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Dimensionally Stable $Sn_{1-x-y}Ir_xSb_yO_{2+2.5y}$ Anodes for Acidic Water Electrolysis

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Abstract

$Ti/Sn_{1-x-y}Ir_xSb_yO_{2+2.5y}$ (x=0-0.65 and y=0.05-0.16) electrodes were prepared by thermal calcinations of $SnCl_4$, $SbCl_5$ and H_4IrCl_6/butanol mixture precursors at 550°C on three dimensions titanium substrate. The electrodes were characterized and examined as dimensionally stable anodes for oxygen generation during electrolysis at $10^4 Am^{-2}$ in 3M H_2SO_4 solution. $Ti/Sn_{0.41}Ir_{0.46}Sb_{0.13}O_{2.325}$ and $Ti/Sn_{0.29}Ir_{0.65}Sb_{0.06}O_{2.15}$ electrodes showed service life of 1300 and 2000h, respectively, compared with 400h for Ti/IrO_2 electrode. The specific electrocatalytic activity of $Ti/Sn_{1-x-y}Ir_xSb_yO_{2+2.5y}$ electrodes was comparable to that of Ti/IrO_2 electrode, especially at low current density applications. Effective dispersion of Ir species in the SnO_2-Sb_2O_5 matrix and formation of single phase solid solution oxide with compact structure are responsible for the unique performance of these electrodes. The beneficial role of Ir in ternary oxides was discussed in terms of resistivity and crystal tortuosity of coatings. A mechanism for oxygen evolution reaction is proposed.

Keywords: *composite, nanocrystalline, oxygen anode, cyclic voltammetry, XPS*

1. Introduction

Oxygen evolution in acidic environment represents a very severe test for evaluating anode materials required for *hydrogen fuel generation* from proton exchange membrane water electrolysis, electrowinning and electrofloation processes. Only precious IrO_2 and RuO_2 are recommended anodes for such applications, however, the application of these anodes is strongly restricted by high costs and limited electrode lifetime. Consequently composite materials, where the precious compound is dispersed in a less active but more stable matrix, such as SnO_2 and TiO_2, are being intensively studied to offer less expensive electrodes which might show good electrocatalytic activity, stability toward anodic dissolution and electronic conductivity. For example, RuO_2-SnO_2 [1-2], IrO_2-SnO_2 [3-4], RuO_2-TiO_2-SnO_2 [5,6], and IrO_2-TiO_2-SnO_2 [7,8] systems are often adopted to improve the electrode performances for oxygen evolution in acidic media. Compared with SnO_2, SnO_2-Sb_2O_5 is known by its excellent optical property, electrical conductivity and stability in extremely acidic environments, beside it provides good properties for disposal of organic pollutants. In this regard, Chen et. al. utilized SnO_2-Sb_2O_5 as an excellent dispersing matrix for RuO_2 and IrO_2 electrocatalyts to develop anodes with excellent electrocatalytic activity and stability for oxygen evolution during acidic water electrolysis [9,10]. The developed Ti/IrO_2−Sb_2O_5−SnO_2 and Ti/RuO_2-Sb_2O_5.SnO_2 electrodes containing at 5-10 mol % of RuO_2 or IrO_2 nominally in the coatings had a service life about two and three times higher than Ti/RuO_2 and IrO_2, respectively. In the present work, pretreated three dimensions titanium substrate was coated with IrO_2−SnO_2-Sb_2O_5 containing up to 40 mol.% IrO_x and investigated as dimensionally stable anodes with high electrocatalytic activity and service life during electrolysis in extremely acidic environment. Particular attention is given to the contribution of oxide composition, surface chemistry, roughness and structure to the activity and stability of the newly developed Ti/IrO_2-SnO_2-Sb_2O_5 anodes

2. Experimental

2.1.Electrode preparation and physciochemical characterization

Punched titanium substrate mesh of 100x50x1 mm in dimension was polished in 0.5 M HF solution for 5 min and then subjected for surface roughening by etching in 11.5 M H_2SO_4 solution at 80°C until hydrogen evolution was ceased. Pre-treated Ti substrate was coated with $Sn_{1-x-y}Ir_xSb_yO_{2+2.5y}$ active layers by a thermal decomposition of 0.5M $SnCl_4$, $5H_2O$, 0.5M $SbCl_5.5H_2O$ and 0.5M H_4IrCl_6/butanol in precursor mixtures. The ternary oxides were produced by combining

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