Appraisal of a Multitasking Air Cleaner Process Based on Multiple Combined Techniques

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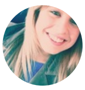

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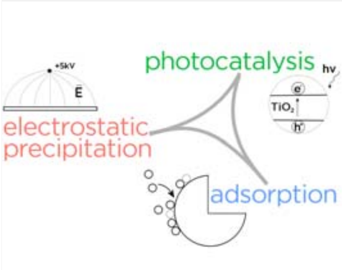

Nowadays there is an amplified interest in maintaining suitable Indoor Air Quality (IAQ). Besides a wide range of available interventions, air cleaners are considered a valuable tool since based on inexpensive and easily implementing technologies to improve IAQ. The purpose of this work is to combine the TiO_2-photocatalysis with the electrostatic and adsorptive processes, in order to improve efficiency and selectivity. A TiO_2-photocatalytic oxidation combined with an electrostatic filter has been studied. Nitrogen oxide reduction and degradation of many Volatile Organic Compounds over different catalyst support were monitored jointly with CO and CO_2 production. The choice of materials with diversified adsorptive characteristics plays an important role in the observed efficiency and selectivity.

Background

Nowadays people spend a substantial amount of time indoor; consequently, there is a growing concern over Indoor Air Quality (IAQ).

Photocatalytic Oxidation (PCO) over TiO_2 is reported as well-known technique for decomposition of various toxic compounds.

Electrostatic Precipitation (ESP) is a technique usually selected to remove suspended fine particles. On the positive side, the high collection efficiency, the low-pressure drop and low operating costs make ESP to be selected by industries for removing particulate matter from gas flow, or for cleaning indoor environments. On the other side, both techniques can produce unsafe by-products during the degradation process.

Adsorption is a widely implemented process for water and air de-pollution. One of its strengths is the high removal efficiency of pollutants even at low concentrations.

Operating those three techniques in a single "hybrid" stage make it possible to achieve higher removal efficiency and to increase selectivity to harmless compounds [1,2,3].

Objectives

The purpose of this work is to combine the TiO_2-photocatalysis with the electrostatic and adsorptive processes, in order to improve the efficiency and selectivity of the combined one.

Methods

TiO_2 P25 by Aeroxide® was used as catalyst. Ad-hoc TiO_2 paint was obtained by mixing the catalyst with water, dispersant and primer. The solution was applied on three supports: an aluminium plate, a commercial activated carbon fiber cloth and a graphite electrode.

A plug-flow reactor was used to test sample activity in NO removal and NO_2 production, during the PCO-only, PCO+ESP and ESP-only conditions.

VOC mineralization were carried out in a batch reactor. Methyl-Ethil-Keton (MEK), Acetone, Acetaldehyde, Toluene, Benzene were employed as indoor pollutant and CO and CO_2 productions were monitored under different operative conditions. Ozone production was also monitored.

Results

As known, electro-filters generate ozone by excitation and dissociation of oxygen atoms. The presence of irradiated TiO_2 decreases the ozone concentration (Figure 1) and it favourites the photocatalytic process.

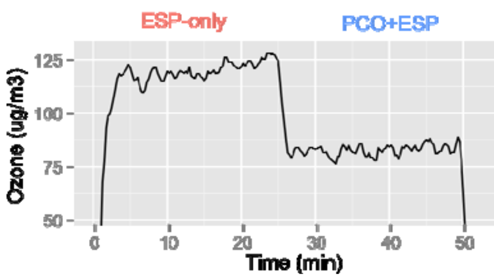

Fig. 1 Ozone production during ESP-only and PCO+ESP phases in the plug-flow reactor.

Coupling ESP with PCO makes it possible to achieve higher NO conversion comparing to the application of the single processes (Figure 2, on

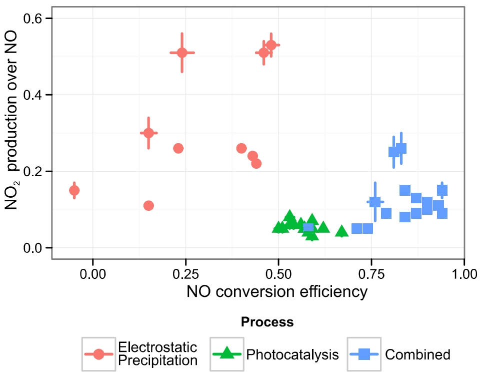

Fig. 2 NO conversion efficiency versus NO2 generation over initial NO plot, grouped by process (PCO-only, ESP-only, PCO+ESP).

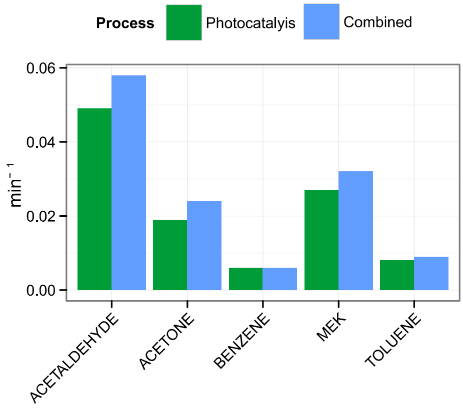

Fig. 3 VOC degradation kinetic constant by PCO-only and PCO+ESP processes. Pseudo-first order kinetic was used.

the abscissa), moreover NO_2 generation is lower for PCO+ESP than PCO-only. (Figure 2, on the ordinate).

NO_2 steady production over time depends either on the support material, either on the NO conversion efficiency.

Similarly, the combination of PCO and ESP, for the degradation of selected organic pollutants, leads to an enhance activity and selectivity into CO_2 [2]. In Figure 3 are reported the measured removal rate of different compounds as a pseudo-first order kinetic.

Conclusions

PCO oxidation is a surface reaction, mainly related to the TiO_2 loading and environmental conditions, such as temperature, humidity and irradiation.

The application of an electric field spreads oxidant radical species into the reactor volume.

Among these, ozone can react with NO to form NO_2, not only on the catalytic surface. Coupling PCO and ESP in the same environment enhance the NO conversion efficiency.

We observed that the choice of an appropriate adsorptive support, on which perform the “hybrid” process described, leads to lower the production of NO_2, ozone and to increase the process stability over time.

Nevertheless, the application of an electric field over the adsorptive media increases its adsorptive capacity.

Further studies are required to focus on reaction by-products and to optimize the whole process.

References

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