MECHANICAL PROPERTY, FUNCTIONAL GROUP & PORE SIZE DISTRIBUTION ANALYSES

of Electrospun Gelatin–Cellulose Acetate
for Suitability in Wound Dressing Applications

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INTRODUCTION & BACKGROUND OF STUDY

THE CLINICAL NEED

Rising cases of chronic wounds, burns, diabetic ulcers and post-surgical injuries have increased the demand for effective wound dressings (Ahmed *et al.,* 2022).

An ideal dressing should maintain a moist environment, allow gaseous exchange, prevent microbial invasion and provide mechanical support during healing.

Conventional dressings (gauze, cotton) often fail due to poor moisture management and limited structural integrity (Xue *et al.,* 2019). More durable bio-based dressings support resilient healthcare systems.

ELECTROSPINNING ADVANTAGE

Electrospun nanofibers offer high surface area, interconnected porosity and a 3-D architecture that closely resembles the native extracellular matrix (Xue *et al.,* 2019).

Gelatin is biocompatible and bioactive but mechanically weak. Cellulose acetate (CA) provides strength, chemical stability and moderate water resistance (Liu *et al.,* 2021).

Blending the two polymers is expected to combine biological performance with improved mechanical integrity (Sriyanti *et al.,* 2016).

STATEMENT OF THE PROBLEM

01

Conventional Dressings

Poor moisture retention, limited gas permeability and inadequate protection against infection can delay wound healing (Ahmed *et al.,* 2022).

02

Pure Gelatin Limitation

Excellent biocompatibility and cell-recognition sequences, but weak mechanical strength and poor aqueous stability restrict practical use.

03

Cellulose Acetate Limitation

Good mechanical strength and spinnability, yet lacks sufficient biological activity for active tissue regeneration.

04

Research Gap

There is a need for gelatin–cellulose acetate composites that combine gelatin's biological properties with CA's mechanical reinforcement and stability.

AIM AND SPECIFIC OBJECTIVES OF THE STUDY

AIM

To develop and characterize electrospun gelatin–cellulose acetate composites for potential application as a wound dressing material, focusing on functional-group interactions, pore-size characteristics and mechanical properties.

SPECIFIC OBJECTIVES

1. Produce electrospun pure gelatin and gelatin–CA composites at 1, 3 and 5 wt.% CA.
2. Determine chemical composition and functional groups using Fourier-transform infrared spectroscopy (FTIR).
3. Evaluate mechanical properties: tensile strength, elastic modulus, elongation at break and energy at break.
4. Characterize surface morphology and average pore size distribution via SEM and ImageJ analysis.
5. Identify the optimum CA concentration that balances strength, flexibility and pore characteristics for wound dressing use.

SCOPE OF THE STUDY

Matrix Polymer

Type A gelatin derived from cow bone

Reinforcement

Cellulose acetate at 0, 1, 3 and 5 wt.%

Solvent System

30 mL binary mixture (24 mL acetic acid + 6 mL deionised water)

Electrospinning

15–25 kV, 0.5–1.5 mL h^{-1}, 10–15 cm tip-to-collector distance

Characterization Focus

FTIR (functional groups), Tensile testing, SEM + ImageJ (pore size)

Application Target

Potential wound dressing material – mechanical integrity and porosity for healing environment

JUSTIFICATION OF THE STUDY

01

Healthcare Impact

Supports better wound-care outcomes through biocompatible, mechanically reliable dressings that contribute to more resilient healthcare systems.

02

Sustainable Materials

Utilises renewable biopolymers (gelatin from animal by-products and cellulose derivatives), supporting sustainable development of medical materials.

03

Local Capacity Building

Encourages local production of advanced biomaterials and can stimulate related enterprise and employment.

04

Knowledge Contribution

Provides systematic data on the effect of CA content on functional groups, pore structure and mechanical performance of gelatin nanofibers.

LITERATURE REVIEW – KEY STUDIES

Table 1.0: Summary of key related studies

Authors	Focus / Result	Gap Identified
Ahmed *et al.* (2022)	High porosity & surface area improve oxygen permeability and cell attachment; blending natural + synthetic polymers enhances performance.	Gelatin–CA systems and optimisation of blend composition not investigated.
Khalil *et al.* (2023)	Ultrafine fibres with enhanced antibacterial activity; polymer blending improved flexibility and durability.	No experimental work on gelatin–CA or effect of varying CA content.
Liu *et al.* (2021)	CA shows good electrospinnability, biodegradability and high mechanical strength with improved moisture resistance.	Treated CA as stand-alone; interaction with gelatin not examined.
Xue *et al.* (2019)	Controlled morphology, high surface area and interconnected pores resembling ECM, supporting cell adhesion.	Process-focused; optimisation for stable gelatin–CA fibres not discussed.

MATERIALS AND METHODS

MATERIALS

- Type A gelatin (cow-bone, China)
- Cellulose acetate (reinforcing phase)
- Glacial acetic acid + deionised water
- All reagents used as received

EQUIPMENT

- Digital balance & magnetic stirrer
- Single-nozzle electrospinning set-up
- FTIR spectrometer
- Universal testing machine & SEM

Table 2.0: Formulation of gelatin–cellulose acetate electrospinning solutions

Sample	Gelatin (g)	CA (g)	Acetic acid (mL)	Water (mL)
Control (0%)	17.00	0	24.0	6.0
A (1%)	16.83	0.17	24.0	6.0
B (3%)	16.49	0.51	24.0	6.0
C (5%)	16.15	0.85	24.0	6.0

EXPERIMENTAL PROCEDURE AND CHARACTERIZATION

1

Solution Prep

17 g total polymer in 30 mL solvent; stirred 80–100 °C, 500–600 rpm, ~2 h

2

Electrospinning

15–25 kV, 0.5–1.5 mL h^{-1}, 10–15 cm distance, 21 G needle

3

Collection

Mats collected on grounded aluminium plate and stored sealed

CHARACTERISATION TECHNIQUES

FTIR

4000–400 cm^{-1}; identify functional groups and intermolecular interactions

Tensile Test

Universal testing machine; strength, modulus, elongation, energy at break

SEM + ImageJ

Morphology and average pore size measured across multiple regions

RESULTS & DISCUSSION – FTIR ANALYSIS

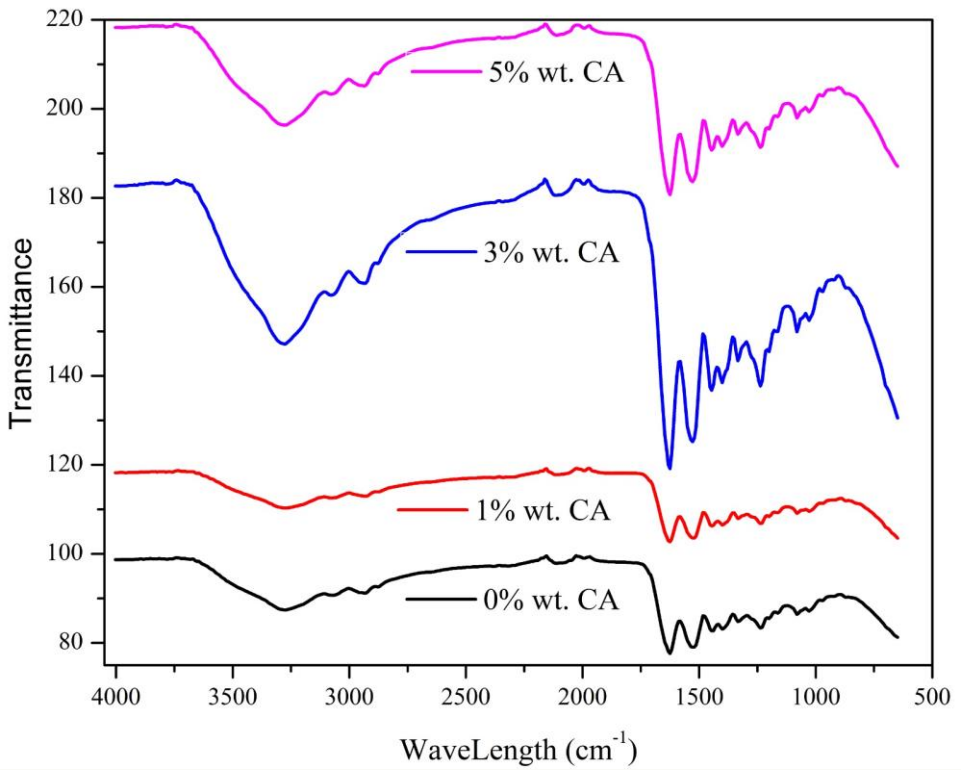


Figure 1.0: Combined FTIR Spectra of pure gelatin and gelatin–cellulose acetate composites

KEY OBSERVATIONS

- Amide I (~1625 cm^{-1}) and Amide II (~1520–1536 cm^{-1}) confirm gelatin backbone is preserved.
- Slight shift of O–H/N–H band (3280 → 3272 cm^{-1}) indicates intermolecular hydrogen bonding between gelatin and CA.
- No new absorption peaks appear → interaction is predominantly physical.
- Increasing CA produces minor peak shifts consistent with improved molecular compatibility.

RESULTS & DISCUSSION – MECHANICAL PROPERTIES

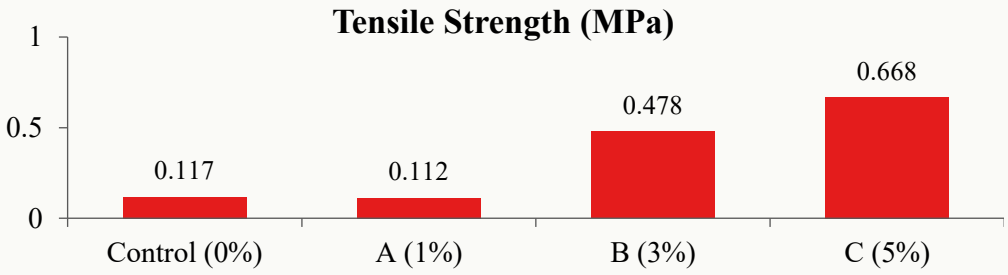


Figure 2.0: Ultimate Tensile Strength of Samples

Table 3.0: Mechanical properties of gelatin / gelatin–cellulose acetate composites

Sample	Tensile (MPa)	Modulus (MPa)	Elongation (%)	Energy (J)
Control (0%)	0.117	11.920	8.590	0.00201
A (1%)	0.112	1.250	18.850	0.00610
B (3%)	**0.478**	**3.940**	**24.970**	**0.05210**
C (5%)	0.668	14.630	12.991	0.02250

STRENGTH TREND

Tensile strength rises with CA content and reaches a maximum of 0.668 MPa at 5 wt.%. Elastic modulus recovers and exceeds the control only at 5 wt.%.

OPTIMUM BALANCE – 3 wt.%

3 wt.% CA delivers the best combination of strength (0.478 MPa), ductility (24.97%) and toughness (0.0521 J), making it most suitable for flexible wound dressings.

RESULTS & DISCUSSION – SEM MORPHOLOGY

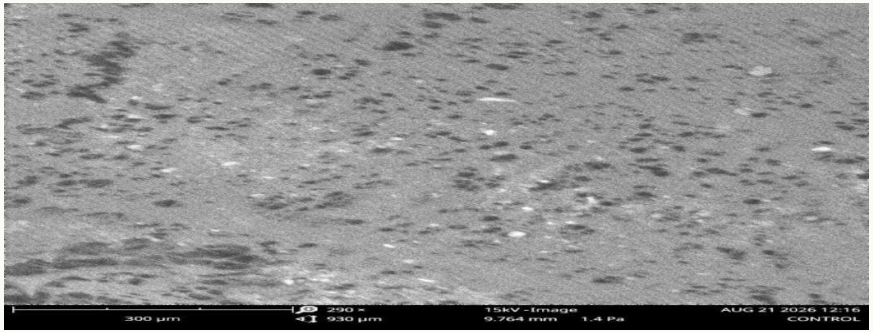


Figure 3.0: SEM of Control (0 wt.% CA)

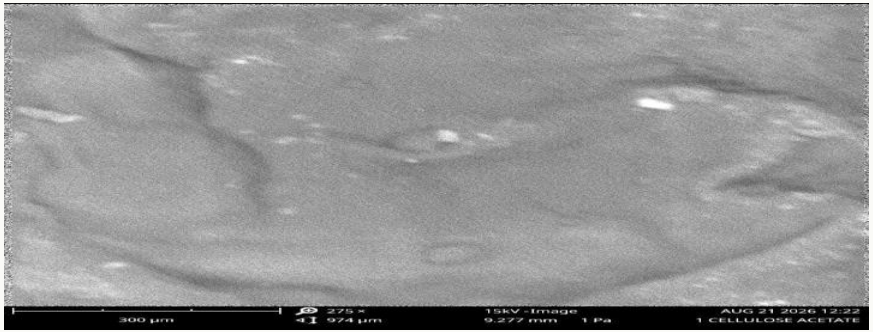


Figure 4.0: SEM of 1 wt.% CA

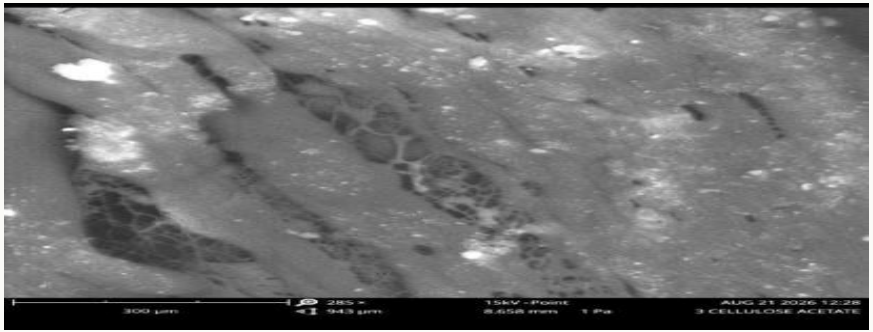


Figure 5.0: SEM of 3 wt.% CA

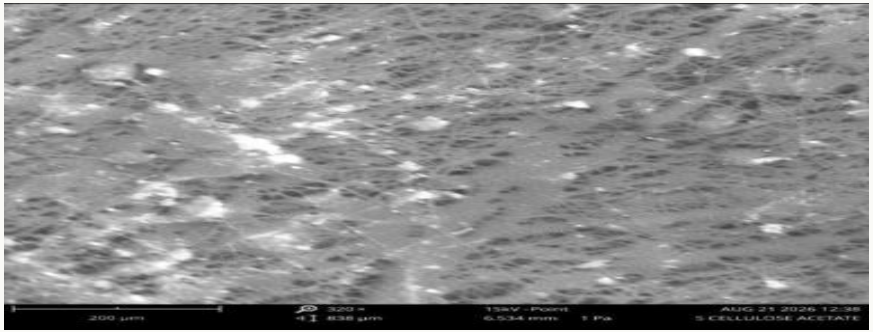


Figure 6.0: SEM of 5 wt.% CA

RESULTS & DISCUSSION – PORE SIZE DISTRIBUTION (ImageJ)

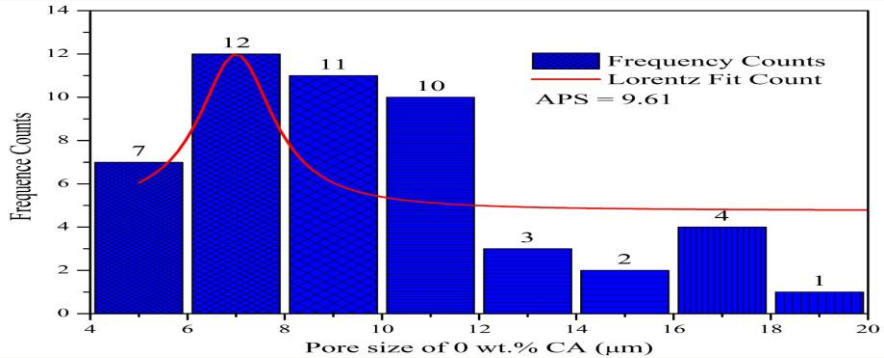


Figure 7.0: Pore size – Control (0 wt.%) Avg 9.61 µm

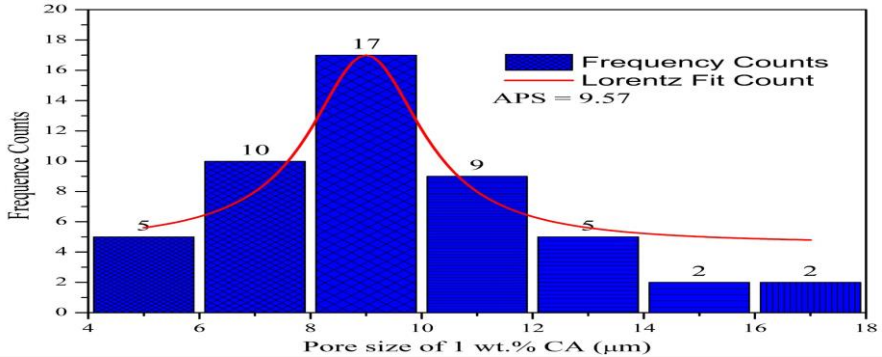


Figure 8.0: Pore size – 1 wt.% CA Avg 9.57 µm

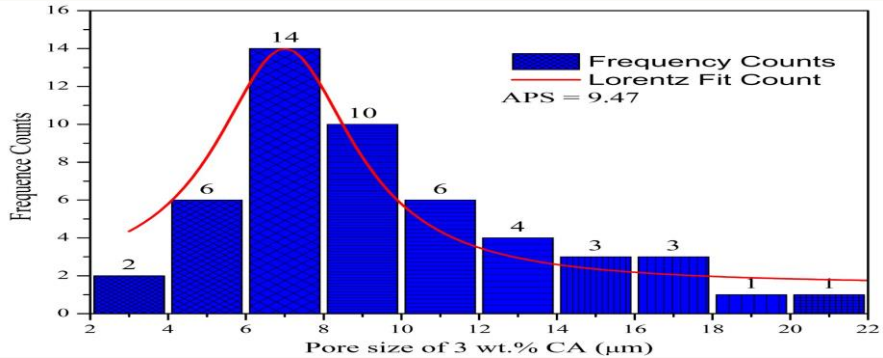


Figure 9.0: Pore size – 3 wt.% CA Avg 9.47 µm

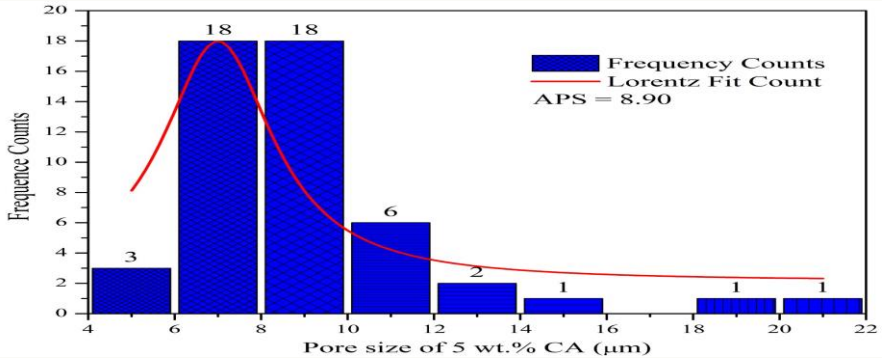


Figure 10.0: Pore size – 5 wt.% CA Avg 8.90 µm

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

- Gelatin nanofibers containing 0–5 wt.% cellulose acetate were successfully fabricated by electrospinning.
- FTIR confirmed intermolecular hydrogen bonding between the polymers without formation of new covalent bonds.
- Pore sizes ranged from 8.90 to 9.61 µm; the open interconnected structure was best retained at 3 wt.% CA.
- 3 wt.% CA provided the optimum balance of tensile strength (0.478 MPa), elongation (24.97%) and energy at break (0.0521 J), offering a promising bio-based material that supports sustainable and resilient wound-care solutions.

RECOMMENDATIONS

- Evaluate swelling behaviour, fluid absorption capacity and moisture-vapour transmission rate under moist conditions.
- Explore chemical or physical crosslinking to improve long-term aqueous stability.
- Study finer CA increments between 3–5 wt.% and incorporate antimicrobial or bioactive agents for enhanced clinical performance.

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THANK YOU FOR LISTENING

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