Plasma Regeneration of TiO_2 Surface Saturated by IPA: Influence of Air Relative Humidity.

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Summary

Characterization of gas phase is performed by FTIR spectroscopy down stream a surface discharge ignited on IPA saturated TiO_2. This work aims at (i) Evaluating the regeneration process efficiency, (ii) Understanding the chemistry induced by surface discharge on VOC saturated surface.

Abstract

Indoor air cleaning and volatile organic compound (VOCs) decomposition is becoming most attractive, because air pollution is recognized as a serious issue to humans and living organisms. In the recent years, adsorption of VOCs on metal oxides, and conversion into the useful products or decomposition to CO, CO_2 and water have attracted more attention from the researchers. The regeneration of VOC adsorbed metal oxide surface is challenging task, due to high energy demand and potential deactivation of active sites. In this context, atmospheric pressure Non Thermal Plasma (NTP) is found to be an alternate method, due to its ambient working condition with low energy consumption.

TiO_2 is a widely used metal oxide to adsorb VOCs, and several authors reported that NTP coupled with TiO_2 reactor shows better conversion on gaseous VOCs decomposition comparatively to empty discharge gap reactors [1,2]. Hence, the regeneration of isopropyl alcohol (IPA) saturated TiO_2 surface using NTP surface discharge has been investigated. The NTP assisted TiO_2 surface regeneration was monitored by online FTIR spectroscopy equipped with liquid Nitrogen cooled MCT (Mercury, Cadmium, and Tellurium) detector. Detection limits are: CO_2=10ppb, CO=75ppb, IPA=1.4ppm and Acetone=80ppb.

First, the influence of air relative humidity on IPA adsorption and regeneration has been studied, since moisture is always present in the treated effluents, and H_2O considerably influences the adsorption and oxidation processes [3]. The amount of IPA adsorbed on TiO_2 surface was calculated by breakthrough method using N_2O as tracer. The different modes of IPA adsorption on TiO_2 surface under dry and humid air was investigated. The air relative humidity varied between 0 to 65%, for a fixed flow rate of 1000 sccm. The plasma was ignited with a constant 10 kV AC input voltage, 1000 Hz frequency using homemade high voltage power source. Furthermore, the influence of air humidity (0 to 65%) on plasma injected power has been studied. However, with the fixed applied voltage, the plasma injected power increased from 0.3 W to 2 W due to saturation of TiO_2 surface by water molecules.

Air relative humidity globally decreases the amount of reversible and irreversibly adsorbed IPA on TiO_2. However, the regeneration efficiency increased from 35 to 90%. Despite, to achieve 100% carbon balance (complete surface regeneration) TiO_2 surface was heated at 430° C under dry air; thereafter the carbon balance increased to 96%. On the other hand, the most stable side product selectivity Acetone was investigated as a function of air humidity, and found that it decreased from 25 to 3% with increasing air humidity 0 to 65%. In addition to that, the CO_X selectivity as a function of humidity was studied, and it increased from 5 to 25% by increasing air humidity 0 to 65%.

In summary, humid air Non Thermal Plasma Surface discharge treatment efficiently regenerates the IPA saturated TiO_2 surface by oxidizing adsorbed IPA and organic intermediates by using active species such as OH°, O° and O_3 into the close vicinity of TiO_2 surface.

References

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