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Citation for published version (APA):

Majid, A. I., Tang, Y., Finotello, G., van der Schaaf, J., & Deen, N. G. (2023). *Dendritic Iron Formation in Low-Temperature Iron Oxide Electroreduction Process using Alkaline Solution*. Abstract from Netherlands Process Technology Symposium 2023, Enschede, Netherlands.

Document status and date:

Published: 06/07/2023

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

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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 CO₂-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 (Fe₂O₃) 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

