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Photocatalytic Smog-Eating Coatings — Delhi and IIT Madras Partner to Fight Air Pollution

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SUBJECTS COVERED

ENVIRONMENT SCIENCE & TECH

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WHY IN NEWS

The Government of NCT of Delhi has signed a Memorandum of Understanding (MoU) with the Indian Institute of Technology Madras (IIT-M) to conduct a six-month pilot study on photocatalytic "smog-eating" surface coatings that can chemically break down air pollutants using sunlight.

Photocatalytic Smog-Eating Coatings — A New Weapon Against Delhi's Air Crisis

What Is Photocatalysis?

Photocatalysis is a chemical process in which a **catalyst (photocatalyst)** accelerates a chemical reaction when exposed to **light energy (typically UV radiation from sunlight)**. The most commonly used photocatalyst is **Titanium Dioxide (TiO_2)**, a non-toxic, stable, and abundant material.

When TiO_2 is exposed to sunlight:

1. UV photons excite electrons in TiO_2, creating **electron-hole pairs**
2. These reactive species interact with water and oxygen in the air
3. **Hydroxyl radicals (OH-)** and **superoxide anions** are generated
4. These radicals oxidise harmful pollutants — primarily **NO_2** (Nitrogen Dioxide) and **VOCs** (Volatile Organic Compounds) — converting them into harmless **nitrates, water, and carbon dioxide**

The Delhi-IIT Madras Pilot Study

The project is titled: "Comprehensive Study on the Effectiveness of Photocatalytic Smog-Eating Surfaces, Specifically Utilising Titanium Dioxide (TiO_2) or Similar Safe Photocatalysts for Abatement of Air Pollution in Delhi."

FEATURE	DETAIL
Partners	Delhi Government + IIT Madras
Duration	6 months
Phase 1	Laboratory testing in IIT-M smog chamber
Phase 2	Field trials on Delhi's high-traffic corridors
Target pollutants	NO2, VOCs
Key catalyst	TiO2 (Titanium Dioxide)

Application Methods Being Tested

The study will evaluate multiple integration methods:

1. **Mixing into concrete and asphalt** — photocatalytic material blended directly into road surfaces during construction
2. **Surface coatings on infrastructure** — spray-on or paint-on TiO2 coatings for existing roads, walls, and barriers
3. **Innovative panels** — standalone photocatalytic panels mounted on rooftops or streetlight poles, similar to solar panels but designed for pollutant removal

Global Precedents

Photocatalytic technology has been piloted in several cities worldwide:

CITY/COUNTRY	APPLICATION	RESULTS
Milan, Italy	TiO2-coated pavement blocks	60% reduction in NO2 in treated areas
Tokyo, Japan	TiO2 highway sound barriers	Measurable NO2 reduction along highways
Mexico City	TiO2 building facade coating	Reduced localised VOC levels
London, UK	Self-cleaning TiO2 glass panels	Reduced particulate adhesion

Delhi's Air Pollution Challenge

Delhi consistently ranks among the world's most polluted cities. Key facts:

- Delhi's annual average PM2.5: **~100-120 micrograms per cubic metre** (20-24x WHO guideline of 5 ug/m3)
- Winter AQI routinely exceeds **300-500** (Very Poor to Severe)
- Major sources: vehicular emissions (28%), dust (22%), industry (21%), crop burning (seasonal)
- Health impact: estimated 10,000-12,000 premature deaths annually from air pollution in Delhi

Existing Anti-Pollution Measures in Delhi

MEASURE	AUTHORITY	STATUS
GRAP (Graded Response Action Plan)	CAQM	Active since 2017 (revised 2024)
Odd-Even vehicle rationing	Delhi Government	Periodic implementation
Anti-smog guns	Delhi Government	Deployed at construction sites
Green War Room	Delhi Government	Real-time AQI monitoring
Electric bus induction	DTC	1,500+ e-buses planned

Limitations and Challenges

While promising, photocatalytic coatings face several challenges:

- **Effectiveness depends on sunlight** — reduced performance during overcast days and winter months (when Delhi pollution peaks)
- **Surface fouling** — dust and particulate matter can coat the catalyst, reducing its activity
- **Scale of impact** — localised pollutant reduction may not significantly alter city-wide AQI
- **Cost** — TiO_2 coatings add to infrastructure costs, though prices are declining
- **Byproduct management** — nitrates washed off surfaces may enter stormwater systems

UPSC RELEVANCE

TiO_2 photocatalysis mechanism, NCAP target, CAQM Act 2021, GRAP stages.

MAINS GS-3:

Innovative S&T solutions for environmental challenges; Delhi air pollution — causes, impacts, governance framework; role of public-private-academia partnerships in pollution mitigation.

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PHOTOCATALYTIC TECHNOLOGY:

Catalyst: Titanium Dioxide (TiO_2) — most common

Activation: UV light from sunlight

Target pollutants: NO_2, VOCs

Mechanism: Generates hydroxyl radicals that oxidise pollutants

Byproducts: Harmless nitrates, water, CO_2

DELHI-IIT MADRAS MOU:

Study duration: 6 months

Two phases: Lab (IIT-M smog chamber) + Field trials (Delhi high-traffic areas)

Applications: Road surfaces, infrastructure coatings, rooftop/streetlight panels

DELHI AIR POLLUTION KEY DATA:

Annual PM2.5: ~100-120 ug/m3 (WHO guideline: 5 ug/m3)

Major sources: Vehicles (28%), Dust (22%), Industry (21%), Stubble burning (seasonal)

GRAP: 4-stage pollution response under CAQM

NATIONAL CLEAN AIR PROGRAMME (NCAP):

Launched: January 2019

Target: 40% reduction in PM concentration by 2025-26 (base year: 2017)

Covers: 131 non-attainment cities

Implementing agency: CPCB + State PCBs

COMMISSION FOR AIR QUALITY MANAGEMENT (CAQM):

Statutory body under CAQM Act 2021

Jurisdiction: Delhi-NCR and adjoining areas

Replaced: EPCA (Environment Pollution (Prevention and Control) Authority)

OTHER RELEVANT FACTS:

WHO estimates 4.2 million premature deaths globally from outdoor air pollution annually

India's National Ambient Air Quality Standards (NAAQS): PM2.5 annual limit = 40 ug/m3

> IIT Madras: established 1959, Chennai; ranked among top 3 engineering institutes in India

Sources: ANI , Tribune India , ESG News

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