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Effects of various cold plasma atmospheres and external influencing factors on the adsorption of formaldehyde gas by bamboo-based carbon microfibers

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ABSTRACT

To effectively enhance the adsorption performance of gaseous formaldehyde (HCHO) by bamboo-based carbon microfibers (BCMFs), the active oxygen (O) and nitrogen (N)-containing functional groups were rapidly introduced by cold plasma. The effects of plasma time, plasma atmospheres including oxygen (O_2), nitrogen (N_2), air, and argon (Ar) as well as ambient temperature, flow rate, and initial concentration of gaseous HCHO on the adsorption performance of BCMFs were comprehensively investigated. The typical kinetic, isothermal, and thermodynamic models were also evaluated. The O_2-plasma activated BCMFs showed the most serious etching effects among four atmospheres. The adsorption capacities were ranked as BCMF-800-N-10 (203.87 mg g^{-1}) > BCMF-800-Ar-10 (166.26 mg g^{-1}) > BCMF-800-Air-10 (151.28 mg g^{-1}) > BCMF-800-O-10 (144.21 mg g^{-1}), which were 112.99%, 73.69%, 58.04%, and 50.66% higher than the control, respectively. The O–C=O and pyrrolic N groups were more easily formed onto BCMF-800-N-10. The Langmuir and the Freundlich models displayed the excellent fitting properties. The optimal kinetic model tended to transfer to the pseudo-second-order from the pseudo-first-order after cold plasma modification. The BCMFs activated by plasma showed a synergistic single/multi-layer adsorption mechanism with a complex physicochemical adsorption. The HCHO adsorption performance was positively correlated with its concentrations but negatively correlated with environmental temperature.

1. Introduction

Formaldehyde (HCHO) is a prevalent and toxic indoor air pollutant (Xiong et al., 2024). Human exposed to HCHO atmosphere may induce dizziness, nausea, headache, the irritations of eye, skin, and respiratory system, even teratogenic disease, leukemia and cancer (Na et al., 2019; Yue et al., 2021). Numerous approaches have been tried to mitigate gaseous formaldehyde pollution. Adsorption is a simple and feasible method with its good availability, low cost, and easy operation (Su et al., 2020). Coal-based and biomass-based (wood, bamboo, and coconut) activated carbon (AC) have been widely used as commercial HCHO sorbent with the available manufacturing production (Lee et al., 2013). However, theses AC products suffer from insufficient surface chemical active sites for capturing HCHO molecules (Vikrant et al., 2020), which are generally modified by the conventional wet impregnation with long period, poor performance, and secondary pollution (Laureano-Anzaldo et al., 2021). Therefore, developing an efficient and green adsorbent for removing indoor HCHO is imminent.

Previous literature reported that activation or doping of carbon-based materials (CBMs) with O, N-containing functional groups through impregnation, sintering, and blending can greatly enhance the adsorption capabilities (An et al., 2012; Unglaube et al., 2024; Zhao et al., 2023). The primary role of O-containing functional groups is to modify the electronic structure, thereby increasing the dispersion and

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MOF衍生物/生物质碳基钠电池电极材料的研究进展

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摘　要：钠（Na）电池具有原料成本低、储量大、能量密度较大等特点，是极具发展前景的下一代电池材料之一。生物质具有可持续发展、环境友好、结构多样和高反应活性等优点。由金属-有机骨架（MOF）衍生物和生物质材料制备的多孔碳基材料能够提供主体框架，利用孔结构增大碳的层间间距，保证足够的层间空间用于Na^+插入，促进电子转移，从而提高电池的电化学性能。综述了常见的生物质碳基材料、MOF及其衍生物、MOF/生物质复合材料钠电池负极材料的相关研究进展，以期为开发高性能MOF衍生物/生物质碳基复合钠电池电极材料提供理论依据。

关键词：钠电池；生物质；MOF；复合材料；电极材料
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The Review on the Research Progress of MOF Derivatives/Biomass Carbon-Based Electrodes in Sodium Battery

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Abstract: Sodium batteries with the inherent advantages of low cost, abundant amount and large energy density is considered as one of the most promising anode materials for the next generation of batteries. Biomass has the advantages of sustainability, eco-friendly property, structural diversity and high reactivity. The porous carbon-based materials made from MOF derivatives and biomasses can provide the main frame, increase the interlayer spacing of carbon by the pore structure enlargement, which can ensure sufficient interlayer space for Na^+ insertion, and promote electron transfer. Hence, it is used to improve the electrochemical performance of the battery. The application of biomass materials, MOFs and their derivatives, and MOF/biomass composites in sodium battery anodes was reviewed in this article, and their electrochemical performance was also analyzed. This provided a theoretical basis for the preparation of high-efficient MOF derivatives/biomass anode in sodium battery.

Key words: Sodium batteries; Biomass; MOF; Composites; Electrode

生物质及其衍生材料具有可持续性、环境友好性、结构多样性和高反应活性等优点，能够缓解化石燃料的过度使用所带来的能源危机和环境污染，在绿色储能材料中具有巨大的发展潜力[1-3]。随着电动汽车、可穿戴电子产品和智能手机的快速发展，以及市场对储能设备需求的不断增加，近年来，锂离子电池（LIBs）[3]、钠离子电池（SIBs）[4]及电容器等备受国内外研究者的关注[5]。LIBs虽已被广泛应用于3C产品和新能源汽车等领域，但在大规模储能系统中，LIBs因原料总体储量偏低和成本较高等问题限制了其快速发展。相比于LIBs，SIBs的钠资源丰富，且钠和锂原子两者具有相似的化学性质和反应机理，因此成为LIBs潜在的替代材

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