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Characterization and investigation of lignin derived silicon-carbon nanocomposite anode for lithium-ion battery

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Converting lignin to high-value chemicals and products along with biofuel production will substantially enhance the economic viability thus contributing to the success of a biorefinery. Silicon has gained increasing attention because of its high specific capacity compared to the commonly used graphite negative electrode in lithium-ion batteries (LIBs). However, the process of lithiation and delithiation inevitably leads to volume expansion of silicon, which causes rapid capacity fading and electrode cracking. In this study, a 3-dimensional, interconnected Si/C composite synthesized from Kraft lignin and silicon nanoparticles is shown to have a high specific capacity of 2932 mAh/g and was reversibly cycled at 0.72A/g with a 2130 mAh/g capacity over 85 cycles as a LIB negative electrode. In order to obtain a mechanistic understanding of the effect of lignin properties and processing conditions on the mechanical and electrochemical properties of the lignin-derived electrode materials, the synthesis process of Si/C nanocomposites was investigated in an analytical micropyrolyzer–GC/MS. The product distributions, including gas, liquid, and solid residue, were anylized. The morphology, pore structure, conductivity, interfacial chemistry, mechanical behavior of the Si/C nanocomposites were further characterized by XRD, BET, SEM/in-situ TEM, conductance measurement, FT-IR/Raman/XPS, and nano-indentation. This study establishes a link between lignin source, synthesis condition, properties of Si/C nanocomposite materials and their electrochemical performance and durability as electrodes in the next generation LIBs.