Electrochemical deposition of ruthenium oxide from deep eutectic solvent

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Transition metal oxides (TMOs) have gathered increasing attention in material science due to their good electrical, mechanical, optical properties and great chemical and thermal stability. Among them, ruthenium oxide (RuO_2), with its excellent catalytic performances has been the subject of numerous studies. It serves as a crucial material for electrodes in (electro)catalysis, energy storage systems, and semiconductor devices. RuO_2-based catalysts have shown good potential in many important reactions such as the low-temperature dehydrogenation of small molecules (NH_3, HCl, methanol), and have been utilized in industrial electrolysis for chlorine-alkali production [1,2]. There are numerous techniques to synthesize RuO_2 [1]. In response to the challenges associated with RuO_2 synthesis, and to customize the particle size and shape of RuO_2, an electrochemical deposition from a new class of non-aqueous electrolytes, namely the deep eutectic solvents (DESs), can be a good alternative. So far, there have been recorded some attempts to electrochemically deposit ruthenium/ruthenium oxides from DES [3,4].
This study focuses on the electrochemical deposition of ruthenium oxide onto palladium working electrode from choline chloride (ChCl): urea (1:2 ratio) DES at 80 °C with 0.01M Ru(III) ions concentration. $RuCl_3$ was added as a source of Ru ions in the working electrolyte. To determine the potential range available for Ru electrodeposition in DES, cyclic voltammetry (CV) on Pd working electrode in the electrolyte containing ChCl and urea was recorded. The potential window of electrochemical stability was between -1.2 and +0.3V vs. Pt. The electrochemical behaviour of Ru(III) in choline chloride-urea has been investigated at palladium using cyclic voltammetry (CV) and square wave voltammetry (SWV). The CV results showed only cathodic peaks without corresponding anodic counterparts, and SWV was used for further investigation in order to gain a better understanding of the Ru(III) electroreduction process. The electrochemical impedance spectroscopy (EIS) results indicate diffusion-controlled RuO_2 deposition. Relatively small deposition overpotential (-1.0 V) applied in the electrodeposition experiments, resulted in ruthenium oxide being electrodeposited. The morphology of the obtained deposits was characterized using scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS). X-ray diffraction (XRD) analysis of the produced particles provided conformation that the RuO_2 was formed onto a palladium working substrate.

Acknowledgement: This research has been financially supported by the Ministry of Science, Technological Development and Innovation of Republic of Serbia (Contract No: 451-03-66/2024-03/200026).

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