World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:18, No:09, 2024

Mesocarbon Microbeads Modification of Stainless-Steel Current Collector to Stabilize Lithium Deposition and Improve the Electrochemical Performance of Anode Solid-State Lithium Hybrid Battery

Authors : Abebe Taye

Abstract : The interest in enhancing the performance of all-solid-state batteries featuring lithium metal anodes as a potential alternative to traditional lithium-ion batteries has prompted exploration into new avenues. A promising strategy involves transforming lithium-ion batteries into hybrid configurations by integrating lithium-ion and lithium-metal solid-state components. This study is focused on achieving stable lithium deposition and advancing the electrochemical capabilities of solid-state lithium hybrid batteries with anodes by incorporating mesocarbon microbeads (MCMBs) blended with silver nanoparticles. To achieve this, mesocarbon microbeads (MCMBs) blended with silver nanoparticles are coated on stainless-steel current collectors. These samples undergo a battery of analyses employing diverse techniques. Surface morphology is studied through scanning electron microscopy (SEM). The electrochemical behavior of the coated samples is evaluated in both half-cell and full-cell setups utilizing an argyrodite-type sulfide electrolyte. The stability of MCMBs in the electrolyte is assessed using electrochemical impedance spectroscopy (EIS). Additional insights into the composition are gleaned through X-ray photoelectron spectroscopy (XPS), Raman spectroscopy, and energy-dispersive X-ray spectroscopy (EDS). At an ultra-low N/P ratio of 0.26, stability is upheld for over 100 charge/discharge cycles in half-cells. When applied in a full-cell configuration, the hybrid anode preserves 60.1% of its capacity after 80 cycles at 0.3 C under a low N/P ratio of 0.45. In sharp contrast, the capacity retention of the cell using untreated MCMBs declines to 20.2% after a mere 60 cycles. The introduction of mesocarbon microbeads (MCMBs) combined with silver nanoparticles into the hybrid anode of solid-state lithium batteries substantially elevates their stability and electrochemical performance. This approach ensures consistent lithium deposition and removal, mitigating dendrite growth and the accumulation of inactive lithium. The findings from this investigation hold significant value in elevating the reversibility and energy density of lithium-ion batteries, thereby making noteworthy contributions to the advancement of more efficient energy storage systems.

Keywords : MCMB, lithium metal, hybrid anode, silver nanoparticle, cycling stability
Conference Title : ICEED 2024 : International Conference on Environmental Engineering and Development
Conference Location : San Francisco, United States
Conference Dates : September 26-27, 2024