Exploration of the Optimal Thickness and N-doping Concentration of WBM Biochar for Photothermal Water Purification

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The thermal conversion efficiency of photothermal water purification systems is influenced by material composition and physical structure [1]. Wood biochar monoliths (WBM) are emerging as sustainable materials for photothermal water purification [2]. While previous studies note that nitrogen doping (N-doping) biochar and increased thickness both independently increase the evaporation rate [3; 4], optimizing their combined impact on evaporation efficiency remains underexplored, and can aid future researchers in developing optimal photothermal filters to mass-produce.

In this study, we investigate the effects of N-doping concentration and sugar maple WBM thickness on photothermal performance by examining their influence on evaporation. We hypothesize that as thickness and N-doping concentration increase, evaporation rate and thus photothermal performance will increase. Biochar monoliths were fabricated through pyrolysis at 700ºC, using melamine as a nitrogen source at 2%wt. Structural characterization was performed using scanning electron microscopy (SEM) and X-ray diffraction (XRD). Evaporation tests were conducted under controlled solar simulation using a calibrated cold light source at 900 lumens. Surface and bottom temperatures were recorded using a Type K thermocouple and an infrared sensor.

Our results show that N-doping enhances photothermal performance, and that thicker monoliths exhibited improved thermal localization and higher steady-state surface temperatures, suggesting a synergistic effect between doping and geometry. These findings demonstrate that optimizing both chemical composition and physical structure can markedly improve the solar evaporation efficiency of biochar-based systems, allowing for scalable, sustainable, clean water technologies. Future directions include durability testing, integration into modular desalination units, and performance evaluation under variable solar conditions.

Citations

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