

Reversible Intercalation of Multivalent Al³⁺ Ions into Potassium-Rich Cryptomelane Nanowires for Aqueous Rechargeable Al-Ion Batteries

Jickson Joseph, Dr. Jawahar Nerkar, Cheng Tang, Professor Aijun Du, Professor Anthony P. O'Mullane & Professor Kostya (Ken) Ostrikov

What is the most significant result of this study?

This research reports a highly promising cathode material for aluminum-based aqueous batteries and a new mechanism of ion exchange that enables charge storage. Potassium-doped manganese dioxide, where potassium is present in the tunnel structure, creates a pathway for smaller aluminum ions to intercalate into the material. The results show that an exchange of potassium ions with aluminum ions is a favorable mechanism for effective charge storage. This cryptomelane cathode material shows high capacity and cycling stability in aluminum ion-based aqueous electrolytes. Our findings may lead to the development of new, alternative to lithium, ion batteries with low cost, high power density, safe operation, and easy recycling.

What prompted you to investigate this topic/problem?

The availability constraints of lithium and the large radius of sodium ions impede further commercial developments of lithium and sodium ion-based batteries. To make aqueous-based systems viable, there is a need for a multivalent ion-based battery system such as magnesium and aluminum, which have higher volumetric capacities. This important feature prompted us to investigate a new charge storage mechanism and develop a suitable cathode for next-generation aqueous batteries.

What new scientific questions/problems does this work raise?

We expect this work will lead to the development of new functional materials to serve as intercalation hosts for Al ions in aqueous electrolyte systems. This mechanism of employing ions with large ionic radii as an intercalation host will attract the attention of researchers working on the development of high-performance anode and cathode materials for aqueous energy storage systems.

Does the research open other avenues that you would like to investigate?

Even though we have investigated a new mechanism of ion exchange for intercalation chemistry and presented a suitable cathode, the development of a suitable anode is also necessary for the practical

application of aqueous aluminum-ion batteries. We are currently looking at developing high-performance aluminum battery cells.

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