0-6636: Photocatalytic NOx/HRVOC/O3 Removal in Transportation Applications

Background

Air pollution is a topic of concern in urban areas. It is responsible for damage to vegetation, animals, materials, and, most importantly, to human health. Nitrogen oxides (NOx) are considered to be one of the key ambient air pollutants and are important because of their direct health effects on people and because they take part in the formation of ground-level ozone. Hence, finding ways to remove NOx from ambient air would be beneficial.

Titanium dioxide (TiO2) is a photocatalyst that has been studied for its ability to remove NOx from air when in close proximity to NOx sources. However, much of the laboratory testing of these materials to date was not designed to be representative of realistic outdoor conditions, and field tests have been inconclusive as to their effectiveness. Therefore, this project was designed to test TiO2 photocatalysts for removal of NOx, ozone, and highly reactive volatile organic compounds (HRVOC) in Texas highway applications under representative conditions. Coatings that could be applied on existing concrete highway structures were chosen for evaluation, since these are the most easily implemented on a large scale.

What the Researchers Did

The study consisted of four parts: laboratory chamber studies evaluating four different commercially available TiO2-containing coatings for concrete; outdoor exposure studies to evaluate the environmental stability of the coatings; modeling to determine the potential effect of the coatings on non-attainment areas in Houston and Dallas; and a field study to evaluate the “real world” effectiveness and durability of the coating with the best performance in the first two parts of the study. The laboratory chamber studies were designed to examine the impact of variables such as temperature, relative humidity, time, light intensity, and pollutant concentrations on NOx removal by the coatings. Laboratory studies were also used to screen ineffective coatings and provide input variables for photochemical smog modeling. Outdoor exposure studies involved placement of coated concrete adjacent to roadways in Houston and Austin, examining the effect of field exposure on photocatalytic material properties and subsequent NOx removal efficacy. Photochemical smog modeling using a Comprehensive Air Quality Model with extensions (CAMx) for the Houston-Galveston-Brazoria and Dallas-Fort Worth areas was performed to predict the effect of coating large surface areas of concrete on air quality. The best performing coating, a stucco,

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was used to coat 7700 ft2 of highway barriers at a site in north Austin and air quality was monitored in coated and uncoated regions over two ozone seasons.

What They Found

The screening tests in laboratory chambers demonstrated that a stucco cement containing TiO2 was the most effective in removing NOx, ozone, and non-methane hydrocarbons. When conditions in the chamber were varied, the coatings performed best in the testing conditions with a lower relative humidity, lower temperature, higher light intensity, and longer contact time. After one and two years of outdoor, roadside exposure, the NOx removal capacity of the stucco-coated samples decreased, but could be partially restored by soap and water washing once returned to the laboratory for testing.

A CAMx for the Houston-Galveston-Brazoria and Dallas-Fort Worth areas showed the potential of the stucco to reduce average ozone concentrations if large areas of highway structures are coated. Testing at a field site in north Austin (Figure 1), however, showed no conclusive difference between measured air quality in areas with coated and uncoated highway barriers.

What This Means

While photocatalytic concrete coatings have promise for improving air quality, the data from this project suggest that such improvements may not be significant enough to be measured experimentally. Therefore, the cost of applying these coatings in the field to reduce air pollution is too large for the insubstantial NOx reduction expected based on these test results.

Figure 1: Field site in north Austin

For More Information

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