

Stabilising Additives for High Nickel Content Sodium-ion Cathode Inks

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Sodium-ion batteries have the potential to be cheaper alternatives to the ever-commercial lithium-ion battery, mainly due to sourcing the alkali metals; the price of the mineral sources of lithium, spodumene ($\text{LiAlSi}_2\text{O}_6$), and lithium brine sources, Li_2CO_3 and LiOH , have increased by more than 15% between 2015-2016 and continued to rise.[1] Studies of sodium-ion cathodes establish layered nickel based oxides as potential active materials,[2] for which the highest energy density to date has been demonstrated in a full cell configuration (320Wh/L) [3]. However, further investigations have shown a need to modify some of the existing manufacturing methods used for lithium and sodium ion batteries, due to revealed material instabilities in air.[4] Current layered nickel based oxides are unstable in air and can cause gelation of the binder material, PVDF.[5] Therefore, the current ink preparations requires changes that ensure low temperatures and a dry atmosphere. Similarly, the inks exhibit poor time stability and variations in the viscosity of the inks appear within hours of creation. This means standard formulations and methods unfeasible for the sodium nickel cathodes as it is generally deemed that at least 4-5 hrs (or longer) at a stable viscosity is vital for coat homogeneity and uniform thickness.[6]

We have investigated and compared a collection of additives that successfully reduce the effects of the instabilities of materials in an electrode ink, in air. These inorganic additives reduce the need for drastic changes to the manufacturing methodologies used in lithium ion batteries, such as mixing and coating in a dry room. Low concentrations (0.1-5 wt%) of inorganic additives were added to sodium-ion cathode inks containing layered nickel based oxides as the active material, C65 carbon black as a conductive additive, PVDF as a binding material, and NMP as solvent.

A number of measurements were used to verify these interactions. Under controlled conditions, ink rheology over time was measured, viscosity and stability improvements against 'standard' (or non-additive-containing) electrode formulations were observed. X-ray diffraction (XRD) of the electrodes, under controlled humidity conditions over time, showed enhancements to the stability of the materials in air. Similar observations were noted in the analysis of the physical properties and homogeneity of the electrodes. Furthermore, in a sodium metal $\frac{1}{2}$ cell arrangement, the cells demonstrated comparable electrochemical performance to 'standard' coatings.

References

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