Integrated UV photocatalytic active membrane water purification

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Motivation

One of the improvements regarding water purification is to treat the water more effectively and economically, avoiding the production of secondary waste pollutants and ensuring safe water supply.

Advanced oxidation techniques and membrane filtration have attracted increasing attention to treat and purify water. Among these methods photocatalytic oxidation with titanium dioxide (TiO_2) is widely studied as this treatment avoids the solid waste [1], and membranes have gained an important place in chemical technology and are used in a broad range of applications [2].

This research seeks to provide a novel water treatment method, based on the synergy between photocatalytic oxidation and membrane separation within a single material to remove micropollutants and inactivate microorganisms. Unique metal membranes in combination with UV light will be used to provide new safe drinking water solutions.

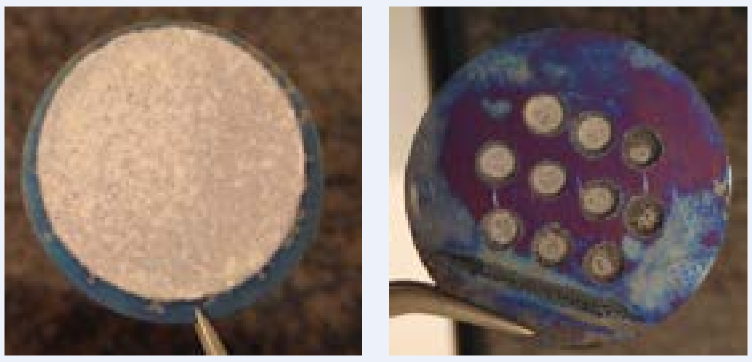

Fig 1. Pictures of both sides of the metal membrane. Highly porous ceramic layer (left) and metal layer connected with the ceramic layer through the openings (rigth).

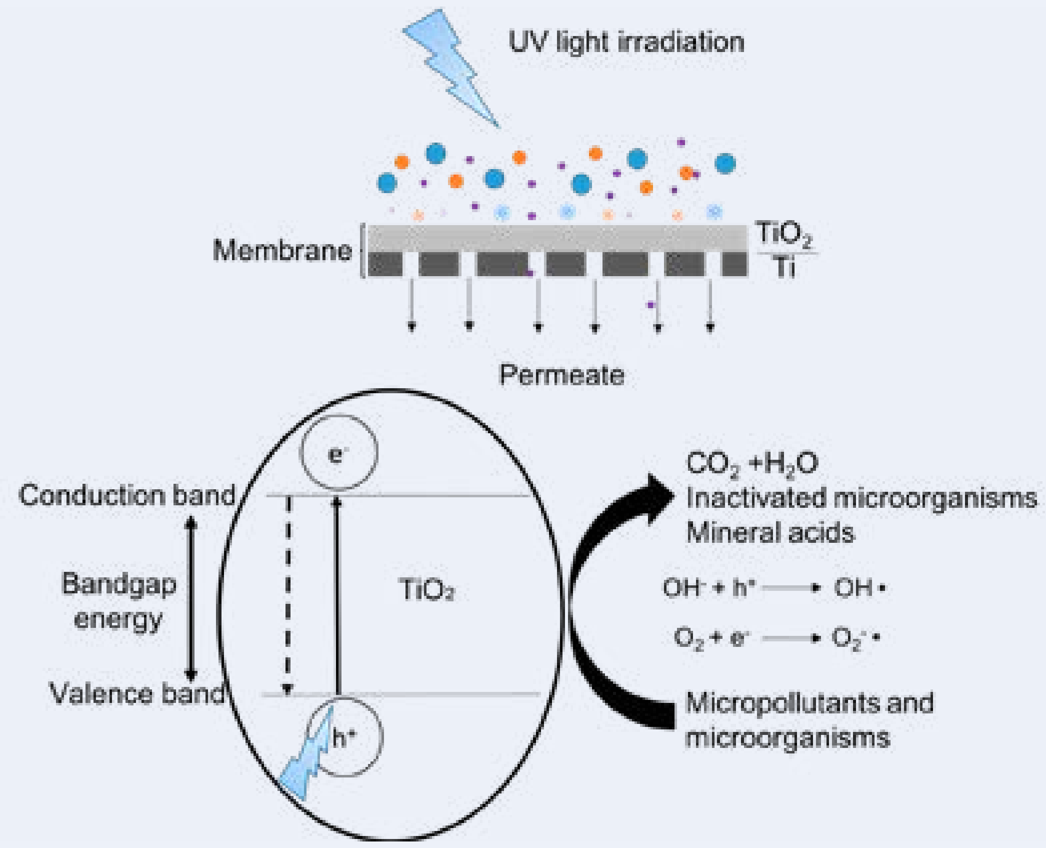

Fig 3. Graphical abstract of the project. Schematic view of the process in the membrane (top) and diagram of the photocatalytic degradation taking place (bottom).

Technological challenge

The main challenge is to design a reactor that ensures efficient irradiation of the photocatalytic membrane and filtration, avoiding the fouling of the membrane. This requires fundamental understanding of the materials, photochemistry and transport processes.

Membrane filtration results in accumulation of retained species at the membrane surface, known as concentration polarization (CP). Reduction of CP directly results in improved flux, or production, of purified water. A reactive membrane is expected to reduce the CP and biofouling layers via the chemical conversion of reactants, which is conceptually innovative, see comparison in Fig.2. Furthermore, photocatalytic degradation of contaminants in water is considered as a viable method to remove micropollutants and inactivate microorganisms.

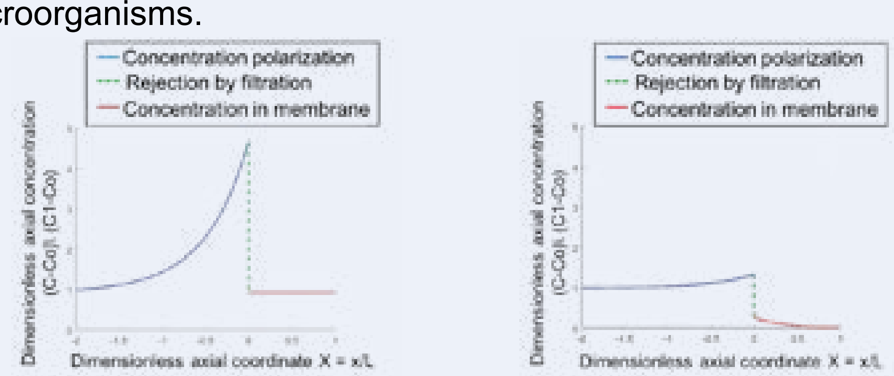

Fig 2. Model predictions for concentration profile with only membrane filtration (left) and with reaction and filtration (right).

Research goals

- Provide a novel water treatment method combining membrane separation and photocatalytic oxidation. The process will be characterized by size (and/or charge) selective filtration that retains contaminants from the aqueous feed, assisted by photocatalytic oxidation of bacteria, viruses and organic contaminants in contact with the same membrane surface.
- Elucidate and optimize the synergy between membrane rejection and photocatalytic conversion.
- Study the transport and distribution of the UV light and its interplay with the chemical oxidation process. First, using methylene blue as a model compound and later on with bacteriophage MS2, a commonly used surrogate for waterborne pathogenic viruses
- Obtain a transport model that contains the membrane function (rejection) and the photocatalytic degradation (reaction) including light distribution.

[1] Leong, S. et al., Journal of Membrane Science 472 (2014) 167-184.
[2] Baker, R. W., Membrane Technology and Applications (2012).

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