Assessment of airborne titanium particulate matter from the wearing of a photocatalytic bituminous pavement in an urban area

M. Palacios[1], M. Pujadas[1], L. Núñez[1], M. Germán[1], E. Díaz[1], B. Gómez-Mancebo[1], M. Fernández[1], E. Coz[1], B. Artíñano[1], J. Fernández-Pampillón[2]

[1]Department of Environment, Research Center for Energy, Environment and Technology (CIEMAT), Madrid, Spain (magdalena.palacios@ciemat.es)

[2]National University of Distance Education (UNED), Madrid, Spain

Applying TiO_2-modified coatings onto the external covering of roads might be a supplement to conventional technologies for mitigating NO_x air pollution. In the framework of the LIFE MINOx-STREET European project, co-financed by the EU, different commercial photocatalytic coatings, designed for use on bituminous mixtures, were tested under both laboratory and on-road conditions. From the results of those essays, one of the products was selected to be implemented in a real urban scenario in order to evaluate its effect on the degradation of atmospheric nitrogen compounds (Palacios et al 2015, Pujadas et al 2016).

Considering that the wearing of the photocatalytic pavement by road traffic produces particles with titanium (Ti) that could be resuspended on air with potential harmful effects on public health, this influence on the ambient and ground deposited titanium particle concentration levels has been assessed.

EXPERIMENTAL SET UP

EXPERIMENTAL SITE

The depolluting capability of the selected photocatalytic coating has been assessed in a real urban scenario of Alcobendas, a municipality of the Region of Madrid. The place selected for the experiments was the Paseo de la Chopera, a street of Alcobendas with a median strip and moderate traffic. The photocatalytic coating was implemented on an area of 1000 m^2 corresponding to sixty meters along the road. Traffic was reopened on September, 25th 2015, two days after the product application. Measurements of ambient and ground deposited particle concentration were done before the implementation of this coating and also several days later (4, 12, 20, 27 days).

SIZE RESOLVED ATMOSPHERIC AEROSOL

- **MOUDI M110R (MSP Corporation) cascade impactor. Placed in the median strip of the road at 1 m high.**
- **Eleven equivalent cut-off diameters (18 to 0.056 µm-uncoated aluminium foils). Backup stage (<0.056 µm-quartz fibre filter).**
- **Samples were taken at 30 lm^{-1} in a 3.5 h time basis around 7 UTC.**

DEPOSITED DUST ON THE ROAD PAVEMENT

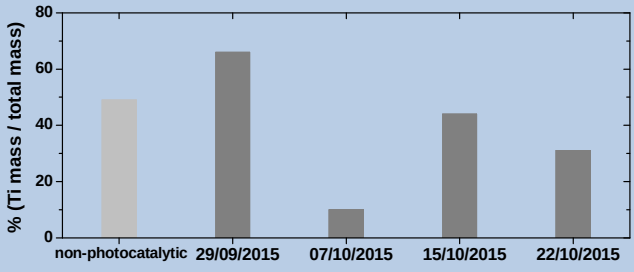
- **Vacuum pump operating at 20 m^3h^{-1} during 15 minutes.**
- **A flow controller fixed at 20 lm^{-1}.**
- **Holder device containing a quartz fiber filter located at the beginning of the sampling line.**
- **Dust was sucked on several 1 m^2 areas at different occasions.**

CHEMICAL ANALYSIS

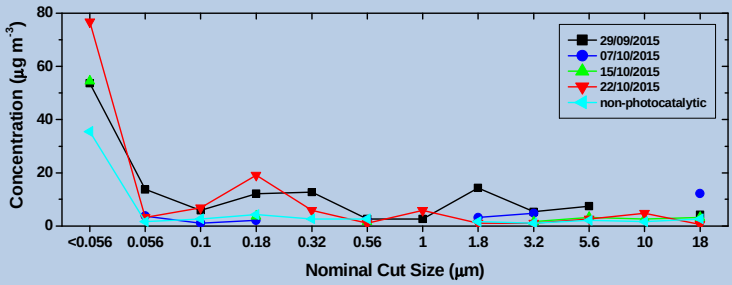
- **After digestion using acid extraction all the samples were analysed for Ti content by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS, Thermo X Series II, VARIAN 735ES).**
- **The crystal structures determination was performed on quartz filters from X-Ray Diffraction measurements (XRD, PANalytical X´Pert PRO).**

RESULTS

ICP-MS analysis corresponding to on-road deposited dust



Mass concentration size distribution from MOUDI



DEPOSITED DUST ON THE ROAD PAVEMENT

- **Deposited Ti over the non treated pavement (49 %) is likely to arise from soil or resuspension (crustal Ti).**
- **A decrease of the deposited Ti over the photocatalytic road pavement is observed as a consequence of the wearing of the coating due to road traffic. The minimum value was obtained on the second sampling day when the pavement was washed by rainfalls of previous days.**
- **XRD patterns showed the presence of TiO_2 in the anatase-type phase (photocatalytic coating) only in the samples of 29/09/2015.**

SIZE RESOLVED ATMOSPHERIC AEROSOL

- **Airborne Ti was only determined in the filters of the backup stage of the MOUDI (< 0.056 µm) but XRD analysis could not detect crystalline phases.**
- **These two facts indicate that the source of ambient Ti aerosol is not the wearing of the photocatalityc coating as the anatase-TiO_2 was not detected.**
- **The presence of Ti in ultrafine particles in ambient air could be attributed to wearing of car brakes (Nosko, 2015).**

CONCLUSION: The presence of Ti in the airborne particles could not be attributed to the wearing of the photocatalytic bituminous pavement but most likely to the wearing of car brakes.

REFERENCES

1. Palacios M., Núñez L., Pujadas M., Fernández-Pampillón J., Germán M., Sánchez B. S., Santiago J. L., Martilli A., Suárez S., Cabrero B. S. (2015), Estimation of NO_2 deposition velocities for selected commercial photocatalytic products", WIT Transactions on the Built Environment, vol. 168, DOI 10.2495/SD150642015.
2. Pujadas M., Palacios M., Núñez L., Germán M., Fernández-Pampillón J., Iglesias J. D., Santiago J. L., (2016). Real scale demonstration of the depolluting capabilities of a photocatalytic pavement in a real urban area, Proceedings 17th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, pp. 197-201, ISBN 978-963-9931-10-7.
3. Nosko O, Olofsson U, Alemani M. (2015) Temperature effect on emission of airborne wear particles from car brakes. In: Proceedings of *Europe's Braking Conference and Exhibition*, May 2015, Dresden, Germany

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