Traitement des eaux usées par procédés membranaires. Utilisation des énergies propres et valorisation des eaux usées de la zone industrielle de Oued Sly. Chlef

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Introduction Photocatalysis is an advanced oxidation technique with promising opportunities of applications in the treatment of water. Hybrid photocatalysis-membranes systems are now intensively investigated. This study deals with the development of a simple and robust synthesis of a titania-based ultrafiltration membrane with photocatalytic properties from a commercial titania hydrosol deposited on commercial macroporous alumina supports. Its performance in term of separation (pure water permeance, molecular weight cut-off) is evaluated. The photocatalytic efficiency is tested from photo-oxidation experiments of a reference organic dye (methylene blue) and of phenol as typical organic pollutant in water.

Membrane preparation and morphology

Formulated sol

1. Basic anatase hydrosol S5-300B Millenium Inorganic Chemicals *volume V_1*
+
2. Ammonia aqueous solution with pH = 11.5 *volume $V_2 = 9\ V_1$*
+
3. Aqueous Hydroxy Ethyl Cellulose solution with wt% HEC = 5 *volume $V_3 = 0.133\ (V_1 + V_2)$*
+
4. Ammonia aqueous solution with pH = 11.5 *volume $V_4 = (V_1 + V_2 + V_3)$*

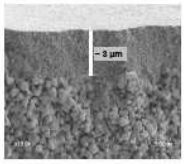
Slip-casting on alumina tubes *(length 200 mm; internal diameter 7 mm; 200 nm pore-sized top layer, Pall Exekia)* or **Dip-coating on alumina disks** *(diameter 47 mm, thickness 1 mm, 200 nm pore-sized top layer, Inocermic)*

→ **Drying at RT for one day**

→ **Calcination up to 450 °C**

Equivalent powder B was prepared by drying the formulated sol in large beakers. It was compared to a commercial titania powder P25 (from Evonik) used as reference for photocatalysis.

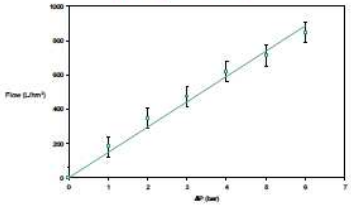
SEM cross section image



➢ From such formulated sol and usual deposition procedures, it is possible to easily reproduce homogenous and defect-free membranes with a thickness of ~3 µm.

Membrane properties

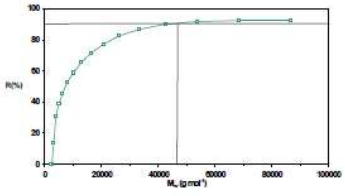
Water permeation



➢ The water permeance was determined from the slope of the linear evolution of pure water flow versus ΔP.
Its is equal to ~ **150 L h^{-1} m^{-2} bar^{-1}**.

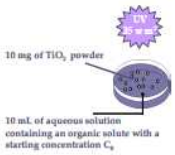
➢ Retention data were collected from permeation experiments using an aqueous solution containing a mixture of Dextran® as feed.
The Molecular Weight Cut-Off (MWCO) is equal to ~ **50 kDa**.

Retention curve

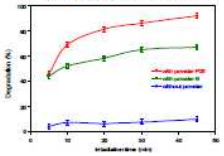


Photocatalytic properties

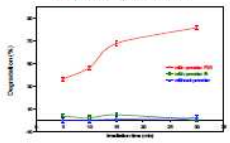
Experiments with powders



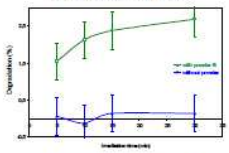
Methylene Blue with $C_0 = 1.5\ 10^{-5}$ mol L^{-1}



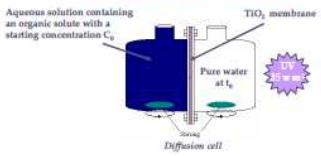
Phenol with $C_0 = 10^{-3}$ mol L^{-1}



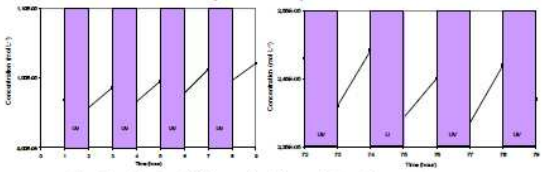
Phenol with $C_0 = 10^{-4}$ mol L^{-1}



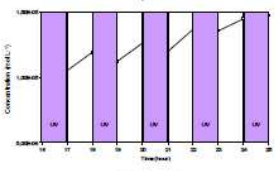
Experiments with a membrane



Methylene Blue with $C_0 = 10^{-4}$ mol L^{-1}



Phenol with $C_0 = 10^{-3}$ mol L^{-1}



Quantity of destroyed MB per units of time and of membrane surface area:
~ 1 10^{-7} mol s^{-1} m^{-2} —— ~ 3 10^{-7} mol s^{-1} m^{-2}

For phenol:
~ 5 10^{-7} mol s^{-1} m^{-2} —— ~ 1.5 10^{-7} mol s^{-1} m^{-2}

➢ The photocatalytic process is complex and very sensitive to the nature of the organic molecule to be photo-oxidized and also to the titania crystalline state.
➢ The decrease of activity can be explained by the formation of various products of phenol photo-oxidation which would be progressively adsorbed on the titania surface.

Conclusion

A simple and robust synthesis route has been developed to prepare a photocatalically-active titania-based ultrafiltration membrane from a commercial titania hydrosol and alumina supports. The membrane performance in term of separation and photocatalytic activity has been measured. The photocatalytic efficiency is better for the reference organic dye (methylene blue) than for phenol selected as typical organic pollutant in water.
A filtration pilot enabling coupled membrane separation and photocatalytic degradation in dynamic conditions is currently under construction in order to test possible technological applications of such device with water containing different types of organic pollutants.