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**Education:**

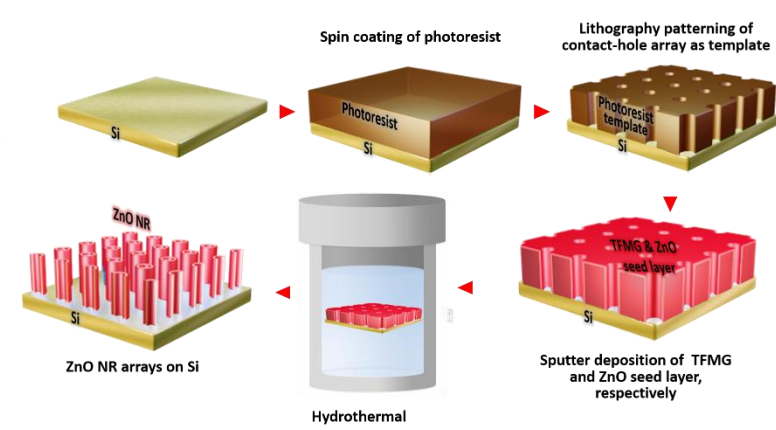
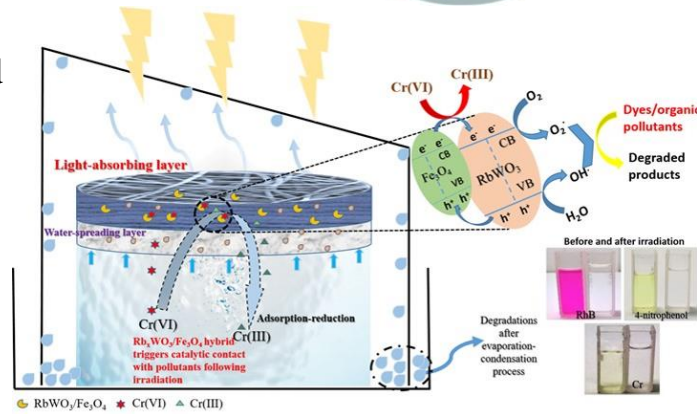
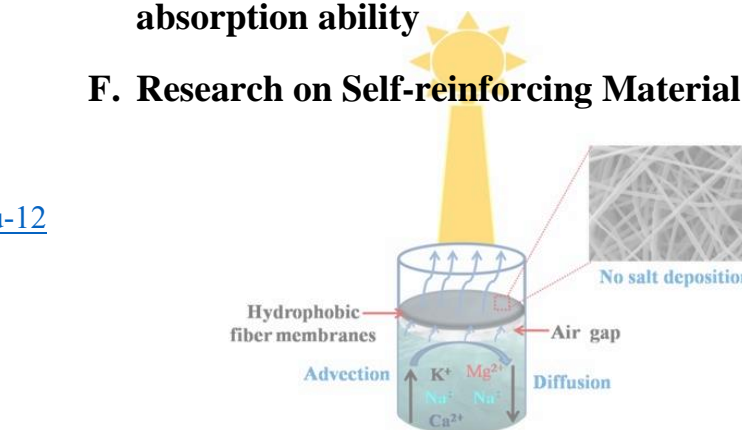
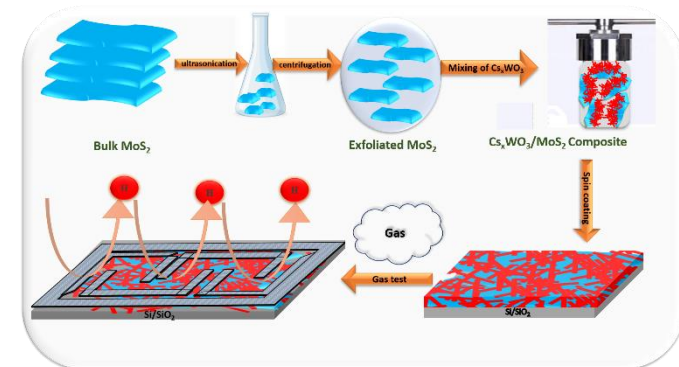
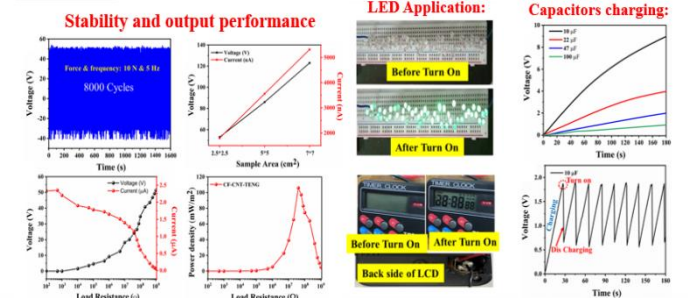
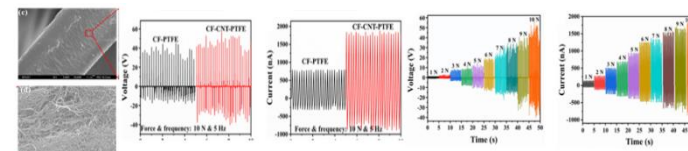
- Dr. of Eng.,  
National Sun Yat-sen University

**Lectures:**

- Spcial Topics on Fiber Reinforced Composite Materials
- Introduction to Polymer Systems
- Fiber Materials and Manufacturing

**Polymer Nanocomposites Lab.**

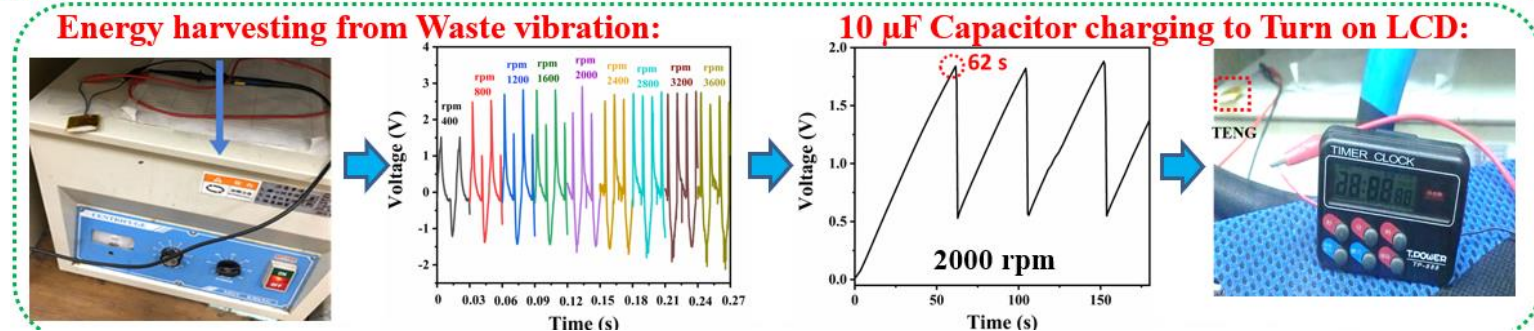
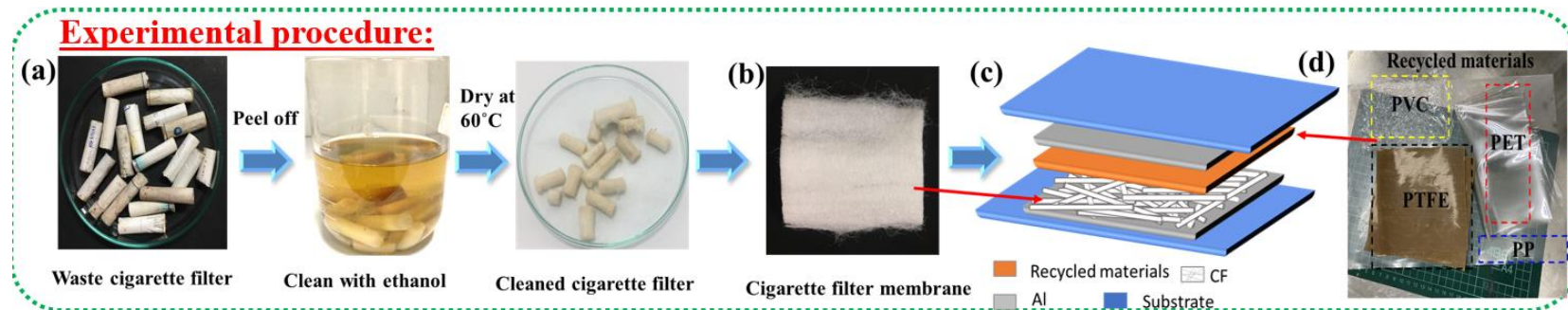
- A. Research on nanogenerators, energy harvesting.
- B. Research on Gas Sensor
- C. Research on Water Evaporation
- D. Research on Photocatalytic absorption ability
- E. 3D printed structures on energy
- F. Research on Self-reinforcing Material



A. 應用於奈米發電機之能源轉換研究 Research on nanogenerators, energy harvesting.

A-1 變廢為能：利用回收廢料製造摩擦納米發電機，用於機械能量收集 (Waste-to-energy: Utilization of recycled waste materials to fabricate triboelectric nanogenerator for mechanical energy harvesting.)

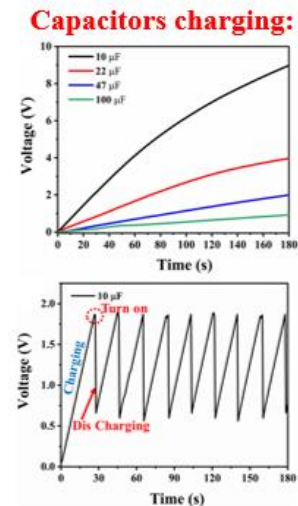
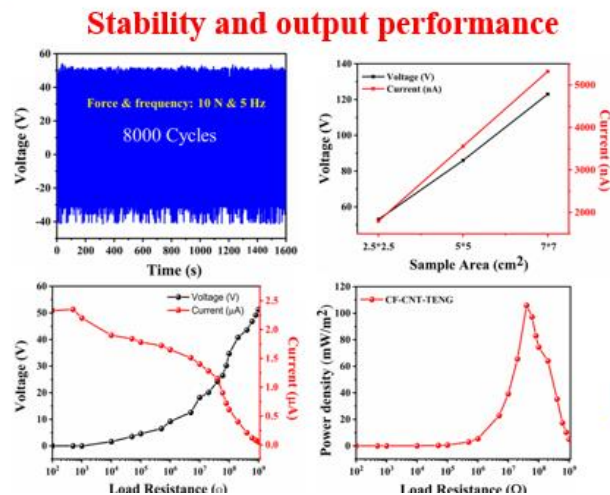
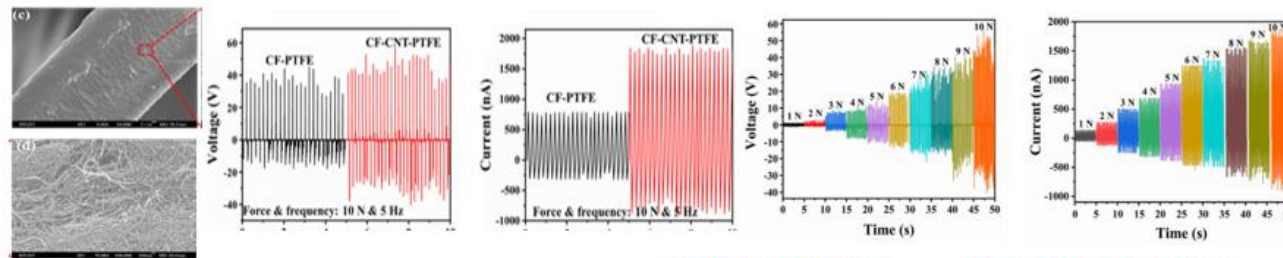
這項研究的目的是從回收的廢料中產生電能。這是首次成功使用廢棄香煙過濾嘴 (CF) 作為正摩擦電材料，將塑料廢料作為負摩擦電材料開發之摩擦奈米發電機 (TENG) 裝置。製造的香煙 CF-TENG 裝置表現出出色的電輸出性能，在  $40\text{ M}\Omega$  的負載電阻下產生的最大輸出功率密度為  $63.2\text{ mW/m}^2$ 。CF-TENG 設備收集的能量可以打開 44 個 LED (發光二極管) 並開啟一個 LCD (液晶顯示器) 定時器時鐘，表明它有可能為便攜式電子設備供電。研究開發的 CF-TENG 在日常生活中的適用性，以從正常使用的離心機中收集廢振動能，結果表明該設備可以收集 3 V 的輸出電壓。因此，這項工作為開發基於廢料的 TENGs 用於環境修復，以及生產可再生和綠色能源鋪平了道路。



## A-2 用於機械和聲能收集的基於自然驅動的基於 CF-CNT 的摩擦納米發電機的聲電轉換和摩擦電特性

### (Acoustic-electric conversion and triboelectric properties of nature driven CF-CNT based triboelectric nanogenerator for mechanical and sound energy harvesting)

當前，全球面臨水污染、氣溫超標、大氣污染等嚴峻環境挑戰，塑料廢料和煙頭 (CB) 或香煙過濾嘴 (CF) 正在造成重大環境問題。因此，處理這些廢料已成為一個關鍵問題。在這種情況下，將廢物轉化為能源被認為是對廢棄材料最有效的處理過程。此外，將廢物與納米材料結合可以帶來新的技術方面。在此，我們利用廢棄的 CFs 和塑料垃圾分別作為正負摩擦材料來製造摩擦納米發電機 (TENG) 裝置，結合 TENG 設備的 CNT 表現出卓越的能量收集性能。製造的設備收集的能量可以有效地點亮 50 個綠色 LED 並為便攜式定時器時鐘的 LCD 供電。開發的 CF-CNT TENG 裝置在各種壓縮力下表現出穩健的電氣性能，並顯示出長期穩定性。此外，製造的設備可以用作聲音驅動的 TENG 設備，可以在 100 Hz 到 400 Hz 的寬帶寬範圍內有效工作。從而減少聲音污染，同時產生綠色清潔能源。因此，我們預計本研究將為綠色能源生產和環境修復鋪平道路。



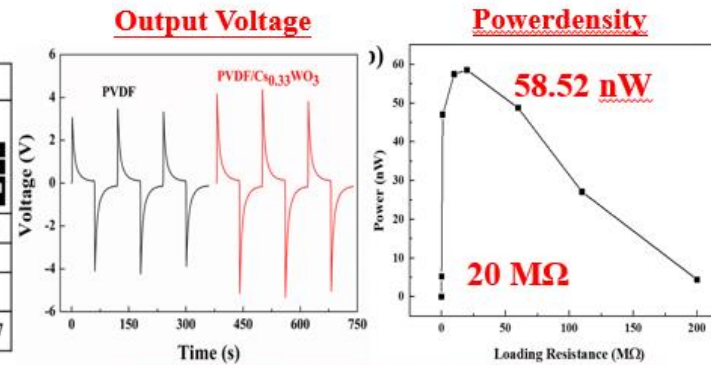
### A-3 圖案化電極對近紅外光觸發鈷鎢青銅/聚偏二氟乙烯納米複合材料的能量收集熱釋電納米發電機的影響

#### (Effects of patterned electrode on near infrared light-triggered cesium tungsten bronze/poly(vinylidene)fluoride nanocomposite-based pyroelectric nanogenerator for energy harvesting)

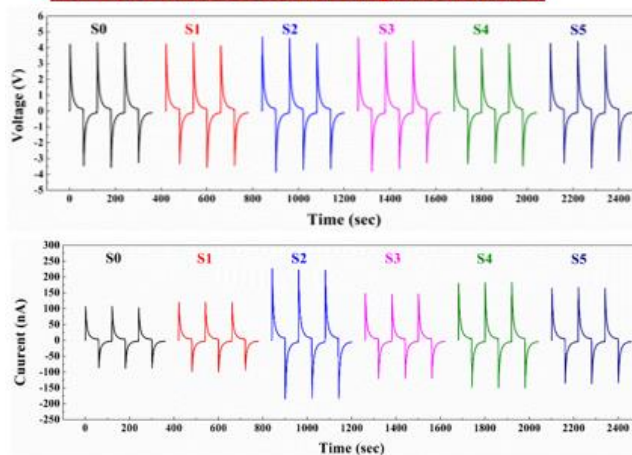
熱釋電納米發電機 (PyNG) 對於將廢熱轉化為電能至關重要，在這項研究中，我們開發了帶有絲網印刷蛇形電極 (SRE) 的 PyNG 設備，並用鈷鎢青銅 (Cs<sub>0.33</sub>WO<sub>3</sub>) 進行了修改。我們將 Cs<sub>0.33</sub>WO<sub>3</sub> 結合到電極和聚(偏二氟乙烯) (PVDF) 層中。我們研究了 Cs<sub>0.33</sub>WO<sub>3</sub> 對熱釋電響應和光熱轉換的影響以及電極圖案對熱釋電特性的影響。在 20 MΩ 的負載電阻下產生 23.28 μW/m<sup>2</sup> 的功率密度。電能 PyNG 設備產生電源液晶顯示器 (LCD) 和四個發光二極管 (LED)。我們的 PyNG 設備比公開文獻中的 PyNG 設備具有更好的熱電性能。這項研究代表了設計和開發 PyNG 設備以收集太陽能的替代方案。

#### Serpentine Electrode

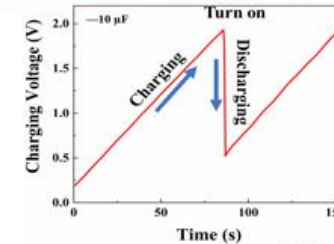
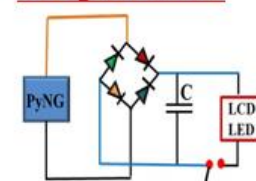
蛇形型電極						
NO.	S0	S1	S2	S3	S4	S5
線粗 (cm)	-	0.10	0.20	0.30	0.40	0.50
間距 (cm)	-	0.15				
Voltage (V)	4.34	4.34	4.70	4.66	4.24	4.41
Current (nA)	107.14	121.01	225.63	148.06	182.70	166.87



#### SRE Electrode Electrical performance



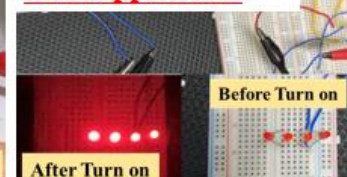
#### Bridge Rectifier



#### LCD Application

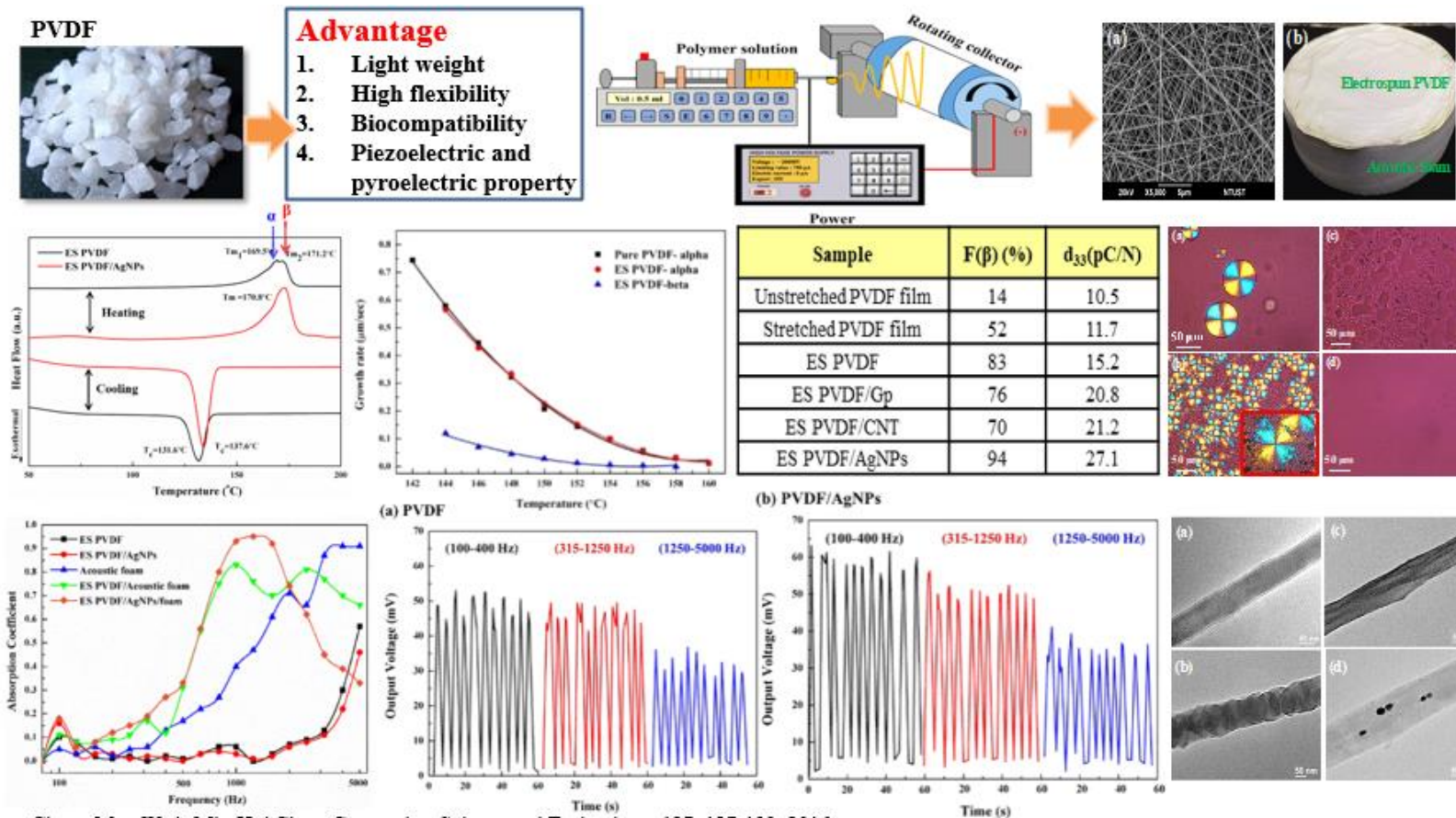


#### LED Application



## A-4 電紡聚偏二氟乙烯/銀納米纖維膜的聲電轉換和壓電性能 (Acoustic-electric conversion and piezoelectric properties of electrospun polyvinylidene fluoride/silver nanofibrous membranes)

開發了一種基於柔性電紡聚偏二氟乙烯 (PVDF) 納米纖維膜的新型聲能採集裝置。研究了靜電紡絲和添加銀納米粒子 (AgNPs) 對 PVDF 納米纖維膜的晶體結構和壓電性能的影響。靜電紡絲和 AgNPs 的添加有效地誘導了  $\beta$  相的形成並增加了壓電性。壓電電紡 PVDF 樣品對於將聲能轉化為電勢和吸收聲波至關重要。這裡製造的壓電 PVDF 裝置不僅可以減少聲音傳輸，還可以將聲能轉化為電能。這種新穎的聲能採集設備在各種傳感和能量收集應用中實用高效，有助於低功耗消費電子設備的運行和維護綠色環境。



Chang-Mou Wu\*, Min-Hui Chou, Composites Science and Technology, 127, 127-133, 2016

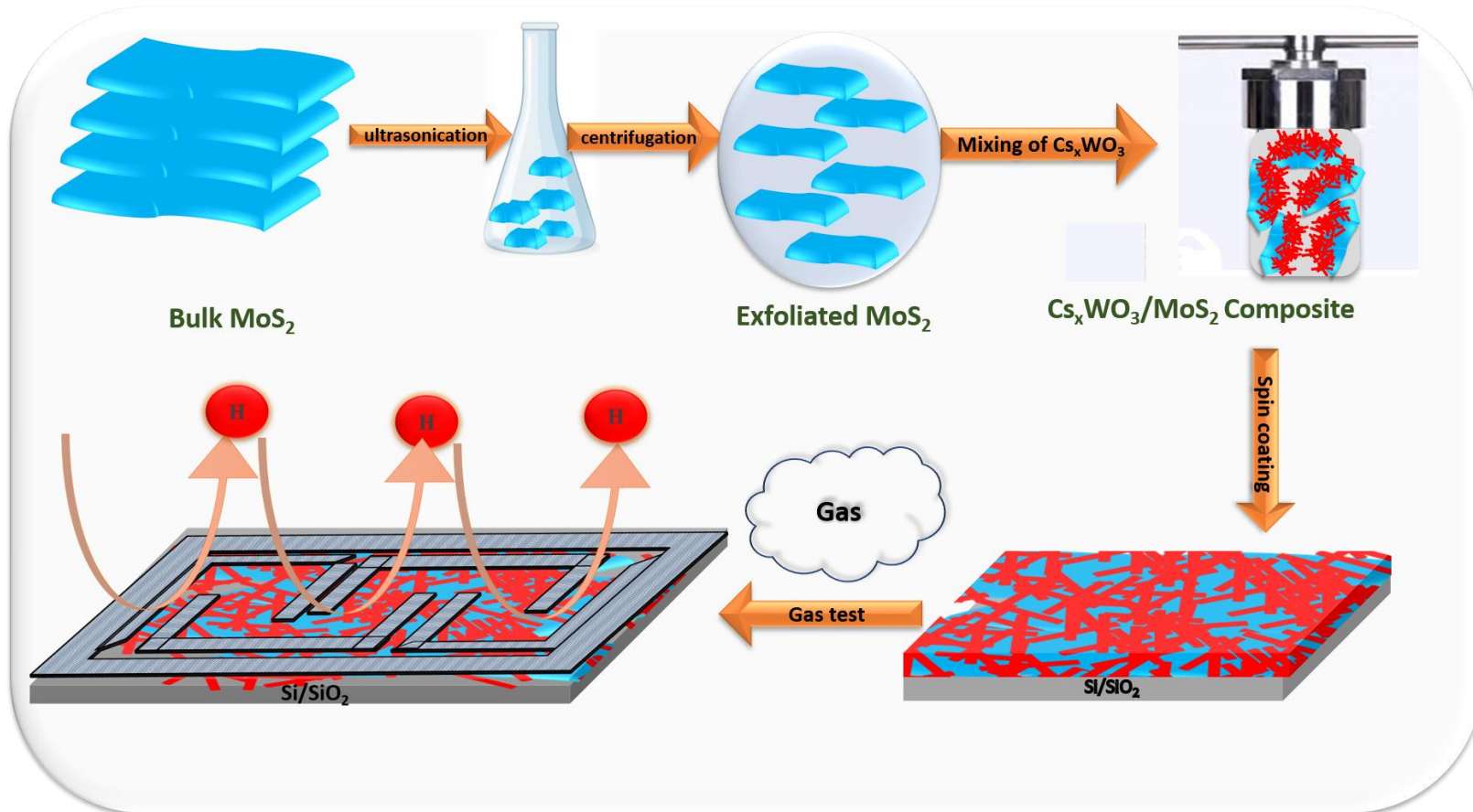
Chang Mou Wu\*, Min Hui Chou, Express Polymer Letters, 14(2), 103-114, 2020

Chang-Mou Wu\*, Min-Hui Chou, European Polymer Journal, 82, 35-45, 2016

## B. 氣體傳感器之研究 Research on Gas Sensor

### B-1 高效的 $\text{MoS}_2/\text{Cs}_x\text{WO}_3$ 納米複合氫氣傳感器 (Highly Efficient $\text{MoS}_2/\text{Cs}_x\text{WO}_3$ Nanocomposite Hydrogen Gas Sensors)

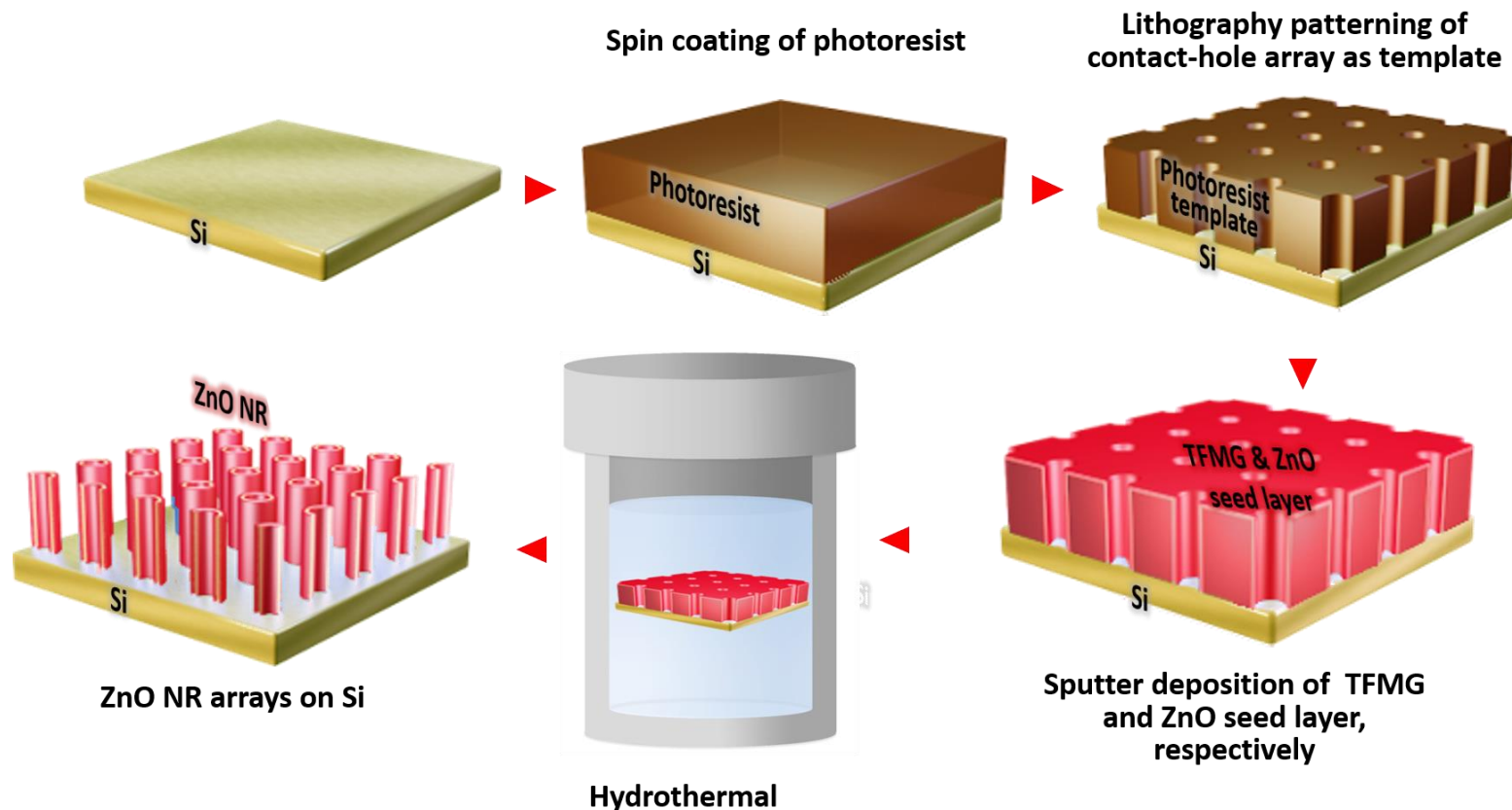
因氫氣在工業和商業應用中被大量使用，因此氫氣感測器對於環境危害檢測非常重要。在這項研究中，我們合成了一種新型  $\text{Cs}_x\text{WO}_3/\text{MoS}_2$  使用溶劑熱法的納米複合材料。樣品在  $\text{Si}/\text{SiO}_2$  上旋塗基板，感測器由叉指電極製成。考察了感測器的氫氣感測特性。 $\text{Cs}_x\text{WO}_3/\text{MoS}_2$  在室溫下表現出出色的氫氣感測能力。特別地，納米複合材料包含 15 重量%的  $\text{MoS}_2$  (15%  $\text{Cs}_x\text{WO}_3/\text{MoS}_2$ ) 在室溫下對氫氣的反應為 51%。此外，它在氫氣感測中表現出優異的循環穩定性，這對於實際應用至關重要。因此，本研究有助於開發可在室溫下操作的有效和高效的氫氣感測器。



## B-2 水熱法於鈳基金屬玻璃納米管陣列上開發 P 型氧化鋅納米棒用於氣體傳感應用

### (Development of p-type zinc oxide nanorods on zirconium-based metallic glass nanotube arrays by facile hydrothermal method for gas sensing applications)

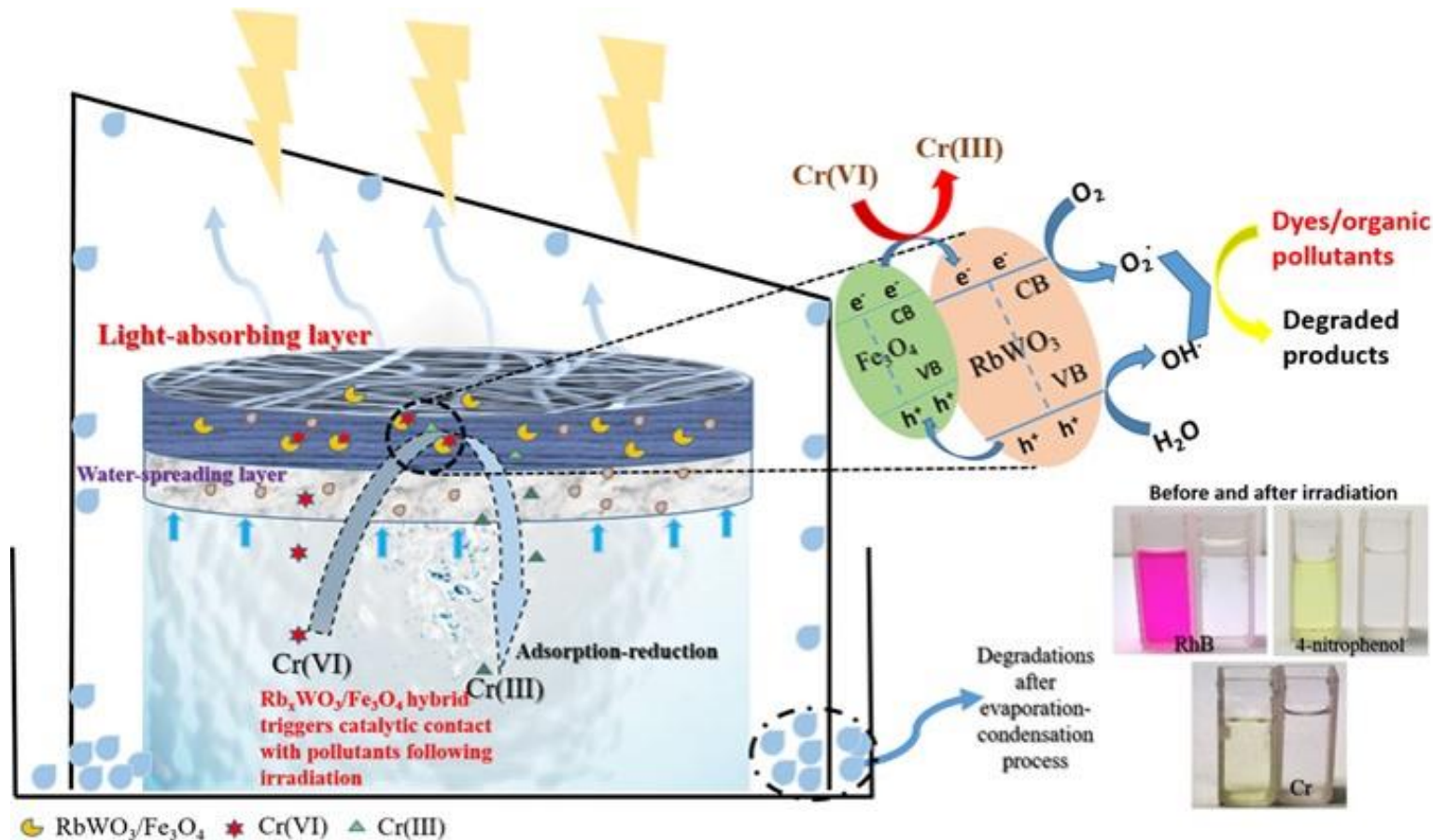
在鈳基金屬玻璃納米管陣列上生長的 p 型氧化鋅 (ZnO) 納米棒被開發用於氫氣傳感應用。通過在使用光刻膠模板 (直徑, 2  $\mu\text{m}$ ) 創建的接觸孔陣列上濺射沉積金屬玻璃 (Zr60Cu25Al10Ni5) 來合成異質鈳基金屬玻璃納米管陣列。為了在鈳基金屬玻璃納米管陣列內為納米棒的生長提供成核位點, 沉積了 ZnO 種子層。使用水熱法生長 ZnO 納米棒。它還具有出色的循環和長期穩定性, 這對於實際應用至關重要。該製備方法也簡單、快速、低溫。因此, 本研究為 p 型 ZnO 的開發鋪平了道路, 並在各個領域具有潛在的應用前景; 開發的傳感器可用於環境修復和監測。



## C. 水氣蒸發之研究 Research on Water Evaporation

### C-1 用於脫鹽和協同光催化水淨化的新型多功能 $\text{RbxWO}_3@Fe_3O_4$ 固定化 Janus 膜 (Novel multifunctional $\text{RbxWO}_3@Fe_3O_4$ immobilized Janus membranes for desalination and synergic-photocatalytic water purification)

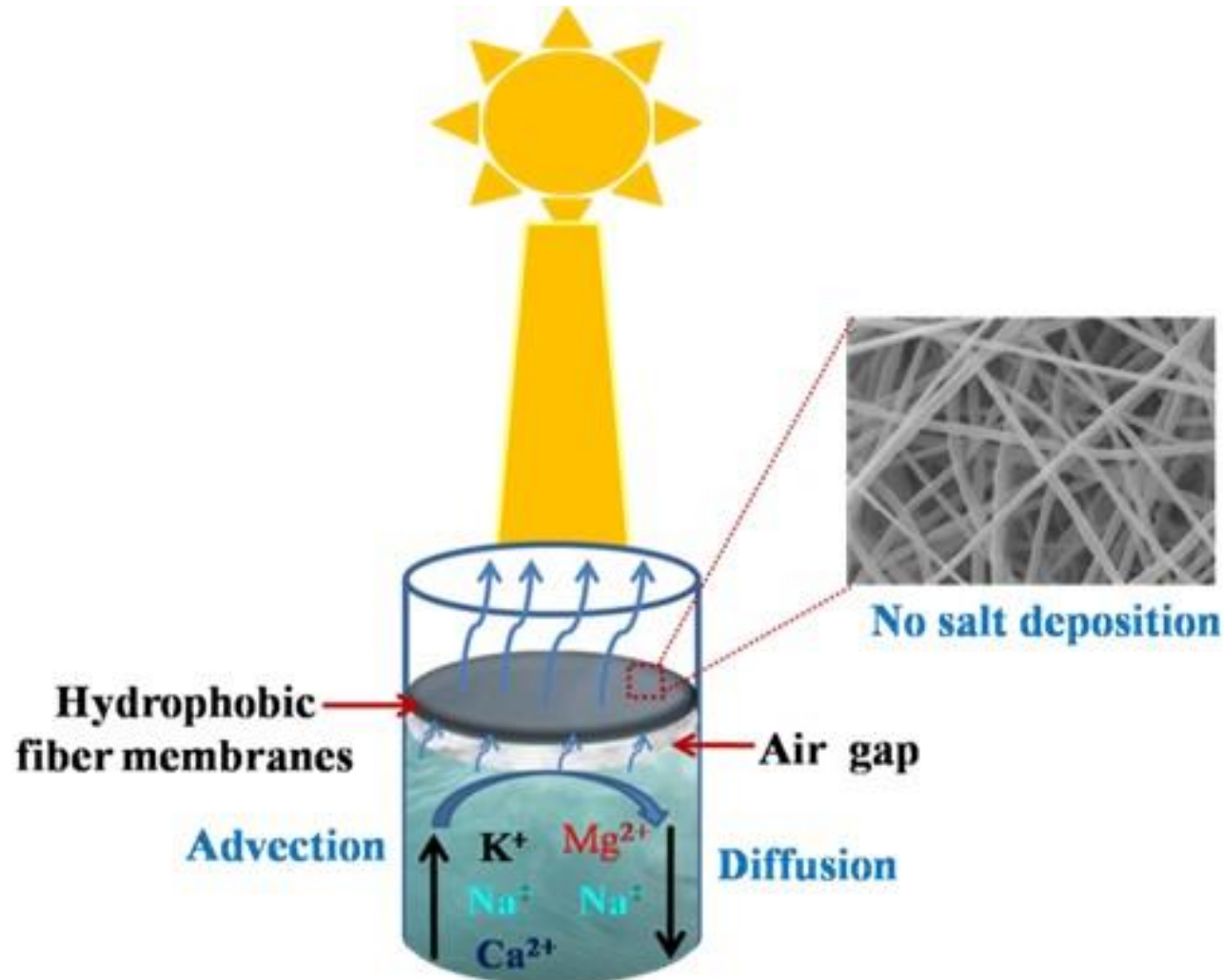
在這項工作中，通過溶液靜電紡絲將太陽能活性  $\text{RbxWO}_3@Fe_3O_4$  納米複合材料結合到用作主體基質和 PET 基板的回收三乙酸纖維素 (rTAC) 中，開發了新型多功能 Janus 膜。Janus 膜專門設計有多孔疏水性 rTAC 頂層，該頂層包含功能性複合材料和親水性無紡布 PET 底層，具有相反的表面潤濕性，便於從 PET 無紡布泵送水。系統地研究了所開發的 Janus 膜的多功能適用性，用於界面水蒸發、光熱轉化、污水處理、海水淡化以及同步光催化和水蒸發。





## C-2 用於界面水蒸發、海水淡化和污水處理的高效耐鹽 Cs<sub>x</sub>WO<sub>3</sub>@g-C<sub>3</sub>N<sub>4</sub>/PVDF 纖維膜 (Highly-efficient and salt-resistant Cs<sub>x</sub>WO<sub>3</sub>@g-C<sub>3</sub>N<sub>4</sub>/PVDF fiber membranes for interfacial water evaporation, desalination, and sewage treatment)

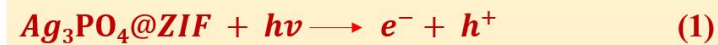
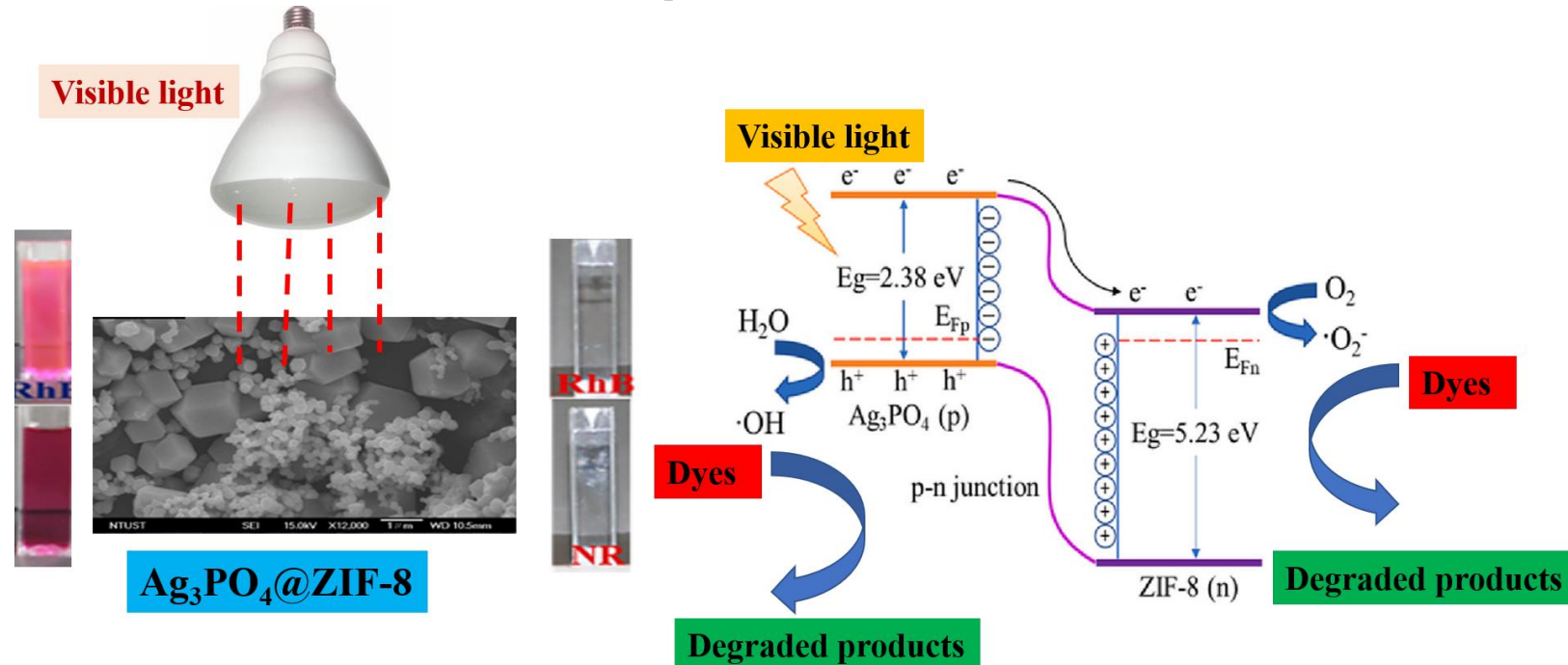
使用溶劑熱法合成鈯鎢氧化物/石墨碳氮化物 (Cs<sub>0.32</sub>WO<sub>3</sub>@gC<sub>3</sub>N<sub>4</sub>) 雜化物。將雜化物摻入 PVDF 中並電紡成 Cs<sub>0.32</sub>WO<sub>3</sub>@g-C<sub>3</sub>N<sub>4</sub>/PVDF 纖維膜。使用光熱纖維膜研究了水蒸發、脫鹽和污水處理。這些優越的性能歸因於 PVDF 的疏水性，它能夠在水和纖維膜之間形成氣隙。這個氣隙選擇性地讓水蒸氣進入纖維膜，同時鹽分和有機污染物擴散回大量水中，這對於脫鹽的成功至關重要。這項研究為設計用於污水處理，尤其是海水淡化的新型多功能纖維膜。



## D. 光催化之研究 Research on Photocatalytic

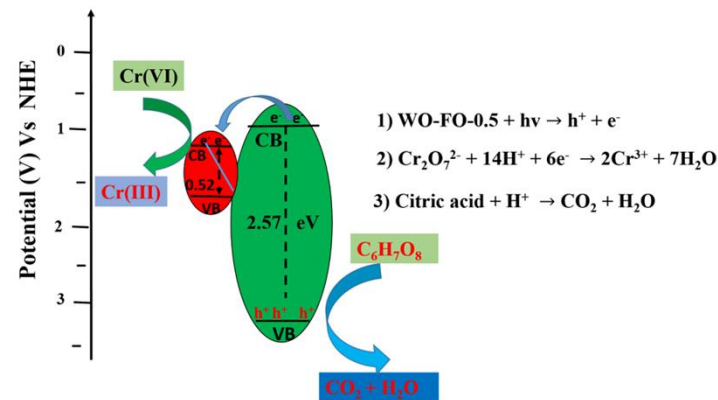
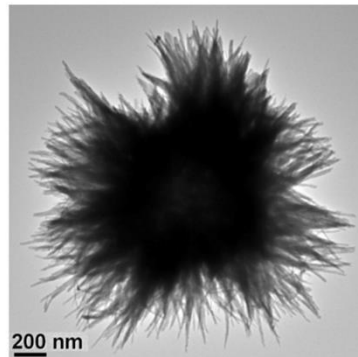
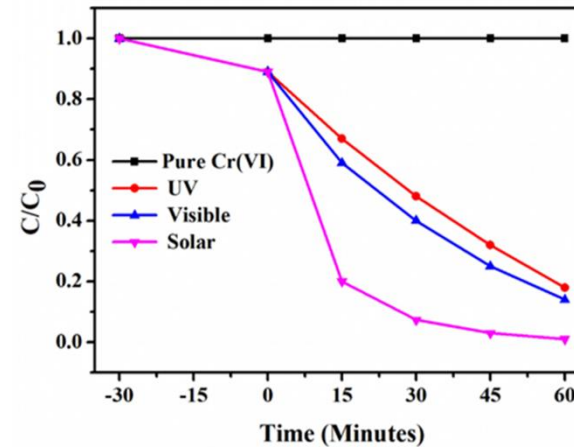
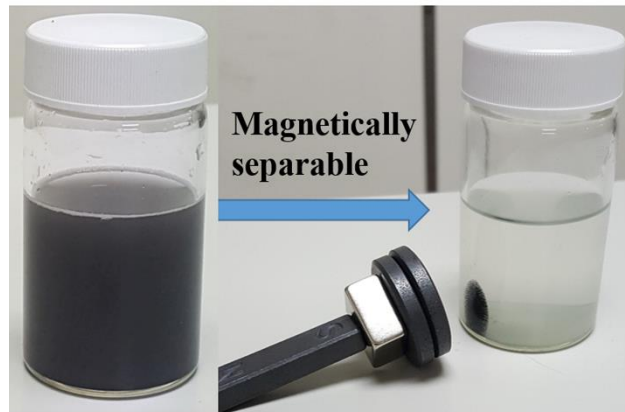
### D-1 用於有效光降解有機污染物的新型 Ag<sub>3</sub>PO<sub>4</sub>@ZIF-8 p-n 異質結 (Novel Ag<sub>3</sub>PO<sub>4</sub>@ZIF-8 p-n heterojunction for effective photodegradation of organic pollutants)

採用化學沉澱法在室溫下製備了一種新型磷酸銀@沸石咪唑酯框架-8 (Ag<sub>3</sub>PO<sub>4</sub>@ZIF-8) p-n 異質結。研究了所開發的 p-n 異質結對有機水污染物的光催化性能。製備的 Ag<sub>3</sub>PO<sub>4</sub>@ZIF-8 p-n 異質結對有機污染物結晶紫 (CV)、剛果紅 (CR) 和羅丹明 B (Rh B) 表現出優異的光催化性能。異質結還表現出優異的循環穩定性。所開發的 Ag<sub>3</sub>PO<sub>4</sub>@ZIF-8 p-n 異質結的優異光催化性能可歸因於光生電荷複合的抑制、表面積的增加、p-n 異質結的形成和光吸收的延長。



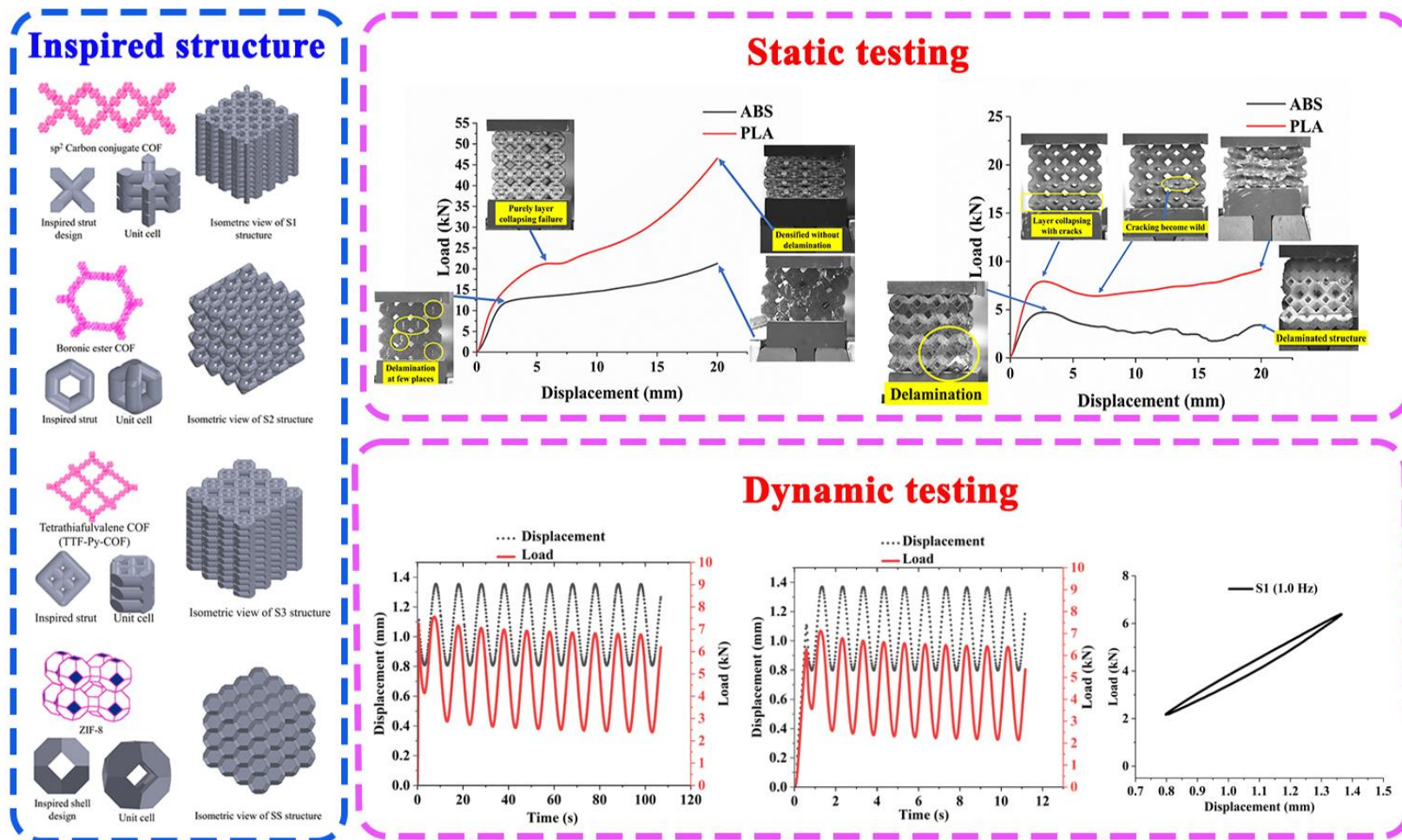
## D-2 磁分離高效全光譜光驅動 WO<sub>2.72</sub>/Fe<sub>3</sub>O<sub>4</sub> 納米複合材料用於光催化還原致癌鉻 (VI) 和有機染料降解 (Magnetically separable highly efficient full-spectrum light-driven WO<sub>2.72</sub>/Fe<sub>3</sub>O<sub>4</sub> nanocomposites for photocatalytic reduction of carcinogenic chromium (VI) and organic dye degradation)

通過溶劑熱法合成了磁可分離、高效全光譜光活性 WO<sub>2.72</sub>/Fe<sub>3</sub>O<sub>4</sub> 納米複合位點，並對其進行了很好的表徵。WO<sub>2.72</sub>/Fe<sub>3</sub>O<sub>4</sub> 納米複合材料在太陽光下光降解亞甲藍 (MB)、甲基橙 (MO) 和羅丹明 B (Rh B) 染料以及在紫外 (UV) 下光還原 Cr(VI) 的光催化性能，可見光，和太陽光進行了研究。WO<sub>2.72</sub>/Fe<sub>3</sub>O<sub>4</sub> 納米複合材料對 MO、MB 和 Rh B 染料在太陽光下的光降解以及 Cr(VI) 在可見光、紫外線和太陽光下的光還原表現出優異的光催化活性。它不僅顯示出對不同有機和無機污染物的光催化的普遍適用性，而且還具有出色的穩定性和易分離性。該納米複合材料還表現出比報導的在太陽光下光還原 Cr(VI) 更高的光催化活性。由於其成本低、生態友好、易於製備，也便於大規模應用。



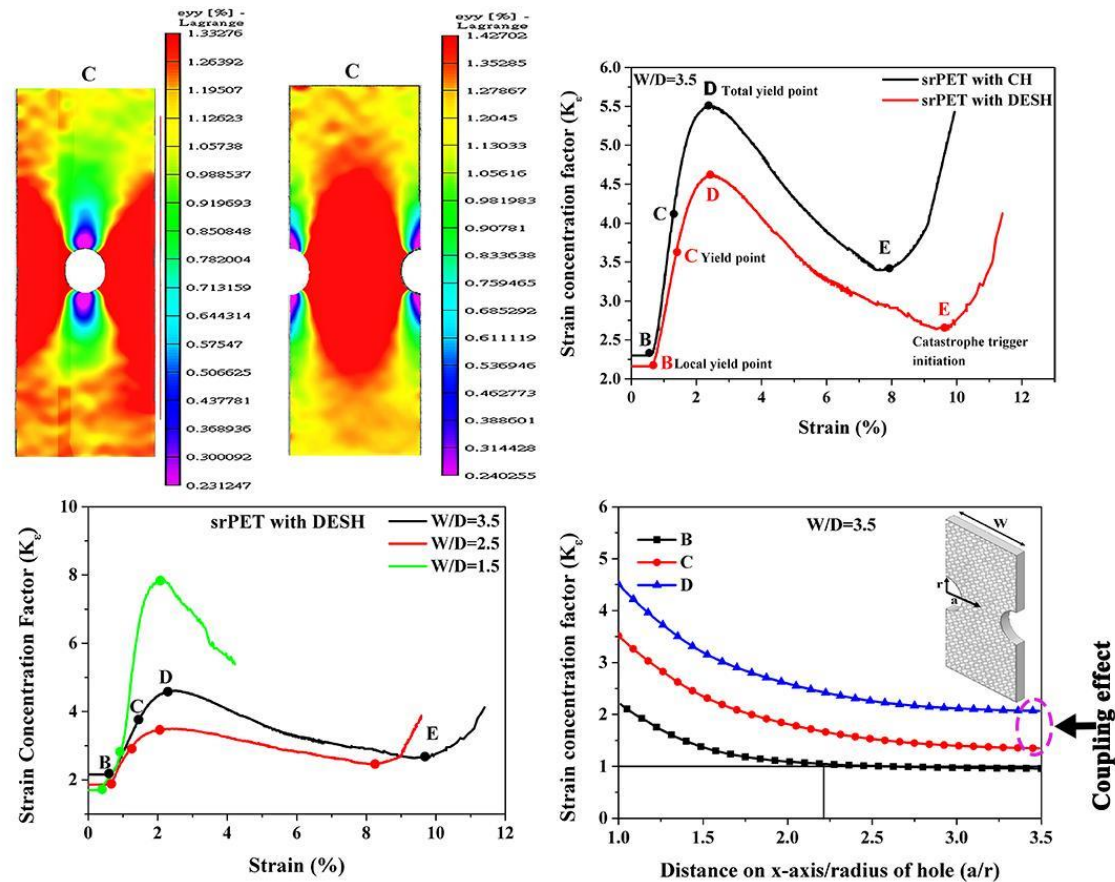
## E. 3D 列印結構對動態循環載荷下脆性聚合物能量吸收能力的影響 (Influence of 3D printed structures on energy absorption ability of brittle polymers under dynamic cyclic loading)

結構變化可以改變構成材料的能量吸收能力。使用聚乳酸 (PLA) 和丙烯腈丁二烯苯乙烯 (ABS) 聚合物通過融合沉積建模 (FDM) 打印的碳有機框架 (COF) 啟發結構用於分析結構效應。結構的特徵在於靜態壓縮下的特定能量吸收。靜態測試結果中的最佳結構進一步表徵為動態壓縮，使用正弦位移計算動態彈性恢復 (DER)、滯後功和  $\tan \delta$ 。彎曲主導的結構吸收了最高的能量，並且表面結構提供了最好的 DER。因層的純粹坍塌而失效的結構顯示出最佳的特定值。儘管有材料，但印刷層在加載過程中的分層會降低結構的性能。



## F. 雙刃孔韌性複合材料全變形範圍內的數字圖像相關應變集中 (Strain concentration of double-edge hole ductile composites in the full range of deformation by digital image correlation)

本研究使用不同寬度的數字圖像相關 (DIC) 研究了具有雙邊緣半圓孔 (DESH) 的自增強聚對苯二甲酸乙二醇酯複合材料 (srPET) 在整個變形範圍內應變集中因子 ( $K_\epsilon$ ) 的變化直徑 (W/D) 比。  $K_\epsilon$  的值與彈性變形範圍內的理論集中因子 ( $K_t$ ) 一致；結果將有助於提高對裸孔材料屈服現象的理解，並在最終材料損壞之前提供早期預警。 因此，應首選具有 DESH 的複合材料作為結構應用的替代品。



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