UDC 621.355

SILICON BASED COMPOSITE ANODES FOR LITHIUM-ION BATTERIES

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Introduction: Lithium-ion batteries (LIBs) are essential for modern energy storage, powering devices from smartphones and laptops to electric vehicles and renewable energy systems. Conventional graphite anodes, with a capacity of approximately 372 mAh/g, fall short of the energy demands of emerging technologies. Silicon, with a theoretical capacity nearing 4200 mAh/g, presents a highly promising alternative; however, its practical application is limited by significant volume expansion and poor cycling stability during charge–discharge cycles. Both domestic and international studies (e.g., by Kim et al. and Toki et al.) have explored alternative materials such as transition metal oxides and tin-based compounds, yet these too suffer from structural degradation and volumetric instability. This report proposes the development of a composite anode by integrating silicon with graphene, a material noted for its excellent electrical conductivity and mechanical strength, to overcome these inherent challenges [1 – 3].

Main Part: The proposed solution is planned to be implemented using an original and economical approach based on a modified Hummers' method for synthesizing graphene oxide (GO). In our study, natural graphite at first stage is oxidized using concentrated sulfuric acid in combination with specific oxidizing agents. The resulting GO dispersion is purified through acid washing, dialysis, sonication, and centrifugation. Then the GO undergoes hydrothermal treatment and freeze-drying to produce high-quality graphene [4,5]. Subsequently, the synthesized graphene is incorporated into a composite structure by suspension in an aqueous solution containing a surfactant and a silica precursor. This mixture is reacted at an elevated temperature, washed, and freeze-dried to form a SiO_2/graphene composite. Finally, magnesiothermic reduction is applied to convert SiO_2 into silicon, yielding the desired Si/G composite. Advanced characterization techniques are utilized to verify the structure, composition, and morphology of the synthesized materials. These experiments are designed to comprehensively assess the composite's capacity, cycle stability, and potential for scalable application.

Conclusions: This study is expected to demonstrate that the integration of silicon with graphene can effectively mitigate the drawbacks of silicon anodes, particularly volume expansion and poor cycle stability. By combining silicon's high capacity with graphene's superior conductivity and structural integrity, the Si/G composite is anticipated to deliver enhanced performance, including improved capacity retention and rate capability. The proposed synthesis approach, based on the modified Hummers' method and magnesiothermic reduction, is both cost-effective and scalable, making it a viable candidate for next-generation LIB applications. The practical implications of this research are significant: successful implementation of Si/G composite anodes could lead to the development of high-performance, long-lasting lithium-ion batteries, thereby addressing a critical need in the transition to more sustainable energy solutions. Future work will focus on optimizing the synthesis process, ensuring long-term durability under real-world conditions, and exploring strategies for industrial-scale production.

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