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Photocatalytic degradation of NO using Mn–doped TiO2 nanostructured powders applied on different supporting materials

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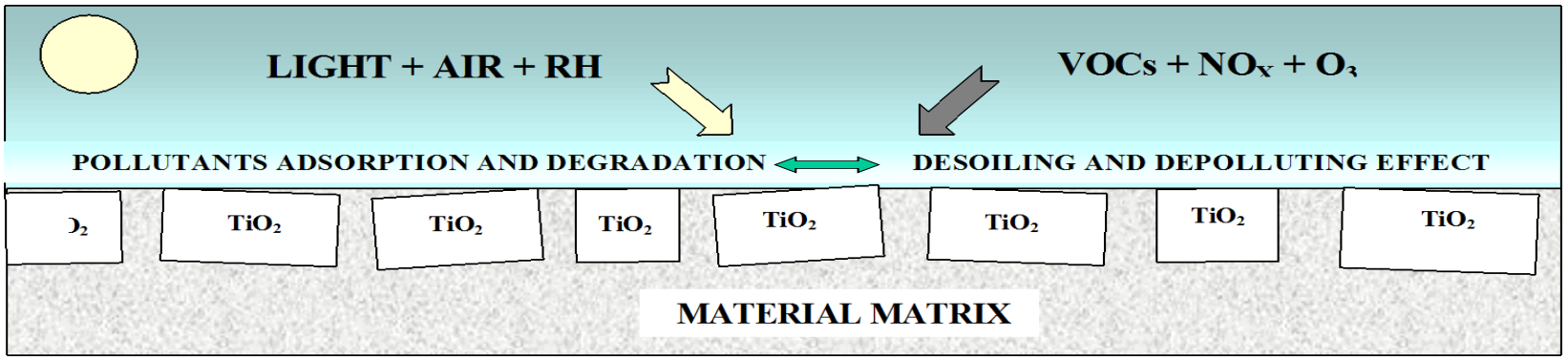

EREL

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- **Environmental Research Laboratory (EREL)**

NCSR Demokritos

(http://www2.ipta.demokritos.gr/)

Role: Evaluate the photocatalytic performance

- **Transparent Conductive Materials Laboratory (TCM)**

FORTH (Foundation for Research and Technology)

Role: Syntesize the photocatalytic material

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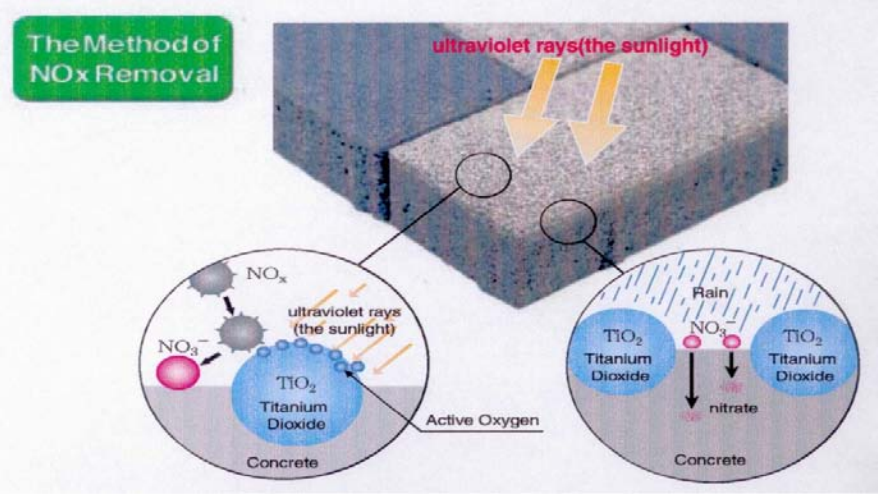
APPLICATION OF TiO_2 PHOTOCATALYTIC PROPERTIES ON ATMOSPHERIC DEPOLLUTION

The use of TiO_2 in building matrix or surface coating could give to the material **self cleaning** and **depolluting activities**

Such materials, when exposed to solar UV rays, will act as a catalyst for the photoinduced decomposition of inorganic and organic molecules adsorbed on its surface.



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Testing Photo-materials

The experimental set-up and the procedures employed to perform the photocatalytic tests seems to play a significant role on the photocatalyst behavior

Parameters mainly infuence the pollutant degradation

- *Experimental conditions (pollutant nature, init.conc., light, mixtures, RH, T)*
- *Reactor design (batch reactor, fixed bed annular reactor, honey comp monolith etc)*
- *Substrate nature When powders, paints or thin films are tested, it is very important to use a suitable sample holder which ideally will not inhibit or enhance the photoactivity of the material*

Several different substrates are nowadays reported in the literature, including: glass, teflon, cement, metals

SCOPE

It is the purpose of this study to investigate the NO abatement efficiency of laboratory made Mn–doped TiO2 nanostructured powder on three different substrates

Glass, plywood and gypsum were the three different substrates that were used.

In addition, the influences of formulation parameters such as the amount of photocatalyst and environmental parameters such as light wave length (UV and Vis) on the photocatalytic efficiency of the material were tested.

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EXPERIMENTAL PROCEDURE

- ***Photocatalytic Testing Materials***

Mixture of : Commercial Cement paint
+ 5% TCM-1
+ 10% TCM-1

←Gypsum

←Plywood

←Glass

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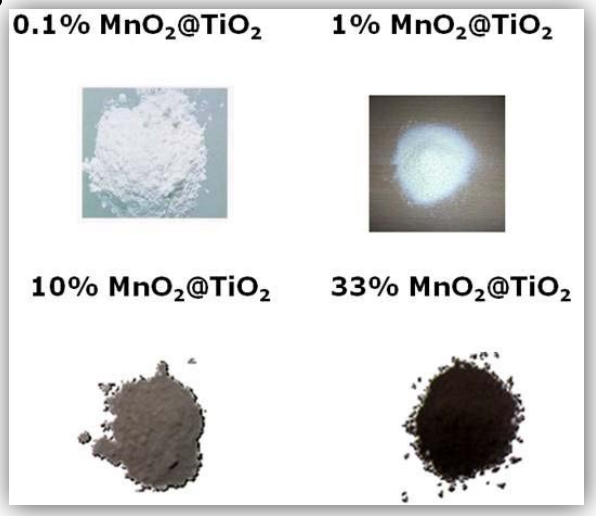
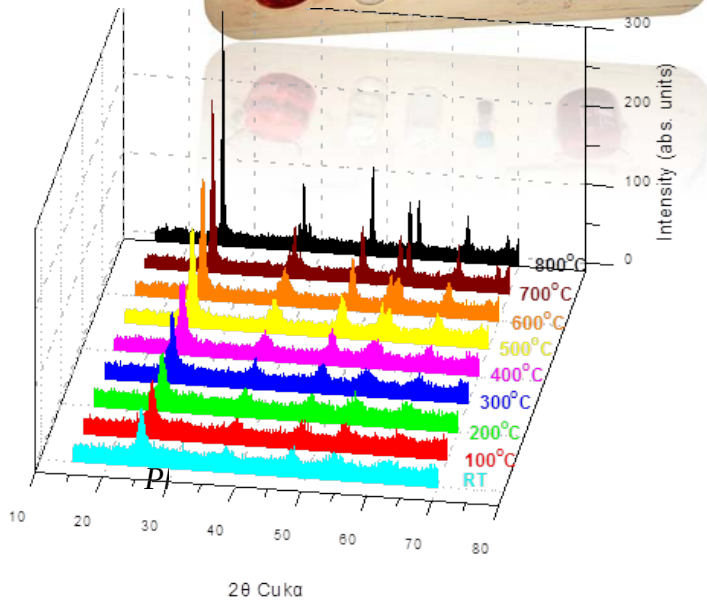
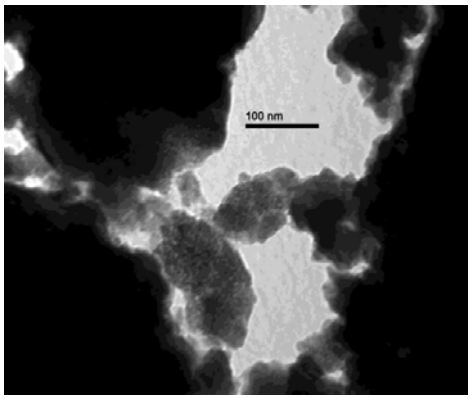
What is TCM-1 ???

Sol gel
Method





Crystal structure
Anatase



Grain size 20-30 nm

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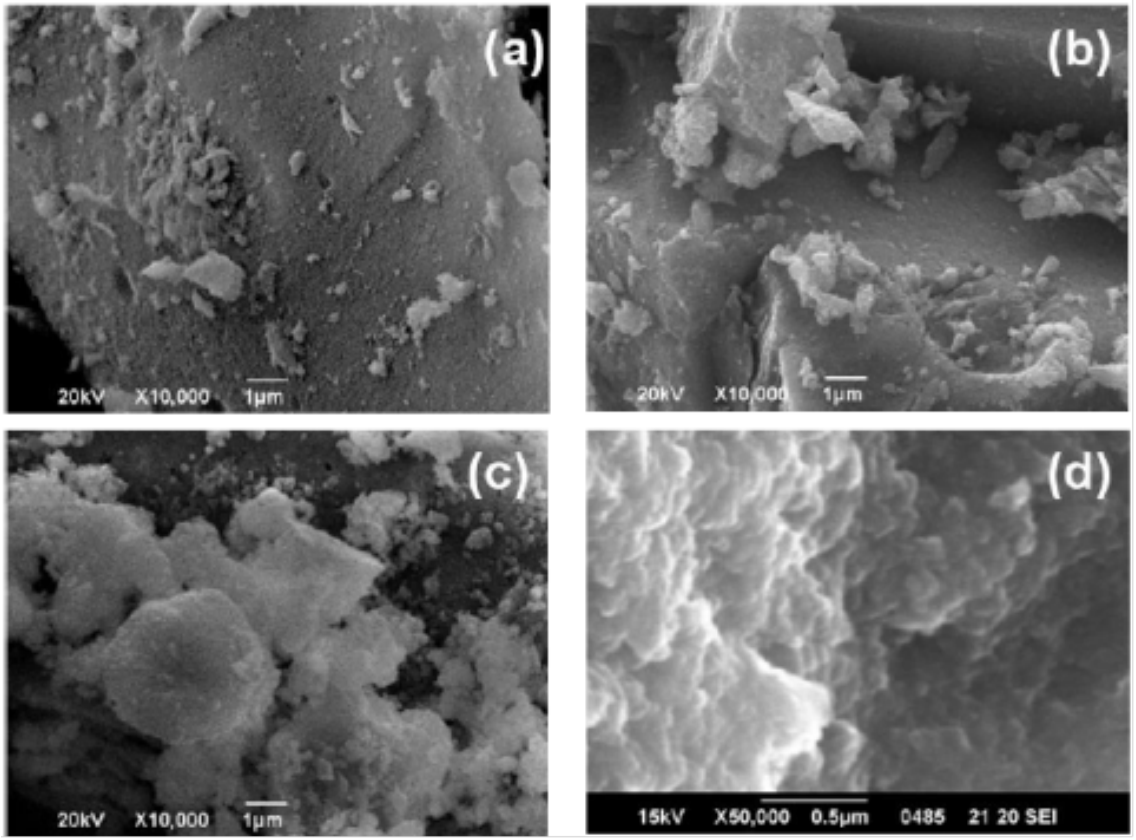
What is TCM-1 ???



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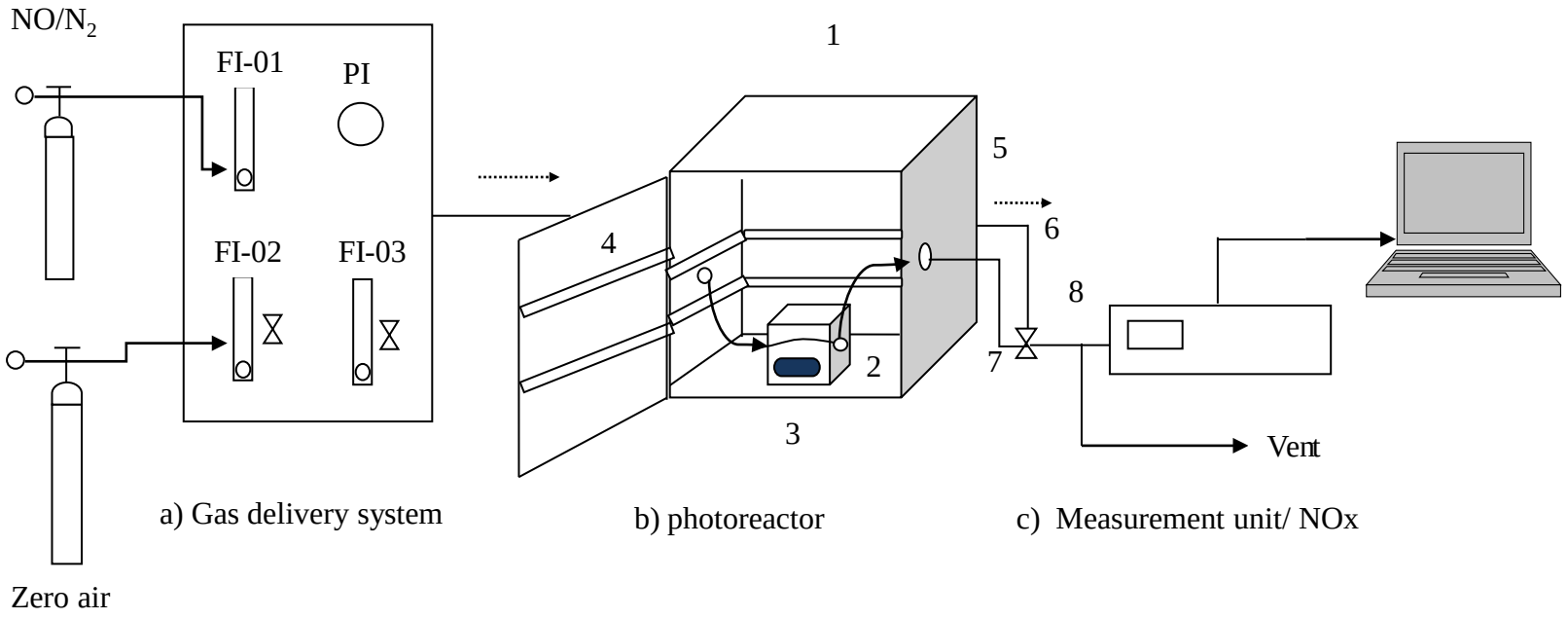
EXPERIMENTAL PROCEDURE

➢ *Experimental Set-up*

The photocatalytic activity of the nanostructured poweders was examined employing a photocatalytic system, which comprised of a gas delivery unit, a reactor chamber and a measurement unit.



a) Gas delivery system

b) photoreactor

c) Measurement unit/ NOx

Photocatalytic experiments were carried out in a cubic pyrex-glass reaction chamber of 0.125 m3 volume capacity (50 cm x 50 cm x 50 cm), which was placed inside a (light) sealed irradiation box.

The photocatalytic material were subsequently placed at the bottom surface of the cell. The cell's loading factor lf (photocatalyst surface/cell volume ratio) was estimated to be about 0.72 m^2 m^{-3}

- NO…….....….....…….....~200 $\mu g m^{-3}$
- U.V black light TLD lamps…....10x15W
- Distance lamp-sample…….20cm
- Irradiation time…….....…45 min
- UV irradiation……. ….……2.6 Wm^{-2}
- Vis irradiation……..7.6 Wm^{-2}
- Temperature…….....24-27 ^oC
- RH……34-45 %

- ***Experimental procedure for the evaluation of air pollutants removal due to photocatalytic oxidation***

The principle on which the measurement and evaluation of the materials' photocatalytic activity is based refers to the loss of the pollutant's amount that is observed over the whole photocatalytic process.

The reduction of the air pollutant's concentration within the chamber can be attributed to the appearance of the following four (4) different mechanisms:

1. Sink effect (on the walls of chamber)
2. Absorption on the surface of the sample
3. Photolysis by U.V light
4. Photocatalysis by TiO2 and U.V light.

Therefore, the measurement can give information on the TiO_2 activity provided that the above side effects 1-3 have been taken into account.

The catalytic activity of the materials assessed by the following parameters :

a) the Photocatalytic Decomposition Percentage (%PD), which displays the percentage of air pollutant that is photo-removed during the photocatalytic experiment

$$\%NO_{photo-removal} = \left(\frac{[NO]_{u.v} - [NO]_{blank}}{[NO]_{u.v}} * 100 \right)$$

(b) The photocatalytic/oxidation rate (PR, μg m^{-2} s^{-1}), which is regarded to provide a more precise estimation of the depollution capacity of a material since for its calculation the sample surface, the chamber volume and the duration of the irradiation period are also taken into account

$$Photocatalytic - rate(PR) = \left(\frac{V * [NO]_{reduv}}{A * t} \right)$$

RESULTS ➢ **Photocatalytic removal rate of NO under different experimental set up**

NO degradation rate ($\mu g\ m^{-2}s$)	GYPSUM		PLYWOOD		GLASS	
	5%	**10%**	**5%**	**10%**	**5%**	**10%**
UV	0.143	0.156	0.144	0.142	0.161	0.162
Vis	0.055	0.065	0.053	0.076	0.079	0.080

• On the glass matrix the NO abatement is slightly higher than the other 2 substrates under both UV & Vis irradiation and TiO_2 percentage

RESULTS ➢ **% Photocatalytic removal of NO under different experimental set up**

NO degradation %	GYPSUM		PLYWOOD		GLASS	
	5%	**10%**	**5%**	**10%**	**5%**	**10%**
UV	68.9	72.5	71.0	75.9	76.8	77.9
Vis	20.2	27.9	18.4	26.6	16.3	20.9

• Better photocatalytic activity was monitored for the 10% Mn:TiO2 powder for all substrates under both UV & Vis irradiation

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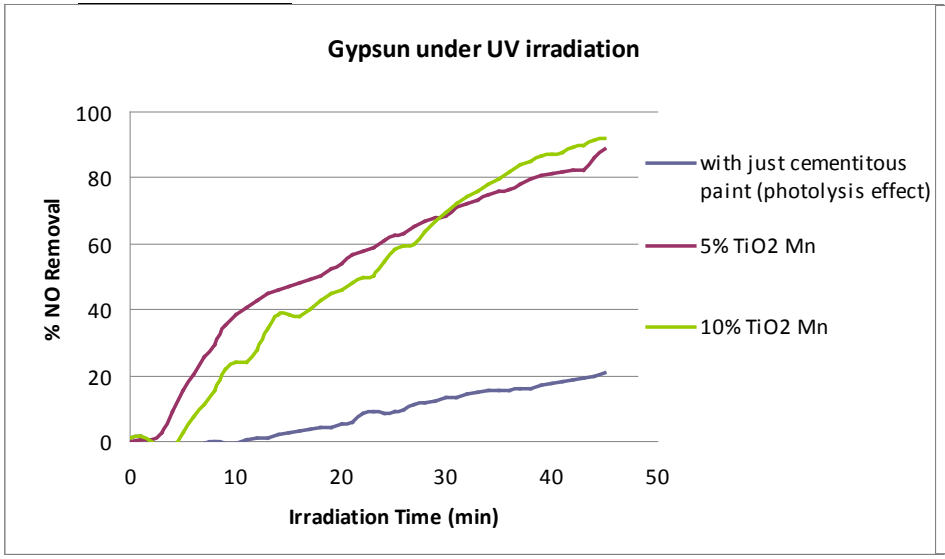
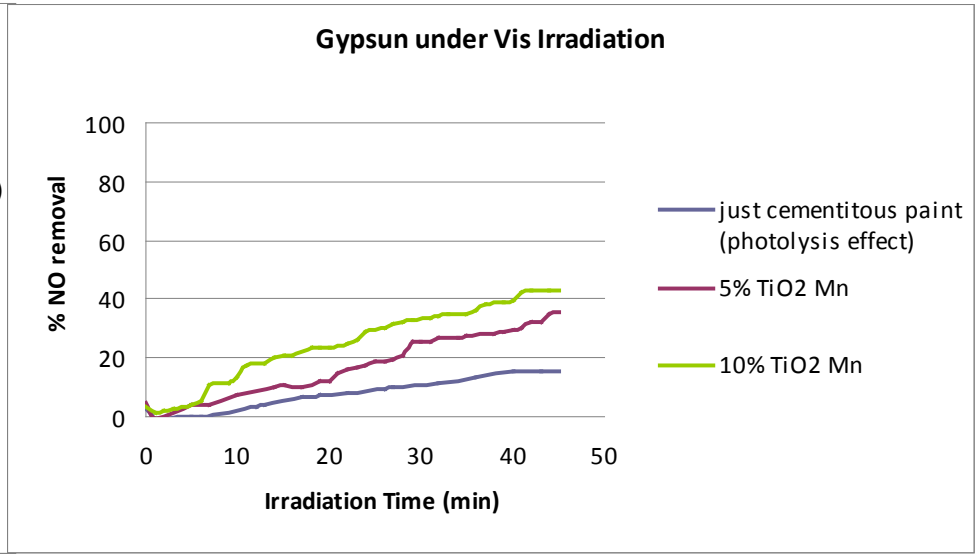
RESULTS





• **Higher photocatalytic activity under UV irradiation and 10%TiO_2 in the powder on the gypsum substrate**

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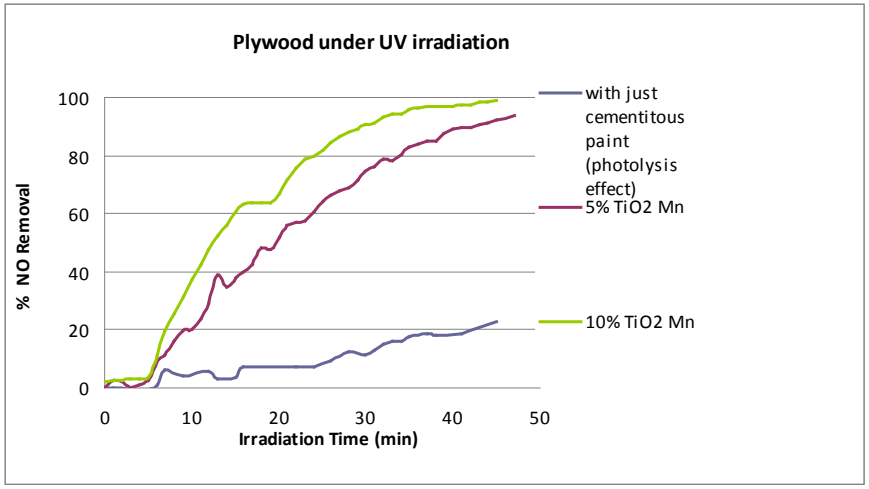
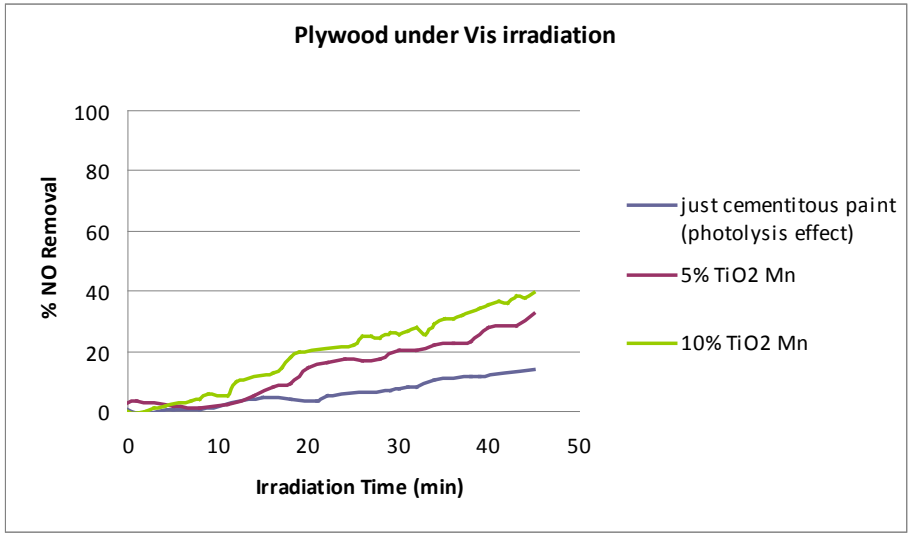
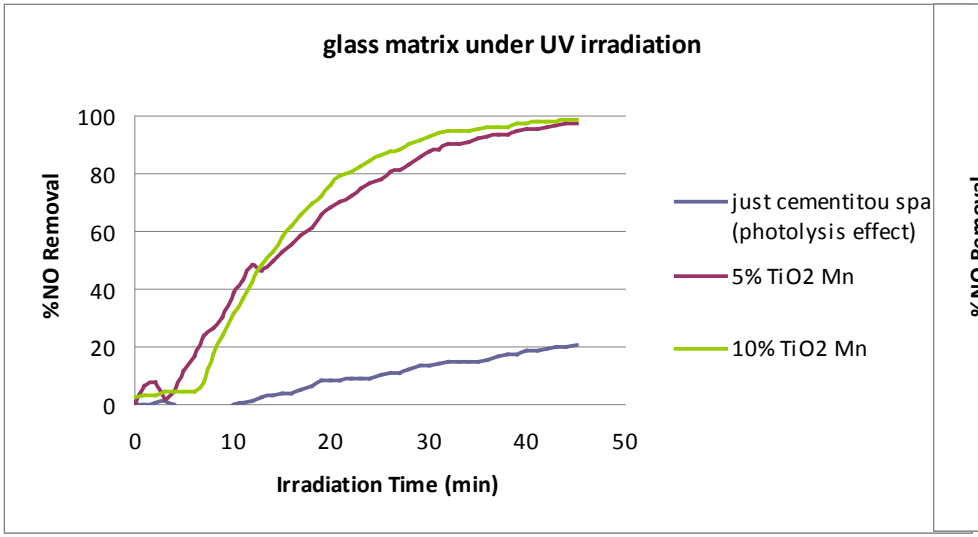
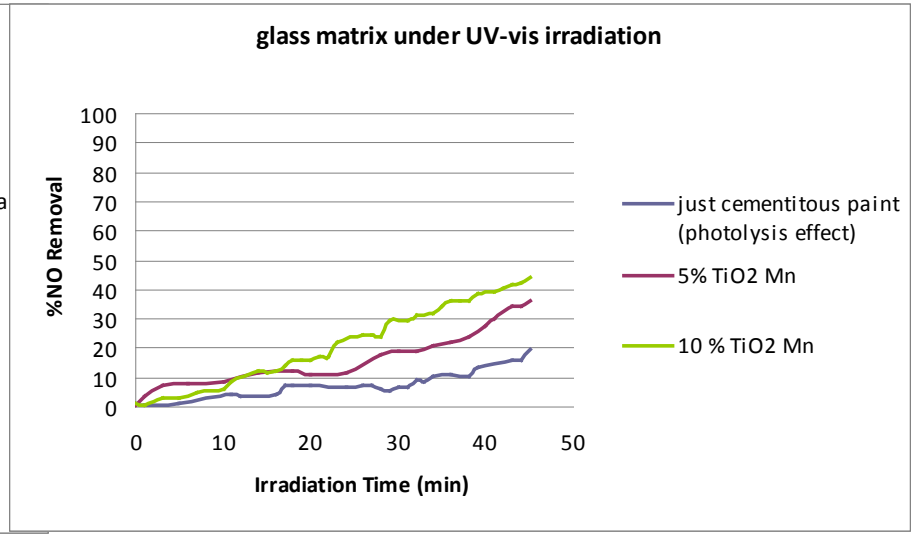
RESULTS









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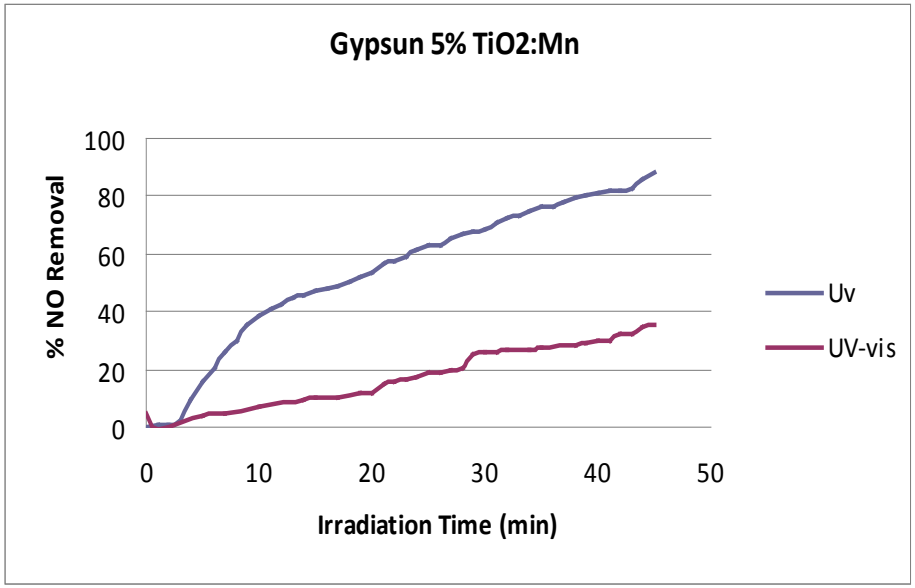
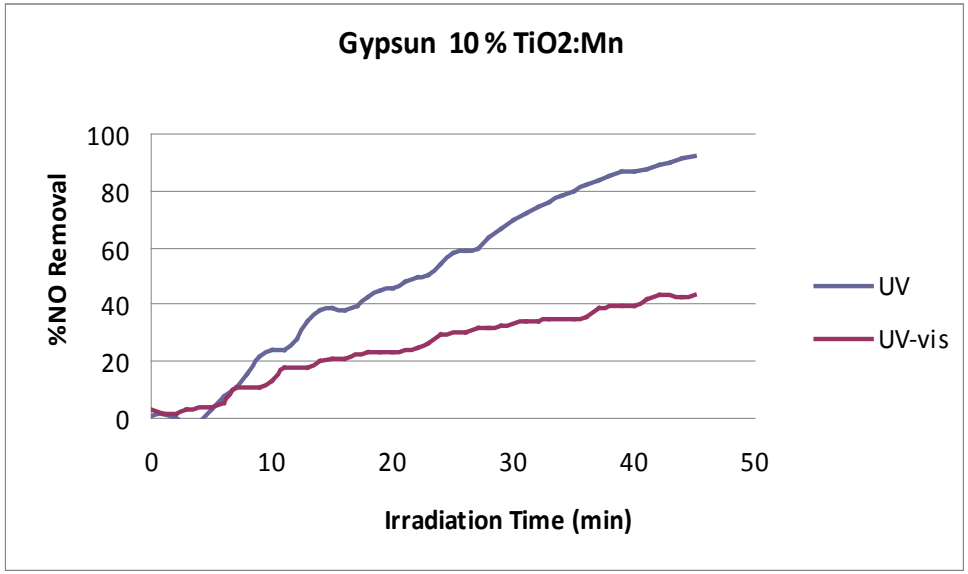
RESULTS





• **Significant higher photocatalytic activity under UV irradiation for all substrates and both 5% & 10% powder**

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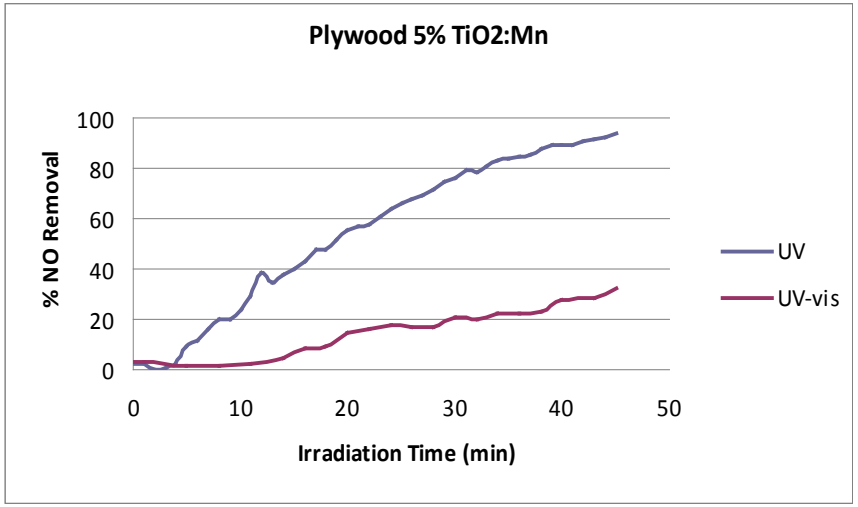
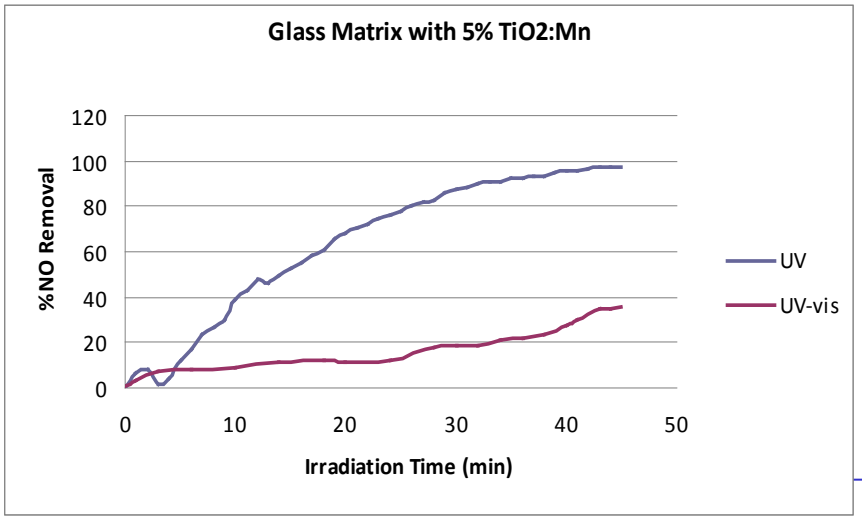
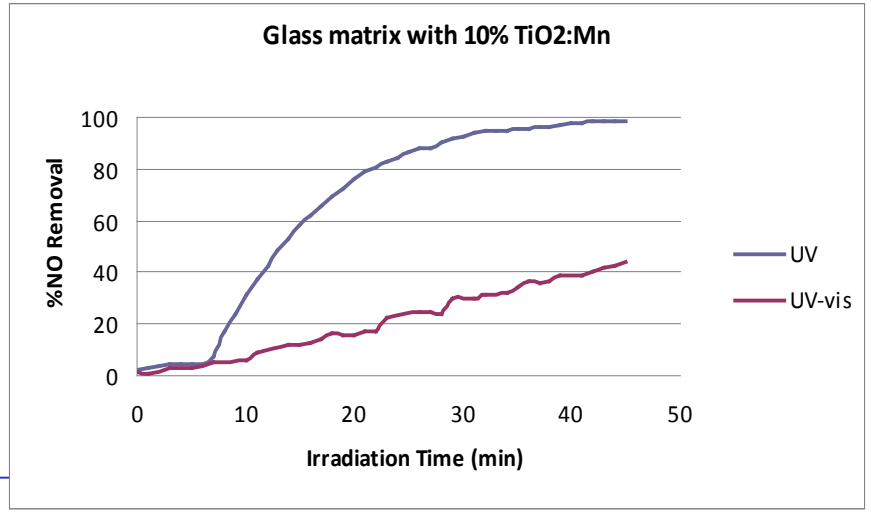
RESULTS







CONCLUSIONS

✓ The supporting material could inhibit or enhance the photoactivity of a photocatalytic material while tested in a photocatalytic reactor

✓ Glass seems to play a positive role on powders photoactivity when comparing with gypsum and plywood substrates

✓ Both materials (5%, 10% TiO_2) present better photocatalytic activity under UV than Vis irradiation independently of the substrate nature

✓10% TiO2 present slightly better photoactivity than 5% under all the examined substrates

Thank you

for your attention

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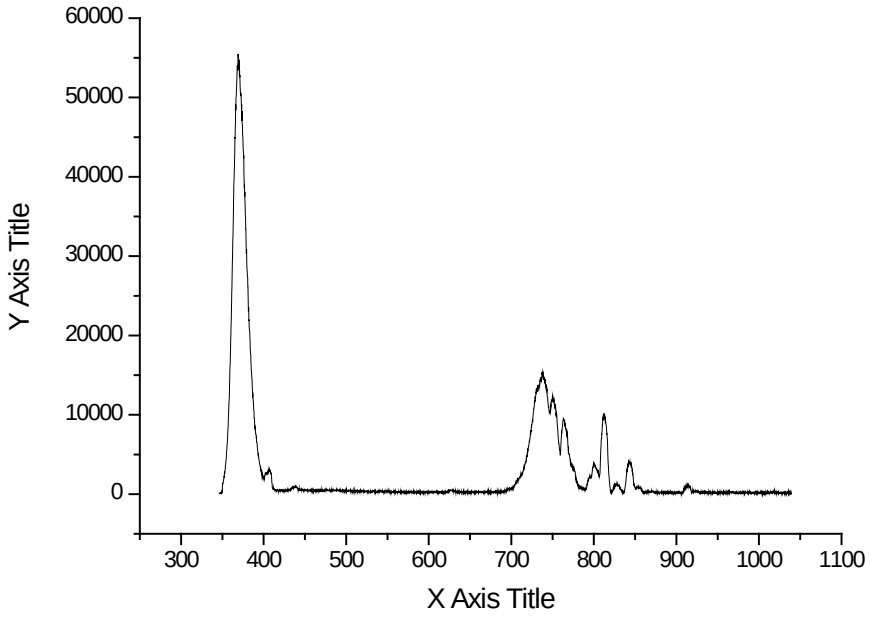
Ealing radiometer/photometer

10 UV lamps: TOTAL IRRADIANCE 2.6 W/m2

55% UV = 1.43 W/m2

45% NIR = 1.17 W/m2



10VIS lamps: TOTAL IRRADIANCE 7.6 W/m2
99.4% VIS = 7.55 W/m2
0.6% UV = 0.04 W/m2