

Abstract

The rapid discharge of synthetic dyes into aquatic ecosystems presents significant environmental and health issues, underscoring the necessity for effective and sustainable treatment technology. This study synthesized and extensively characterized a bimetallic Ni–Co metal–organic framework (MOF) adorned with nanobiochar to investigate its catalytic potential in dye degradation. The integration of nanobiochar into the MOF matrix enhanced structural stability, electrical conductivity, and surface functionality, mitigating the intrinsic limits of pristine MOFs. The synthesized composites were examined through X-ray diffraction, Fourier-transform infrared spectroscopy, scanning electron microscopy, and UV–Vis spectroscopy, validating the successful creation of highly porous and functionalized hybrid frameworks. The catalytic study on the materials revealed that the Ni–Co MOF–nanobiochar composite displayed significantly higher dye degradation efficiency and recyclability relative to pristine MOFs, across diverse evaluation variables including pH, catalyst dosage, and irradiation duration. The enhanced performance is due to the synergistic interaction of bimetallic active sites with nanobiochar, which promoted efficient charge transfer, augmented the adsorption of dye molecules. The findings indicate that Ni–Co MOF nanobiochar composites are effective, sustainable catalysts for wastewater treatment and possess promise for further environmental remediation applications.