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Research Scholarship for International Graduate Students

Eco-friendly biochar-based materials in removal of contaminants from aqueous solutions: Fabrication, characterization and applications

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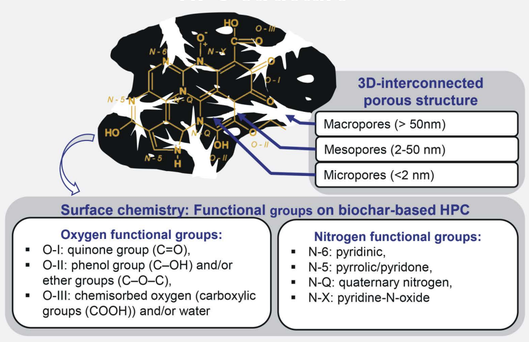
ABSTRACT

Eco-friendly biochar (BC)-based materials presented as efficient sustainable materials for water treatment. BC-based HPCs were developed from rice husk BC by a hard-templating method using a nature SiO_2 template and activation process BC-based HPC demonstrated a very high adsorption capacity (265 mg g^{-1}) and adsorption rate (0.90 g mg^{-1} min^{-1}) for copper ions. The large SSA ensures a high adsorption capacity, while the mesoporosity are preferable for faster ion removal during the adsorption process. The BC-based HPC electrodes exhibited excellent electrochemical properties with a high specific capacitance as well as good reversibility for capacitive charge storage. Significantly, the large ion-accessible surface area, the creation of hierarchical porosity, and the presence of mesoporosity are critical for the high-performance electrosorption of ions. In addition, an active MnO_2/BC composite (MBC) was successfully synthesized to enhance the As(III) removal. As a result, MBC showed a high adsorption capacity for As(III), which was tenfold higher than that of BC. This improvement can be ascribed to the redox transformation of As(III) via MnO_2, resulting in the more effective adsorption of As(V) species. Importantly, a powerful transformation capability of As(III) via MBC was presented; namely, only 5.9% As(III) remained in solution under neutral conditions. Most interestingly, the application of MBC in the treatment of simulated groundwater demonstrated an efficient arsenic removal of 94.6% and a concentration of arsenic as low as the 10 µg L^{-1} WHO guideline.

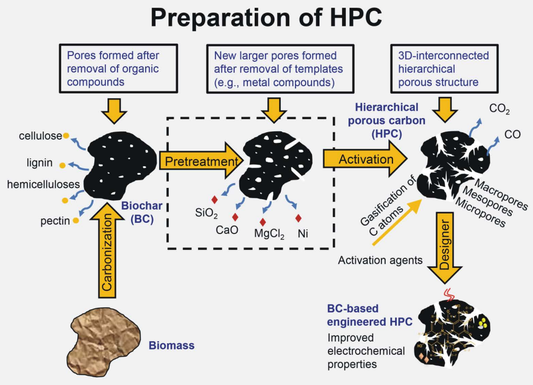
RESULTS

BC-BASED HIERARCHICAL POROUS CARBON (HPC)

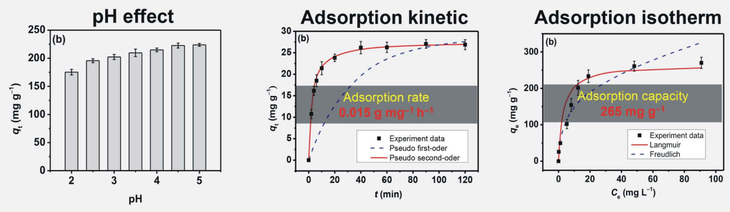
HPC structure



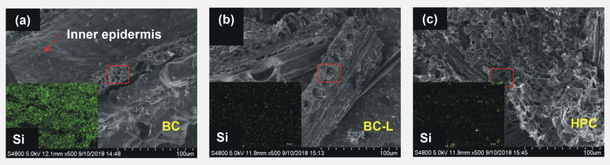
Preparation of HPC



Application for adsorption of copper ions

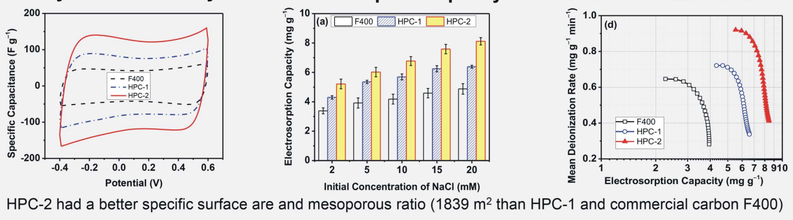


Morphological characteristics and element analysis



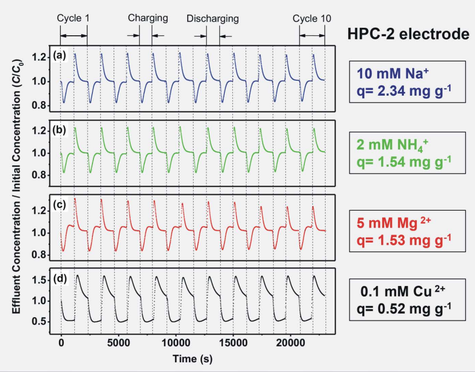
(1)The ratio of KOH:BC-L = 3, the activation time under CO_2 gas = 0.5 h and the activation temperature = *800* °C.

Electrochemical behavior and eletrosorption performance



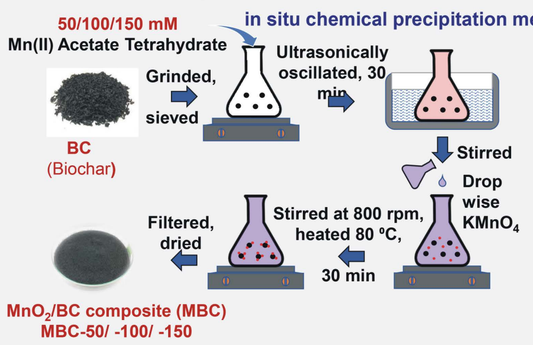
HPC-2 had a better specific surface are and mesoporous ratio (1839 m^2 than HPC-1 and commercial carbon F400)

Application for electrosorption of inorganic compounds

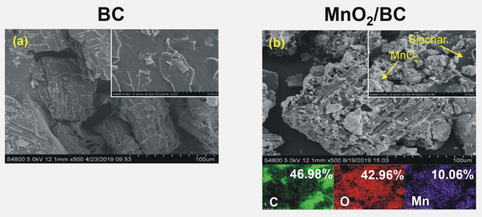


BC-BASED COMPOSITE

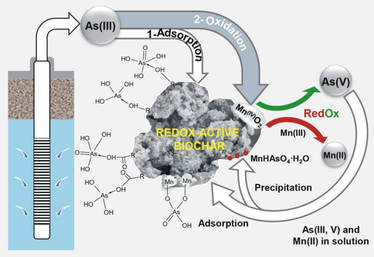
Preparation of HPC



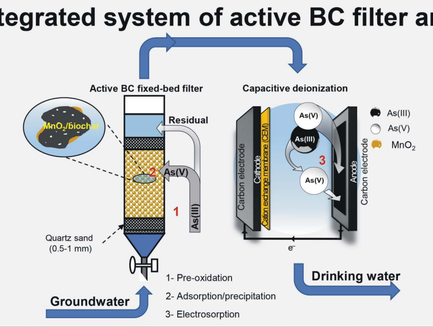
Morphological characteristics and element analysis



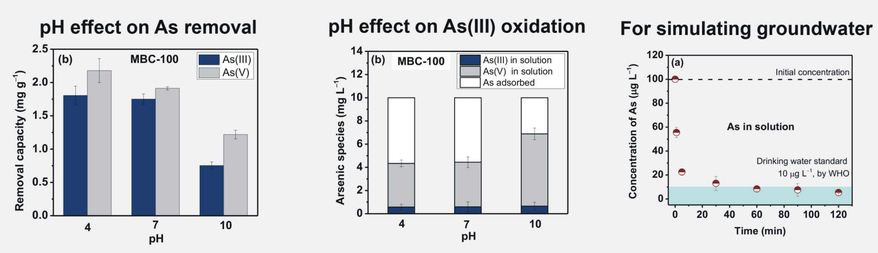
Oxidation and removal As(III) via MnO_2/BC



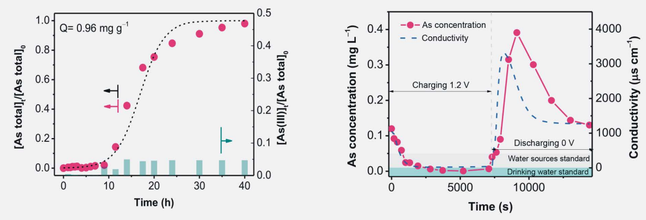
Integrated system of active BC filter and CDI



Oxidation and removal As(III) via MnO_2/BC



Removal of arsenic via MnO_2/BC filter and CDI



CONCLUSIONS

- ❑ The large SSA ensures a high adsorption capacity of Cu(II), while the mesopores are preferable for faster Cu(II) removal during the adsorption process.
- ❑ The large SSA, unique hierarchical porosity, and high mesoporosity of the HPC electrode are critical for the high-performance electrosorption of ions (i.e., achieving a high electrosorption capacity, fast deionization rate, and energy-efficient desalination).
- ❑ As(III) can be oxidized to As(V) and subsequently removed by MnO_2/BC composite (MBC). pH has a strong effect on arsenic removal due to electrostatic repulsion. Redox transformation plays a crucial role in enhancing the removal of As(III).
- ❑ Active MnO_2/BC effective oxidized As(III) to As(V) and prior removed As. Meanwhile, the electrosorption process by capacitive deionization (CDI) was subsequently applied for post-treatment of arsenic as well as other ions in groundwater.

SELECTED PUBLICATIONS

1. **Dinh Viet Cuong**, Po-Chang Wu, Lo-I Chen, Chia-Hung Hou, 2020. Active MnO_2/biochar composite for efficient As(III) removal: Insight into mechanisms of redox transformation and adsorption. *Water Research*, 116495, *Q1, SCI/IF: 9.130*.
2. **Dinh Viet Cuong**, Po-Chang Wu, Nei-Ling Liu, Chia-Hung Hou, 2020. Hierarchical porous carbon derived from activated biochar as an eco-friendly electrode for electrosorption of inorganic pollutants. *Separation and Purification Technology*, 116813 (Q1, SCI-IF: 5.774).
3. **Dinh Viet Cuong**, Nei-Ling Liu, Nguyen Viet Anh, Chia-Hung Hou, 2019. Meso/micropore-controlled hierarchical porous carbon derived from activated biochar as a high-performance adsorbent for copper removal. *Science of The Total Environment*, 692, 844-853 (Q1, SCI-IF: 6.551).

ACKNOWLEGEMENT

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