

AI-Empowered Synthesis of Organic Waste-Derived Functional Carbons towards Energy and Environmental Sustainability

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Abstract

Solid waste pollution (i.e., plastic pollution) and climate change are interconnected global environmental challenges. To simultaneously address these two critical environmental issues, we upcycle solid waste into functional carbon materials, enabling high-performance post-combustion CO₂ capture in a transformative and practical manner. We conduct systematic studies, including experimental validations, numerical simulations, and machine learning (ML)-empowered optimizations to provide detailed guidelines for upcycling plastic wastes into porous carbons with high-performance CO₂ capture. This holistic and multidisciplinary strategy, combining materials science, AI algorithms, and environmental engineering, offers a carbon-negative and economically viable path to simultaneously mitigate climate change and achieve a circular plastic economy. Moreover, the similar functionalized carbon materials are verified for catalytic CO₂ conversion, energy storage (i.e., supercapacitors), which are beneficial to achieving circular carbon economy and solidifying energy security. In addition, from both environmental and economic perspective, upcycling solid waste into advanced carbon materials is highlighted as one promising and practical alternative to sustainable waste management and several UN SDGs including Goals 7 and 13.

Keywords: Circular carbon economy, Energy storage, Active learning, Environmental impacts, Economic feasibility

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