Photocatalytic system for decomposition of non-CO_2 greenhouse gases

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Introduction

Non-CO_2 gases can account for even one-third of the global warming [1]. The greatest contribution comes from CH_4, emitted mainly from anthropogenic sources – agriculture and wastes [2]. In this work, we try to develop an efficient, low-cost and adjustable photocatalytic system which could be used, among others, in barns and other animal husbandry.

We tested two types of photocatalytic nanoparticles – commercially available TiO_2-based and synthesized CuO/ZnO-based materials. It was already reported that these materials can be useful in photocatalytic methane decomposition [3-4].

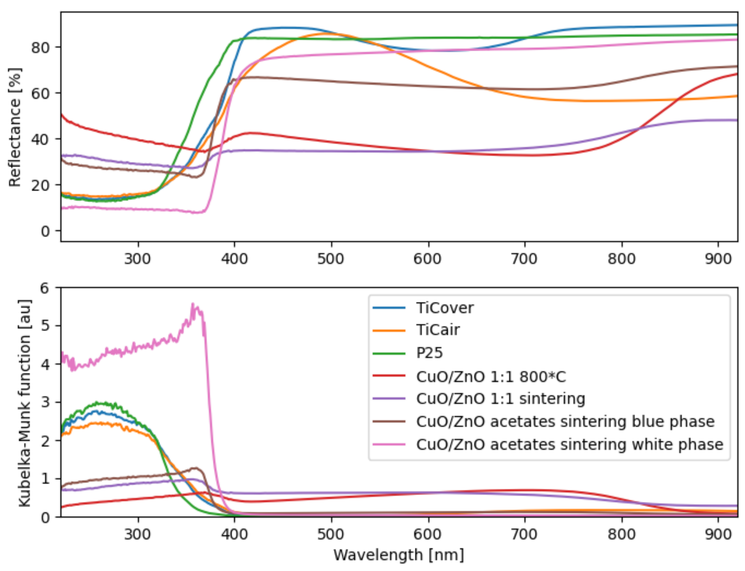
UV-Vis spectra of TiO_2-based and CuO/ZnO photocatalysts

UV-Vis spectra collected to $BaSO_4$ reference.

Band gaps determination based on a *Tauc* transformation T of Kubelka-Munk function F_{KM} [4]

$$F_{KM} = \frac{(1-R)^2}{R}$$

$$T = \sqrt{F_{KM} \cdot E(\lambda)}$$



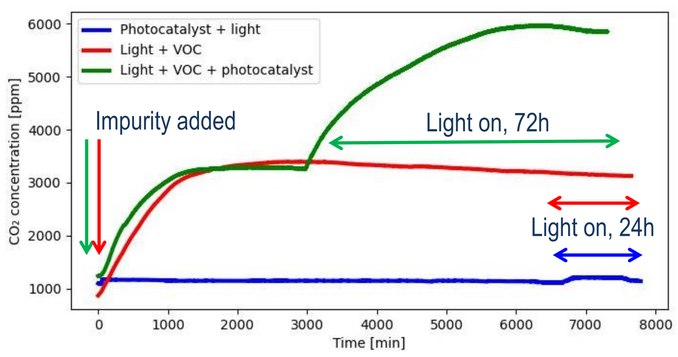
Photocatalyst	Band gap energy [eV]	Corresponding wavelength [nm]
TiCover	3.03	409.19
TiCair	3.03	409.19
P25	3.11	398.67
CuO/ZnO 1:1 with 0,15 Na_2CO_3	3.22	385.04
CuO/ZnO 1:1 800ºC	3.01	411.91
CuO/ZnO acetates sintering blue phase	3.21	386.24
CuO/ZnO acetates sinteringwhite phase	3.00	413.28

VOC photocatalytic degradation on plasma treated PP net coated with TiO_2-based

HCOOH was used as a model impurity The total photocatalytic decomposition monitored in this system is described by the following equation

$$HCOOH \longrightarrow CO_2 + H_2$$

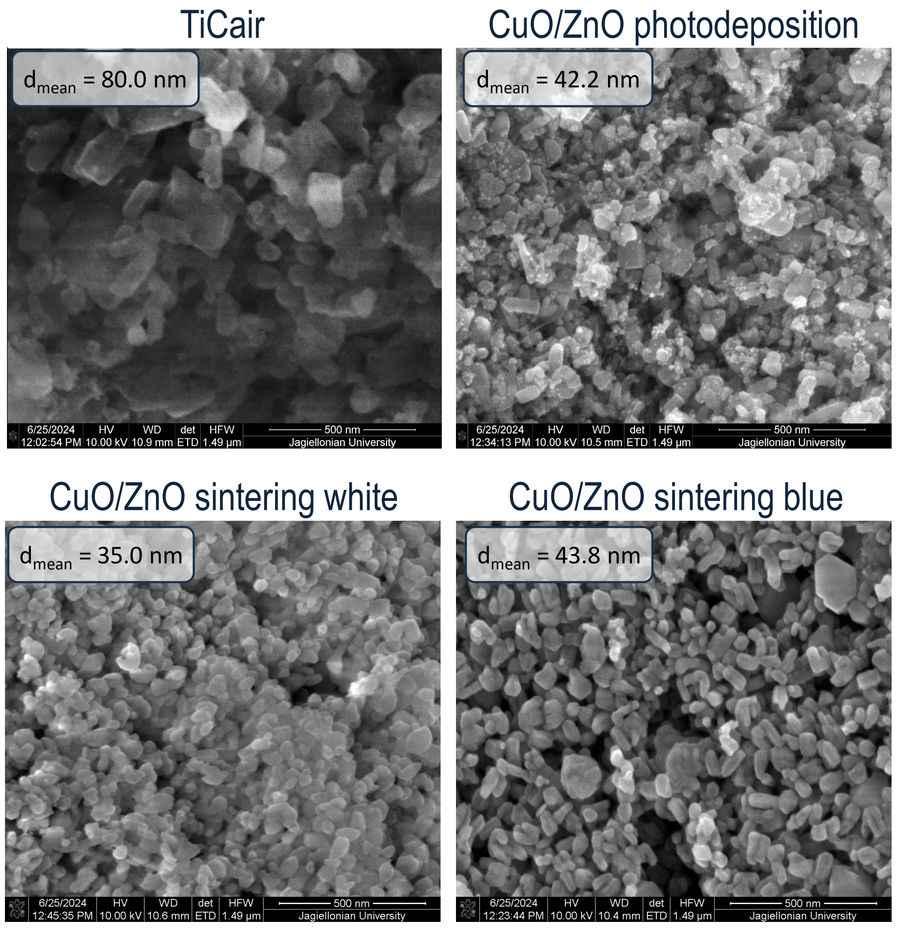
Concentration of CO_2 during HCOOH degradation



Chamber setup	UVA-Blacklight, photocatalyst	UVA-Blacklight, no photocatalyst	UV365 nm LED, no photocatalyst	LED white, no photocatalyst	UVA-Blacklight, photocatalyst	UV365 nm LED, photocatalyst	LED white, photocatalyst
CO_2 increase, [ppm]	93	-68	-63	27	1680	639	177
% HCOOH degradation*	N/A	-0,55	-0,52	0,22	13,81	5,16	1,47

* Chamber volume 43 dm^3, mass of HCOOH to CO_2 volume coefficient, [dm^3/g] = 0.52, formic acid concentration 85%

SEM analysis

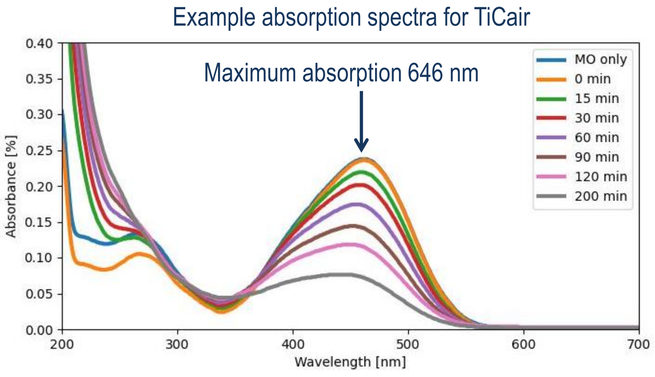


MO photocatalytic degradation with TiO_2-based and CuO/ZnO photocatalysts

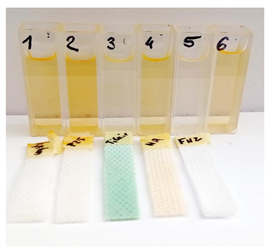
Photocatalytic methyl orange (MO) degradation was conducted under **UVA blacklight illumination**.
The amount of degraded MO was calculated based on the maximum of the absorption spectrum.

FN2 and NanoAmor materials exhibited better efficiency, but the coatings started to fall off the support.

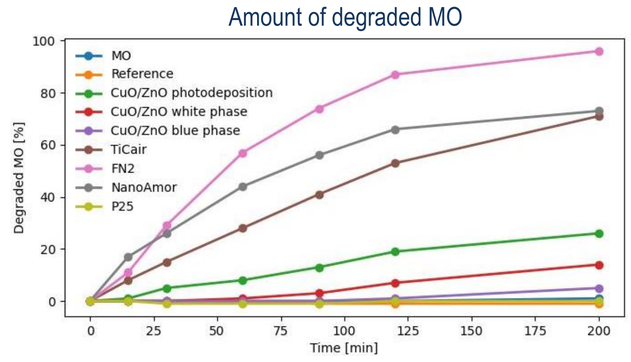
Example absorption spectra for TiCair



Quvettes with MO after all illumination cycles



Amount of degraded MO



Conclusions

In this work nanopowders of commercially available TiO_2 and synthesized CuO/ZnO were characterized over their photocatalytic activity. TiO_2-based product TiCair, exhibited more than 2 times better performance during photocatalytic degradation of methyl orange. Therefore it was used for further studies of photocatalytic reactions in the gas phase.
In the gas phase the degradation of formic acid was measured. In most efficient setup TiO2-based photocatalyst illuminated with UVA light removed almost 14% of the introduced pollutant.
In the future, we want to optimize these photocatalysts to also remove CH4, NH3 and NOx.

References

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Acknowledgements

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REPAIR

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