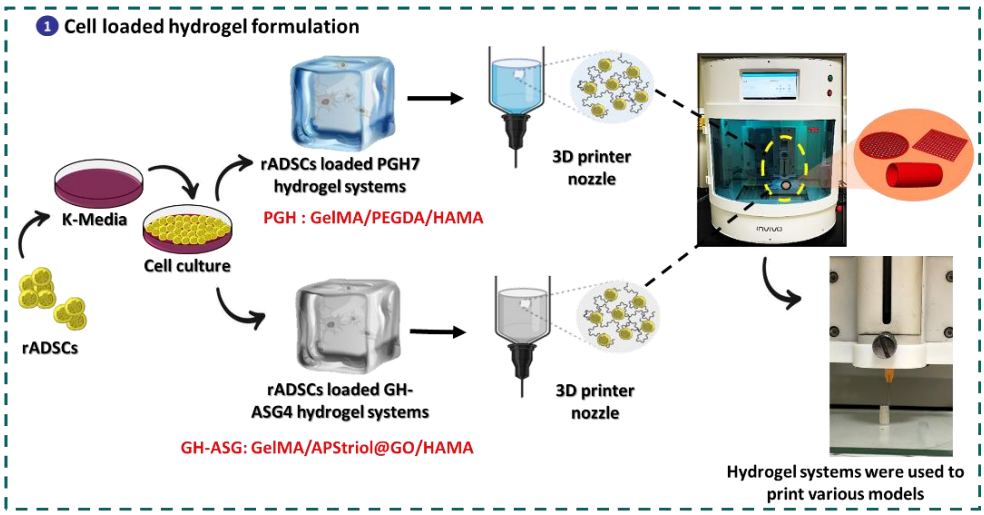
王志光 教授

生命科學院/醫藥暨應用化學系

本研究利用先進的可 3D 列印生物墨水成功維持平滑肌細胞（SMC）的表型。首先，將聚乙二醇二丙烯酸酯（PEGDA）引入由甲基丙烯酸明膠（GelMA）與甲基丙烯酸透明質酸（HAMA）所組成的光固化複合水凝膠，形成 GelMA/HAMA/PEGDA（PGH）第一類系統。同時，將由 3-丙烯醯氧丙基三醇矽烷與氧化石墨烯合成之矽烷化丙烯基氧化石墨烯奈米片（APStriol@GO）加入 GelMA/HAMA 光固化水凝膠中，構成 GelMA/HAMA/APStriol@GO（1%）GH-ASG4 第二類系統。這些功能化平台可提供最佳的微環境，促使兔脂肪來源幹細胞（rADSCs）向收縮型 SMC 分化。系統性分析顯示，GH-ASG4 為最具效能的配方，兼具優異的活性氧（ROS）清除能力與止血特性，有助於提升幹細胞存活率。分化後的 SMC 經 TRAP 染色、關鍵標誌基因（α-SMA、SM-MHC）轉錄分析，以及免疫細胞化學與西方墨點法之蛋白表現驗證。利用 GH-ASG4 生物墨水進行擠出式 3D 列印，可成功產生管狀與盤狀支架，具有高結構精準度、生物相容性與良好細胞增生能力，並有效重建平滑肌組織再生所需的細胞外基質結構。



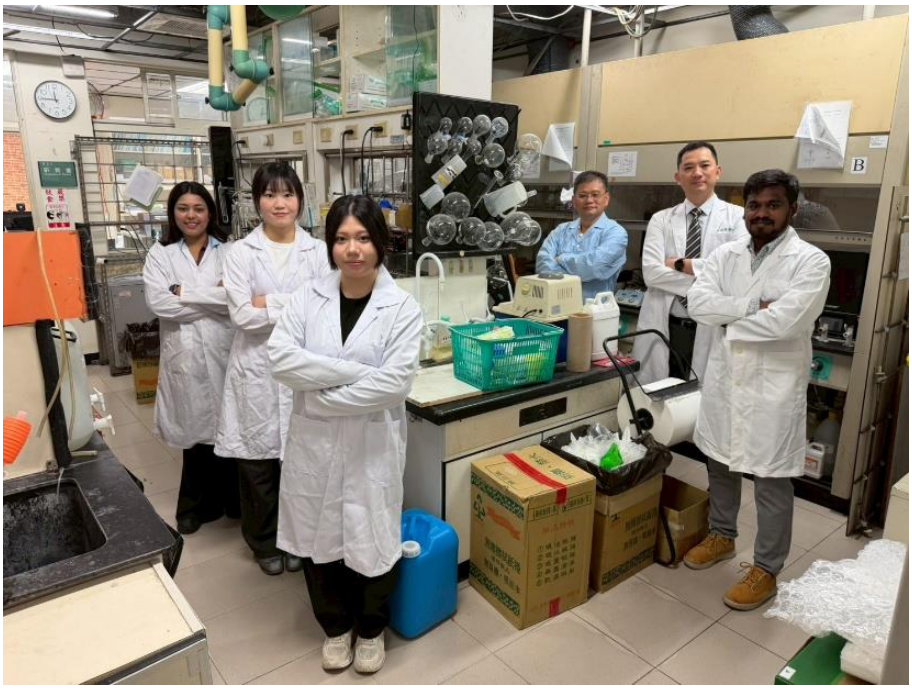
圖說明：開發 GelMA/HAMA/PEGDA(PGH)與 GelMA/HAMA/APStriol@GO(1%) GH-ASG4 兩類可光固化生物水凝膠系統，適合作為平滑肌再生與其他組織再生的生物列印墨水潛力。

【具體成果】

圖說明：Atturu Pavanchandh 博士於 2025 年度全國化學年會(Chemistry National Meeting) 發表題為「矽烷化丙烯酸石墨烯氧化物奈米複合材料強化、具可調機械性之 GelMA/HAMA 可列印生物墨水，用於脂肪幹細胞分化成熟平滑肌細胞」之研究，並榮獲「優秀壁報論文獎」。

- 學術成就

1. 完成與順臻生物有限公司的產學合作計畫案”評估仿生生物水凝膠系統與間質幹細胞的增生與分化活性研究”。主要成果顯示特殊生物水凝膠於 K-medium 培養 ADSCs 可使得維持幹細胞 phenotype 優異能力。
2. 與清華大學 腦科學中心，江安世 教授/院士合作申請發明專利(POLYMER AND ITS PRODUCTION METHOD, US Patent application no. 19/034,452, Jan 22,2025.
3. 2025 Chemistry National Meeting, 並獲得優秀壁報論文獎(Silanized acrylic graphene oxide nanocomposite reinforced mechanically tunable GelMA/HAMA printable bio-ink for adipose-derived stem cells differentiated mature smooth muscle cells), March 8-9, 2025, Providence University, Taichung, Taiwan
4. Chih-Kuang Wang，Yen-Han Lai，Ke-Hsun Yang，Pei-Ying Lee, METHOD FOR INDUCING CELLS TO SECRETE EXTRACELLULAR VESICLES WITH PREDETERMINED MOLECULES AND USE THEREOF, US Patent Provisional 63/912,350, Nov. 6, 2025.
5. 研究室主持人擔任 113-114 年度高雄市地方型 SBIR 審查員。
6. 主持人帶領品醫生技團隊於科技部 109-2 FITI 榮獲傑出創業獎(200 萬新創基金)，並於 **110 年度再獲得教育部「U-start 創新創業計畫」，因而所成立品醫生技新創公司**，除於校內募得新台幣 292 萬元，並於 112 年 9 月將”積層製造 3D 生物陶瓷骨移植替代物”授權給品醫生技股份有限公司，目前公司實收資本額為新台幣 3,292 萬元，且校方持股比例為 12%。本人擔任公司董事持續帶領公司，並於 2025 年 10 月 13 日申請 TFDA 上市許可，預計 2026 年取得上市許可。
7. 2024 年含共同作者發表三篇 papers [International Journal of Biological Macromolecules, 265: 130710, 2024.][Water Research, 259: 121810, 2024.][International Journal of Clinical Medicine and Bioengineering, 2024, 4, 1-10.]，2025 年有關 3D 生物陶瓷於動物臨床的實驗論文已經投稿有 2 篇。生物水凝膠系統的 SCI paper 有一篇已接受[Biomaterials Advances 171 (2025) 214226, 2025.]，另兩篇正在撰寫中。



圖說明：生物水凝膠團隊照片。(由右上順時針方向為：王志光 教授、賴衍翰 醫師/醫研所博士生、Atturu Pavanchandh 博士、楊可勛 大學生、李佩穎 大學生、Suhana 博士生)

【研究團隊】

生物水凝膠團隊：Pavanchandh Atturu 博士、賴衍翰 博士生、Suhana 博士生、楊可勛 大學生、李佩穎 大學生

3D 陶瓷團隊：蔡雨柔 大學生、陳顗同 大學生

團隊簡介：本人除了持續進行 3D 氧化物陶瓷研究與開發外，本實驗室目前生物水凝膠團隊成員致力於光固化生物水凝膠系統的創新開發與應用，聚焦於細胞分化、組織再生、活性外泌體分離及類器官體外高通量檢測等前沿醫學研究。我們不僅掌握生物列印核心技術，更積極整合微流體生物晶片平台，以實現精確、高效的類器官培養與藥物篩選。團隊成員組成具高度互補性，形成跨領域協作的堅實研發陣容。

研究聯繫 Email：ckwang@kmu.edu.tw

The preservation of the smooth muscle cell (SMC) phenotype was achieved using advanced 3D-printable bioinks. The first type of bioink was engineered by introducing polyethylene glycol diacrylate (PEGDA) into a hybrid photocurable hydrogel of methacrylated gelatin (GelMA) and methacrylated hyaluronic acid (HAMA), represented by (GelMA/HAMA/PEGDA-PGH). Similarly, the second type of bioink, denoted GelMA/HAMA/APStriol@GO-1%-GH-ASG4, consists of silanized acrylic graphene oxide nanosheets (APStriol@GO), synthesized from 3-acryloyloxypropyl silanetriol and graphene oxide, and incorporated into a hybrid photocurable hydrogel of GelMA and HAMA. These functionalized platforms provided an optimized microenvironment for rabbit adipose-derived stem cells (rADSCs), guiding their differentiation into contractile SMCs. Systematic characterization revealed GH-ASG4 as the most effective formulations, combining excellent reactive oxygen species scavenging with hemostatic activity to enhance stem cell survival. Differentiated SMCs were validated through TRAP staining, transcript analysis of key markers (α-SMA and SM-MHC), and protein expression confirmed by immunocytochemistry and western blotting. Using GH-ASG4 bioink, extrusion-based 3D printing successfully produced tubular and disk-shaped scaffolds with high structural fidelity, biocompatibility, and cell proliferation, elegantly replicating the extracellular matrix essential for smooth muscle tissue regeneration.

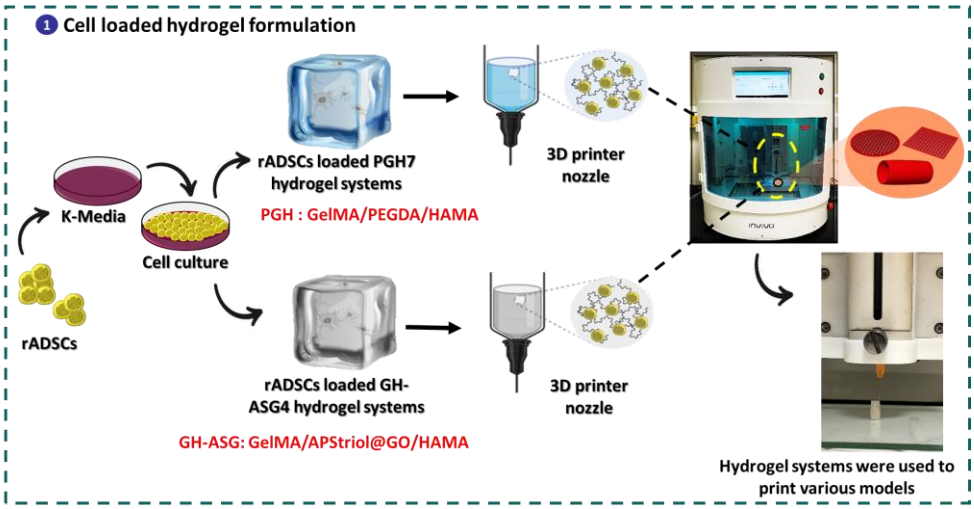


Figure. Two photo-curable biohydrogel systems—GelMA/HAMA/PEGDA (PGH) and GelMA/HAMA/APStriol@GO (1%) (GH-ASG4)—were developed, demonstrating strong potential as bioinks for smooth muscle regeneration and broader tissue engineering applications.

【Concrete Results】

Figure. Dr. Pavanchandh Atturu presented his work titled "Silanized acrylic graphene oxide nanocomposite–reinforced, mechanically tunable GelMA/HAMA printable bio-ink for adipose-derived stem cell–differentiated mature smooth muscle cells" at the 2025 Chemistry National Meeting and received the Outstanding Poster Award.

- **Academic Achievements**

1. Completed the industry–academia collaborative project with Soon-Chen Biomedical Co., Ltd., titled "Evaluation of Proliferation and Differentiation Activities of Mesenchymal Stem Cells in a Biomimetic Hydrogel System." The main findings demonstrate that the specialized biohydrogel, when used with K-medium to culture ADSCs, effectively maintains an excellent stem cell phenotype.
2. Collaborated with Prof./Academician An-Si Jiang from the Brain Research Center at National Tsing Hua University to apply for an invention patent (POLYMER AND ITS PRODUCTION METHOD, U.S. Patent Application No. 19/034,452, Jan 22, 2025).
3. Presented at the 2025 Chemistry National Meeting and received the Outstanding Poster Award for the study titled "Silanized acrylic graphene oxide nanocomposite–reinforced mechanically tunable GelMA/HAMA printable bio-ink for adipose-derived stem cells differentiated mature smooth muscle cells" (March 8–9, 2025, Providence University, Taichung, Taiwan).
4. Chih-Kuang Wang, Yen-Han Lai, Ke-Hsun Yang, Pei-Ying Lee, METHOD FOR INDUCING CELLS TO SECRETE EXTRACELLULAR VESICLES WITH

PREDETERMINED MOLECULES AND USE THEREOF, U.S. Provisional Patent Application 63/912,350, Nov. 6, 2025.

5. The laboratory PI served as a reviewer for the Kaohsiung City Local SBIR Program during 2024–2025.
6. Under the PI's leadership, the Phi-Med Biotech team won the Outstanding Startup Award (NT$2 million startup fund) at the MOST 109-2 FITI Program and subsequently received support from the Ministry of Education's U-start Innovation and Entrepreneurship Program in 2021. This led to the establishment of Phi-Med Biotech Co., Ltd.

   In addition to raising NT$2.92 million internally at KMU, the team licensed the "Additively Manufactured 3D Bioceramic Bone Graft Substitute" technology to Phi-Med Biotech in September 2023.

   The company's current paid-in capital is NT$33.92 million, with the university holding 12% equity.

   The PI serves as a board director and continues to lead the company. A TFDA market approval application was submitted on October 13, 2025, and approval is expected in 2026.
7. Published three papers in 2024 (including co-authored works):
   - International Journal of Biological Macromolecules, 265: 130710, 2024.
   - Water Research, 259: 121810, 2024.
   - International Journal of Clinical Medicine and Bioengineering, 2024, 4, 1–10.

   In 2025, two manuscripts related to animal clinical studies of 3D bioceramics have been submitted. One SCI paper on the biohydrogel system has been accepted:
   - Biomaterials Advances, 171 (2025) 214226, 2025.

   Two additional manuscripts are currently in preparation.

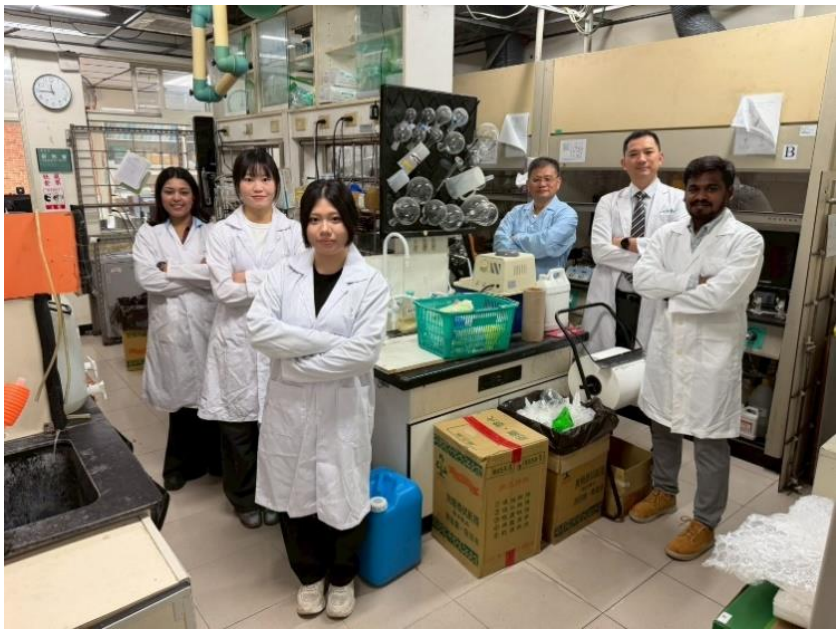


Figure. Nano and Biomedical Materials Laboratory biohydrogel team photo. (From the upper right, clockwise: Prof. Chih-Kuang Wang, Dr. Yen-Han Lai / PhD student in the Institute of Medical Science, Dr. Atturu Pavanchandh, undergraduate student Yang Ke-Hsun, Pei-Ying Lee, and PhD student Suhana.)

【Research Team】

Biohydrogel Members: Dr. Atturu Pavanchandh, PhD student Suhana, undergraduate student Yang Ke-Hsun, Pei-Ying Lee, and Dr. Yen-Han Lai / PhD student in the Institute of Medical Science,

3D Ceramic Members: Cai Yu-Rou, Chen Yi-Tong

Research Team Introduction: I have also continued to support Precisely Printed Medical Ltd.'s product development, and in parallel, our laboratory's biohydrogel research team is dedicated to the innovative development and application of photo-cured biohydrogel systems. Our work focuses on cutting-edge biomedical fields, including cell differentiation, tissue regeneration, active extracellular vesicle isolation, and high-throughput organoid-based assays. Beyond mastering core bioprinting technologies, we are actively integrating microfluidic biochip platforms to enable precise and efficient organoid culture and drug screening in the future. The composition of our team is highly complementary, forming a strong, interdisciplinary research and development force.

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