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2018

Dostupný z <http://www.nusl.cz/ntk/nusl-387475>

Dílo je chráněno podle autorského zákona č. 121/2000 Sb.

Tento dokument byl stažen z Národního úložiště šedé literatury (NUŠL).

Datum stažení: 28.09.2024

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Preparation of palladium catalysts supported on activated carbons from agricultural waste biomass

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Catalytic oxidation is efficient, cost-effective and environmentally friendly way to treat volatile organic compounds (VOCs) and, thus, to meet the increasingly stringent environmental regulations. Noble metals are considered suitable catalysts for the total oxidation of harmful VOCs.

In the framework of the presented study, the low-cost activated carbons from tropical agricultural waste biomass including cocoa pod husks (denoted as CPH-AC) were prepared. The raw materials collected in Tumbes region in Peru were mixed with activating agent based on $ZnCl_2$ in the weight ratio of 1/1. Subsequently, the mixture was put in a ceramic reactor and afterwards in a horizontal oven to be directly carbonized under nitrogen atmosphere. The temperature increased with the rate of 10 min/min until a final carbonization temperature of 600 °C was reached and it was kept during 2 h.

Palladium nanoparticles were deposited into the parent activated carbons by means of a wet impregnation technique. Palladium(II) acetate as a precursor were dissolved in the mixture of acetone and methanol (volumetric ratio 2:1). 3.5 wt. % of citric acid was added into the impregnation solution.

The Pd content according to ICP-AES analysis was 0.28 wt.% Pd, 0.61 wt.% Pd and 2.64 wt. % Pd for the 0.005Pd/CPH-AC, 0.01Pd/CPH-AC and 0.05Pd/CPH-AC catalysts, respectively. The mean size of Pd crystallites estimated from X-ray diffractograms was 20 nm for both 0.01Pd/CPH-AC and 0.05Pd/CPH-AC catalysts. In the oxidation of ethanol, which was employed as a model volatile organic compound, the catalytic performance increased in the order of CPH-AC < 0.005Pd/CPH-AC < 0.01Pd/CPH-AC < 0.05Pd/CPH-AC (the T_{50} was 249 °C, 206 °C, 158 °C and 123 °C, respectively). The reduction properties of the catalyst surface were investigated using temperature-programmed reduction by hydrogen. A good correlation was observed between the catalytic performance of the catalysts and their H_2 -TPR profiles, which points to Mars–van Krevelen reaction mechanism. The temperature of the reduction of Pd^{2+} to metallic palladium decreased in the order 0.005Pd/CPH-AC > 0.01Pd/CPH-AC > 0.05Pd/CPH-AC (242 °C, 227 °C and 208 °C, respectively).

Acknowledgement

The financial support of the Technology Agency of the Czech Republic (The Competence Centres Programme, project no. TE01020080) and of the Czech Science Foundation (project no. 17-08389S) is gratefully acknowledged.