

## 謝誌

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## 中文摘要

本研究內容主要為利用自行合成之聚苯乙烯 (polystyrene) 為模版，配合溶膠-凝膠法製備多孔性的二氧化鈦以及二氧化矽材料，再以表面溶膠-凝膠將二氧化鈦光觸媒鍍於多孔二氧化矽材料的表面，使光觸媒以超薄膜之型態穩固地附著於基材表面，製備出骨-膚 (bone-skin) 型態的多孔複合光觸媒材料。

在此研究中，聚苯乙烯經由乳化聚合法合成，並以十二烷基磺酸鈉(Sodium dodecyl sulfate, SDS) 作為穩定劑，其最佳條件為加入1 CMC 之SDS，反應溫度為80 °C，經預熱過程合成出之單一分散性聚苯乙烯小球 (直徑約190 nm)。在此條件下合成出之聚苯乙烯小球，經重力沈降排列後作為模版，再將二氧化矽前驅物填充入模版間隙內，經溶膠-凝膠反應後，利用鍛燒將模版移除以獲得具規則孔洞排列之多孔性二氧化矽基材。之後利用表面溶膠-凝膠將二氧化鈦以超薄膜之型態鍍於多孔二氧化矽材料的表面，製備出骨-膚多孔複合光觸媒材料。同時會進行自行製備之光觸媒其表面物化特性之鑑定，並藉由其與單純多孔性二氧化鈦光觸媒光降解 Rhodamine B 染劑之效果，比較兩者之光催化能力。

結果顯示自行製備之骨-膚多孔複合光觸媒材料不僅維持量子特性且具有高比表面積 (410.5 ~ 534.9 m<sup>2</sup>/g)，對於Rh B 染劑之降解也具有高比光催化活性 ( $2.9 \times 10^{-2} \sim 3.6 \times 10^{-2} \text{ min}^{-1}\text{mg}^{-1}$ )。由溶膠-凝膠法製備而成之二氧化鈦超薄膜，其膜厚 (4.6 ~ 9.4 nm) 可藉由在表面溶膠-凝膠之過程中，調控二氧化鈦前驅物之濃度，以達到良好的控制；骨-膚多孔複合光觸媒之光活性亦和二氧化鈦超薄膜之厚度有高度的相關性。在二氧化鈦前驅物和異丙醇之重量比為 0.2 之條件下製備而成的骨-膚多孔二氧化矽-二氧化鈦複合光觸媒具有最高的比光催化活性，此結果可歸因於其大比表面積以及二氧化鈦超薄膜所提供之較短電荷擴散路徑。同時，在此研究中，也將會探討光觸媒物化特性對其光催化活性的影響以及兩者之間的關係。

## Abstract

In this study, the ultra-thin TiO<sub>2</sub> films were coated onto the highly porous silica to form bone-skin-like photocatalysts with controllable film thickness and high photoactivity by the combination of templating sol-gel method and surface sol-gel method. Monodisperse polystyrene microspheres in this study were prepared by emulsion polymerization method with sodium dodecyl sulfate (SDS) as stabilizer. The optimal condition to synthesize monodisperse polystyrene is reacting at 80 °C in a preheated procedure when 1 CMC of SDS was added. The resulting monodisperse polystyrene microspheres with a diameter of about 190 nm were used as templates to fabricate the porous framework by infilling sol-gel derived silica into the voids between microspheres. The porous silica framework (bone structure) with ordered hexagonal porous structures in three dimensions was obtained by subsequently removing microspheres with calcinations. The ultra-thin TiO<sub>2</sub> layers obtained from the surface sol-gel method were then coated on the surface of the porous silica framework to form the bone-skin-like structures. Results showed that the developed bone-skin-like porous photocatalyst has a high surface area (410.5 ~ 534.9 m<sup>2</sup>/g) and retains quantum properties to perform the novelty on high specific photocatalytic activities ( $2.9 \times 10^{-2} \sim 3.6 \times 10^{-2} \text{ min}^{-1} \text{ mg}^{-1}$ ). The thickness of the sol-gel-derived TiO<sub>2</sub> thin films ranged from 4.6 to 9.4 nm can be well-controlled by simply adjusting the concentrations of the TiO<sub>2</sub> precursors in the surface sol-gel process, while the photoactivity of the photocatalysts is highly dependent on the thicknesses of the ultra-thin TiO<sub>2</sub> coatings. The bone-skin-like SiO<sub>2</sub>/TiO<sub>2</sub> with the precursor concentration of 0.2 had the highest specific photocatalytic activity due to the highest surface area and short charge diffusion length. The relationship between degradation rate and physicochemical properties of photocatalysts was also discussed in this study.

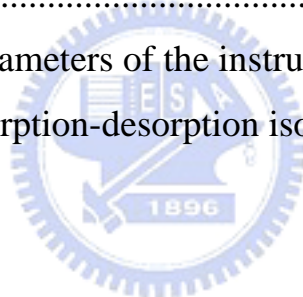
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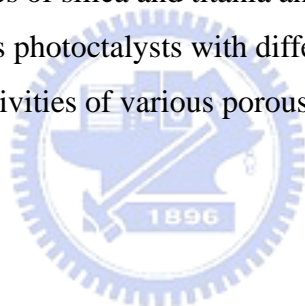
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