# 3D nanoarchitectures of reduced graphene oxide (rGO)/transition metal dichalcogenides; promising anode materials for sodium ion batteries.

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## Background of Sodium Ion Batteries (NIBs)

Due to their high energy density, high operating voltage, and long lifetime, Li-ion batteries (LIBs) find use in a wide range of applications. Nevertheless, several issues including cost, safety, and capacity restrict the further development of LIBs. Alternatively, NIBs (Fig. 1) have attracted attention because of the natural abundance of sodium resources and the potential low cost for large-scale electrochemical energy storage. However, due to the larger ionic radius of $Na^+$, typical LIB anode intercalation materials are not suitable for NIBs, mainly due to limited interlayer distances.[1] New NIB anode materials will require **large interlayer distances, large surface area, high electrical conductivity, high charging rate, high volumetric capacity and excellent rate capability.**

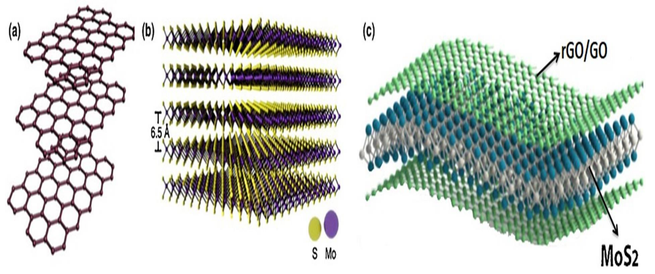



**Fig 2. Illustration of multilayered graphene sheets, (b) cross-section illustration of multilayered $MoS_2$ with an interlayer spacing of ~0.65 nm, (c) Exfoliated few-layer MoS2 and rGO flakes. Figure adapted from [3]**

## References

1. Ruxing, W., $MoS_2$@rGO Nanoflakes as High Performance Anode Materials in Sodium Ion Batteries. 2017.
2. J. F. Peters, A. Peña Cruz and M. Weil, Exploring the Economic Potential of Sodium-Ion Batteries. 2019
3. Nanjundan, A.K, et al Graphene and molybdenum disulfide hybrids: synthesis and applications. 2019

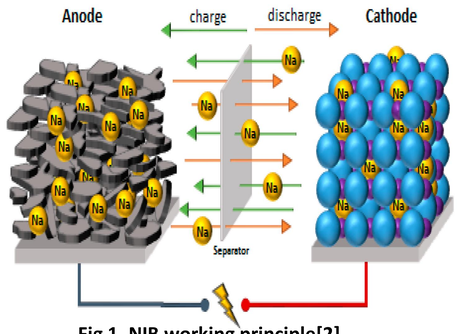
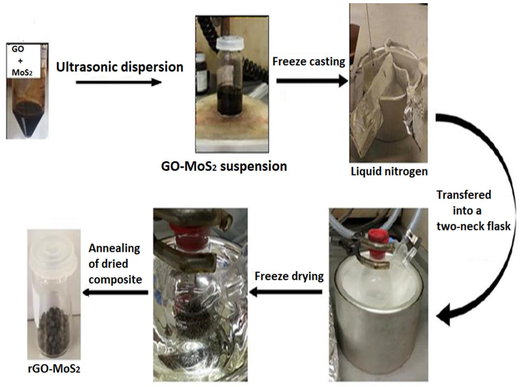



**Fig 1. NIB working principle[2]**

## Our research

One of the aims of our work was to synthesise rGO/$MoS_2$ composites (Fig. 2) using an environmentally-friendly and energy efficient aqueous ice-templating methodology. $MoS_2$ composites were prepared by combining graphene oxide (GO) with pre-synthesised $MoS_2$ nanosheets to freeze-cast porous matrices. Thermal treatment of the prepared composites can then reduce GO to yield 3D nano-r(GO)/$MoS_2$ which has been used as an anode for NIBs (Scheme 1).




**Scheme 1: Schematic diagram of the synthesis of rGO-$MoS_2$ composite**

## Electrochemical performance of the rGO-$MoS_2$ anode material

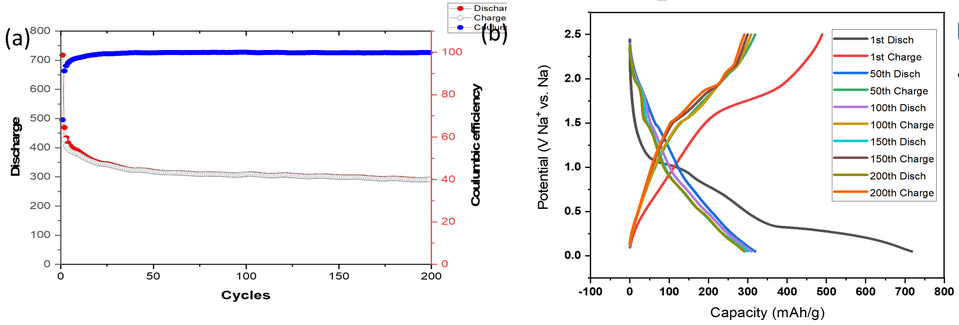



**Fig 5. (a) Rate performance of the rGO-$MoS_2$ electrode at a current density of 500 mA $g^{-1}$; (b) galvanostatic charge/discharge voltage profiles (current density of 500 mA $g^{-1}$) for the rGO-$MoS_2$ composite from the 1st, 50th, 100th and 200th cycles, respectively.**

- initial discharge and charge capacities of this r(GO)-$MoS_2$ composite were 720 mAh $g^{-1}$ and 490 mAh $g^{-1}$, respectively, corresponding to an initial coulombic efficiency of 68 %
- Reversible capacity of 320 mAh g−1 and a coulombic efficiency of 100% for 200 cycles at a current density of 500 mA g−1 over a cut-off voltage range of 0.005 – 2.5 V.

### Future work

- Check the rate performance of the electrode
- Compare the performance of different $MoS_2$ to rGO ratios in the composites

## Characterisation

- **$MoS_2$ nanosheets**

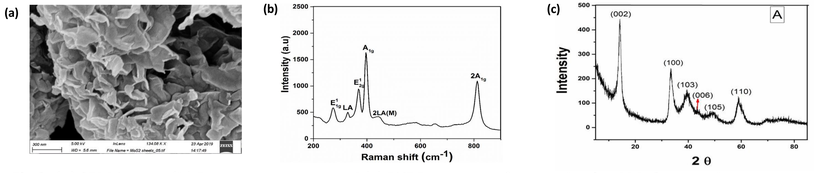



**Fig 3. (a) SEM Image; (b) Raman spectrum and (c) PXRD pattern of as-synthesised $MoS_2$ nanosheets**

- **GO-$MoS_2$ nanocomposite**

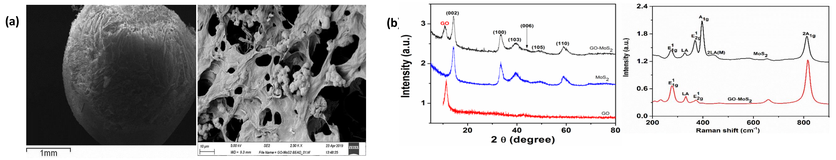



**Fig 4. (a) SEM images; (b) PXRD patterns and (c) Raman spectra of the 3D GO-$MoS_2$ composite.**

- Evidence of enlarged d-spacing
- Electronic interaction between GO and $MoS_2$ sheets