Dendritic Iron Formation in Low-Temperature Iron Oxide Electroreduction Process using Alkaline Solution

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ABSTRACT

Low-temperature electrochemical reduction (electroreduction) is considered to be a suitable method for iron oxide reduction due to its attractive aspects, such as its CO_2-free operation and low electric energy consumption and temperature requirements. Aiming at metallic iron of powder form as product, our research promotes dendritic electrodeposition rather than to grow compact deposition layers as in conventional electrowinning methods. Proof-of-concept experiments are performed using a single parallel plate electrode, immersed in a mixture of micro-sized hematite (Fe_2O_3) powder and strong aqueous alkaline (NaOH, 50%wt, 18 M) electrolyte. The effects of current density, hematite mass fraction, temperature, and particle size on deposit morphology and Faradaic efficiency are also investigated. It is found out that the dendritic structures are more likely to grow in a non-homogeneous environment, e.g. when experiments carried out without stirring or with local heating. Furthermore, the dendrites are located primarily on the side and edge of the cathode, indicating a diffusion-controlled mechanism. A cathodic deposition of metallic iron with a high Faradaic efficiency (> 90%) is successfully accomplished. The present findings provide new insight into the production of electrolytic iron powder (e.g. in the metal fuel application) and the acceleration of sustainable ironmaking technologies.

Keywords: Iron electrodeposition, dendritic iron, cathodic reduction, current efficiency, iron oxide reduction.

Graphical abstract