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Title of dissertation			
Cellulose-Based Polymer Electrolytes Exploring Their Applications in Li-ion Batteries			
RONPAKU Fellow			
Name	**Qolby SABRINA**		
Position	Junior Researcher	ID No.	R12004
Department	Research Center for Advanced Materials		
Institution	National Research and Innovation Agency (BRIN)	Nationality	Indonesia
Japanese Advisor			
Name	Hiroshi UYAMA		
Position	Professor	Institution	Department of Applied Chemistry Graduate School of Engineering, The University of Osaka

Body Text

This dissertation explores various techniques to enhance the properties of cellulose for use as a polymer electrolyte in lithium-ion batteries. Indonesia has an abundant cellulose supply derived from coconut and palm oil production. Cellulose is being explored as a polymer electrolyte due to its low cost, eco-friendliness, and renewability. The hydroxyl (-OH) groups in cellulose act as electron donors for coordinating with lithium ions, as evaluated through the following key findings:

Chapter 1 introduces on bacterial cellulose (BC) utilization as an ion-storage polymer. The high crystalline structure of BC compared to other cellulose types causes a lithium-ion interaction inhibitor. However, in polymer electrolyte systems, high crystallinity often results in poor ionic conductivity. In this study, the crystalline structure of bacterial cellulose was reduced using simple and conventional techniques. First, BC was modified through drying techniques, which are critical for controlling the pore structure and optimizing the lithium salt absorption process. The drying process disrupts intermolecular and intramolecular hydrogen bonding networks. Freeze-drying creates a more porous structure for enhanced electrolyte absorption compared to oven-drying. Subsequent modifications involved the addition of carboxymethyl cellulose (CMC) and glycerol. Glycerol acts as a plasticizer, disrupting intermolecular hydrogen bonds between cellulose chains. CMC serves as a stabilizer, preventing aggregation and forming a homogeneous polymer matrix. In the final modification, acetyl groups ($-COCH_3$) were introduced to bacterial cellulose dissolved in a DMAC/LiCl system and continue by electrospinning. This approach effectively reduced crystallinity and increased porosity in the polymer matrix, outperforming traditional techniques such as drying and polymer blending.

Chapter 2 highlights the reinforcement of cellulose into polyethylene oxide (PEO) matrices. The molecular weight of PEO significantly influences mechanical properties and ionic diffusion. Higher molecular weight (PEO#600,000) provides superior structural integrity and cycling performance. In this study, nanocellulose as an additional polar group was facilitated lithium-ion mobility and enhanced the formability of polymer membranes. The resulting well-balanced nanocellulose-PEO structure exhibited improved performance, achieving a specific capacity of 131 mAh/g.

Chapter 3 focuses an experimental and simulation-based approach to investigate how substituent hydroxyl groups in cellulose derivatives promote ion transport. Derivatives such as hydroxypropyl methylcellulose (HPMC), hydroxypropyl cellulose (HPC), and hydroxyethyl cellulose (HEC) were investigated for their interactions with nanocellulose and lithium salt (LiTFSI). The substituent hydroxyl groups in these cellulose derivatives facilitated the dissociation of LiTFSI and improve lithium-ion mobility. Specifically, the methoxy substituent group in HPMC enhanced polarity, enabling greater dissociation of lithium salts. HPMC demonstrated the highest ionic conductivity (1.93×10^{-4} S/cm).

In summary, this research presents sustainable and innovative strategies for developing cellulose-based polymer electrolytes. These approaches address key safety and performance challenges of next-generation lithium-ion batteries.

Photos

Laboratory experiments conducted as part of the RONPAKU research project

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