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An Ambient NO_X Reduction Reactor System with and without Forced Air

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Introduction

California's economy depends heavily on trade and goods movement, but that comes at a cost to air quality, especially in communities already facing health and environmental challenges. Nitrogen oxides (NO_X) are greenhouse gases, and reductions in tailpipe emissions and ambient NO_X reduce the effects of climate change on California communities. Ambient NO_X is one of the main ingredients of ground-level ozone (smog). It contributes to the formation of particulates in the atmosphere, contributing to global warming and causing respiratory illnesses, especially in children, older adults, and people with preexisting lung conditions.

Investigations on the addition of titanium dioxide (TiO_2) nanoparticles to paint used on concrete like buildings for reducing ambient NO_X concentration have provided opportunities for passive control and filtration of the ambient NO_X. Applying paint infused with TiO_2 to building surfaces has shown antifouling performance and ambient NO_X reduction by 30%–40% near the surface. The present research used numerical optimization to identify optimized surface geometries of half-stepped cylinders for increased recirculation and contact between ambient air and painted surface for increased NO_X reduction.

Study Methods

A numerical optimization method was used to identify an optimized surface geometry to increase contact between ambient air and the painted surface. The investigation was followed by experimental verification of the numerical results using an optimized surface of a half-stepped cylinder covered with paint-infused TiO_2 powder. The experiments were conducted with paints at different TiO_2 concentrations using the ISO 22197-1-2007 standard.

Findings

Figure 1 shows the changes in nitrogen dioxide (NO_2) concentration for the flat and 5X samples with 7% TiO_2-infused paint under ISO standard testing conditions. For the flat surface, the nitrogen NO_2 concentration decreases initially, before it increases to

a maximum of 0.0844 ppm at the light-off. For the 5X-parallel sample, with the light on, the maximum NO_2 concentration is 0.089 ppm just before the light off, and for the 5X-perpendicular, the maximum is 0.093 ppm before it decreases to 0.089 at the light off. Table 1 shows the total NO_2 increase by the test pieces between the light on and off. The increase in NO_2 concentration is 5.3% for the 5X parallel and 11.5% for the 5X perpendicular. Previous investigations have shown that a 13.6% increase in NO_2 production is associated with 35.6% and 21.6% reduction in NO and NOx concentrations, respectively. Based on this previous investigation, for the 5X textured surfaces, we can infer that the increase in NOx reduction would be between 7% and 15%.

An optimized wavy surface painted with 20% TiO_2 can increase ambient NO_X reduction by more than 30%.

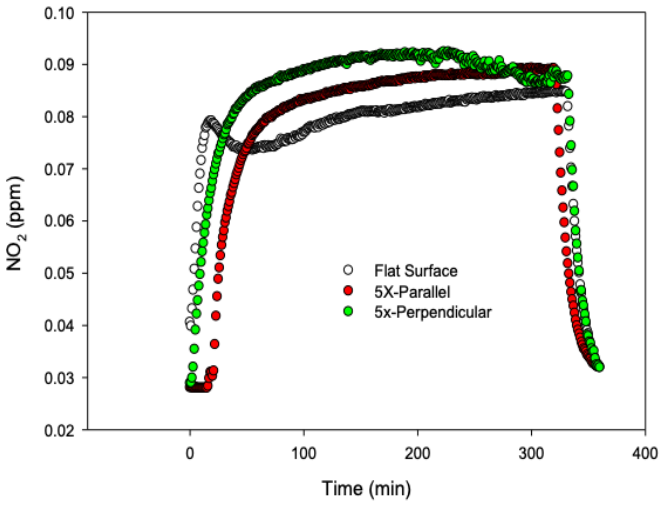
The 5X parallel surface sample was tested for increased TiO_2 concentration from 7% to 20%, and results showed a 25% increase in NO_2 formation. The surfaces were then tested with a forced gas-air mixture at 1 m/s. without changing the incoming NO concentration, and results indicated increases in NO_2 formation for smooth, 5X parallel, and 5X-perpendicular by 4.4, 3.54, and 3.0 folds, respectively, when compared with the corresponding results from the ISO standard tests (Table 1).

µmol/hr	Flat	5X Parallel	5X Perpendicular
ISO-Standard	0.58	0.61	0.64
Forced Air	2.55	2.16	1.925
Ratio	4.4	3.54	3.0

Policy Recommendations

Funding support for innovation and technology development for reducing ambient NO_X will result in improved air quality and reduce the adverse impact of trade and goods movement on the California population.

Figure 1. Variation of NO_2 for Different Surface Geometries



About the Authors

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To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2442

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