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Recovery of valuable elements from Platinum Group Metal (PGM) tailings and synthesis of iron-based materials

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Mining operations associated with the primary production of Platinum Group Metal (PGM) in South Africa have generated and continue to generate millions of tons of mineral waste and by-products annually. These include waste rocks and tailings which are commonly stored as stockpiles in a tailings storage facility (TSF). Mine tailings have been identified as a major source of environmental impact for many mining operations and more stringent requirements have been placed on the management of TSF's. Mineral beneficiation of PGM's has become a key focus area in South Africa to ensure sustainable growth of the economy beyond mining [1]. This initiative could potentially be expanded to include associated mineral waste products which could create a suitable platform to minimize the volume of tailings stored in a TSF and reduce associated environmental impact. Finding routes for recovering value from these wastes will assist in minimizing their disposal and in making treatment processes more viable economically.

PGM tailings contain a significant portion of Al, Fe, Ca, and Mg bearing silicates which have the potential to serve as a secondary mineral source. Tailings can be reprocessed and converted into value-added products, provided that a suitable economically-viable technological process can be developed. For instance, elements such as iron could be used by the iron and steel industry [2] or as feedstock for the synthesis of nano-based materials for wastewater treatment processing [3-4], while aluminium could be used to prepare e.g. alumina [5] and magnesium could be converted to magnesite ($MgCO_3$) as a CO_2 sequestration mineral technology [6]. PGM tailings have been assessed for mineral carbonation technologies; however, efficient elemental extraction proved problematic using direct acid leaching methods [7-8].

This paper investigates the valorization potential of PGM tailings by extraction of major components via solid-solid thermochemical treatment using ammonium sulphate ($(NH_4)_2SO_4$), a widely available, low-cost, recyclable chemical agent, followed by aqueous leaching. Extraction efficiencies greater than 50% (Fe) and 60% (Al) (60%) were achieved using this process. Key variables included temperature, duration and solid-solid stoichiometric ratio used during thermochemical treatment. A combination of co-precipitation with reduction processes was then used to synthesize magnetic nano-iron particles, which could potentially be used in wastewater treatment. Detailed characterization of synthesized nanoparticles was achieved using a set of complementary techniques (XRD, ICP-OES, FTIR, TEM, and FE-SEM) which will also be presented.

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