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Transfer function analysis of hydrogen permeation through an iron membrane in a Devanathan cell.

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Hydrogen penetration in ferrous materials may have severe deleterious effects by structural embrittlement. The phenomenon can result from metal corrosion, particularly during cathodic protection. This problem has been largely investigated, nevertheless the mechanism of hydrogen entry in the metal is still a matter of discussion. It is generally admitted that the rate of penetration is governed by the surface coverage θ_H by adsorbed atomic hydrogen, as intermediate of the hydrogen evolution reaction (1). An alternative model, which seems to apply in the case of palladium, assumes a direct entry of hydrogen (2,3).

In the present work, hydrogen penetration mechanism in a pure iron foil (Goodfellow 99.5% annealed) was studied by combining the classical Devanathan - Stachurski (4) method with electrochemical impedance analysis on the entry face and with analysis of the transfer functions linking the two sides. This new approach was recently proposed by several authors for investigation on hydrogen permeation into steel, iron or palladium (5-8)

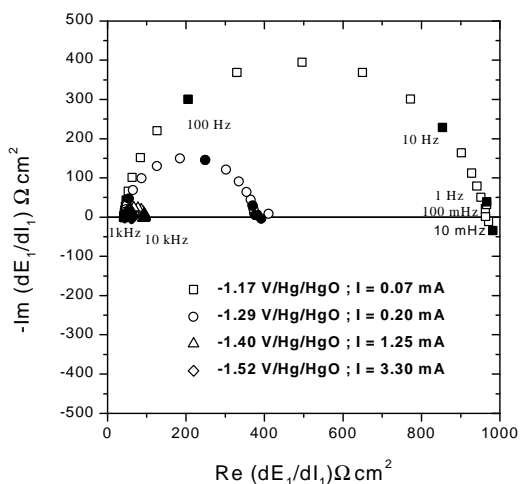


Fig. 1 Impedance diagrams recorded on the input side in sulfuric acid solution, for various potentials.

Hydrogen was cathodically evolved on the input side under galvanostatic or potentiostatic control in a 0.1 M NaOH or H₂SO₄ solution. In most cases, the output side was electroplated by a thin palladium layer. Permeated hydrogen was fully oxidized at the output side in a 0.1M NaOH solution. The permeation current I_p is a direct measurement of the overall permeation kinetics. A small ac-signal was superimposed to the entry potential and, by using a Solartron SI 1254 four channel Frequency

Analyzer, the electrochemical impedance of the entry side and the transfer function between the permeation current I_2 and the input current I_1 were recorded simultaneously.

Contrary to palladium (7), the hydrogen flow of absorption into iron is very small with respect to the flow of hydrogen evolution, and the impedance data (Fig. 1) are unable to give information on the hydrogen penetration process.

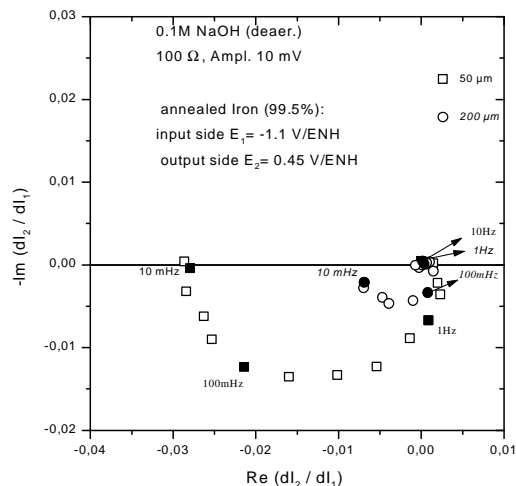


Fig 2 : Nyquist plot of the transfer function dI_2/dI_1 for two iron foil thickness (alkaline medium) in the 10 Hz to 0.01 Hz frequency range.

It was observed that the different transfer functions between the two sides are very sensitive to the input parameters (potential, current density, composition of the electrolyte) and also to the diffusion conditions such as the thickness of the membrane (Fig. 2).

A mathematical model of the transfer functions is proposed. It will allow the specific contribution of the kinetics of hydrogen penetration on the entry side, to the overall permeation process to be analyzed.

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