IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Novel 2D materials for the realisation of magnesium ion battery**	
Project Number	**IMURA0610**	
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Research Academy Themes:

Highlight which of the Academy's Theme(s) this project will address?

(*Feel free to nominate more than one. For more information, see www.iitbmonash.org)*

1. Advanced computational engineering, simulation and manufacture
2. Infrastructure Engineering
3. Clean Energy
4. Water
5. Nanotechnology
6. Biotechnology and Stem Cell Research

The research problem

Lithium ion batteries (LIBs) have made great contribution to the satisfactory power-source performance in most portable electronic devices so far but their high cost impedes the promotion of more accessible large scale commercial applications such as electric vehicles. Rechargeable magnesium ion batteries (MIBs) are considered as potential safe and economical alternatives because of their higher availability

and reliability. Furthermore, MIBs have higher charge density than LIBs, allowing a huge increase in the density of energy storage in MIBs.

However, the development of MIBs is stagnant largely due to the active interaction between metallic Mg anode and the reducing electrolyte, resulting in the formation of a blocking layer which is impermeable to Mg^{2+}. One feasible solution is to replace the metallic anode with a Mg-ion insertion anode. The insertion anodes have achieved great success in LIBs and several researchers have found that two-dimensional (2D) nanomaterials, such as MoS_2 monolayer can effectively improve the Li storage performance and charge/discharge rate by increasing the specific Li capacity and lowering the Li^+ diffusion barrier. Analogically, it is speculated that the energy storage performance of MIBs can also be improved by incorporating metallic Mg with these 2D nanomaterials in the anode. Moreover, the noble 2D MoS_2 may have ability to reduce the anode/electrolyte interaction and hence minimize the formation of passivating blocking layer.

Project aims

The objectives of this project:

(1) To investigate the effectiveness of insertion anode made of 2D MoS_2 in enhancing the specific Mg capacity and energy density from experiments and to compare with the traditional metallic Mg anode.

(2) To determine the optimum morphology of 2D MoS_2 and the key electrochemical parameters that will provide the maximum specific capacity and cycle number of MIBs from experiments.

Expected outcomes

The idea of the work is inspired by the great success of Li ion batteries attributed to replacing Li metal with the insertion anode and the effectiveness of MoS_2 anode in LIBs. It is expected that this project will contribute to a variety of innovations and inspirations.

(1) A self-limiting chemical vapour deposition approach has been established to synthesize large-area, high quality 2D MoS_2 with reasonable uniformity and controllability and this approach is compatible with the standard industrial fabrication process. In this project, this method will be utilized to further demonstrate its feasibility and practicality in the preparation of high-performance MIBs. It is expected that the project will figure out the 2D MoS_2 growth mechanism involved in this approach, gaining more insight into the large scale commercial production of more 2D nanomaterials, such as VS_2.

(2) *The primary theme concentrates on devising Mg ion batteries with 2D MoS_2 insertion anode having good energy storage performance. The experiment part in this project will characterize of the morphology of 2D MoS_2 anode and examine the cycle number and specific capacity of the batteries.*

How will the project address the Goals of the above Themes?

NanoTechnology – The project will deliver the superior MIBs with new class of advanced electrode materials.
Clean Energy – The advanced electrode will create superior energy storage devices for storing renewable energy such as solar and wind.

Capabilities and Degrees Required

- *Chemistry as major with sound knowledge in inorganic material synthesis, electrochemistry and solid-state chemistry*
- Chemical Engineering with relevant experience in materials synthesis and characterization are must
- Materials Science with relevant experience in materials synthesis and characterization are must

Potential Collaborators

Prof. Doug McFarlane, Raman Singh from Monash

Please provide a few key words relating to this project to make it easier for the students to apply.

Nanotechnology, exfoliation of 2D layered materials, advanced electrode materials, sodium ion battery