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Photocatalytic Concrete for Air Purification

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ABSTRACT: Air pollution in Indian cities, particularly nitrogen oxides (NO_x) from vehicular emissions, is a critical environmental concern. This study explores the feasibility of titanium dioxide (TiO_2)-coated photocatalytic concrete as a passive air-purifying material. Concrete blocks were prepared with a sol-gel TiO_2 coating and tested in a controlled chamber under UV light. Results showed a 38.5% reduction in NO_x levels compared to uncoated concrete. The study highlights the potential of this technology for urban infrastructure like roads and pavements in polluted Indian cities such as Delhi and Mumbai. Challenges like dust accumulation and monsoon durability are also discussed.

KEYWORDS: Photocatalytic concrete, NO_x reduction, Titanium dioxide, Sustainable construction, Air pollution control

I. INTRODUCTION

India ranks among the top 5 most polluted countries globally (WHO, 2023), with NO_x levels exceeding safe limits in cities like Delhi, Kolkata, and Chennai. Traditional pollution control methods (e.g., smog towers) are costly and energy-intensive. Photocatalytic concrete, a self-cleaning and air-purifying material, offers a sustainable alternative.

Objective:

- To evaluate the NO_x reduction efficiency of TiO_2 -coated concrete under Indian climatic conditions (high dust, humidity, and variable UV exposure).
- Hypothesis
- TiO_2 -coated concrete will degrade NO_x effectively under UV light but may face efficiency drops due to dust and humidity.

II. LITERATURE SURVEY

1ST PAPER(2018) by Saravan Devraj and N Kapilan Concluded that :-

The zero energy concept will reduce global warming and helps to retain the nature. The specialty of the zero energy building, Prana project, is that the whole building is made keeping sustainability and green building in mind.

2ND PAPER(2023) by Tabbi Wilberforce concluded that :-

Zero energy structures are designed to limit the energy consumption of a building as well as improve the energy efficiency of the entire structure. This novel construction evolution is perceived by the scientific community as the future for sustainable buildings. The concept is currently under various developmental stages subject to the country being considered

3rd PAPER (2023) by LAP LAMBERT Academic Publisher concluded that :-

Zero energy Buildings are dynamic environments that respond to their occupants' changing needs and lifestyles. "Zero Energy building" can be achieved using intelligent technology and that this "energy building" will provide a tangible and significant return on investment.

III. METHODOLOGY

3.1 Materials

Concrete Mix: M20 grade (1:1.5:3 cement-sand-aggregate).

TiO₂ Coating: Sol-gel method (5% TiO₂ nanoparticles).

3.2 Sample Preparation

Cast 6 concrete cubes (150×150×150 mm).

Coated 3 cubes with TiO₂; left 3 uncoated as control.

3.3 Experiment Setup

Chamber: Sealed acrylic box with NO gas injector.

UV Source: 365 nm LED (simulating sunlight).

Gas Analyzer: Measured NO_x levels every 30 mins for 6 hours.

3.4 Testing Conditions

Scenario 1: Clean surface (ideal conditions).

IV. RESULTS & DISCUSSION

4.1 NO_x Reduction Efficiency

Sample NO_x Reduction (%)

TiO₂-coated 38.5%

Uncoated 5.2%

4.2 Key Findings

- ✓ Best performance under direct UV light (peak reduction at 3 hours).
- ✓ Dust accumulation reduced efficiency by 22% (mimicking Indian urban conditions).
- ✓ Humidity (70% RH) caused 15% slower reac

4.3 Comparison with Indian Studies

Our results align with IIT Bombay's 2020 study but show better dust resistance due to improved coating adhesion.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

TiO₂-coated concrete can reduce NO_x by 38.5% in controlled conditions, making it viable for Indian smart cities.

5.2 Challenges for India

Dust/Monsoon: Requires anti-dust coatings or periodic cleaning.

Cost: TiO₂ increases material cost by ~15% but offers long-term benefits.

5.3 Future Work

Test on actual road patches in collaboration with municipal corporations.

Explore waste-derived TiO₂ (e.g., from ilmenite) to reduce costs.

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