Beyond Flatland: Spinning the path to better Li-S Batteries with 3D current collectors

Investigating electro-spun lignin-derived carbon fibre current collectors

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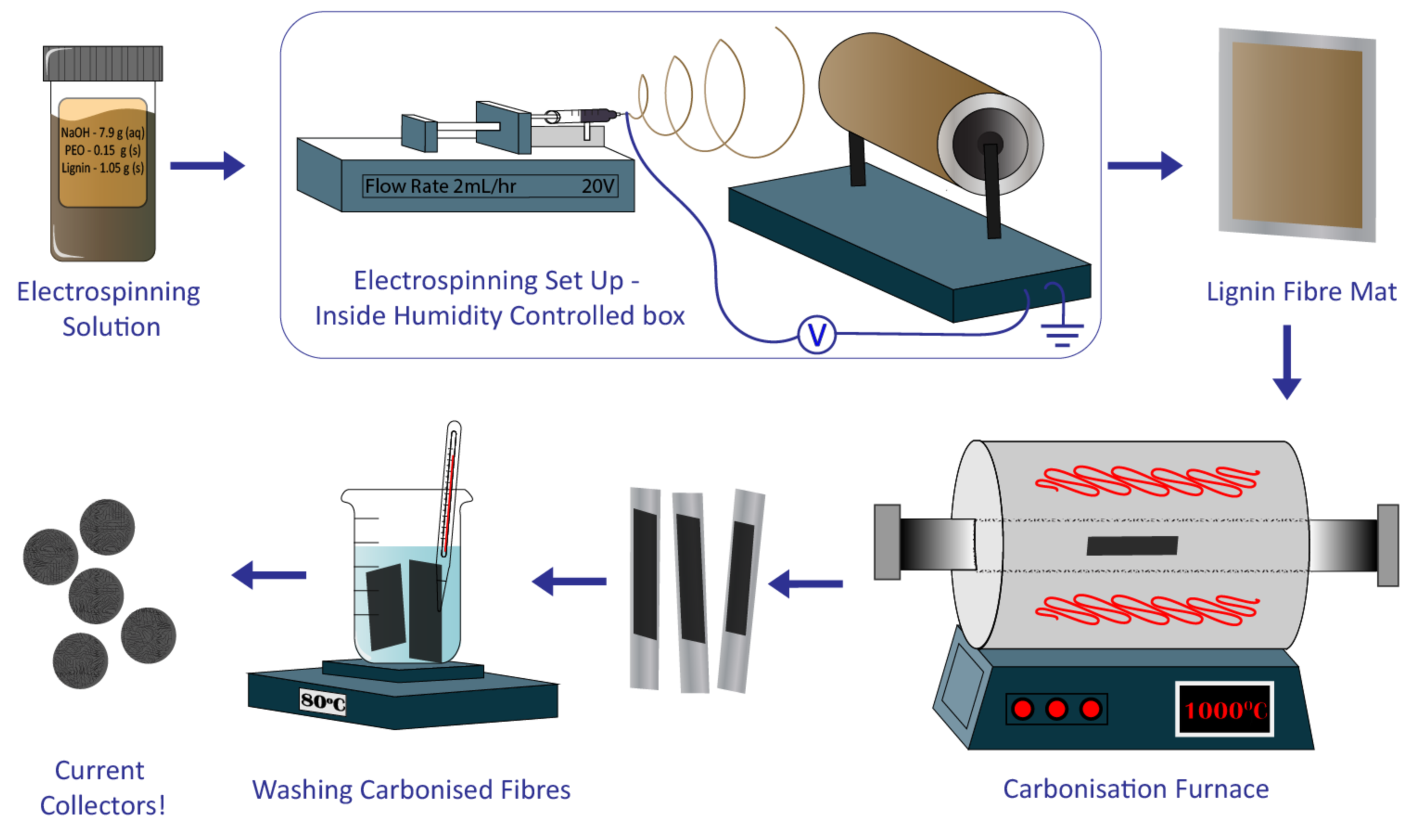
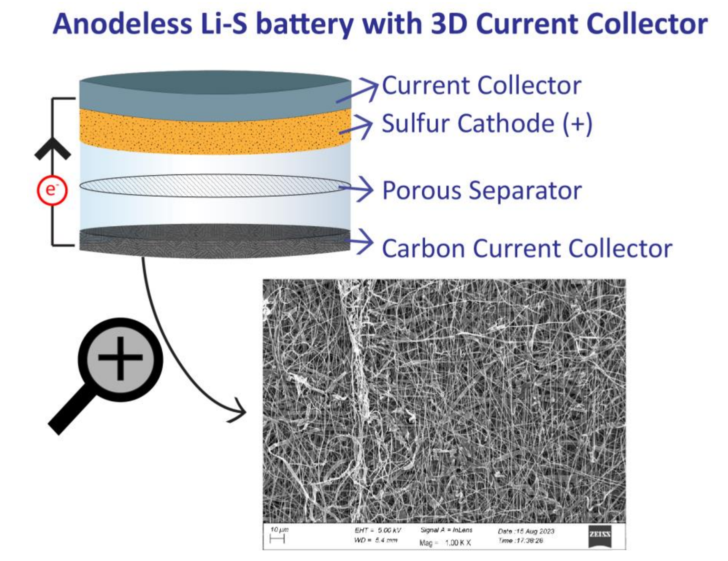
Abstract

Electro-spun carbon fibre current collectors, sourced from paper waste, are synthesised for Li-S batteries. The ideal carbon fibre material aims to control lithium deposition and reduce dendrite-related issues in Li batteries by having a high lithiophilicity, optimal surface area and enhanced conductivity.



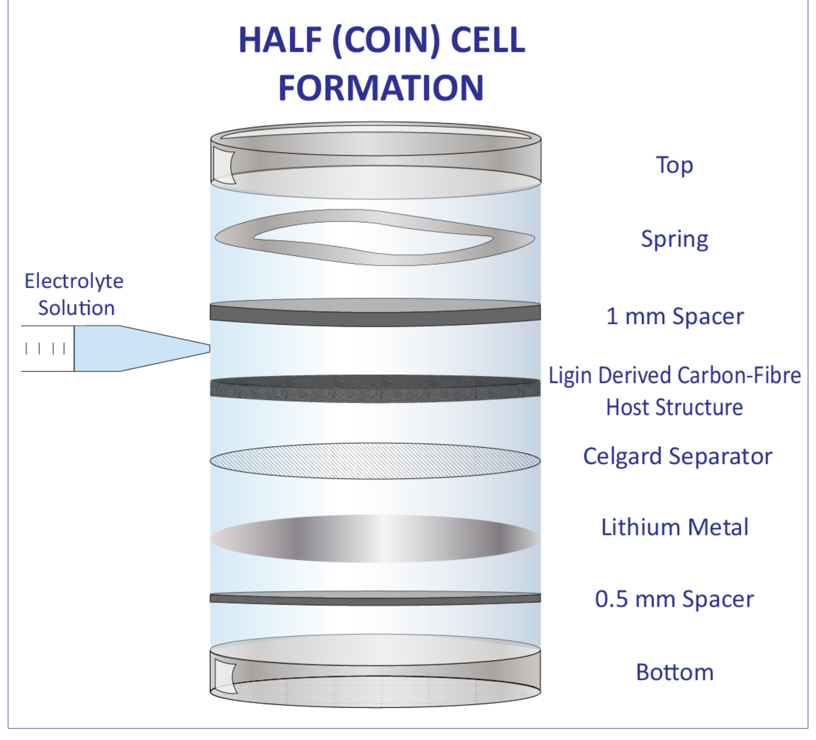
Motivation

- Anodeless Li-S batteries offer amplified energy storage and density capabilities compared to traditional Li-ion batteries.
- Utilizing sustainable current collectors derived from biomass helps mitigate uneven Li plating and large volume changes.



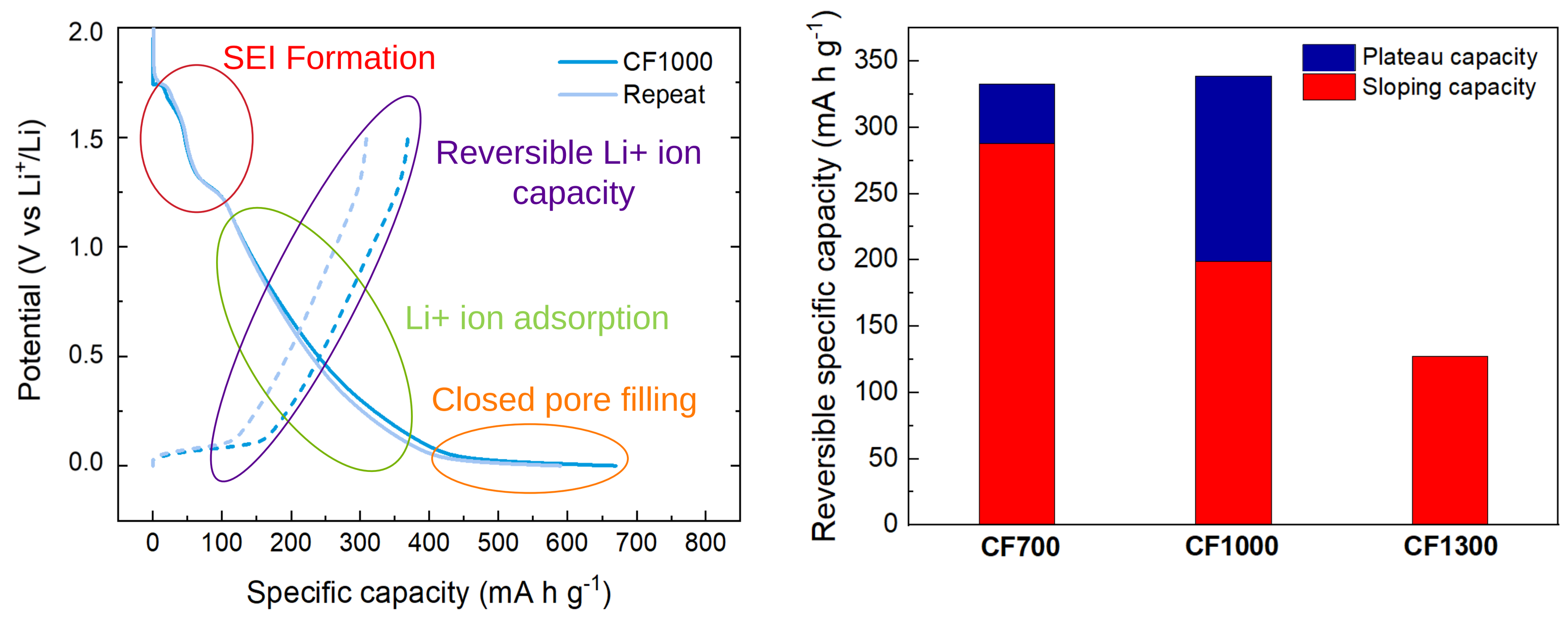
Method

Information about lithium plating overpotentials is derived from galvanostatic voltage profiles acquired from coins in the half-cell configuration.

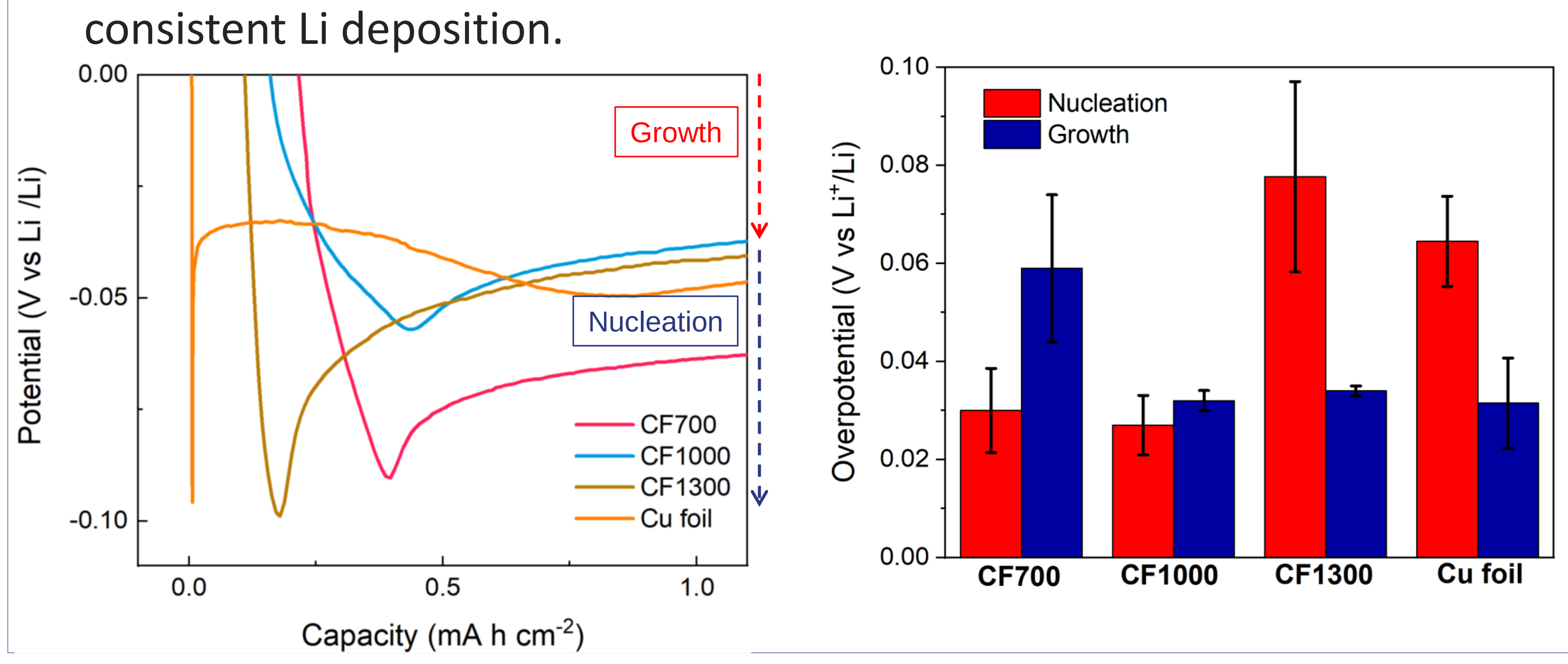


Results

- Following the synthesis of the lignin fibre mat, the samples underwent carbonisation at three distinct temperatures: 700°C, 1000°C, 1300°C, yielding the designated samples CF700,CF1000, and CF1300.
- CF1000 exhibited the most promising fibre performance based on its SEI (solid electrolyte interface) formation and Li^+ ion capacity. It displayed the highest reversible Li capacity (~400 mA h g^{-1}) and demonstrated superior pore filling in the plateau region.

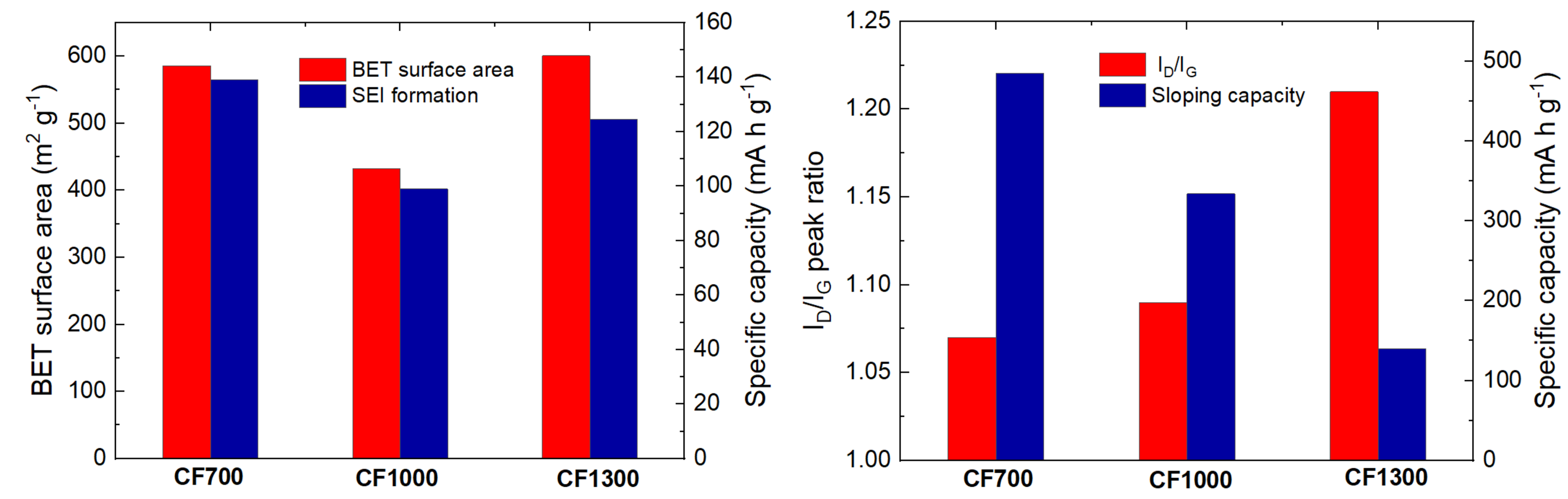


- CF1000 also showcased the lowest deposition overpotential and exhibited the smallest discrepancy between nucleation and growth, indicative of consistent Li deposition.

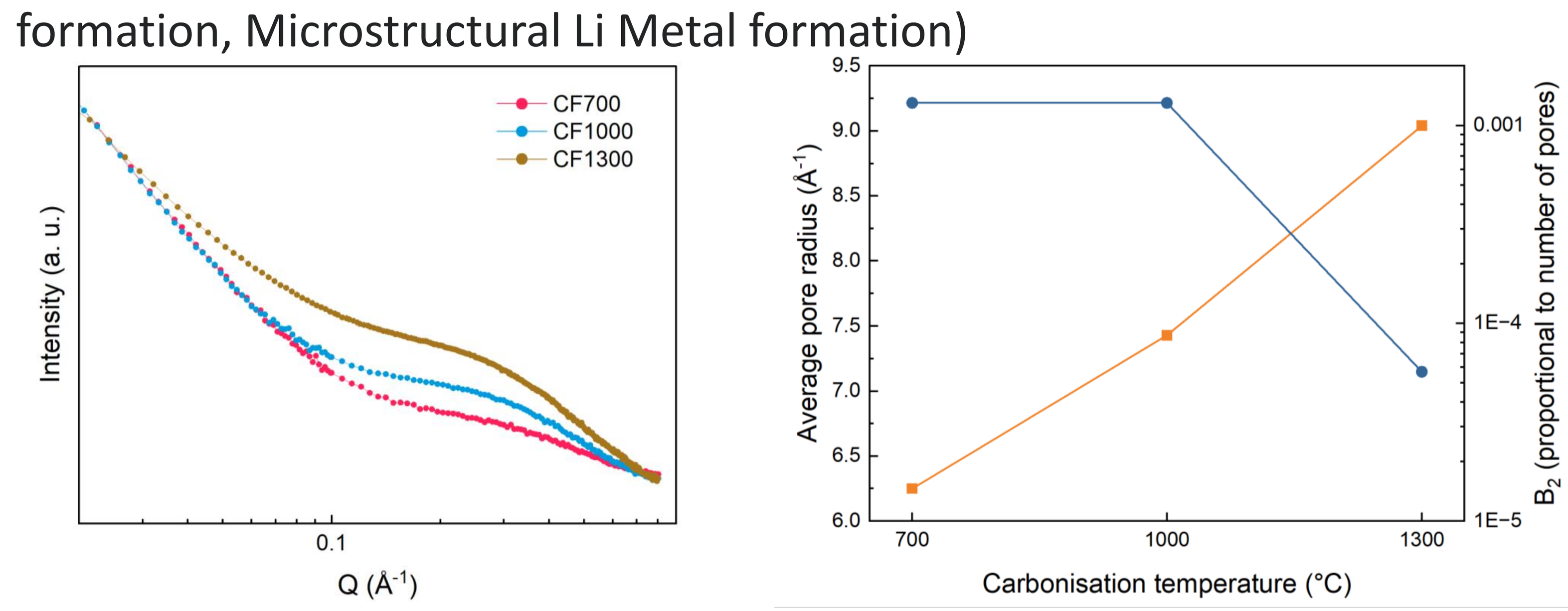


Discussion

- Analytical methods are used to investigate the properties of CF1000. BET shows CF1000 has the smallest surface area relative to CF700 & CF1300. Raman spectroscopy reveals graphitic disorder within the fibres. The d/g ratio and sloping capacity have inverse trends with increasing temperature.



- Closed porosity is measured via small angle x-ray scattering (SAXS). It is yet to be determined exactly how differences in porosity lead to different Li ion mechanisms (Intercalation, Li+ ion adsorption, Li+ ion nanocluster formation, Microstructural Li Metal formation)



- The combination of the physical properties of CF1000 result in its improved electrochemical behavior. The optimal graphitic disorder and surface area aid Li deposition and allows diffusion into pores to maximize coulombic efficiency and improve battery performance, providing a cheap alternative to traditional copper current collectors.

Impact / Next steps

- Uncovering the deposition mechanisms directs research towards optimizing its properties. Notably, 1000CF has demonstrated exceptional reversible Li deposition, positioning it as a prospective next-generation sustainable current collector.
- Due to the broader impact of SEI formation on battery performance, it's vital to test the current collectors with various electrolytes to measure differences in electrochemical performance.
- Scaling the electrospinning process is challenging yet is undoubtably advantageous for future research and industry.

References

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Intern bio

Bhavini Patel is a final-year MSc Chemistry Undergraduate at The University of Oxford. She is captivated by the potential of functionalised materials to pave the way for a sustainable future. With a sharp focus on the intersection of chemistry and environmental consciousness, Bhavini is excited to make a substantial impact on the journey to a greener world.

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