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Development of a high pressure hydrometallurgical process for the extraction of iron from iron oxide bearing materials

Rolfe, Wesley

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ABSTRACT

The feasibility of extracting iron from iron(III) oxide bearing materials with acetylacetone has been under investigation for many years. This is an alternate, environmentally friendly process for the recovery of iron compared to conventional processes that are energy intensive, have numerous costly process steps and produce large quantities of greenhouse gases. Iron(III) oxide bearing waste materials can be used in this process which reduces its environmental impact as it would not require waste storage.

This study investigated the feasibility of reducing the reaction time of the liquid phase extraction of iron from iron ore fines by performing the extraction at elevated pressures and temperatures. It was found that that the extraction under pressure was dependent on temperature, pressure, particle size and solid to liquid ratio. It was found that at high temperatures and long extraction times, an unknown secondary reaction occurs that consumes the desired product, iron(III) acetylacetonate, and inhibits the recovery of these crystals. This results in lower extraction yields. It was found that the side reaction was largely dependent on the temperature of the system and the amount of iron(III) acetylacetonate present. The effects of the side reaction could be limited by lower operating temperatures and reducing the total reaction times.

An optimum conversion of iron(III) oxide to iron(III) acetylacetonate of 47.2% was achieved for synthetic iron (III) oxide (> 95 wt% Fe_2O_3) at a total extraction time of 4 h, 160 °C, 0.025 g:1 mL, operating pressure of 1700 kPa, initial N_2 feed pressure of 1010 kPa and 375 rpm stirrer speed. The optimum extraction of iron from iron ore fines (> 93 wt% Fe_2O_3) to iron(III) acetylacetonate was found to be 20.7% at 4 h, 180 °C, 0.025 g:1 mL and operating pressure of 1900 kPa, initial N_2 feed pressure of 1010 kPa and 375 rpm stirrer speed. These are the optimum conditions where the side reaction is limited to improve the recovery and desired reaction conversion capabilities of the process.

The operation under pressure yielded lower conversions than that of the atmospheric leaching process developed by Tshofu (acetylacetone water system under reflux). It was also found that it was not possible to reduce the extraction time and achieve comparable extractions when operating at higher temperatures and pressures. The formation of an additional unwanted product would also lead to unnecessary treatment costs in an industrial process. Hence, it was found that pressure leaching as an alternative is not currently viable

due to the lower yields and associated high costs. Atmospheric leaching seems to be the most economically feasible option until a better alternative is found.