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OPTIMISED LAB SCALE SOLAR PHOTOCATALYTIC MEMBRANE REACTOR (PMR) FOR WASTEWATER TREATMENT

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Introduction

Coupling photocatalysis with membrane processes proved to represent a promising alternative for municipal wastewater treatment. The use of solar radiation for removal of organic compounds offers the advantages of using visible light and an increase lifetime for the membrane. Therefore present paper focuses on municipal wastewater treatment using a lab scale solar photocatalytic membrane reactor (PMR) with photocatalyst in suspension and its operation optimization in terms of photocatalyst dose, type of radiation influence, photocatalyst regeneration and membrane cleaning.

Materials and methods

Experimental setup consisted from a custom-made photocatalytic reactor with photocatalyst in suspension and a commercial membrane module (KMS Laboratory Cell CF-2). Photocatalytic step was performed for an irradiation time of 5 hours under simulate and natural sunlight. In order to study photocatalyst recirculation a Heraeus type photocatalytic reactor was used instead of the custom-made reactor and the irradition time was set at 3 hours. 1% wt Fe-TiO_2 obtained by a modified sol-gel method was used as catalyst and a polymeric membrane, obtained by phase inversion, starting from a polymeric solution of 10% polysulfone (Psf) was used for photocatalyst recovery and reuse. Chemical Oxygen Demand (COD) was monitored as global indicator for organic compounds degradation/removal. All experiments were performed using real municipal wastewater.

Results and conclusions

First experiment was carried using a doped photocatalyst dose of 400 mg/L under simulated sunlight. Experimental results showed an overall COD removal efficiency of 70.59% and an apparent degradation rate constant for the photocatalytic step of 0.0029 min^{-1} = 4.83 x 10^{-5} s^{-1}. Secondly, the 1%wt Fe-TiO_2 dose influence was analysed by varying it in the domain 200-600 mg/L. Experimental results showed that the best overall efficiency was obtained for the 400 mg/L dose but good results were achieved also for a dose of 600 mg/L. In order to investigate the influence of radiation source the results obtained for the optimum 1%wt Fe-TiO_2 dose of 400 mg/L under simulated sunlight were compared with the results obtained under natural sunlight.

Results showed that best COD overall removal efficiency (88.24 %) was obtained under natural sunlight, behaviour that is correlated with the higher light intensity under natural light compared with simulated sunlight (Table 1).

Table 1 Simulated sunlight vs. natural sunlight

Time (min)	Simulated sunlight		Natural sunlight	
	COD (mg O_2/L)	η (%)	COD (mg O_2/L)	η (%)
0	149.6	0.00	149.6	0.00
30	140.8	5.88	123.2	17.65
60	123.2	17.65	96.8	35.29
120	96.8	35.29	75.4	49.60
180	88.0	41.18	44.0	70.59
240	79.2	47.06	35.2	76.47
300 (end of photocatalytic step)	61.6	**58.82**	26.4	**82.35**
after membrane separation	44.0	**70.59**	17.6	**88.24**

In order to study photocatalyst reusability degradation experiments were performed using UV/VIS radiation and the results showed that photocatalyst activity decreased in time but can be used with good results for five treatment cycles (Figure 1) and can be reactivated using a simple washing / thermal treatment process (Figure 2).

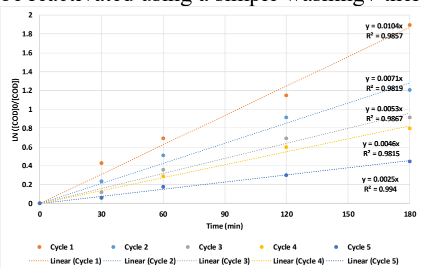

Figure 1 Pseudo first order kinetic vs. catalyst recirculation cycle

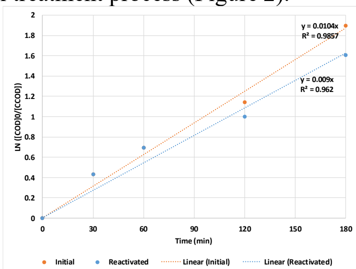

Figure 2 Pseudo first order kinetic initial vs. reactivated catalyst

The same polymeric membrane (obtained starting from a 10% Psf solution) was used for 15 photocatalyst separation cycles, proving that is a suitable choice for use within the lab scale PMR. Both physical and chemical cleaning methods were tested and best results was obtained for chemical cleaning - improvement of ultrapure water flow with 110% compared with 80% improvement when physical cleaning was used.

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