

Brief information about the project

Name of the project	AP25795359 «Synthesis and characterization of gelatin derivatives with unsaturated anhydrides for the development of hydrogels intended for drug delivery and tissue engineering»
Relevance	Developing novel dosage forms based on gelatin with enhanced properties poses a significant challenge for the pharmaceutical industry. Gelatin, derived from collagen, is a natural polymer that has attracted considerable attention in biomedicine due to its high biocompatibility, solubility in aqueous solutions, and low immunogenic response. These attributes render gelatin particularly suitable for applications in tissue engineering and drug delivery systems. However, its mechanical strength and stability under physiological conditions are limited, which constrains its broader application. To address these limitations, various chemical modifications can enhance the functional properties of gelatin. One promising strategy involves the functionalisation of gelatin with unsaturated anhydrides, such as methacrylic, crotonic, and itaconic anhydrides. This approach not only improves the mechanical strength of gelatin derivatives but also enhances their potential for photopolymerisation, thereby facilitating the formation of three-dimensional hydrogel networks with tailored properties. Methacryloylated gelatin (gelatin-MA) has emerged as a focal point of research due to its ability to form hydrogels upon UV irradiation in the presence of photoinitiators. Additionally, gelatin inherently contains bioactive sequences, such as the arginine-glycine-aspartate (RGD) sequence, which promotes cell adhesion and migration within the matrix. The modification of gelatin with crotonic and itaconic anhydrides introduces additional functional groups, thereby opening new avenues for further enhancing its properties.
Purpose	This project aims to synthesise and characterise methacryloylated, crotonoylated, and itaconoylated gelatin derivatives for developing hydrogels designed for drug delivery and tissue engineering applications.
Objectives	1. Synthesis of methacryloylated, crotonoylated, and itaconoylated gelatin derivatives using methacrylic, crotonic, and itaconic anhydrides, respectively. 2. The structural investigation of the synthesised derivatives will employ infrared (IR) and nuclear magnetic resonance (NMR) spectroscopies. To determine the degrees of substitution, a colourimetric assay using 2,4,6-trinitrobenzenesulfonic acid (TNBS) will be utilized. Understanding these structural changes will enable predictions of the properties of modified gelatins and facilitate correlations with subsequent evaluations of their rheological characteristics. 3. The rheological properties will be investigated by determining melting and gelation points across temperature ranges of 0-40 °C (heating cycle) and 40-0 °C (cooling cycle), respectively. Isoelectric points will be assessed using dynamic light scattering (DLS) through electrophoretic mobility measurements. Additionally, the impact of pH on conformational changes will be analysed using a viscometric technique. These measurements are

	essential for understanding material behaviour in biomedical applications and will contribute to the characterisation of hydrogels. 4. Developing photocrosslinked hydrogels using methacryloylated, crotonoylated, and itaconoylated gelatin derivatives in the presence of a photoinitiator followed by UV light treatment. The physicochemical characteristics, including porosity, swelling degree, mechanical properties, and kinetics of model drug release from hydrogel matrices, will be systematically studied. These properties, influenced by earlier tasks, will inform the applicability of the hydrogels in drug delivery systems and tissue engineering. 5. The biocompatibility of methacryloylated, crotonoylated, and itaconoylated gelatin derivatives will be investigated through methodologies assessing cytotoxicity, cell migration, proliferation, and morphology. These evaluations will provide insight into the potential applications of the hydrogels in tissue engineering and will correlate directly with their physicochemical characteristics.
Expected and achieved results	Achieved results (2025) – Methacryloylated, crotonoylated, and itaconoylated gelatin derivatives were successfully synthesized using methacrylic, crotonic, and itaconic anhydrides. – Structural characterization of the modified gelatin derivatives was carried out using infrared (IR) and nuclear magnetic resonance (NMR) spectroscopy. – The degree of functional group substitution was quantified using the 2,4,6-trinitrobenzenesulfonic acid (TNBS) assay. – Isoelectric points were determined by dynamic light scattering (DLS) based on electrophoretic mobility measurements. – The influence of pH on conformational changes in the gelatin derivatives was investigated using viscometry. Expected results By 2026: – Investigation of rheological properties, including gelation and melting temperatures in the ranges of 0–40 °C and 40–0 °C. – Development of photocrosslinked hydrogels based on Gelatin-MA, Gelatin-CA, and Gelatin-IA using a photoinitiator and UV-induced crosslinking. – Publication of one research article in a journal indexed in Web of Science (first three quartiles) or Scopus (≥ 50 CiteScore percentile). By 2027: – Evaluation of physicochemical properties of the hydrogels, including porosity, swelling degree, and mechanical properties. – Analysis of drug release kinetics of a model compound from hydrogel matrices. – Assessment of biocompatibility of methacryloylated, crotonoylated, and itaconoylated gelatin derivatives using cytotoxicity, cell migration, proliferation, and morphology assays. – Publication of one research article in a journal indexed in Web of Science (first three quartiles) or Scopus (≥ 50 CiteScore percentile).

Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles	1. Shatabayeva Elvira, PhD. H-index in Scopus – 2, Scopus Author ID 57188923162, https://www.scopus.com/authid/detail.uri?authorId=57188923162. H-index in the Web of Science database – 2, Researcher ID R-3120-2018, ORCID 0000-0000-1915-35198, https://orcid.org/0000-0000-1915-35198. 2. Kaldybekov Daulet, PhD – H-index in Scopus – 11, Scopus Author ID 55975396000, https://www.scopus.com/authid/detail.uri?authorId=55975396000. H-index in the Web of Science database – 11, Researcher ID F-1321-2014, ORCID 0000-0002-7191-5465, https://orcid.org/0000-0002-7191-5465
Usage	The developed photocrosslinked hydrogels are considered promising materials for drug delivery systems and tissue engineering. They may enable controlled release of therapeutics, allowing the creation of prolonged formulations, reduced administration frequency, and enhanced therapeutic efficacy. The presence of RGD sequences in gelatin suggests potential for cell adhesion and migration, while photocrosslinking provides the possibility of forming structures with defined mechanical properties
Priority compared to real-world alternatives	Compared to synthetic polymers (PEG, PVA, etc.): gelatin derivatives offer superior biocompatibility, lower immunogenicity, and contain natural bioactive sequences (such as RGD) that promote cell adhesion and migration, making them more suitable for biomedical applications. Compared to commercial GelMA: methacrylated gelatin is already available and well-studied, whereas crotonylated and itaconylated derivatives remain largely unexplored and lack commercial equivalents. This provides scientific novelty and opens opportunities to design hydrogels with unique properties, including tunable mechanical performance and controlled drug release.
List of publications with links to them	-
Patents	-