DTU Energy Conversion
Department of Energy Conversion and Storage

Corrosion behaviour of construction materials for high temperature steam electrolysers

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Introduction

The energy efficiency of water splitting can be significantly improved with elevated temperature because of decreased thermodynamic energy requirement, enhanced electrode kinetics and possible integration of heat recovery.

At the anodic compartment of an electrolyser, strong corrosive conditions will generally exist due to high polarization in combination with presence of oxygen. It is therefore an important task to choose materials which possess sufficient corrosion resistance.

In our recent research (1-3), possible construction and catalyst support materials have been studied in concentrated H_3PO_4 at temperatures up to 150 °C.

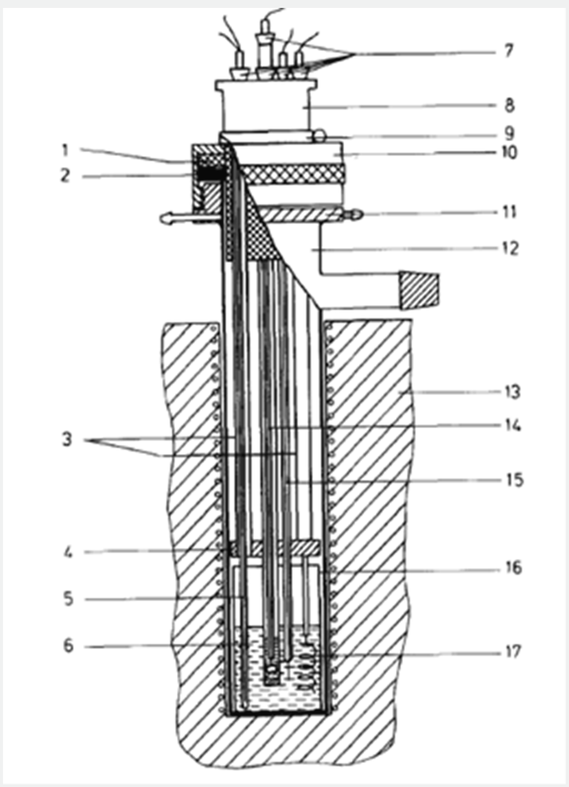

Figure 1. The electrochemical cell.

1. Teflon ring; 2. Viton ring; 3. Ceramic tubes; 4. Ceramic screen;
5. Thermocouple; 6. Electrolyte. 7. Silicon rubber stoppers; 8. Teflon lid;
9. Fixation ring; 10. Stainless steel cover; 11. Stainless steel lid;
12. Quartz tube; 13. Oven; 14. Reference electrode; 15. Working electrode;
16. Pyrex glass; 17. Counter electrode

Our present research is dedicated to evaluation of corrosion resistance of possible construction materials for the intermediate temperature (200-400 °C) water electrolysers. At these temperatures only ceramic proton-conducting electrolytes can be used. The most promising is CsH_2PO4, which was earlier successfully implemented in fuel cells (5). Molten KH_2PO4 was used for simulation of intermediate temperature water electrolysis in this work.

Voltammetric behavior of Pt and Au has been studied before in molten $KHSO_4$ at 265 °C in Ar atmosphere (4). It has been shown that at Pt, $KHSO_4$ has potential window of 1.05 V, with the cathodic and anodic limits corresponding to the electrochemical reduction of hydrogen and electrooxidation of oxygen. Au presented hydrogen reduction at the same potential, but corroded at positive polarization with formation of soluble Au(SO4)n(2n+3) complexes.

Experimental part

Voltammetric measurements were performed in three-electrode quartz cell shown in Fig.1 (4).

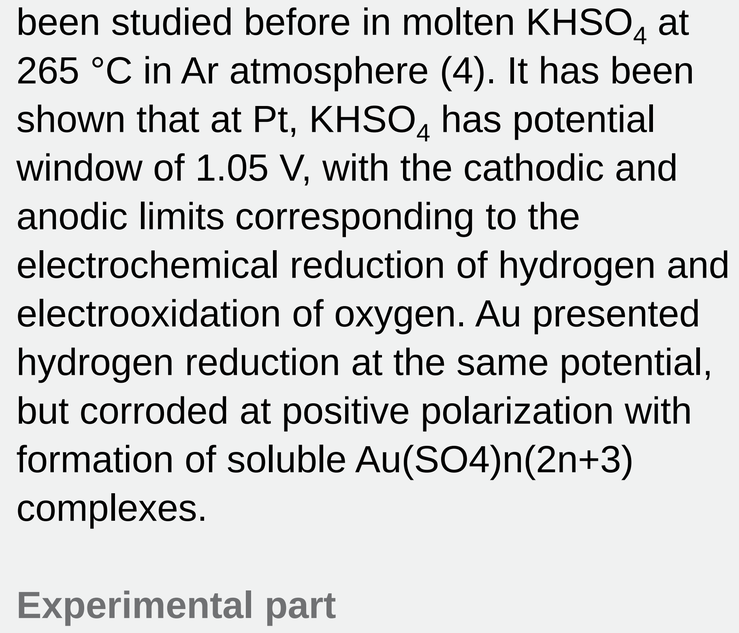

Figure 2. The voltammetric curve obtained on Pt.

Gold and platinum wires sealed in Pyrex tubes served as working electrodes. Tantalum coated stainless steel wire was sealed in the alumina tube using alumina paste. CVD-coated AISI316L stainless steel wire was provided by Tantaline A/S (Denmark). The working electrodes area was around 0.24 cm^2. A gold wire spiral served as a counter electrode.

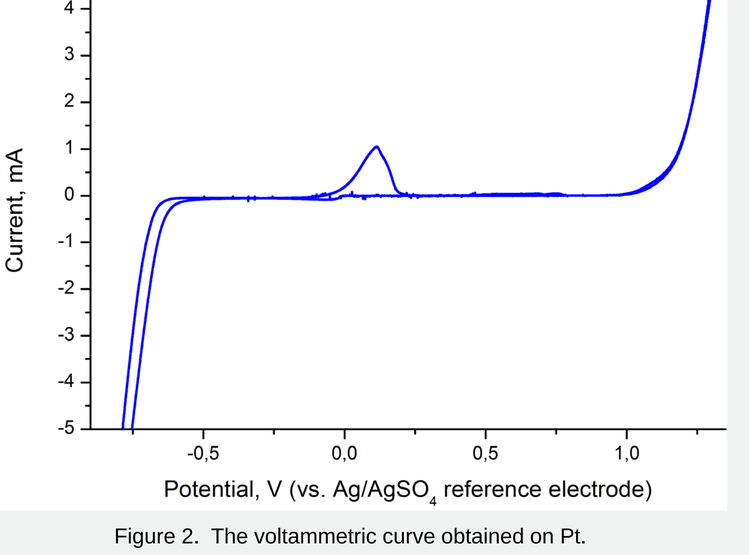

Figure 3. The voltammetric curve obtained on Au.

Discussion and conclusions

Electrochemical behavior of gold, platinum and Ta coated stainless steel in molten KH_2PO_4 at 260 °C in air was investigated. It has been found that the electrolyte has the same stability region (around 1.5V) at Pt and Au electrodes (Figs. 2-3). However, there is an electrochemical dissolution of gold at the potential more negative than electrooxidation of oxygen.

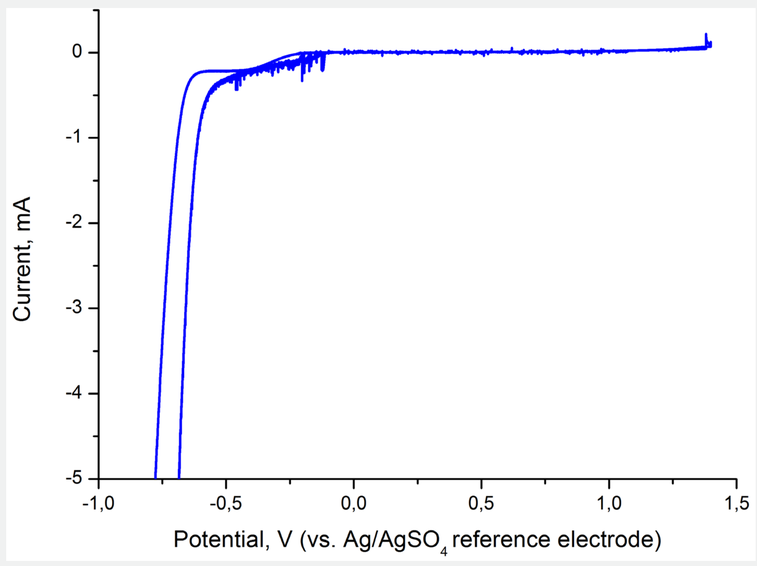

Figure 4. The voltammetric curve obtained on Ta.

The preliminary study showed severe corrosion of stainless steels and Ni-based alloys, examined in (1-3). Therefore, we concentrated on the tantalum coated stainless steel (Fig. 4). Ta coated stainless steel demonstrated a remarkable corrosion resistance and can be recommended as a material for bipolar plates of intermediate temperature steam electrolyser.

References

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