



Multifunctional materials in indoor environments: air remediation and cooling properties

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$\text{Bi}_x\text{O}_y\text{I}_z$ synthesis and characterization



Photocatalytic activity and mechanism



Thermal performance



Construction materials

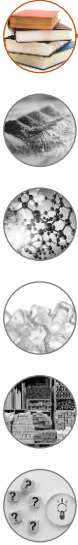


Conclusions and future work

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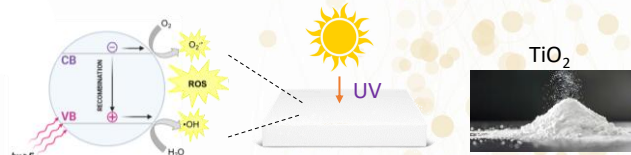
Introduction



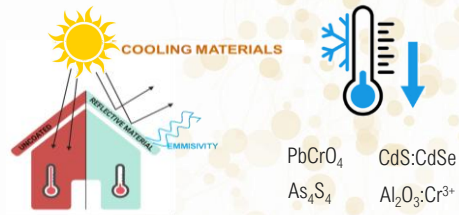
MOTIVATION



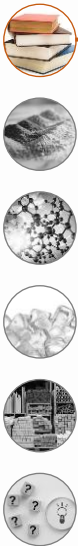
Photocatalytic construction materials



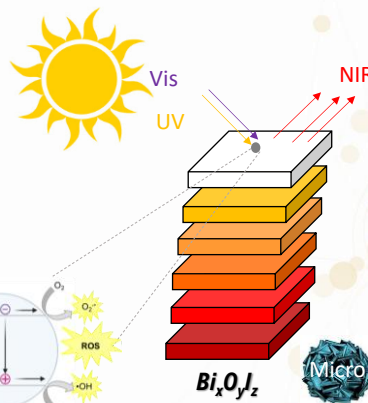
Cooling construction materials



Introduction



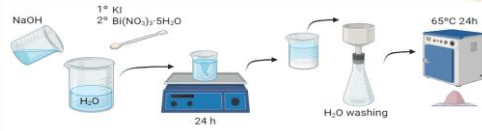
OBJECTIVE



Air quality + confort

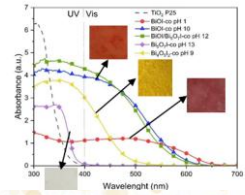
Bi_xO_yI_z synthesis and characterization

Coprecipitation

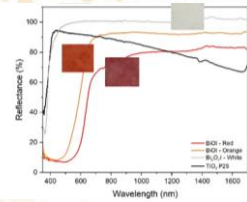


	pH of synthesis	Base used	Crystall phase	S _{BET} (m ² /g)	E _g (eV)	E _{CB} (V vs SHE)	E _{VB} (V vs SHE)	Crystallite size (nm)	SEM
	-	-	TiO ₂ P25	43±1	3.1	-0.2	2.9	17	
* *	1		BiOI	2±1	1.8	-0.1	1.7	53	
* *	10	NaOH	BiOI	26±1	1.9	-0.1	1.7	7	
	12	NaOH	BiOI/Bi ₂ O ₇ I	26±1	1.9	-	-	16	
* *	13	NaOH	Bi ₂ O ₇ I	2±1	3.1	-0.3	2.8	41	
*	9	NH ₃	Bi ₄ O ₃ I ₂	13±1	2.3	-	-	-	

UV-Vis absorption



NIR reflectance



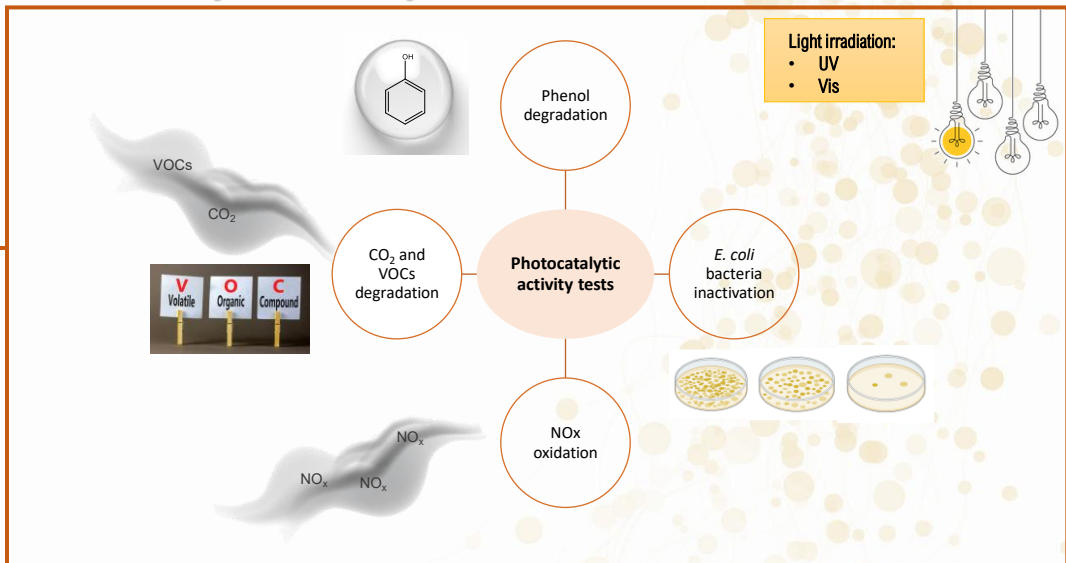
* Alkyd resin

* Lime, gypsum, cement, paints

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Photocatalytic activity and mechanism



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Photocatalytic activity and mechanism

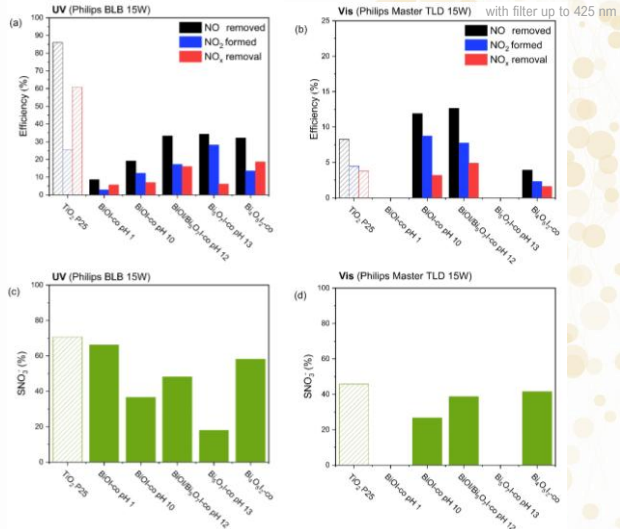
NO_x oxidation

UV irradiation

Bi_xO_yI_z do not exhibit competitive performance with TiO₂ P25.

Vis irradiation

improved performance.



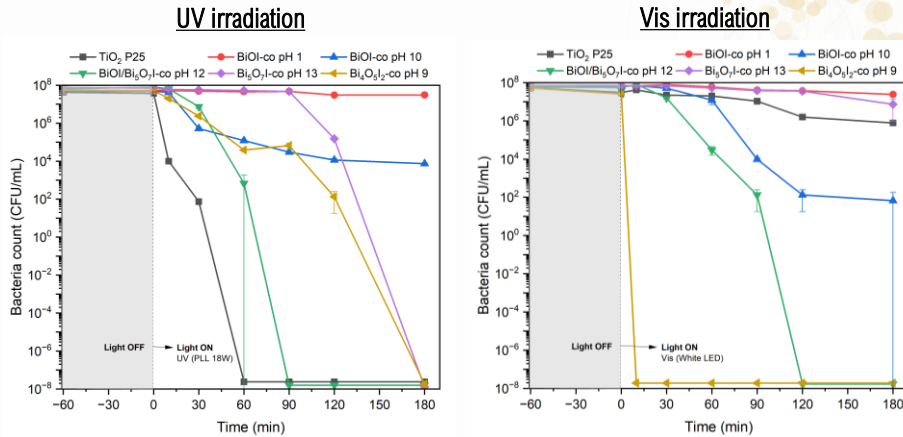
Martinez-Topete et al., *J Mater. Sci: Mater Eng.* 20, (2025), 39.

Photocatalytic activity and mechanism

Bacteria Inactivation

E. coli MG 1655

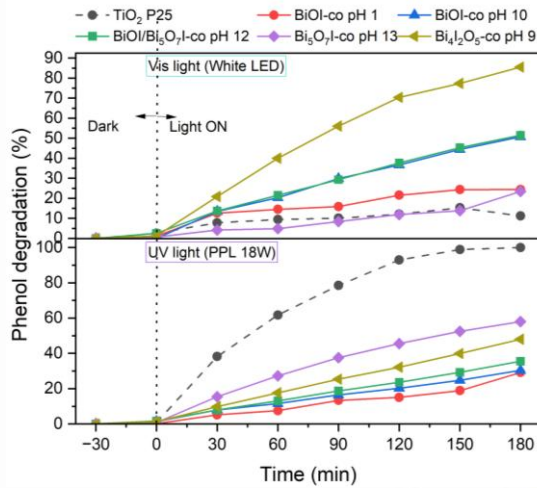
High disinfection efficiency under both illumination conditions.



Manuscript under revision

Photocatalytic activity and mechanism

Phenol degradation



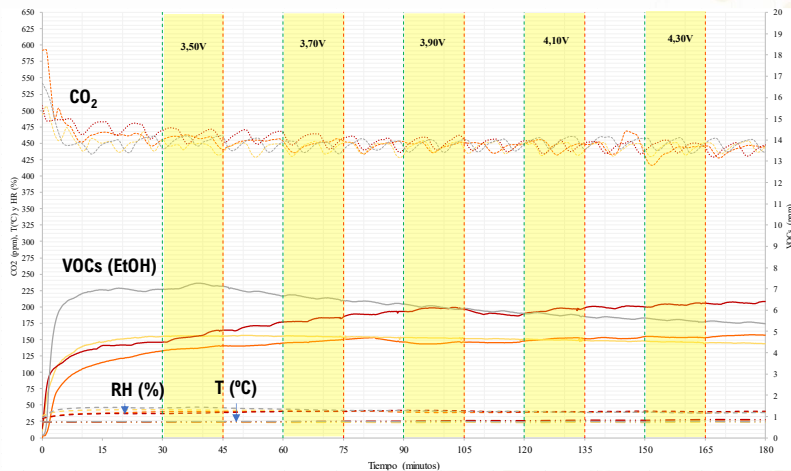
Vis irradiation improved performance

UV irradiation $\text{Bi}_x\text{O}_y\text{I}_z$ do not exhibit competitive performance with TiO_2 P25.

Martinez-Topete et al., *J Mater. Sci: Mater Eng.* 20, (2025), 39.

Photocatalytic activity and mechanism

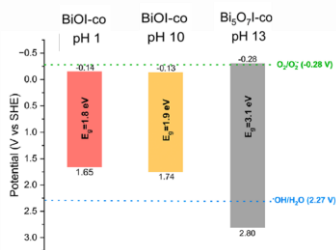
CO_2 and VOCs degradation



UV irradiation (different intensities) VOCs and CO_2 photocatalytic degradation under these conditions not observed → further testing needed

Photocatalytic activity and mechanism

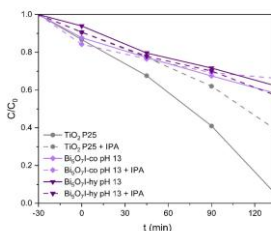
Mechanism: ROS



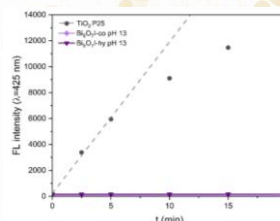
No •OH formation observed for $\text{Bi}_5\text{O}_7\text{I}$ through any experiment.

Proposed mechanism:
Direct h^+ oxidation and/or involvement of $^1\text{O}_2$

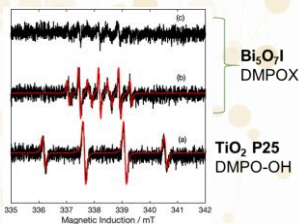
Scavenger tests (IPA)



Fluorescent probe (TA)



EPR (Spin-trap DMPO)



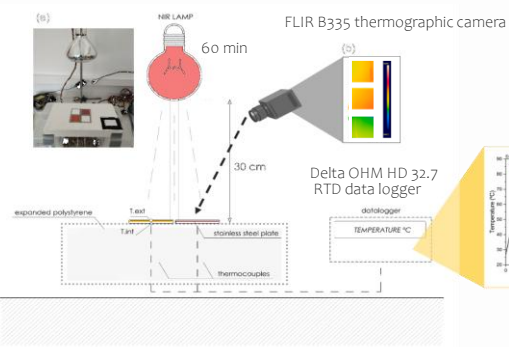
Martínez-Topete et al., *J Mater. Sci: Mater Eng.* 20, (2025), 39.

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Thermal performance ("cooling")

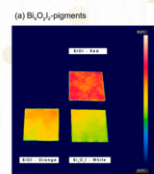
Cooling set-up:



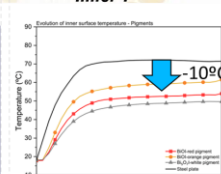
Thermal performance:
Inner temperature (thermocouples + datalogger)
Outer temperature (thermographic camera)

Studied parameters:
Reflectance (ability to reflect sunlight)
Emissivity (ability to radiate heat)

Outer T^a



Inner T^a



$\text{BiOI-red} > \text{BiOI-orange} > \text{Bi}_5\text{O}_7\text{I-white}$
 $-R \quad +R \quad ++R$
 $-E \quad +E \quad ++E$

$\text{BiOI-orange} > \text{BiOI-red} > \text{Bi}_5\text{O}_7\text{I-white}$
 $+R \quad -R \quad -R$
 $+E \quad -E \quad +E$

a. $\text{Bi}_5\text{O}_7\text{I}$ Pigments

Compound	Emissivity	NIR Reflectance (%)
BiOI-red	0.40 ± 0.01	78.4 ± 1.1
BiOI-orange	0.71 ± 0.02	92.7 ± 6.5
$\text{Bi}_5\text{O}_7\text{I-white}$	0.77 ± 0.02	97.0 ± 3.3

All $\text{Bi}_5\text{O}_7\text{I}_2$ -coated metal samples exhibited significantly better thermal performance, with lower surface and inner temperatures than uncoated samples

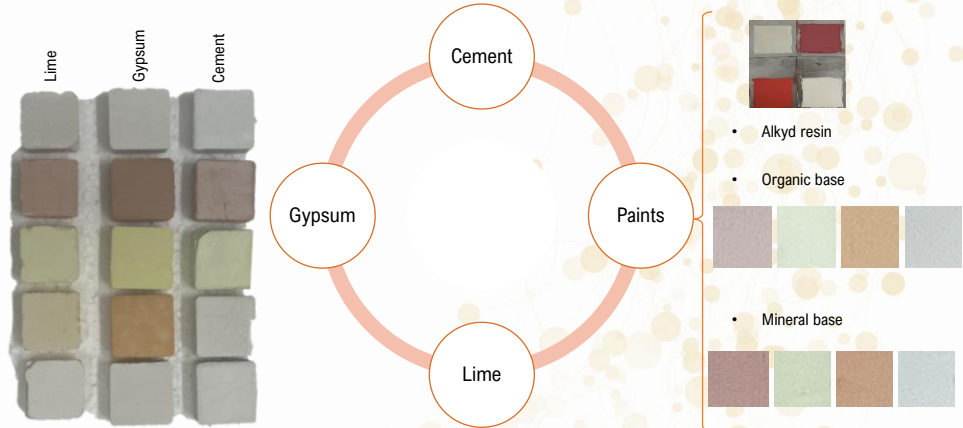
Martínez-Topete et al., *J. Photochem. Photobiol. A*, 460 (2025), 116151.

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Construction materials

Synthesized $\text{Bi}_x\text{O}_y\text{I}_z$ were incorporated as additives into various construction material matrices to evaluate whether they retain their photocatalytic and cooling properties.



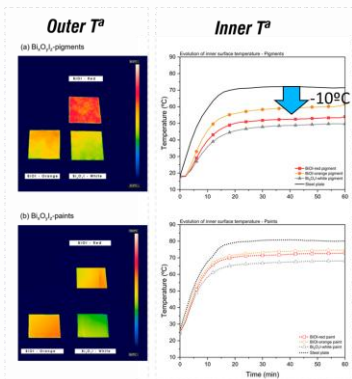
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Construction materials

Alkyd resin coatings

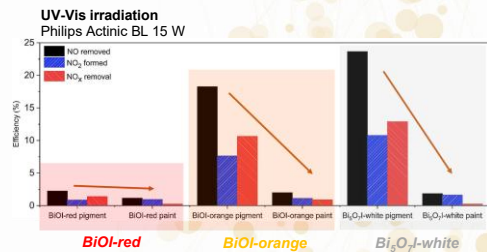
Thermal performance



Maintains significantly **better** thermal performance, with lower surface and inner temperatures than uncoated samples

Tests with other construction materials in progress

Photocatalytic performance: NOx



The incorporation of pigments into the resin **significantly reduce** their photocatalytic reactivity likely due to resin degradation or pigment-resin incompatibility.

Martínez-Topete et al., *J. Photochem. Photobiol. A*, 460 (2025), 116151.

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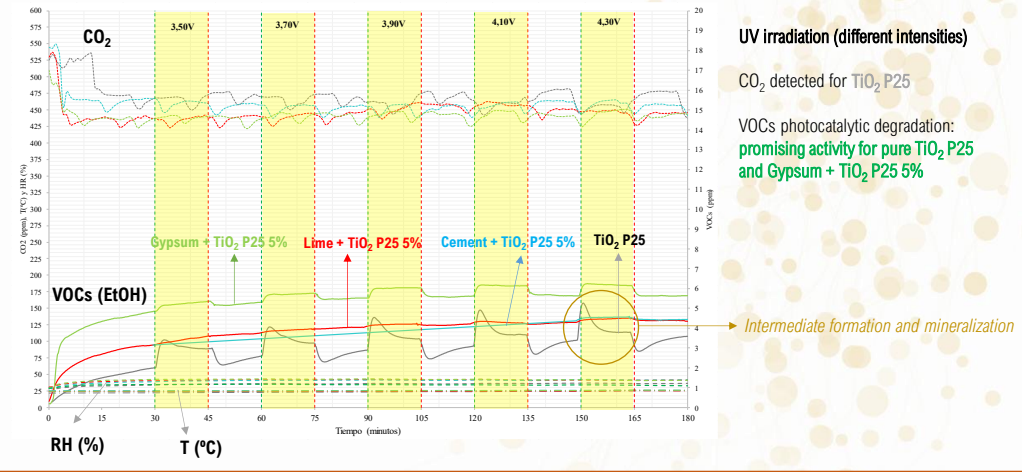
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Construction materials

Alkyd resin coatings

Tests with other construction materials in progress


Photocatalytic performance: VOCs and CO₂



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Conclusions and future work

- Successful preparation of **Bismuth Oxyiodides (Bi_xO_yI_z)**
- **Room temperature** and **scalable** synthesis: pH dependent co-precipitation procedure
- Wide range of colors and crystal structures 
- Promising **photocatalytic** activity under **visible** light
- Favorable **thermal** (cooling) performance
- Incorporation into various construction material matrices: lime, gypsum, cement and paints (alkyd, organic and mineral)
- Ongoing evaluation to identify the most suitable matrix for multifunctional applications (photocatalytic + cooling) aimed at improving **indoor air quality and thermal comfort**

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Thank you for your attention!



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PID2022-141812OB-I00 and InterPHOT Network RED2022-134413-T from the AIE (Spanish Research Agency)

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