INHIBITION OF ALUMINUM CURRENT COLLECTOR CORROSION IN AQUEOUS NA-ION BATTERY

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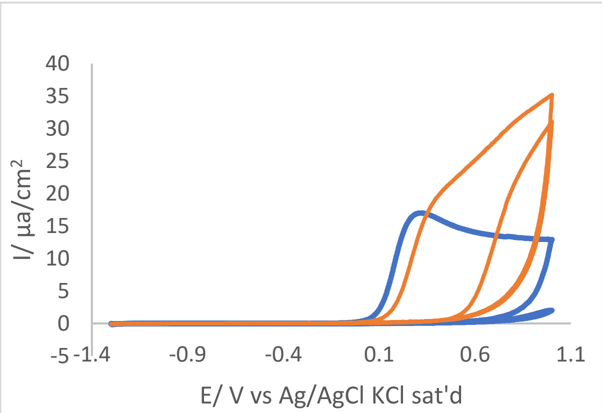
Rechargeable lithium-ion batteries with organic electrolytes are widely used as commercial energy storage devices. They have many attractive properties, such as high efficiency, energy density and stability. However, as the energy demand increases, growing prices on scarce lithium resources also increase, making lithium-ion batteries less attractive. On the other hand, sodium is the 6th most abundant element in earth's crust. Another big issue of commercial batteries remains the usage of organic solvents, which increase production cost and raise safety concerns. This problem can be solved by replacing organic solvents with aqueous electrolytes. Traditionally, usage of aqueous electrolytes in batteries was limited by narrow potential window of operation, beyond which water decomposes. However, recently developed water-in-salt electrolytes can expand this potential window [1], making aqueous electrolytes a viable alternative. One of the other factors, which affects the long-term performance of aqueous batteries, is the corrosion of current collectors. Aluminum current collectors offer many advantages, such as low density and cost, good conductivity and easy manufacturing. However, the long-term corrosion problem of aluminum in aqueous electrolytes remains a major problem.

This study addressed the problem of the aluminum current collector corrosion. Naturally, aluminum is covered with a thin oxide layer, making it relatively stable. However, depending on the electrolyte pH and electrode potential, this layer can be damaged, causing rapid corrosion, which leads to poor electrode performance and capacity fade. Previously, it has been shown that chromate conversion coatings (CCC) can successfully passivate aluminum's surface with negligible increase in electrical resistance [3,4]. In this work, corrosion properties of pristine, CCC and non-chromate conversion passivated (Iridite NCP™) aluminum current collectors were studied by cyclic (CV) and linear sweep voltammetry (LSV) at various pH values. Tafel analysis of studied samples revealed that CCC shows the lowest corrosion current density, indicating its superior resistance, while pristine aluminum and NCP foil exhibit similar behavior. Alongside surface passivating coatings, different electrolyte additives are explored as potential corrosion inhibitors. For example, CVs recorded in electrolyte containing 0.1M sodium phosphate show sharp drop in current density after the first CV scan for all of the studied samples. NASICON-structured $NaTi_2(PO_4)_3$ (NTP) electrodes cast on aluminum foil also perform better (show higher capacity) when phosphate is present in the electrolyte. Overall, results indicate that electrolyte additives, as well as passivating coatings can be used to suppress the aluminum current collector corrosion in aqueous batteries, leading to enhanced performance and making aqueous batteries a viable alternative to organic ones.



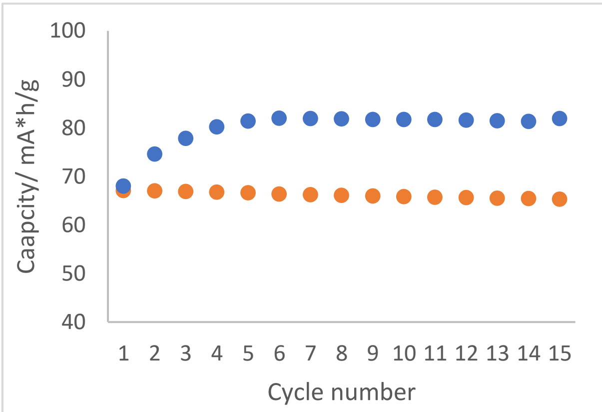


Fig 1. First two CV scans on aluminum foil(left) and galvanostatic cycling of NTP (right) in 1M Na_2SO_4(yellow) and 0.85M Na_2SO_4 + 0.1M Na_3PO_4(blue) electrolytes

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[1] L. Suo et al., "Water-in-salt" electrolyte enables high-voltage aqueous lithium-ion chemistries, Science **350**, 938-943 (2015)
[2] X. Wang et al., Inhibition of anodic corrosion of aluminum cathode current collector on recharging in lithium imide electrolytes, Electrochimica Acta **45**, 2677-2684 (2000)
[3] N. Piao et al., Corrosion resistance mechanism of chromate conversion coated aluminum current collector in lithium-ion batteries, Corrosion science **158**, 108100 (2019).
[4] S. Gheyani et al., Chromate conversion coated aluminum as a lightweight and corrosion-resistant current collector for aqueous lithium-ion batteries. Journal of Materials Chemistry A **4**, 395-399 (2016).