Laser-induced Graphene from Lignin and its Multifunctional Applications

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Lignin is a promising precursor for renewable advanced carbon materials. Our study shows that lignin can be transformed into highly conductive, porous graphene by direct laser writing. Reactive force-field molecular dynamics simulation coupled with machine learning provides valuable insights for optimizing the fabrication of laser-induced graphene from lignin. It was revealed that laser power is a critical factor of laser induction affecting LIG properties. The mechanistic study also emphasizes the importance of lignin molecular weight, abundance of carbon atoms and aromatic rings, and interlinkages of lignin for high-quality LIG production. We also demonstrate the versatility of lignocellulose/lignin processing into a suitable substrate for LIG fabrication. The fabricated electronic devices, including all-solid-state planer supercapacitor, electrochemical and strain biosensors, and Joule heater, all show great performance. Moreover, we showcase a lignin-containing ink in 3D printing for LIG production. This fully biomass-based ink enhances the z-axis utilization in LIG electronic devices, significantly boosting their performance in energy storage. Overall, the proposed laser-enabled lignin/lignocellulose upgrading strategy would open a new avenue to the facile, versatile, scalable fabrication of low-cost and renewable multifunctional graphene-based electronics.

Keywords: Laser-induced graphene, direct laser writing, lignin, cellulose, electronics