Advanced Protective Epoxy Coatings with Photoactive TiO_2-LDO Nanofillers for Corrosion Protection and Potential NOx mitigation

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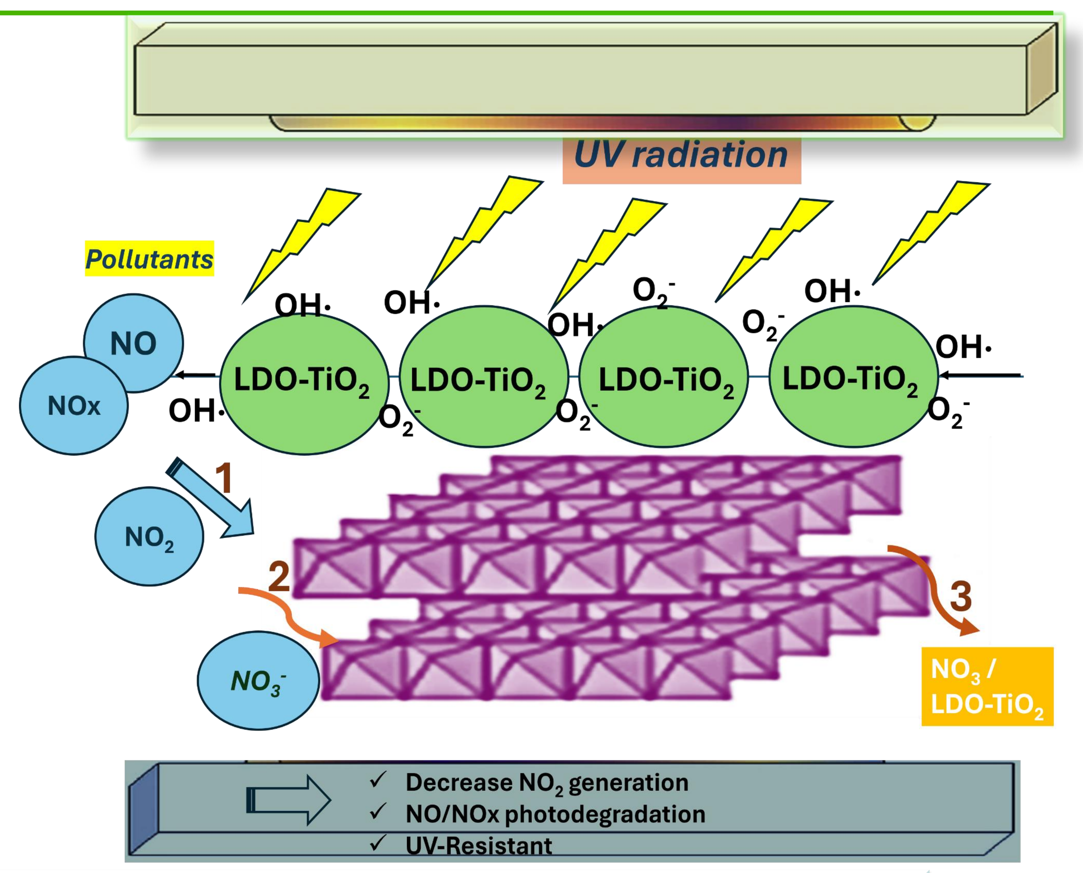
Highlights

- ❑ TiO_2 under UV facilitates NOx abatement, but it also releases NO_2 (byproduct) during NOx photocatalysis, ⟶ **Thus posing environmental risks.**
- ❑ TiO_2–LDO (**Layered double oxides**) reduces NO_2 release and NOx abatement ⟶ **Thus can be an alternative of pure TiO_2 in coating systems.**
- ❑ Epoxy/LDO–TiO_2 composite offers ⟶ **Excellent UV resistance properties.**
- ❑ Coating performance and barrier integrity remain ⟶ **unaffected.**
- ❑ Suitable for durable, eco-friendly outdoor applications.

➢ **Aim:** ***Develop an epoxy coating with TiO_2–ZnAl LDO nanofillers to improve UV resistance of epoxy systems, and enable NOx mitigation under UV exposure for durable, sustainable applications.***

Synthesis and Methods

- ❖ Synthesis: TiO_2-LDO nanocatalyst (TiO_2:ZnAl = 1:10) prepared **via wet impregnation, and advanced in NOx abatement** compared to pure TiO_2 (Figure 1).
- ❖ Formulation**: 2 wt.% TiO_2-LDO incorporated into epoxy resin.**
- ❖ Application: Coatings applied on AA2024 substrates via bar coater (final thickness ~20 ± 2 μm).
- ❖ Photocatalysis Testing: Performed under continuous NO flow in a **custom-built reactor (20 W/m², λ = 365 nm).**
- ❖ Corrosion Testing: Electrochemical Impedance Spectroscopy (EIS) for 28 days; **UV-ageing for 10 days using fluorescent UV source.**
- ❖ Physical and electrochemical characterisation included scanning electron microscopy (SEM), X-ray diffraction (XRD), BET specific surface area analysis, and impedance analysis after UV ageing (10 days).

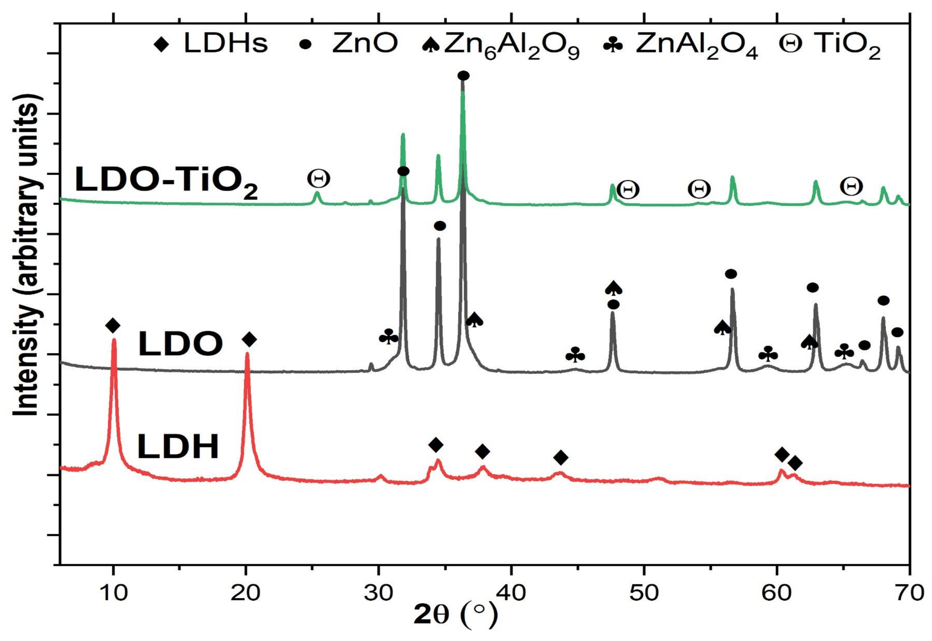


Breakthrough: ***NO_2 reduction by TiO_2–LDO was quantitatively confirmed using a portable novel NOx analyser, demonstrating safer UV-resistant and thus photocatalytic performance.***

Table 1: NOx abatement comparison of selected TiO_2 nanomaterials, from (Figure 2).

Catalyst	NO Conversion (%)	NO_2 Formation (%)
TiO_2 (anatase)	~80	20–25
ZnAl-LDO	25–30	<5
TiO_2-LDO (1:10)	~80	3–4

Figure 1: XRD spectra of LDH, LDO and LDO-TiO_2.



Results

- ❑ **EIS results after 28 days- and- after 10-day UV exposure:**
  - ❑ **Pure epoxy exhibited visible micropore formation and impedance drop (Figure 3).**
  - ❑ **TiO_2-LDO based epoxy system maintained barrier integrity and higher impedance, indicating UV resistance and reduced photodegradation.**
- ❑ **The embedded TiO_2-LDO acted as a UV shield and helped preserve coating performance under light exposure (Figure 2, 3).**
- ❑ **NOx mitigation is improved and more significantly with only 3-4 % NO_2 release (byproduct), compared to 10-25% for TiO_2.**

Figure 2: NO conversion profile during the photodegradation of gaseous NO under light irradiation (Wm^{-2}) of pure TiO_2 (anatase).

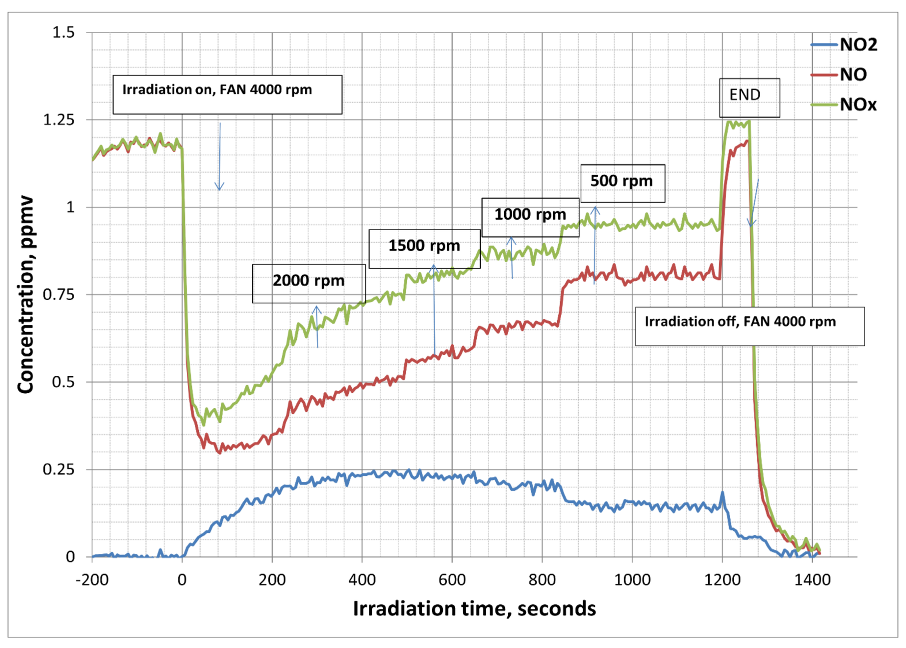


Table 2: Basic concept of utilisation of LDO-TiO_2

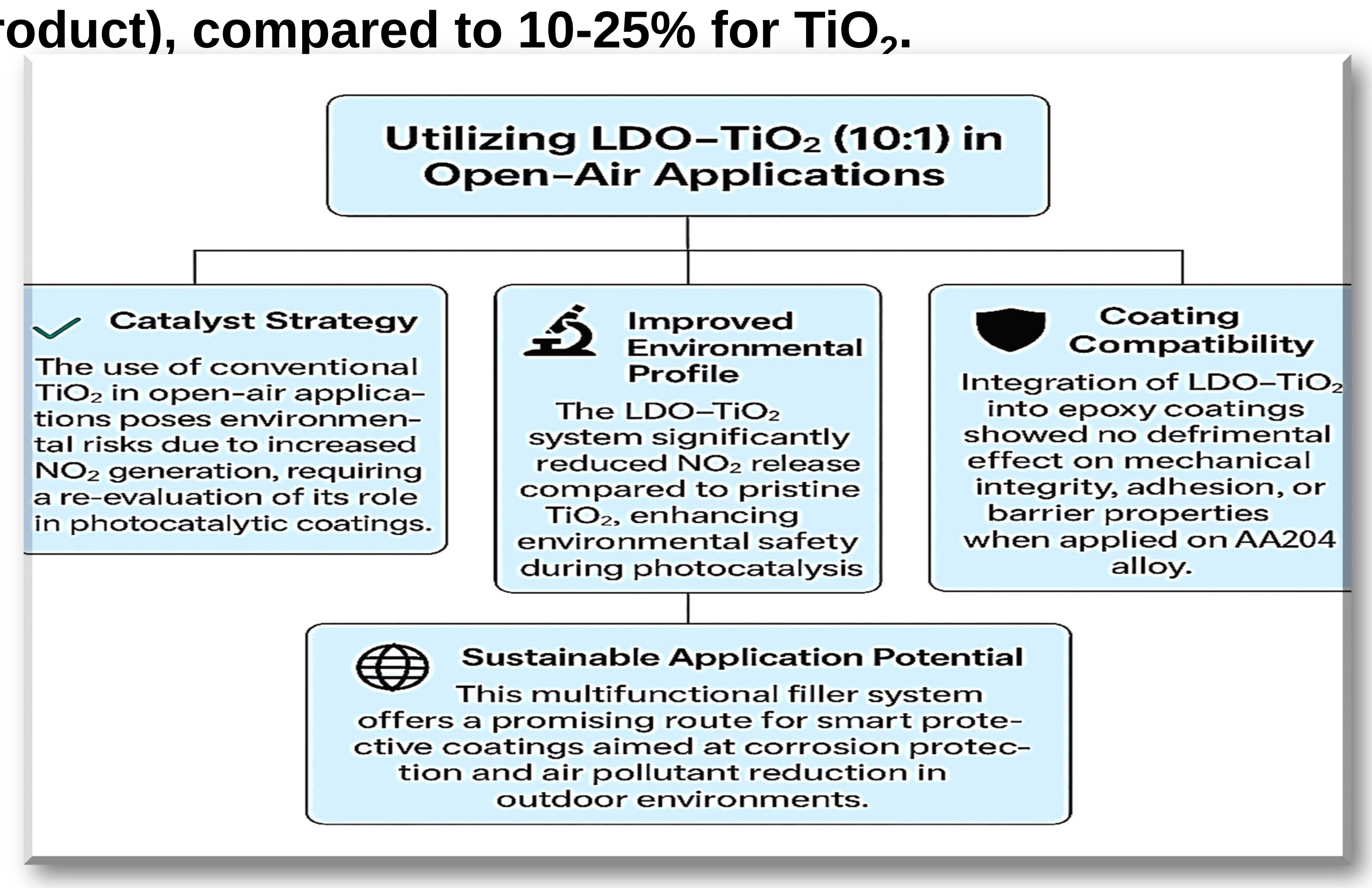
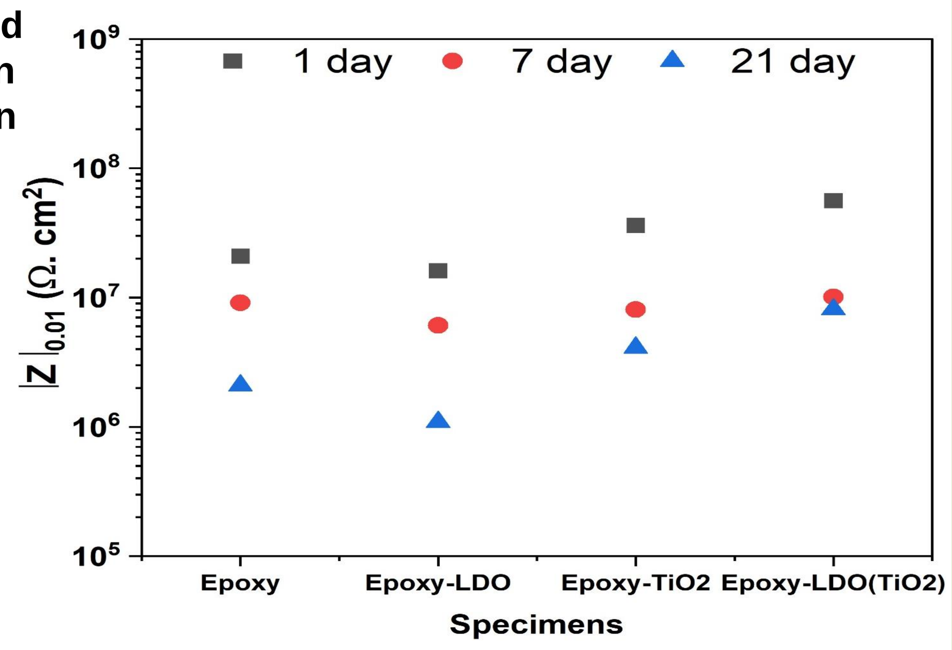


Figure 3: 0.01 Hz impedance comparative analysis of developed systems dispersed in epoxy and applied on AA2024.



Conclusions

- ✓ **TiO_2-LDO nanofiller offers dual functionality:**
  - ✓ Acts as a photoactive catalyst for NOx mitigation**, with minimal NO_2 generation (3-4%).**
  - ✓ Enhances UV stability and corrosion resistance in epoxy coatings- **potential to redesign the Epoxy base System for UV-resistant systems.**
- ✓ **The developed environmentally friendly Epoxy–TiO_2-LDO composite is a promising solution for UV-resistant protective coatings in environmental and structural applications, especially in UV-exposed environments.**

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