# Lignin-Derived Hard Carbon: A Promising and Economically Viable Amorphous Carbon Anode Material for Sodium-Ion Batteries

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The study investigated the impact of pre- and post-treatment conditions on the electrochemical parameters of sodium-ion battery (SIB) half-cells. It introduces a novel amorphous carbon anode material derived from lignin (LDC), showcasing a versatile microstructure suitable for sodium-ion batteries. Twelve distinct amorphous hard carbons were successfully synthesized using combinations of hydrothermal carbonization (HTC) and/or pyrolysis of lignin, followed by an assessment of their sodium storage capabilities in a half-cell SIB setup. The resulting microstructure of the amorphous carbon varied depending on the temperature treatment conditions, influencing the electrochemical performance in sodium-ion batteries through defects and the degree of graphitization. Notably, among the different hard carbon materials, pre-pyrolyzed LDC-300-1400 exhibited the most favorable outcomes, demonstrating a reversible capacity of 359 mAh $g^{-1}$, a 1$^{st}$ cycle coulombic efficiency of 81%, and excellent rate capabilities. Hydrothermally pre-treated LDCs showed a slightly lower specific capacity value, reaching up to 337 mAh $g^{-1}$ (Fig. 1). The Full Width at Half Maximum (FWHM) and $I_D/I_G$ ratio values were found to be correlated with the synthesis temperature, demonstrating the tunability of the microstructure of synthesized materials and their power and energy storage properties in SIB applications. This research not only introduces a highly promising, economically viable amorphous carbon anode for sodium-ion batteries but also outlines a strategy for diverse electrode material designs in prospective applications.[1]

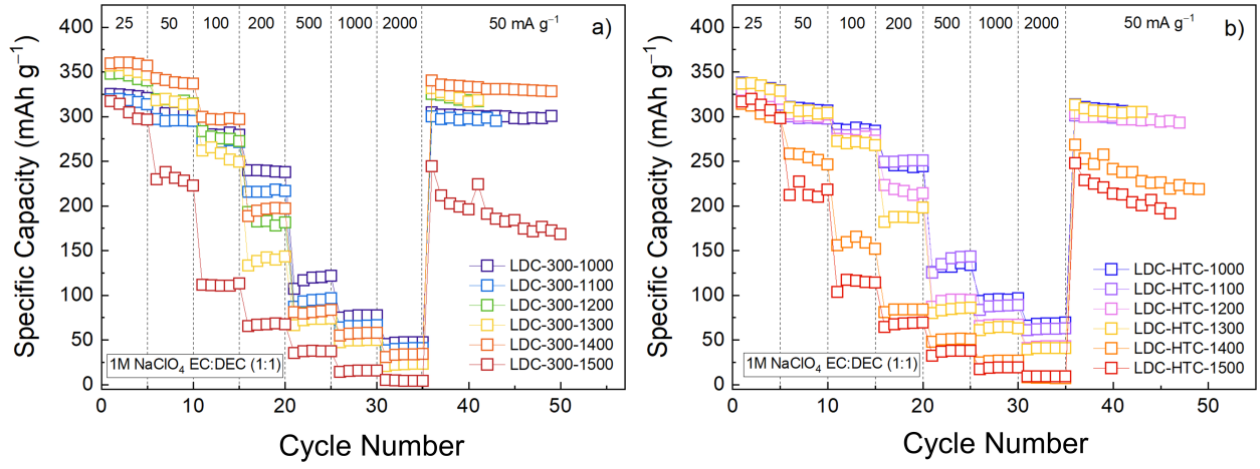


Figure 1. Rate capability for pre-pyrolyzed LDC-300-(1000-1500) (a) and hydrothermally treated LDC-HTC-(1000-1500) (b) materials on different current densities, noted in figure.

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**Reference**
[1]M. Härmas et al., 2024, J. Electrochem. Soc. https://doi.org/10.1149/1945-7111/ad28d7