PHOTOCATALYTIC COMPOSITE MEMBRANES FOR WATER TREATMENT: RESULTS, LIMITATIONS, AND NEW INSIGHTS

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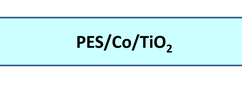
Results

Photocatalytic membranes for degradation of DYES from WATER
(*initial concentration; removal efficiency (%); light source; exposure time.*)

PAN/GO-ZnO	Methylene blue	10 mg/L; 98%; visible light; 70 min.
		Mottaleba MM, et al. J Mech Behav Biomed Mater. 2019; 96:118–24.
PVDF/TiO_2-SnO_2	Rhodamine B	10 mg L^{-1}; 91.84%; UV light irradiation; 270 min.
		Hong W, et al. New J. Chem., 2021, 45, 2631-2642
PMMA/TiO_2	Methyl orange	10 mg/L MO; UV illumination; 50 min.
		Li Y, et. al. J Colloid Interface Sci. 2017; 508:500–07.
CA-PU/ZnO	Reactive Red 11	98%; 40 min; UV light irradiation; neutral pH.
		Rajeswari A, et al. Chem. Eng. J., 2017;313: 928-37.
PA6/TiO_2	Remazol Black B	3 mg/L; 80 %; UV (365 nm); 240 min.
		Blanco M, et al. Polymers (Basel). 2019; 11:1–11.
Chitosan/ZnO	Crystal violet	25-100 microM; ~100%; Tungsten lamp; 300 min.
		Abarna B, et al. J Mater Sci Mater Electron. 2019; 30: 21355–68.



Photocatalytic membranes for degradation of PHARMACEUTICALS from WATER
(*initial concentration; removal efficiency (%); light source; exposure time.*)

PVDF/$ZnIn_2S_4$	tetracycline	0.45 g; 92%; visible light; 36 h.
		B Gao, et al. J Photochem. Photobiol. A: Chem. 364, 2018; 732-739.
Zn-Co-LDH/biochar	gemifloxacin	92.7%; UV light irradiation; 80 min.
		P Gholami, et al. J. Hazard. Mat, 382, 2020, 121070.
TiO_2/graphene oxide/Fe_3O_4	amoxicillin	27 wt% -TiO_2-Fe_3O_4; 90%; visible light; 120 min.
		Q Li, et al. J. Hazard. Mat., 373, 2019, 437-446.
PSF/Cu_2O	ibuprofen	86%; visible light; 60 min.
		R Singh, et al. Sep. Purif. Technol., 2018, 2-33.
PVDF-HFP/Ag–TiO_2	norfloxacin	80.7%; visible light; 300 min.
		H Salazar, et. al. Chemosphere, 2020, 250, 1–30.

Photocatalytic membranes for degradation of PESTICIDES from WATER
(*initial concentration; removal efficiency (%); light source; exposure time*)

rGO/TiO_2	methomyl	complete degradation; 25 min irradiation.
		G. Luna-Sanguino, et. al. Sci. Total Environ., 737, 2020, 140286.
TiO_2/SiC foams	paraquat	UV-C (254 nm); 91%; 3h.
		C. Marien, et. al. J. Hazard. Mat. 370, 2019, 164-171.
PVDF/PDA-$BiOCl_{0.875}Br_{0.125}$	Roxarsone	~100%; visible light; 3h.
		J Zhou, et. al. Chem. Eng. J. 402, 2020, 126048.
PES/Co/TiO_2	2,4-dichlorophenol	50 mg; 53%; visible light irradiation; 120 min.
		N Hoseini, et. al. J. Water Process Eng., 17, 2017, 124-134.

Limitations /Solutions

Recombination of photo-generated electron-hole pairs
- doping membranes with metals/non-metals;
- incorporation of TiO_2 into organometallic frames;
- presence of different species (scavengers), such as dissolved oxygen.

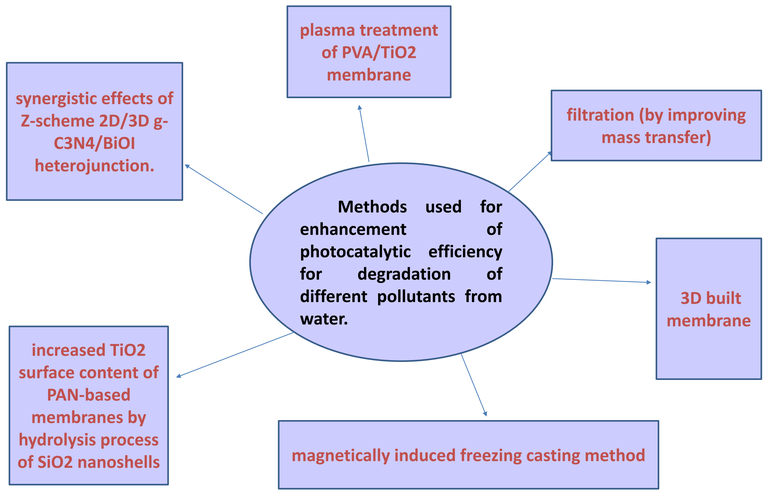
Fast-backward reaction
- solve by doping of the semiconductor with a noble metal (e.g. Pt, Au, Pd, Rh, Ni, Cu, Ag).

Difficulty in employing visible light
- the researchers use defect engineering to increase light harvesting by light sensitizers and defect engineering (e.g. vacancies, heteroatoms or ions doping).

Fouling phenomenon
- modification of membranes by changing its hydrophilicity, roughness, and surface charge (identifying the optimum pH will reduce membrane fouling).

Separation of suspended nanosize d photocatalyst from treated water
- immobilizing the photocatalyst in membranes or floating the photocatalyst in the solution.

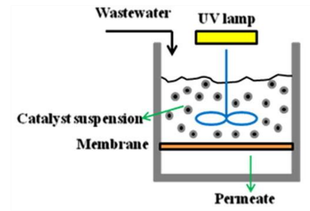
Self-cleaning ability and reusability of photocatalyst (or a membrane)
- to increase the recycle/recovery and reuse of photocatalyst particles at the end of photocatalysis, a synergy of membrane filtration and photocatalysis has been, over time, employed.



New insights

From laboratory scale to pilot-plant and commercial scale photocatalytic membranes

Laboratory scale

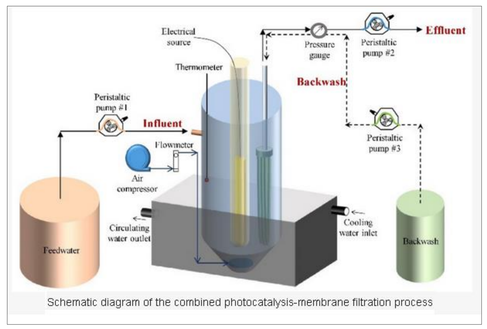


Pilot-plant scale

Industrial/commercial scale

The implementation of photocatalytic membranes at large-scale (industrial / commercial level) have been scarce due to:
- low photocatalytic activity, in particular, under visible and solar illumination;
- associated economic, energy efficiency, and environmental impacts;
- efforts necessary to design and develop the photocatalytic reactor;

(R. Molinari, C. Lavorato P. Argurio, The Evolution of Photocatalytic Membrane Reactors over the Last 20 Years: A State of the Art Perspective, Catalysts 2021, 11(7), 775; https://doi.org/10.3390/catal11070775).



Schematic diagram of the combined photocatalysis-membrane filtration process

*(Wang, Q. et al. Submerged membrane photocatalytic reactor for advanced treatment of p-nitrophenol wastewater through visible-light-driven photo-Fenton reactions. Sep. Purif. Technol. **2021**, 256, 117783)*

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