

Electrooxidation over Ti/SnO₂-Sb₂O₅ anodes for water condensates recovery in shuttle orbiters

L. Rutigliano¹, D. Fino^{1*}, G. Saracco, V. Specchia¹, P. Spinelli¹ and L. Grizzaffi²

¹Department of Materials Science and Chemical Engineering, Politecnico di Torino,
Corso Duca degli Abruzzi 24, 10129, Torino, Italy

²Thales Alenia Space, Strada Antica di Collegno 253, 10146 Torino, Italy
*deborafino@polito.it

Introduction

Several projects were proposed in the last years for condensates water reclamation, for atmospheric revitalization, thermal and humidity control as well as hygiene keeping during long time manned missions [1]. Particularly, the humidity condensates is contaminated with short chain alcohols, carboxylic acids and other hydrophilic low molecular weight organics which originate as airborne contaminants due to human metabolism and material out-gassing from wet phases aboard (initial total TOC = 95 ppm) [2]. A particular electrochemical cell was built for regeneration of humidity condensates during shuttle missions (Fig. 1). In this context, the anodes used for oxidation of the organic pollutants require high oxygen over-potential to produce high concentration of the hydroxyl radical, which is the strongest oxidant agent generated by an electrochemical process [3].

Materials and Methods

Pure titanium foils used as substrate were sandblasted, degreased with NaOH, etched in HCl, washed and dried and lastly treated in ultrasonic bath. After these preliminary treatments, the deposition of SnO₂/Sb₂O₅ was realized several techniques: brush coating, chemical vapour deposition and sputtering using as precursor SnCl₄ or SnEt₄ and SbCl₃ or SbEt₃ into a 2-propanol solution or water depending on the preparation method used [4]. The Ti/SnO₂-Sb₂O₅ was fully characterized by XRD, SEM, EDS, linear and cyclic voltammetry (CV) analyses. Among different contaminant dissolved in the solution, urea was chosen to carry out the electrochemical tests. Tests for the abatement of this organic compound were performed under galvanostatic condition (0.4 – 18 mA/cm²), by monitoring during time chemical species dissolved using colorimeter (Orbeco- Hellige model 975-MP) or with a DR 5000 Hach-Lange spectrophotometer.

Results and Discussion

The XRD spectra show, for all the electrodes deposited, diffraction peaks corresponding to the desired structure; the SEM views reveal a very uniform structure. Cyclic voltammograms with urea showed the formation of a slightly passivating polymeric film on the electrode surface; whilst anodic linear voltammetry have determined oxygen over-potential of about 1.2 V that suggested the formation of OH[•] species, which are known to effectively participate into the direct electro-oxidation of organic pollutants. All prepared anodes showed in the electrochemical tests for all parameters monitored the same trends vs time. In particular, a sharp pH drop was observed in the first hour of treatment due to two different effects: the formation of organic acids as intermediates in the electro-oxidation and the acidification as a consequence of O₂ evolution with formation of H⁺ species. Using a cationic membrane to

separate anodic and cathodic compartment, the nitrogen species can permeate like NH₄⁺, where the basic environment converted them into ammonia. This phenomenon is much remarked as the lower the current density. The presence of free chlorine seems to improve TOC abatement efficiency forming hypochlorous acid, a strong oxidant that can easily reacts with organic species without decreasing during time the free chlorine concentration. Comparison of TOC removal among different synthesized anodes and commercial ones have been performed at different current densities. A further decrease of TOC was obtained by reversing the cell polarity for 15 min (indicated in fig. 2 by arrows)

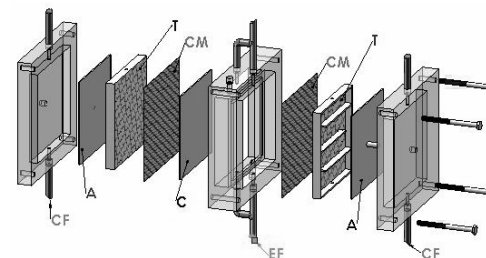


Figure 1. Exploded cell scheme. CF: condensate feed; A: anode; T: turbulence promoter; CM: cationic membrane; C: cathode; EF: electrolytic feed.

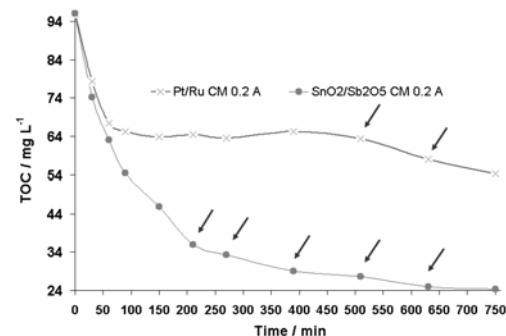


Figure 2. Comparison of TOC evolution vs time between Pt/Ru and SnO₂/Sb₂O₅ electrodes at 0.2 A; Pt/Ru CM (x); SnO₂/Sb₂O₅ CM (•).

References

1. Akse, J.R., Holtsnider, J.T., and Carter L., *SAE* 2004-01-2405 (2004).
2. Behrend, A.F., MacElroy, R.D., and Reysa, R.P., *SAE* 1991-SP-873 (1991).
3. Comminelis, C., De Battisti A., *Electrochem. Acta* 93, 673 (1996).
4. Yao, P., Chen, X., Wu, H., and Wang, D., *Surf. Coat. Tech* 202, 3850 (2008).