Project title: Materials Innovation for Next-generation Batteries

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Faculty Research Area (Theme): Advanced Materials

School Research Area: Energy

Applicable to other Engineering schools/disciplines: N/A

Abstract*: (Maximum 200 Words)

The development of advanced battery systems has been triggered by the ever-increasing demand for energy storage applications ranging from portable electronic devices to electric vehicles (EVs), hybrid EVs, and large-scale grid energy storage. Lithium-ion (Li-ion) batteries have dominated the battery market for portable electronic devices since their successful launch in the 1990s. After continuous optimization of nearly 30 years, the energy density of Li-ion batteries is reaching their theoretical limits but still not satisfactory for the demands of the future key markets.

Lithium-sulfur (Li-S) batteries have been considered as one of the most promising candidates for next-generation energy storage devices. Li-S batteries use abundant elemental sulfur as the key material and have a high theoretical energy density of 2600 Wh kg^{-1}, which is five times higher than that of commercially available Li-ion batteries. However, Li-S battery performance has been hindered by fundamental challenges including the insulating nature of sulfur and high solubility of intermediates in the electrolytes. Incorporating conductive matrix as well as interception space in the sulfur cathode is an effective approach to improve the electronic conductivity of sulfur cathode and intercept the soluble polysulfides, resulting in improved battery performance with specific capacity and cycling stability.

Research Environment: (Maximum 100 Words)

The students selected for this project will be given opportunity to work in Particles and Catalysis Research Group (PartCat) at School of Chemical Engineering, under the supervision of A/Prof. Da-Wei Wang and Dr Ruopian Fang. The students will have access to state-of-the-art experimentation facilities, mentoring opportunities and fun and nurturing working environment to gain necessary expertise facilitating their career in academic research. Further information can be obtained by contacting A/Prof. Da-Wei Wang (da-wei.wang@unsw.edu.au).

Novelty and Contribution: (Maximum 100 Words)

Rational design of conducting and interception matrix for sulfur cathodes is a very promising research field in the quest to overcome the existing challenges of sulfur cathode. Both materials design and electrode architecture will be taken into consideration for the design of high-performance sulfur cathodes with practical reliability.

Expected Outcomes: (Maximum 100 Words)

The aim of this project is to develop novel cathode materials with tailored structure and surface chemistry for sulfur hosting and optimize Li-S battery performance with high energy density and long durability.

Reference Material Links:(Maximum 100 Words)

1. P.G. Bruce, S.A. Freunberger, L.J. Hardwick, J.M. Tarascon, Li-O_2 and Li-S batteries with high energy storage, Nat. Mater. 11 (2012) 19–29.
2. S.S. Zhang, Liquid electrolyte lithium/sulfur battery: fundamental chemistry, problems, and solutions, J. Power Sources 231 (2013) 153–162.
3. Z.W. Seh, Y. Sun, Q. Zhang, Y. Cui, Designing high-energy lithium-sulfur batteries, Chem. Soc. Rev. 45 (2016) 5605–5634.
4. R. Fang, Zhao, S., Sun, Z., Wang, D.-W., Cheng, H.-M., Li, F. More Reliable Lithium-Sulfur Batteries: Status, Solutions and Prospects. Adv. Mater. (2017) 1606823.