3-D electrodes for large-scale electrochemical H_2 production

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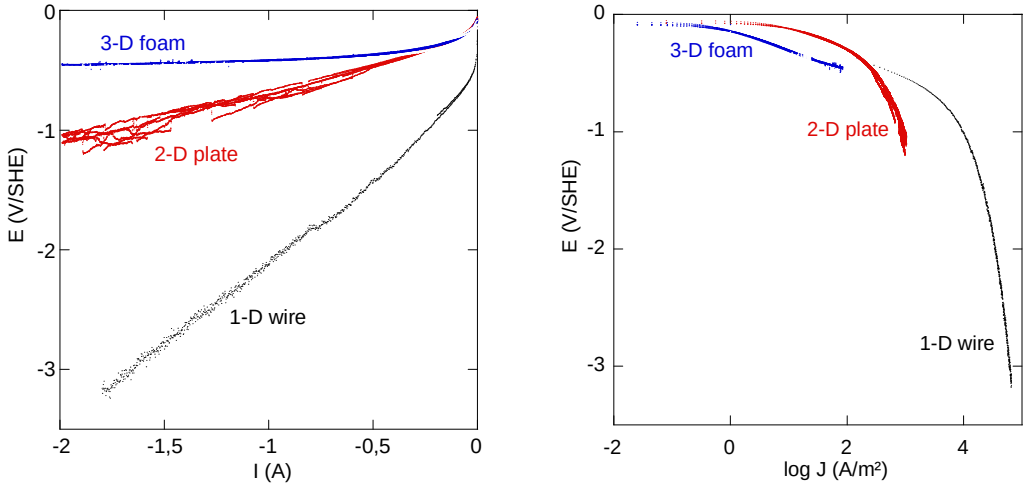
Hydrogen is a promising and well-accepted energy vector to store electricity produced by intermittent sources, such as solar panels and wind turbines. In this respect, the electrochemical production of H_2 from water electrolysis is at present considered to be the technologically most viable route. However, the efficiency of low-cost electrolysers must still be improved before they can actually be used industrially on a large scale. Such improvements can be obtained by increasing the rate of electron transfer between water and the electrode, or by improving mass transport of reactants and gaseous products. This presentation will focus on a most simple way to increase the efficiency of water electrolysis by the use of 3-D porous electrodes. These will be shown to allow for a significant reduction in overpotential, while at the same time improving the intrinsic mass transfer characteristics of a conventional electrochemical cell [1]. As a result, both the energy requirement and the technological cost of water electrolysers can be significantly reduced, while keeping low-cost Ni as electrode material.

More specifically, we will discuss the electrochemical performance of macro-porous Ni electrodes during water electrolysis in alcaline electrolytes, using a commercial filter-press cell in flow-by mode. Commercial Ni cathodes with different geometries were compared, including 1-D wires, 2-D plates and 3-D foams, the latter with porosities of 30, 60 and 100 ppi. This resulted in effective surface area's varying over more than 3 orders of magnitude, from 2.8 10^{-3} dm^2 and 1.9 10^{-1} dm^2 for the wires and plates, respectively, upto 2.4, 4.9 and 8.3 dm^2 for the 30, 60 and 100 ppi foams, respectively. From a quantitave analysis of chrono-potentiometric and linear sweep polarisation measurements, it was found that the required (over-)potential to drive the macroscopic current is lowest for the 3-D foam electrodes (Fig. a, left) . Moreover, for the wire and plate electrodes, a sharp and sudden increase in potential was observed which was taken as indicative for the appearance of a limiting current (Fig. b, right). This can be associated with mass transfer limitations for the hydrogen evolution reaction at these 1-D and 2-D electrodes.



Recorded cathode potential as a function of imposed current in linear coordinates (a, left), and as a function of current density on a semi-logarithmic scale (b, right).

Keywords: 3-D electrodes, H_2 production

References

[1] Q. de Radiguès, P.-Y. Sévar, R. Santoro, F. Van Wonterghem and J. Proost, Industrial & Engineering Chemistry Research 51 (2012) 14229–14235.