Abstract Biochar (Bio) has gained prominence as an economical and effective adsorbent for eliminating dyes from water, attributed to its expansive surface area and eco-friendly nature.Rigorous characterizations, including scanning electron microscopy, X-ray photoelectron spectroscopy, Fourier-transform infrared spectroscopy, and Brunauer-Emmett-Teller analysis, validate the shell's uniform morphology, chemical robustness, and enhanced surface chemistry, which facilitate robust CV binding via electrostatic, ?-?, and coordination interactions.In environmental remediation, PB analogues have shown exceptional promise for removing heavy metals, radionuclides, and organic pollutants, as demonstrated by studies like Zhang et al. [27], who reported efficient methylene blue adsorption using iron-based PB nanoparticles, and Wu et al. [28], who developed cobalt-PB composites for enhanced dye uptake.2.2 Structural characterization The morphology of the optimized core-shell nanostructure catalysts was analyzed using field emission scanning electron microscopy (FE-SEM, INCA 400 Oxford) with an EDS analyzer, and high-resolution transmission electron microscopy (HR-TEM, JEM-2010HT).Advanced characterizations, such as scanning electron microscopy, X-ray photoelectron spectroscopy, and Fourier-transform infrared spectroscopy, confirm the shell's structural integrity and chemical composition, revealing its pivotal role in enhancing adsorption through abundant active sites and optimized surface interactions.Electrical potentials obtained against the AgIAgCl reference electrode were converted to the RHE scale using the following formula: ERHE = EAgIAgCl + 0.059 pH + E0AgIAgCl (1) where ERHE represents the conversion potential against RHE; at 25 ?C, E0AgIAgCl is 0.210 V. 2.4 Adsorpion experments A solution of crystal violet (CV) with a high concentration (100 mg L-1) was prepared.Comprehensive characterizations, including scanning electron microscopy, X-ray photoelectron spectroscopy, and nitrogen adsorption-desorption isotherms, elucidate the composite's structural, chemical, and textural properties, providing insights into its enhanced adsorption performance.Keywords: Water oxidation, Dye water pollution, Oxygen vacancies, Prussian blue analogue 1 Introduction Water pollution, particularly from synthetic dyes like crystal violet (CV), remains a pressing global challenge due to their widespread use in industries such as textiles, paper, leather, and pharmaceuticals [1, 2].This innovative design harnesses the complementary strengths of biochar's porous, high-surface-area framework and ZnFePB's dense coordination sites, resulting in exceptional adsorption efficiency that significantly outperforms unmodified biochar.However, pristine Biochar often exhibits suboptimal adsorption capacity for cationic dyes like CV due to its limited density of active sites and relatively low surface charge, necessitating modifications to enhance its performance [19, 20].Prussian blue (PB) and its analogues, a class of metal-organic frameworks, have garnered significant interest for their remarkable properties, including chemical stability, low toxicity, and facile synthesis using earth-abundant metals like iron, cobalt, and zinc [21, 22].By addressing the critical need for efficient, sustainable, and cost-effective water purification technologies, this work aligns with global environmental priorities, including the United Nations' Sustainable Development Goals and Saudi Arabia's Vision 2030, which emphasize clean water access and sustainable industrial practices [37, 38].The electrochemical properties of the synthesized materials were evaluated using chronoamperometry (CA), linear sweep voltammetry (LSV), cyclic voltammetry (CV), and electrochemical impedance spectroscopy (EIS) techniques.Utilizing abundant, non-toxic metals and an eco-friendly synthesis approach, the ZnFePB/Biochar composite offers a cost-effective, sustainable solution to mitigate dye pollution, addressing a critical environmental challenge.The ZnFePB/Biochar composite holds immense promise for combating dye pollution, contributing to sustainable environmental remediation and aligning with global efforts to address water quality challenges.(hv = 1486.8 eV) radiation source..1.2.3.4.5.9.10.10.11.12.12.2.(2009).3.4.5.6.7.8.9.10.11.12.13.14.15.16.17.18.19.20.21.22.23.24.25.26.27.28.29.30.31.32.33.34.35.36.37.(2015).38.(2016).