In the framework of the LIFE MINO-STREET European project, co-financed by the EU, a variety of commercial photocatalytic building and construction materials and coatings has been subjected to rigorous laboratory essays and then, some of these products selected in order to evaluate their photocatalytic effect at real scale. In order to assess which could be the environmental effect on pollution levels if photocatalytic materials were applied in one street of a particular city or, furthermore, modelling the foreseen effect if such materials were implemented in the whole city, NOx deposition velocities need to be estimated. Here, the air purifying ability of a variety of commercial photocatalytic coatings, applied on different concrete pavements, has been quantified by means of laboratory tests and the kinetic for the nitric oxide (NO) removal of such products investigated. Additionally, a numerical approach for estimating NO deposition velocities has been applied and the estimates presented.

EXPERIMENTAL AND KINETIC APPROACH

After a market study of photocatalytic products available for use in urban settings, several of these products, considered as potentially useful for their application on concrete pavements, were selected for testing their photocatalytic activity under the ISO 22197:2007 international standard method.

In bed flow photo-reactor experiment, like the ones presented here, a test gas mixture flow (NOx, air, H2O) (50% relative humidity) is passed over the flat rectangular sample of typical 5 cm x 10 cm and is irradiated by UV-A light (10 W/m2 irradiance) (300-400 nm) through a UV-transparent window with a distance to the sample of 5 mm. Under the conditions applied, a laminar-plugged flow is assumed and very short reaction times of only a few seconds are obtained.

Suitable samples need to be available of appropriate dimensions. For bituminous concrete pavements, coring asphalt mix has been needed to carry out firstly. Bituminous and sidewalk concrete pavements samples were cut into 99 mm x 49 mm x 5 mm specimens to be introduced in the photo-reactor.

Regression fit to approximate solution by using NO mass balance data is presented for a photocatalytic water emulsion coating applied on a sidewalk concrete pavement (paving slab), another water emulsion applied on a bituminous concrete pavement and, additionally, a photocatalytic coating applied on a sidewalk concrete pavement. The inverse of the order allowed to derive the corresponding surface deposition velocities for the three selected photocatalytic materials.

The greater NO removal capability of the photocatalytic material, the lower the slope of the regression fit and, consequently, the greater its inverse, the deposition rate estimated. The average NO deposition velocities computed by means of those kinetic parameters for the different photocatalytic materials selected were of the order 6.875 ± 1.499 (standard deviation) (10−3 m s−1).

CONCLUSIONS

Several TiO2-based photocatalytic products commercialized to be applied on concrete surfaces have been essayed to test their NOx removal performance. Among them, several photocatalytic coatings, applied on both sidewalk and bituminous concrete pavements, have been chosen to carry out a kinetic study of the NO photocatalytic degradation based on a suitable ISO international standard. Different operating conditions were selected to develop the experiments varying NO inlet concentration in a range of 100 to 1000 ppm, representative for air pollution episodes) while relative humidity, temperature, flow rate and irradiance remained constant during the tests (50%, 20°C, 1 m/s and 10 W/m2). Using these experimental data and the kinetic expressions derived from a Langmuir-Hinshelwood model, the kinetic parameters for NO were computed for each surface deposition velocities estimated. These estimates can be used for models to be implemented into microscopic atmospheric dispersion models and predict the possible effects of photocatalytically active surfaces on the air pollution in a highly populated and polluted urban area.

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