Development of Innovative Magnetic Microbeads Containing Co-Immobilized Nanoparticles for Toxic Dye Removal

Arik, Aylin (School: Adiyaman Bilim ve Sanat Merkezi)
Kocadag, Zeynep (School: Adiyaman Bilim ve Sanat Merkezi)
Aydin, Muhammed Efe (School: Adiyaman Bilim ve Sanat Merkezi)

Water pollution caused by organic dyes is one of the main environmental problems due to their toxic effects and persistence in aquatic environments. The purpose of this project was to develop a sustainable, magnetically recoverable nanocomposite catalyst for the removal of toxic dyes before they are discharged into water sources. In this project, a ferromagnetic microbead catalyst (FeNP@SA@CTS@Ag) containing co-immobilized silver nanoparticles was synthesized using a sodium alginate and chitosan polymer matrix. The structure and magnetic properties of the microbeads were characterized by FT-IR, SEM, EDX, XRD, UV-Vis, and VSM analyses. XRD analysis confirmed the presence of Fe3O4 and metallic Ag phases, while VSM results showed that the material retained near-superparamagnetic behavior with magnetization values of approximately 13–15 emu g?¹ after coating and Ag immobilization. The catalytic activity of the microbeads was evaluated by the NaBH4-assisted reduction of methylene blue, monitored using UV-Vis spectroscopy. The reduction followed pseudo-first-order kinetics, and optimum conditions were determined as 4 mg catalyst, 4 ppm methylene blue, and 0.003 M NaBH4. Under these conditions, the catalyst showed a high mass-normalized rate constant (k????˜ 16 s?¹ g?¹) and maintained over 96% catalytic efficiency after 10 reuse cycles. The results demonstrate that these magnetically recoverable microbeads are highly efficient, reusable, and environmentally friendly catalysts for wastewater treatment applications.

Awards Won: