# Al(III)-Mediated Ionic Conduction in New Abundant Metakaolin Solid Electrolyte for Safe, Efficient Power Grid Na-Ion Batteries

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Many concerns have arisen in recent years regarding lithium-ion batteries (LIBs), mostly due to the rapid depletion of lithium reserves and the volatile liquid electrolytes used to make them. This limits their ability to be incorporated into the energy storage systems (ESSs) of renewable energy power grids. Sodium is 37 times cheaper and 2000 times more abundant than lithium and can be used in sodium-ion batteries (SIBs). However, SIBs are less energy-dense than LIBs and possess the same issues with liquid electrolytes. In this research, a new metakaolin solid electrolyte (MSE) was developed. This electrolyte is derived from the highly abundant clay aluminosilicate kaolinite. Full CR2032 cells were built with MSE pellets and standard $NaNiO_2$ cathodes and biochar anodes. These cells exhibited a maximum voltage of 1.1V and indicated no loss of capacity after 200 cycles despite undergoing tests that would have otherwise compromised conventional LIBs and liquid-electrolyte SIBs. In addition, a cost analysis revealed that the MSE SIBs were capable of providing power for $587/kWh on a laboratory scale, with the potential of producing power for less than $300/kWh on an industrial scale. Meanwhile, LIBs can currently only provide power in ESSs for $810/kWh, making MSE SIBs a feasible cost-effective alternative. Metakaolin was found to be able to transmit ions via a potentially previously-undiscovered conduction mechanism, which was hypothesized in this research to rely on the unique metastability of the material as well as the speculated presence of three-coordinated aluminum atoms. Experimental support for this theory was found in this research, though more investigation is necessitated to assess the intricacies of the mechanism.