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Direct electrodeposition of metallic iron from Fe2O3 in alkaline and eutectic media

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Significant CO2 emissions are a global concern due to environmental pollution and the greenhouse effect. As a result, the UN and the European Green Deal aim to make the global and European economies more sustainable, focusing on clean and low-carbon energy. Blast furnaces and oxygen furnaces, responsible for a large portion of steel production (71% through conventional carbothermic reduction of iron ores to produce pig iron), while the rest is produced by electric furnaces. However, all this iron production is essential for human development, yet we face the following problem: how to obtain iron sustainably and economically viable? For this challenge, electrolytic iron production has shown promise. The research aims to study the direct electrodeposition of Fe2O3 to metallic iron in alkaline and eutectic solutions. Cyclic voltammetry and electrodeposition were conducted at a potential of -1.0 V using graphite electrodes, for alkaline solutions at concentrations of 5, 10, and 18 mol/L of NaOH, and for the eutectic solution at a molar ratio of 1:2 in choline chloride and ethylene glycol, both containing 20 mmol/L of Fe2O3, at a temperature of 80°C. After identifying the best solution, the optimal Fe2O3 concentration for the solutions was investigated, varying concentrations of 10, 20, and 50 mmol/L. With the result of the best Fe2O3 concentration, a study of electrodeposition potential and current density was conducted for both alkaline and eutectic solutions. The formation of iron deposits in both solutions was examined using a scanning electron microscope, and the metal could be deposited with significantly higher current efficiency in these concentrated solutions. It is observed that most of the electrical energy applied is efficiently directed towards the reduction of iron(III) oxide into metallic iron, with another part of the energy being lost by forming hydrogen but also creating an iron layer covering the graphite electrode. The research aims to contribute to advancing the sustainable manufacture of metallic iron, promoting the use of clean energy, and transitioning to a cleaner energy matrix, and to contribute to future work improving iron electrodeposition and ferrous materials.