A Novel Poly (Vinyl Alcohol) – Boric Acid Gel Electrolyte for Lead Acid Battery Storage

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Lead-acid batteries are essential due to their cost effectiveness and reliability, but the environmental impact and safety concerns of traditional liquid electrolytes necessitate alternative solutions. Gel electrolytes, which enhance stability and safety by encapsulating liquid electrolytes in a solid-like form, are a promising substitute. This study focuses on developing and optimizing a novel polymer gel electrolyte composed of polyvinyl alcohol (PVA) and boric acid (BA). The effects of different gel electrolyte compositions, varying the types and amounts of gelling agents, on the electrochemical performance of lead-acid batteries were investigated. The creation of crosslinking bonds between PVA and BA, highlighting their chemical interactions, was confirmed by structural characterization techniques, including Fourier-Transform Infrared (FTIR) spectroscopy. It was revealed that the combination of PVA and BA in the electrolyte is defined by temperature-dependent hydrogen bonding, which influences the crosslinking within the polymer matrix. Notably, the broad band around 3400 cm^{-1} in the PVA spectrum diminishes in intensity with increasing BA concentration, indicating the formation of covalent crosslinks between polymer segments. Electrochemical analysis, including cyclic voltammetry and electrochemical impedance spectroscopy, was used to evaluate the PVA-BA gel electrolyte's performance. The optimal composition (labeled as PE-2), with 40 wt% BA relative to PVA, exhibited superior anodic peak values, lower resistance (156.4 Ω), and higher conductivity (0.502 S m^{-1}). The increase in conductivity at elevated temperatures is attributed to complex molecular interactions, making the PVA-BA gel electrolyte a promising candidate for practical battery applications.

Keywords: Polymer Gel Electrolyte, Cyclic Voltammetry, Electrochemical Impedance, Fourier-Transform Infrared Spectroscopy

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