National Research and Development Institute for Industrial Ecology-ECOIND

INTERNATIONAL SYMPOSIUM „THE ENVIRONMENT AND THE INDUSTRY" 2023

METAL – TITANIUM DIOXIDE DOPED CATALYSTS FOR WASTEWATER TREATMENT UNDER SIMULATED SOLAR LIGHT

Lucian-Alexandru Constantin, Ioana Alexandra Ionescu, Mirela Alina Constantin, Mihai Stefanescu, Nicoleta Mirela Marin

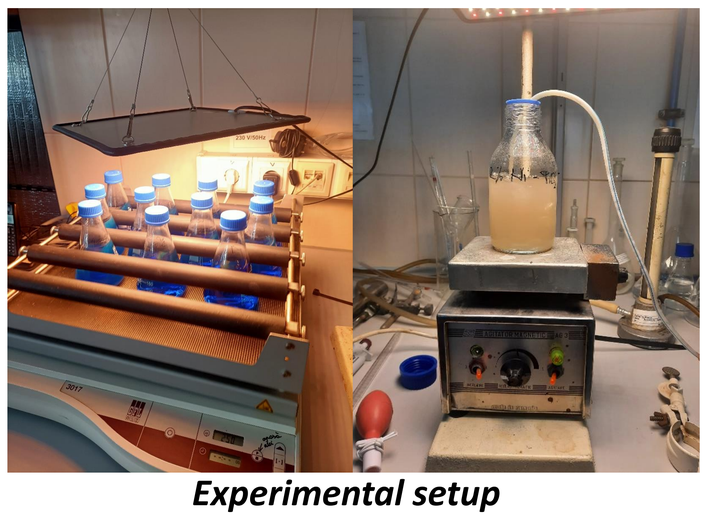
National Research and Development Institute for Industrial Ecology – ECOIND, 57-73 Drumul Podu Dambovitei St., Bucharest – 6, Romania

Introduction

TiO_2 assisted photo catalysis was widely studied in the last years for the advanced degradation or organic compounds from aqueous systems, mainly for those not removed by conventional treatment processes. The main drawback of TiO_2 is that is activated only by UV radiation and uses only about 5% of available solar radiation. TiO_2 doping with metals proved to be a good method to improve its photocatalytic properties and to enhance its response to solar radiation.

Materials and methods

Three types of metal-doped TiO_2 catalysts (Fe-TiO_2, Ni-TiO_2, Co-TiO_2) were prepared using sol-gel method. The TiO_2 precursor was titanium (IV) isopropoxide and $Fe(NO_3)_3 \cdot 9\ H_2O$, $Ni(NO_3)_2 \cdot 6\ H_2O$, $Co(NO_3)_2 \cdot 6\ H_2O$ (were used as metal sources. Catalysts with 1wt%, 2wt%, 5wt% were prepared. A lamp with the following characteristics: 35W, 380-800 nm, 1000 lumens, photosynthetic photon flux density 300 µmol quanta/m^2·s was used to simulate solar radiation. Dimensional analyse was performed using a Mastersizer 2000 – Malvern equipment and a FEI Quanta FEG 250 scanning electronic microscope was used for morphological characterisation and EDX characterisation. Two sets of experiments were performed using a synthetic solution of methylene blue – MB and real wastewater from a municipal wastewater treatment plant.



Experimental setup

Results and Conclusions

Dimensional analyse

Catalyst	d (0.1) µm	d (0.5) µm	d (0.9) µm
1% wt. Ni-TiO_2	0.176	0.331	0.634
1% wt. Co-TiO_2	0.176	0.330	0.630
TiO_2 Merck	0.175	0.327	0.612
1% wt. Fe-TiO_2	0.388	0.505	0.979
P25 Degussa	0.295	0.459	1.017

EDX results

1 wt% Fe-TiO_2		1 wt% Ni-TiO_2		1 wt% Co-TiO_2	
Element	Atomic %	Element	Atomic %	Element	Atomic %
O	66.43	O	66.97	O	70.53
Fe	0.22	Ni	0.21	Co	0.90
Ti	33.35	Ti	32.82	Ti	28.57

Photocatalytic activity of all catalysts were tested using MB. MB initial concentration and after 3 hours of exposure to solar simulated radiation and a catalyst dose of 100 mg/L were measured based on the absorbance at 662 nm (maximum MB absorbance).

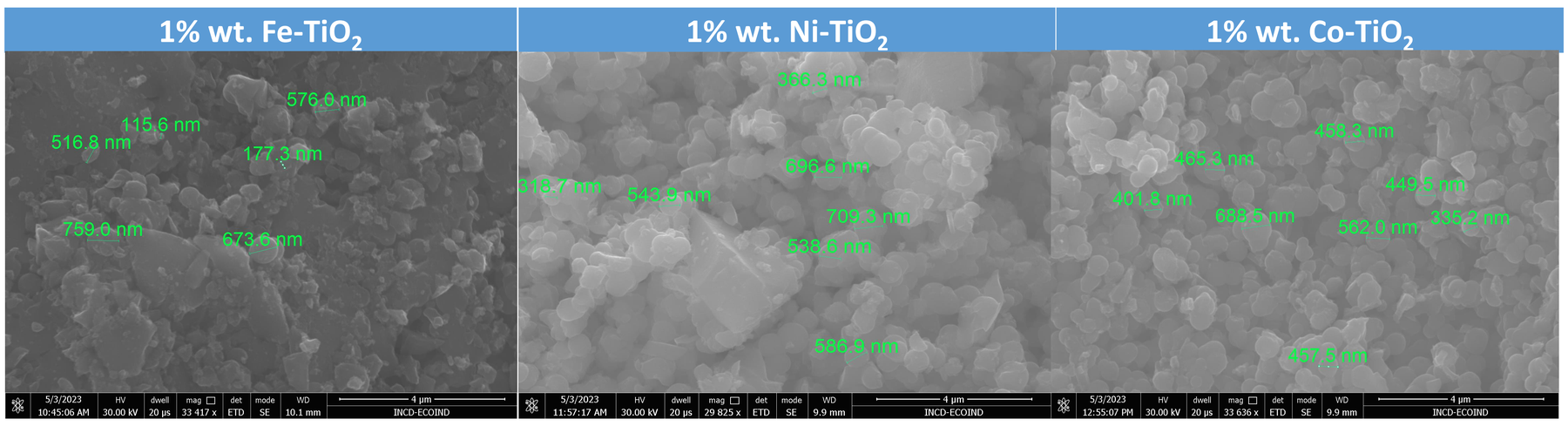
Best results were obtained for 2wt% Metal – TiO_2 catalysts with a MB degradation efficiency of 6.00% for 2%wt Co-TiO_2, 6.91% for 2wt% Ni-TiO_2 and 13.82% for 2%wt Fe-TiO_2.

The 2wt% Metal-TiO_2 catalysts were further used for treatment of real wastewater samples varying the initial catalyst concentration.

The best degradation efficiencies for organic compounds (expressed as COD) after 120 minutes of irradiation were obtained for the following catalysts doses: 200 mg/L for 2wt% Ni-TiO_2 (28.57%), 100 mg/L for 2wt% Co-TiO_2 (33.33%), 100 mg/L for 2wt% Fe-TiO_2 (50.00%).

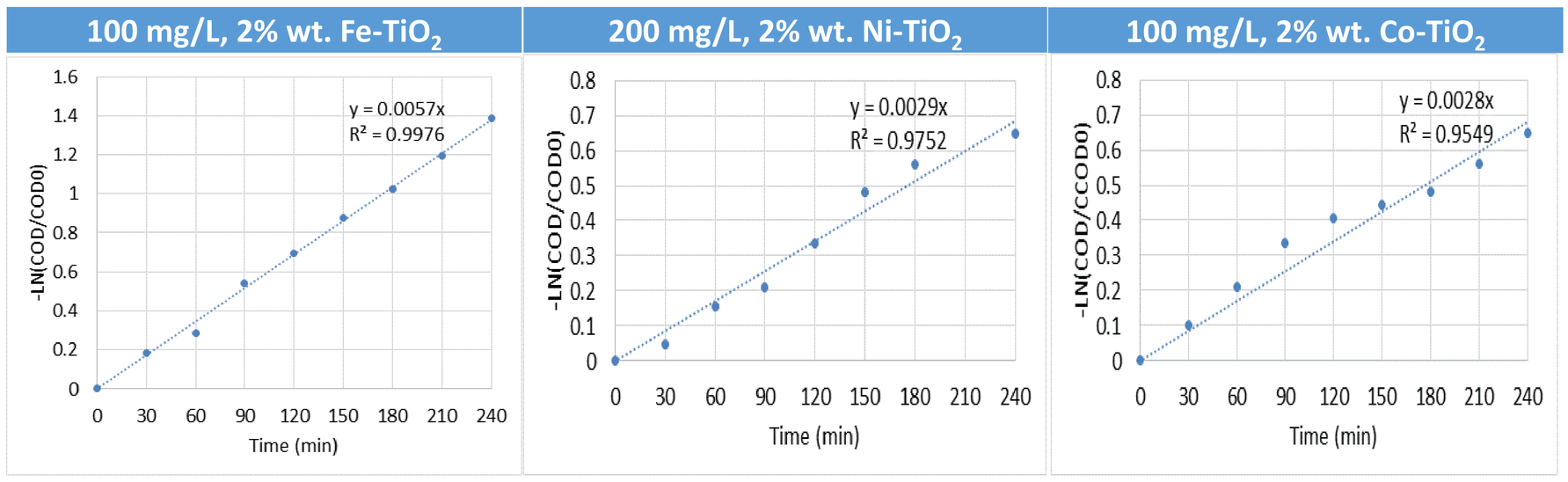
Further increase of irradiation time to 240 minutes led to a degradation of organic compounds (expressed as COD) of 47.69% for both 2wt% Ni-TiO_2 and 2wt% Co-TiO_2 and 75.00% for 2wt% Fe-TiO_2.

1% wt. Fe-TiO_2	1% wt. Ni-TiO_2	1% wt. Co-TiO_2



SEM images

100 mg/L, 2% wt. Fe-TiO_2	200 mg/L, 2% wt. Ni-TiO_2	100 mg/L, 2% wt. Co-TiO_2



Pseudo-first order kinetic for optimum catalysts, irradiation time 240 min

Acknowledgments

This work was carried out through the "Nucleu" Program within the National Research Development and Innovation Plan 2022-2027 with the support of Romanian Ministry of Research, Innovation and Digitalization, contract no. 3N/2022, Project code PN 23 22 03 01.