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Sustainable biogenic transformation of iron from industrial waste to magnetic nanoparticles

SAMI ULLAH[1], RICH CRANE[2] AND JAMES M. BYRNE[1]

[1]University of Bristol

[2]University of Exeter

Presenting Author: sami.ullah@bristol.ac.uk

Industrial wastes such as acid mine drainage (AMD) pose a significant environmental challenge, leading to elevated concentrations of ecotoxic metals in the UK and around the world [1]. Despite the adverse impact on ecosystems and human health, these wastes shelter a potential resource in the form of valuable metals. The abundance of Iron (Fe) in the AMD and many industrial wastes presents an opportunity to sustainably produce magnetic nanoparticles (MNPs). This study proposes a sustainable and novel biogenic approach for the sequential and selective recovery of iron from various wastes. Leveraging advancements in selective extracellular and intracellular nanoparticle synthesis [2], this research aims to valorise metals and metalloids into functionalized nanoparticles, particularly magnetic nanoparticles (MNP) that hold immense promise across various technological applications. However, conventional MNP synthesis methods entail unsustainable processes reliant on iron ore extraction and refining. By exploring biogenic routes facilitated by microbial pathways, particularly biologically induced magnetite (BIM) [3] this study seeks to establish a sustainable domestic supply of MNPs from industrial wastes such as AMD.

Four industrial waste samples, including three AMDs from different UK sites and one from a German company (GEH Wasserchemie), were tested. Under anoxic conditions, *Shewanella oneidensis* reduced iron in the waste using sodium lactate as an electron donor in a HEPES buffer solution (pH 7.0). The transformation occurred overnight, converting some of the waste into magnetite nanoparticles, confirmed qualitatively by a magnetic susceptibility.

Microscopic techniques revealed nanoscale magnetite particles from the GEH material and a mixture of particles and rod and flake shaped material, resembling goethite in AMDs. Mossbauer spectroscopy confirmed magnetite nanoparticle formation in the factory waste. This approach presents a promising strategy for sustainable metal recovery from industrial wastes, contributing to environmental remediation and resource utilization.

References:

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