Enhancing the corrosion resistance of ferritic stainless steel bipolar plates in simulated PEMFC cathodic environments by surface enriched Cr_2O_3

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Abstract The stainless steel with low Cr content (such as AISI 316L) cannot meet the corrosion resistance requirements of PEMFC bipolar plates in the PEMFC cathode environment. Preparation of a ferritic stainless steel(Steel A) with high Cr (28%) and low Ni (1%) by optimization of alloy composition. The steel A forms a surface Cr_2O_3-rich and outer (0-1.6 nm) Cr/Fe>1 passive film in the simulated PEMFC cathode environment. The self-corrosion potential E_{coor} of Steel A is -0.146 V_{MSE}, which is 0.575 V_{MSE} higher than that of AISI 316L of -0.721 V_{MSE}, and the self-corrosion current density I_{coor} is 7.31×10^{-7} A·cm^{-2}, which is 3 orders of magnitude lower than that of AISI 316L, the corrosion sensitivity and corrosion rate are significantly reduced. After the potentiodynamic polarization, test, local pitting corrosion occurs in Steel A, with only a small number of pitting pits with a size of less than 0.5 μm; whereas slight total corrosion and local severe pitting corrosion occurred on the surface of 316L, with a small number of large and deep pitting pits distributed in the honeycomb organization. The potentiostatic polarization(cathodic potential 0.23 V MSE) current density of Steel A <1 μA·cm^{-2} for 0.5 h, decreasing to 0.27 μA·cm^{-2} at 6 h, whereas the current density of AISI 316L is consistently >180 μA·cm^{-2}. Mott-Schottky and XPS analyses shows that outer layer Cr_2O_3-rich passive film lower donor concentration N_D and flat charged potential E_b inhibited the reaction of aggressive F^- with the passive film and also hindered the oxidation of iron. Thus significantly reducing the dissolution rate of passive films and the occurrence of pitting corrosion.

Keywords PEMFC, stainless steel, corrosion resistance, semiconducting properties, XPS