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LIFETIME CONSIDERATIONS FOR LEAD-FREE OXYGEN GALVANIC SENSORS

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Abstract. *In this paper we perform an electrochemical characterization of noble metals like copper, bismuth and antimony which were selected from thermodynamic considerations to replace the lead anode in future lead-free galvanic oxygen sensors. The aim of this study was to estimate by Coulombic calculations the amount of metal and optimum metal-electrolyte system, which may assure a five-year lifetime of the sensor, in the ideal case, when the anode consumption is the only failure mode limiting the sensor life. This study has shown that under ideal conditions, when no other failure modes are present, antimony has very attractive electrochemical properties, which may assure a minimum anode mass of about* 6.5 *grams for a five-year lifetime of the galvanic sensor. Failure modes, like anode passivation and self-corrosion, which are also predictable from the thermodynamics of the reactions between metals and aqueous solution, are briefly described here. Thus, a more realistic picture of the complex electrochemical processes to be considered for the design of the lead-free oxygen galvanic sensors is shown here.*

Keywords: oxygen, galvanic sensors, passivation, self-corrosion, lead-free, noble metal, antimony, copper, bismuth

1. Introduction

Electrochemical sensors for toxic gas and oxygen detection are extensively used by industry for process control, personal safety and ambient monitoring [1]. Due to their powerless, low cost and reliable operation, the lead-based electrochemical galvanic sensors for environmental oxygen measurement at room temperature represent the most important technical solution in fixed and portable instruments. However, considering the lead carcinogenic character and toxic effects on the environment, the European Directive on “Restrictions of Hazardous Substances” (EU-ROSH) followed by the 2011/65/EU Directive of EU Parliament Directive have requested that lead be eliminated from the design of gas monitoring instruments by 2024 [2].

Today, the manufacturers of oxygen galvanic sensors are making huge efforts to replace the lead anode, which is consumed by electrochemical oxidation during

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