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Green extraction technology for the extraction of iron from iron ore fines

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ABSTRACT

Large quantities of iron ore fines accumulate near iron ore mining operations and cannot be used in conventional iron ore treatment processes. Existing iron ore fines processing techniques are associated with high costs, high energy consumptions and high greenhouse gas emissions. Greater environmental concern in the last few years creates the need to develop greener extraction techniques. In this study, a green method for the extraction of iron from iron ore fines using acetylacetone ($C_5H_8O_2$) was investigated and several processes for the utilization of the extraction products were proposed.

The extraction experiments were performed on iron ore fines containing 93 wt% of hematite. In the gas phase, it was found that the extraction increases with temperature and acetylacetone flowrate but decreases with bed weight. Very low extractions were observed at all the operating conditions under investigation. The highest extraction of only 3.88 % was obtained at 9 mL/min of acetylacetone after 6 hours. The low extractions were attributed to mass transfer limitations probably associated with the passivation of the active surface of the iron ore fines. In order to overcome these limitations the extraction experiments were performed in the liquid phase (leaching). Using a 2^k factorial design method, it was found that temperature and solid to liquid ratio had significant effects on the leaching process. The highest iron extraction of 97.7% was obtained at 140 °C, 0.025:1 solid to liquid ratio and a particle size of 106 to 150 μm after 48 hours. An adapted form of the shrinking core model was used for the kinetic analysis of the leaching process and the best fit was found to be the chemical reaction controlled model. However, the calculated activation energy from the modelling was 4.22 kJ/mol suggesting that the process might be controlled by diffusion. The extraction products were easily separated from unreacted acetylacetone using a Heidolph evaporator and iron(III) acetylacetonate

crystals were formed in the process. A preliminary study showed that the gas phase recovery of iron from iron(III) acetylacetonate using hydrogen is practically feasible.

This work has shown that the proposed extraction method can be used as a platform for the development of two manufacturing processes; the production of iron nanoparticles and that of iron(III) acetylacetonate crystals. An economic feasibility study of the latter process was performed and the large net present value (NPV) of 1.153 Billion Rand, and high internal rate of return (IRR) of 63% were indicators of a profitable process.