Comparison of Three Metal Doped Titanium Dioxide Photo-Catalysts Performances for Treatment of Municipal Wastewater Under Simulated Solarlight

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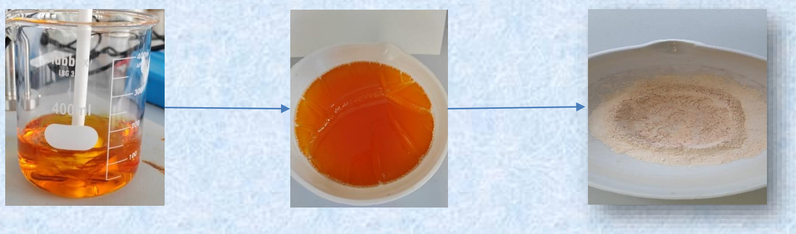
Introduction:

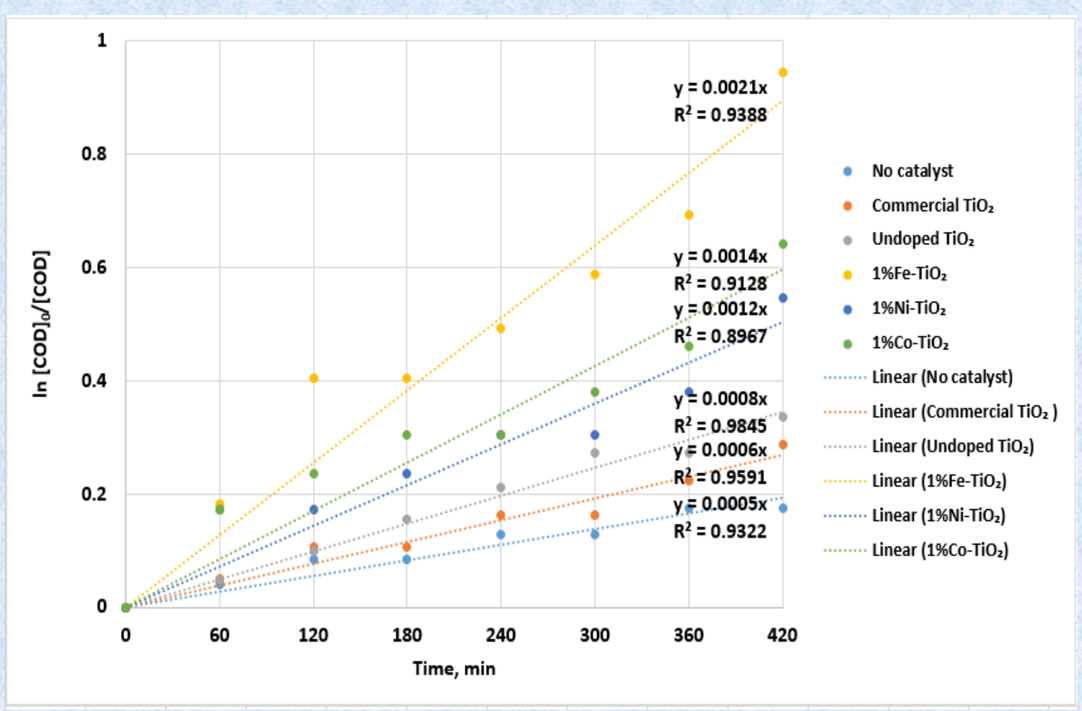
This study aimed to assess performance of a solar slurry photocatalytic membrane reactor for municipal wastewater treatment, using three metal – doped TiO_2 catalysts (for photocatalytic step) and a polymer based membrane (for membrane separation step).

Results & Discussions:

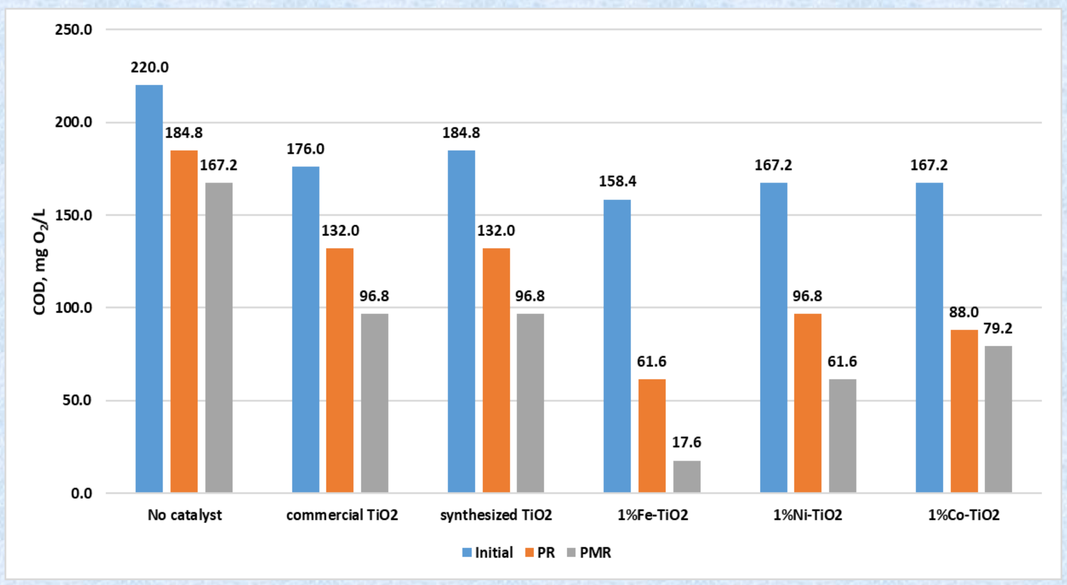
1. Catalysts were characterized with spectrometer XRF Rigaku which confirmed the presence of Ti=98% (TiO_2) and aprox. 1% metal content (Fe=0,91%, Co=1%, Ni=0,93%) also SEM analysis.
2. The efficiency of organic matter removal was measured with COD parameter after 7h radiation (photocatalytic step): only radiation=16,67%, commercial TiO_2=25%, synthesized TiO_2 = 28,57%; 1% Fe-TiO_2 = 61,11%, 1% Co-TiO_2 = 47,37%, 1% Ni-TiO_2 = 42,11%.
3. Overall COD removal after membrane separation step: the degradation efficiency followed the order 1%Fe-TiO_2 > 1% Ni-TiO_2 > 1% Co-TiO_2 (residual COD = 17,6 / 61,6 / 79,2 mg O_2/L).



The degradation of organic compounds for photocatalytic step follows a pseudo 1st order kinetics (COD).



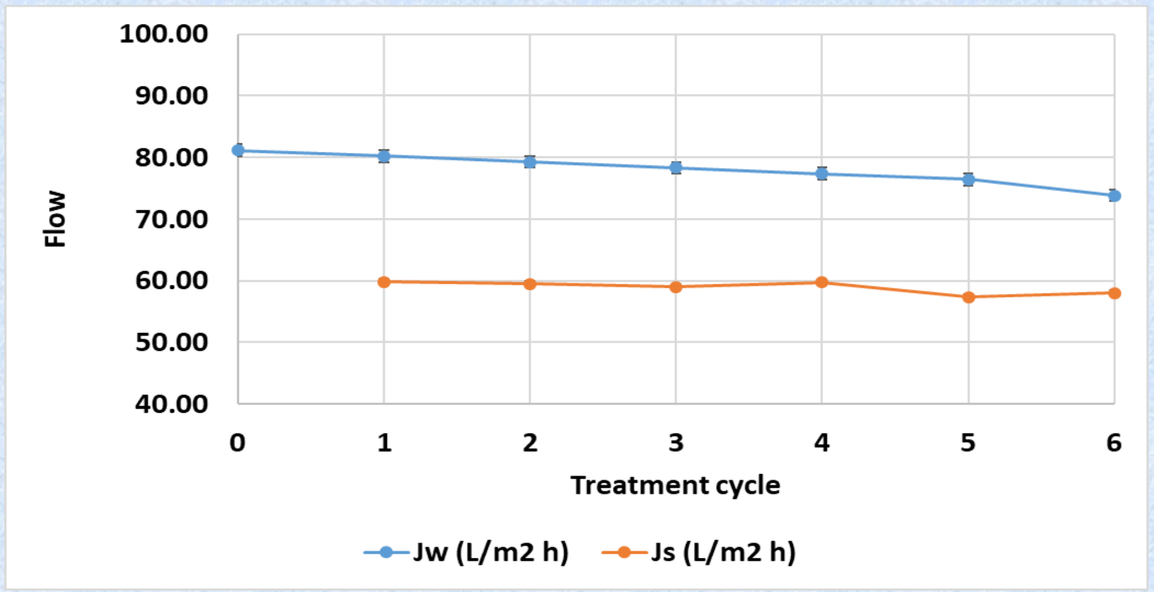
Fe doped TiO_2 catalyst presented best removal efficiency (COD=17,6 mg O_2/L, efficiency=88,89%) while TSM were less than 5mg/L for every experiment:



Research:

1. Three different metal doped catalysts were synthezed by sol-gel method (1% Fe-TiO_2, 1% Ni-TiO_2 and 1% Co-TiO_2) and compared with commercial TiO_2 – anatase form (Merck) and un-doped TiO_2.
2. The concentration of catalyst used in experiments was 200 mg/L and each wastewater sample was exposed to radiation for 7 hours by simulated solar light (intensity within 35-47 W/m^2).
3. A polymeric membrane was synthesized using a solution of 12% Psf (polysulfone) by phase inversion technique and used after the irradiation process to recover the catalyst.
4. A custom made photocatalytic installation was used for the experimental part & composed of 4 PETG transparent tubes, feed/recirculation pump connector, supply/recirculation pump, aeration system, plastic panel support (covered with Al) and a supply/recirculation tank (2L).
5. For the separation & recycling stage was used KMS Laboratory Cell – CF 2 (Koch Membrane Systems) (max. 500 mL volume, working pressure 2.5-3 bar & 28 cm^2 effective surface area).

After 6 separation cycles the membrane didn't show any significant changes in the separation flow and ultrapure water flow.



CONCLUSION

1. The removal efficiency of the organic matter (COD) varied depending on used catalyst as follows: 1%Fe-TiO_2 > 1% Ni-TiO_2 > 1% Co-TiO_2 > synthesized TiO_2 > commercial TiO_2 > only radiation.
2. Doped catalysts increase the efficiency in removing organics from water compared to the un-doped TiO_2: 88,89% (1% Fe-TiO_2), 63,16% (1% Ni-TiO_2) and 52,63% (1% Co-TiO_2) versus 47,62% (TiO_2 synthesized) and 45,00% (commercial TiO_2).
3. By using the catalyst 1% Fe-TiO_2 the COD was reduced from 158,4 to 17,6 mg O_2/L , obtaining the highest efficiency (88,89%).
4. The experiments highlighted that the solar PMR technological flow is a viable alternative for real wastewater treatment.
5. Membrane fouling was evaluated – after 6 treatment cycles the membrane system maintains its efficiency: reduction of only 4,01% for separation flow & 9,07% for ultrapure water flow.

Acknowledgements
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