Title of dissertation			
Conversion of Biomass Waste into Functional Carbon Materials for Sustainable Energy Applications			
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Body Text

In this dissertation, several facile and efficient synthesis approaches are developed for converting underutilized Indonesian biomass waste, specifically coconut coir, into cost-effective and sustainable functional carbon materials. These materials show significant promise for applications in energy conversion and storage technologies. The electrochemical performance of these carbon materials as electrodes in Proton Exchange Membrane Fuel Cells (PEMFCs) and Lithium-Ion Batteries (LIBs), was evaluated, resulting the following key findings:

Chapter 1 explores the use of amorphous carbon materials derived from direct pyrolysis of coconut coir for producing conductive carbon composite paper (CCP) as gas diffusion layer (GDL)of PEMFC. The carbon materials, derived through direct pyrolysis, are used to fabricate CCP. Optimal compositions, such as 70 wt.% carbon fibers and 10 wt.% carbon powder, achieve the highest electrical conductivity at 2.22 S/cm. The study emphasizes the importance of surface characteristics, including low surface roughness and small pores, in enhancing PEMFC performance. The findings reveal the promising potential of CCPs developed from coconut coir as sustainable and renewable GDL materials for PEMFC, demonstrating performance comparable to commercially available GDLs.

In Chapter 2, the structural improvement of amorphous carbon from coconut coir obtained by the method in Chapter 1 was carried out through a Ni-based catalytic graphitization. This strategy efficiently allows for the formation of graphitic carbon nanostructures at 1200 oC, a temperature lower than that required for conventional graphitization methods, saving energy and simplifying production steps. The resulting well-ordered graphitic structure exhibits good electrochemical performance with a specific capacity of 192.6 mAh/g, good cycling stability, and excellent rate performance. The good electrochemical characteristics of this carbon graphite make it a promising alternative material for LIB anodes, providing a sustainable solution with a low-energy process and renewable raw materials.

In Chapter 3, an advanced synthesis approach is introduced to further improve the structure and properties of the previously synthesized graphitic carbon material from Chapter 2, by employing a combined Ni-based catalyst and potassium hydroxide (KOH) in a one-pot graphitization process. This simple and cost-effective synthesis method allows for the simultaneous generation of graphitic and pore structures, resulting in porous graphitic carbon materials. The synergistic interaction between K and Ni metals initiates the formation of an early-stage graphitic structure at a lower temperature, around 800 oC, promoting the growth of larger graphitic clusters. As the LIB anode, 1000-ANi-KOH delivers the highest reversible capacity of 451.83 mAh/g at 0.05C, related to the optimal contribution between the graphitic structure and surface area. The unique characteristics of porous graphitic carbon enhance Li-ion and electron transport, resulting in increased active sites and improved performance. Incorporating the Ni-KOH reaction in this one-pot graphitization process proves to be a highly effective and energy-efficient method for converting coconut coir waste into a suitable material for LIB anodes.

In summary, this research demonstrates prospective technology for biomass conversion into functional carbon material as new insight on shifting technology from fossil based to bio-based resources. Valorizing agricultural waste not only addresses environmental concerns by providing eco-friendly waste management but also reduces reliance on fossil fuels to achieve sustainable energy solutions.

Photos

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