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Sodium-Ion and sodium Metal Batteries for efficient and sustainable next-generation energy storage

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SODIUM-ION AND SODIUM METAL BATTERIES

SIMBA – Deliverable Report

D2.4 – Optimized P2- and O3-type layered oxides tested at coin cell level

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Publishable summary

Current and emerging active materials for sodium-ion cathodes have been reviewed. The leading classes of cathode active materials are Prussian Blue Analogues (PBAs) and layered oxides. Within this report, we summarise the published work on layered oxides, explore competitive layered oxide materials, and frame the results within the context of wider material options and the key project metrics targeting reduced levelized cost of energy storage (LCoS) for grid applications. Cathode active material performance metrics are thus prioritised according to cycle life, energy density, and coulombic efficiency. Material production capex, disposal cost, raw materials cost, and production cost are also factors for LCoS; however, these are not specifically accounted within this report.

The results from reviewing the leading candidate layered oxide materials found sodium nickel manganese oxides with a wide range of dopants explored academically and amongst industrial product development. The optimisation of materials and their performance in a device are critical for industrial development, whereas academic work offers more fundamental insights. Drawing from both areas, we have explored the effect of introducing a small amount of lithium into layered oxides along with other dopants designed to stabilise the structure. Lithium was reported to occupy nickel sites to enable increased sodium inventory and improve structural stability within the limits of the reversible metal redox capacity. We tested the new materials and comparative materials in half-cell coin-cell format to assess performance in terms of discharge capacity, capacity retention and average voltage. Our results show that although improvement is observed in specific energy (Wh kg^{-1}), further development activity is required to meet performance results for materials that have benefited from longer development timelines. Compatibility with electrolyte is a key factor that requires further work to optimise target device performance.

Amongst materials optimised by industrial players and reported within the last five years, the PBAs present superior lifetime to typical layered oxide materials though the latter exhibit higher energy. SIMBA ultimately will utilise a solid single-ion polymer electrolyte which is expected to improve electrolyte compatibility to enable longer lifetime which may result in competitiveness for higher energy materials. Thus, this report serves as the baseline results for materials tested in a liquid electrolyte prior to assessing competitiveness when the battery comprises solid single-ion polymer electrolyte.