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CORROSION, MATERIALS AND ENVIRONMENTAL PROTECTION

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ZAŠTITE MATERIJALA I ŽIVOTNE SREDINE*

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Promoting effect of Zn in platinum catalyst for effective ethanol electrooxidation reaction

Promotivni efekat Zn u platinskom katalizatoru za efikasnu reakciju elektrooksidacije etanola

Sanja I. Stevanović^{1,*}, Dragana L. Milošević¹, Dušan V. Tripković¹, Vladan R. Čosović¹, Vesna M. Maksimović², Nebojša D. Nikolić¹

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Abstract

Polymer electrolyte membrane fuel cells (PEMFCs) are pure electrochemical energy converters that are key components of energy sources for vehicles and for stationary and portable energy suppliers. Searching for a good catalyst for the ethanol oxidation reaction is one of the most significant issues in material science. To increase the economic potential of fuel cell technology, catalyst must be extremely active, stable, and inexpensive. Due to its high catalytic activity, structural and chemical stability, and widespread use in commercial fuel cells, platinum is still the material of choice for making cathodes. Although there is extensive continuing research to reduce the Pt concentration while keeping the high catalytic activity, its high cost remains a barrier to a wider adoption of fuel cell technology. Therefore, the potential for cost reduction lies in the optimization of the catalyst, i.e. obtaining the maximum catalytic efficiency with the lowest possible content of noble metals. The focus of this research will be on novel synthesis techniques for PtSnZn catalysts with better efficiency and durability for the ethanol oxidation reaction. This research demonstrates the potential of studying new PtSnZn catalytic materials as catalysts for the oxidation of ethanol. This study used the microwave assisted polyol technique to create PtZn and PtSnZn nanoparticles supported on high surface area carbon Vulcan XC-72R material. By using cyclic voltammetry, electro-oxidation of adsorbed CO, and the chronoamperometric method, the electrochemical behavior of synthesized catalysts was examined. X-ray diffractometry, transmission electron microscopy analysis and thermogravimetric analysis were applied to obtain the physicochemical properties of the catalyst. The advantages of microwave synthesis and carefully balanced metal alloying in the PtSnZn/C catalysts led to a high catalytic activity of the synthesized catalyst in the ethanol oxidation reaction compared to the Pt/C catalyst. This work was financially supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (contract no. 451-03-68/2022-14/200026) and the Science Fund of the Republic of Serbia under grant no. 7739802.

Keywords: platinum catalysts; microwave polyol synthesis; ethanol oxidation;

Izvod

Gorivne ćelije sa polimernim membranama (PEMFC) su čisti elektrohemijski izvori energije koji mogu biti ključne komponente izvora energije za vozila i za stacionarne i prenosive uređaje. Pronalaženje dobrog katalizatora za reakciju oksidacije etanola jedno je od najznačajnijih pitanja u nauci o materijalima. Da bi se povećao ekonomski potencijal tehnologije gorivnih ćelija, katalizator mora biti izuzetno aktivan, stabilan i jeftin. Zbog svoje visoke katalitičke aktivnosti, strukturne i hemijske stabilnosti i široke upotrebe u komercijalnim gorivnim ćelijama, platina je i dalje materijal

izbora za izradu katalizatora. Iako postoji opsežna kontinuirana istraživanja za smanjenje koncentracije Pt uz zadržavanje visoke katalitičke aktivnosti, visoka cena platine ostaje prepreka širem usvajanju tehnologije gorivih ćelija. Prema tome, potencijal za smanjenje troškova leži u optimizaciji katalizatora, tj. maksimalna katalitička efikasnost sa najmanjim mogućim sadržajem plemenitih metala. Fokus ovog istraživanja biće na novim tehnikama sinteze za PtSnZn katalizatore sa boljom efikasnošću i stabilnošću za reakciju oksidacije etanola. U istraživanju je korišćena poliol tehnika uz primenu mikrotalasne pećnice za kreiranje nanočestica PtZn i PtSnZn na ugljeničnom Vulcan XC-72R materijalu. Primenom ciklične voltometrije, elektrooksidacije adsorbovanog CO i hronoamperometrijske metode ispitano je elektrohemijsko ponašanje sintetizovanih katalizatora. Za dobijanje fizičko-hemijskih svojstava katalizatora primenjeni su rendgenska difraktometrija, transmisiona elektronska mikroskopska analiza i termogravimetrijska analiza. Prednosti mikrotalasne sinteze i pažljivo izbalansiranog legiranja metala u PtSnZn/C katalizatorima dovele su do visoke katalitičke aktivnosti sintetizovanog katalizatora u reakciji oksidacije etanola u poređenju sa Pt/C katalizatorom.

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Ključne reči: platinski katalizatori; mikrotalasna sinteza; oksidacija etanola