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Silver nanoparticles capped by polydopamine as a sensitive probe for detecting cartap

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Keywords: silver nanoparticles, polydopamine, colorimetric probe, nanosensor, cartap

In this research, polydopamine (PDA) was used to functionalize the surfaces of silver nanoparticles (AgNPs) to form PDA-AgNPs for sensing cartap. UV–Vis spectrophotometry, Fourier transform infrared spectroscopy, transmission electron microscopy, X-ray photoelectron spectroscopy, and zeta potential measurements were used to characterize PDA-AgNPs. PDA-AgNPs were spherical with an average size of 12.6 nm. In the presence of cartap, it will cause the aggregation of PDA-AgNPs. As a result, the absorption ratio (A_{600}/A_{400}) of PDA-AgNPs showed good linearity in the range of 0.1 to 1.0 ppm ($R_2 = 0.983$) and 1.0 to 10 ppm ($R_2 = 0.997$) with a limit of detection (LOD) of 0.049 ppm. Furthermore, adding other pesticides did not significantly change the absorption ratio of PDA-AgNPs, indicating its high selectivity and anti-interference for the detection of cartap. Finally, the application of PDA-AgNPs was proved by determining cartap in lake water and rice samples.

Gallic acid-modified copper nanoclusters/silver nanoparticles for the fluorescent and colorimetric dual-mode detection of streptomycin)

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Keywords: copper nanoclusters, silver nanoparticles, streptomycin, dual-mode sensor

In this study, gallic acid was used to modify copper nanoclusters and silver nanoparticles as GA-CuNCs and GA-AgNPs that were used for detecting streptomycin (STR) based on fluorescent and colorimetric approaches. GA-CuNCs had an average size of 5 nm and exhibited blue fluorescence under ultraviolet irradiation and a maximum emission of 410 nm at an excitation wavelength of 330 nm. The fluorescence of GA-CuNCs was quenched occurs in the presence of GA-AgNPs through the fluorescence resonance energy transfer (FRET). In the presence of streptomycin, it will cause the aggregation of GA-AgNPs and decrease the absorbance at 400 nm and recover the fluorescence intensity at 410 nm. The linear range of fluorescent method was 0.5-20 μM ($R^2=0.995$) with a limit of detection (LOD) of 0.25 μM the linear range of colorimetric method was 0.5-20 μM ($R^2=0.996$) with a LOD of 0.36 μM . This dual-mode detecting system was successfully applied for determining STR in real samples with good recoveries of the fluorescent method between 92.27% and 109.25%; and the recoveries of the colorimetric method between 91.34% and 107.99%.

Dual-Functional Silver Nanoparticles for Colorimetric Detection of Cartap and Catalytic Degradation of Methyl Orange and Rhodamine B

雙功能銀奈米粒子用於比色檢測培丹和催化降解甲基橙和玫瑰紅 B

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Keywords: cartap, catalytic degradation, organic dye, colorimetric detection, gallic acid, silver nanoparticles

This study presents a facile approach for synthesizing gallic acid-capped silver nanoparticles (GA-AgNPs). GA-AgNPs were synthesized under the optimized conditions and characterized using various techniques (ultraviolet–visible, Fourier-transformed infrared (FTIR), X-ray diffraction, and transmission electron microscopy). GA-AgNPs were spherical in shape with an average diameter of 11.2 nm. The FTIR and Zeta potential analyses proved the presence of gallic acid on the surface of AgNPs, stabilizing the nanoparticles. GA-AgNPs were used for the colorimetric detection of cartap (S,S’-[2-(dimethylamino)-1,3-propanediyl] dicarbamothioate) and catalytic degradation of methyl orange (MO) and rhodamine B (RB). GA-AgNPs were highly selective and sensitive to cartap, with a detection limit of 0.059 ppm in a linear range of 0.1–2.0 ppm. GA-AgNPs also showed excellent catalytic activity in degrading MO and RB, achieving complete conversion within 15 min. The catalytic process followed pseudo-first-order kinetics with rate constants of 0.3596 and 0.3369 min⁻¹ for MO and RB, respectively. Finally, the application of GA-AgNPs was validated by determining cartap in rice samples and the degradation of MO and RB in lake water samples.

References:

- 1.----- Chatterjee, S.; Lou, X.-Y.; Liang, F.; Yang, Y.-W., Surface-functionalized gold and silver nanoparticles for colorimetric and fluorescent sensing of metal ions and biomolecules. *Coordination Chemistry Reviews* 2022, 459, 214461.
- 2.----- Ratnarathorn, N.; Chailapakul, O.; Henry, C. S.; Dungchai, W., Simple silver nanoparticle colorimetric sensing for copper by paper-based devices. *Talanta* 2012, 99, 552-557.
- 3.----- Gupta, N.; Singh, H. P.; Sharma, R. K., Metal nanoparticles with high catalytic activity in degradation of methyl orange: An electron relay effect. *Journal of Molecular Catalysis A: Chemical* 2011, 335 (1), 248-252.

Aggregation-Induced Emission Investigation of Bipyrazole[1,5-a]pyridines Bearing Polycyclic Aromatic Substituents

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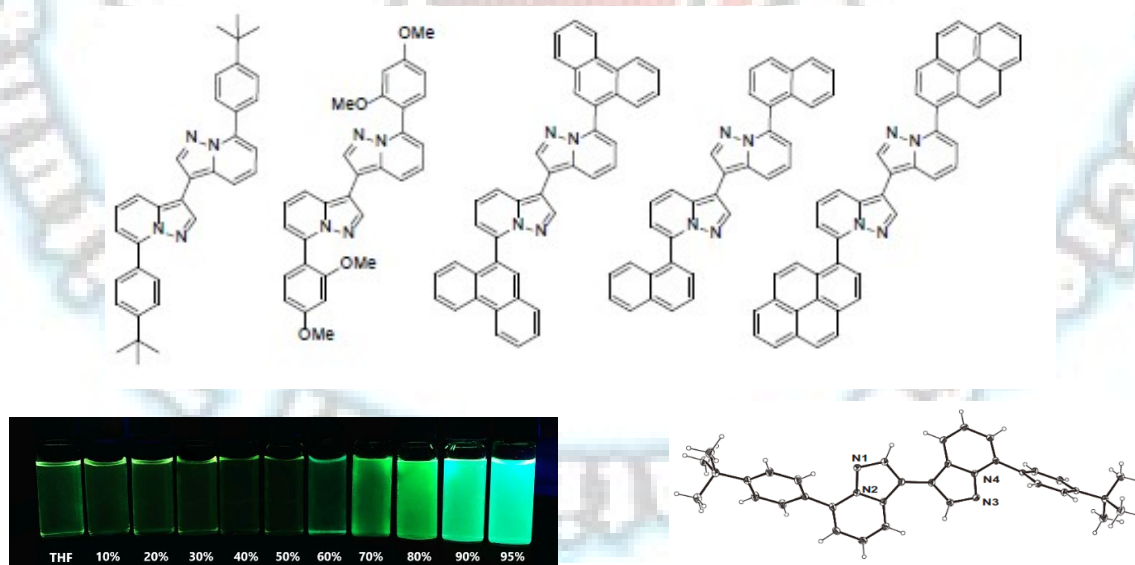
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Keywords: (Times New Roman/標楷體, Single space, 12 point, Italics, Separated with semicolon, left-justified) AIE, Bipyrazole[1,5-a]pyridines, pyrene

A series of 3,3'-bipyrazolo[1,5-a]pyridines bearing various polycyclic aromatic substituents was synthesized via C–H bond activation with modest to good yields. The structure of 7,7'-bis(4-(*tert*-butyl)phenyl)-3,3'-bipyrazolo[1,5-a]pyridine was further elucidated through X-ray crystallography. Photophysical properties including fluorescence quantum yields in solution and solid states, were carried out by UV-Vis and fluorescence spectroscopy. The experimental results show that bis(pyrenyl)-substituted 3,3'-bipyrazolo[1,5-a]pyridine gives a low quantum yield (0.02), whereas that of others are around 0.2–0.3. For this type of molecules, both steric hindrance and π – π interaction play important roles in aggregation-induced emission effect.



References: (Times New Roman/標楷體, Single space, 10 point, ACS style, left-justified in numbered order)

1. Hsiao, P. Y.; Chu, J. H.* Chem. Commun. 2021, 57, 12281–12284.
2. Hsiao, P.-Y.; Chang, R.; Sue, A. C.-H.; Chu, J.-H.*; Lee, Y.-H.; Huang, J.-Y. J. Org. Chem. 2022, 87, 9851–9863.

Exploring the Reduction of Nitrous Acid to Nitric Oxide Using Cobalt Compounds as Catalytic Centers

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Keywords: Nitrite reductase enzymes; nitric oxide

We will utilize $[\text{CoIII}(\text{Cl})\text{P}(\text{C}_6\text{H}_3\text{-3-SiMe}_3\text{-2-S})_3]$ (CoCl) previously studied in the laboratory and nitrite salts to generate $[\text{CoIII}(\text{NO}_2)\text{P}(\text{C}_6\text{H}_3\text{-3-SiMe}_3\text{-2-S})_3]$ (CoNO_2). Subsequently, different acids will be used for reduction to induce the formation of nitric oxide. Nitric oxide will be reacted with $[\text{MnIII}(\text{DABCO})\text{P}(\text{C}_6\text{H}_3\text{-3-SiMe}_3\text{-2-S})_3]$ (MnDABCO) to confirm successful nitric oxide generation during the reaction.

References:

1. Wasser, I. M.; de Vries, S.; Moënne-Loccoz, P.; Schröder, I.; Karlin, K. D., Nitric Oxide in Biological Denitrification: Fe/Cu Metalloenzyme and Metal Complex NO_x Redox Chemistry. *Chemical Reviews* **2002**, 102 (4), 1201-1234.
2. Chiang, C.-K.; Chu, K.-T.; Lin, C.-C.; Xie, S.-R.; Liu, Y.-C.; Demeshko, S.; Lee, G.-H.; Meyer, F.; Tsai, M.-L.; Chiang, M.-H.; Lee, C.-M., Photoinduced NO and HNO Production from Mononuclear $\{\text{FeNO}\}_6$ Complex Bearing a Pendant Thiol. *Journal of the American Chemical Society* **2020**, 142 (19), 8649-8661.

Tannic acid decorated copper–gold bimetallic nanoparticles with high catalytic activity for the degradation of 4-nitrophenol and rhodamine B

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Keywords: 4-nitrophenol; bimetallic nanoparticles; catalytic degradation; rhodamine B; sodium borohydride; tannic acid

In the present study, tannic acid decorated copper-gold (TA-CuAu) bimetallic nanoparticles were prepared using a facile method. The TA-CuAu nanoparticles were characterized by UV–VIS, FTIR spectrometry, TEM, XRD, and XPS. The TA-CuAu nanoparticles exhibited excellent catalytic activity for the degradation of 4-NP and RB. Under optimal conditions, the individual degradation of 4-NP and RB was completed within 10 min, and the apparent rate constants were calculated as 0.3429 and 0.3225 min⁻¹, respectively, and the reactions followed pseudo-first-order kinetics. In addition, the mixture of 4-NP and RB was also successfully degraded within 10 min, indicating that TA-CuAu nanoparticles have the ability to degrade both 4-NP and RB. Finally, the successful treatment of the tap and lake water samples spiked with 4-NP and RB using the TA-CuAu nanoparticles confirmed their application potential as catalysts in environmental water remediation.

References:

1. Deshmukh, A. R.; Kim, B. S., Flower-like biogenic gold nanostructures for improved catalytic reduction of 4-nitrophenol. *Journal of Environmental Chemical Engineering* **2021**, 9 (6), 106707.
2. Liu, K.; Han, L.; Zhuang, J.; Yang, D.-P., Protein-directed gold nanoparticles with excellent catalytic activity for 4-nitrophenol reduction. *Materials Science and Engineering: C* **2017**, 78, 429-434.
3. Wang, G.; Zhao, K.; Gao, C.; Wang, J.; Mei, Y.; Zheng, X.; Zhu, P., Green synthesis of copper nanoparticles using green coffee bean and their applications for efficient reduction of organic dyes. *Journal of Environmental Chemical Engineering* **2021**, 9 (4), 105331

製備鈷烴基 烴基 甲基、乙基 硫磷錯合 物之一氧化碳鍵入反應探討

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Keywords: Wood-Ljungdahl pathway、一氧化碳脫氫酶和乙醯輔酶 A 合成酶

文獻中提到在厭氧環境下Wood - Ljungdahl pathway中一氧化碳脫氫酶和乙醯輔酶A合成酶是重要的一部份，且此反應為全球碳循環的重要組成，因此CO和中心金屬反應的探討是非常重要的。本實驗室會先合成的錯合物2和3，兩者屬於熱不穩定及對水氧敏感的錯合物因此須在手套箱內操作且灌入CO進行反應時需在-10°C以下的條件下反應，而後產生的錯合物4和5也須在手套箱內純化及長晶，並存放在冰箱中。

參考文獻

1.
Eric L. Hegg Unraveling the Structure and Mechanism of Acetyl-Coenzyme A Synthase. Acc. Chem. Res. 2004, 37, 10, 775 783
2.
Can M , Giles LJ , Ragsdale SW , Sarangi R . X-ray Absorption Spectroscopy Reveals an Organometallic Ni-C Bond in the CO-Treated Form of Acetyl-CoA Synthase. Biochemistry 2017, 56, 9, 1248–1260

Isolation, purification and identification of Ovatodiolide from *Anisomeles indica*

自魚針草中分離純化並鑑定 Ovatodiolide

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關鍵字: 抗發炎、魚針草內酯、魚針草

"*Anisomeles indica*" 是一種藥用植物。其主要成分之一是 "ovatodiolide"，這是一種類二萜化合物，具有抗菌消炎的功效。研究人員利用溶劑萃取、層析和重結晶技術，成功地從魚針草中提取出了魚針草內酯。研究人員採用了核磁共振、傅立葉轉換紅外光譜和高效液相層析儀等多種方法來確定魚針草內酯的成分和立體結構。與 "*A. indica*" 中的其他化合物（如 Ovatodiolide）相比，*Anisomeles acid*, *Acteoside* 具有更好的水溶性和生物活性。儘管還需要進一步的研究，但對 ovatodiolide 的研究為癌症治療和其他治療應用帶來了希望。

Synthesis and Reactivity of Disulfide Manganese Nitrosyls

Complexes : Photoinduced Production of Nitric Oxide

雙硫亞硝基錳錯化合物的合成與反應性探討：光誘導一氧化氮生成

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Keywords: Mn(PhPS₂)₂, (1), Mn(NO)(SPhS-SPhS) (2), and [Mn(NO)(SPhS-SPhS)][PF₆] (3)

Abstract :

This study synthesized different manganese-sulfur-phosphorus complexes: Mn(PhPS₂)₂ (1), Mn(NO)(SPhS-SPhS) (2), and [Mn(NO)(SPhS-SPhS)][PF₆] (3). UV-Vis and IR spectroscopy were used to characterize the complexes. Complex 2 can be photolyzed to release NO and generate complex 1. Complex 3 can be photolyzed to form complex 2, which then releases NO.

Motivation:

Since the discovery of nitric oxide (NO) as a signaling molecule in vasodilation and neurotransmission, there has been great interest in the chemical pathways that lead to NO generation. NO can be harmful to the human body in large quantities, but beneficial in small quantities. Therefore, we have developed a controllable NO donor molecule that generates NO upon light irradiation. This material has potential future applications in the medical field.

Conclusion:

We report the synthesis and photophysical characterization of complexes 1–3. Photolysis of complex 2 leads to the release of NO and conversion to complex 1, while photolysis of complex 3 leads to conversion to complex 2. We have designed a NO donor molecule that can control the flux and timing of NO release by light source control. This molecule has potential applications in human treatment and has great potential in the medical field.

Synthesis and Spectral Investigation of the Redox Properties of Iron-Sulfur-Nitroso Coordination Complexes

Chia-Hsuan Lin, Jian-Lun Xu, Chien-Ming Lee

1. organometallic complex, $\{\text{TMSFeNO}\}_7 \text{Fe}(\text{NO})(\text{TMSPhPS})_2$ (1) 2. $\{\text{TMSFeNO}\}_6 [\text{Fe}(\text{NO})(\text{TMSPhPS})_2]^+ ([2]^+)$ 3. $\{\text{TMSFeNO}\}_8 [\text{Fe}(\text{NO})(\text{TMSPhPS})_2]^- ([3]^-)$ 4. $\{\text{TMSFeNO}\}_6 [\text{Fe}(\text{NO})(\text{TMSPhPS})_2 (\text{H}_2\text{O})]^+ ([4]^+)$ 5. $\text{MnIII}(\text{TMSPS}_3)(\text{DABCO})$

研究動機：

一氧化氮 (NO) 及其單電子還原衍生物亞硝基 (HNO/NO⁻) 在許多生理過程中發揮著重要作用。NO 和 HNO/NO⁻ 的目標受體通常包含鐵中心 (血紅素或非血紅素) 或硫配體 (硫醇或硫醇酸)，從而形成負責生物過程的 NO 加成物。舉例來說，由 NO 結合到可溶性鳥苷酸環化酶 (sGC) 中的鐵血紅素中心觸發的環磷酸鳥苷 (cGMP) 的形成，對神經調節或血管擴張起著關鍵作用。HNO 也誘導血管舒張反應，並顯示出比 NO 更具血管擴張效果，因此有望作為正性心肌收縮藥物用於心衰治療。受到 NO 和 HNO 在生物系統或醫學應用中的重要性啟發，許多研究致力於製備基於 Metal-NO 化合物的 NO 或 HNO 釋放劑。來自外源金屬-亞硝基鹽基的 NO 釋放可受 pH、溶解、熱和光的變化刺激。與來自金屬-亞硝基鹽基的 NO 釋放化學相比，從金屬-亞硝基 (M(HNO/NO⁻)) 種類生成 HNO 的化學過程仍然相對未被探索。一般認為，將 iron-NO 錯合物 ($\{\text{FeNO}\}_x$, $x=6$ 或 7 ; Enemark-Feltham 標記) 的還原為電子豐富的 $\{\text{FeNO}\}_8$ 種類是 HNO 釋放化學的關鍵步驟。隨後，對帶有更有可能 NO⁻ 特性的 NO 結合 Fe 物種的質子化將產生 HNO。

研究摘要：

在此，我們報導了一種特別的有機金屬 $\{\text{TMSFeNO}\}_7 \text{Fe}(\text{NO})(\text{TMSPhPS})_2$ (1) 物種，錯合物 1 通常非常穩定且不活潑，透過初步電化學的研究顯示，錯合物 1 可以被活化以進行氧化還原形成 $\{\text{TMSFeNO}\}_6 [\text{Fe}(\text{NO})(\text{TMSPhPS})_2]^+ ([2]^+)$ 及 $\{\text{TMSFeNO}\}_8 [\text{Fe}(\text{NO})(\text{TMSPhPS})_2]^- ([3]^-)$ 物種，我們推測氧化還原得物種不會改變鐵中心的配位環境。藉此我們將利用化學方法來證實錯合物 1 氧化還原的可行性。另外，在錯合物 1 氧化的過程中，還發現了 $\{\text{TMSFeNO}\}_6 [\text{Fe}(\text{NO})(\text{TMSPhPS})_2 (\text{H}_2\text{O})]^+ ([4]^+)$ 物種的生成，我們將對其與錯合物 2 之間的關聯性進行探討，再利用 FT-IR 進行表徵。

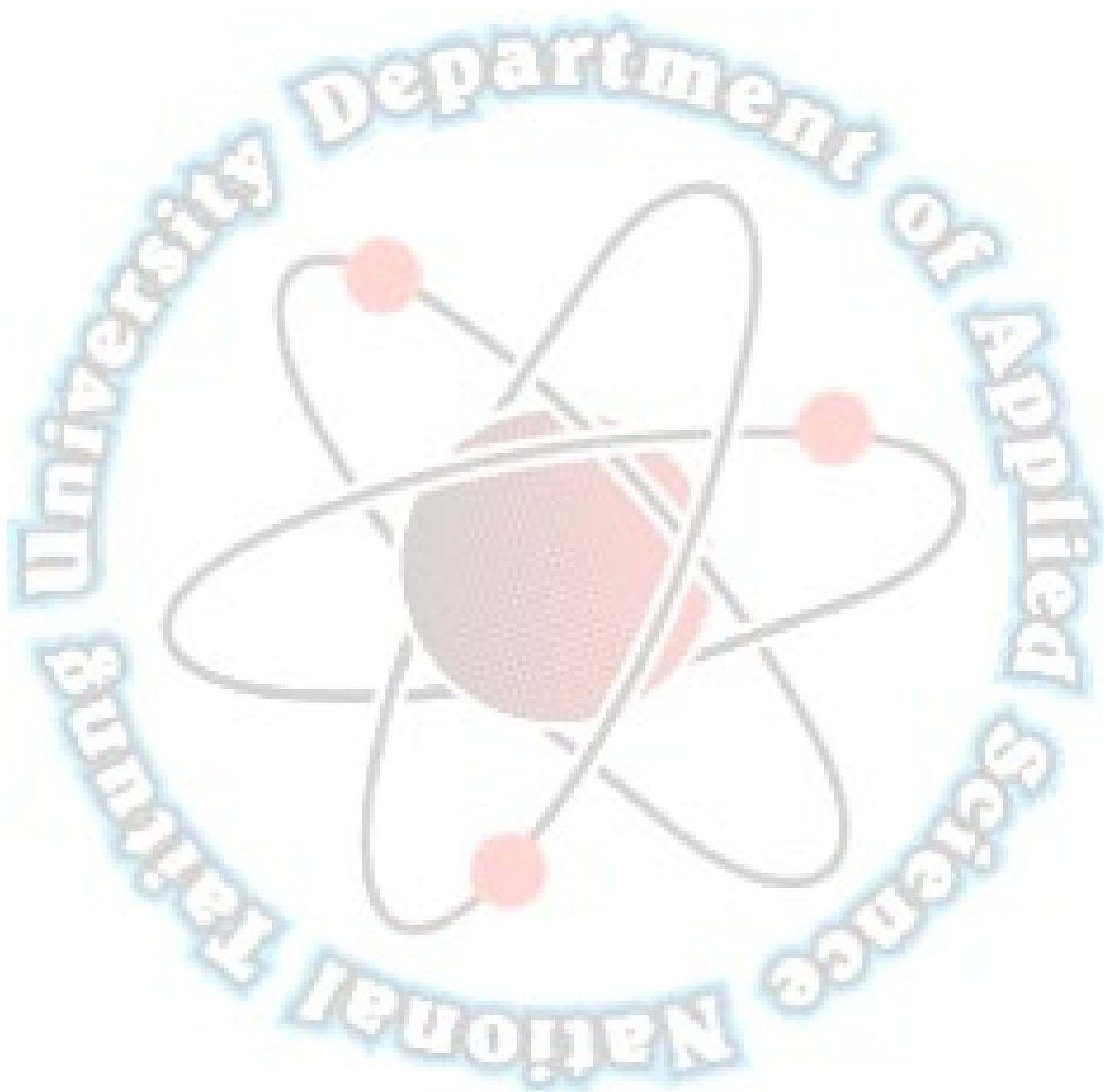
此外，在本篇中我們還對錯合物 2 及錯合物 4 對光、熱、溶劑等影響進行了研究探討，並且使用 UV-Vis Spectroscopy 來對之中的改變進行追蹤。最後，利用先前實驗室研發的 NO/NO⁻ 捕集劑 $\text{MnIII}(\text{TMSPS}_3)(\text{DABCO})$ ，證明錯合物 4 在光照射下會釋放 NO。

結論：

在這項實驗研究中，確認了複合物 1 的氧化還原過程的可行性，並使用各種光譜方法對 $\{\text{TMSFeNO}\}_{6-8}$ 物種進行了表徵。成功合成了複合物 1 和 2，並通過 X 射線晶體學進行了表徵。結果表明 $\{\text{TMSFeNO}\}_{6-8}$ 系列中的氧化還原轉化是基於 Fe-NO 的。當複合物 2 的溶液在室溫下放置時，它會與空氣中的水發生反應，形成複合物 4。複合物 2 與複合物 4 之間的相關性得到了 X 射線和傅立葉紅外分析的支持。最後，通過使用 UV-Vis 和 FT-IR 光譜的觀察，我們確定了複合物 2 是一種對氧氣和熱具有抵抗性的物種。在不同溶劑中，複合物 2 可能與 CH₃CN 發生相互作用，導致信號的變化。對複合物 4 進行光照射會在光譜中出現等吸收點，表明其光敏感性。此外，通過 $\text{MnIII}(\text{TMSPS}_3)(\text{DABCO})$ 的捕獲，已經證明複合物 4 在光照射下釋放 NO。

References:

1. C. Kupper, J. Am. Chem. Soc. 2016, 138, 25, 7888–7898.
2. A. J. Speelman, J. Am. Chem. Soc. 2018, 140, 36, 11341–11359.
3. C.-K. Chiang, J. Am. Chem. Soc. 2020, 142, 19, 8649–8661



Synthesis of Bis(biaryl)bipyrazolo[1,5-a]pyridines via C–H Bond

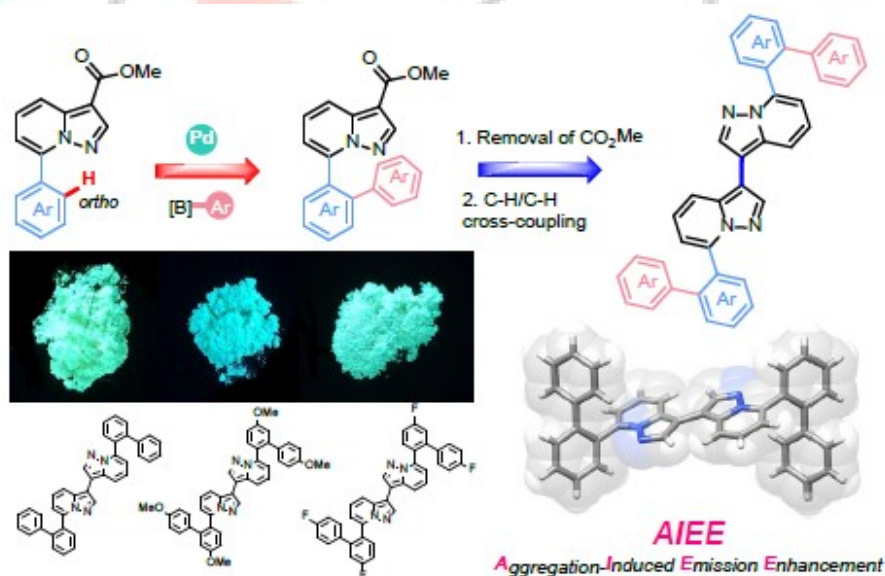
Activation as Aggregation-Induced Emission Enhancement Luminogens

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via palladium-catalyzed C–H bond, aggregation-induced emission enhancement (AIEE) effect

A series of 7,7'-bis(biaryl)-3,3'-bipyrazolo[1,5-a]pyridines via palladium-catalyzed C–H bond activation/arylation of 7-arylpyrazolo[1,5-a]pyridines. These compounds' photophysical properties, including fluorescence quantum yield, were measured to show a good aggregation-induced emission enhancement (AIEE) effect.



References:

1. Hsiao, P.-Y.; Chu, J.-H. Chem. Commun. 2021, 57, 12281-12284.
2. Hsiao, P.-Y.; Chang, R.; Sue, A. C.-H.; Chu, J.-H.; Lee, Y.-H.; Huang, J.-Y. J. Org. Chem. 2022, 87, 9851-9863.
3. Wu, H.-C.; Chu, J.-H.; Li, C.-W.; Hwang, L.-C.; Wu, M.-J. Organometallics 2016, 35, 288-300.

Palladium-Mediated C-H Bond Activation/Arylation of Dibenzosuberone and Mechanistic Investigation

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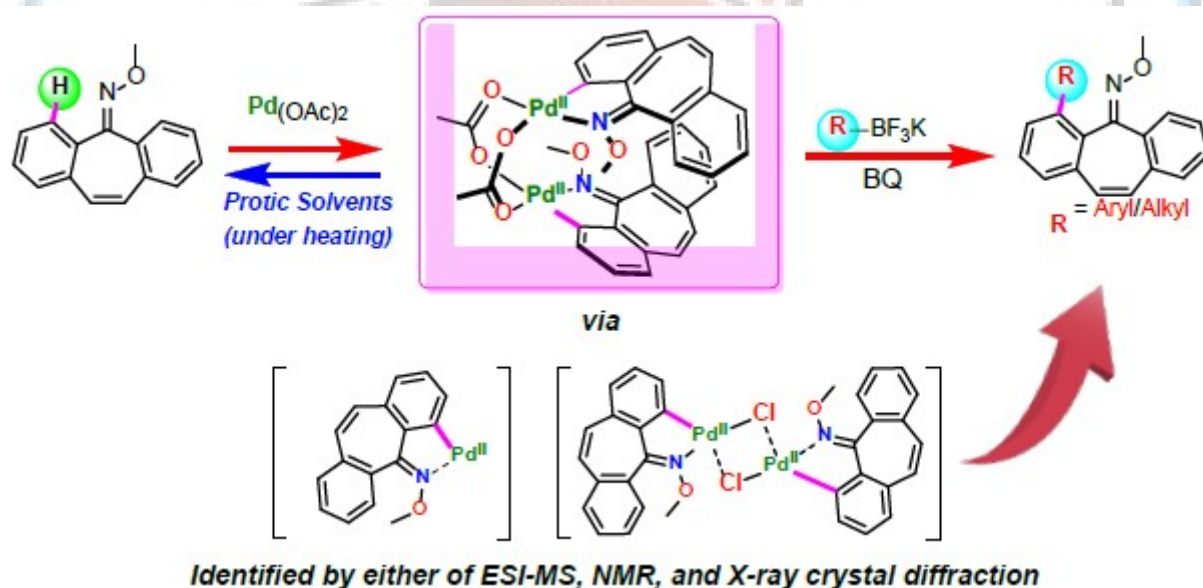
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Keywords: Dibenzosuberone; C(sp²)-H bond activation; Reaction mechanism; Key intermediates.

In this work, methoxyimine was utilized as a directing group to assist in the palladium-mediated *ortho* C(sp²)-H bond activation and arylation/alkylation of dibenzosuberone, leading to the formation of 1-arylated/alkylated dibenzosuberones. The reaction mechanism was insightfully investigated through controlled experiments, kinetic isotope effect experiments, ESI mass detections, and the identification of key intermediates. The structure of key intermediates was finally elucidated by X-ray crystallography.



References:

1. Chen, S.-Y.; Lin, Z.-X.; Chang, R.; Lin, C.-W.; Shen, L.-C.; Sue, A. C.-H.; Tseng, M.-C.; Chu, J.-H.* J. Org. Chem. 2023, 88, 8441-8453.
2. Chu, J.-H.*; Su, Z.-H.; Yen, K.-W.; Chien, H.-I. Organometallics 2020, 39, 3168-3179.
3. Chan, C.-W.; Zhou, Z.; Chan, A.-S.-C.; Yu, W.-Y.* Org. Lett. 2010, 12, 3926-3929.

Synthesis, Photophysical Measurement, and Aggregation-Induced Emission-Induced

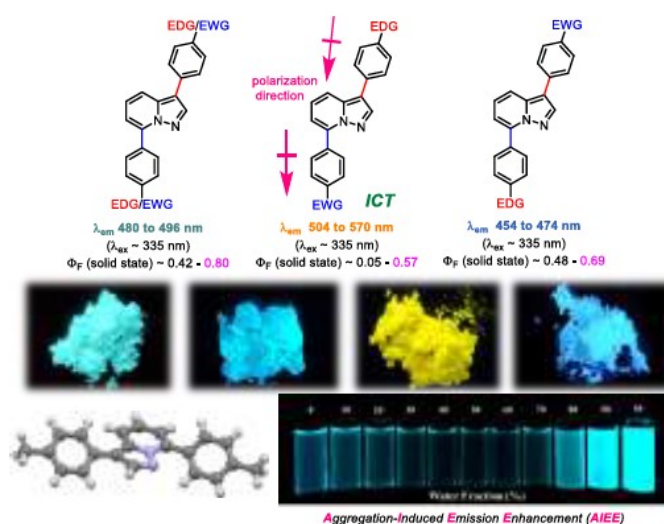
Emission Enhancement Investigation of Novel 3,7-Diarylpyrazolo[1,5-a]pyridine Luminogens

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Aggregation-Induced Emission Enhancement Investigation · C–H bond activation

This study explores the selective C – H bond activation and subsequent arylation using a palladium(II) catalyst. A range of 3,7-diaryl-substituted pyrazolo[1,5-a]pyridine molecules was synthesized directly from parental pyrazolo[1,5-a]pyridine, exhibiting intriguing aggregation-induced emission enhancement (AIEE) properties. Their luminescent characteristics were thoroughly investigated through comprehensive photophysical measurements and detailed analysis of X-ray structural stacking. The molecular absorption and emission wavelengths can be finely tuned by introducing electron-donating or electron-withdrawing groups, leading to changes in the HOMOLUMO energy levels. Furthermore, the study delves into the solid-state luminescence and charge transfer properties in various solvents. The series of molecules exhibit a remarkable solid-state fluorescence quantum yield, reaching a maximum of 0.80.



References:

1. Hsiao, P. Y.; Chu, J. H.* Chem. Commun. 2021, 57, 12281-12284.
2. Wu, H.-C.; Chu, J.-H.*; Li, C.-W.; Hwang, L.-C.; Wu, M.-J.* Organometallics 2016, 35, 288-300.

Performance Enhancement of Blue Light-Emitting Diodes with Double Hole Transport Layers

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Key Word-- Blue light-emitting diodes, double-layer hole injections

Abstract: Quantum dot light-emitting diodes (QLEDs) is a promising candidate of new generation for flat-panel displays for its bright and saturated emission colors. In the experiment, the effect of double hole transport layers (HTLs) consisting of poly-TPD and TFB on the performance of blue QLEDs was demonstrated. Compared to the QLED with single hole injection layer of poly-TPD, the QLED with double HTLs was with a turn-on voltage of 3.0 V, a maximum brightness of 111000 cd/m² and current efficiency of 9.42cd/A.

Introduction

As a potential light-emitting technology, merits of high-efficiency and high-reliability of inorganic CdSe/ZnS quantum dots for electrically-pumping light-emitting diodes are very promising to replace the currently used liquid-crystal display (LCD) and organic light-emitting diode (OLED). Due to the high bandgap of CdSe/ZnS QDs for blue light emission, it is still very difficult to find a suitable hole transport material to effectively reduce the energy barrier for holes to inject into the QDs, and further achieve the charge balance. As a result, the reported blue QLEDs were typically with worse performance when compared with their green and red counterparts. The current QLED architecture is composed of QD (the emission layer) sandwiched between the MgZnO electron transport layer (ETL) and the hole transport layer (HTL), which can promote carriers to inject into QD for efficient light emission [1]. In this study, the QLED with double HTLs of poly(N,N'-bis-4-butylphenyl-N,N'-bisphenyl)benzidine (poly-TPD) and poly(9,9-dioctylfluorene-alt-N-(4-sec-butylphenyl)-diphenylamine) (TFB) was fabricated and compared to the reference-device with single HTL of poly-TPD. As demonstrated, the QLED with double HTL was with a turn-on voltage of 3.0 V, a maximum brightness of 111000 cd/m², and current efficiency of 9.42 cd/A.

Experiments

Firstly, the chemical-composition gradient CdSe@CdZnSeS/ZnS QD powder was obtained from Taiwan Nanocrystals Inc. Accordingly, the synthesis was similar to a previously reported protocol [2]. With mixed ligands of oleic acid (OA) and trioctylphosphine (TOP) capping, the QD powder was readily dispersed in the octane in a concentration of 12 mg/mL before device fabrication. The fine MgZnO nanoparticles (NPs) were synthesized by the sol-gel method as previously reported [3]. The synthesized

MgZnO NPs were finally dispersed in absolute ethanol in a concentration of 15 mg/mL. The hole-injecting poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS), hole transporting poly-TPD and TFB were purchased from Lumtec and American Dye Source, respectively. To make double HTL, poly-TPD and TFB were dissolved in orthogonal solvents, chlorobenzene and toluene, respectively. In device fabrication, patterned indium tin oxide (ITO)-glass substrates were sequentially cleaned by detergent, acetone, isopropyl alcohol, and de-ionized water, respectively. The substrates were then UV-ozone treated for 25 minutes to remove any cleaning agent residues and to modify the work function of ITO. PEDOT:PSS, poly-TPD, and TFB were spin-coated on the substrates at different speed. QD solution was then coated as the emission layer and MgZnO NPs was the ETL, respectively. Finally, the substrates were baked at 110 °C in a nitrogen-filled oven and then transferred to a thermal evaporator to deposit Ag cathodes with a thickness of 120 nm.

Experiments

The luminance-current density-voltage (L - J - V) characteristics of the blue QLEDs are shown in Fig. 1(a) and Fig. 1(b) shows the current efficiency as a function of the injected current density. Additionally, a device with QD blended with TFB in toluene was fabricated and compared. The fabricated device structures were listed in Table 1. The addition of TFB as the second HTL or in the emission layer can increase the turn-on voltage. However, the improved hole injection due to the second TFB HTL can effectively balance the charge in the QD to achieve higher efficiency, as shown in Fig. 1(b). It should be mentioned that the device with mixed QD and TFB has the worst performance, possibly due to the poor dispersibility of QD in toluene. Overall, the QLED with double HTL was with a turn-on voltage of 3.0V, a maximum brightness of 111000 cd/m², and current efficiency of 9.42 cd/A, surpassing the maximum brightness (65477 cd/m²) and efficiency (4.92 cd/A) of the device with single HTL.

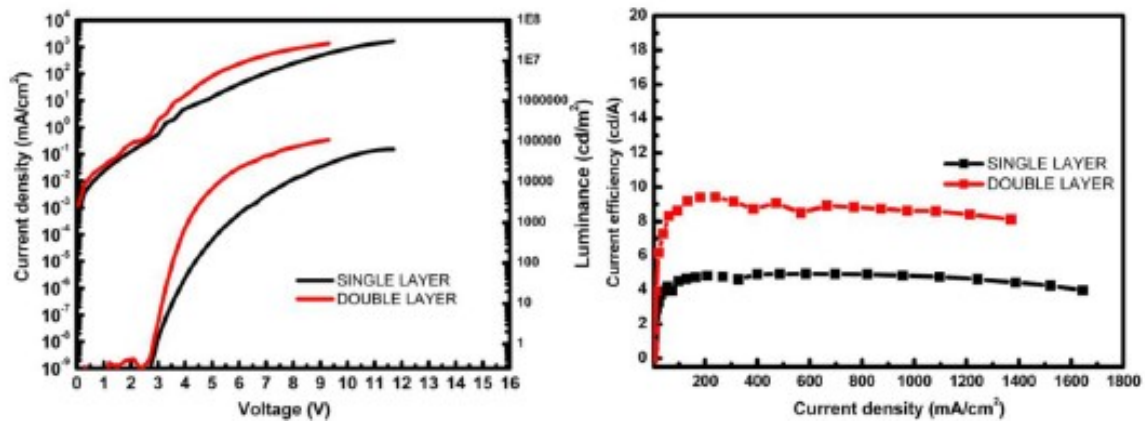


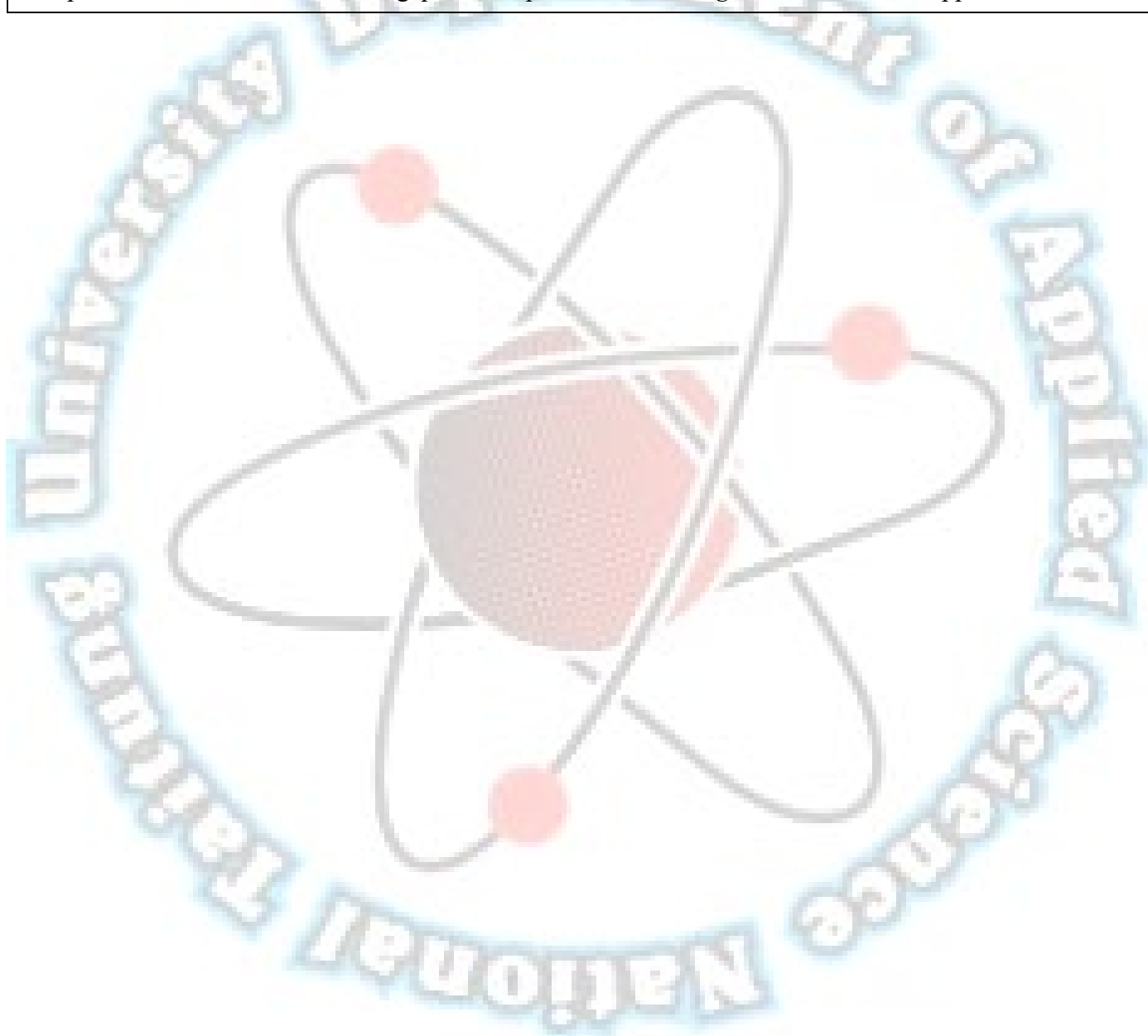
Fig. 1. (a) L - J - V and (b) current efficiency-current density curves of the blue QLEDs.

Table 1. The structure and device performance of QLEDs.

Structure	L_{max} (cd/m ²)	CE (cd/A)
Single layer: ITO/PEDOT/TFB/1025B-QD/MgZnO/Ag	65477	4.92
Double layer: ITO/PEDOT/p-TPD/TFB/1025B-QD/MgZnO/Ag	111000	9.42

References

- [1] F. Wang, W. Sun, P. Liu, Z. Wang, J. Zhang, J. Wei, Y. Li, T. Hayat, A. Alsaedi, and Z. Tan, "Achieving Balanced Charge Injection of Blue Quantum Dot Light-Emitting Diodes through Transport Layer Doping Strategies," *J. Phys. Chem. Lett.* 2019 10 (5), 960-965.
- [2] H. Y. Liu, W. Y. Su, C. J. Chang, S. Y. Lin, and C. Y. Huang, "Van der Waals epitaxy of thin gold films on 2D material surfaces for transparent electrodes: all-solution-processed quantum dot light-emitting diodes on flexible substrates," *ACS Appl. Mater. Interfaces*, vol. 14, pp. 36855–36863.
- [3] C. Y. Huang and J. H. Lai, "Efficient polymer light-emitting diodes with ZnO nanoparticles and interpretation of observed sub-bandgap turn-on phenomenon," *Org. Electron.*, vol. 32, pp. 244-249, 2016.



以 PEDOT:PSS 優化 PNIPAM 製作導電性水凝膠

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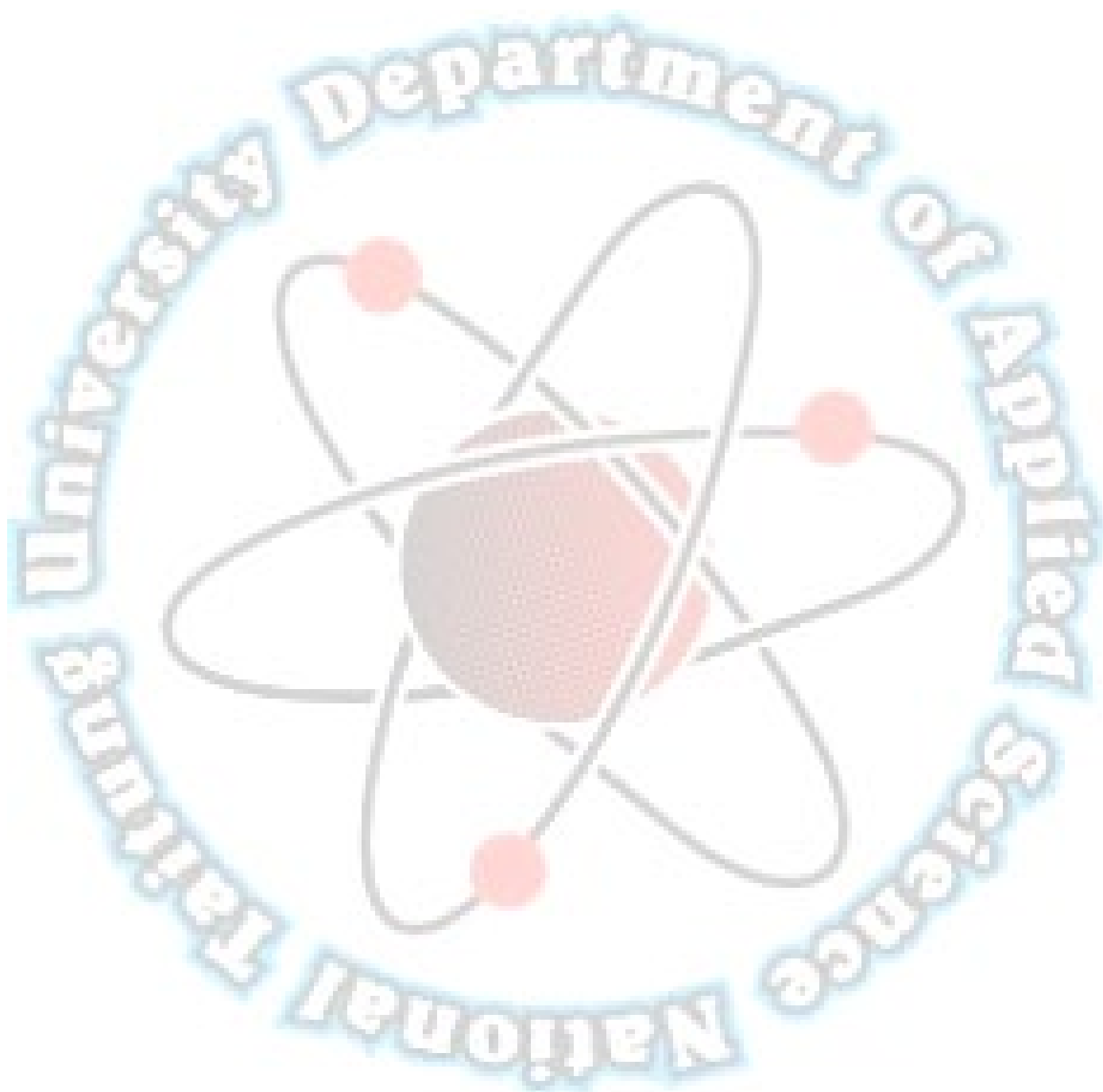
Keywords: PNIPAM, PEDOT:PSS, MoS₂, CoFe₂O₄,

響應性聚合物如：聚(N-異丙基丙烯酰胺)(PNIPAM)，可以在膨脹和塌陷狀態之間改變其分子構型，導致體積變化。當溫度低於/高於其較低臨界溶液溫度(LCST)(約 32°C)時，PNIPAM 會膨脹/塌陷。我們同時研究 MoS₂ 晶格結構特性以提升金屬性使材料具備導電性質。由本實驗室的經驗得知，我們的智慧開關電阻值太高，我們將使用 PEDOT:PSS 來優化高電阻值問題。

References:

- [1] Jiawei Liu, Jiahui Liu, Feiyang Ma, and Jiguang Liu. "Smart Conducting PANI/P(St-NIPAM) Particles and Their Switchable Conductivity" ACS Applied Polymer Materials 2019 1 (2), 152-159
- [2] Enas M.Ahmed. "Hydrogel: Preparation, characterization, and applications: A review" Journal of Advanced Research, Volume 6, Issue 2, March 2015, Pages 105-121
- [3] Lian-Hua Fu, Chao Qi, Ming-Guo Ma and Pengbo Wan. "Multifunctional cellulose-based hydrogels for biomedical applications" Journal of Materials Chemistry B, 2019, 7, 1541-1562
- [4] Deepika Gupta, Vishnu Chauhan, Rajesh Kumar. "A comprehensive review on synthesis and applications of molybdenum disulfide (MoS₂) material: Past and recent developments" Inorganic Chemistry Communications, Volume 121, November 2020, 108200
- [5] Zhidong Pan, Yanmin Wang, Huining Huang, Zhiyuan Ling, Yonggang Dai, Shanjun Ke. "Recent development on preparation of ceramic inks in ink-jet printing" Ceramics International. Volume 41, Issue 10, Part A, December 2015, Pages 12515-12528
- [6] Jun Zhou, Xiangfeng Shu, Yueqin Wang, Jialin Ma, Yin Liu, Ruiwen Shu, Lingbing Kong. "Enhanced microwave absorption properties of (1-x)CoFe₂O₄/xCoFe composites at multiple frequency bands" Journal of Magnetism and Magnetic Materials Volume 493, 1 January 2020, 165699
- [7] Fahad Alhashmi Alamer, Khalid Althagafy, Omar Alsalmi, Asal Aldeih, Hissah Alotaiby, Manal Althebaiti, Haifa Alghamdi, Najlaa Alotibi, Ahmad Saeedi, Yusra Zabarmawi, Mohammed Hawsawi, and Modhi A. Alnefaie "Review on PEDOT:PSS-Based Conductive Fabric" ACS Omega 2022, 7, 40, 35371–35386
- [8] Yao, Y., Ao, K., Lv, P., & Wei, Q. (2019). "MoS₂ coexisting in 1T and 2H

phases synthesized by common hydrothermal method for hydrogen evolution reaction.” *Nanomaterials*, 9(6), 844.



有機小分子和寡合物螢光材料在白光發光二極體的應用

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Keywords: light emitting diodes、organic materials、spin coating、solution process

Text

有機發光二極體(OLED)由簡潔的三明治結構組成(陽極/電洞注入層/發光層/電子注入層/陰極)，可透過熱蒸鍍、旋轉塗佈等薄膜沉積技術進行低成本加工，能夠輕易製造輕量、大面積、柔性和透明的發光裝置，在現今的顯示技術中佔有一席之地。其中，白光照明在日常生活中隨處可見，如街道上的路燈或是桌面上的檯燈。白光有機發光二極體(WOLED)可透過光的三原色(紅、藍、綠)或是兩互補色(藍、黃)的材料在裝置內部的發光層進行混光獲得。本研究使用寡合物 HFSO 和小分子材料 Alq3，以全溶液製程的方式，製作出簡易且高效的白光有機發光二極體，亮度和電流效率最高可達 12343cd/m² 及 1.5cd/A。此外，也在本文探討在實驗過程中，旋轉塗佈對元件製作的影響。

References:

1. Farinola, G. M., & Ragni, R. (2011). Electroluminescent materials for white organic light emitting diodes. *Chemical Society Reviews*, 40(7), 3467-3482.
2. Li, Y., Wu, H., Zou, J., Ying, L., Yang, W., & Cao, Y. (2009). Enhancement of spectral stability and efficiency on blue light-emitters via introducing dibenzothiophene-S, S-dioxide isomers into polyfluorene backbone. *Organic Electronics*, 10(5), 901-909.
3. 有機電機光顯示器之光電分析技術【台灣儀器科技研究中心】

製作氧化亞銅/備長炭/線性低密度聚乙烯之三相複合保鮮膜並用於食材 抗菌保鮮

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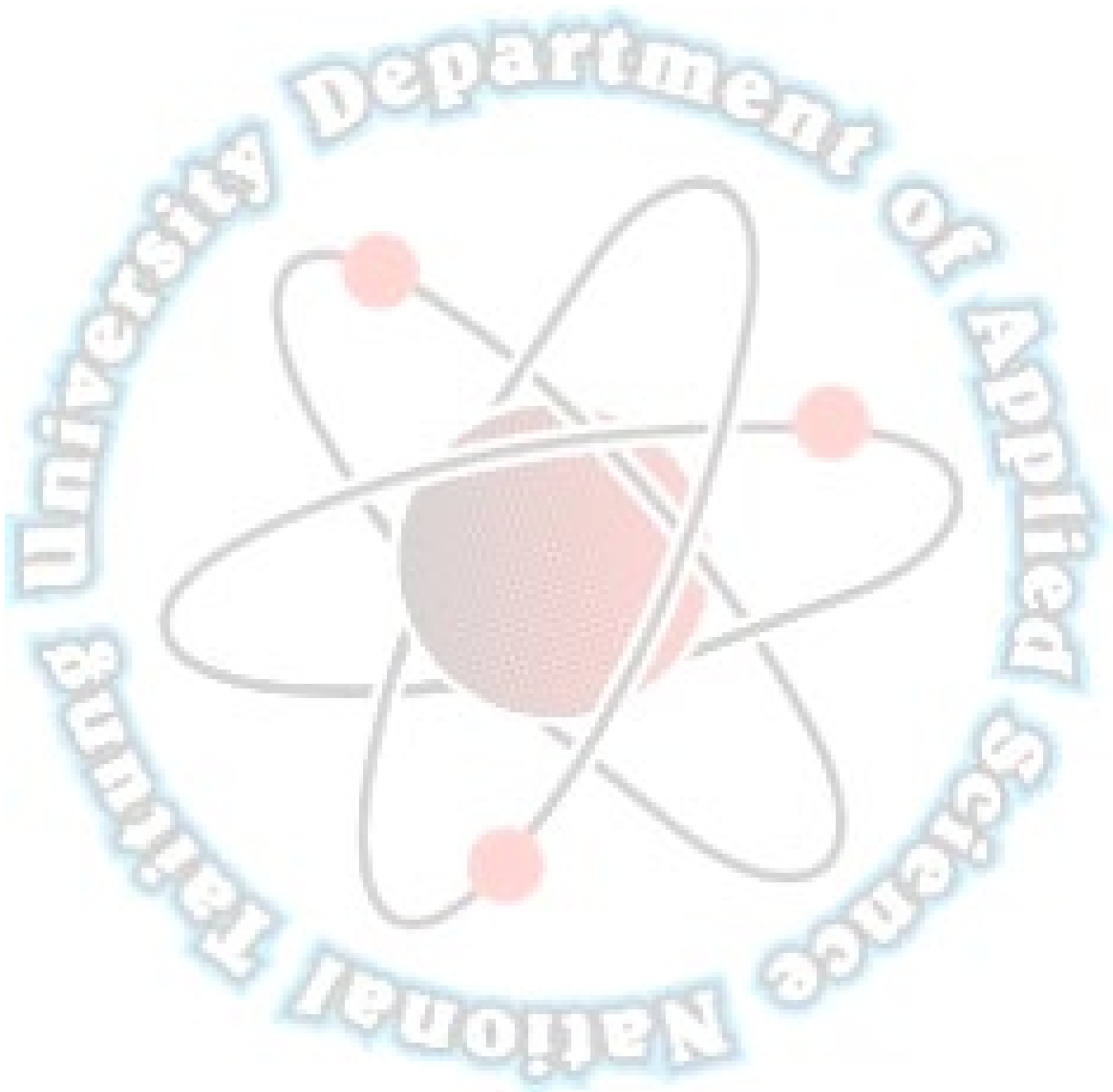
Keywords: Cu₂O ; White charcoal ; LLDPE ; Preservation and antibacterial

隨著科技的日新月異，人們對身體的健康也相對越來越受到重視，食品的衛生與身體的健康息息相關，如何減少食品上的細菌也成為重要的課題。據報告統計顯示，氧化亞銅(Cu₂O)的奈米粒子能夠有效殺死細菌與微生物，備長炭粉末具有防潮防濕、除臭淨化、過濾雜質等等…眾多優異功能。

本實驗透過Cu₂O 奈米粒子、備長炭粉末與線性低密度聚乙烯(LLDPE)複合，用熔融的方式合成出5wt% Cu₂O、3wt% 備長炭之複合材料，並透過檢測菌數殘存的多寡，發現在食材的包覆上，能夠有效的抑制大腸桿菌與金黃色葡萄球菌的產生。以結果來說，對於往後發展，做成保鮮膜與塑膠袋等等生活用品，都能夠達到抗菌、保濕、淨化等等的多種效果，提升生活品質與生活的健康。

References:

- [1]國立科學工藝博物院 奈米材料製作
- [2]Jia Ren, Wenzhong Wang, Songmei Sun, Ling Zhang, Lu Wang, and Jiang Chang, Crystallography Facet-Dependent Antibacterial Activity: The Case of Cu₂O, ACS, 2011, 50(17), 10366-10369.
- [3]C.H.Chia, S.D.Joseph, A.Rawal, R.Linser, J.M.Hookb P.Munroe, Microstructural characterization of white charcoal, Journal of Analytical and Applied Pyrolysis, Volume 109, September 2014, Pages 215-221
- [4] X.M Zhang, S Elkoun, A Ajji, M.A Huneault, Oriented structure and anisotropy properties of polymer blown films: HDPE, LLDPE and LDPE, Polymer, Volume 45, Issue 1, January 2004, Pages 217-229
- [5]D.S.Achilias, C.Roupakias, P.Megalokononimos, A.A.Lappas, E.V.Antonakou, Chemical recycling of plastic wastes made from polyethylene (LDPE and HDPE) and polypropylene (pp), ScienceDirect, 2007, 149(3), 536-542
- [6]Dedy Hariadi, Sofyan M.Saleh, R.Anwar Yamin, Sri Aprilia, Utilization of LDPE plastic waste on the



Development of High Stability TBAI-CsPbI₃ Quantum Dot Thin Film

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Keywords: Quantum Dots, Perovskite, Tetrabutylammonium iodide, High Stability

本研究選用高溫注入的方式來合CsPbI₃鈣鈦礦量子點(Perovskite Quantum Dots, PQDs)，因為PQDs使用有機溶劑提供膠體合成和加工將晶粒生長與薄膜沉積分離。具有可調能隙(Energy Gap)與良好的光吸收特性，並且不存在有機成分揮發性而增強了穩定性。但在CsPbI₃ QDs中，由於在室溫下的低形成能、高度不穩定的離子結構和熱力學不穩定性，在合成過程中很容易隨著純化和薄膜製備過程中封端配體的去除形成碘空缺(V_I)。因此，為了提高CsPbI₃ QDs的穩定性，需要製備低V_I缺陷密度的CsPbI₃ QDs且在配體交換過程中，常用的長鏈配體油酸(Oleic Acid, OA)和油胺(Oleylamine, OAm)會導致QDs表面裸露，使QDs薄膜易受水分滲透的影響。為了改善CsPbI₃ QDs在水、極性溶劑、氧、熱的穩定性，將尋找具有更大表面鍵合強度的有機配體在PQD合成中替代OA-OAm對將有利於提高QDs純化和在周圍環境中的穩定性。

本研究利用Cs₂CO₃、PbI₂粉末及OA、OAm、1-octadecene等溶劑，並利用離心機及真空幫浦成功製備出高品質的量子點粉末，再利用辛烷當作量子點粉末的分散劑。並且為了解決CsPbI₃ QDs在水、氧以及極性溶劑環境中容易產生相變的問題，本研究利用四丁基碘化銨(Tetra-n-butylammonium iodide, TBAI)來輔助原本的OA-OAm有機配體，增強在水中的穩定性;同時，也可以填補合成中形成的碘空缺(V_I)。

References: (Times New Roman/標楷體, Single space, 10 point, ACS style, left- justified in numbered order)

1. Wang, Y.; Jia, B.; Wang, J.; Xue, P.; Xiao, Y.; Li, T.; Wang, J.; Lu, H.; Tang, Z.; Lu, X. High-Efficiency Perovskite Quantum Dot Hybrid Nonfullerene Organic Solar Cells with Near-Zero Driving Force. *Adv. Mater.* 2020, 32, 2002066.
2. Wheeler, Lance M., et al. "Targeted ligand-exchange chemistry on cesium lead halide perovskite quantum dots for high-efficiency photovoltaics." *Journal of the American Chemical Society* 140.33 (2018): 10504-10513.
3. Straus, Daniel B., Shu Guo, and Robert J. Cava. "Kinetically stable single crystals of perovskite-phase CsPbI₃." *Journal of the American Chemical Society* 141.29 (2019): 11435-11439.

利用陽極氧化法製備 TiO₂ 奈米管複合 CdSe-ZnS 量子點於可見光下光催化降解亞甲基藍染劑

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Anodizing TiO₂ nanotube; CdSe/ZnS; Methylene Blue degradation

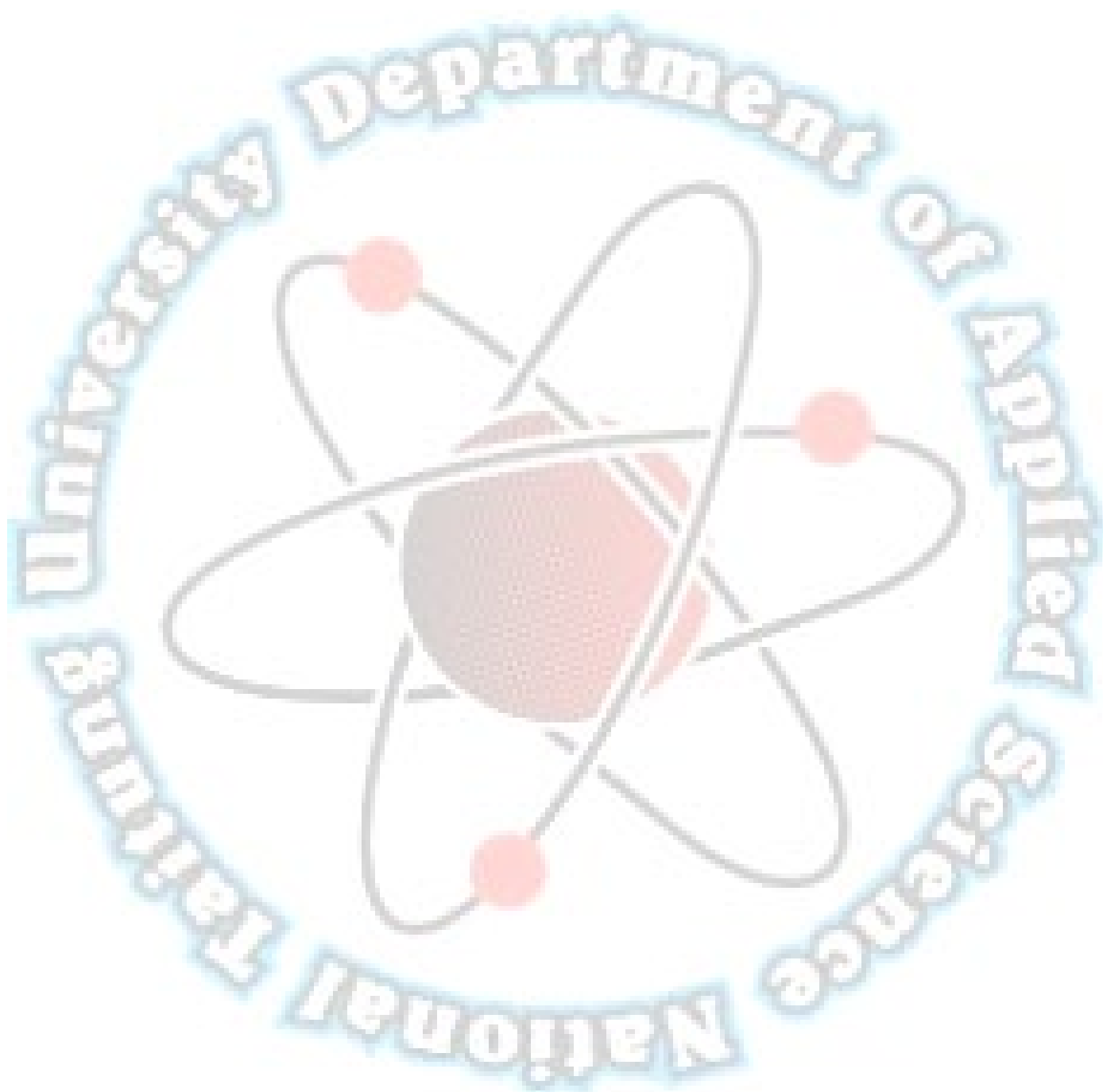
本研究利用一維管狀結構的 TiO₂ 奈米管為光催化劑。TiO₂ 奈米管具有高度定向性、穩定的結構、大內部表面積，以及優越的電子通道，可在界面之間進行向量式電荷轉移。本研究將 CdSe-ZnS 量子點複合 TiO₂ 奈米管上，改變其能隙大小，使 TiO₂ 奈米管可以有效的在可見光下激發電子電洞對，將亞甲基藍染劑降解。

本研究討論了低含量到高含量的 CdSe-ZnS 量子點對降解效率的影響，可以歸納出幾個特性。TiO₂ 奈米管與 CdSe-ZnS 量子點用不同熱處理溫度複合後，透過 UV-vis 測量出 60°C 具有良好的降解效果，若溫度再往上升，會使 CdSe-ZnS 量子點活性下降，進而影響降解效率。所以本研究將針對 60°C 熱處理溫度去做進一步的研究。

References:

1. Mohd. Rafatullah; Othman Sulaiman ; Rokiah HashimAnees Ahmad .Adsorption of methylene blue on low-cost adsorbents: A review. Received 25 June 2009, Revised 23 October 2009, Accepted 8 December 2009, Available online 16 December 2009
2. Tonni Agustiono Kurniawan;Zhu Mengting; Dun Fu;Swee Keong Yeap;Mohd Hafiz Dzarfan Othman; Ram Avtar ; Tong Ouyang.Functionalizing TiO₂ with graphene oxide for enhancing photocatalytic degradation of methylene blue (MB) in contaminated wastewater. Received 22 November 2019, Revised 15 April 2020, Accepted 27 May 2020, Available online 17 June 2020, Version of Record 17 June 2020.
3. Nakata, K.; Kagawa, T.; Sakai, M.; Liu, S.; Ochiai, T.; Sakai, H.; Murakami, T.; Abe, M.; Fujishima, A. Preparation and Photocatalytic Activity of Robust Titania Monoliths for Water Remediation. ACS Appl. Mater. Interfaces 2013, 5, 500–504.
4. Rioult, M.; Magnan, H.; Stanescu, D.; Barbier, A. Single Crystalline Hematite Films for Solar Water Splitting: Ti-Doping and Thickness Effects. J. Phys. Chem. C 2014, 118, 3007–3014.\
5. Ives, M. B.; Luo, J. L.; Rodda, J. R. Passivity of Metals and Semiconductors: proceedings of the Eighth International Symposium Pennington, NJ : Electrochemical Society. 2001.
6. Hirakawa, T.; Nosaka, Y. Properties of O₂ – · and OH· formed in TiO₂ aqueous suspensions by photocatalytic reaction and the influence of H₂O₂ and some ions. Langmuir 2002, 18, 3247–3254.

7. Xuemei Zhou, Ning Liu, and Patrik Schmuki . Photocatalysis with TiO₂ Nanotubes: “Colorful” Reactivity and Designing Site-Specific Photocatalytic Centers into TiO₂ Nanotubes. ACS Catalysis 2017, 7 (5) , 3210-3235



Preparation of nitrogen-doped graphene aerogel composite

CoFe₂O₄ for Rhodamine B degradation

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nitrogen-doped graphene aerogel; CoFe₂O₄; Rhodamine B degradation

本研究利用三維材料石墨烯氣凝膠當作基底。石墨烯有著高機械強度、高比表面積和化學穩定性等特性，且能合成氣凝膠態。本專題結合了石墨烯氣凝膠的三維多孔性互連結構與氮摻雜優異的電催化活性，並再複合上磁性材料 CoFe₂O₄；CoFe₂O₄ 屬於尖晶石型鐵氧體，其比表面積大、催化活性高、晶體結構穩定，再加上石墨烯氣凝膠較大的比表面積與導電性，能有效地增加 CoFe₂O₄ 接觸羅丹名 B 水溶液的面積，大大降低降解所需的時間。本研究利用水熱法合成摻氮石墨烯氣凝膠複合 CoFe₂O₄，使用 SEM 拍攝及在實驗中的觀察，再透過 UV-vis 測量出 170°C 有很好的降解效率，大約在 8 分鐘就完全將羅丹名 B 降解完畢，雖然 160°C 從 SEM 上來看有很好的孔洞性，但實際降解時的機械強度沒有 170°C 來的堅固，所以本實驗較針對 170°C 來進行進一步的研究。

References:

1. Dongdong Liu, Dengqian Chen, Zhengkai Hao, Yibo Tang, Lipeng Jiang, Tianqi Li, Bing Tian, Cuiping Yan, Yuan Luo , Boyin Jia . (2022). Efficient degradation of Rhodamine B in water by CoFe₂O₄/H₂O₂ and CoFe₂O₄/PMS systems: A comparative study. Chemosphere, 307, 135935.
2. Zi, Z., Sun, Y., Zhu, X., Yang, Z., Dai, J., & Song, W. (2009). Synthesis and magnetic properties of CoFe₂O₄ ferrite nanoparticles. Journal of Magnetism and Magnetic Materials, 321(9), 1251-1255
3. Chen, Y., Jiang, Y., Liu, Z., Yang, L., Du, Q., & Zhuo, K. (2021). Hierarchical porous N-doped graphene aerogel with good wettability for high-performance ionic liquid-based supercapacitors. Electrochimica Acta, 366, 137414.
4. Wang, J., Duan, X., Dong, Q., Meng, F., Tan, X., Liu, S., & Wang, S. (2019). Facile synthesis of N-doped 3D graphene aerogel and its excellent performance in catalytic degradation of antibiotic contaminants in water. Carbon, 144, 781-790.

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