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Design and Synthesis of Fully Benzoxazine-Based Porous Organic Polymer Through Sonogashira Coupling Reaction for CO_2 Capture and Energy Storage Application

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Abstract : The growing production and exploitation of fossil fuels have placed human society in serious environmental issues. As a result, it's critical to design efficient and eco-friendly energy production and storage techniques. Porous organic polymers (POPs) are multi-dimensional porous network materials developed through the formation of covalent bonds between different organic building blocks that possess distinct geometries and topologies. POPs have tunable porosities and high surface area making them a good candidate for an effective electrode material in energy storage applications. Herein, we prepared a fully benzoxazine-based porous organic polymers (TPA–DHTP–BZ POP) through sonogashira coupling of dihydroxyterephthalaldehyde (DHPT) and triphenylamine (TPA) containing benzoxazine (BZ) monomers. Firstly, both BZ monomers (TPA-BZ-Br and DHTP-BZ-Ea) were synthesized by three steps, including Schiff base, reduction, and mannich condensation reaction. Finally, the TPA–DHTP–BZ POP was prepared through the sonogashira coupling reaction of brominated monomer (TPA-BZ-Br) and ethynyl monomer (DHTP-BZ-Ea). Fourier transform infrared (FTIR) and solid-state nuclear magnetic resonance (NMR) spectroscopy confirmed the successful synthesis of monomers as well as POP. The porosity of TPA–DHTP–BZ POP was investigated by the N_2 absorption technique and showed a Brunauer–Emmett–Teller (BET) surface area of 196 $m^2\ g^{-1}$, pore size 2.13 nm and pore volume of 0.54 $cm^3\ g^{-1}$, respectively. The TPA–DHTP–BZ POP experienced thermal ring-opening polymerization, resulting in poly (TPA–DHTP–BZ) POP having strong inter and intramolecular hydrogen bonds formed by phenolic groups and Mannich bridges, thereby enhancing CO_2 capture and supercapacitive performance. The poly(TPA–DHTP–BZ) POP demonstrated a remarkable CO_2 capture of 3.28 mmol g^{-1} and a specific capacitance of 67 F g^{-1} at 0.5 A g^{-1}. Thus, poly(TPA–DHTP–BZ) POP could potentially be used for energy storage and CO_2 capture applications.

Keywords : porous organic polymer, benzoxazine, sonogashira coupling, CO_2, supercapacitor
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