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Nitrogen-phosphorous co-doped palladium electrocatalyst for glycerol electro-oxidation reaction (GEOR): An efficient system for mesoxalic acid and dihydroxyacetone production

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ABSTRACT

Electro-oxidation reaction of glycerol (GEOR) is a promising and eco-friendly technique for producing commercially valuable organic acids. In contrast to conventional non-metallic doping into single or multiwalled carbon nanotubes, our work reported the incorporation of N, and P into the Pd/CNTs framework for selective oxidation of glycerol to 1, 3-dihydroxyacetone and mesoxalic acid. Electrochemical and physicochemical characterization showed that the NP doped/PdCNTs has superior electrocatalytic performance for GEOR in alkaline media compared to counter catalysts. NP doped/PdCNTs exhibits better resistivity (I_f/I_b = 1.71) and requires only 0.09 V electrocatalysis voltage to achieve 76.67 mA cm^{-2} current density, demonstrating an energy-efficient and cost-competitive method to produce mesoxalic acid and dihydroxyacetone. At 0.09 V vs Ag/AgCl in 0.5 M Gly/0.5 M KOH, the Pd mass activity of NP doped/PdCNTs was 307.30 $mAmg^{-1}_{Pd}$, representing 2.45, 1.06, and 1.051 times higher than Pd/CNTs, N doped/PdCNTs, and P doped/PdCNTs, respectively. The yield of 1, 3-dihydroxyacetone was 29.76 times higher than Pd/CNTs, 24.06 times higher than N doped/PdCNTs, and 1.06 times higher than P doped/PdCNTs.

1. Introduction

Over the decades, fossil fuel remains the primary source of energy for numerous industries, particularly land, air, and water transportation. This heavy reliance on non-renewable resources and their rapid consumption due to surplus demand depletes the fuels reserves beyond expectations [1]. Growing global environmental concerns and frequent changes in governmental policies for reducing or permanent discontinuation of fossil fuels fasten the shift into more eco-friendly process [2,3]. In past few decades, electro-oxidation of alcohols has been widely reported due to the abundance, non-toxicity, and simplicity of these molecules. Alcohols can be efficiently converted into a variety of chemicals using various techniques such as fermentation, chemical and electro-oxidation, steam reforming and so on [4].

Glycerol is an abundant, non-toxic byproduct produced from biodiesel synthesis [5]. Biodiesel remains the dominant source of glycerol mainly due to the growing adaptation towards natural resources. Each 100 kg of biodiesel produce almost 10 kg of glycerol as a waste

Abbreviations: GEOR, Glycerol electro-oxidation reaction; MOXA, Mesoxalic acid; DHA, Dihydroxyacetone; GLYC, Glyceric acid.

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