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# Ultrasonic Irradiation Synthesis of High-Performance Pd@Copper Nanowires/MultiWalled Carbon Nanotubes-Chitosan Electrocatalyst by Galvanic Replacement toward Ethanol Oxidation in Alkaline Media

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**Abstract :** The direct ethanol fuel cells (DEFCs) are contemplated as a promising energy source because, In addition to being used in portable electronic devices, it is also used for electric vehicles. The synthesis of bimetallic nanostructures due to their novel optical, catalytic and electronic characteristic which is precisely in contrast to their monometallic counterparts is attracting extensive attention. Galvanic replacement (sometimes is named to as cementation or immersion plating) is an uncomplicated and effective technique for making nanostructures (such as core-shell) of different metals, semiconductors, and their application in DEFCs. The replacement of galvanic does not need any external power supply compared to electrodeposition. In addition, it is different from electroless deposition because there is no need for a reducing agent to replace galvanizing. In this paper, a fast method for the palladium (Pd) wire nanostructures synthesis with the great surface area through galvanic replacement reaction utilizing copper nanowires (CuNWS) as a template by the assistance of ultrasound under room temperature condition is proposed. To evaluate the morphology and composition of Pd@ Copper nanowires/MultiWalled Carbon nanotubes-Chitosan, emission scanning electron microscopy, energy dispersive X-ray spectroscopy were applied. In order to measure the phase structure of the electrocatalysts were performed via room temperature X-ray powder diffraction (XRD) applying an X-ray diffractometer. Various electrochemical techniques including chronoamperometry and cyclic voltammetry were utilized for the electrocatalytic activity of ethanol electrooxidation and durability in basic solution. Pd@ Copper nanowires/MultiWalled Carbon nanotubes-Chitosan catalyst demonstrated substantially enhanced performance and long-term stability for ethanol electrooxidation in the basic solution in comparison to commercial Pd/C that demonstrated the potential in utilizing Pd@ Copper nanowires/MultiWalled Carbon nanotubes-Chitosan as efficient catalysts towards ethanol oxidation. Noticeably, the Pd@ Copper nanowires/MultiWalled Carbon nanotubes-Chitosan presented excellent catalytic activities with a peak current density of 320.73 $mAcm^2$ which was 9.5 times more than in comparison to Pd/C (34.2133 $mAcm^2$). Additionally, activation energy thermodynamic and kinetic evaluations revealed that the Pd@ Copper nanowires/MultiWalled Carbon nanotubes-Chitosan catalyst has lower compared to Pd/C which leads to a lower energy barrier and an excellent charge transfer rate towards ethanol oxidation.

**Keywords :** core-shell structure, electrocatalyst, ethanol oxidation, galvanic replacement reaction
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