Masters Thesis Information Showcase
Spring Semester-2026
Year 2026

	Department: Chemistry Programme: Masters of Science Specialization: Industrial Chemistry
1	**Title of the Thesis** Industrial Application of TiO_2 NPs-Enhanced Paints in Air Quality Management.
2	**Abstract** (min 300 to 500 words) In recent decades, the air quality in urban areas has worsened considerably, mainly due to the accumulation of nitrogen oxides (NOx) and volatile organic compounds (VOCs) generated by vehicle traffic and industrial activity. These pollutants are implicated in the formation of photochemical smog and pose well-documented risks to human respiratory health. While titanium dioxide (TiO_2) has long attracted interest as a photocatalytic material capable of oxidatively degrading such species, its practical utility under ambient conditions is constrained by a wide band gap (~3.2 eV) that confines photocatalytic activity almost exclusively to the UV portion of the solar spectrum — a region representing only a small fraction of available sunlight. The present work addresses this limitation by developing carbon-nitrogen co-doped TiO_2 (CN-TiO_2) nanoparticles (NPs) through a sol-gel route in which a novel short-chain aromatic compound was employed as a stabilizing agent during particle growth. Urea and citric acid served as the nitrogen and carbon precursors, respectively. The resulting nanoparticles were characterized by UV-Visible spectroscopy, which revealed a measurable red-shift in optical absorption relative to undoped TiO_2, and by Atomic Force Microscopy (AFM), which confirmed near-spherical particle morphology with markedly reduced aggregation compared to unstabilized preparations. Photocatalytic paints were then prepared by dispersing the CN-TiO_2 NPs powder in a compatible binder system, and their performance was assessed against both NOx and VOC model pollutants under visible-light irradiation. The coatings showed better performance with respect to reference formulations made with conventional TiO_2NPs, showing higher pollutant removal and activity after repeated test cycles. In conclusion, these findings show that CN-TiO_2NPs photocatalytic paints represent a feasible and energy-passive strategy for air pollution mitigation in built environments, which can be scaled-up in urban infrastructure without the need for dedicated power sources.
3	**Impact on SDG#___"** (min 500 words) (Please mention the impact of the relevant attained SDG) The developed CN-TiO_2 photocatalytic paint directly contributes to the targets of SDG 11 by providing a scalable, energy-passive technology for air quality improvement in urban environments. As urban populations continue to grow, the concentration of nitrogen oxides (NOx) and volatile organic compounds (VOCs) from industrial and vehicular sources creates

	significant public health burdens. By enabling existing urban infrastructure—such as building facades, tunnel walls, and road barriers—to act as active pollution-mitigation surfaces, this technology offers a continuous, sunlight-driven solution that operates without the need for additional power, maintenance, or complex installations. Beyond mere remediation, the implementation of self-cleaning and antimicrobial coatings also enhances the longevity and hygiene of urban surfaces, promoting cleaner and more resilient city living. The use of low-cost, readily available precursors (urea and citric acid) for the synthesis of these nanoparticles further aligns with the sustainability requirements of urban development, ensuring that the technology is economically viable for large-scale application. Consequently, integrating these photocatalytic coatings into broader city-level air quality management strategies represents a practical and sustainable pathway toward reducing the environmental footprint of cities and protecting the respiratory health of urban residents, directly addressing the core objectives of creating inclusive, safe, and sustainable human settlements.
4	**Scholar Name** (along with contact details) Laiba Khan
5	**Supervisor & Co-supervisor Name** (along with contact details) Supervisor Name: Dr. Rafia Usman Khan
6	**Graphical Abstract**

CARBON–NITROGEN CO-DOPED TiO_2 NANOPARTICLES
Visible-Light-Driven Photocatalyst for NO_x and VOCs Abatement
FROM SIMPLE PRECURSORS...
Urea
(N source)
+
Citric Acid
(C source)
Sol–Gel
Synthesis
CN–TiO_2
C
N
Ti
O
Engineered at the Nanoscale.
Active for a Cleaner Future.
VISIBLE-LIGHT PHOTOCATALYSIS
CB e⁻ e⁻
VB h⁺ h⁺
O_2
$\cdot O_2^-$
NO_x (NO, NO_2) → NO_3^-
$\cdot OH$ → VOCs (Toluene, Benzene)
H_2O / OH^-
$CO_2 + H_2O$
Harnessing light to turn harmful pollutants
into harmless molecules.
NO_x
(NO, NO_2)
VOCs
(Toluene, Benzene)
Photocatalytic Paint
for Self-Cleaning Surfaces
CO_2
H_2O
BENEFITS
Works under Visible Light
Efficient Removal of NO_x and VOCs
Stable & Durable Performance
Easy Integration as Paint
Sustainable Solution for Urban Air
TOWARDS CLEANER CITIES
Energy-Passive. Scalable. Sustainable.
For a Better Urban Tomorrow.