115 年度國立臺北科技大學暨學術合作夥伴聯合成果發表會

時　　間：115 年 6 月 2 日（二）9:00–16:00

地　　點：國立臺北科技大學億光大樓 3 樓

艾爾法廳(301)、西格瑪廳(303)、 岱爾達廳(304)

主辦單位：國立臺北科技大學

協辦單位：馬偕紀念醫院、振興醫院、新北市立土城醫院、萬芳醫院、北京工業大學、深圳大學、泰國先皇技術學院、泰國法政大學、泰國蒙庫國王科技大學、馬來亞大學、日本東北大學、波蘭格但斯克科技大學、布拉格捷克理工大學、立陶宛威爾紐斯科技大學、立陶宛威爾紐斯大學、美國紐澤西理工學院、美國辛辛那提大學、美國賓州州立大學

115 年度國立臺北科技大學暨學術合作夥伴聯合成果發表會

活動時間

115 年 6 月 2 日（星期二）

主會場

國立臺北科技大學億光大樓 3 樓艾爾法廳(301)

09:00-09:30	報 到	
09:30	發表會開始/開幕式（統一在艾爾法廳 301）	
09:30-10:00	長官致詞 國立臺北科技大學-白敦文副校長 國立臺北科技大學-鍾仁傑研發長 馬偕紀念醫院-張文瀚院長 振興醫院-陳思甫部主任 新北市立土城醫院-曾元昀主席 臺北市立萬芳醫院- 江振源研發副院長 合影留念	
10:10-11:30	海報競賽（艾爾法廳 301）	B-1、C-1 場次演講
11:30-13:00	**午 餐**	
13:00-14:00	海報競賽（艾爾法廳 301）	B-2、C-2 場次演講
14:00-14:15	**中 場 休 息**	
14:15-15:15	B-3、C-3 場次演講	
15:15-15:30	**中 場 休 息**	
15:30-16:00	閉幕式、海報競賽頒獎（統一在艾爾法廳 301）	

A 場次活動地點：國立臺北科技大學億光大樓 3 樓艾爾法廳(301)

09:00-09:30	報 到
09:30	發表會開始/開幕式
09:30-10:00	長官致詞 國立臺北科技大學-白敦文副校長 國立臺北科技大學-鍾仁傑研發長 馬偕紀念醫院-張文瀚院長 振興醫院-陳思甫部主任 新北市立土城醫院-曾元昀主席 萬芳醫院-江振源研發副院長 合影留念
10:00-10:10	**中 場 休 息**
10:10-11:30	海報競賽 評審 馬偕紀念醫院 李勝祥研究員 國立臺北科技大學 孫勤昱助理教授
11:30-13:00	**午　　餐**
13:00-15:15	海報競賽 評審 萬芳醫院 姚智榮行政副主任 國立臺北科技大學 陳錦文副教授
15:15-15:30	**中 場 休 息**
15:30-16:00	海報競賽頒獎、閉幕式

B 場次活動地點：國立臺北科技大學億光大樓 3 樓西格瑪廳(303)

時間		發表名稱	主持人	報告者
B-1　主持人：馬偕紀念醫院 黃昌弘技術主任				
10:10-10:40	1	聚麩胺酸/二氧化矽有機無機橋接材料之研發與生醫應用	臺北科技大學–鍾仁傑特聘教授 馬偕紀念醫院–王慧媛主治醫師	臺北科技大學 鍾仁傑特聘教授
10:40-10:50	**中 場 休 息**			
10:50-11:20	2	透過人工智慧技術分析睡眠中心病患之過往病歷資料以探索影響睡眠之相關因素	臺北科技大學–鄭麗珍教授 新北市立土城醫院 –沈世閔主治醫師	臺北科技大學 鄭麗珍教授
11:30-13:00	**午　　餐**			
B-2　主持人：萬芳醫院 陳杰峰主治醫生				
13:00-13:30	3	開發具提示注入緩解功能的強化學習式乳癌重建 AI 決策輔助系統之研究	臺北科技大學–孫勤昱助理教授 萬芳醫院–陳杰峰主治醫生	萬芳醫院 陳杰峰主治醫生
13:30-14:00	4	以低玻璃轉移溫度聚合物製備光滑注液的多孔表面塗層應用於體外循環管路之研究	臺北科技大學–郭志宇副教授 振興醫院–陳柏菘主治醫師	臺北科技大學 郭志宇副教授
14:00-14:15	**中 場 休 息**			
B-3　主持人：國立臺北科技大學 郭志宇副教授				
14:15-14:45	5	磷酸鈷和磷酸鐵鈷催化劑在析氧反應中質子耦合電子轉移的反應機制	臺北科技大學–張裕煦教授 泰國先皇技術學院 –Tawan Sooknoi 教授	臺北科技大學 張裕煦教授
14:45-15:15	6	開發有機金屬框架 Mg-MOF-74/CuCl2 奈米複合材料應用於自供電濕度感測器	臺北科技大學–曾釋鋒教授 泰國法政大學–許舒涵助理教授	臺北科技大學 曾釋鋒教授
15:30-16:00	**海報競賽頒獎、閉幕式（統一在艾爾法廳 301）**			
16:00	**賦歸**			

C 場次活動地點：國立臺北科技大學億光大樓 3 樓岱爾達廳(304)

時間		發表名稱	主持人	報告者
C-1　主持人：國立臺北科技大學 Jean-Sébastien Bénas 博士後研究員				
10:10-10:40	1	Manipulation of perovskite properties for polymeric-based photomemory and photosynaptic devices	臺北科技大學–郭霽慶特聘教授 深圳大學–周曄特聘教授	臺北科技大學 Jean-Sébastien Bénas 博士後研究員
10:40-10:50	**中 場 休 息**			
10:50-11:20	2	應用於次世代場效生物感測之設計型液晶材料	臺北科技大學–陳秀慧教授 美國賓州州立大學 - Ebrahimi, Aida 副教授	臺北科技大學 陳秀慧教授
11:30-13:00	**午　　餐**			
C-2　主持人：國立臺北科技大學 邱德威特聘教授				
13:00-13:30	3	雜原子摻雜二維 MXene 結合銅赤銅鐵礦複合氧化物用於甲醇蒸汽重組及水分解製氫	臺北科技大學–邱德威特聘教授 日本東北大學–殷澍教授	臺北科技大學 邱德威特聘教授
13:30-14:00	4	新型低成本 ZIF-8 與二異丙基乙基銨基離子液體複合材料用於高容量儲氫	臺北科技大學–狄雅南副教授 泰國蒙庫國王科技大學 –Jatupon Chaiwasu 教授	臺北科技大學 狄雅南副教授
14:00-14:15	**中 場 休 息**			
C-3　主持人：國立臺北科技大學 陳紅章助理教授				
14:15-14:45	5	設計可解釋的機器學習方法來評估 3D 列印不同晶格結構對疲勞反應的影響	臺北科技大學–江卓培特聘教授 波蘭格但斯克科技大學 –Wojciech Macek 教授	Chinmai Bhat 研究助理教授
14:45-15:15	6	使用嵌套格子結構開發可解釋機器學習模型用以優化冷卻流道	臺北科技大學–陳紅章助理教授 布拉格捷克理工大學 –Libor Beránek 教授	臺北科技大學 陳紅章助理教授
15:30-16:00	**海報競賽頒獎、閉幕式（統一在艾爾法廳 301）**			
16:00	**賦歸**			

【海報競賽–上午場】

海報競賽
展示時間：115 年 6 月 2 日 (二) 10:10-11:30
展示地點：國立臺北科技大學億光大 3 樓艾爾法廳(301)

上半場評審 馬偕紀念醫院 李勝祥研究員 國立臺北科技大學 孫勤昱助理教授		
海報展示目錄		
海報編號	計畫題目	雙邊計畫主持人
1	仿蝸牛自體修復的口腔修復敷料設計：殼質蛋白/角蛋白/GelMA 複合材料	臺北科技大學–魏暘副教授 馬偕紀念醫院–林弘斌主治醫師 報告者：化工所 碩一 尤涵憶
2	聚麩胺酸/二氧化矽有機無機橋接材料之研發與生醫應用	臺北科技大學–鍾仁傑特聘教授 馬偕紀念醫院–王慧媛主治醫師 報告者：化工所 博四 Susaritha Ramanathan
3	應用機器學習方法搭配慣性感測器與捏握力數據建構台灣老年人肌少症預測模型	臺北科技大學–李育奇助理教授 馬偕紀念醫院–鄭雅心物理治療師 報告者：工管系 碩一 李彤
4	以低玻璃轉移溫度聚合物製備光滑注液的多孔表面塗層應用於體外循環管路之研究	臺北科技大學–郭志宇副教授 振興醫院–陳柏菘主治醫師 報告者：化工所 碩二 楊甯凱
5	運用電子病歷系統研究阻塞性睡眠呼吸中止症	臺北科技大學–鄭麗珍教授 新北市立土城醫院–沈世閔主治醫師 報告者：資財系 研究助理教授 李燕芬
6	透過改良修飾電極的電化學傳感器進行尿液檢體中抗癌藥物的檢測	臺北科技大學–陳生明特聘教授 新北市立土城醫院–許桓源主治醫師 報告者：化工所 碩一 吳晨禾
7	使用影像系統實現即時離床監測警示系統之建立	臺北科技大學–鍾明桉副教授 新北市立土城醫院–楊為巽主治醫師 報告者：創新所 博一 翟崧雲
8	開發具提示注入緩解功能的強化學習式乳癌重建 AI 決策輔助系統之研究	臺北科技大學–孫勤昱助理教授 萬芳醫院–陳杰峰主治醫生 報告者：資工所 碩二 陳彥宇
9	FFA-Net：面向機器視覺的快速頻率感知雷射雷達點雲壓縮	臺北科技大學–吳牧恩教授 北京工業大學–王瑾副研究員 報告者：資財系 碩一 陳相汝
10	面向多種疾病輔助診斷的眼科影像融合分析技術研究	臺北科技大學–黃有評講座教授 北京工業大學–李建强教授 報告者：電機系 博二 Redina An Fadhila Chaniago

海報編號	計畫題目	雙邊計畫主持人
11	跨文化脈絡下水災地圖視覺變量與感知機制之影響研究	臺北科技大學–鄭孟淙副教授 北京工業大學–劉鍵教授 報告者：工設系 碩二 張愛若
12	透過配體調控準二維鈣鈦礦以提升浮動閘極光電晶體記憶體穩定性	臺北科技大學–郭霽慶特聘教授 深圳大學–周曄特聘教授 報告者：高分所 碩一 高嘉陽
13	無限振盪流中外泌體黏彈性 -慣性操控機理研究	臺北科技大學–林正釧助理教授 深圳大學–闫昇助理教授 報告者：製科所 碩二 陳柏宇
14	應用非接觸式支撐策略於超薄氧化鋯牙科貼片製造之積層製造設計	臺北科技大學–江卓培特聘教授 深圳大學–陳張偉教授 報告者：製科所 碩二 許懋鈞
15	0D/2D $ZnMn_2O_4$ 奈米球/g-C_3N_4奈米片異質結構之製備及其於環境樣品中呋喃他酮電化學檢測之應用	臺北科技大學–邱德威特聘教授 泰國先皇技術學院–Vittayakorn Naratip 教授 報告者：材料所 博二 Thilak Sabareesh Malayalam Amarnath
16	鈷基催化劑在析氧反應中質子耦合電子轉移反應機制之探討	臺北科技大學–張裕煦教授 泰國先皇技術學院–Tawan Sooknoi 教授 報告者：資源所 碩一 Dang Thi Thuy Tien
17	開發永續高級氧化處理程序降解生物難分解之藥物污染物	臺北科技大學–王立邦教授 泰國法政大學–Sandhya Babel 教授 報告者：環境所 博一 陳彥甫
18	利用生物質衍生多孔碳並結合超音波耦合超臨界-CO2 方法製作先進儲能裝置之可撓性透明電極	臺北科技大學–莊賀喬特聘教授 泰國法政大學–Iamprasertkun Pawin 助理教授 報告者：工程學院 外籍生專班 (EOMP) Angelin Rubavathi Panneer Selvam
19	開發有機金屬框架 Mg-MOF-74/CuCl2 奈米複合材料應用於自供電濕度感測器	臺北科技大學–曾釋鋒教授 泰國法政大學–許舒涵助理教授 報告者：機械系 機電整合碩二 陳宥任
20	應用於優異 SERS 增強與感測技術之先進 MXene 奈米複合材料	臺北科技大學–林家弘特聘教授 泰國蒙庫國王科技大學–Cheunkar Sarawut 助理教授 報告者：光電系 碩一 曾翊宸
21	運用金屬有機骨架（MOF）複合材料，開發高效能且符合淨零排放目標之次世代氫能升級技術	臺北科技大學–狄雅南副教授 泰國蒙庫國王科技大學–Jatupon Chaiwasu 教授 報告者：化工所 碩二 Pradnya Paramitha
22	以金屬有機框架製備 MoS2/ZnSe-FeSe2 奈米複合材料應用於卵巢癌細胞 CA-125 之經濟有效即時電化學免疫感測	臺北科技大學–鍾仁傑特聘教授 馬來亞大學–Ramesh T Subramaniam 教授 報告者：化工所 博三 Mosas Vinsy Arul Thomas

仿蝸牛自體修復的口腔修復敷料設計：殼質蛋白/角蛋白/GelMA複合材料

尤涵憶[1] 林子揚[1] 鍾仁傑[1,2,*] 林弘斌[3,4,5,6,*] 魏暘[1,2,*]

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摘要

溫敏性水凝膠的使用能解決許多臨床醫療問題，角蛋白能當作天然細胞支架，促進傷口細胞的貼附和增殖。本研究萃取人類頭髮角蛋白，混合殼聚醣和β-甘油磷酸鹽(β-GP)製備溫敏性水凝膠，此水凝膠能在37°C下凝膠並具有多孔性，有利於細胞貼附，且水凝膠在添加角蛋白後，其細胞存活率皆在100%左右，顯示良好的生物相容性。本研究證實添加角蛋白的水凝膠配方有臨床應用潛力。

關鍵字：角蛋白；殼聚糖；溫敏性水凝膠。

Snail-Inspired Oral Repair Dressing Design: Conchiolin/Keratin/GelMA Composite

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Abstract

Thermosensitive hydrogels offer promising solutions to a wide range of clinical challenges. Keratin serves as a natural cellular scaffold that promotes cell adhesion and proliferation. In this study, human hair–extracted keratin was incorporated with chitosan and β-glycerophosphate (β-GP) to fabricate thermosensitive hydrogels. These hydrogels gelled at 37℃ and exhibited a porous structure, which is favorable for cell adhesion. Notably, keratin-incorporated hydrogels demonstrated approximately 100% cell viability, indicating favorable biocompatibility. These findings confirm that the incorporation of keratin improves the clinical applicability of these hydrogels.

Keywords: Keratin; Chitosan; Thermosensitive hydrogel.

聚麩胺酸/二氧化矽有機無機橋接材料之研發與生醫應用

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摘要

慢性且複雜的皮膚傷口因其多重病理生理機制，以及高度易受感染、發炎與延遲癒合的特性，長期以來仍是臨床治療上的重大挑戰。為克服上述限制，本研究設計並開發一種新世代光熱響應型複合支架，整合海藻酸鈉（SA）、生物活性玻璃（BG）與還原氧化石墨烯（rGO），在 808 nm 近紅外光（NIR）刺激下實現同步抗菌與組織再生功能。該支架策略性結合 SA 之保濕與生物相容特性、BG 之離子介導再生潛能，以及 rGO 之光熱轉換與抗菌能力，建構單一且具協同效應之多功能平台。形態學分析顯示其具有高度多孔且互相連通之網狀結構，有利於營養物質擴散與細胞浸潤。在 NIR 照射下，rGO 賦予支架可精確調控之光熱轉換特性，可產生適合促進細胞增殖與遷移的溫和熱效應（42–43℃），而較高溫度（≥50℃）則可有效殺滅細菌。體外研究證實該支架對纖維母細胞與內皮細胞具優異生物相容性，並對金黃色葡萄球菌（S. aureus）與大腸桿菌（E. coli）展現顯著抗菌效果。本研究建立一種兼具保濕癒合、光熱治療與再生刺激之多功能 NIR 活化生物支架，為加速且無感染之皮膚傷口修復提供具突破性的治療策略。

關鍵字: 光熱響應型支架；海藻酸鈉；生物活性玻璃；還原氧化石墨烯；近紅外光照射；傷口再生

Development and biomedical applications of polyglutamic acid/silica organic-inorganic hybrid materials

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Abstract

Chronic and complex skin wounds pose a persistent clinical challenge due to their multifaceted pathophysiology and high susceptibility to infection, inflammation, and delayed wound healing. To address these limitations, a next-generation photothermal-responsive composite scaffold that integrates sodium alginate (SA), bioactive glass (BG), and reduced graphene oxide (rGO) was engineered to achieve synchronized antibacterial action and tissue regeneration under 808 nm near-infrared (NIR) stimulation. The scaffold was strategically designed to harness the moist-retentive and biocompatible nature of SA, the ion-mediated regenerative potential of BG, and the photothermal and antibacterial properties of rGO within a single, synergistic platform. Morphological analysis revealed a highly porous, interconnected network enabling efficient nutrient diffusion and cell infiltration. Under NIR irradiation, rGO endowed the scaffold with precise, power-tunable photothermal conversion, achieving controlled mild hyperthermia (42-43℃) conducive to cellular proliferation and migration, while higher temperatures (≥50℃) effectively eradicated bacteria. In vitro studies confirmed excellent cytocompatibility with fibroblasts and endothelial cells, alongside pronounced antibacterial efficacy against Staphylococcus aureus (S. aureus) and Escherichia coli (E. coli). This study establishes a multifunctional, NIR-activated bioactive scaffold that seamlessly integrates moist healing, photothermal therapy, and regenerative stimulation, offering a transformative strategy for accelerated and infection-free skin wound repair.

Keywords: Photothermal-responsive scaffold; Sodium alginate; Bioactive glass; Reduced graphene oxide; Near-infrared irradiation; Wound regeneration

應用機器學習方法搭配慣性感測器與捏握力數據建構台灣老年人肌少症預測模型

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摘要

本研究以慣性量測單元 (Inertial Measurement Unit, IMU) 為基礎，針對人體步態進行分析與性別分類建模。實驗以 27 位健康老年人為對象，於 6 公尺步行測試中蒐集 9 顆 IMU 資料 (取樣頻率 60 Hz)，9 顆放至於左右手腕、上臂、腳尖、小腿和薦椎，並透過鞋部角速度閾值法進行步態事件偵測，進而切割完整步態週期，同時排除原地踏步與非穩態步行段落，以提升資料品質與分析準確性。本研究針對每一步態週期萃取多項步態特徵，包含時間參數，如步態週期時間 (Stride time)、步頻(Cadence)、空間參數，如步長 (Stride length)、步速 (Gait speed)以及動態穩定性與訊號特徵，如加速度均方根 (RMS acceleration)、加速度變化率 (Jerk)、諧波比 (Harmonic ratio)、樣本熵 (Sample entropy)、過零率 (Zero-crossing rate)等，以全面描述人體步態行為。統計分析結果顯示，多數步態特徵於男女之間達顯著差異 ($p < 0.05$)，其中步頻與部分穩定性指標具有中等效果量，顯示其在區分不同族群上具有實質意義。在機器學習模型方面，本研究採用支援向量機(Support Vector Machine, SVM)、隨機森林 (Random Forest, RF) 及 XGBoost，並以 Group K Fold (以受試者為分組單位) 進行交叉驗證，以避免資料洩漏問題。結果顯示，SVM 模型表現最佳 (Accuracy = 0.974，ROC-AUC = 0.992)，RF 次之，而 XGBoost 雖整體準確率較低，但仍具良好之區辨能力。整體而言，本研究證實僅利用 IMU 所萃取之步態特徵，即可有效進行人體動作分析與性別分類，並且建立預測模型，顯示 IMU 在無需額外生理訊號輔助下，仍具備高潛力應用於臨床評估與健康監測領域，並為未來步態分析與疾病早期篩檢提供可行之技術基礎。

關鍵字：IMU、握力、步態分析、肌少症

A Machine Learning–Based Sarcopenia Prediction Model Integrating Inertial Sensor and Grip Strength Data in Taiwanese Older Adults

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Abstract

This study is based on inertial measurement units (IMUs) for human gait analysis and gender classification modeling. A total of 27 healthy older adults participated in the experiment. During a 6-meter walking test, data were collected using nine IMU sensors at a sampling frequency of 60 Hz. The sensors were placed on the left and right wrists, upper arms, toes, shanks, and the sacral region. Gait events were detected using a foot-mounted gyroscope threshold method, enabling segmentation of complete gait cycles. In addition, non-steady-state segments, including in-place stepping and transitional walking phases, were excluded to improve data quality and analysis accuracy. For each gait cycle, multiple gait features were extracted, including temporal parameters such as Stride time and Cadence; spatial parameters such as Stride length and Gait speed; as well as dynamic stability and signal-based features, including RMS acceleration, Jerk, Harmonic ratio, Sample entropy, and Zero-crossing rate, to provide a comprehensive description of human gait behavior. Statistical analysis revealed that most gait features exhibited significant differences between males and females ($p < 0.05$). Among them, cadence and several stability-related features demonstrated moderate effect sizes, indicating their practical significance in distinguishing between groups. For machine learning modeling, this study employed Support vector machine (SVM), Random forest (RF), and XGBoost classifiers. Group K Fold cross-validation was applied, treating each subject as a grouping unit to avoid data leakage. The results showed that the SVM model achieved the best performance (accuracy = 0.974, ROC-AUC = 0.992), followed by RF. Although XGBoost showed relatively lower accuracy, it still demonstrated satisfactory discriminative capability. Overall, the findings of this study demonstrate that gait features extracted solely from IMU data are sufficient for effective human motion analysis and gender classification. The proposed approach establishes a reliable predictive model and highlights the high potential of IMU-based systems for clinical assessment and health monitoring without the need for additional physiological signals. Furthermore, this work provides a feasible technical foundation for future gait analysis and early disease screening applications.

Keywords: IMU, Grip strength, Gait analysis, Sarcopenia

以低玻璃轉移溫度聚合物製備光滑注液的多孔表面塗層應用於體外循環管路之研究

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摘要

本研究以豬籠草為啟發，採用潤滑液體浸潤多孔表面（SLIPS）技術製備抗沾黏塗層，旨在降低血液於體外循環管路輸送過程中的紅血球損傷。塗層以羧甲基殼聚醣與二氧化矽奈米顆粒於基材上形成特殊結構，進而構築出無需界面活性劑的多孔表面。再以具生物相容性的矽油作為潤滑劑，藉毛細作用填充孔隙形成穩定的SLIPS結構。該塗層對水、酒精、牛奶及咖啡皆展現良好的滑動性能，水接觸角約為105.3°，滑動角低於10°，顯示其表面具有優異的液體排斥性。此外，該塗層亦具備抗冰、抗蛋白吸附與自癒合等多重功能，能有效抑制污染物與生物分子的附著。本研究的核心特色在於無需使用含氟化合物即可達到與氟基材料相當的防沾黏效果，並兼具可生物降解、製備簡便與環境友好等優勢。此由羧甲基殼聚醣與二氧化矽奈米顆粒構築的塗層可應用於表面能低之PVC材質的體外循環管路，於抗沾黏、生醫器材及相關表面改質領域展現良好應用潛力。

關鍵字：
潤滑液體浸潤多孔表面（SLIPS）、殼聚醣、塗層、抗沾黏、體外循環管路

Study on slippery Liquid-infused Porous surface coatings with low glass transition temperature polymers for extra-corporeal circulation.

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Abstract

Inspired by the pitcher plant, this study employs the slippery liquid-infused porous surface (SLIPS) technique to fabricate an anti-fouling coating aimed at reducing red blood cell damage during blood transport in extracorporeal circulation tubing. The coating is constructed by forming a special structure composed of carboxymethyl chitosan and silica nanoparticles on the substrate, thereby creating a porous surface without the use of surfactants. Biocompatible silicone oil is infused into the pores via capillary action to form a stable SLIPS structure. The coating exhibits excellent sliding performance against various liquids such as water, alcohol, milk, and coffee, with a water contact angle of approximately 105.3° and a sliding angle below 10°, indicating superior liquid repellency. In addition, the coating demonstrates multiple functionalities, including anti-icing, anti-protein adsorption, and self-healing properties, effectively preventing the adhesion of contaminants and biomolecules. The core feature of this study lies in achieving anti-fouling performance comparable to fluorinated materials without the use of fluorine-containing compounds, while maintaining biodegradability, facile fabrication, and environmental friendliness. The coating constructed from carboxymethyl chitosan and silica nanoparticles can be applied to low-surface-energy PVC materials used in extracorporeal circulation tubing, showing great potential in anti-fouling, biomedical device, and surface modification applications.

Keywords：Slippery Liquid-Infused Porous Surface (SLIPS), chitosan, coating, anti-adhesion, extracorporeal circulation tubing

運用電子病歷系統研究阻塞性睡眠呼吸中止症

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摘要

人工智慧（Artificial Intelligence, AI），尤其是大型語言模型（Large Language Models, LLMs），在臨床工作流程優化、臨床決策支援與醫病溝通方面展現高度潛力，並可能改變睡眠醫學的照護模式。近年已有研究探討LLMs於阻塞型睡眠呼吸中止症（Obstructive Sleep Apnea, OSA）之病人衛教、臨床推理與資料處理等應用，然而現有文獻多為概念驗證或單一情境研究，整體證據仍相對零散，缺乏整合性架構以釐清LLMs在OSA照護中的實際角色與限制。本研究旨在彙整並分析現有文獻，以歸納LLMs在OSA照護中的主要應用主題、潛在價值與相關風險，並提出未來研究與臨床導入之方向。本研究依循PRISMA指引進行文獻檢索，於PubMed、Scopus與ISI Web of Science資料庫搜尋2020至2025年間探討LLMs於OSA臨床情境應用之研究，排除非LLM類人工智慧及無臨床情境之純技術開發研究，並由兩位研究者獨立進行文獻篩選與資料擷取，透過定量與定性綜合方式分析研究特性、應用情境與成效。最終共納入7篇研究，主要發表於2024至2025年間，研究內容可歸納為三大主題：（1）病人支持與衛教：LLMs能以清楚易懂的語言回應病人對OSA與治療方式之疑問，並可能降低治療焦慮與提升治療依從性；（2）臨床推理與決策支援：在標準化情境中與睡眠醫學專科醫師具有高度一致性，惟於共病複雜或治療不耐受情境下表現下降，且有過度建議檢查之傾向；（3）臨床文件與資料解讀：LLMs具備整合多項生理檢查資料與電子病歷之潛力，然而真實世界資料之驗證仍有限，且資料隱私、模型透明度與法規遵循仍為重要挑戰。整體而言，LLMs在OSA照護中具備強化醫病溝通、支援初步臨床判斷及處理高容量臨床資料之潛力，但現階段仍應定位為輔助工具而非取代專業決策。

關鍵字: 阻塞型睡眠呼吸中止症；大型語言模型；臨床決策支援；病人衛教；系統性文獻回顧

Research on Obstructive Sleep Apnea Using Electronic Medical Record Systems

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Abstract

Artificial intelligence (AI), particularly large language models (LLMs), has demonstrated substantial potential to optimize clinical workflows, support clinical decision-making, and enhance patient–clinician communication, and may ultimately transform care models in sleep medicine. In recent years, several studies have explored the application of LLMs in obstructive sleep apnea (OSA), including patient education, clinical reasoning, and data processing. However, the existing literature is largely limited to proof-of-concept studies or single-scenario investigations, and the overall evidence remains fragmented, lacking an integrative framework to clarify the practical roles and limitations of LLMs in OSA care. This study aimed to synthesize and analyze the current literature to identify the major application domains, potential benefits, and associated risks of LLMs in OSA care, and to propose directions for future research and clinical implementation. A systematic literature search was conducted in accordance with the PRISMA guidelines. PubMed, Scopus, and ISI Web of Science databases were searched for studies published between 2020 and 2025 that examined the application of LLMs in clinical contexts related to OSA. Studies involving non-LLM artificial intelligence or purely technical developments without clinical scenarios were excluded. Two independent reviewers performed study screening and data extraction. Both quantitative and qualitative synthesis approaches were employed to analyze study characteristics, application scenarios, and outcomes. A total of seven studies were ultimately included, primarily published between 2024 and 2025. The findings were categorized into three major themes: (1) patient support and education: LLMs were able to provide clear and understandable responses to patient inquiries regarding OSA and its treatments, potentially reducing treatment-

related anxiety and improving treatment adherence; (2) clinical reasoning and decision support: LLMs demonstrated high agreement with sleep medicine specialists in standardized scenarios; however, performance declined in cases involving complex comorbidities or treatment intolerance, and there was a tendency toward over-recommending diagnostic tests; and (3) clinical documentation and data interpretation: LLMs showed potential for integrating multiple physiological datasets and electronic medical records, although validation using real-world data remains limited, and concerns regarding data privacy, model transparency, and regulatory compliance remain significant challenges.Overall, LLMs demonstrate considerable potential to enhance patient–clinician communication, support preliminary clinical judgments, and manage high-volume clinical data in OSA care. However, at the current stage, LLMs should be positioned as supportive tools rather than replacements for professional clinical decision-making.

Keywords: obstructive sleep apnea; large language models; clinical decision support; patient education; systematic review

透過改良修飾電極的電化學傳感器進行尿液檢體中抗癌藥物的檢測

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摘要

開發了一種新型且具成本效益的電化學感測器，利用結合還原氧化石墨烯的稀土鎢酸鹽奈米複合材料 (REW@rGO) 來快速且靈敏地檢測美沙拉秦 (mesalamine) 。透過多種分析與光譜技術合成並表徵該奈米複合材料，確認其成功形成 。REW與rGO之間的協同效應顯著提升了電催化性能，提供了 0.01-723 μM 的寬線性檢測範圍、1.3406 μA μM^{-1} cm^{-2} 的高靈敏度，以及 0.0039 μM 的低偵測極限 (LOD) 。奈米複合材料的大界面面積提升了電子轉移速率，造就了感測器的卓越性能 。這些結果表明，基於 REW@rGO 的感測器是一個高效的平台，可用於藥物與臨床應用中美沙拉秦的即時分析。

關鍵字: 抗發炎藥物、稀土鎢酸鹽、還原氧化石墨烯、伏安法、電化學感測器

Detection of Anticancer Drugs in Urine Samples Using an Electrochemical Sensor with a Modified Electrode

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Abstract

A novel and cost-effective electrochemical sensor was developed for the rapid and sensitive detection of mesalamine using a nanocomposite of rare earth tungstate incorporated with reduced graphene oxide (REW@rGO). The nanocomposite was synthesized and characterized through various analytical and spectroscopic techniques to confirm its successful formation. The synergetic effect between REW and rGO significantly enhanced the electrocatalytic performance, offering a broad linear detection range of 0.01–723 μM, a high sensitivity of 1.3406 μA μM^{-1} cm^{-2} and a low detection limit (LOD) of 0.0039 μM. The enhanced electron transfer rate attributed to the large interfacial area of nanocomposite contributed to the sensor's superior performance. These results demonstrated that the REW@rGO-based sensor is a highly efficient platform for the real-time analysis of mesalamine in pharmaceutical and clinical applications.

Keywords: Anti-inflammatory drug, Rare earth tungstate, Reduced graphene oxide, Voltammetry, Electrochemical sensor

使用影像系統實現即時離床監測警示系統之建立

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摘要

現代社會面臨老齡化挑戰，對年長者而言，跌倒不僅影響日常生活，還可能引發多種併發症，甚至死亡。由於老年人身體機能減退，醫療照護成本隨之增加。在醫療場所中，住院病患如肢體外傷、腦中風或失智，更容易發生跌倒。一旦跌倒，可能引發重大醫療安全事件。因此，住院期間，病患通常有家屬或照護員協助移位，醫護人員也會定期評估跌倒風險，必要時會與復健團隊合作進行移位指導或使用輔具降低風險。然而，當照護人員短暫離開時，若病患試圖自行離床，尤其在夜晚，因缺乏他人協助，環境昏暗，病患肢體協調性及視力較差，跌倒風險增加。此時，如果有實時監測系統，在病患離床時能及早警示醫護人員，便能降低潛在跌倒事件，快速介入救援，減少併發症發生。此次試驗計劃運用電腦視覺技術，通過病房內高解析度相機及 ToF 深度攝影機記錄病患肢體動作，建立離床警示模型，有效降低跌倒風險。本計畫旨在開發一套先進的離床跌倒監測系統，應用於老人照護和醫院住院病患的跌倒預防。該系統具高度應用價值，完成研製後可將應用擴展至如：中風患者、術後康復者等高風險跌倒群體的監測與預防。計畫擬開發自動化跌倒監測與警示系統，預計使用 2K RGB 相機和 ToF 深度相機進行病患姿態監控與異常動作分析，並整合 IMU 感測器實時追蹤病患的活動狀況。以此實現對病患的精確監控和即時警示。預期本計畫將顯著提高跌倒預防的效果，促進醫療機構對於老人與病患的照護技術。

關鍵字: 跌倒監測、臨床診斷、跌倒預防、監控、人工智慧、醫療服務、感應器、物聯網、智慧感測器、物聯網網

Establishment of a real-time bed exit monitoring and alert system using imaging technology

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Abstract

The aging population in today's society brings significant challenges, especially for older adults who are at higher risk of falls. When older individuals fall, it can lead to a loss of independence and may cause various complications, including serious illness or even death. As people age, their physical abilities decline, which increases the need for medical care and raises healthcare costs. In hospitals, patients with conditions like physical injuries, strokes, or dementia are even more likely to fall. If a fall happens, it can easily turn into a serious medical incident. To reduce this risk, hospitals usually have caregivers, family members, or volunteers to help patients move around. Medical staff also regularly assess patients for fall risks. When a patient is found to be at higher risk, the medical team may work with rehabilitation specialists to teach safe movement techniques or provide assistive devices to lower the chance of falling. However, problems can occur when caregivers are not present, such as when they step out to buy supplies, eat, or use the bathroom. Falls can also happen at night when caregivers are resting, or when medical staff are busy helping other patients. If a patient tries to get out of bed on their own during these times, the lack of assistance, combined with a dark room, poor vision, and reduced physical coordination—especially after waking up—can increase the risk of a fall. A real-time monitoring system could help solve this problem by detecting when a patient tries to leave the bed and alerting medical staff early. This would allow for faster intervention, preventing falls and reducing the risk of further complications. In this trial, we plan to use computer vision technology to monitor these events. By placing high-resolution cameras and Time-of-Flight (ToF) depth cameras in patient rooms, we will be able to capture and record patient movements. The recorded data will then be used to develop an early-warning system that can help reduce falls and ensure that patients receive assistance when needed.

This project aims to develop an advanced bed-exit fall monitoring system applied to elderly care and hospital patient fall prevention. The system has high application value,

and after completion, it can be extended to high-risk groups such as stroke patients and postoperative rehabilitation. The project intends to develop an automated fall monitoring and alert system, using 2K RGB cameras and ToF depth sensors for patient posture monitoring and abnormal movement analysis, and integrating IMU sensors to track patient activity in real time. This will enable precise monitoring and timely alerts. It is expected that this project will significantly improve fall prevention effectiveness and promote advanced care techniques for elderly and patient care.

Keywords: Fall monitoring, Clinical diagnosis, Fall prevention, Monitoring, Artificial intelligence, Medical services, Sensors, Internet of Things (IoT), Smart sensors, Internet of Things (IoT)

開發具提示注入緩解功能的強化學習式乳癌重建AI決策輔助系統之研究

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摘要

近年生成式人工智慧與大型語言模型逐漸應用於醫療諮詢與衛教輔助場景。然而，醫療對話系統若缺乏安全控管，可能受到提示詞注入攻擊影響，導致模型產生不當回應，進而影響醫療決策品質與資料安全。因此，本研究以乳癌重建術前諮詢為應用場景，建構可於本地端運行之提示詞注入防禦架構，以提升醫療對話系統的安全性與可控性。

本研究採用雙模型分工設計，將「輸入安全判斷」與「醫療內容生成」分離處理。系統前端透過微調後的安全分類模型，辨識使用者輸入是否包含提示詞注入攻擊，並進一步區分攻擊類型、計算風險分數，結合使用者信用機制進行分級控管。僅當輸入風險落於可接受範圍時，才交由後端醫療諮詢模型產生回應，以降低生成模型受到惡意干擾的可能性。

實驗結果顯示，安全分類模型於二分類任務中達到 0.97 的 F1 score，於五分類攻擊辨識任務中達到 0.91 的 F1 score；醫療問題分類模組亦由原系統 0.74 提升至 0.88。研究結果證明，在有限運算資源下，透過任務拆分、風險量化與信用控管機制，可有效提升生成式人工智慧於醫療場域中的安全可控性與實務應用可行性。

關鍵字：提示詞注入防禦、本地端部署、安全分類、風險治理、乳癌重建諮詢

Development of a Reinforcement Learning-Based Breast Reconstruction AI Decision Support System with Prompt Injection Mitigation Features

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Abstract

In recent years, generative artificial intelligence and large language models have gradually been applied to medical consultation and health education assistance scenarios. However, if medical dialogue systems lack security control, they may be affected by prompt injection attacks, causing the model to generate inappropriate responses and further affecting the quality of medical decision-making and data security. Therefore, this study takes preoperative consultation for breast reconstruction as the application scenario and constructs a locally executable prompt injection defense framework to improve the safety and controllability of medical dialogue systems.

This study adopts a dual-model division-of-labor design, separating "input safety judgment" and "medical content generation" into two tasks. At the front end of the system, a fine-tuned safety classification model is used to identify whether user input contains prompt injection attacks, further distinguish attack types, calculate risk scores, and combine a user credit mechanism for graded control. Only when the input risk falls within an acceptable range will it be passed to the back-end medical consultation model to generate a response, thereby reducing the possibility that the generative model is maliciously interfered with.

The experimental results show that the safety classification model achieves an F1 score of 0.97 in the binary classification task and an F1 score of 0.91 in the five-class attack identification task. The medical question classification module also improves from 0.74 in the original system to 0.88. The results demonstrate that, under limited computational resources, task separation, risk quantification, and a credit control mechanism can effectively improve the safety, controllability, and practical applicability of generative artificial intelligence in medical scenarios.

Keywords: Prompt Injection Defense, Local Deployment, Safety Classification, Risk Governance, Breast Reconstruction Consultation

FFA-Net：面向機器視覺的快速頻率感知雷射雷達點雲壓縮

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摘要

高效的點雲壓縮對於自動駕駛和機器人視覺導航等應用至關重要。近年來，點雲資料在依賴精確幾何表示的機器視覺任務中受到了廣泛關注。然而，現有的大多數點雲壓縮方法是為人類視覺感知設計的，並非專門針對機器視覺任務，且其解碼過程通常計算開銷較大，限制了在快速處理場景中的適用性。為了更好地支援依賴全域幾何結構的機器視覺任務，我們提出了一種用於點雲壓縮的快速頻率感知網路（FFA-Net），並以大規模三維目標檢測作為代表性的評估場景。我們觀察到，在依賴穩定結構線索而非精細局部細節的幾何驅動感知任務中，高頻分量對保持全域形狀資訊的重要性低於低頻分量。基於這一觀察，FFA-Net 採用圖濾波將點雲分離為高頻和低頻分量。隨後，它應用自我調整量化策略，對高頻點使用較大的量化步長，對低頻點使用較精細的步長以保留結構細節。此外，引入羽量級適配器，自我調整地調整高-低頻比例並增強低頻表示。實驗結果表明，所提方法能夠有效保留對幾何驅動機器視覺任務至關重要的任務相關幾何結構，同時顯著提升處理速度。

關鍵字: 點雲壓縮、機器視覺、頻率感知、自我調整量化

FFA-Net: Fast Frequency-Aware LiDAR Point Cloud Compression for Machine Vision

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Abstract

Efficient point cloud compression is essential for applications such as autonomous driving and robotic vision navigation. Recently, point cloud data has received significant attention in machine vision tasks that rely on accurate geometric representations. However, most existing point cloud compression methods are designed for human visual perception rather than specifically for machine vision tasks, and their decoding processes are often computationally expensive, limiting applicability in fast-processing scenarios. To better support machine vision tasks that depend on global geometric structure, we propose a Fast FrequencyAware Network (FFA-Net) for point cloud compression, with large-scale 3 object detection serving as a representative evaluation scenario. We observe that high-frequency components are less critical than low-frequency components for preserving global shape information in geometry-driven perception tasks, which typically rely on stable structural cues rather than fine-grained local details. Based on this observation, FFA-Net employs graph filtering to separate point clouds into high-frequency and low-frequency components. It then applies an adaptive quantization strategy, using a larger step size for high-frequency points and a finer step size for low-frequency points to preserve structural details. Furthermore, a lightweight adapter is introduced to adaptively adjust the high-to-low frequency ratio and enhance low-frequency representations. Experimental results demonstrate that the proposed method effectively preserves task-relevant geometric structures that are fundamental to geometry-driven machine vision tasks, while significantly improving processing speed.

Keywords: Point cloud compression, Machine vision, Frequency aware, Adaptive quantization

面向多種疾病輔助診斷的眼科影像融合分析技術研究

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摘要

早產兒視網膜病變 (Retinopathy of Prematurity, ROP) 是可預防的兒童失明主要原因之一，源自早產兒視網膜血管發育異常。臨床評估需精確辨識視網膜分區、偵測早期病灶，並評估以後血管迂曲與擴張為特徵的plus disease。然而，目前 ROP篩檢多仰賴眼科醫師人工判讀，流程耗時且具主觀性，觀察者之間的一致性差異可能造成轉介與治療延誤。基於ICROP-3指引之臨床需求，本研究旨在建立一套自動化且標準化的ROP篩檢與追蹤框架，並以解剖學導向的方式進行分析。

本研究提出一套多任務流程，首先以BiRefine-YOLO模型進行視神經盤與黃斑部定位，以支援一致且可靠的Zone I劃定；接著採用YOLOv8並結合Double-CLAHE影像增強以突顯細微病灶，進行分界線(demarcation line)與隆起脊(ridge)偵測，並以YOLO為基礎的分類模型針對臨床追蹤相關類別進行分期判讀。此外，使用 AG-MoE Swin-UNet進行動靜脈分割，以提升血管結構完整性與交叉區域的分離品質，最後以曲率式血管迂曲指標 (Curvature Vessel Tortuosity Index, CVTI)量化Zone I內的血管形態變化，以提供客觀的血管迂曲分析。作為補充實驗，本研究亦探討一種標註需求較低的血管嚴重度估測方法，透過零樣本 (zero-shot)的血管嚴重度分數 (Vascular Severity Score, VSS) 框架，利用深度特徵嵌入與餘弦相似度進行推估。

本研究於公開資料集與多個有別於訓練集之測試資料（臺灣長庚紀念醫院、日本大阪大學、印度Aravind眼科醫院）進行實驗，結果顯示各模組能提供可靠的解剖定位與臨床關鍵特徵的穩健偵測。視神經盤定位在mAP@50-95上達到 0.889 (bbox) 與0.836 (mask)，分界線／隆起脊偵測在mAP@50上達到0.953；分期分類在各類別皆呈現AUC高於0.92的良好可分性。動脈分割達到IoU/Dice 0.809/0.894，靜脈分割達到 IoU/Dice 0.830/0.907。整體而言，本研究所提出之框架可提升ROP評估的客觀性與可重現性，並為臨床篩檢與追蹤提供量化決策支援的計算基礎。

關鍵字：早產兒視網膜病變（ROP）、深度學習、自動化影像分析、Plus disease、血管迂曲度

Research on Ophthalmic Image Fusion Analysis Technology for Auxiliary Diagnosis of Various Diseases

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Abstract

Retinopathy of Prematurity (ROP) is a preventable cause of childhood blindness resulting from abnormal retinal vascular development in premature infants. Clinical assessment requires accurate identification of retinal zones, detection of early-stage lesions, and evaluation of plus disease characterized by posterior pole vessel tortuosity and dilation. However, ROP screening remains largely subjective and time-consuming, with inter-observer variability that can delay referral and treatment. Motivated by ICROP-3 guidance, this study aims to develop an automated and standardized framework for ROP screening and monitoring with anatomically grounded analysis.

We propose a multi-task pipeline integrating optic disc and macula localization using a BiRefine-YOLO model to support consistent Zone I delineation, demarcation line and ridge detection using YOLOv8 with Double-CLAHE enhancement to highlight subtle lesions, YOLO-based stage classification for clinically monitored categories, artery-vein segmentation using AG-MoE Swin-UNet, and tortuosity quantification using the curvature vessel tortuosity index (CVTI) for objective analysis of vascular distortion. As a supplementary experiment, we further explore label-efficient vascular severity estimation through a zero-shot vascular severity score (VSS) framework using deep feature embeddings and cosine similarity.

Experiments on public datasets and other test datasets (Chang Gung Memorial Hospital, Taiwan; Osaka University, Japan; Aravind Eye Hospital, India) demonstrate that the proposed modules provide reliable anatomical referencing and robust detection of clinically relevant features. Optic disc localization achieved mAP@50-95 of 0.889 (bbox) and 0.836 (mask), while demarcation line/ridge detection achieved mAP@50 of 0.953. Stage classification achieved strong separability with AUC values above 0.92 for all classes. Artery-vein segmentation achieved IoU/Dice of 0.809/0.894 for arteries and 0.830/0.907 for veins. Overall, this study supports objective and reproducible ROP

assessment and provides a computational foundation for quantitative clinical decision support in screening and monitoring.

Keywords: Retinopathy of Prematurity (ROP), deep learning, automated image analysis, plus disease, vascular tortuosity

跨文化脈絡下水災地圖視覺變量與感知機制之影響研究

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摘要

隨著氣候變遷的影響，全球水災的發生頻率顯著上升，水災危害分佈圖（Flood Hazard Map, FHM）已成為協助國際政府、一般民眾等使用者進行水災風險溝通的重要工具。然而，現今缺乏一致性的 FHM 資訊視覺化規範，導致在跨國傳遞與協作中，易因文化背景差異產生認知偏誤。因此本研究以歐洲與亞洲地區為例，針對歐亞洲代表國家：台灣、中國、英國、捷克內共 240 位受測者進行線上問卷調查法，評估視覺變量（色彩配色、色彩階數）組合對受測者在理解、視覺美感及風險感知上的主客觀影響。

研究結果發現，歐、亞兩洲受測者均傾向透過豪雨預報等發布資訊查找水災風險（歐洲：$M=3.88$；亞洲：$M=3.85$）。在視覺變量表現中，「藍紅配色」、「 4 階色階」等組合在兩大洲對各感知面向的主觀偏好中主觀偏好中均展現顯著優越性，於量表評估中普遍為表現高位的組合；相較之下，樣本 Ca（黃紅配色 ＋ 4 階）雖在歐洲受測者的各項量表中獲得最高分數，但對亞洲受測者而言則表現最差，顯示此視覺組合在跨文化設計中的局限性。

此外，綜合三大感知面向之評估並經 Spearman 相關性分析揭示，使用者對水災危害分佈圖的客觀認知與主觀審美具有各自獨立的邏輯。也反映未來的 FHM 跨文化設計規範，除優化水災的視覺呈現形式外，亦須同步考量整體架構與資訊層級等其餘因素，以建構具跨文化應用性的設計規範，提升國際間風險溝通的實際成效。

關鍵字：水災危害分佈圖、災害資訊視覺化、文化差異、群體感知

Research on the Effects of Visual Variables and Perception Mechanisms of Flood Hazard Map in a Cross-Cultural Context

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Abstract

Due to climate change, global flood frequency has risen significantly, and Flood Hazard Maps (FHM) are vital tools for governments and the public in flood risk communication. However, lacking consistent visualization standards leads to cognitive biases during transnational collaboration due to cultural differences. Therefore, this study surveyed 240 participants from representative countries—Taiwan, China, the UK, and the Czech Republic—to evaluate the objective and subjective impacts of visual variable combinations (color schemes, color levels) on understanding, aesthetics, and risk perception.

The research results found that participants in both Europe and Asia tend to seek flood risk information through published information such as heavy rain forecasts (Europe: M = 3.88; Asia: M = 3.85). Among the performances of visual variables, combinations such as the "blue-red color scheme" and "4-level color steps" demonstrated significant superiority in subjective preferences across various perception dimensions in both continents, generally being high-performing combinations in scale assessments. In contrast, although sample Ca (yellow-red color scheme + 4 levels) received the highest scores in various scales from European participants, it performed worst in Asia, showing the limitations of this combination in cross-cultural design.

Furthermore, Spearman correlation analysis reveals that users' objective cognition and subjective aesthetics of FHMs have independent logics. This suggests future cross-cultural FHM standards must, besides optimizing visual forms, consider map structure and information hierarchy to enhance the practical effectiveness of international risk communication.

Keywords: Flood Hazard Map, Hazard Information Visualization, Cultural Differences, Group Perception

透過配體調控準二維鈣鈦礦以提升浮動閘極光電晶體記憶體穩定性

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摘要

本研究探討配體修飾之準二維鈣鈦礦結合含長烷基鏈或芳香側基高分子於光記憶體應用中的表現。研究中使用 PEABr 與 PDMA 分別建構 RP 相與 DJ 相鈣鈦礦，並進一步導入含苯環或芘基團之高分子，以分析其對薄膜微結構與光電性質的影響。

結果顯示，RP 相鈣鈦礦搭配芘功能化高分子時，因配體與高分子間具有良好相容性，且芘基團可形成受控的聚集行為，有助於提升晶體取向、減少晶界缺陷並改善電荷傳輸。因此，所製備之光記憶體元件展現出高 ON/OFF 比、低操作電壓、快速響應以及良好的熱穩定性。此結果說明，透過配體立體效應與高分子功能基設計，可有效調控鈣鈦礦微結構並提升元件性能。

關鍵字： 準二維鈣鈦礦、光電機體記憶體

Quasi-2D Perovskite with Ligand Engineering to Improve the Stability of Phototransistor Memory with a Floating Gate

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Abstract

This study investigates ligand-modified quasi-2D perovskites combined with polymers containing long alkyl chains or aromatic side groups for photomemory applications. PEABr and PDMA were used to construct RP- and DJ-phase perovskites, which were further integrated with polymers bearing benzene or pyrene groups to examine their effects on microstructure and optoelectronic properties.

The RP-phase perovskite paired with a pyrene-functionalized polymer exhibits improved crystal orientation, reduced grain boundaries, and enhanced charge transport due to favorable ligand–polymer compatibility and controlled pyrene aggregation. Consequently, the photomemory devices demonstrate a high ON/OFF ratio, low operating voltage, fast response, and good thermal stability. These results highlight ligand steric effects and polymer functionality as effective strategies for optimizing perovskite microstructure and device performance.

Keywords: Quasi-2D perovskite, phototransistor

無限振盪流中外泌體黏彈性-慣性操控機理研究

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摘要

微流控技術利用微尺度流體進行外泌體操控，為早期癌症篩查提供了有效的技術手段，但現有的分選技術依賴於精確的流量控制，這嚴重限制了微流控分選平台的小型化。本項目充分利用深圳大學閻昇專長和北科大林正釧模擬專長的研究背景，提出利用無限振盪微流控技術進行外泌體黏彈性－慣性分選，圍繞振盪流中外泌體黏彈性－慣性操控機理這一關鍵問題。此研究之首要步驟是通過CFD-DEM數值模擬計算顆粒所受的多種力，並將這些力的計算結果作為牛頓運動定律和納維－斯托克斯方程的邊界條件，結合拉格朗日粒子追蹤方法精確追蹤顆粒在流道中的運動軌跡，與實際實驗進行模型驗證，並提供顆粒運動的流變行為分析。

關鍵字: 振盪流、外泌體聚焦、CFD-DEM、固液二相流

The Study on Elasto-Inertial Migration of Exosomes in Infinite Oscillatory Microflows

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Abstract

Microfluidic technology leverages microscale fluids for the manipulation and sorting of exosomes, offering an effective technological approach for early cancer screening. However, current sorting techniques rely heavily on precise flow control, significantly hindering the miniaturization of microfluidic sorting platforms. This project combines the research expertise from Sheng Yan's research group at Shenzhen University and Cheng Chuan Lin's research group at National Taipei University of Technology and proposes the infinite oscillatory microfluidic technology for elasto-inertial sorting of exosomes. Focusing on the pivotal issue of the elasto-inertial manipulation mechanism of exosomes in oscillatory flows, we aim to develop a pump-free infinite oscillatory microfluidic chip and elucidate the migration mechanism of exosomes in oscillatory flows. This study begins by employing a coupled CFD–DEM numerical approach to compute the various forces acting on particles. These force calculations are then incorporated as boundary conditions into Newton's equations of motion and the Navier–Stokes equations. By integrating a Lagrangian particle tracking method, the trajectories of particles within the flow channel are accurately resolved. The numerical results are subsequently validated against experimental data, and the framework further enables a detailed analysis of the rheological behavior of particle motion.

Keywords: Oscillatory flow, Exosome focusing, CFD-DEM, Solid-liquid two-phase flows

應用非接觸式支撐策略於超薄氧化鋯牙科貼片製造之積層製造設計

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摘要

隨著全球化快速發展，以及旅宿與航空產業的顯著成長，社會對美學的要求已提升至新的標準。現今，外貌已成為自信的重要指標，進一步帶動全球美學市場的發展。本研究採用數位光處理（Digital Light Processing, DLP）技術製備氧化鋯牙科貼片。牙科貼片是一種廣泛應用於補綴牙科的修復方式，具備微創特性，可有效改善牙齒外觀。傳統牙科貼片在列印製程中需要大量實體支撐結構，進而增加後處理的困難度。由於貼片厚度極薄（約 0.4 mm），在移除支撐時，生胚（green body）容易產生裂紋與損傷。因此，本研究提出一種新穎的非接觸式支撐策略，可在提升列印精度的同時，消除後處理步驟。此策略利用漿料（slurry）黏度作為非接觸式支撐機制，使試件於製造過程中維持類懸浮（pseudo-floating）狀態。實驗結果顯示，該策略可有效提升表面品質，避免條紋與裂紋的產生。研究成功製備厚度低至 0.36 mm 的超薄牙科貼片，且未發生破損。此外，透過將貼片與非接觸式支撐之間的距離最佳化至 0.5 mm，可進一步提升尺寸精度。精度分析結果顯示，製備試件相較於 CAD 模型在 X 軸與 Y 軸方向的偏差分別僅為 1.70% 與 0.84%。經超細纖維拋光（microfiber polishing）後，此偏差可再進一步降低。所製備之牙科貼片於不同位置亦展現出良好的硬度表現，其維氏硬度值（HV）介於 1190–1255 之間。

關鍵字: 氧化鋯、牙科貼片、積層製造

Design for Additive Manufacturing Using the Contactless Support Strategy for the Fabrication of Ultrathin Zirconia Dental Veneers

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Abstract

The rapid globalization, along with significant growth in the hospitality and aviation industries, has set a new standard for aesthetics. Nowadays, physical appearance has become an indicator of self-confidence, boosting the global aesthetics market. In this study, zirconia dental veneers were fabricated using the digital light processing technology. Dental veneers are a widely used prosthodontic option that serves as a minimally invasive restorative option to enhance tooth appearance. The traditional fabrication of dental veneers requires extensive physical supports while printing, which increases the post-processing challenges. Due to the thickness of the veneers (~0.4 mm), support removal resulted in cracks and damage to the green bodies. Thus, this study employs a novel contactless support strategy that increases printing accuracy while eliminating post-processing steps. The novel strategy utilizes the slurry's viscosity as a contactless support, with the sample in a pseudo-floating state during fabrication. Using this strategy successfully resulted in enhanced appearance without striations/cracks. The ultrathin dental veneers, with a thickness as low as 0.36 mm, were fabricated without failure. Further accuracy enhancement was achieved by optimizing the distance between the veneer and the contactless support to 0.5 mm. The precision analysis showed that the fabricated samples deviated by 1.70% (X-axis) and 0.84% (Y-axis) from the CAD model. This deviation is further reduced with microfiber polishing. The fabricated veneers also demonstrated satisfactory hardness values of 1190-1255 HV at different locations. Abstract

Keywords: Dental Veneer, ceramic additive manufacturing, contactless support, biomaterials, customization

0D/2D $ZnMn_2O_4$奈米球/g-C_3N_4奈米片異質結構之製備及其於環境樣品中呋喃他酮電化學檢測之應用

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摘要

呋喃他酮（Furaltadone, FLD）是一種屬於硝基呋喃類（nitrofuran）的獸用抗生素，其代謝產物具有致癌性與致突變性，並可透過水體污染對環境及人體健康造成重大危害。基於此問題，本研究開發了一種具成本效益且高精準度的電化學感測器，利用鋅錳氧化物/石墨相氮化碳（$ZnMn_2O_4$/g-C_3N_4, ZMO/GCN）奈米複合材料，用於環境樣品中 FLD 的高效檢測。$ZnMn_2O_4$ 奈米球係採用簡單的一步共沉澱法（one-pot co-precipitation）合成；同時，g-C_3N_4 奈米片則透過尿素熱聚合法製備而成。透過各項物理化學分析技術，對 ZMO、GCN 及其複合材料之結構與形貌進行了完整探討。將所製備之 ZMO/GCN 奈米複合材料修飾於玻碳電極（glassy carbon electrode, GCE）上，並結合電化學阻抗分析（EIS）、循環伏安法（CV）及差分脈衝伏安法（DPV）進行 FLD 的電化學檢測。結果顯示，此感測器具有優異的靈敏度（0.4652 μA μM^{-1} cm^{-2}）、寬廣的線性檢測範圍（0.01–747 μM 及 867–2187 μM），以及極低的檢測極限（0.007 μM）。此外，在實際樣品如水樣、牛奶及四環黴素樣品中測試時，該感測器亦展現出優異的檢測性能，證實其具備實際應用潛力。綜上所述，ZMO/GCN 奈米複合材料作為電極修飾材料，在環境監測中對 FLD 的精準且可靠的電化學檢測具有良好發展前景。

關鍵字：環境樣品、電化學感測、呋喃他酮、二維複合材料

Fabrication of 0D/2D $ZnMn_2O_4$ Nanospheres/g-C_3N_4 Nanosheets Heterostructure for Electrochemical Detection of Furaltadone in Environmental Samples

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Abstract

Furaltadone (FLD), a veterinary antibiotic belonging to the nitrofuran class, is known for its carcinogenic and mutagenic metabolites, which provide significant hazards to environmental and human health via water-related contamination. In consequence of this issue, we have developed, cost-effective, and highly precise electrochemical sensor utilizing zinc manganese oxide/graphitic carbon nitride ($ZnMn_2O_4$/g-C_3N_4) nanocomposites for the efficient detection of FLD in environmental samples. The ZMO nanospheres were synthesized using a simple one-pot co-precipitation approach. In parallel, GCN nanosheets were synthesized via thermal polymerization of urea. The structural and morphological properties of ZMO, GCN and ZMO/GCN nanocomposite were thoroughly studied using physicochemical analysis. The engineered ZMO/GCN nanocomposite-modified glassy carbon electrode (GCE) was utilized for the electrochemical detection of FLD, employing electrochemical impedance spectroscopy (EIS), cyclic voltammetry (CV), and differential pulse voltammetry (DPV) methodologies. The sensor demonstrated remarkable sensitivity (0.4652 μA μM^{-1} cm^{-2}), extensive linear detection range (0.01 to 747 μM and 867 to 2187 μM), and an exceptionally low detection limit (0.007 μM) under optimal conditions. Moreover, the sensor exhibited outstanding performance in actual water, milk, and tetracycline samples, validating its practical utility. These findings emphasize the potential of ZMO/GCN nanocomposite as an effective electrode modifier for precise and dependable electrochemical measurement of FLD in environmental monitoring.

Keywords: Environmental samples; Electrochemical sensing; Furaltadone; 2D composites

鈷基催化劑在析氧反應中質子耦合電子轉移反應機制之探討

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摘要

析氧反應 (OER) 由於其遲緩的四電子轉移動力學，為水分解過程中的主要動力學瓶頸。為了克服高能中間體與尺度關係限制，近期研究轉向開發具備質子耦合電子轉移機制的催化劑。本研究中，我們報導了一種經由水熱法理性設計與合成之鐵與磷酸根共修飾鈷氧氫氧化物($Co_{1-x}Fe_xOOH$-Pi)，並透過簡易滴塗法將其製備於鎳網基材上作為工作電極。Fe^{3+} 離子參雜入 CoOOH 晶格後，藉由形成高活性的 Co–Fe 氧氫氧化物結構單元，有效降低反應活化能；同時，磷酸根離子則作為質子接受中間體，促進質子耦合電子轉移過程。為了即時觀測反應過程中的結構變化，本研究利用原位拉曼光譜技術，在不同電位的 OER 操作條件下監測表面鐵與磷物種的動態行為及相變化。陽離子 Fe 活性中心與陰離子磷酸根中繼之間的協同作用，從根本上改變了反應能量學，解耦關鍵中間體的吸附能，進而顯著降低過電位並加速反應動力學。

關鍵字： 析氧反應、鈷氧氫氧化物、原位拉曼光譜

Investigating the Reaction Mechanisms of Proton-Coupled Electron Transfer in the Oxygen Evolution Reaction Using Cobalt-Based Catalyst

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Abstract

The oxygen evolution reaction (OER) is the primary kinetic bottleneck in water splitting due to its sluggish four-electron transfer kinetics. To circumvent high-energy intermediates and scaling-limit constraints, recent research has pivoted toward catalysts capable of proton-coupled electron transfer (PCET) mechanisms. Herein, we report the rational design of an iron and phosphate co-decorated cobalt oxyhydroxide ($Co_{1-x}Fe_xOOH$-Pi) synthesized via a hydrothermal method and fabricated into working electrodes using a facile drop-casting approach on nickel mesh. The integration of Fe^{3+} ions into the CoOOH lattice lower the activation energy through the formation of highly active Co-Fe oxyhydroxide motifs, while phosphate ions serve as proton-accepting relays to facilitate PCET. *Operando* Raman spectroscopy was utilized under real-time OER conditions at different potentials to monitor the structural phase transformations and dynamic behavior of iron and phosphorus species on the surface. The synergy between cationic Fe-centers and anionic phosphate relays fundamentally alters reaction energetics, decoupling the binding energies of key intermediates to achieve significantly reduced overpotentials and accelerated reaction kinetics.

Keywords: oxygen evolution reaction, cobalt oxyhydroxide, operando Raman

開發永續高級氧化處理程序降解生物難分解之藥物污染物

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摘要

製藥和醫療廢水中含有各種生物難分解的藥物污染物，其中，氯四環素(Chlortetracycline, CTC)是目前廣泛用於治療人類和家畜疾病的四環素類抗生素，CTC因毒性和持久性被認為是具有高環境風險的典型代表，並容易造成耐藥性細菌的產生。高級氧化處理程序(Advanced Oxidation Processes, AOPs)為分解這些藥物污染物的最有效解決方案之一。AOPs通過形成高活性的羥基自由基來分解污染物。常用技術包括 UV/H_2O_2、芬頓及光芬頓反應、臭氧化、光催化和聲解。然而，目前多數相關技術普遍存在高成本與高能耗的問題。因此，發展具備永續性的高級氧化程序（AOPs），以有效降解生物難分解的藥物類污染物，具有極其重要的意義。其中，奈米氧化鈰作為非均相類芬頓觸媒(Heterogeneous Fenton-like Catalyst)相較於會產生含鐵污泥的傳統芬頓法，以固體觸媒與液相混合進行反應，具有高穩定性、操作pH範圍廣、易分離再利用等優點，是開發永續AOPs降解生物難分解的藥物污染物的潛力材料。另外，目前奈米氧化鈰觸媒使用氯化鈰等含鈰化合物試劑進行合成，製備成本較高，如能使用含鈰廢棄物為原料製備觸媒應用於催化降解藥物污染物，將可降低製備成本、減少廢棄物掩埋量，促進鈰資源循環利用，並實現醫院及工業製藥廢水的有效處理。

本計畫回收來自玻璃拋光廢棄物中的奈米氧化鈰作為觸媒濕式過氧化反應(Catalytic Wet Peroxide Oxidation, CWPO)的催化劑，添加H_2O_2進行CWPO反應催化降解氯四環素(CTC)，以探討用於催化降解生物難分解藥物污染物的可行性。另外，為提升催化性能，亦將使用酸浸、沉澱和煅燒的自下而上方法(Bottom-up)，從玻璃拋光廢棄物回收和製備奈米氧化鈰觸媒，探討不同煅燒溫度製備奈米氧化鈰之物理化學性質，以及測試回收的奈米氧化鈰對於CTC的催化降解性能。

關鍵字: 藥物污染物、高級氧化處理程序、觸媒濕式過氧化反應、奈米氧化鈰、玻璃拋光廢棄物

Development of Sustainable Advanced Oxidation Processes for Degrading Bio-Recalcitrant Pharmaceutical Pollutants

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Abstract

Pharmaceutical and medical wastewaters contain bio-recalcitrant drug pollutants, among which chlortetracycline (CTC), a widely used tetracycline antibiotic, poses significant environmental risks due to its toxicity and pseudo-persistence, contributing to antibiotic resistance. Advanced Oxidation Processes (AOPs), which generate highly reactive hydroxyl radicals, are effective for degrading such contaminants. Common AOPs include UV/H_2O_2, Fenton and photo-Fenton reactions, ozonation, photocatalysis, and sonolysis, though they often involve high costs and energy consumption. Nanoceria, as a heterogeneous Fenton-like catalyst, offers advantages over conventional Fenton systems, including high stability, a wider pH operating range, and easy recovery without producing iron sludge, making it promising for sustainable AOP development. However, its synthesis typically relies on costly cerium precursors. Utilizing cerium-containing waste as a raw material could reduce costs, minimize landfill, and promote resource recycling.

This study aims to recover nanoceria from glass polishing waste and apply it as a catalyst in catalytic wet peroxide oxidation (CWPO) for CTC degradation. A bottom-up approach involving acid leaching, precipitation, and calcination will be used to prepare the catalyst. The physicochemical properties of nanoceria at different calcination temperatures and its catalytic performance in degrading CTC will be systematically evaluated.

Keywords: Advanced Oxidation Processes, Pharmaceutical Pollutants, Catalytic Wet Peroxide Oxidation, Nanoceria, Glass Polishing Waste

利用生物質衍生多孔碳並結合超音波耦合超臨界-CO_2方法製作先進儲能裝置之可撓性透明電極

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摘要

超級電容器（SCs）因其高比功率、快速充放電特性以及長循環壽命，被視為最具潛力的儲能裝置之一，並廣泛應用於電動車、脈衝電力系統及可攜式電子設備。然而，儘管可撓性(軟性)電子技術已取得顯著進展，多數超級電容器仍依賴剛性器件結構，限制了其在次世代軟性能源系統中的整合應用。本研究計畫提出一種具成本效益的方法，利用鐵（Fe）摻雜之生物質衍生活性碳（Fe-AC）製備可撓性超級電容器電極及實用裝置。所製備材料經系統性表徵，以分析其相組成、表面形貌及功能特性。可撓性電極構築於鋁接枝聚醯亞胺（Al－PI）基板上，並透過標準電化學分析技術評估其電化學性能。Fe-AC@Al–PI 電極展現以表面控制電容行為為主（61.17%），並伴隨較小比例的擴散控制貢獻（38.82%）。在 0.5 A g^{-1} 的電流密度下，其比電容可達 200.84 F g^{-1}，且具有低電荷轉移電阻（7.14 Ω）。此外，進一步組裝對稱型可撓性超級電容器裝置，可在 1.2 V 的寬電壓視窗下穩定運作，並提供 14.89 Wh kg^{-1} 的能量密度與 250 W kg^{-1} 的功率密度。實際應用方面，透過串聯裝置成功點亮一顆 1V LED，證明其實用可行性。同時，在 45°、90°及 180°彎曲條件下，該裝置仍維持穩定的電化學行為，其循環伏安（CV）曲線未出現明顯變形。上述結果顯示，Fe-AC/Al－PI 電極在可撓性儲能應用領域中具有良好的發展潛力。

關鍵字: 活性碳；可撓性電極；鐵摻雜；超級電容器

Flexible transparent electrode for the advanced energy storage device using biomass derived porous carbon via ultrasonic coupled supercritical-CO_2 method

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Abstract

Supercapacitors (SCs) are most promising energy storage devices owing to their high specific power, fast charge–discharge characteristics, and long cycle life, enabling applications in electric vehicles, pulse power systems, and portable electronics. However, despite progress in flexible electronic technologies, most SCs still rely on rigid device architectures, which limits their integration into next-generation flexible energy systems. In this study, we report a cost-effective approach for the fabrication of flexible SC electrodes and a practical device using iron (Fe)-doped biomass-derived activated carbon (Fe-AC). The prepared materials were systematically characterized to examine their phase composition, surface morphology, and functional features. Flexible electrodes were fabricated on aluminium-grafted polyimide (Al–PI) substrates, and their electrochemical performance was evaluated using standard electroanalytical techniques. The Fe-AC@Al–PI electrode exhibited predominantly surface-controlled capacitive behavior (61.17%), with a smaller contribution from diffusion-controlled processes (38.82%). A high specific capacitance of 200.84 F g^{-1} was achieved at a current density of 0.5 A g^{-1}, along with a low charge-transfer resistance of 7.14 Ω. A symmetric flexible supercapacitor device was further assembled and operated over a wide potential window of 1.2 V, delivering an energy density of 14.89 Wh kg^{-1} and a power density of 250 W kg^{-1}. Practical feasibility was demonstrated by illuminating a 1V LED using series-connected devices. In addition, the device retained stable electrochemical behavior under bending angles of 45°, 90°, and 180°, with no noticeable distortion in the CV profiles. These results indicate that Fe-AC/Al–PI electrodes are promising candidates for flexible energy storage applications.

Keywords: Activated carbon; Flexible electrode; Iron dopant; Supercapacitor.

開發有機金屬框架Mg-MOF-74/$CuCl_2$奈米複合材料應用於自供電濕度感測器

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摘要

濕度為一項關鍵環境參數，精確監測對於半導體製造、農業及生醫應用至關重要。傳統濕度感測器通常需依賴外部電源，限制其在無電源或偏遠環境中的應用潛力。本研究開發一種基於原電池行為之電壓型自供電濕度感測器。其感測層採用氯化銅($CuCl_2$)修飾之 Mg-MOF-74，透過後合成修飾提升表面活性位點密度，進而增強水分子吸附能力。該感測層進一步結合多壁碳奈米管(MWCNTs)與紫外雷射誘導石墨烯(LIG)，構建高效導電複合網絡。透過銅與鋁所構成之非對稱電極配置，使裝置能在濕度變化下自發產生電壓訊號，無需外部電源。結果顯示，MWCNT 濃度對輸出電壓及動態響應具有關鍵影響。在最佳濃度 100 μg/mL 條件下，感測器於 94 %RH 時可達最高輸出電壓約 0.74 V，並具備快速響應與恢復時間，分別為 5.92 s 與 35.68 s。此優異表現歸因於完善之導電網絡，有效促進電荷傳輸。此外，該感測器於 11 – 94 %RH 範圍內展現穩定且可逆之電壓輸出，其遲滯效應與 15 天電壓衰減皆低於 10 %，顯示其具備良好之重現性與長期穩定性。綜上所述，本研究透過整合 MOFs 之多孔結構、導電複合材料網絡及電化學自供電機制，提出一種具潛力之設計策略，可應用於新世代可撓式、低功耗及非接觸式濕度感測器，特別適用於穿戴式裝置與物聯網系統。

關鍵字: MOF-74、氯化銅、雷射誘發石墨烯、多壁碳奈米管、自供電濕度感測器

Development of a metal–organic framework Mg-MOF-74/$CuCl_2$ nanocomposite material for application in a self-powered humidity sensor

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Abstract

Humidity is a critical environmental parameter whose accurate monitoring is essential for semiconductor manufacturing, agriculture, and biomedical applications. Conventional humidity sensors typically require external power sources, which limits their applicability in power-free or remote environments. In this study, a novel voltage-type self-powered humidity sensor based on galvanic cell behavior is developed. The sensing layer consists of $CuCl_2$-modified Mg-MOF-74, in which post-synthetic modification increases the density of surface active sites, thereby enhancing water molecule adsorption. This layer is integrated with multi-walled carbon nanotubes (MWCNTs) and UV laser-induced graphene (LIG) to construct a high-performance conductive composite network. A non-symmetric electrode configuration employing copper and aluminum enables spontaneous voltage generation driven by humidity variations, eliminating the need for external power. Optimization results indicate that the MWCNT concentration plays a critical role in determining both the output voltage and dynamic response. At an optimal concentration of 100 μg/mL, the sensor achieves a maximum output voltage of approximately 0.74 V at 94 %RH, along with a fast response time of 5.92 s and a recovery time of 35.68 s. This performance is attributed to the well-developed conductive network, which facilitates efficient charge transport. Furthermore, the device exhibits stable and reversible voltage output over a wide humidity range of 11 – 94 %RH, with both hysteresis and 15-day voltage decay maintained below 10 %, demonstrating excellent reproducibility and long-term stability. By synergistically integrating the porous structure of MOFs, conductive composite networks, and electrochemical self-powering mechanisms, this study provides a promising strategy for the development of flexible, low-power, and non-contact humidity sensors for next-generation wearable and IoT applications.

Keywords: MOF-74, $CuCl_2$, Laser-induced graphene, Multi-walled carbon nanotubes, Self-powered humidity sensor

應用於優異SERS增強與感測技術之先進MXene奈米複合材料

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摘要

本研究旨在開發一種結合天然仿生微結構與新型二維過渡金屬碳化物$Ti_3C_2T_x$ (MXene)奈米材料之高靈敏柔性表面增強拉曼散射（SERS）感測基板。本計畫利用天然蟬翼表面之高密度週期性奈米柱作為初級生物模板，透過軟影印技術進行精密之「一拓」翻模技術。此外，也利用液相剝離法製備單層和少層之MXene奈米碎片，並將其與聚乙烯醇（PVA）高分子基質進行物理混煉，配製成穩定之1 wt%複合膠體溶液。隨後於PDMS母模上完成「二拓」成膜程序，獲得具備蟬翼仿生陣列之柔性MXene/PVA複合薄膜。透過拉曼光譜分析結果顯示，在532nmCW雷射激發下，具備二拓結構之MXene基板展現出優異的訊號增強效應。實驗數據量化對比證實，仿生結構組之訊號強度顯著優於無結構之對照組。此現象歸因於雙重增強機制之協同作用：首先是蟬翼微奈米結構有效增強光的散射效應，其次是MXene材料特有的化學增強機制，透過MXene與目標分子間的電荷轉移（Charge Transfer）大幅提升了拉曼散射截面。此外，PVA的加入賦予了基板優異的機械韌性與化學穩定性，能有效減緩MXene在環境中的氧化降解。本研究成功建立了一套低成本、高重現性且具備臨床應用潛力之柔性仿生檢測平台，為未來微量農藥監測、疾病標誌物篩檢及穿戴式生醫感測器之開發奠定堅實技術基礎。

關鍵字: 表面增強拉曼散射(SERS)、$Ti_3C_2T_x$ (MXene)、仿生蟬翼結構、軟影印轉印技術、協同增強效應

Advanced MXene Nanocomposites for Superior SERS Enhancement and Sensing Technologies

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Abstract

This study aims to develop a highly sensitive and flexible surface-enhanced Raman scattering (SERS) substrate by integrating biomimetic microstructures with a two-dimensional transition metal carbide, $Ti_3C_2T_x$ (MXene). The fabrication process employs the high-density periodic nanopillar arrays of cicada wings as a primary template, transferred via a Soft-lithography replication ("first molding") technique. Furthermore, single- and few-layer MXene nanosheets were prepared by a liquid-phase exfoliation method and blended with a poly(vinyl alcohol) (PVA) matrix to form a stable 1 wt% composite colloidal solution, followed by a secondary replication ("second molding") process to obtain a flexible MXene/PVA biomimetic film. Under 532 nm laser excitation, the substrate exhibits significantly enhanced Raman signals, attributed to a dual mechanism: electromagnetic (EM) enhancement from the biomimetic nanostructure and chemical enhancement (CE) via charge transfer in MXene. Moreover, PVA encapsulation improves mechanical flexibility and chemical stability, effectively suppressing MXene oxidation and degradation. This work establishes a low-cost, highly reproducible flexible SERS platform, with strong potential for pesticide detection, biomarker sensing, and wearable biosensing applications.

Keywords: Surface-enhanced Raman scattering(SERS), $Ti_3C_2T_x$ (MXene), Biomimetic cicada wing, Soft-lithography replication, Synergistic enhancement effect

運用金屬有機骨架（MOF）複合材料，開發高效能且符合淨零排放目標之次世代氫能升級技術

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摘要

鑑於溫室氣體排放量持續攀升，氫氣作為一種永續能源已受到廣泛關注。本研究評估原始 ZIF-8 與 UiO-66 金屬有機骨架（MOF），以及 ZIF-8@氯化膽鹼（ChCl）–單乙醇胺（MEA）之 MOF 複合材料，對 CO_2 與 H_2 之吸附性能，以應用於變壓吸附（PSA）氫氣純化製程。於 263.15 K 至 323.15 K 之溫度範圍及 1 至 50 bar 之壓力條件下，進行平衡吸附實驗。此外，亦進行 H_2 與 CO_2 混合氣體之吸附實驗，以探討其競爭吸附行為。結果顯示，在所有測試條件下，CO_2 之吸附容量均顯著高於 H_2。於 263.15 K 時，ZIF-8@ChCl–MEA 之 CO_2 吸附容量最高，達 41.19 mmol/g，優於 ZIF-8（34.06 mmol/g）與 UiO-66（37.45 mmol/g），顯示其於 PSA 製程中具有強大潛力。實驗數據與 Langmuir 等溫線模型具有良好的一致性，所獲得之平衡與動力學參數進一步導入 Aspen Adsorption V14 進行 PSA 製程模擬。透過 MATLAB 遺傳演算法進行製程最佳化，於 CO_2:H_2 進料比為 0.2:0.8 之條件下，氫氣純度可達 97% 以上，回收率超過 60%，估計氫氣生產成本約為 0.7 USD/kgH_2。

關鍵字: ZIF-8、ZIF-8@ChCl–MEA、吸附、Langmuir 等溫線、儲氫

Next-Generation Upgrading H_2 using MOFs-Composites for High-Performance toward Net-Zero Emissions

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Abstract

Due to increasing greenhouse gas emissions, hydrogen has attracted significant interest as a sustainable energy source. This study investigates the adsorption capacities of CO_2 and H_2 on metal–organic frameworks (MOFs), including pristine ZIF-8, UiO-66, and the composite ZIF-8@choline chloride (ChCl)-monoethanolamine (MEA), for hydrogen purification via Pressure Swing Adsorption (PSA). Equilibrium adsorption experiments were conducted at temperatures from 263.15 to 323.15 K and pressures between 1 and 50 bar. Mixed-gas adsorption experiments of H_2/CO_2 were also performed to evaluate competitive adsorption behavior. The results showed that CO_2 exhibited significantly higher adsorption capacities than H_2 under all conditions. At 263.15 K, ZIF-8@ChCl-MEA showed the highest CO_2 adsorption capacity (41.19 mmol/g), compared with ZIF-8 (34.06 mmol/g) and UiO-66 (37.45 mmol/g), indicating strong potential for PSA applications. The experimental data were well fitted by the Langmuir model, and the obtained equilibrium and kinetic parameters were implemented in Aspen Adsorption V14 for PSA simulation. Process optimization using a genetic algorithm in MATLAB achieved hydrogen purity above 97% and recovery above 60% for a CO_2:H_2 feed ratio of 0.2:0.8, with an estimated hydrogen production cost of approximately 0.7 USD/kgH_2

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Keywords: ZIF-8, ZIF-8@ChCl-MEA, Adsorption, Langmuir isotherm, Hydrogen storage

以金屬有機框架製備MoS_2/ZnSe-$FeSe_2$ 奈米複合材料應用於卵巢癌細胞 CA-125 之經濟有效即時電化學免疫感測

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摘要

卵巢癌的早期檢測由於缺乏明確的症狀而變得困難。透過內部檢查、超音波和癌抗原125（CA-125）腫瘤指數測試的診斷至關重要。臨床上通常使用傳統的化學螢光免疫分析法來測量CA-125的濃度，然而其最低檢測極限僅為35 U mL^{-1}，可能不足以檢測早期症狀。因此迫切需要一種方法來偵測低濃度CA-125，以用於卵巢癌的診斷。全球研究團隊對快速、精確、使用方便且無創診斷工具的需求引起了極大的關注，本研究將開發一種新的奈米結構免疫感測器，用於早期檢測CA-125。

本研設計並置備低成本、快速和一次性的電化學免疫感測器技術，用於標記無標籤的CA-125檢測，使用抗體（Ab）-二硫化鉬/硒化鋅-硒化鐵（MoS_2/ZnSe-$FeSe_2$）生物共軛物。使用幾丁聚醛-戊二醛交聯化學將抗CA-125抗體吸附到MoS_2/ZnSe-$FeSe_2$修飾的玻璃碳電極（GCE）表面。隨後，通過處理牛血清蛋白（BSA-1%）來封鎖非特異性結合位點。GCE上的BSA/抗CA-125/戊二醛/幾丁/MoS_2/ZnSe-$FeSe_2$生物共軛物將用於通過分析由於抗原-抗體複合物形成而引起的峰電流響應的變化來檢測CA-125-Ag濃度的存在。為了評估修飾電極的電化學性能，使用循環伏安法（CV）、電化學阻抗譜學（EIS）和差動脈衝伏安法（DPV）技術。MoS2/ZnSe-FeSe2/GCE在CA-125檢測方面預期將表現出良好的電化學免疫感測性能，包括選擇性、穩定性、重現性和重複性，並與商業上可用的ELISA試劑進行比較。接著使用OVCAR-3卵巢癌細胞系進行體外細胞培養。將使用免疫感測技術對CA-125濃度進行連續監測癌細胞生長。此外，將使用共焦激光掃描顯微鏡進行細胞成像實驗。該研究具有基於使用MoS2/ZnSe-FeSe2的感測器設備的生物醫學應用的潛力。

關鍵字: 電化學免疫感測器；CA-125檢測；卵巢癌細胞；MoS_2/ZnSe-$FeSe_2$奈米結構；金屬有機框架

Cost-effective real-time in vitro electrochemical immunosensing of CA-125 in ovarian cancer cells using 3D Flower-like MoS2/ZnSe-FeSe2 nanostructures derived from metal-organic framework

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Abstract

Early detection of ovarian cancer is difficult due to the absence of clear symptoms. Diagnosis through internal examination, ultrasound, and the cancer antigen 125 (CA-125) tumor index test is crucial. The conventional chemical fluorescence immunoassay is typically utilized to measure the levels of CA-125. However, its lowest detection limit is merely 35 U mL^{-1}, which may not be sufficient to detect early symptoms. Therefore, an urgent need exists for a method to extract information about CA-125 for the diagnosis of ovarian cancer. The demand for rapid, precise, user-friendly, and non-invasive diagnostic tools is a subject of great interest among research groups worldwide. As a result, we propose the development of a new nanostructured immunosensor for the early detection of CA-125, a cancer biomarker.

In this study, we will design a low-cost, rapid, and disposable electrochemical immunosensor technique for label-free detection of CA-125 using an antibody (Ab)-molybdenum disulfide/zinc selenide-iron selenide (MoS_2/ZnSe-$FeSe_2$) bioconjugates. Chitosan-glutaraldehyde cross-linking chemistry is used to adsorb anti-CA-125 antibodies onto the surfaces of MoS_2/ZnSe-$FeSe_2$ modified glassy carbon electrodes (GCE). Subsequently, non-specific binding sites will be blocked by treating with bovine serum albumin (BSA-1%). The BSA/Anti-CA-125/Glut/Chit/MoS_2/ZnSe-$FeSe_2$ bio-conjugates on GCE will be utilized to check the presence of CA-125-Ag concentrations by analyzing the change in peak current response due to the antigen-antibody complex formation. To evaluate the electrochemical performances of the modified electrodes, cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and differential pulse voltammetry (DPV) techniques are used. We anticipate that the MoS_2/ZnSe-$FeSe_2$/GCE shows good electrochemical immunosensing performances for CA-125 detection, including selectivity, stability, reproducibility, and repeatability. To demonstrate the practical feasibility of the electrochemical immunosensor, human biological samples such as serum will be used, and the recovery results will be compared to those of the commercially available ELISA Kit. Nevertheless, we will utilize OVCAR-3 ovarian cancer cell lines for *in vitro* cell culture. Continuous monitoring of cancer cell growth will be done using immuno-

sensing techniques for CA-125 concentrations. Additionally, cell imaging experiments will be conducted with confocal laser scanning microscopy. This research has the potential to expand its biomedical applications based on sensing devices that use MoS_2/ZnSe-$FeSe_2$.

Keywords: Electrochemical immunosensor; CA-125 detection; Ovarian cancer cells; MoS_2/ZnSe-$FeSe_2$ nanostructures; Metal-organic framework Keywords,

【海報競賽–下午場】

海報競賽
展示時間：115 年 6 月 2 日 (二) 13:00-15:15
展示地點：國立臺北科技大學億光大 3 樓艾爾法廳(301)

下午場評審 萬芳醫院 姚智榮行政副主任 國立臺北科技大學 陳錦文副教授		
海報展示目錄		
海報編號	計畫題目	雙邊計畫主持人
23	鎳修飾 $Cu_2Y_2O_5$ 奈米纖維塗層電極於高效析氧反應之應用	臺北科技大學–邱德威特聘教授 日本東北大學–殷澍教授 報告者：材料所 博一 Aishwarya Naik
24	Al-Cu-Fe 準晶顆粒用於製造金屬基複合材料之可行性及界面相穩定性探討	臺北科技大學–林哲宇副教授 日本東北大學–亀岡聡教授 報告者：製科所 碩一 陳泓翰
25	用於電化學能源和環境建模的生物質衍生催化劑研發	臺北科技大學–陳映竹教授 日本東北大學–笘居高明教授 報告者：土木系 研究助理教授 Manjula Natesan
26	設計可解釋的機器學習方法來評估 3D 列印不同晶格結構對疲勞反應的影響	臺北科技大學–江卓培特聘教授 波蘭格但斯克科技大學–Wojciech Macek 教授
27	評估利用電泳沉積塗層複合材料於鈦合金表面的骨植入物之生物特性和滅菌效應	臺北科技大學–方旭偉特聘教授 波蘭格但斯克科技大學–Łukasz Pawłowski 助理教授 報告者：化工所 碩一 簡筠恩
28	利用雷射粉末床融合開發基於 TPMS 的散熱結構：模擬與實驗研究	臺北科技大學–陳紅章助理教授 布拉格捷克理工大學–Libor Beránek 教授 報告者：機電所 碩二 邱鈺傑
29	鈷-鐵甘油酸鹽雙金屬助催化劑應用於釩酸鉍光陽極以改善電荷轉移和光電化學催化水氧化能力	臺北科技大學–林律吟教授 布拉格捷克理工大學–Ing. Karel Roubik 教授 報告者：化工所 碩一 盧奕安
30	使用缺陷碳奈米結構的雜原子：探討性能和高級應用技術	臺北科技大學–陳映竹教授 立陶宛維爾紐斯科技大學–Aušra Maeikien 教授 報告者：土木系 研究助理教授 Manjula Natesan
31	開發瓦級氮化鎵功率放大器及 CMOS 鎖相迴路設計	臺北科技大學–王紳教授 立陶宛維爾紐斯科技大學–Vaidotas Barzdenas 教授 報告者：電子系 碩二 彭彥穎

海報編號	計畫題目	雙邊計畫主持人
32	開發一種基於活性、具比率型(ratiometric)電化學訊號的底物,用於在全血樣本中感測循環血液生物標誌物二肽基肽酶-IV(DPP-IV/CD26)	臺北科技大學–黃聲東特聘教授 立陶宛維爾紐斯科技大學 –Inga Morkvnait Vilkonien 副教授 報告者：化工系 P Arul 研究助理教授
33	發展層狀複金屬氫氧化物做為光觸媒轉化二氧化碳成 C1 化學的研究	臺北科技大學–楊重光特聘教授 立陶宛維爾紐斯大學–Aivaras Kareiva 教授 報告者：化工系 博一 Olzhas Shalkhar
34	具金融倫理與金融科技應用的 AI 原則	臺北科技大學–鄭麗珍教授 立陶宛維爾紐斯大學–Hashimoto Tomoyuki 副教授 報告者：資財系 碩一 吳姿穎
35	以單渦旋和多渦旋光束研究磁性材料中的非線性光學效應	臺北科技大學–董容辰副教授 美國紐澤西理工學院–Andrei Sirenko 教授 報告者：光電系 碩二 曹澤夫
36	基於光交聯三元聚合物共混物之高效率互補式反向器	臺北科技大學–李文亞教授 美國辛辛那堤大學–Yeongin Kim 助理教授 報告者：化工所 碩一 劉秀一
37	PDVT-10/DTCP 混合薄膜的形貌控制:透過彎月面引導塗佈法建構應用於次世代生物感測器之設計型類液晶材料平台	臺北科技大學–陳秀慧教授 美國賓州州立大學- Ebrahimi, Aida 副教授 報告者：分子系 碩一 何彥佑
38	溶液剪切結合 SBS 添加劑與製程最佳化提升 PDVT-10 有機場效電晶體之應變誘導遷移率	臺北科技大學–李文亞教授 美國賓州州立大學 - Seong H. Kim 特聘教授 報告者：化工所 碩一 蕭涵宇
39	用於低溫共燒陶瓷(LTCC)應用的高熵玻璃陶瓷的特性分析	臺北科技大學–王錫福特聘教授 美國賓州州立大學- Lanagan, Michael, Thomas 教授 報告者：材料所 博三 Anushka Sanjeewani Rathnayake
40	透過多層透明混合膜實現光譜選擇性收集熱能應用於能源中性建築結構	臺北科技大學–楊詠菠助理教授 美國辛辛那提大學–Donglu Shi 教授 報告者：材資系 三年級 羅鈺雯
41	利用原位 NAP-XPS 與拉曼光譜探討 CoP 在中性與鹼性環境下電化學硝酸鹽還原生成氨的反應機制	臺北科技大學–張裕煦教授 日本九州大學–Tsuyohiko Fujigaya 教授 報告者：化工所 碩二 Supapitch Kositsarakhom
42	供體-受體-供體有機染料混合薄膜的放大自發性輻射研究	臺北科技大學–林家弘特聘教授 日本九州大學–安達千波矢教授 報告者：光電系 博一 魏心怡
43	2,2':6',2''-三吡啶相關的鐵鈷金屬錯合物的合成與理論計算	臺北科技大學–許益瑞教授 日本大阪大學–Yasutaka Kitagawa 教授 報告者：分子系 三年級 陳佑為

鎳修飾 $Cu_2Y_2O_5$ 奈米纖維塗層電極於高效析氧反應之應用

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摘要

高效能的析氧反應（Oxygen Evolution Reaction）電催化劑對於以水電解製氫技術而言是不可或缺的。在本研究中，藉由靜電紡絲及熱處理法成功合成 $Cu_2Y_2O_5$ 奈米纖維，並進一步與鎳（Ni）奈米粒子結合，製備成複合塗層電極。X 射線繞射（XRD）分析證實形成結晶性 $Cu_2Y_2O_5$ 的，而掃描式電子顯微鏡與能量散射分析（SEM–EDAX）顯示出連續的奈米纖維網絡結構，且 Ni 均勻分散於其中。電化學量測結果顯示，相較於單一材料，該複合電極具有更優異的析氧反應性能。線性掃描伏安法（LSV）顯示在 10 $mAcm^{-2}$ 電流密度下具有較低的過電位，而 Tafel 分析則指出其反應動力學有所提升。電化學阻抗分析（EIS）顯示電荷轉移電阻降低，這與 Ni 的導入提升導電性相一致。此外，定電流測試（Chronopotentiometry）證實該電極在穩定電流條件下具有良好的操作穩定性。此優異性能主要歸因於奈米纖維結構提供較大的比表面積，以及 Ni 活性位點的存在，有助於促進析氧反應動力學與電荷傳輸。因此，本研究結果支持 Ni 修飾 $Cu_2Y_2O_5$ 奈米纖維複合材料作為高效析氧反應電催化劑的潛力。

關鍵字：$Cu_2Y_2O_5$ 奈米纖維、析氧反應（OER）、電紡技術、電催化、複合電極

Ni-Decorated $Cu_2Y_2O_5$ Nanofiber Coated Electrodes for High-Performance Oxygen Evolution Reaction

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Abstract

Efficient oxygen evolution reaction (OER) electrocatalysts are required for water electrolysis–based hydrogen production. In this work, $Cu_2Y_2O_5$ nanofibers were synthesized via electrospinning-assisted thermal treatment and subsequently integrated with Ni nanoparticles to form composite-coated electrodes. X-ray diffraction (XRD) confirms the formation of crystalline $Cu_2Y_2O_5$, while SEM–EDAX analysis shows a continuous nanofiber network with well-dispersed Ni species. Electrochemical measurements indicate improved OER performance compared to individual components. Linear sweep voltammetry shows a lower overpotential at 10 mA cm^{-2}, and Tafel analysis indicates enhanced reaction kinetics. Electrochemical impedance spectroscopy (EIS) reveals a reduced charge-transfer resistance, consistent with improved conductivity from Ni incorporation. Chronopotentiometry demonstrates stable operation under constant current conditions. The observed performance is attributed to the nanofiber morphology, which increases accessible surface area, and the presence of Ni active sites that facilitate OER kinetics and charge transfer. These results support the use of Ni-decorated $Cu_2Y_2O_5$ nanofiber composites as OER electrocatalysts.

Keywords: $Cu_2Y_2O_5$ nanofibers, Oxygen evolution reaction (OER), Electrospinning, Electrocatalysis, Composite electrodes

Al-Cu-Fe 準晶顆粒用於製造金屬基複合材料之可行性及界面相穩定性探討

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摘要

將準晶（Quasicrystal）強化相引入鋁基複合材料（AMCs）是提升結構性能的一種極具潛力的途徑。本研究旨在探討透過超音波固結 (UC) 與摩擦攪拌製程 (FSP) 之技術，製造 Al-Cu-Fe (QCp) 強化鋁基複合材料的製程可行性及力學性能。研究系統性地分析了強化相種類（QCp 與 Al_2O_3p）、製程參數以及體積分率 對接合完整性的影響。

透過 SEM 與 EDS 的微結構分析顯示，相較於傳統的 Al_2O_3 陶瓷顆粒，QCp 與鋁基材之間具有更優異的潤濕性與金屬鍵結合，能形成更緻密的強化層。力學測試結果表明，優化的 3° 工具傾角與 1400 rpm 的高轉速顯著提升了材料的塑性流動與顆粒分散效果。實驗數據顯示，當體積分率為 13% 時，接頭展現出最佳的抗拉強度與延展性平衡，且微硬度峰值達到 140 HV，較基材提升了 40%。相對地，當體積分率過高達到 39% 時，會導致顆粒團聚並使強度大幅下降。研究結果證實，利用塑性流動製程開發 Al-Cu-Fe 準晶強化鋁基複合材料具有極高的應用價值。

關鍵字： 摩擦攪拌製程、超音波固結、鋁基複合材料、Al-Cu-Fe 準晶

Feasibility and Interfacial Phase Stability of Al-Cu-Fe Quasicrystal Particles for Fabrication of Metal Matrix Composites

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Abstract

Integrating quasicrystal reinforcements into aluminum matrix composites (AMCs) presents a promising route for enhancing structural performance. This study investigates the manufacturing feasibility and mechanical properties of **Al-Cu-Fe (Qc_p)** reinforced aluminum composites produced via a combined approach of **Ultrasonic Consolidation (UC)** and **Friction Stir Processing (FSP)**. The influence of reinforcement type (**Qc_p** vs. **Al_2O_{3p}**), processing parameters and volume fraction on the FSP integrity were systematically examined.

Microstructural analysis via SEM and EDS revealed that **Qc_p** provides superior **wettability** and **metallic bonding** compared to traditional **Al_2O_{3p}** ceramic particles, resulting in a denser reinforcement layer. FSP mechanical testing demonstrated that an optimized **3° tool tilt angle** and a rotational speed of **1400 rpm** significantly improved material consolidation and particle dispersion. Results exhibited that a volume fraction of **13%** yielded the highest tensile strength and a peak microhardness of **140 HV**, which is 40% higher than the base metal. In contrast, exceeding this limit to **39%** volume fraction led to particle clustering and a substantial drop in strength.

These findings highlight the potential of Al-Cu-Fe quasicrystals in developing high-strength aluminum matrix composites through plastic flow processing.

Keywords: Friction Stir Processing, Ultrasonic Consolidation ,Aluminum Matrix Composite, Al-Cu-Fe Quasicrystal.

用於電化學能源和環境建模的生物質衍生催化劑研發

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摘要

生質殘渣為先進電催化材料提供了具永續性的前驅物來源。本研究以蒜皮為原料，轉製成富含缺陷之介孔碳材料，並進一步負載單金屬（Ni/C、Co/C、Fe/C）及雙金屬（NiFe/C、CoNi/C、CoFe/C）奈米結構，用於鹼性氧析出反應（OER）。經由碳化與活化處理，可形成具亂層（turbostratic）sp^2碳骨架與良好可接近性的介孔結構；而金屬導入則透過催化活化作用進一步促進孔隙發展。材料之結構與表面化學特性透過XRD與XPS進行系統性分析，形貌與金屬分散性則以FESEM與TEM觀察。氮氣吸附–脫附（BET）結果顯示，在金屬負載後，比表面積與介孔體積皆明顯提升，有助於改善質傳效率。在1 M KOH電解液中的電化學測試顯示，所有金屬/碳複合材料的表現皆優於純碳材料；在單金屬催化劑中，以Ni/C展現最低過電位，而在雙金屬系統中，Fe有助於促進Ni的氧化還原轉變。NiFe/C催化劑展現最佳反應動力學（於25 mA cm^{-2}電流密度下，最低過電位為290 mV）及優異的循環穩定性，其優異性能歸因於原位生成之Ni(Fe)OOH奈米相，與導電碳骨架之間具有強烈界面耦合。本研究展示了一種簡單且具可規模化潛力的方法，能將廢棄生質資源轉化為高效且穩定的OER陽極材料，並透過高密度單金屬與雙金屬氧氫化物奈米結構及其強界面耦合效應，大幅提升催化效能。

關鍵字： 生物質衍生催化劑、氧析出反應、介孔碳、金屬氧氫化物、界面耦合

Biomass-Derived Catalysts for Electrochemical Energy and Environmental Modeling

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Abstract

Biomass residues offer sustainable precursors for advanced electrocatalysts. In this work, garlic peel is converted into defect-rich mesoporous carbon and used to host single-metal (Ni/C, Co/C, Fe/C) and bimetallic (NiFe/C, CoNi/C, and CoFe/C) nanodomains for the alkaline oxygen evolution reaction (OER). Carbonization/activation yields a turbostratic sp^2 carbon framework with accessible mesoporosity, while metal incorporation promotes additional pore development through catalytic activation. The structure and surface chemistry were systematically examined by XRD and XPS, while morphology and dispersion were evaluated by FESEM and TEM. N_2 adsorption–desorption (BET) confirms increased surface area and mesopore volume after metal loading, supporting improved mass transport. Electrochemical tests in 1 M KOH show that all metal–carbon composites outperform bare carbon; among single-metal catalysts, Ni/C exhibits the lowest overpotential, and Fe promotes the Ni redox transition in bimetallic systems. The NiFe/C catalyst delivers the best kinetics (lowest overpotential 290 mV cm for 25 mA cm^{-2}) and stable cycling, attributed to the in-situ formation of Ni(Fe)OOH nanophases strongly coupled to the conductive carbon scaffold. This study demonstrates a simple, scalable route to transform waste biomass into efficient and robust OER anode materials via high-density single- and dual-metal oxyhydroxide nanodomains with strong interfacial coupling.

Keywords: Biomass-derived catalysts, Oxygen Evolution Reaction, OER , Mesoporous carbon, Metal oxyhydroxides, Interfacial coupling.

設計可解釋的機器學習方法來評估 3D 列印不同晶格結構對疲勞反應的影響

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摘要

本計畫旨在開發機器學習模型，預測表面型鑲嵌晶格結構的疲勞反應。此類仿生結構可分為邊對邊（Edge-to-Edge, ETE）、非邊對邊（Non-Edge-to-Edge, NETE）與重疊型（overlapping），不同型態會影響載荷傳遞與結構性能。

本研究使用多層感知機（multi-layer perceptron, MLP）模型，針對單位晶格高度、單位晶格寬度、殼層厚度與鑲嵌距離四項設計參數進行最佳化，以獲得較高的彈性模數。彈性模數與疲勞載荷下的裂紋尖端張開位移（crack-tip opening displacement, CTOD）呈反比，因此會影響結構抵抗裂紋成長的能力。

研究中將系統性改變上述參數以建立資料集，並用於訓練 MLP 模型。訓練後，模型將以獨立測試資料進行驗證，並與有限元素分析（finite element analysis, FEA）結果比較，以評估預測準確性。同時，將採用 Shapley 加法解釋法（Shapley additive explanations, SHAP）分析各參數對預測結果的影響。

最後，表現最佳的設計將以 IN-718 材料透過雷射粉末床熔融技術（laser powder bed fusion, L-PBF）製作，並進行疲勞測試。本研究目標是建立可靠的疲勞預測與設計最佳化工具，以提升鑲嵌晶格結構的性能。

此外，本研究也將探討製程參數、疲勞壽命與斷裂表面形貌之間的關係，並找出可表徵斷裂行為的參數，以分析不同載荷條件下的裂紋形成與擴展機制。

關鍵字：

晶格結構、機器學習、裂紋尖端張開位移、有限元素分析、Inconel 718 鎳基超合金

Design of an interpretable machine learning approach to evaluate the fatigue response of 3D printed tessellation lattice structures

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Abstract

This project aims to develop a machine-learning model to predict the fatigue response of surface-based tessellation lattice structures. These nature-inspired structures are categorized into Edge-to-Edge (ETE), Non-Edge-to-Edge (NETE), and overlapping types, each affecting load transfer and structural performance differently. The focus is on using a multi-layer perceptron (MLP) model to optimize four key design parameters - unit cell height, unit cell width, shell thickness, and tessellation distance - to achieve the highest elastic modulus. Elastic modulus is crucial because it inversely relates to crack-tip opening displacement (CTOD) under fatigue, affecting the structure's resistance to crack growth. The project involves generating a large dataset by varying these parameters and using it to train the MLP model. This model will then be tested on a separate dataset (test data) to evaluate its accuracy compared to finite element analysis (FEA) results. Shapley additive explanations (SHAP) will be used to understand the impact of each parameter on the predictions. Finally, the best-performing designs will be fabricated using laser-powder bed fusion technology with IN-718 material and subjected to experimental fatigue tests. The goal is to enhance the design and performance of tessellation lattice structures by providing a reliable tool for predicting and optimizing their fatigue resistance. In addition, the relationship between the fabrication process parameters, fatigue resistance, and fracture surface topography will be investigated. Parameters characterizing fracture and providing support in the search for cracking mechanisms under various load conditions will be discovered.

Keywords: Lattice structures, machine learning, crack-tip opening displacement, finite element analysis, Inconel 718

評估利用電泳沉積塗層複合材料於鈦合金表面的骨植入物之生物特性和滅菌效應

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摘要

植入物周圍組織的細菌感染是導致植入手術失敗的主要原因之一，因此開發兼具抗菌與促進骨整合能力的功能性塗層已成為生醫材料研究的重要方向。本研究利用電泳沉積法，成功於 Ti-13Nb-13Zr 合金表面製備以幾丁聚醣、介孔生物活性玻璃奈米粒子（MBGNPs）及銀奈米粒子（AgNPs）為基礎之多功能複合塗層，並分別加入 Eudragit E100（EE100）與 poly(4-vinylpyridine)（P4VP）兩種高分子材料，以調控塗層之理化特性與生物性能。研究結果顯示，所製備之 MBGNPs 具有均勻球形與孔隙結構，兩種塗層皆形成厚度約 10 μm、均勻且具孔隙性的表面，並展現良好附著力。根據表面分析之結果， CS/EE100 塗層呈疏水性，而 CS/P4VP 塗層則具有較高親水性與表面張力，進而提升其電化學活性與離子釋放能力。離子釋放測試顯示，CS/P4VP 系統於酸性環境下具有較高的銀離子釋放量，同時可調控鈣離子釋放行為。抗菌實驗證實，兩種塗層皆對大腸桿菌與金黃色葡萄球菌具有顯著抑菌效果，其中對革蘭氏陽性菌之抑制效果略佳。細胞相容性測試顯示，CS/P4VP/MBGNPs/AgNPs 塗層具有較高銀離子釋放量，仍能維持超過 80% 的細胞存活率，並保有良好的鹼性磷酸酶表現，顯示其具備促進成骨生成特性。綜合而言，以 P4VP 為基礎之複合塗層在抗菌性能、可控離子釋放與細胞相容性之間展現較佳平衡，具有作為先進植入物表面修飾材料之潛力。

關鍵字：複合塗層、電泳沉積法、智慧聚合物、植入物

Evaluation of biological properties and effects of selected sterilization techniques on electrophoretically deposited composite coatings on titanium alloy for bone implant applications

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Abstract

Bacterial infection surrounding peri-implant tissues is one of the major causes of implant failure, making the development of multifunctional antibacterial coatings with osteointegration capability an important topic in biomedical materials research. In this study, multifunctional composite coatings based on chitosan (CS), mesoporous bioactive glass nanoparticles (MBGNPs), and silver nanoparticles (AgNPs) were successfully deposited onto Ti-13Nb-13Zr alloy substrates using electrophoretic deposition (EPD). Two different polymer systems, Eudragit E100 (EE100) and poly(4-vinylpyridine) (P4VP), were incorporated to tailor the physicochemical and biological properties of the coatings. The synthesized MBGNPs exhibited a uniform spherical morphology and mesoporous structure, while both coatings formed homogeneous porous layers approximately 10 μm thick with good adhesion strength. Surface characterization revealed that the CS/EE100 coating displayed hydrophobic behavior, whereas the CS/P4VP coating exhibited enhanced hydrophilicity and higher surface energy, resulting in increased electrochemical activity and ion-release capability. Ion-release studies demonstrated controlled calcium release from MBGNPs and significantly higher silver ion release from the CS/P4VP system under acidic conditions.

Antibacterial assays confirmed that both coatings showed strong antibacterial activity against Escherichia coli and Staphylococcus aureus, with slightly higher efficacy against Gram-positive bacteria. Cytocompatibility studies indicated that the CS/P4VP/MBGNPs/AgNPs coating maintained high cell viability (>80%) despite increased Ag^{+} release, while also sustaining alkaline phosphatase (ALP) expression, suggesting favorable osteogenic activity. Overall, the P4VP-based composite coating demonstrated a superior balance between antibacterial performance, controlled ion release, and cytocompatibility, highlighting its potential for advanced biomedical implant surface applications.

Keywords: Composite coating、Electrophoretic method、Smart biopolymers、Implant

利用雷射粉末床融合開發基於 TPMS 的散熱結構：模擬與實驗研究

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摘要

在製造過程中，溫度控制為一關鍵因素，直接影響產品品質與設備壽命。所謂隨形冷卻通道（conformal cooling channels），係指其流道設計可貼合元件幾何輪廓，相較於傳統線性冷卻通道，能提供更均勻且穩定之散熱機制。進一步將三重週期最小曲面（Triply Periodic Minimal Surface, TPMS）結構導入冷卻通道中，可有效增加流體與壁面之接觸面積，並提升流動擾動程度，從而增強對流熱傳係數。然而，基於 TPMS 之隨形冷卻通道在設計最佳化上仍具挑戰性，主因在於其設計評估通常需針對不同候選幾何反覆進行計算流體力學（Computational Fluid Dynamics, CFD）模擬。此種反覆設計與評估之流程不僅提高計算成本，亦限制設計空間之快速探索。此外，針對應用於隨形冷卻之薄壁與傾斜 AlSi10Mg 結構，其在雷射粉床熔融（Laser Powder Bed Fusion, L-PBF）製程下之可製造性限制，迄今仍缺乏系統性量化分析。為彌補上述研究缺口，本研究於國立臺北科技大學建立一套整合 CFD 模擬、人工神經網路（Artificial Neural Network, ANN）代理模型，以及 L-PBF 實驗之最佳化架構。該架構之主要目標，在於降低熱性能預測之計算成本，同時將 L-PBF 製程之可製造性限制納入設計考量。研究結果顯示，所建構之 ANN 模型可準確預測熱傳係數，顯著減少對重複 CFD 模擬之依賴。另一方面，於捷克布拉格理工大學(Czech Technical University in Prague）進行 L-PBF 製程實驗與高精度量測，並以 153 組 AlSi10Mg 試片建立製程可製造性限制條件。量測結果顯示，名義壁厚為 0.4 mm 之結構可穩定製作，而低於 0.3 mm 之壁厚則可視為 L-PBF 製程之實務下限。

關鍵字：Conformal cooling, TPMS, CFD simulation, ANN model, L-PBF

Development of TPMS-Based Heat Dissipation Structures using Laser Powder Bed Fusion: Simulation and Experimental Study

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Abstract

In manufacturing processes, temperature control is a critical factor that directly affects product quality and equipment lifespan. Conformal cooling channels, which are fluid conduits designed to mirror the contours of a given component, offer a more consistent mechanism for heat dissipation when compared to traditional, linear channels. Integrating TPMS structures into cooling channels increases the contact surface area and enhances flow turbulence, thereby improving the heat transfer coefficient. Despite these advantages, the optimization of TPMS-based conformal cooling channels remains challenging because it typically requires repeated CFD evaluations for different design candidates. This iterative design–evaluation process increases the computational cost and limits rapid design exploration. In addition, the manufacturability limits of L-PBF for the specific thin-walled and inclined AlSi10Mg features used in conformal cooling applications remain insufficiently quantified. To address this research gap, an optimization framework integrating CFD simulation, ANN surrogate modeling, and L-PBF experimentation was developed at National Taipei University of Technology. The main objective of this framework is to reduce the computational cost of thermal-performance prediction while incorporating L-PBF manufacturability constraints into the design process. The results demonstrate that the ANN model can accurately predict the heat transfer coefficient, reducing the need for repeated CFD evaluations. In parallel, L-PBF experiments and high-fidelity measurements were conducted at Czech Technical University in Prague using 153 AlSi10Mg specimens to define manufacturability constraints for the framework. The measurements show that a nominal wall thickness of 0.4 mm can be reliably achieved, whereas thicknesses below 0.3 mm represent a practical limitation of the L-PBF process.

Keywords: Conformal cooling, TPMS, CFD simulation, ANN model, L-PBF

鈷-鐵甘油酸鹽雙金屬助催化劑應用於釩酸鉍光陽極以改善電荷轉移和光電化學催化水氧化能力

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摘要

釩酸鉍($BiVO_4$，BVO)因其合適的帶隙和有利的能帶邊緣位置，是一種很有前景的光電化學(PEC)水分解中析氧反應(OER)光陽極材料。然而，其催化活性受限於緩慢的界面電荷轉移和載子複合。本研究引進非晶態雙金屬鈷鐵甘油酸鹽(CoFe-G)作為助催化劑，以提高BVO的PEC性能。採用甘油輔助法合成了尺寸和負載量可調的CoFe-G，並將其沉積在BVO上。在所有組分中，CoFe1.0-G/BVO光陽極表現出最佳性能，在1.23 V vs. RHE下實現了2.19 mA/cm^2的光電流密度和優異的電荷轉移效率。作為對比，本研究也製備了單金屬Co-G/BVO和Fe-G/BVO光陽極。雙金屬CoFe-G/BVO系統相比單金屬系統展現出協同優勢，包括更高的載子濃度、更優的電荷分離和更低的界面電阻。結構和光譜分析證實了助催化劑的非晶態性質及其與BVO的良好相互作用。CoFe1.0-G/BVO光陽極在連續運轉4.5小時後仍能維持初始光電流的59%，表現出良好的運轉穩定性。本研究強調了雙金屬甘油酸鹽助催化劑在提升BiVO4基光陽極光電化學性能的潛力，可用於高效穩定的水氧化反應。

關鍵字：$BiVO_4$；雙金屬甘油酸鹽；助催化劑；析氧反應；光電化學水分解

Engineering Bimetallic Cobalt–Iron Glycerate Co-Catalysts on Bismuth Vanadate for Improved Charge Transfer and Photoelectrochemical Catalytic Water Oxidation

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Abstract

Bismuth vanadate ($BiVO_4$, BVO) is a promising photoanode material for the oxygen evolution reaction (OER) in photoelectrochemical (PEC) water splitting due to its suitable bandgap and favorable band edge positions. However, its catalytic activity is limited by sluggish interfacial charge transfer and carrier recombination. In this work, amorphous bimetallic cobalt–iron glycerate (CoFe-G) is introduced as a co-catalyst to enhance the PEC performance of BVO. CoFe-G with tunable size and loading is synthesized via a glycerol-assisted method and deposited onto BVO. Among all compositions, the CoFe1.0-G/BVO photoanode exhibits the best performance, achieving a photocurrent density of 2.19 mA/cm^2 at 1.23 V vs. RHE and superior charge-transfer efficiency. For comparison, monometallic Co-G/BVO and Fe-G/BVO photoanodes are also prepared. The bimetallic CoFe-G/BVO system shows synergistic advantages over single-metal systems, including enhanced carrier density, improved charge separation, and lower interfacial resistance. Structural and spectroscopic analyses confirm the amorphous nature of the co-catalysts and favorable interaction with BVO. The CoFe1.0-G/BVO photoanode also maintains 59% of its initial photocurrent after 4.5 hours of continuous operation, demonstrating good operational stability. This study highlights the potential of bimetallic glycerate co-catalysts in boosting the PEC performance of $BiVO_4$-based photoanodes for efficient and stable water oxidation.

Keywords: $BiVO_4$; bimetallic glycerate; co-catalyst; oxygen evolution reaction; photoelectrochemical water splitting

使用缺陷碳奈米結構的雜原子：探討性能和高級應用技術

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摘要

生質衍生碳材料為開發高效率且低成本的潔淨能源轉換電催化劑提供了具永續性的理想平台。本研究以廢棄蒜皮為原料，透過水熱處理、氮氣氣氛下碳化以及 KOH 活化，成功製備具階層式孔結構之多孔活性碳材料。後續進行氮（N）與鈷（Co）共摻雜，以調控材料之電子結構並引入氧析出反應（OER）所需之活性位點。結構與表面分析結果顯示，所得材料具有部分石墨化之碳基體，並富含缺陷、高比表面積及發達之微孔/介孔結構，這些特性有利於電解液擴散、電荷傳輸以及活性位點之暴露。於所有製備材料中，以氮、鈷共摻雜之多孔碳展現最佳 OER 性能，在鹼性條件下於 10 mA cm^{-2} 電流密度時，其過電位為 340 mV，Tafel 斜率為 162 mV dec^{-1}，並具良好的電化學穩定性。其性能提升主要歸因於氮摻雜所引發之電子結構調變效應，與鈷基活性中心於缺陷豐富之多孔碳網絡中的協同作用。本研究展示了一種有效的廢棄物高值化策略，成功將蒜皮轉化為高效電催化材料，並凸顯生質來源之異質原子/金屬共摻雜碳材料於永續鹼性水電解應用中的潛力。.

關鍵字： 蒜皮衍生碳、氮鈷共摻雜、階層式孔結構、氧析出反應、電子結構調變

Heteroatom engineered using defective carbon nanostructures: Implications for properties and advanced applications

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Abstract

Biomass-derived carbon materials provide a sustainable platform for developing efficient and low-cost electrocatalysts for clean-energy conversion. In this work, waste garlic peel was valorized into porous activated carbon through hydrothermal treatment, carbonization under N_2, and KOH activation to construct a hierarchical porous framework. Subsequent nitrogen (N) and cobalt (Co) doping was employed to tune the electronic structure and generate catalytically active sites for the oxygen evolution reaction (OER). Structural and surface analyses revealed a partially graphitized carbon matrix with abundant defects, high surface area, and well-developed micro/mesoporosity, all of which are favorable for electrolyte diffusion, charge transport, and active-site exposure. Among the prepared materials, the N,Co co-doped porous carbon exhibited the best OER performance in alkaline medium, delivering an overpotential of 340 mV at 10 mA cm^{-2}, a Tafel slope of 162 mV dec^{-1}, and good electrochemical stability. The enhanced activity is attributed to the synergistic effect of N-induced electronic modulation and Co-based active centers within the defect-rich porous carbon network. This study demonstrates an effective waste-to-value strategy for transforming discarded garlic peel into high-value electrocatalysts and highlights the potential of biomass-derived heteroatom/metal co-doped carbons for sustainable alkaline water electrolysis.

Keywords: Garlic peel-derived carbon, N,Co co-doping, Hierarchical porous framework , Oxygen Evolution Reaction, OER, Electronic structure modulation.

開發瓦級氮化鎵功率放大器及CMOS鎖相迴路設計

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摘要

本計劃設計採用 180nm CMOS 製程，實現一組應用於 X 頻段的鎖相迴路（PLL）。其核心電路為具備負跨導增強（*gm*-boosted）技術之堆疊式壓控振盪器（VCO），透過變壓器之磁耦合特性與交叉耦合堆疊電晶體結構，在不增加功耗的情況下有效補償諧振腔損耗並提升輸出擺幅。該 VCO模擬結果顯示其輸出頻率達 9.02 GHz（調諧範圍為 8.8 至 9.29 GHz），核心功耗僅 6.9 mW，於 1 MHz 偏移頻率下之相位雜訊達 -110.24 dBc/Hz。系統整合高速電流模式邏輯除頻器 CML(Current Mode Logic Divider)與真單相時鐘邏輯級 TSPC（True Single Phase Clock logic stage），整體鎖相迴路之鎖定時間為 2.7 μs。本設計具備高頻、低相位雜訊與低功耗與等特性，適用於 X 頻段雷達或衛星通訊之頻率合成核心元件。

關鍵字：
壓控振盪器（VCO）、鎖相迴路（PLL）、負跨導增強、低相位雜訊、低功耗

Development of Watt-level GaN Power Amplifiers and CMOS PLLs

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Abstract

This project employs an 180nm CMOS process to implement a phase-locked loop (PLL) for X-band applications. Its core circuit is a stacked voltage-controlled oscillator (VCO) featuring gm-boosted technology. By utilizing the magnetic coupling characteristics of transformers and a cross-coupled stacked transistor structure, it effectively compensates for resonator losses and enhances output swing without increasing power consumption. Simulation results for this VCO show an output frequency of 9.02 GHz (with a tuning range of 8.8 to 9.29 GHz), a core power consumption of only 6.9 mW, and phase noise of -110.24 dBc/Hz at a 1 MHz offset frequency. The system integrates a high-speed current-mode logic divider (CML) and a true single-phase clock logic stage (TSPC), with an overall phase-locked loop (PLL) lock time of 2.7 μs. This design features high frequency, low phase noise ,and low power consumption, making it suitable as a core frequency synthesis component for X-band radar or satellite communications.

Keywords: VCO, PLL, Negative Transconductance Enhancement, Low-Phase Noise, Low-Power Consumption.

開發一種基於活性、具比率型（ratiometric）電化學訊號的底物，用於在全血樣本中感測循環血液生物標誌物二肽基肽酶-IV（DPP-IV/CD26）

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摘要

二肽基肽酶（DPP-IV）是一種重要的循環血液生物標誌物，可用於診斷胰臟癌、甲狀腺癌以及第二型糖尿病。目前的 DPP-IV 檢測方法雖展現出潛力，但在全血樣本檢測方面仍存在限制，通常需要繁瑣的樣本前處理程序，因而不利於即時檢測。為了克服這一挑戰，我們設計了一種針對 DPP-IV 的電化學探針 DPPLPOH，並結合電化學分析方法，使其能夠在複雜的生物流體（如全血）中進行直接且便捷的檢測。DPPLPOH 可被 DPP-IV 選擇性水解，隨後探針發生自裂解（self-immolative）反應，釋放出被遮蔽的電化學敏感胺基二茂鐵報導分子（AFOH）。該針對 DPP-IV 的電化學分析工具展現出優異的感測性能，具備卓越的酵素結合能力。DPPLPOH 探針具有高靈敏度、高選擇性以及寬廣的線性檢測範圍（0.1–100 ng/mL），同時檢測下限低至 0.021 ng/mL。此外，該探針能精準辨識 DPP-IV，不受其他具電活性物質、酵素或水解酶的干擾。更重要的是，DPPLPOH 能夠即時監測腫瘤細胞表面的 DPP-IV 活性，並可在無需繁瑣分離程序的情況下，直接追蹤全血中的 DPP-IV 活性。我們所設計的 DPP-IV 活性感測方法具備優異的應用潛力，有望用於胰臟癌與甲狀腺癌的早期診斷以及治療後的監測。

關鍵字:
二肽基肽酶（DPP-IV）、胰臟癌、自裂解（self-immolative）反應、電化學探針

Developing an activity-based ratiometric electrochemical substrate for sensing circulating blood biomarker of Dipeptidyl Peptidase-IV/CD26 in whole blood samples

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Abstract

Dipeptidyl peptidase (DPP-IV) is a vital circulating blood biomarker for diagnosing pancreatic and thyroid cancers, as well as Type 2 diabetes. Currently, DPP-IV detection methods show promise but have limitations toward whole blood sensing without a tedious sample pre-treatment process, which makes it difficult for real-time detection. To overcome this challenge, we designed a DPP-IV targeted electrochemical probe DPPLPOH, coupled with electrochemical analytical method enabling direct and convenient sensing of DPP-IV in complex biofluid whole blood samples. DPPLPOH was selectively hydrolyzed by DPP-IV, and the probe underwent a self-immolative reaction to eject a masked electrochemical sensitive amino ferrocene reporter (AFOH). Our electrochemical analytical tool against DPP-IV demonstrated excellent sensing performance, characterized by exceptional enzyme binding properties, DPPLPOH probe offers superior sensitivity, selectivity, and a broad linear detection range of 0.1-100 ng/mL, along with a low detection threshold of 0.021 ng/mL. The probe accurately targeted DPP-IV without interference from other electroactive species, enzymes, and hydrolases. Furthermore, DPPLPOH enabled real-time monitoring of DPP-IV activity on tumour cell's surface and direct tracking DPP-IV activity in whole blood without a tedious separation process. Our designed DPP-IV activity sensing method capabilities make it a valuable tool that promises the early identification of pancreatic and thyroid cancer and post-treatment surveillance.

Keywords: Circulating biomarker; pancreatic cancer; Dipeptidyl peptidase-IV; redox probe; tumor cell surface; whole blood

發展層狀複金屬氫氧化物做為光觸媒轉化二氧化碳成C1化學的研究

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摘要

鎳基層狀雙氫氧化物（LDHs）由於其表面羥基在高溫下具有良好的穩定性，於二氧化碳還原反應中展現出極大的應用潛力。本研究透過溶膠–凝膠法合成不同 Ni/Fe 比例之 LDHs，以探討鎳含量在熱催化二氧化碳甲烷化過程中對催化性能的影響。在所有樣品中，Ni_4Fe 表現出最高的 CH_4 生成速率，明顯優於低鎳含量材料。此性能提升主要歸因於隨著鎳含量增加，氣體擴散能力以及 CO_2/H_2 吸附行為的改善。BET 與光致發光（PL）分析結果顯示，催化效率不僅取決於比表面積與物理吸附特性，亦受到缺陷相關性質的顯著影響，特別是空位的形成。此外，原位漫反射傅立葉轉換紅外光譜（DRIFTS）辨識出關鍵反應中間體，支持在 LDH 表面進行之多步驟甲烷化反應機制。上述結果凸顯了在優化 LDH 催化劑以實現高效率二氧化碳轉化過程中，材料組成、缺陷化學與反應機制之間的關鍵交互作用。

關鍵字:
DRIFTS、二氧化碳還原反應、鎳基層狀雙氫氧化物、缺陷工程、甲烷化反應

The development of layered double hydroxides (LDHs) as the photocatalyst for CO_2 conversion and C1 chemistry

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Abstract

Ni-based layered double hydroxides (LDHs) show strong potential for the CO_2 reduction reaction due to the stability of surface hydroxyl groups at elevated temperatures. In this study, LDHs with varying Ni/Fe ratios were synthesized via a sol-gel route to investigate the role of Ni content in catalytic performance during thermal CO_2 methanation. Among the samples, Ni_4Fe exhibited the highest CH_4 productivity, outperforming materials with lower Ni content. This enhancement is attributed to improved gas diffusion and CO_2/H_2 adsorption with increasing Ni incorporation. BET and photoluminescence (PL) analyses reveal that catalytic efficiency is governed not only by surface area and physical adsorption but also by defect-related properties, particularly vacancy formation. Furthermore, in-situ Diffuse Reflectance Infrared Fourier Transform spectroscopy (DRIFTS) identifies key reaction intermediates, supporting a multistep methanation mechanism on the LDH surface. These findings highlight the critical interplay between composition, defect chemistry, and reaction mechanism in optimizing LDH-based catalysts for efficient CO_2 conversion.

Keywords: DRIFTS, CO_2 reduction, Ni-based LDHs, Defect Engineering, Methanation

具金融倫理與金融科技應用的AI原則

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摘要

人工智慧（Artificial Intelligence, AI）已成為金融科技（FinTech）發展的核心技術，廣泛應用於演算法交易、信用風險評估、欺詐偵測與投資組合管理等關鍵場景。透過對大量金融與行為資料的自動化分析，AI 能有效提升營運效率、優化風險控管，並提供高度個人化的金融服務。然而，隨著 AI 深度介入金融決策流程，其所帶來的倫理風險與治理挑戰亦逐漸浮現，包括演算法黑箱化、模型偏見、資料隱私與資訊安全等問題，均可能對金融機構的合規性與信任基礎產生重大影響。

本研究為一跨國與跨領域合作計畫，由台灣人工智慧領域學者與立陶宛經濟與商業管理學者共同參與，從多元視角探討 AI 與倫理議題對金融科技產業的影響。研究聚焦於大型語言模型（Large Language Models, LLM）在金融領域的應用，特別關注其在高風險決策情境中的可靠性、安全性與公平性問題。首先，本研究透過系統性文獻回顧，整合既有研究中 LLM 於金融服務中的應用模式與潛在風險，建立理論基礎並釐清核心概念，進一步辨識其在實務應用中所面臨的主要挑戰與研究缺口。

其次，本研究採用文獻計量分析方法，系統性檢視近年 LLM 在金融領域相關研究的發展趨勢。分析結果顯示，自 2023 年起該領域研究呈現快速成長，反映學界對 AI 在金融應用中的風險與治理議題日益重視。在金融監理日趨嚴格的背景下，金融機構需在技術創新與法規遵循之間取得平衡，確保 AI 系統符合公平性、透明性與可問責性等核心原則。

整體而言，本研究不僅揭示 LLM 在金融科技中的應用現況與發展脈絡，亦強調倫理設計與人機協作機制的重要性，並針對風險控管與責任歸屬提出具體觀察。研究成果可作為金融機構導入 AI 系統時之治理參考，並為推動可信賴人工智慧（Trustworthy AI）之發展提供理論與實務上的重要依據。

關鍵字:
人工智慧、金融科技、演算法治理、演算法偏見、法規監理、系統性文獻回顧

AI Principles for Ethical Governance in Financial Technology Applications

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Abstract

Artificial Intelligence (AI) has become a core technology driving the development of financial technology (FinTech), with wide-ranging applications in algorithmic trading, credit risk assessment, fraud detection, and portfolio management. By enabling automated analysis of large-scale financial and behavioral data, AI enhances operational efficiency, improves risk management, and supports the delivery of highly personalized financial services. However, as AI becomes deeply embedded in financial decision-making processes, significant ethical risks and governance challenges have emerged. Issues such as algorithmic opacity, model bias, data privacy concerns, and information security vulnerabilities pose substantial threats to regulatory compliance and institutional trust.

This study presents a cross-national and interdisciplinary research collaboration between AI scholars from Taiwan and experts in economics and business administration from Lithuania. It aims to examine the impact of AI and ethical considerations on the FinTech industry from multiple perspectives. The research focuses on the application of Large Language Models (LLMs) in financial contexts, with particular emphasis on their reliability, safety, and fairness in high-stakes decision-making environments.

The study begins with a systematic literature review to synthesize existing research on the use of LLMs in financial services. This process establishes a theoretical foundation, clarifies key concepts, and identifies critical challenges and research gaps in deploying LLMs within complex and high-risk financial systems. By organizing prior findings, the study provides a structured understanding of how LLMs are currently applied and where potential vulnerabilities may arise.

In addition, the study employs bibliometric analysis to examine the development trends of LLM-related research in finance. The findings indicate a rapid increase in publications since 2023, reflecting growing academic attention to the risks and governance implications of AI in financial applications. Under increasingly stringent regulatory environments, financial institutions must balance technological innovation with regulatory compliance, ensuring that AI systems adhere to principles of fairness,

transparency, and accountability.

Overall, this research not only highlights the current landscape and evolution of LLM applications in FinTech but also emphasizes the importance of ethical design and human-AI collaboration mechanisms. It further provides insights into risk management and accountability in AI-driven financial systems. The findings offer valuable theoretical and practical implications for financial institutions seeking to implement AI responsibly, and contribute to the advancement of trustworthy AI in the financial sector..

Keywords: Artificial Intelligence、Financial Technology (FinTech)、Financial Applications Algorithmic Governance、Trustworthy AI

以單渦旋和多渦旋光束研究磁性材料中的非線性光學效應

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摘要

在二維離軸泵浦條件下，可以利用 $Nd:YVO_4$ 雷射產生具有利薩如曲線橫向模態的高功率結構光束。我們在簡併條件下精細調節共振腔長度，並使用單透鏡像散模式轉換器進行光束轉換。此過程將所產生的利薩如模態轉換為結構渦旋光束，其橫向圖案分布於擺線曲線上。然而，傳統方法在辨識這些複雜圖案時，往往難以同時兼顧高準確率與高效率。本研究旨在開發一套基於深度學習的方法，利用卷積神經網路（CNN）實現擺線雷射圖樣的自動化影像辨識。

透過理論公式模擬與光學實驗建立了擺線雷射影像資料集，並以此訓練一個基於 ResNet 架構的 CNN 模型，使其能夠區分不同類型的擺線圖案，並預測其對應的參數。本研究展示了辨識複雜雷射光學圖樣的可行性與效率，為相關領域的即時檢測提供了一種新穎的技術方法。

關鍵字： 雷射、擺線、卷積神經網路、影像辨識

Nonlinear Optical Effects in Magnetic Materials Studied with Single and Multiple Vortex Beams

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Abstract

High-power structured beams with transverse forms as the Lissajous-curves figures are generated by an Nd:YVO_4 laser under two-dimensional off-axis pumping. We fine-tune the cavity length around degenerating condition and apply beam transformation using a single-lens astigmatic mode converter. The process converts the generated Lissajous modes into structured vortex beams whose transverse patterns are localized on the trochoidal-curves. However, conventional methods often struggle to achieve both high accuracy and efficiency in identifying these complex patterns. This work aims to develop a deep learning-based method using a convolutional neural network (CNN) for the automated image recognition of trochoidal laser patterns.

A dataset of trochoidal laser images was created through theoretical formula simulations and optical experiments, which was then used to train a ResNet-based CNN model capable of distinguishing between different types of trochoidal patterns and predicting their corresponding parameters. This research demonstrates the feasibility and efficiency of identifying complex laser optical patterns, providing a novel technical approach for real-time inspection in related fields.

Keywords: Laser, Trochoidal, Convolutional Neural Network, Image Recognition

基於光交聯三元聚合物共混物之高效率互補式反向器

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摘要

可拉伸與低功耗電子的發展，仰賴於製造穩定且高效率的數位邏輯電路。然而，如何利用單一、具溶液加工性且相容的材料系統來製造 P 型與 N 型電晶體，目前仍是一項重大挑戰。為了克服此問題，本研究介紹了一種新型的三元聚合物共混物，將彈性體（SBS）與 P 型（PDBT-co-TT）及 N 型（NDI-2T）共軛聚合物結合。藉由採用光交聯策略，我們成功在同一基板上製造出高效率的 P 型與 N 型電晶體。在本研究中，我們探討了不同 P/N 共軛聚合物比例對電晶體性能的影響。結果顯示，當 P/N 比例為 4:6 時，兩種元件均能達到最佳性能，其中 P 型電晶體的電洞遷移率（μh）為 $0.29 \pm 0.05\ cm^2V^{-1}s^{-1}$，N 型電晶體的電子遷移率（μe）則為 $(1.3 \pm 0.2) \times 10^{-3}\ cm^2V^{-1}s^{-1}$。此外，兩種類型的電晶體均表現出超過 10^7 的電流開關比，展現了卓越的開關特性與穩定性。這些互補式電晶體被進一步整合以構建基本的邏輯單元：反向器（NOT 閘）。我們對該反向器的電壓傳輸特性（VTC）曲線進行了詳細研究，結果顯示其具有優異的性能，包括高增益、低靜態功耗以及靈敏的開關行為。這項工作為未來柔性電子應用中製造複雜的數位邏輯電路，建立了一個穩健且具擴展性的平台。

關鍵字：三元混摻系統、互補式反向器、光交聯

High-Performance Complementary Inverters Based on a Photo-Crosslinkable Ternary Polymer Blend

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Abstract

The development of stretchable and low-power electronics relies on the fabrication of stable, high-performance digital logic circuits. A significant challenge remains in creating both P- and N-type transistors from a single, solution-processable, and compatible material system. To address this, our study introduces a novel ternary polymer blend incorporating an elastomer (SBS) with P-type (PDBT-co-TT) and N-type (NDI-2T) conjugated polymers. By employing a photo-crosslinking strategy, we successfully fabricated both high-performance P- and N-type transistors on the same substrate. In this work, we investigated the effect of varying P/N conjugated polymer ratios on transistor performance. The results indicate that a P/N ratio of 4:6 yielded optimal performance for both devices, with the P-type transistor achieving a hole mobility (μ_h) of 0.29 ± 0.05 $cm^2V^{-1}s^{-1}$, and the N-type transistor an electron mobility (μ_e) of (1.3 ± 0.2) × 10^{-3} $cm^2V^{-1}s^{-1}$. Furthermore, both transistor types exhibited an ON/OFF current ratio exceeding 10^7, demonstrating excellent switching characteristics and stability. These complementary transistors were integrated to construct a fundamental logic unit: the inverter (NOT gate). We conducted a detailed investigation of the inverter's Voltage Transfer Characteristic (VTC) curve, which demonstrated excellent performance, including high gain, low static power consumption, and sharp switching behavior. This work establishes a robust and scalable platform for fabricating complex digital logic circuits for future flexible electronic applications.

Keywords: Ternary polymer blend、Complementary inverters、Photo-crosslinking

PDVT-10/DTCP混合薄膜的形貌控制:透過彎月面引導塗佈法建構應用於次世代生物感測器之設計型類液晶材料平台

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摘要

本研究利用市售之共軛高分子poly{3,6-dithiophen-2-yl-2,5-di(2-decyltetradecyl)-pyrrolo[3,4-c]pyrrole-1,4-dione-alt-thienylenevinylene-2,5-yl} (**PDVT-10)** 分別混摻1、3、5、10 wt%的具光響應性小分子dithienylperfluorocyclopentene (**DTCP)**所組成的混合系統，應用於有機場效電晶體(OTFTs)上的半導體層(semiconductive layer)。**DTCP**材料在波長313 nm的紫外光與波長580 nm的可見光交互照射下，會呈現可逆的異構化，分別形成扭曲程度較高的「開環態」(**DTCP-o**) 與共軛程度較高的「閉環態」(**DTCP-c**)。薄膜的製備首先將此混合系統溶於氯仿中，利用彎月面引導塗佈法(meniscus-guided coating，MGC)將樣品塗佈於矽基板上製備出分子排列整齊的薄膜。並且透過偏光顯微鏡(polarized optical microscopy，POM)、紫外光可見光光譜(ultraviolet-visible spectroscopy，UV-Vis)以及掠角入射X光繞射(grazing-incidence X-ray diffraction，GIXRD)確認其有序性。根據實驗結果發現，這兩種異構物的加入皆可達到結構互補的效果，有效優化薄膜內的分子層狀排列與堆疊。

後續製成電晶體並利用電源電錶儀(source measure unit，SMU) 測量其電性。其中，共軛高分子**PDVT-10**元件的電荷遷移率為2.12 $cm^2 V^{-1} s^{-1}$；添加10 wt%的**DTCP-c** 後可提升至2.44 $cm^2 V^{-1} s^{-1}$；添加3 wt%的**DTCP-o** 後達到最高的電荷遷移率3.23 $cm^2 V^{-1} s^{-1}$。結果顯示，僅少量的DTCP添加便有提升元件表現的效果，為光可調控型有機場效電晶體的發展提供新的策略。

關鍵字: 彎月面引導塗佈、DTCP、PDVT-10、有機場效電晶體、分子排列

Morphology Control in PDVT-10/DTCP Hybrid Films: A Designable LC-like Material Platform via Meniscus-Guided Coating for Next-Generation Bio-Sensors

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Abstract

This research investigates a photo-responsive blend system comprising the conjugated polymer poly{3,6-dithiophen-2-yl-2,5-di(2-decyltetra-decyl)-pyrrolo[3,4-c]pyrrole-1,4-dione-alt-thienylenevinylene-2,5-yl} (**PDVT-10)** and varying weight fractions (1, 3, 5, and 10 wt%, respectively) of the photochromic molecule dithienylperfluorocyclopentene (**DTCP)** for application in organic thin-film transistors (OTFTs). DTCP exhibits reversible isomerization between its twisted open-ring (**DTCP-o**) and more conjugated closed-ring (**DTCP-c**) states under UV (313 nm) and visible light (580 nm) irradiation. Highly ordered thin films were fabricated via meniscus-guided coating (MGC) from chloroform solutions. The molecular ordering and morphology were systematically characterized by polarized optical microscopy (POM), ultraviolet-visible spectroscopy (UV-Vis), and grazing-incidence X-ray diffraction (GIXRD), revealing that both **DTCP** isomers improved the molecular stacking.

Electrical measurements using a source measure unit (SMU) showed that while pristine **PDVT-10** devices yielded a mobility of 2.12 $cm^2 V^{-1} s^{-1}$, the performance was significantly enhanced to 2.44 $cm^2 V^{-1} s^{-1}$ with 10 wt% **DTCP-c**, and reached the highest mobility of 3.23 $cm^2 V^{-1} s^{-1}$ with only 3 wt% **DTCP-o**. These findings highlight that trace amounts of photo-responsive additives can effectively modulate and enhance carrier transport, providing a new strategy for next-generation photo-controllable organic electronics.

Keywords: meniscus-guided coating, DTCP, PDVT-10, organic field-effect transistor, molecular alignment.

溶液剪切結合SBS添加劑與製程最佳化提升PDVT-10 有機場效電晶體之應變誘導遷移率

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摘要

高效能有機場效電晶體（organic field-effect transistors, OFETs）對於柔性電子元件的發展至關重要。然而，在溶液製程薄膜中控制分子取向仍然是一項挑戰。本研究結合溶液剪切製程與苯乙烯－丁二烯－苯乙烯（styrene－butadiene－styrene, SBS）添加劑，成功製備高品質的 PDVT-10 薄膜，並探討不同塗佈速度與環境條件對薄膜與元件表現的影響。溶液－刮刀界面所產生的剪切應力可誘導亞穩態分子堆積與晶格應變，進而縮短 $\pi-\pi$ 堆疊距離並提升電荷傳輸能力；同時，SBS 添加劑可改善薄膜均勻性。

相較於傳統旋轉塗佈，此一由液橋導引的製程能促進高度取向結晶區域的形成，並減少晶界缺陷。在最佳化條件下，元件表現出平均遷移率為 2.17 $cm^2 V^{-1} s^{-1}$，較旋轉塗佈元件有顯著提升。這些結果顯示，應變誘導的晶格調控與形貌控制可作為發展高效能有機電子元件的一種可擴展策略。

關鍵字: 溶液剪切技術、高效能有機場效應電晶體、電荷遷移

Strain-Induced Mobility Enhancement in PDVT-10 OFETs via Solution Shearing with SBS Additives and Process Optimization

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Abstract

High-performance organic field-effect transistors (OFETs) are essential for flexible electronics. However, controlling molecular orientation in solution-processed thin films remains challenging. In this study, high-quality PDVT-10 films were fabricated by combining solution shearing with styrene–butadiene–styrene (SBS) additives, while investigating the effects of different coating speeds and environmental conditions. Shear stress at the solution–blade interface induces metastable molecular packing and lattice strain, thereby reducing the π–π stacking distance and enhancing charge transport, while SBS improves film uniformity.

Compared with conventional spin coating, this meniscus-guided process promotes the formation of highly aligned crystalline domains with minimized grain boundaries. Under optimized conditions, the devices exhibited an average mobility of 2.17 $cm^2 V^{-1} s^{-1}$, representing a significant improvement over spin-coated devices. These results demonstrate that strain-induced lattice modulation and morphological control provide a scalable strategy for high-performance organic electronics.

Keywords: Solution shearing, Organic field-effect transistors (OFETs) , Charge Mobility

用於低溫共燒陶瓷（LTCC）應用的高熵玻璃陶瓷的特性分析

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摘要

由於其加工溫度低、多層相容性強且適用於高頻通訊系統，低溫共燒陶瓷（LTCC）技術已成為現代電子封裝與微電子整合領域的重要平台。LTCC材料的性能關鍵在於實現介電常數與介電損耗的最佳組合。本研究旨在開發用於低溫共燒陶瓷（LTCC）的高熵鹼土硼酸鹽－矽酸鹽玻璃陶瓷，以滿足先進電子應用所需的介電與熱性能。本研究採用溶膠－凝膠法，將Mg、Ca、Sr與Ba陽離子摻入硼酸鹽－矽酸鹽玻璃基體中，製備高熵玻璃陶瓷，以提升其微波介電性能。利用X射線繞射（XRD）、差示掃描量熱／熱重分析（DTA/TGA）、拉曼光譜、傅立葉轉換紅外光譜（FTIR）與高解析透射電子顯微鏡（HR-TEM）對所製備的材料進行全面表徵。微波介電性能量測結果顯示，最佳化後的玻璃陶瓷組成在13.47 GHz頻率下展現出4.38的介電常數與0.0019的低介電損耗，顯示其具備優異的介電穩定性與低損耗特性，適用於高頻應用。介電性能的提升歸因於在硼酸鹽－矽酸鹽骨架中引入多種鹼土金屬陽離子後所形成的可控相分離行為與均勻微觀結構。

本研究結果顯示，高熵硼酸鹽－矽酸鹽玻璃陶瓷有望成為下一代低溫共燒陶瓷（LTCC）基板與微波介質元件的理想候選材料。

關鍵字：高熵、介電、高頻、玻璃陶瓷

Characterization of high-entropy glass ceramics for LTCC application

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Abstract

LTCC technology has emerged as a key platform in modern electronic packaging and microelectronic integration owing to its low processing temperature, multilayer compatibility, and suitability for high-frequency communication systems. The performance of LTCC materials is critically dependent on achieving an optimal combination of dielectric permittivity, low dielectric loss. This study investigates the development of high-entropy alkaline earth borate–silicate glass-ceramics for low-temperature co-fired ceramic (LTCC) applications for tailoring the dielectric and thermal properties required for advanced electronic applications. In the present work, Mg, Ca, Sr and Ba cations were incorporated into borate–silicate glass matrices to develop high-entropy glass-ceramic compositions from Sol-gel method to enhanced microwave dielectric performance. The prepared materials were comprehensively characterized using X-ray diffraction (XRD), differential thermal and thermogravimetric analysis (DTA/TGA), Raman spectroscopy, Fourier transform infrared spectroscopy (FTIR), and high-resolution transmission electron microscopy (HR-TEM). Microwave dielectric measurements demonstrated that the optimized glass-ceramic composition exhibited a dielectric constant of 4.38 and a low dielectric loss of 0.0019 at 13.47 GHz, indicating excellent dielectric stability and low-loss characteristics suitable for high-frequency applications. The enhanced dielectric performance is attributed to the controlled phase separation behavior and homogeneous microstructure arising from the incorporation of multiple alkaline earth cations within the borate–silicate framework. The findings of this study demonstrate that high-entropy borate–silicate glass-ceramics are promising candidates for next-generation LTCC substrates and microwave dielectric devices.

Keywords: High entropy, Dielectric, High frequency, Glass ceramics

透過多層透明混合膜實現光譜選擇性收集熱能應用於能源中性建築結構

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摘要

本研究成功建立一套結合微流體精準合成技術與高效率光熱轉換模組評估的完整體系。研究利用微流體晶片平台的連續流動特性，實現對核殼結構奈米顆粒的優異形貌控制，使其粒徑均勻度與結構完整性顯著優於傳統批次合成法。在薄膜製程方面，透過確立 1:4:4（奈米顆粒溶液：環氧樹脂：硬化劑）的最佳混合比例並結合精密旋塗技術，確保了光學透明度與光熱效能之間的理想平衡。實驗結果顯示，本研究創新設計的 3D 垂直堆疊光熱模組（DLPB）能有效提升多角度的光捕捉效率，在 0.1 W/cm² 模擬太陽光下能達成超過 10.5°C 的穩定溫升，並在 90% RH 的高濕環境下展現出卓越的長期環境耐久性。本研究成果不僅在學術上驗證了微流體輔助材料製程的精準度與可控性，更在實務上為未來綠建築與智慧視窗的節能遮蔽需求，提供了一套兼具高效能、高穩定性與量產潛力的創新技術方案。

關鍵字：微流體平台、核殼結構奈米粒子、光熱轉換

Spectral selective solar harvesting and photothermal energy generation via multilayer transparent hybrid films for energy- neutral building structures

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Abstract

This research successfully demonstrates a comprehensive and integrated framework that couples precision nanomaterial synthesis with the development of high-efficiency photothermal modules for green building applications. By leveraging the continuous-flow characteristics of a customized microfluidic platform, superior morphological and size control over Fe_3O_4@$Cu_{2-x}S$ core-shell nanoparticles was achieved, significantly surpassing the uniformity obtained via traditional batch synthesis methods. For thin-film fabrication, an optimal 1:4:4 mixing ratio (nanoparticle solution: epoxy: hardener) was established, which balanced high optical transparency with a robust thermal response when applied via precision spin-coating techniques. Furthermore, the innovative Diffuse Light Photothermal Box (DLPB) 3D vertical stacking design was proven to enhance multi-angle solar harvesting efficiency, yielding a stable steady-state temperature increase of over 10.5°C under 0.1 W/cm² simulated solar intensity. Coupled with outstanding environmental durability demonstrated under long-term high-humidity testing (90% RH), this study not only validates the efficacy of microfluidic-assisted synthesis but also offers a scalable, robust, and high-performance solution for next-generation architectural energy-saving shielding and smart window technologies.

Keywords: Microfluidic platform, Core-shell nanoparticles, Photothermal conversion

利用原位 NAP-XPS 與拉曼光譜探討 CoP 在中性與鹼性環境下電化學硝酸鹽還原生成氨的反應機制

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摘要

電化學硝酸鹽還原反應（NO_3RR）近年來備受關注，因其可作為一種永續的氨生成途徑，同時解決水體中的硝酸鹽污染問題。磷化鈷（CoP）已被證實為一種有效的 NO_3RR 電催化劑；然而，其在不同 pH 環境下的表面化學反應仍缺乏充分理解。本研究以負載於鎳泡棉上的 CoP（CoP/NF）為系統，在中性（pH 7）與鹼性（pH 14）條件下進行硝酸鹽還原生成氨的反應，並著重釐清其反應機制。成果顯示 CoP/NF 催化劑具有高氨還原選擇性，在鹼性環境中於 −0.4 V（vs. RHE）下可達到最高 92.5% 的法拉第效率，而在中性環境同一電位下則為 76.3%。X 光光電子能譜（XPS）分析顯示其表面化學狀態具有明顯的 pH 依賴性變化，指出在 NO_3RR 過程中催化劑表面會發生重組。此外，透過原位近環境壓力 XPS（in situ NAP-XPS）與原位拉曼光譜之分析，提供了逐步氫化反應路徑的直接機制證據，即 $NO_3^- \rightarrow NO_2^- \rightarrow *NO \rightarrow *NH_2 \rightarrow NH_3$，並突顯電解液 pH 值在調控 CoP 催化劑表面演變與反應途徑中的關鍵角色。

關鍵字： 原位拉曼光譜、原位 NAP-XPS、磷化鈷、硝酸鹽還原反應、氨合成

Reaction mechanism of electrochemical nitrate reduction to ammonia on CoP in neutral and alkaline media revealed by in situ NAP-XPS and operando Raman spectroscopy

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Abstract

Electrochemical nitrate reduction reaction (NO_3RR) has attracted increasing interest as a sustainable approach for ammonia production while simultaneously addressing nitrate pollution in aqueous systems. Cobalt phosphide (CoP) has been reported as an effective electrocatalyst for NO_3RR; however, its surface evolution under different pH environments remains insufficiently understood. In this work, CoP supported on nickel foam (CoP/NF) was investigated for NO_3RR to ammonia in neutral (pH 7) and alkaline (pH 14) media, with a particular focus on elucidating the reaction mechanisms. The CoP/NF catalyst exhibited high ammonia selectivity, achieving Faradaic efficiencies of up to 92.5% at −0.4 V vs. RHE in alkaline media and 76.3% at the same potential in neutral media. X-ray photoelectron spectroscopy (XPS) reveals pronounced pH-dependent changes in surface chemical states, indicating catalyst surface reconstruction during NO_3RR. Furthermore, in situ NAP-XPS and operando Raman spectroscopy provide direct mechanistic evidence for a stepwise hydrogenation pathway involving $NO_3^- \rightarrow NO_2^- \rightarrow *NO \rightarrow *NH_2 \rightarrow NH_3$, highlighting the critical role of electrolyte pH in governing surface evolution and reaction pathways on CoP catalysts.

Keywords: Operando Raman spectroscopy, In situ NAP-XPS, Cobalt phosphide (CoP), Nitrate reduction reaction (NO_3RR), Ammonia synthesis

供體-受體-供體有機染料混合薄膜的放大自發性輻射研究

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摘要

本研究採用一系列具有供體-受體-供體（D-A-D）結構之發色團（D-I：2FL-PT、D-II：2DFL-2PT-PT、D-III：2DFL-2Tp-2-C6BTAQ2Me）作為增益介質，並以 4,4´-bis(9H-carbazol-9-yl)biphenyl（CBP）為主體材料製備混合薄膜，以探討其放大自發性輻射特性。為產生放大自發性輻射，實驗中採用波長 337.1 nm、脈衝寬度為 3.5 ns 之氮氣雷射作為激發光源。雷射光束經由柱狀透鏡聚焦形成線狀光束照射於樣品表面，所產生之放大自發性輻射訊號由樣品側向發射，並由光譜儀進行量測與記錄。實驗結果顯示，相較於溶液態雷射染料，摻雜於 CBP 中之 D-A-D 發色團混合薄膜展現出顯著降低的放大自發性輻射閾值。其中，2FL-PT（D-I）發色團表現尤為突出，其吸收光譜與 CBP 發射光譜之高度重疊導致強烈的福斯特共振能量轉移效應，使放大自發性輻射閾值降低達 390 倍。此外，本研究亦探討不同染料摻雜濃度對放大自發性輻射行為之影響。結果發現，當染料濃度為 3.0 wt% 時，薄膜呈現最低的放大自發性輻射閾值與最高的輻射衰減速率。此現象可歸因於該條件下薄膜具備較佳之成膜品質，並有效抑制由分子聚集所引起之淬滅效應。綜上所述，本研究所開發之 D-A-D 發色團與 CBP 所形成之混合薄膜可實現低閾值之固態雷射，並在未來有機固態雷射元件之應用上展現出極大的發展潛力。

關鍵字: 放大自發性輻射、有機雷射染料、固態薄膜、福斯特共振能量轉移

Study on Amplified Spontaneous Emission of Donor-Acceptor-Donor Organic Dye Mixed Thin Films

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Abstract

In this study, a series of donor-acceptor-donor (D-A-D) chromophores (D-I: 2FL-PT, D-II: 2DFL-2Tp-PT, and D-III: 2DFL-2Tp-2-C6BTAQ2Me) were employed as gain media and doped into 4,4 ´ -bis(9H-carbazol-9-yl)biphenyl (CBP) to investigate their amplified spontaneous emission (ASE) characteristics. A nitrogen laser (λ = 337.1 nm, pulse width = 3.5 ns) was used as the excitation source, and the beam was shaped into a stripe profile on the sample surface using a cylindrical lens. The resulting ASE emission was collected from the edge of the blended films and analyzed using a spectrometer. Compared to the D-A-D chromophores in solution, the blended films exhibited a significantly reduced ASE threshold. Notably, the 2FL-PT (D-I) chromophore demonstrated a ~390-fold reduction in threshold, which can be attributed to efficient Förster resonance energy transfer (FRET) arising from the substantial spectral overlap between the absorption spectrum of 2FL-PT and the photoluminescence (PL) emission spectrum of the CBP host. Furthermore, the influence of doping concentration on ASE performance was systematically investigated. The results reveal that a concentration of 3.0 wt% yields the lowest ASE threshold and the highest radiative decay rate. This behavior is attributed to improved film morphology and the effective suppression of aggregation-caused quenching (ACQ) at this optimized concentration. In conclusion, the development of blended films comprising D-A-D chromophores doped into a CBP host enables low-threshold solid-state ASE and highlights their strong potential for future organic solid-state laser applications.

Keywords: Amplified spontaneous emission、Organic Laser Dyes、solid state film、 Förster resonance energy transfer

2,2′:6′,2″-三吡啶相關的鐵鈷金屬錯合物的合成與理論計算

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摘要

自旋交叉（Spin Crossover, SCO）是一種發生於過渡金屬錯合物中的現象，其中金屬中心可在低自旋（LS）與高自旋（HS）狀態之間可逆轉換，並在磁性材料與分子開關等領域展現潛在應用價值。在本研究中，採用密度泛函理論（DFT）計算來闡明 $Co(ftpy)_2(BF_4)_2 \cdot 1.5H_2O$ 錯合物的電子結構與分子間相互作用。透過結合不同片段模型，使用 B3LYP、LC-BLYP、CAM-B3LYP 與 TPSSh 等交換泛函，探討配體–金屬軌域之間的交互作用以及周圍環境分子對自旋態的影響。研究結果顯示，在低溫下低自旋態（LS）在能量上較為穩定，而在接近室溫時高自旋態（HS）則變得更穩定，此結果與實驗觀察一致。包含水分子的模型在 LS → HS 轉變過程中呈現顯著較大的能量變化，顯示溶劑效應會增強自旋態之間的能隙；透過分子軌域分析可知，這主要源於水分子與 ftpy 配體之間的反鍵結作用。此外，電子結構主要由配體到金屬電荷轉移（LMCT）主導，這對於決定自旋態的穩定性具有關鍵作用。

關鍵字: 自旋交叉、密度泛函理論（DFT）、配體到金屬電荷轉移（LMCT）

Synthesis and theoretical calculation on terpyridine based Fe/Co metal complexes

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Abstract

Spin crossover (SCO) is a phenomenon in transition metal complexes which the metal center reversibly switches between low-spin (LS) and high-spin (HS) states, exhibiting potential applications in magnetic materials and molecular switches. In this work, density functional theory (DFT) calculations were applied to illustrate the electronic structures and intermolecular interactions in the $Co(ftpy)_2(BF_4)_2 \cdot 1.5H_2O$ complex. The exchange functional of B3LYP, LC-BLYP, CAM-B3LYP, and TPSSh combined with various fragment models were performed to investigate ligand–metal orbital interactions and environmental effects on spin states. The results show that the LS state is energetically favored at low temperature, while the HS state becomes more stable near room temperature, which is consistent with experimental observations. Models including water molecules exhibit significantly larger energy variations during the LS → HS transition, indicating that solvent effects enhance the spin-state energy gap, which is demonstrated by antibonding interactions between water and the ftpy ligand through molecular orbital analysis. Additionally, the electronic structure is dominated by ligand-to-metal charge transfer (LMCT), which plays a key role in determining spin-state stability.

Keywords: Spin crossover (SCO), density functional theory (DFT), ligand-to-metal charge transfer (LMCT)