

SPYDE PROJECT REPORT

Development of Smart SPraYable Medical DEvices to Alleviate Skin Diseases: One idea for Multiple Purposes

WP1: DESIGN AND DEVELOPMENT OF SMART SPRAYABLE MEDICAL DEVICE (SPYDE).

Francesca Tmperio

Summary

The reporting period of research, aimed on the formulation and development of a sprayable gel system whose matrix is made on four different polymers based on Sericin (Ser), Chitosan (CS), Gellan gum (GG) and hyaluronic acid (HA). To study the proper strategies to apply for the synthesis of the new copolymer, studies were conducted separately on Ser and GG. At first, I focused my attention on the extraction and characterization of silk sericin from pre-sectioned silkworms. Several physicochemical analyses were used to characterize sericin at different molecular weights such as: FT-IR spectroscopy, DLS analysis, Raman analysis. Then by using SDS-page we had the opportunity to determine the molecular weight of the different extracts obtained. Then I started with the pre-formulation of hydrogels using different molecular weight silk sericin and cold water: the objective is to compare the hydrogels and understand how the molecular weight influences the characteristics of the gel formation. Since the results were promising, I proceeded with the morphological analysis of this pre-formulated hydrogels using Scanning Electron Microscopy (SEM).

In parallel the effect of NaCl addition as a crosslinking agent on the viscosity of GG-based hydrogels was investigated through rheological analysis.⁽¹⁾ This evaluation also provided preliminary insights into the gel's expected behavior upon the incorporation of chitosan.

The promising results enabled the continuation of the research by testing hydrogel formulations based on Ser and GG, as well as CS and GG. The experimental design was informed by existing literature⁽²⁾, with appropriate modifications applied to the methodologies. With the aim of further investigating which molecular weight of extracted sericin is most suitable for hydrogel formulation, hydrogels were prepared using sericin at different molecular weights in combination with GG. Morphological studies of the hydrogels were conducted using SEM.

The preparation of CS–GG-based hydrogels was preceded by testing different molar ratios of CS to GG⁽³⁾. These samples were subsequently subjected to morphological analysis using SEM and viscosity measurements using a rheometer *Rheomat RM180* (Mettler Toledo, Milano, Italia).

Training activity

During my fellowship I had the opportunity to attend a training course on Scanning Electron Microscopy (SEM) theory and application to integrate this new skill in the project tasks. This course will provide me with the necessary technical skills for detailed morphological evaluations of the compounds developed through the study.

To further build upon the findings obtained so far, the following steps are also planned:

- 1) functionalization of the most suitable Ser fraction will be performed through literature-inspired chemical reactions with some modifications⁽⁴⁾ and adapted to the properties of the extracted material;
- 2) functionalization and characterization of CS with the aim of enabling its interaction with the extracted Ser;
- 3) preliminary studies on the gelling properties of HA: literature reports the gelling properties of HA and shows how these are influenced by its molecular weight^(5,6), so preliminary studies

will focus on identifying the molecular weight at which HA forms a more stable gel suitable for a formulation containing other polymers, and on understanding how the addition of hyaluronic acid can improve the overall system.

REFERENCES

- (1) Ter Horst B, Moakes RJA, Chouhan G, Williams RL, Moiemmen NS, Grover LM. A gellan-based fluid gel carrier to enhance topical spray delivery. *Acta Biomater.* 2019 Apr 15;89:166-179. doi: 10.1016/j.actbio.2019.03.036. Epub 2019 Mar 20. PMID: 30904549.
- (2) Soo in Kim, Ga Yeong Jeon, Se Eun Kim, Seung Ho Choe, Seung Jae Kim, Jin Sol Seo, Tae Woong Kang, Jeong Eun Song, and Gilson Khang. Injectable Hydrogel Based on Gellan Gum/Silk Sericin for Application as a Retinal Pigment Epithelium Cell Carrier, *ACS Omega* 2022 7 (45), 41331-41340 DOI: 10.1021/acsomega.2c05113
- (3) Ariel C. de Oliveira, Bruno H. Vilsinski, Elton G. Bonafé, Johny P. Monteiro, Matt J. Kipper, Alessandro F. Martins. Chitosan content modulates durability and structural homogeneity of chitosan-gellan gum assemblies, *International Journal of Biological Macromolecules*, Volume 128, 2019, Pages 114-123, ISSN 0141-8130, <https://doi.org/10.1016/j.ijbiomac.2019.01.110>. (<https://www.sciencedirect.com/science/article/pii/S0141813018350669>)
- (4) Blessing C. Ilochonwu, Marko Mihajlovic, Roel F. Maas-Bakker, Charis Rousou, Miao Tang, Mei Chen, Wim E. Hennink, and Tina Vermonden. Hyaluronic Acid-PEG-Based Diels–Alder *In Situ* Forming Hydrogels for Sustained Intraocular Delivery of Bevacizumab. *Biomacromolecules* 2022 23 (7), 2914-2929, DOI: 10.1021/acs.biomac.2c00383
- (5) Qiao Cheng, Changqi Liu, Jing Zhao, Fengxian Guo, Jiawei Qin, Yaosong Wang, Hyaluronic acid promotes heat-induced gelation of ginkgo seed proteins, *Food Chemistry*, Volume 463, Part 1, 2025, 141114, ISSN 0308-8146, <https://doi.org/10.1016/j.foodchem.2024.141114>.
- (6) Gholamali, I.; Vu, T.T.; Jo, S.-H.; Park, S.-H.; Lim, K.T. Exploring the Progress of Hyaluronic Acid Hydrogels: Synthesis, Characteristics, and Wide-Ranging Applications. *Materials* 2024, 17, 2439. <https://doi.org/10.3390/ma17102439>

Chieti, 20/05/2025

Francesca Timperio



Prof. Piera Di Martino

Piera Di Martino
22.05.2025
18:02:47
GMT+02:00