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including general information and program

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Nonthermal plasma regeneration of deactivated catalysts after plasma-catalytic removal of toluene and naphthalene

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Nonthermal plasma (NTP) is well known for its ability to create a highly reactive chemical environment. However, chemical reactions induced by NTP significantly suffer from a low reaction selectivity [1]. This fact must be particularly considered for environmental applications of NTP (e.g., air pollution control) since low reaction selectivity may lead to formation of undesired by-products. In order to enhance the reaction selectivity and, thus, to decrease a yield of undesired by-products, NTP is commonly combined with a catalyst (i.e., plasma catalysis). The selectivity of the plasma catalysis is much higher than NTP alone, however, in real conditions undesired by-products can be still present [2]. This is often a case when plasma-catalytic removal of complex volatile organic compounds (VOCs) or polycyclic aromatic hydrocarbons (PAHs) is employed. The undesired by-products usually create solid carbon deposits on the surface of the catalysts leading to their deactivation (i.e., loss of their catalytic activity and/or selectivity over time) [3]. After a catalyst deactivation, catalyst can be regenerated (restored), recycled, or discarded. From economic and environmental point of view, first option should be preferred to the other two.

In this work, the utilization of NTP generated by atmospheric pressure dielectric barrier discharge (DBD) for regeneration of deactivated catalysts was investigated. The experiment consisted of two consecutive steps. Firstly, the cylindrical DBD reactors packed with various catalytic materials ($Pt/\gamma Al_2O_3$, TiO_2, $BaTiO_3$) were employed for plasma-catalytic removal of toluene or naphthalene with synthetic air as a carrier gas. Toluene and naphthalene were chosen as model VOC and PAH compounds, respectively. Their removal resulted in formation of several gaseous and solid by-products, some of them were found as solid carbon containing deposits on the surface of catalysts. Secondly, deactivated catalysts were regenerated by DBD reactors of the same geometry for several hours with oxygen as a carrier gas at ambient or elevated temperature (100°C).

Regeneration of the catalysts led to formation of gaseous products (CO_2, CO and HCOOH) as a result of oxidation of solid deposits and their concentration as a function of time was evaluated. The results showed that concentration of gaseous products during regeneration decreased over time and rate of the decrease depended on the specific product as well as catalytic material. In addition, an efficiency of the catalyst regeneration strictly depended on the catalytic material, what is probably linked with different discharge modes governing the various DBD reactors. The analysis of gaseous products was performed by FTIR. Surface of the catalysts was analysed by SEM and optical microscopy. Finally, regenerated catalysts were reused for toluene removal in several repetitive cycles. The results obtained with regenerated and non-regenerated were compared.

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