

Green Synthesis of Iron Nanoparticles using Made Tea and Refused Tea for Dye Removal in Wastewater

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Iron nanoparticles are emerging as cost-effective and eco-friendly materials for wastewater treatment. This study developed a sustainable method for synthesizing iron-based nanoparticles using aqueous extracts of made tea and refused tea from black and green tea varieties. Refused tea, which accounts for 4–6% of Sri Lanka's total tea production, is recognized as a waste material that can be used for environmental remediation. This study allowed tea extracts (10% w/v, pH ~5.5) to react with 0.10 M FeCl₃ under mechanical stirring at room temperature for 15 minutes, for the synthesis of nanoparticles. FTIR, UV-Visible Spectroscopy, XRD, and SEM were employed for characterization. FTIR confirmed involvement of polyphenolic functional groups in iron reduction and stabilization, while Fe–O vibrations verified iron oxide formation. Nanoparticle synthesis was confirmed by UV-Vis spectra, which showed strong absorption around 390 nm. XRD indicated predominantly amorphous structures with weak reflections corresponding to α -Fe. SEM analysis revealed irregular quasi-spherical particles (30–80 nm) with agglomeration due to magnetic interactions. Synthesis yield varied among tea types, with green tea samples showing higher yields than black tea. The nanoparticles were evaluated for methyl orange dye removal under optimized conditions (50 mg/L, pH 6.5, 120 min). Black made tea nanoparticles achieved the highest removal efficiency (80.5%), followed by green made tea, green refused tea, and black refused tea nanoparticles. Increased nanoparticle dosage further improved removal efficiency. The findings demonstrate the potential of tea-derived iron nanoparticles as sustainable and efficient adsorbents for dye-contaminated wastewater treatment while promoting tea waste valorization.

Keywords: Black tea; Green synthesis; Green tea; Iron nanoparticles; Methyl orange; Refused tea; Wastewater treatment