

Comparative study of pure iron and white cast iron for ferrate ion production using dual dynamic voltammetry

Ábel Zsubrits¹, Miklós Kuti², Éva Fekete², Mária Ujvári², Gyöző G. Láng²

¹Eötvös Loránd University, Hevesy György PhD School of Chemistry, Pázmány Péter sétány 1/A, H-1117 Budapest, Hungary

²Eötvös Loránd University, Institute of Chemistry, Laboratory of Electrochemistry and Electroanalytical Chemistry, Pázmány Péter sétány 1/A, H-1117 Budapest, Hungary

zsubritsabel.98@gmail.com

Ferrate ions can be produced electrochemically with the transpassive dissolution of iron-containing anodes. Two of the most widely investigated materials are Pure Iron (PI), and White Cast Iron (WCI). It is assumed that the alloyers in the iron can change the structure of the oxo-hydroxide passive layer, enhancing or inhibiting the transpassive dissolution of the anode. The iron carbide in the WCI seems to disintegrate the passive layer, making it porous, and less resistant to the attack of hydroxide ion, making the passivation less complete, and ultimately the transpassive dissolution a more favorable reaction.

During the transpassive dissolution, the parasitic oxygen evolution process is inevitable. The oxygen evolution decreases the current efficiency of ferrate production and makes the characterisation of the ferrate ion formation process difficult. Usually, the electrochemical ferrate production is characterized by the accumulated ferrate ion concentration, and quantities derived from it (effective current density, current efficiency)¹. Ferrate ions are highly unstable, and their decomposition rate depends on many circumstances (including cell design) that are difficult to control, making most characterization of electrochemical ferrate synthesis inadequate, leading to uncertain and sometimes misleading results.

Dual Dynamic Voltammetry (DDV) is a novel method that can be used for Rotating Ring Disk Electrodes (RRDE)². DDV makes the simultaneous, independent polarization of the two electrodes (ring and disk) possible. Since ferrate ion can be properly characterized with its reduction at Platinum electrode, an RRDE setup was used in a generator-collector arrangement for the investigation of ferrate ion production. During the measurements the transpassive dissolution of the iron-containing (Pure Iron or White Cast Iron) disk yielded ferrate, which could be reduced at the Platinum ring. Using a very slow polarization rate at the disk and a fast polarization rate at the ring, the amount of ferrate ion produced could be determined for each potential with relatively high resolution.

Using this arrangement the ferrate ion formation reaction could be independently investigated at the different anode materials, and the results could be compared accordingly. The effective current (current responsible for ferrate ion production) was much higher, and the onset potential of ferrate ion production much lower in the case of White Cast Iron. However, the effective current did not differ that much in the case of the two anode materials, caused by the different rates of the oxygen evolution process.

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