2nd Conference on Green Chemistry and Sustainable Coatings

greenchemco

*Pisa, Italy, 28th-30th June 2023*

# Systematic Optimisation and Scaling-up of Cost-effective Bacterial Cellulose Production for Biomedical Applications

Authors: Elliot Amadi[1], Mahendra Raut[1], Syed Mohammad Daniel Syed Mohamed[1], David Gregory[1], Gavin Welsh[2] and Ipsita Roy[1]

*[1] Department of Materials Science and Engineering, University of Sheffield, S37HQ Sheffield, UK.*
*[2] Bristol Renal, Translational Health Sciences, Bristol Medical School, University of Bristol, BS1 3NY, Bristol, UK.*

*Email: enamadi1@sheffield.ac.uk*

Keywords: Bioplastic, green polymer, biocompatibility, polyhydroxyalkanoates, sustainability

**Introduction**

Biomaterials have revolutionized the field of sustainable alternatives to synthetic polymers by offering eco-friendly solutions that reduce our reliance on fossil fuel-based resources. One such example is bacterial cellulose (BC), a biopolymer with a wide range of properties that can be effectively utilized in various biomedical applications. BC-based products have already made significant contributions in areas such as tissue engineering scaffolds, wound healing patches, and the development of medical devices. The unique chemical structure of BC allows for its functionalization through both *in-situ* and *ex-situ* processes, enabling the attainment of specific properties required for specific applications. Another advantage of BC is its relatively straightforward production process, where bacterial organisms secrete polymeric fibers extracellularly. *Komagataeibacter xylinus*, a commonly used bacterium, is predominantly employed for BC production. However, the current production method heavily relies on costly pure sugars, leading to low yields.

**Experimental**

In this study, a new rotary disc bioreactor was developed to enhance the production yield of bacterial cellulose (BC). Initially, the process was validated using glucose as a substrate, resulting in a yield of 365 g/L of wet BC. To further optimize the production, orange peel extract, a commonly available waste material, was used as a substrate, leading to a yield of 179 g/L of wet BC. The BC obtained was subsequently subjected to oxidation, using the free radical TEMPO to create bioresorbable BC. The characteristics of the BC were analyzed using scanning electron microscopy (SEM), thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), and Fourier-transform infrared spectroscopy (FTIR). Additionally, protein absorption and cell viability assays were conducted using kidney cell lines (conditionally immortalized human podocytes and conditionally immortalized glomerular endothelial cells) as well as a skin cell line (HaCaT) to evaluate the biocompatibility of both pure BC and functionalized BC.

**Results and Discussion**

The effectiveness of the bioreactor was validated by running the culture using a glucose-based medium, resulting in a yield of 365 g/L of wet BC. This confirmed the functionality of the bioreactor in generating a substantial amount of BC. To further enhance the process and its sustainability, optimization of the medium by utilizing orange peel extract managed to achieve a yield of 179 g/L of wet BC. This optimization step successfully demonstrated the feasibility of using waste materials as a cost-effective and environmentally friendly alternative to conventional substrates. Regarding the TEMPO-Oxidation reaction, FTIR analyses was completed, which was able to prove the addition of necessary aldehyde groups to the BC structure. Finally, and not the least the biocompatibility of BC was confirmed using resazurin assays with the conditionally immortalized human podocytes, conditionally immortalized glomerular endothelial cells and the skin cell line (HaCaT).

**Conclusions**

In summary, our study achieved successful production of bacterial cellulose (BC) using both glucose and orange peel extract as substrates. The BC polymer was extensively characterized, and modifications were made to create a bioresorbable form of BC. Furthermore, we assessed the biocompatibility of BC, ensuring its suitability for various applications.

**Acknowledgments:**

The authors acknowledge the members of Kroto Research Institute, University of Sheffield for the help and guidance. This is partly a collaborative work between the Department of Material Science and Engineering, University of Sheffield and Bristol Renal, University of Bristol. EA acknowledges funding by the Faculty of Engineering, University of Sheffield, UK.

**Biography**

Elliot Amadi is a PhD student from the Department of Materials Science and Engineering, University of Sheffield, Sheffield, United Kingdom. He achieved a first-class MEng Degree in Materials Science and Engineering and has recently co-authored a paper entitled *Bacterial Cellulose-Based Blends and Composites: Versatile Biomaterials for Tissue Engineering Applications* in a peer-reviewed journal, International Journal of Molecular Sciences during his PhD study. His PhD is funded by the Faculty of Engineering, The University of Sheffield, Sheffield, United Kingdom via a PhD scholarship.