Electroconductive hydrogels for spinal cord regeneration

Zoe Giorgi [a], Johan Sebastian Moreno Lara[a], Valeria Veneruso [b,c], Emilia Petillo[a,b], Enrico Frigerio [b], Pietro Veglianese[b,c], Giuseppe Perale [c,d,e], Filippo Rossi [a]

[a] Department of Chemistry, Materials and Chemical Engineering "Giulio Natta", Politecnico di Milano, Via Luigi Mancinelli 7, 20131 Milan, Italy

[b] Department of Neuroscience, Istituto di Ricerche Farmacologiche Mario Negri IRCCS, Via Mario Negri 2, 20156 Milan, Italy

[c] Faculty of Biomedical Sciences, Università della Svizzera Italiana, 6900 Lugano, Switzerland

[d] Ludwig Boltzmann Institute for Experimental and Clinical Traumatology, 1200 Vienna, Austria

[e] Regenera GmbH, 1030 Vienna, Austria

E-mail: *filippo.rossi@polimi.it*

Introduction

Spinal cord injury (SCI) is a severe condition that compromises the central nervous system, leading to disability and medical complications [1]. Current treatments fail to fully address SCI due to limited neural regeneration and the complex pathophysiology of the disease. Neural stem cells (NSCs) transplantation offers therapeutic potential by promoting tissue repair [1–2]; however, direct injection often results in poor survival and integration [2]. To overcome these limitations, hydrogels can be used as scaffolds that mimic the physical and biochemical properties of neural tissue [2–3]. Incorporating electroconductive polymers may further enhance neuronal differentiation, improving therapeutic outcomes [3]. This work presents the development of electroconductive hydrogels for NSC delivery in SCI treatment. Agarose and gelatin were selected as the biocompatible matrix, while polypyrrole (PPy) and polyaniline (PAni) were introduced for their conductive and antioxidant properties [3–4].

Methods

Agarose-gelatin (AgaGel) hydrogels were prepared by mixing both polymers at 60 °C and cooling to room temperature. Conductive versions were obtained by adding aniline or pyrrole to the hot blend, followed by oxidative polymerization at 4 °C. Residual monomers were removed by washing. Hydrogels were characterized using rheology, swelling tests, conductivity measures, FT-IR, and SEM.

Results

Different AgaGel formulations were created by varying polymer concentrations. Agarose increased mechanical strength, while gelatin improved elasticity but reduced stability at high levels. An optimal ratio was defined to achieve a storage modulus between 100–1000 Pa, ideal for NSCs support. Conductivity and porosity were enhanced by incorporating PPy or PAni without compromising structural integrity.

Conclusions

The proposed strategy enabled the creation of electroconductive hydrogel scaffolds suitable for NSC-based spinal cord regeneration. The combined bioactivity and conductivity provide a promising platform for enhancing SCI therapies.

REFERENCES

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