Solar Reactor for Photocatalytic Water Purification

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Photocatalytic water purification utilizes light to degrade the organic contaminants in water and bears great hope to alleviate the deteriorating water pollutation problem. This work aims to develop a new solar reactor that features a new reactor design, a low-cost fabrication method of large-area TiO_2 thin films deposited on PMMA substrate and the potential for industrial applications. And the reactor would be used to decompose real sewage water.

The reactor fabrication starts with the development of large-area TiO_2 thin film on a lightweight, non-brittle PMMA substrate, which is the enabling factor for the large solar reactor. In the process, a thin layer of P25 TiO_2 nanoparticle is sprayed onto a PMMA substrate (footprint 1 m x 0.6 m) after mixing the P25 TiO_2 powders with DI water, then the PMMA substrate is soaked into chloroform to stick TiO_2 nanoparticles. After that, other structures for the solar reactor such as the fluidic channels, the reaction chamber and the inlet/outlet are machined by laser cutting on the PMMA plates and are then integrated to form the solar reactor. Finally, the solar reactor is tested in sunlight to decompose the model chemical methylene blue solution to characterize the performances. Currently, it measures a decomposition rate of 30% in 2 hours with a thoughput of 1.9 L/h. More studies are needed to further improve the efficiency and the thoughput.

In summary, this work has developed a solar reactor for photocatalytic water purification. Although the performance is still far from ideal, it is the first step to the development of a low-cost solar reactor and has the great potential for industrial applications.

Acknowledgement

This work is partially supported by National Natural Science Foundation of China (no. 61377068), Research Grants Council (N_PolyU505/13, 5334/12E, 152184/15E, 509513), and Hong Kong Polytechnic University (grants G-YN07, G-YBBE, 4-BCAL, 1-ZVAW, 1-ZE14, A-PM21, 1-ZE27 and 1-ZVGH).

References

[1] N. Wang, X. M. Zhang, Y. Wang, W. X. Yu, H. L. W. Chan, Microfluidic reactors for photocatalytic water purification, *Lab on a Chip*, 2014(14), 1074-1082.
[2] X. Y. Yu, J. J. Cheng and Y. J. Du, TiO_2 photocatalytic material, *Chemical World*, 2000(11), 567-570.
[3] W. X. Liao, N. Wang, T. S. Wang, J. Xu, X. D. Han, Z. Y. Liu, X. M. Zhang, and W. X. Yu, Biomimetic microchannels of planar reactors for optimized photocatalytic efficiency of water purification, *Biomicrofluidics*, vol. 10, paper no. 014123, Jan 2016.

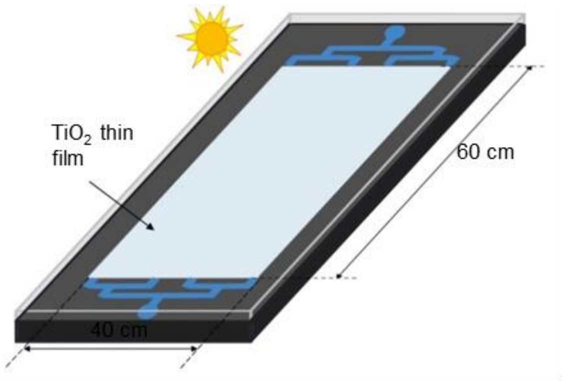

Fig. 1 Schematic of the scaled-up photocatalytic reactor. The reactor consists of a blank transparent PMMA layer as the cover and a TiO_2-coated black PMMA layer as the substrate.

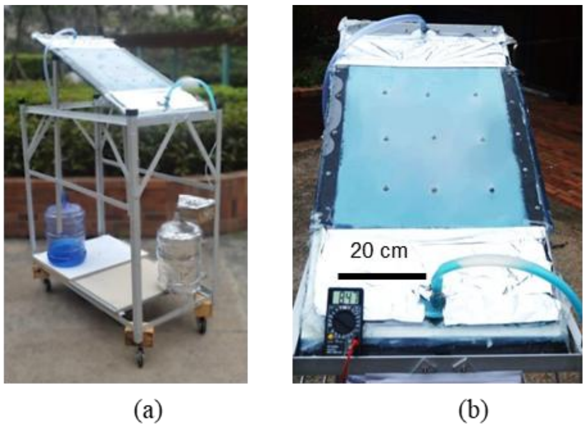

Fig. 2 Photos of the scaled-up reactor system. (a) The whole system; and (b) the reaction chamber region (60 cm × 40 cm).

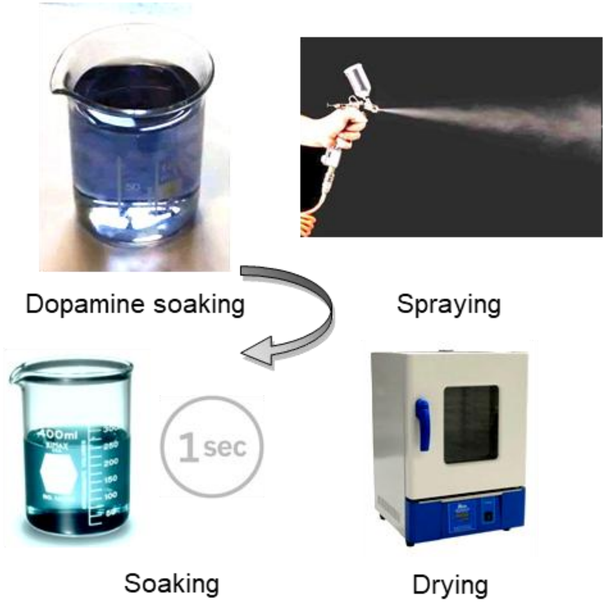

Fig. 3 Process flow for preparing the TiO_2 thin film on the black PMMA substrate at room temperature. It starts with soaking the PMMA sheet in dopamine and then spraying P25 TiO_2 solution. After drying in the oven, the PMMA sheet is soaked in chloroform.

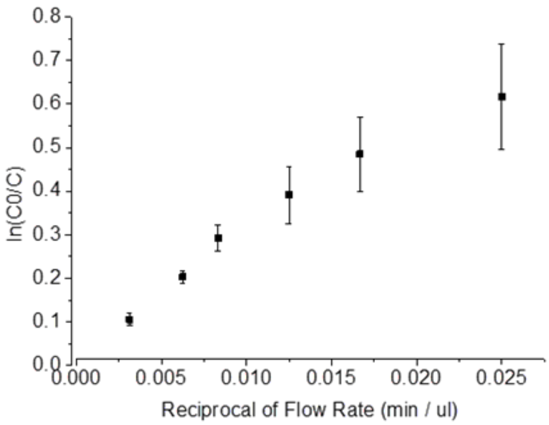

Fig. 4 Photocatalytic performance in degrading methylene blue under the solar simulator using a microreactor (1 × 1 cm^2). It is seen that the value of $ln(C_0/C)$ is approximately linear to the reciprocal of flow rate.