In-situ and real-time monitoring of atmospheric pollutant oxidation on a catalytic surface under plasma exposure

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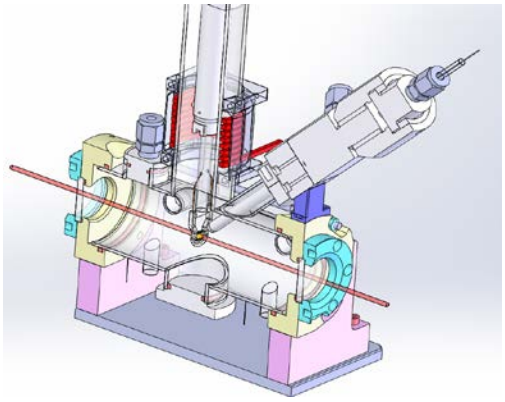
1. Introduction

Major advances have been made the past 15 years in to develop indoor air purification products based on plasma-catalyst coupling [1-3]. Our scientific objectives are to understand the mechanisms of adsorption and oxidation of Volatile Organic Compounds (VOCs) at the surface of a catalyst exposed to short life and long-life species produced by a Non Thermal Plasma. For that purpose, we are developing a world new surface analyzer, SORBENT-TRACK, based on FTIR and laser transmission spectroscopy to monitor "in situ" and in real time the pollutants or reaction intermediates adsorbed on the catalyst surface under pulsed plasma exposure; a major advantage will be to increase the surface diagnostic sensitivity in presence of humidity. The plasma surface interaction and the adsorption/oxidation mechanisms of dedicated pollutants (toluene, formaldehyde, acetone ...) will be studied on catalysts such as CeO2, MnO2 and CuO.

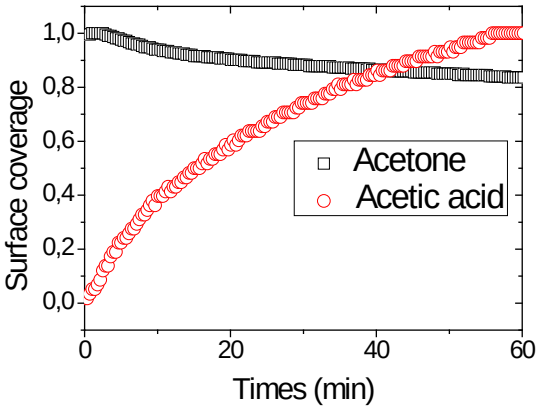
2. Methods and results

We have recently developed a new diagnostic, Sorbent-TRACK, for the in-situ analysis of the adsorbed pollutants and oxidation intermediates under direct plasma exposure. This experimental set-up is unique in the word and will be used to understand and quantify real-time adsorption, co-adsorption and oxidation of pollutants and chemical intermediates. A catalytic pellet is located in a reactor on the optical path of the infrared beam of a FTIR spectrometer. The DBD plasma is generated in contact with a catalytic surface. The main limitation is the transparency of the catalytic materials. Successful experiments have already been performed with TiO2 and CeO2. The plasma exposure time ranges from fraction of seconds to several hours.

In parallel a TANDEM FTIR / DRIFT for the analysis of pollutants in the gas phase and the catalyst surface when it is placed downstream the (post-situ) plasma. This device allows to quantify the VOCs adsorption on catalyst and to quantify the carbon balance during VOC oxidation by cold plasma. The sensitivity is typically 10-50 ppb depending upon the species [4]



Schematic drawing of Sorbent TRACK showing the catalyst holder, the plasma DBD and the Infrared beam



Real time monitoring of adsorbed acetone oxidation (absolute value) under plasma exposure and production of adsorbed acetic acid (arbitrary units). Catalyst is Ceria.

References

[1] F. Thevenet, L. Sivachandiran, O. Guaitella, C. Barakat, A. Rousseau, J. Phys. D: Appl. Phys, 2014 J. Phys. D: Appl. Phys. 47 224011

[2] L. Sivachandiran , F. Thevenet , P. Gravejat , A. Rousseau, Chemical Engineering Journal 214 (2013) 17–26

[3] L. Sivachandiran , F. Thevenet, A. Rousseau, Plasma Chemistry & Plasma Processing, (2013)

[4] C. Barakata, P. Gravejat, O. Guaitella, F. Thevenet, A. Rousseau, Applied Catalysis B: Environmental 147 (2014) 302– 313