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Free-standing open-ended TiO_2 nanotube membranes and their promising through-hole applications

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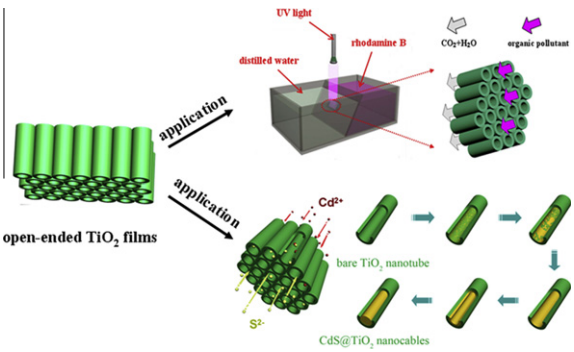
HIGHLIGHTS

- Open-ended ATO membranes were applied to flow-through photocatalysis and nanoreactor.
- Photocatalytic effect of TiO_2 can degrade RhB when RhB molecules diffusion through ATO membranes.
- It can also be used as nanoreactor to fabricate CdS@TiO_2 core–shell nanocables.
- CdS@TiO_2 samples synthesized at 24 h exhibited the maximum photocatalytic activity.

GRAPHICAL ABSTRACT



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ABSTRACT

Free-standing open-ended TiO_2 nanotube membranes were fabricated by raising voltage for a short time at the end of anodization process. Benefiting from its semiconducting nature and distinctive through-hole structure, the applications of open-ended TiO_2 nanotube membranes on flow-through photocatalysis and nanoreactor were demonstrated. As for flow-through photocatalysis, the photocatalytic property of TiO_2 is beneficial to reduce the concentration of RhB solution during RhB molecules diffuse through open-ended TiO_2 nanotube membrane. As for nanoreactor application, CdS@TiO_2 core–shell nanocables were successfully fabricated by a simple paired-cell reaction. A possible formation mechanism for the growth of core–shell structure was discussed on the basis of a series of electron microscopy characterization results. In addition, we evaluated the photocatalytic activity of CdS@TiO_2 samples synthesized at different reaction time through the degradation of rhodamine B under simulated sunlight irradiation. It was found that the CdS@TiO_2 samples synthesized at 24 h exhibited about 100% enhanced photocatalytic activity as compared to bare TiO_2 nanotubes, while the CdS@TiO_2 samples synthesized at 48 h (core–shell nanocables) had the equivalent photocatalytic activity to the bare TiO_2 nanotubes. Such behavior that the photocalytic activity changes with CdS loading amount results from a compromise between a larger amount of light absorption and a lower efficiency of charge separation, as well as limited diffusion by channel blocking higher degree of CdS loading.

1. Introduction

Over the last few years, porous materials with straight channels, narrow pore size distribution and highly self-ordered arrangements have attracted remarkable attention because of their potential applications in electronics, mechanical and optical devices [1,2]. Among them, anodic aluminum oxide (AAO) and anodic titanium oxide (ATO) membranes are ideal candidates due to the relatively easy controllability of the interpore spacing, pore diameter and depth by changing anodization conditions [3–9].

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