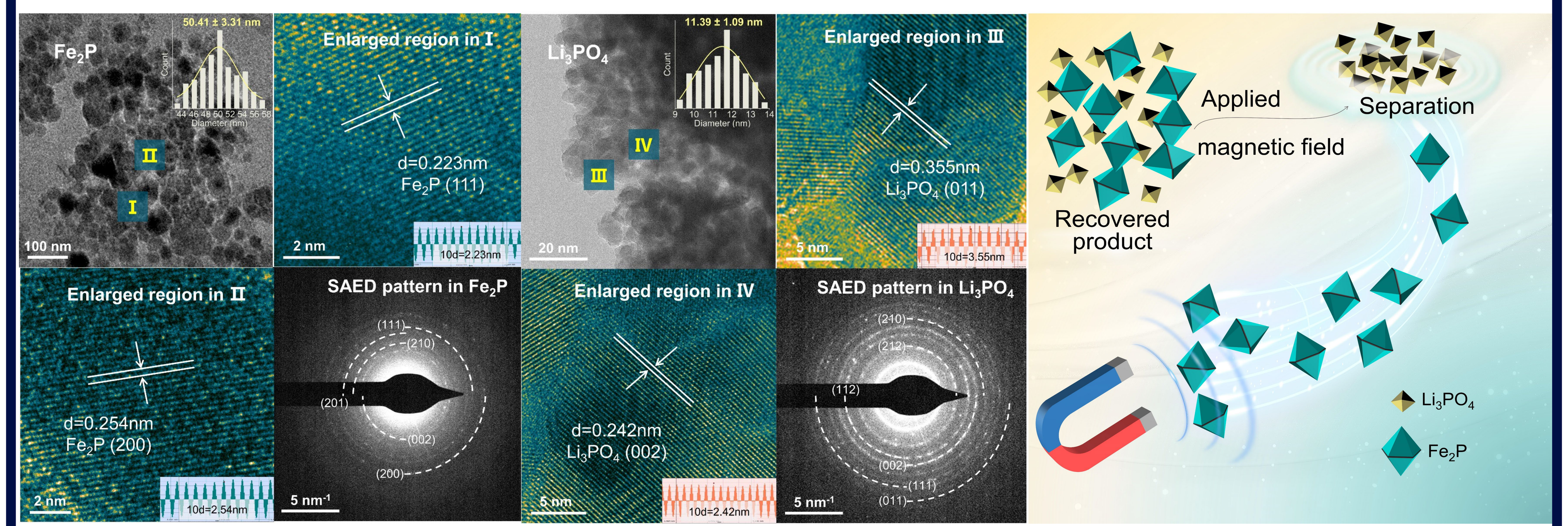
A viscous ChCl-urea deep eutectic solvent (DES) uniformly coats spent $LiFePO_4$ (S-LFP), enabling efficient contact and preventing Li volatilisation.



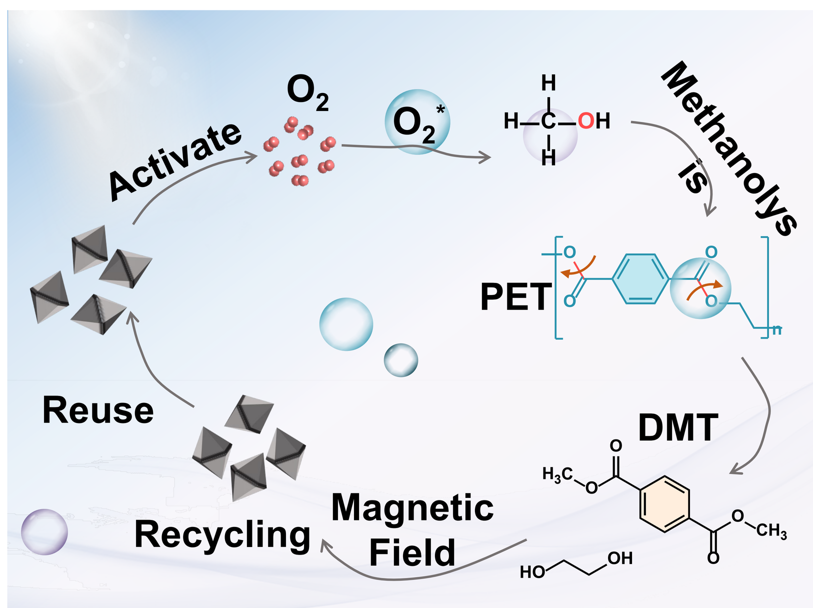
Results

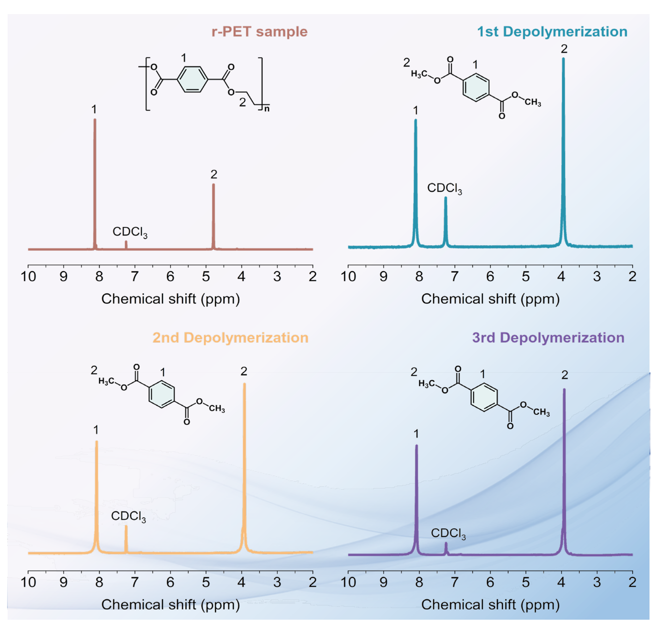


Complete Transformation of S-LFP into Fe_2P and Li_3PO_4.



TEM confirm uniform Fe_2P and Li_3PO_4 nanoparticles through efficient magnetic separation.





Fe_2P Catalyst is recyclable for reuse.

Recovered Fe_2P promotes methanolysis of Polyethylene terephthalate (PET), yielding 98% conversion and 99.5% pure dimethyl terephthalate (DMT).

Conclusions

- A DES-assisted carbothermal shock method was developed for the efficient recycling of spent $LiFePO_4$ cathodes.
- This recycling method enabled complete and rapid decomposition of S-LFP into high-value Li_3PO_4 and Fe_2P.
- Li_3PO_4 and Fe_2P were easily separated through simple magnetic separation.
- Fe_2P exhibited excellent catalytic activity in PET methanolysis.
- This work offers an environmentally friendly and economically viable strategy for S-LFP recycling and provides a synergistic pathway for high-value utilization of plastic waste.

Melbourne Energy Institute
MEI Symposium 25

Reference:
X. Zhu, Y. Wang, et al., ***Small*, 2025**, e09221.
X. Zhu, Y. Wang, et al., ***ACS Nano*, 2025**, 19(42), 36982-36993.
X. Zhu, Y. Wang, et al., ***Angewandte Chemie*, 2023**, 62(15), e202300074

We gratefully acknowledge the financial support provided by the Australian Research Council (DE230100327) and Melbourne Research Scholarship. We thank Dr Helena Wang, Dr Kathryn Mumford, and Dr Hamidreza Arandiyan for their guidance and helpful discussions.