

Development of an Eco-friendly Cotton Fabric Utilizing Biodegradable Chitosan for Enhanced Antibacterial, Crease Recovery, and Water Repellent Properties

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Abstract

Numerous fabric coatings have been developed using chitosan to enhance the antibacterial, crease recovery, and water resistance properties of cotton fabric.. Chitosan (CS) was prepared from chitin, which extracted from prawn shells and prepared chitosan has been chemically modified using allyl bromide and lauric acid to prepare allyl-chitosan (A-CS) and lauric-chitosan (L-CS). The formation of chitosan and its derivatives was confirmed by Fourier Transform Infrared Spectroscopy (FTIR), Powder X-ray Diffraction (pXRD) and Thermogravimetric Analysis (TGA). The resultant coatings were applied on cotton fabric using Tripolyphosphate (TPP), 1,2,3,4-butanetetracarboxylic acid (BTCA) and succinic acid (SA) via dip coating and pad-dry-cure method. Additionally, silane-based chitosan coatings were applied to create reference hydrophobic fabrics. Coated fabrics have proved their antibacterial and hydrophobic properties in different levels and results indicate that crease recovery property will retain after each modification. Based on performance evaluations, industrial applicability, and operational feasibility, L-CS and L-CS with crosslinking agent coated fabrics demonstrated the most favorable results.

Introduction

- Modern easy-care clothing has evolved with a variety of improved textile characteristics that make them suitable for a diverse lifestyle including quick-drying, odor resistance and crease recovery, which help to keep an organized and attractive appearance during wear.
- Chitosan is a renewable biopolymer having biodegradability, biocompatibility, non-toxicity, and multifunctionality, that coincides with the growing demand for environmentally friendly and sustainable textile treatments, making it a promising alternative to traditional synthetic agents
- In this study, chitosan was chemically modified with allyl bromide and lauric acid and were coated on cotton fabric using Tripolyphosphate (TPP), 1,2,3,4-butanetetracarboxylic acid (BTCA) and succinic acid (SA) to improve antibacterial, hydrophobic and crease recovery properties of the fabric.

Conclusions

Chitosan (21% yield, 72.66% deacetylation) and its derivatives (A-CS, L-CS) were confirmed by FTIR and XRD, and TGA showing reduced crystallinity, thermal stability. Antibacterial activity against *S. aureus* and *E. coli*, enhanced of hydrophobic properties and retained crease recovery properties were observed on coated fabrics. Overall, L-CS based coatings demonstrated the best performance and industrial feasibility, making them the most promising outcome of the study.

Methodology

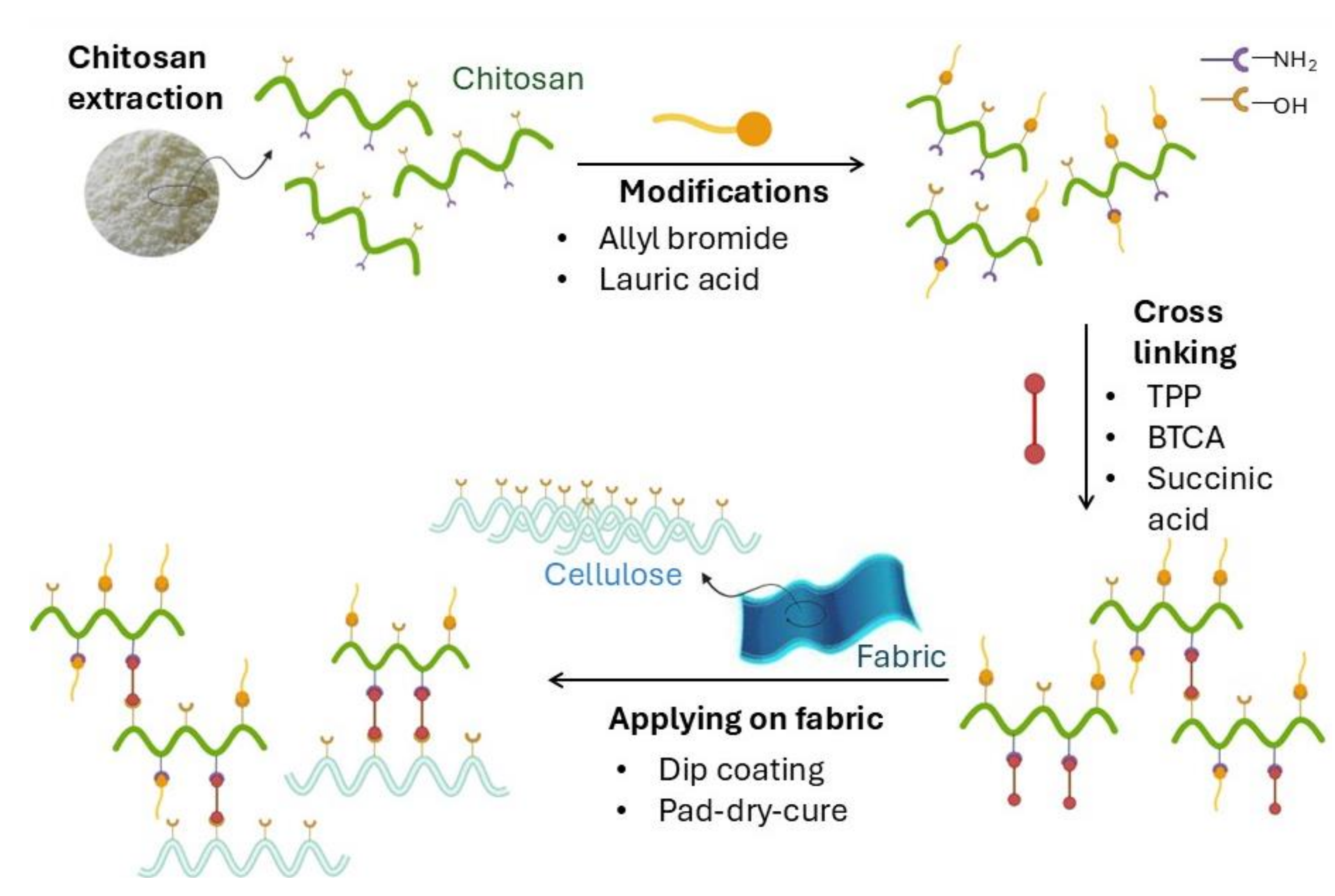


Figure 01: Summary of the methodology.

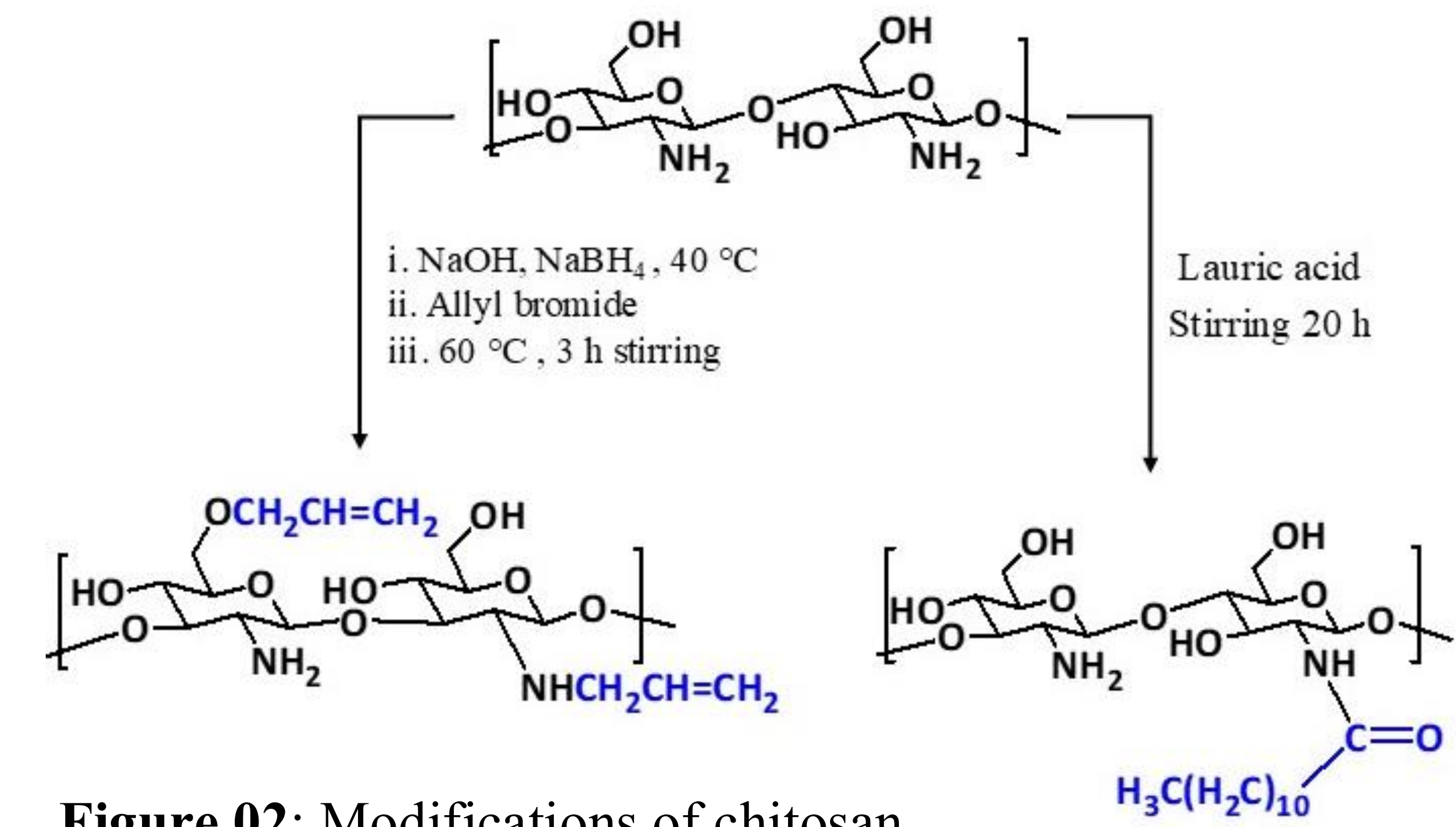


Figure 02: Modifications of chitosan.

- Coatings were applied with TPP, SA via layer-by-layer method and with BTCA via one-pot method.

Results and Discussion

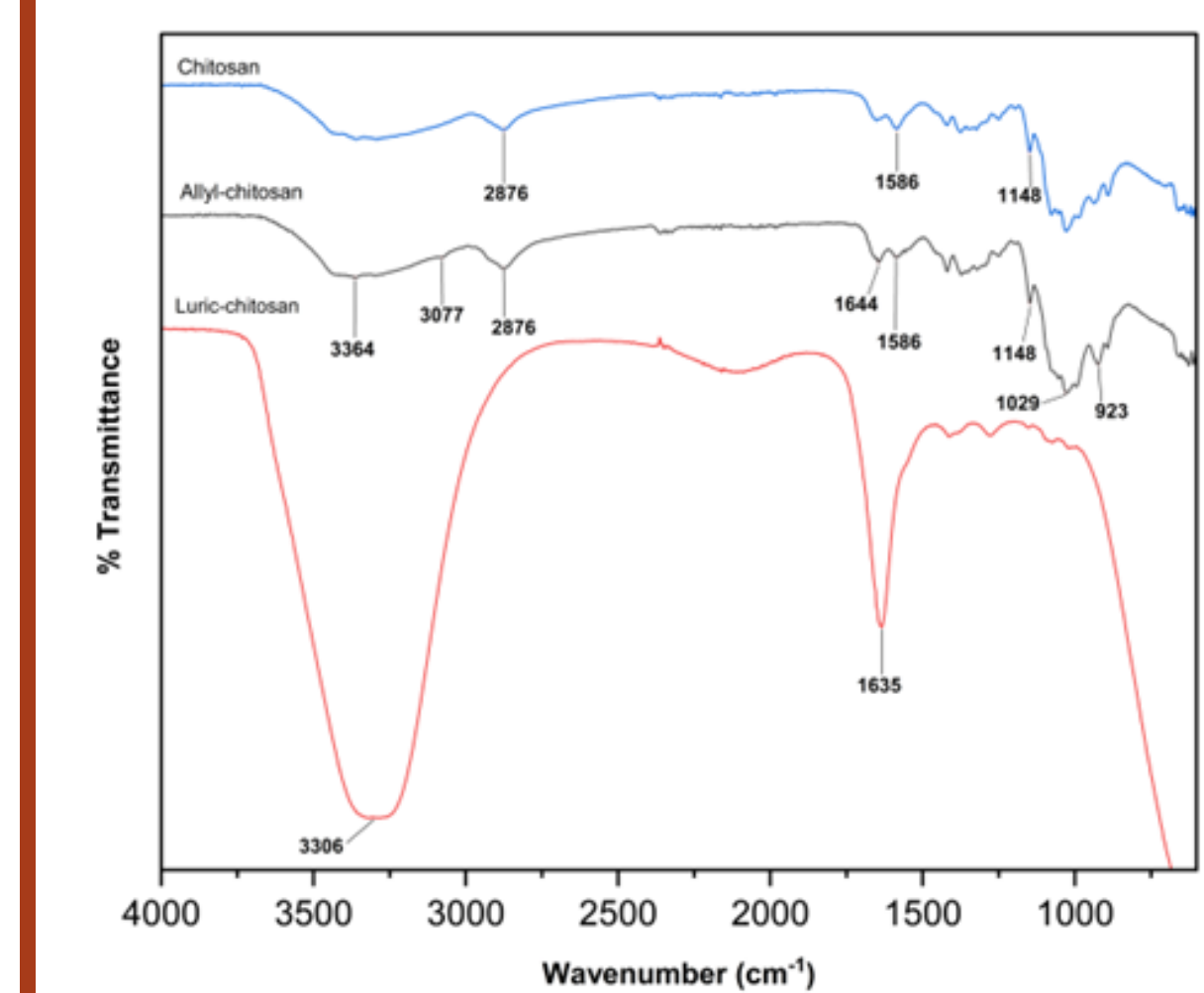


Figure 03: The FTIR spectra of CS, A-CS and L-CS.

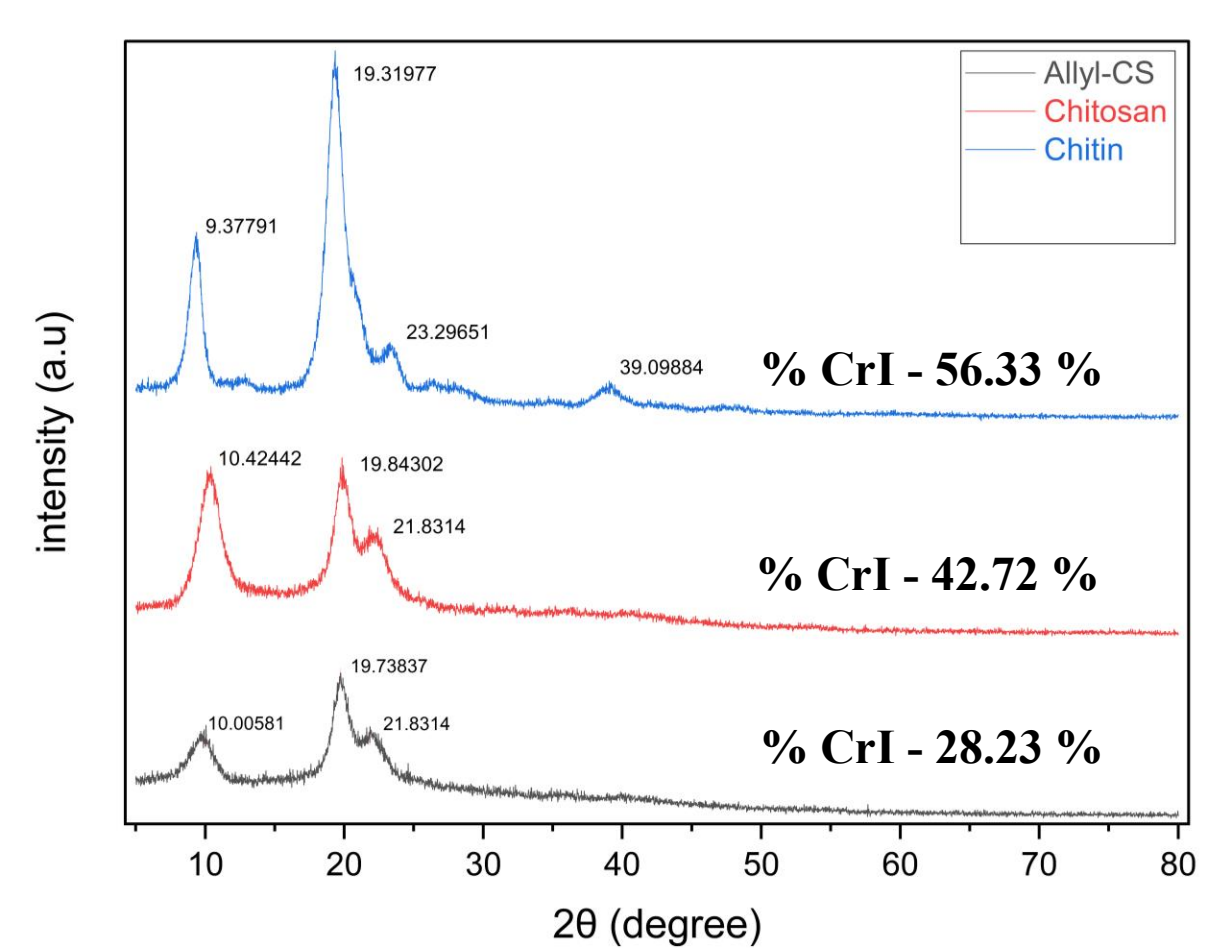
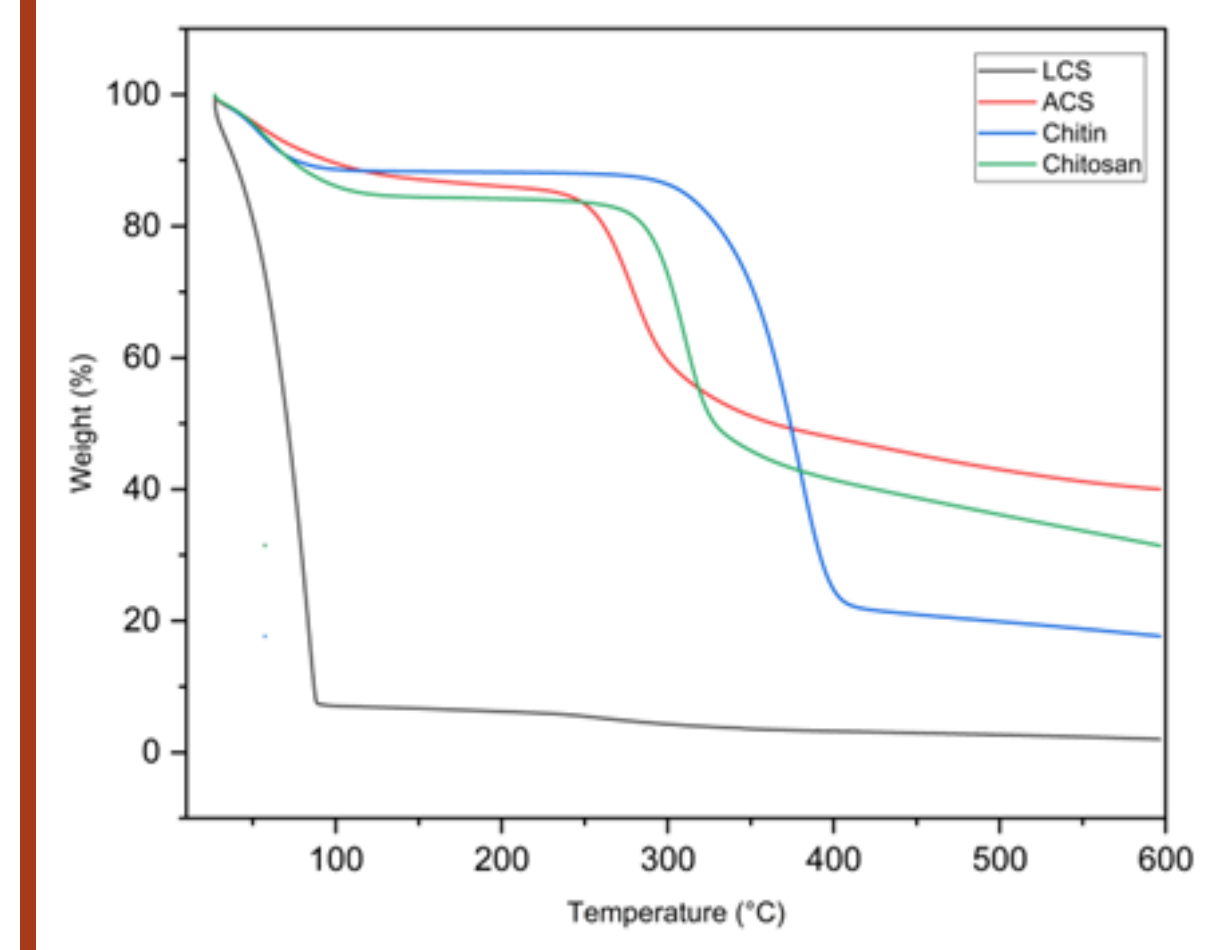
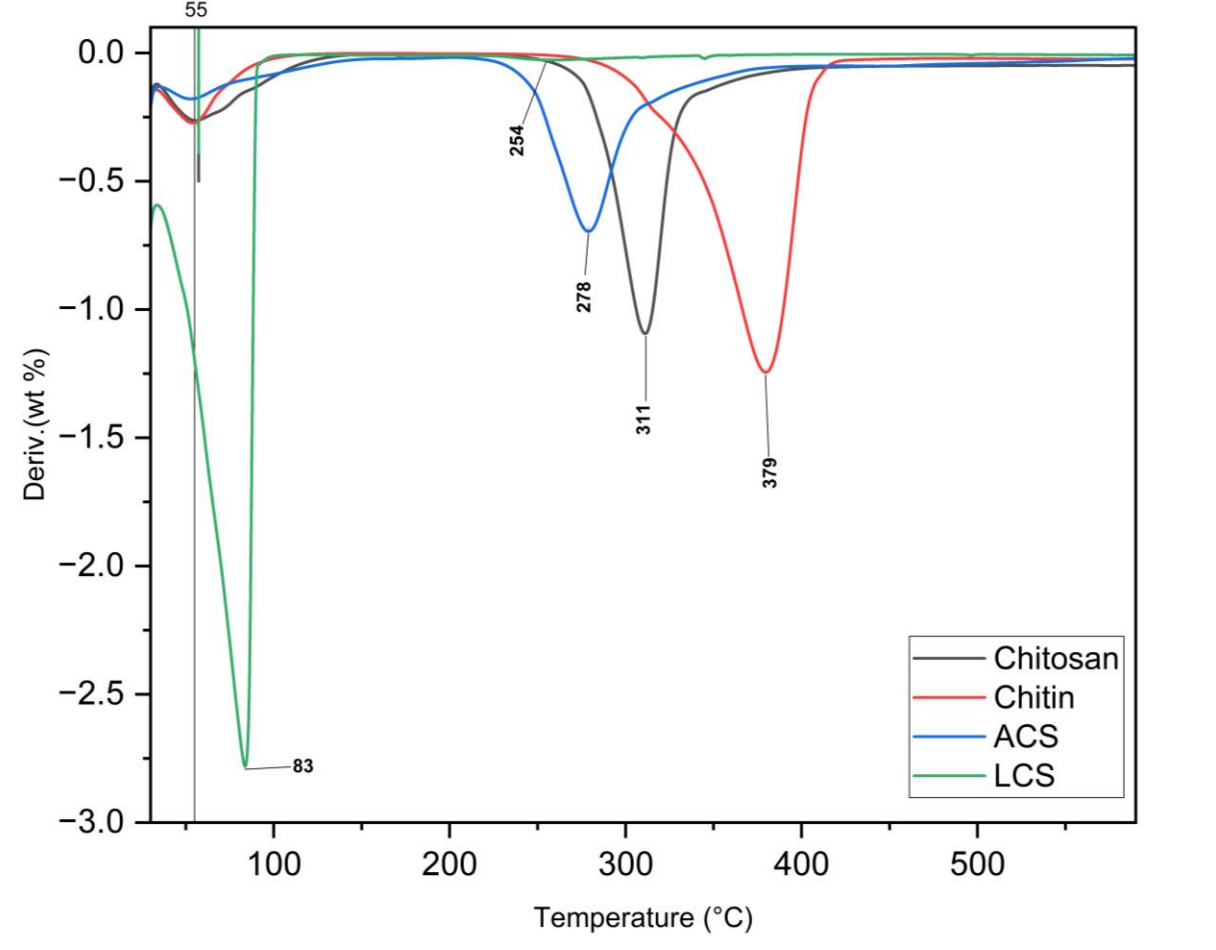


Figure 04: XRD plots of chitin, CS and A-CS



(a)



(b)

Figure 05: (a) TGA and (b) DTG curves for chitin, chitosan, allyl-chitosan (A-CS) and lauric-chitosan (L-CS).

Test/test method	CS	A-CS	A-CS-TPP	L-CS	L-CS-TPP	L-CS-BTCA	L-CS-SA	OT-CS	Cotton
Warp way									
Face to Face	87°	83°	82°	85°	89°	90°	90°	91°	90°
Back to Back	90°	85°	82°	85°	92°	91°	92°	92°	92°
Weft way									
Face to Face	91°	82°	82°	90°	92°	92°	92°	92°	92°
Back to Back	94°	86°	85°	92°	93°	92°	92°	93°	94°

Figure 06: Results of crease recovery test: AATCC 66-2017.

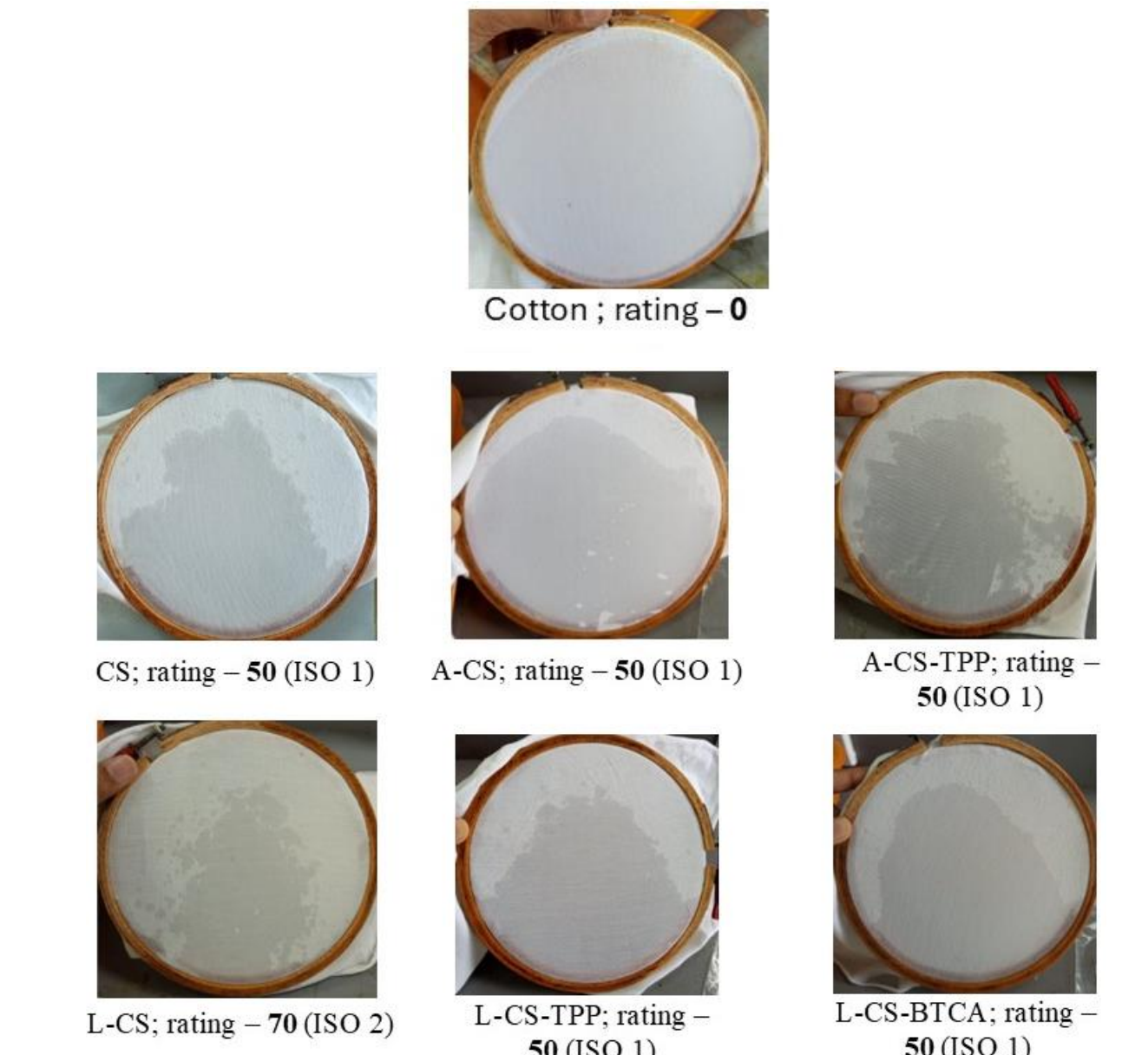


Figure 07: Spray test results of cotton fabric and best resulted samples

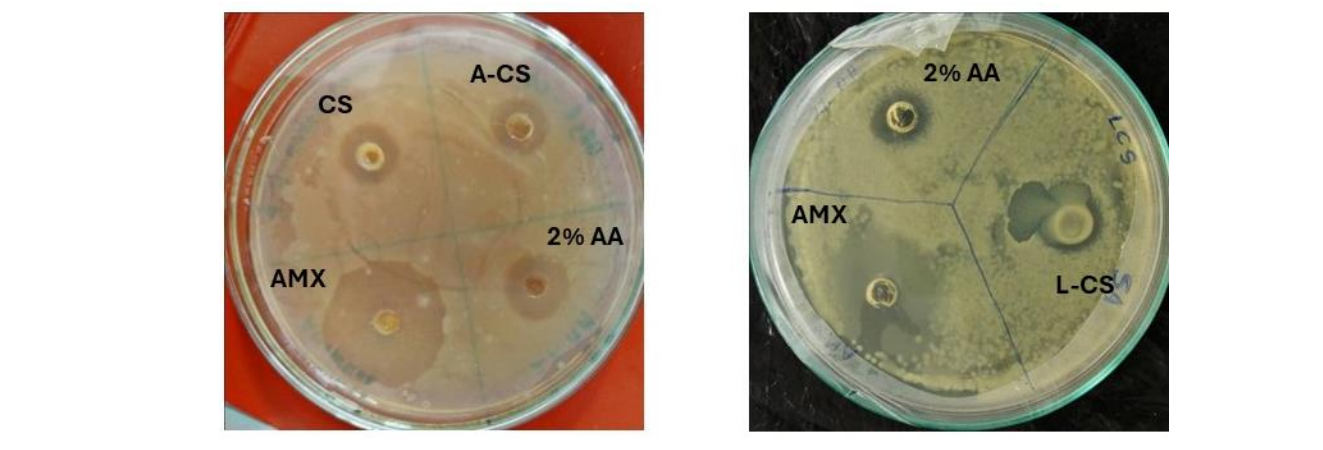


Figure 08: Antibacterial test for CS, A-CS and L-CS against *Staphylococcus aureus*.

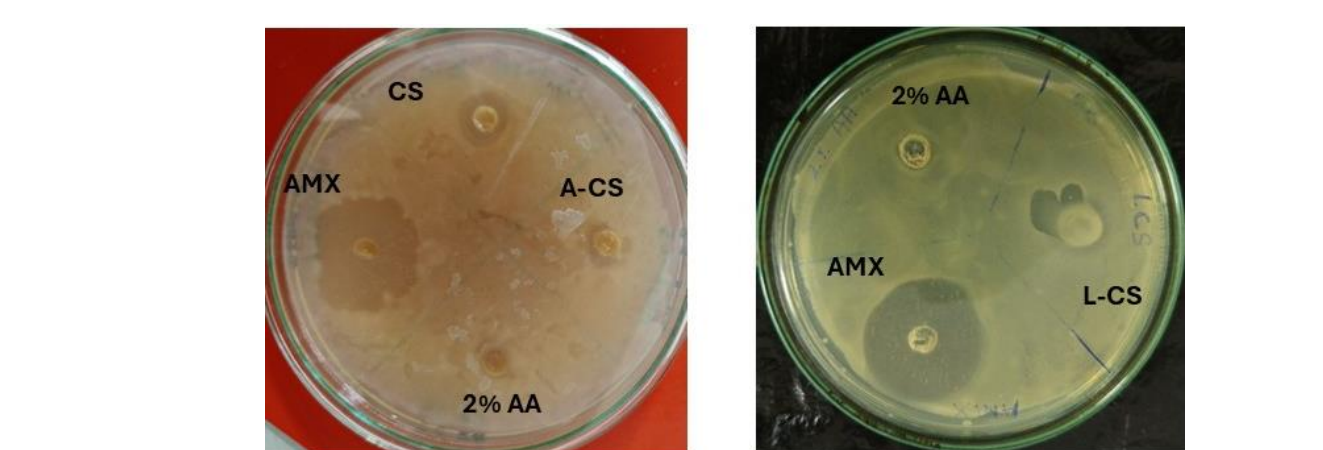
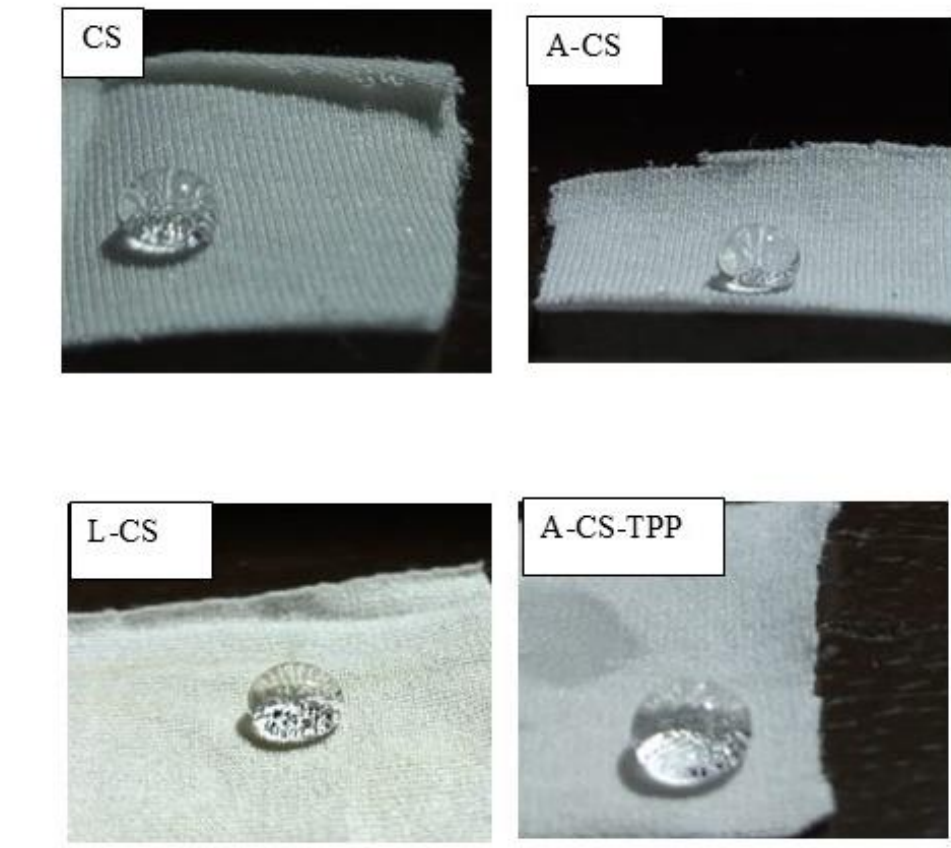


Figure 09: Antibacterial test for CS, A-CS and L-CS against *Escherichia coli*.



Samples	Contact angle values
CS	146.319°
A-CS	149.556°
A-CS-TPP	145.166°
L-CS	138.702°

Figure 10: Results of water contact angle.