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Alkaline electrochemical deposition of metallic Fe for the production of green steel

Steel is an indispensable material for our society. However, the steel industry alone generates 7% of the world's CO_2 emissions. 70% of this enormous carbon footprint is due to the iron production process. This process takes place in blast furnaces heated to 1500°C and uses coking coal as a reagent, which is transformed into CO_2 at the end of the reaction. Consequently, if we want to decarbonize our society, it will be imperative to find technological solutions that enable iron to be produced and recycled in the most sustainable and efficient possible way.

The alkaline electrochemical deposition of iron on an electrode surface is a promising method to produce sustainability metallic iron. This incipient technology makes direct use of electrical energy, which can come from a renewable source, to deposit iron on the surface of an electrode from oxidized iron starting materials. The reaction could use the same raw materials as the conventional and more polluting process, and takes place under relatively low-temperature conditions (60 - 90°C).

Despite there are several research works reporting high and moderate conversions for the electrochemical deposition, little is known about the mechanism behind the reduction of solid-state Fe_2O_3 until metallic Fe. Indeed, there is a controversy about if the conversion is a fully solid-state reaction or involves the partial dissolution of Fe_2O_3 particles followed by electrochemical reduction of soluble Fe^{3+} species.

The aim of this internship is to explore which is the actual mechanism for the deposition in order to understanding the limitations of the process. You will learn how to use electrochemical methods in combination with other analytical tools to characterize redox processes in an environment less rigid than the electrochemical lectures in your bachelor/master courses. The other analytical techniques that could be used are XPS, ToF-SIMS, XRD and RAMAN. If you are curious about this project, do not hesitate to contact me to provide you more details.

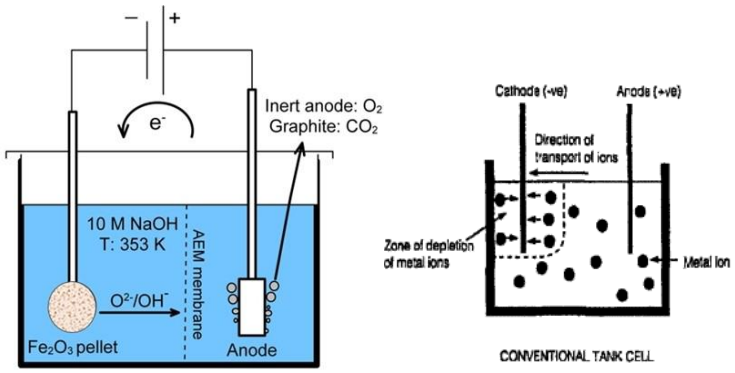

Figure 1. Examples of metallic Fe electrodeposition from a Fe_2O_3 pellet electrode (left) and a Fe_2O_3 suspension (right).

References:

(1) Fayaz, R.; Bösing, I.; La Mantia, F.; Baune, M.; Hanafi, M. I. J.; Gesing, T. M.; Thöming, J. *ChemElectroChem* **2023**, *10* (22), e202300451.

(2) Lopes, D. V.; Quina, M. J.; Frade, J. R.; Kovalevsky, A. V. *Frontiers in Materials* **2022**, 9.

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