**Total Oxidation of VOC on Palladium Catalyst Supported on Activated Carbon from Cocoa Pod Husk**

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**Highlights**

* Activated carbon was prepared from cocoa pod husk by chemical activation
* Palladium nanoparticles were supported on activated carbon
* Catalytic activity and selectivity in the oxidation of ethanol was studied
* At 99% ethanol conversion, the selectivity to CO2 was higher than 95% for all catalysts

**1. Introduction**

Volatile organic compounds (VOCs) represent one of the most significant contributors to the air pollution [1]. Catalytic oxidation is recognized as an efficient, cost-effective and environmentally friendly way to treat VOC emissions [2]. Total catalytic oxidation of VOCs especially at low concentrations is a promising method to convert VOCs to water and carbon dioxide. Moreover, in contrast to thermal oxidation, dangerous reaction by-products such as NOx are not formed [3].

**2. Methods**

For preparation of activated carbon samples, which will be further referred to as CPH–AC, cocoa pod husk was used. The cocoa beans, gathered in Tumbes Region (coastal region in north western Peru), were mixed with an activating agent (ZnCl2) in a weight ratio of 1:1. Then, the mixture was directly carbonized under nitrogen atmosphere at 600 °C for 2 h with heating rate 10 C min-1. After fast cooling with pressurized indirect air, the prepared samples were washed with 0.15 mol L-1 water solution of HCl and with hot and later cold distilled water. Prepared activated carbon was impregnated with the impregnation solution consisting of palladium(II) acetate (99.9% purity, Aldrich, USA) dissolved in the mixture of acetone and methanol (volumetric ratio 2:1) and 3.5 wt% of citric acid. The initial concentration of palladium acetate in the impregnation solution was the same in all cases (0.34 wt.%). The volume of the impregnation solution was adjusted to obtain 0.28 wt.% Pd, 0.61 wt.% and Pd, 2.64 wt.% Pd, for the 0.28Pd/CPH-AC, 0.61Pd/CPH-AC and 2.64Pd/CPH-AC catalysts, respectively.

**3. Results and discussion**

Conversion curves of ethanol oxidation are shown in Figure 1. The catalytic performance increased in the order of CPH-AC < 0.28Pd/CPH-AC < 0.61Pd/CPH-AC < 2.64Pd/CPH-AC (corresponding *T50* was as follows: 249 °C, 206 °C, 158 °C, and 123 °C, respectively). The selectivity to CO2 can be even more important than catalyst activity due to the fact that some by-products of ethanol oxidation (e.g., acetaldehyde) can be even more detrimental for the environment and human health compared to ethanol itself. At 95% ethanol conversion, the selectivity to CO2 decreased in the order of CPH-AC < 0.28Pd/CPH-AC < 2.64Pd/CPH-AC < 0.61Pd/CPH-AC (94%, 79%, 40%, and 33%, respectively). Ethylene, acetaldehyde, ethylacetate and traces of acetic acid were observed as the reaction by-products. However, it should be noted that at 99% ethanol conversion, the selectivity to CO2 was higher than 95% for all catalysts.



**Figure 1.** Conversion curves of ethanol during oxidation reaction over CPH-AC (●), 0.28Pd/CPH-AC (●), 0.61Pd/CPH-AC (●) and 2.64Pd/CPH-AC (●) catalysts

**4. Conclusions**

The activated carbon was prepared from cocoa pod husk using ZnCl2 as an activating agent and employed as a catalyst support. Palladium nanoparticles were introduced by impregnation with palladium acetate in the presence of citric acid. In contrast to typical Pd/activated carbon catalysts, we were able to prepare catalysts with large palladium nanoparticles (~23 nm), which may be beneficial for oxidation catalysis. Moreover, these Pd nanoparticles were present on the external surface of the support and can be prepared even at low Pd loading (0.28 wt. %).

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