Natural Polymers for Conductive Hydrogels: A Review

Paola A. Colón, Grace P. Stibie-Cook
Dr. Jairo Rondón, Prof. Ricardo Bravo
Polytechnic University of Puerto Rico -Biomedical Engineering Department
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ABSTRACT

This research aims to develop a conductive hydrogel using natural polymers like chitosan, sodium alginate, and methyl 2-hydroxyethyl cellulose to improve biocompatibility and mechanical properties. Enhanced with conductive elements, crosslinkers, and humectants, the hydrogel optimizes conductivity, adhesion, and moisture retention. Characterization techniques, including impedance analysis, viscosity measurement, and infrared spectroscopy, will assess its performance against commercial products. This research strives to create cost-effective, environmentally friendly hydrogels aiming to advance biomedical applications and wearable bioelectronics.

INTRODUCTION

Hydrogels, discovered in the late 1800s, have evolved from biomedical applications to bioelectronics, serving as conductive bridges between electrical devices and biological tissue (Lee et al., 2024). Their water-rich, polymer-based structure enables low-impedance signal transmission, improving electrode-skin contact while maintaining biocompatibility (Chong et al., 2023).

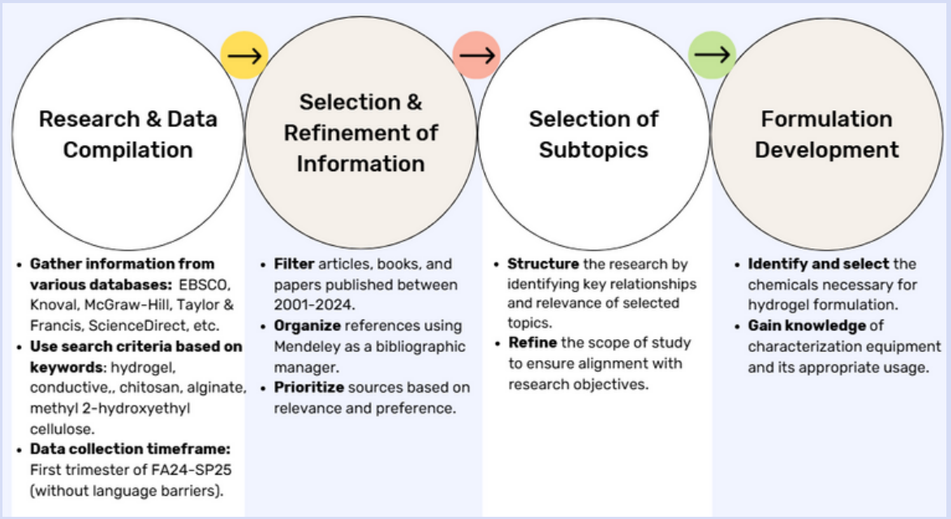
Despite their potential, current conductive hydrogels face compatibility and mechanical issues, including skin irritation and inconsistent adhesion, affecting signal accuracy (Moreno, 2016). To overcome these challenges, natural polymers like chitosan, alginate, and methyl 2-hydroxyethyl cellulose (HEC) are being explored for cost-effective, biocompatible alternatives. Their properties will be tested against commercial ECG gels such as Spectra 360, Axion Electrode Gel, and Signa Gel to enhance stability and performance in bioelectronic applications.

Figure 1 Commercial conductive gels,
Spectra 360, Axion Electrode Conductive Gel, and Signa Gel (Parker Labs Inc & Axion, 2024).

OBJECTIVES

- Base Formulation and Comparison
- Improve Hydrogel Properties
- Enhance Biocompatibility and Mechanical Properties

METHODOLOGY



DATA

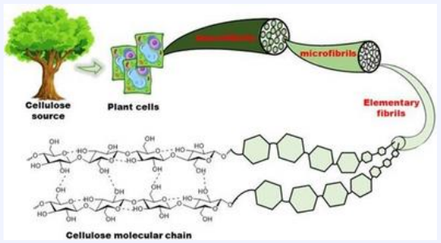


Figure 2 Cellulose hierarchical structure from plant source to molecular level
Source: (Nyamayaro et al., 2023).

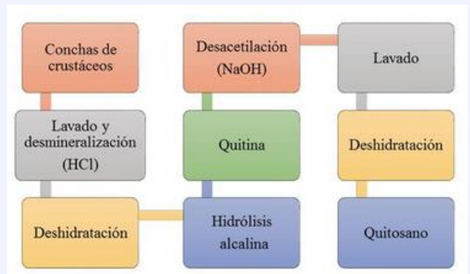


Figure 3 Chitosan procurement from crustacean's shells
(Espinosa et al., 2020).

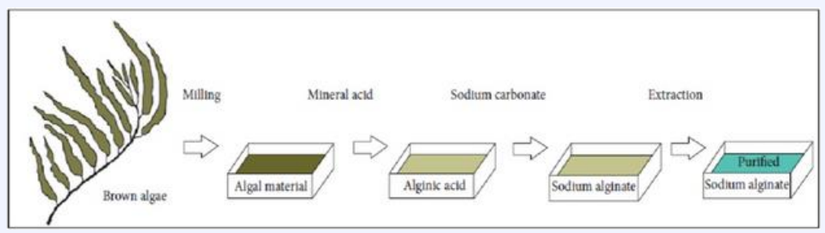


Figure 4 Sodium Alginate Extraction Procedure. Source: (Parveen et al., 2019).

ANALYSIS AND RESULTS

If successful, the formulated conductive hydrogel would provide a biocompatible, cost-effective, and eco-friendly alternative to commercial ECG gels, with potential applications in wearable health monitoring, biosensors, and biomedical electrodes. Considering with more detail the following:

- Characterization of Commercial Hydrogels
- Performance of Formulated Hydrogels
- Impact of Chemical Composition
- Signal Transmission Efficiency
- Comparison to Commercial Standards

CONCLUSION

Conductive hydrogels based on natural polymers offer promising applications in ECG monitoring and bioelectronics due to their biocompatibility, flexibility, and moisture retention. Incorporating chitosan, sodium alginate, and methyl 2-hydroxyethyl cellulose could provide a sustainable, cost-effective alternative to synthetic materials while supporting efficient signal transmission. Enhancing their mechanical properties may further improve their suitability for advanced biomedical technologies in clinical and wearable healthcare settings.

FUTURE WORK

Future efforts will focus on the development and characterization of conductive hydrogel formulations using natural polymers such as chitosan, alginate, and methyl 2-hydroxyethyl cellulose (HEC) in the Polytechnic University Biomedical Engineering Department Laboratory.

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