Harnessing solar energy for sustainable water treatment by photocatalytic membranes: innovative developments overcoming practical limitations

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Abstract:

Photocatalytic membranes have exciting potential for directly utilising sunlight to decontaminate polluted waters that would otherwise have intensive energy requirements and/or need complex systems with long residence times. The dual function (reaction + separation) features however face practical limitations. Researchers have focussed efforts to improve catalysts coated on the membrane surface, which typically utilise light only from the UV region, to use the more abundant light energy from the visible region. More recently, research has explored improvement in the system design to conveniently capture and direct sunlight to the photocatalytic membrane surface. For improving system design, a TiO_2 photocatalyst microfiltration membrane was coated on light transmitting porous glass to allow simulated indirect sunlight equivalent to 0.35 Suns to be directed into the module through the clear permeate to the photocatalytic membrane, then conveniently under the fouling layer. This unique setup was demonstrated to reduce irreversible fouling of a contaminated surface water by 8-fold as compared to when no light was used. This translates to practical benefits of reduced cleaning chemical use and lower pump energy, offset by the simple and convenient introduction of sunlight energy. *Para*-chlorobenzoic acid probe analysis confirmed the action of hydroxyl radicals and were attributed to the anti-fouling effect. However high performance size exclusion chromatography (HPSEC) confirmed the reactions did not lead to any measurable change to the molecular weight profile of the organics and overall DOM concentrations between feed and permeate. Although anti-fouling effects were strong and viable, the testing gave insight into means to improve design of photocatalytic membranes for use in bulk solution organics conversion. Recent innovative developments of the photocatalytic membranes include lower cost transparent polymer substrates, improved photocatalytic materials, and module design concepts to facilitate sunlight delivery to the membrane.

Keywords: Renewable energy, sustainability, photocatalytic membranes, microfiltration, ultrafiltration