Assessment of the key parameters of the photocatalytic properties for construction materials: LIFE-MINOX-STREET European Project

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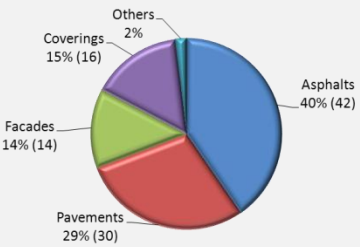

The 'MINOx-STREET' project, funded by EU (Life12 ENV/ES/000280), aims to evaluate the strategies for the abatement of traffic related NOx levels. It will offer to the local authorities a guide to optimize the use of commercial photocatalytic materials designed for air purification in urban environments. The potential usefulness of a range of commercial photocatalytic materials to act as NOx sinks was studied. Facades, asphalts, sidewalks and roof covering were analysed and more than 160 analysis (ISO 22197-1 standard) on 23 photocatalytic products distributed in the European market were performed. The most promising solutions will be implemented on urban surfaces in real condition in the Alcobendas District next to Madrid.

Nitrogen oxides (NO_x) contribute to several key atmospheric phenomena such as the photochemical smog, greenhouse effect or acid rain. Nowadays, and especially in big cities, there is a great concern about the atmospheric pollution provoked by nitrogen oxides. Heterogeneous photocatalysis with solar irradiation has started to be considered a plausible, clean and low cost, technology for NO_x removal [1,2,3]. TiO_2 commercial materials or precursors of titania nanoparticles [4], are included with different formulations into construction materials, e.g. asphalts, pavements, facades. Incorporated materials (where the precursor is included in the preparation of the block) or coated samples (prepared by spray or dip coating techniques) are the two most common procedures to incorporate semiconductors into construction materials. The photo-oxidation process can be described, in a simple way, as a two-stage reaction occurring on the surface of the photocatalyst [2]:

$$NO + OH^{\bullet} \rightarrow NO_2 + H^+ \quad (1)$$

$$NO_2 + OH^{\bullet} \rightarrow NO_3^- + H^+ \quad (2)$$

Therefore, NO_2 is the first oxidation product and the key precursor for further oxidation to nitrate ions. The nitrate species adsorbed on the photocatalyst surface are expected to be washed away from the surface as weak nitric acid.

In this context, the European Project "LIFE MINOx-STREET" arises in order to implement photoactive materials in a neighbourhood of the Alcobendas District (Madrid, Spain). Four entities, INECO (Transport Engineering and Consultancy), the Alcobendas Council, and two Research Centres CIEMAT (Centro de *Investigaciones Energéticas, Medioambientales y Tecnológicas) and CEDEX (Centro de Estudios de* Experimentacion y Obras Publicas) with a total budget of 1.982.619 € are involved. In the first stage of the project, photoactive materials already available in the market, such as concrete, asphalt, paints and roof coverings, were evaluated under the parameters reported in the ISO22197-1 standard (total flow = 3L min^{-1}, [NO] = 1,000 ppb_v, R.H. = 50 %, I = 10 Wm^{-2}, irradiation time = 300 min).

Table 1. Materials evaluated according to ISO 22197-1 standard

Nº ISO test	**228**	**Description**
Facades types	3	- Bricks - Rough concrete
Pavements types	10	- Tile - Paving stones
Asphalts	3	- Porous/non -Aged/non
Commercial products:		
Facades (Paints)	11	-European market
Pavements	6	-European market
Asphalts	5	-European market

Table 1 shows the different types of materials selected, along to the number of commercial products, available in the European market, tested for facades, sidewalks and bituminous materials. To date, more than 200 ISO analyses have been carried out under the frame of the Life Project.

Bituminous materials were tested at full-scale accelerated pavement testing test track. Mechanical and durability properties of pavements treated with photocatalytic materials were analysed. Laboratory tests to evaluate the changes in physical and mechanical properties of asphalt mixture, such as water sensitivity, resistance to permanent deformation, particle loss of porous asphalt, air void content and stiffness modulus evolution were analysed.

Superficial and structure changes by the incorporation of the photoactive material were also evaluated. Analysis of the slip resistance, macrotexture (surface texture), permeability, stability of the photocatalytic materials under wear testing by image analysis were carried out. Cracking, bearing capacity, horizontal deformation were some of the structural properties analysed.

The influence of the aging process in the photocatalytic performance was analysed for facades. For this purpose, experiments at an accelerating aging chamber and at outdoor conditions were carried out at least for 1,000 h.

An example of the general behaviour of the different products analysed is shown in Figure 1. The photocatalytic results obtained for eleven commercial paints, already available in the market are shown. The amount of NO and NOx eliminated from the gas flow and the NO_2 produced during 300 min reaction time, according to the ISO test is represented. The results clearly show the dispersion of the data, where around 50 % of the sample tested shown an ability to erase NOx below 2.0 µmol.

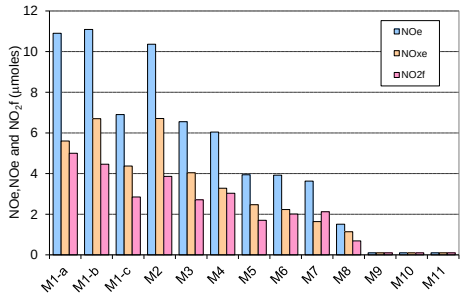

Figure 1. *Photocatalytic properties of different commercial paints available in the market.*

For M1-a and M1-b different deposition method was employed, whereas for M1-c, a facade of different nature was used .The results point out the strong influence of the substrate in the photocatalytic performance. Moreover, the application procedure is identified as a key factor to establish the quantity of photoactive material and the final photocatalytic activity. An important parameter to be considered is the possible lixiviation of the photoactive layer after aging process at outdoor conditions. This is especially relevant for sidewalks materials subjected to periodical cleaning processes. Concerning bituminous materials, accelerating pavements test track indicates the importance to perform these analysis in order to assess the durability of the material.

According to the results obtained with original, aged, rolled and washed samples, a selection of different commercial materials to be applied in real conditions on two streets, walls and sidewalks of the Alcobendas District were performed.

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