抗氧化培養方法及抗氧化輔助設備

Antioxidant culture method and antioxidant auxiliary equipment

作者

曾俞靜1*、宋維文1、楊政龍2、王祥宇2

所屬單位

1 屏東科技大學研究總中心
2 屏東科技大學動物疫苗科技研究所

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1 摘要 Abstract

本研究開發出一種抗氧化培養方法及其輔助設備，旨在解決細胞高密度培養下氧化壓力增加、細胞衰老及生產效率降低的問題。透過電解氫技術及3D列印蠕動幫浦系統，有效減少細胞內活性氧（ROS），提升細胞活性及病毒抗原產量。此技術已於牛流行熱病毒（BEFV）疫苗生產中驗證其效能，並可應用於多種病毒及幹細胞培養領域，具有廣泛的產業應用潛力。

The antioxidant culture method and antioxidant auxiliary equipment were developed to mitigate oxidative stress, cellular senescence, and reduced productivity in high-density cultures. Using electrolytic hydrogen technology with a 3D-printed peristaltic pump lowered intracellular ROS, enhanced cell viability, and increased viral antigen yield. Performance was validated in bovine ephemeral fever virus (BEFV) vaccine production, and the technology is expected to extend to stem cell and large-scale viral culture systems.

2 作品研發創新價值 Innovative Value of the Technology Development

本技術期望於細胞培養系統中導入抗氧化分子氫，進而降低細胞氧化壓力，提升培養穩定性與生產效率。

This technology aims to introduce antioxidant molecular hydrogen into cell culture systems to reduce oxidative stress, thereby enhancing culture stability and improving production efficiency.

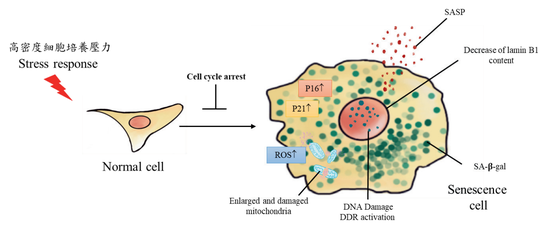

Figure 1.高密度細胞培養壓力下誘導之衰老細胞狀態
(Induction of cellular senescence under high-density culture stress)

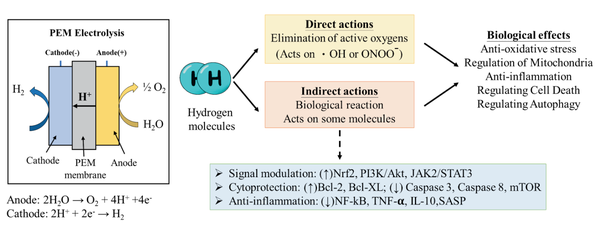

Figure 2.氫分子對於抗氧化、抗發炎與細胞保護的作用機制
(Mechanistic roles of molecular hydrogen in antioxidation, anti-inflammation, and cell protection)

3 系統功能與實際應用性 System Functions and Practical Applications

驗證案例一：抗氧化輔助新型設備應用於BEFV疫苗生產製造效能驗證

Case 1: Efficacy validation of the antioxidant auxiliary equipment applied to BEFV vaccine manufacturing.

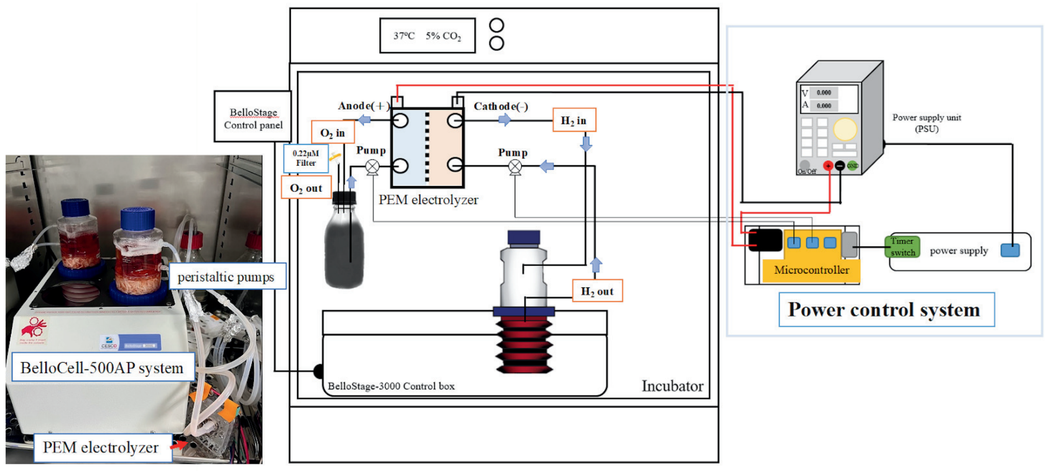

Figure 3. 生物反應器之抗氧化輔助系統之系統建立模型
(Establishment model of the antioxidant auxiliary system for bioreactors)

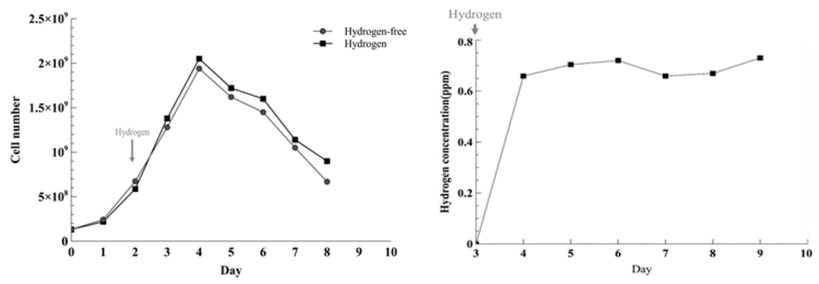

Figure 4. 細胞生長曲線監測與分子氫濃度測量
(Monitoring of cell growth curves and measurement of molecular hydrogen concentration)

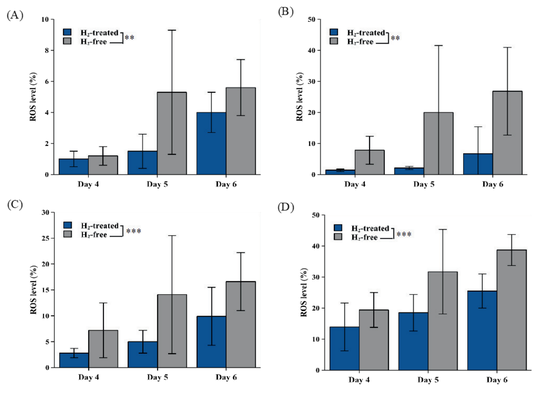

Figure 5. 抗氧化設備減緩病毒量產時的氧化壓力
(Reduction of oxidative stress during viral production by the antioxidant equipment)

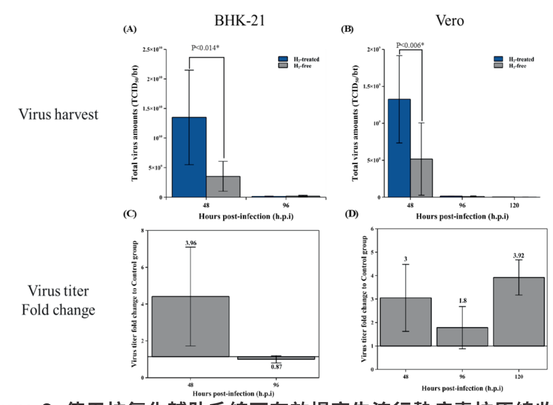

Figure 6. 使用抗氧化輔助系統可有效提高牛流行熱病毒抗原總收穫產量
(Enhancement of total BEFV antigen yield using the antioxidant auxiliary system)

驗證案例二：全自動三維動態培養系統動態細胞培養抗氧化體外模型應用技術

Validation Case 2: Application of an automated 3D dynamic culture system as an in vitro antioxidant model for dynamic cell culture.

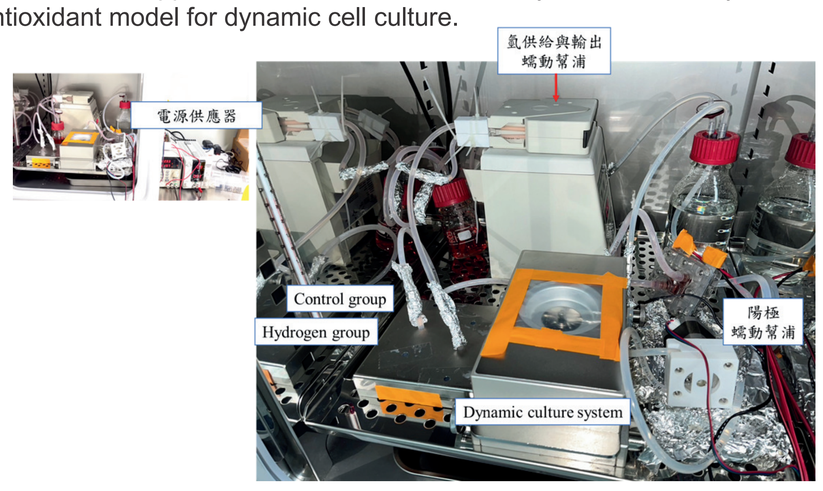

Figure 7. 動態細胞培養抗氧化系統建立
(Dynamic cell culture antioxidant system establishment)

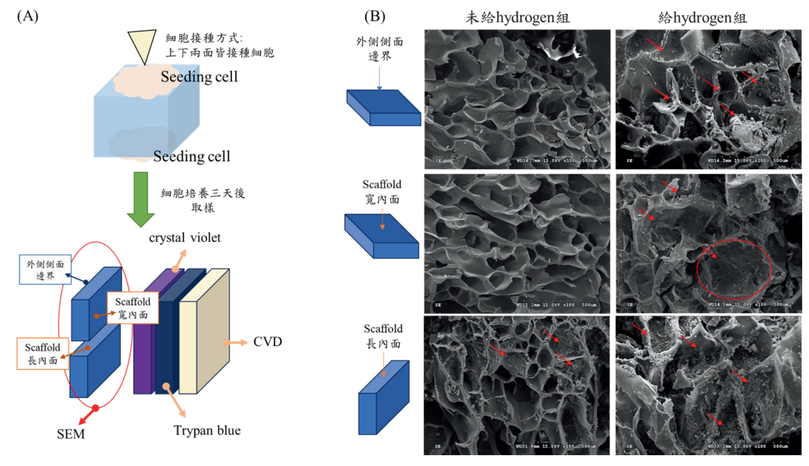

Figure 8. 抗氧化輔助系統提高3D細胞動態培養活性效能驗證
(Validation of enhanced cell viability in 3D dynamic culture using the antioxidant auxiliary system)

商品化程度 Commercialization

目前已成功開發具高效抗氧化效果的細胞培養方法與輔助設備，顯著提升細胞活性與生物製品產量。

A high-efficiency antioxidant cell culture method and auxiliary equipment have been successfully developed, significantly enhancing cell viability and bioproduct yield.

技術突破 Technical Breakthroughs

該設備可應用於各類生物反應器，降低高密度培養的氧化壓力與細胞老化，並具高度生物安全性，無藥物殘留或毒副產物。其可提升細胞對病毒感受性，加速生產循環，並提高細胞活性與密度。整體製程更有效率，能降低成本並減少碳排放，具備產業化應用潛力。

The equipment can be applied to various bioreactors to reduce oxidative stress and cellular senescence in high-density cultures. It ensures high biosafety with no drug residues or toxic byproducts. The system enhances cell susceptibility to viruses, accelerates production cycles, and increases cell activity and density. The overall process becomes more efficient, reducing costs and carbon emissions, and demonstrating strong industrial application potential.

性別友善性 Gender Friendliness

本技術以模組化、輕量化與自動控制設計，營造安全低負擔環境，落實職場平等並適用於不同性別使用者。其抗氧化系統廣泛應用於醫藥與再生醫學等產業，具永續、安全與包容性，展現社會責任與技術價值。

This technology employs modular, lightweight, and automated design to create a safe, low-burden environment that supports workplace equality and inclusivity. The antioxidant system is applicable across pharmaceuticals and regenerative medicine, featuring sustainability, safety, and inclusiveness while demonstrating both social responsibility and technological value.

關鍵字｜抗氧化系統、分子氫、細胞培養、生物反應器、細胞老化、病毒量產、幹細胞技術、無毒殘留、即時監控、GMP製程整合

Keyword | Antioxidant system, Molecular Hydrogen, Cell culture, Bioreactor, Cellular Senescence, Virus Production, Stem Cell Technology, Residue-Free, Real-Time control, GMP Process Integration