Development of PLA Fibers as an Antimicrobial Agent with enhanced infection resistance using electrospinning/plasma technology

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Introduction

Humans are vulnerable and easily prone to all kind of injuries, diseases, and traumas that can be damaging to their tissues (including its building unit, cells), bones, or even organs. Therefore, they would need assistance in healing or re-growing once again. Medical scaffolds have emerged over the past decades as one of the most important concepts in the tissue engineering field as they enable and aide the re-growth of tissues and their successors. An optimal medical scaffold should be addressing the following factors: **biocompatibility, biodegradability, mechanical properties, scaffold architecture/porosity, precise three-dimensional shape and manufacturing technology**.

There are several materials utilized in the fabrication of medical scaffolds, but one of the most extensively studied polymers is polylactic acid (PLA). PLA is **biodegradable thermoplastic aliphatic polyester** that is derived from naturally produced lactic acid. PLA can be fabricated into nanofibers for medical scaffolds used through many techniques; **electrospinning is one of the widely used methods.**

inflammation and infection reported as problem in medical scaffold. Therefore, a surface modification is needed as a solution which mostly focuses on the surface free energy **increase (wettability).** Therefore, **plasma technique** was used as a solution for the surface treatment and.

OBJECTIVES

develop **Medical Scaffolds** with enhanced Infection Resistance by the using **Electrospinning** and **Plasma technology.**

To overcome the problems of PLA, in this project we used a suitable surface modification consisted of combination of **electrospinning technique** with low-temperature **plasma technology**.

Electrospun PLA was fabricated and treated with antimicrobial agent, Ascorbic acid (ASA), using plasma treatment acting as an initiator for a radical grafting mechanism.

The main objective is to achieve a surface modification in terms of surface, adhesion properties without causing adverse effects on mechanical properties exhibiting antimicrobial effect.

METHODOLOGY

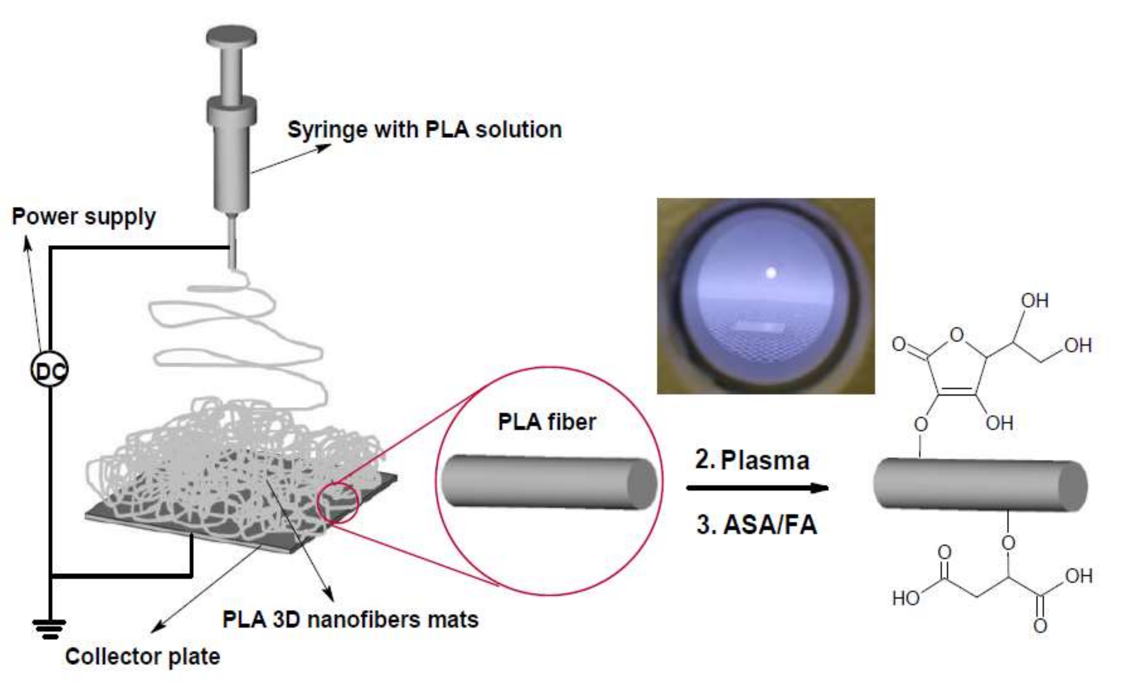
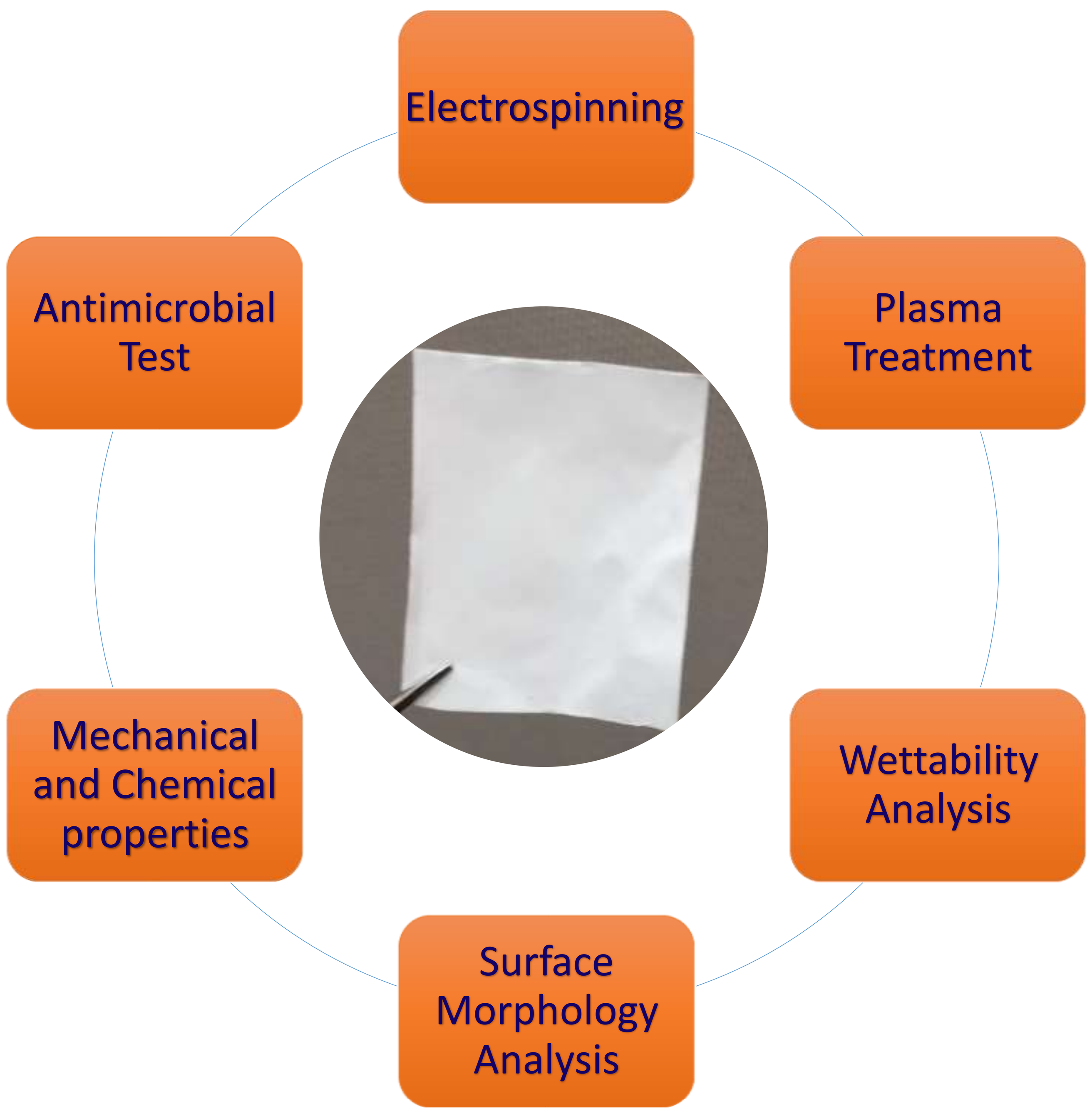


Figure1: Scheme of preparation of antimicrobial PLA nanofibers mats



RESULTS & DISCUSSIONS

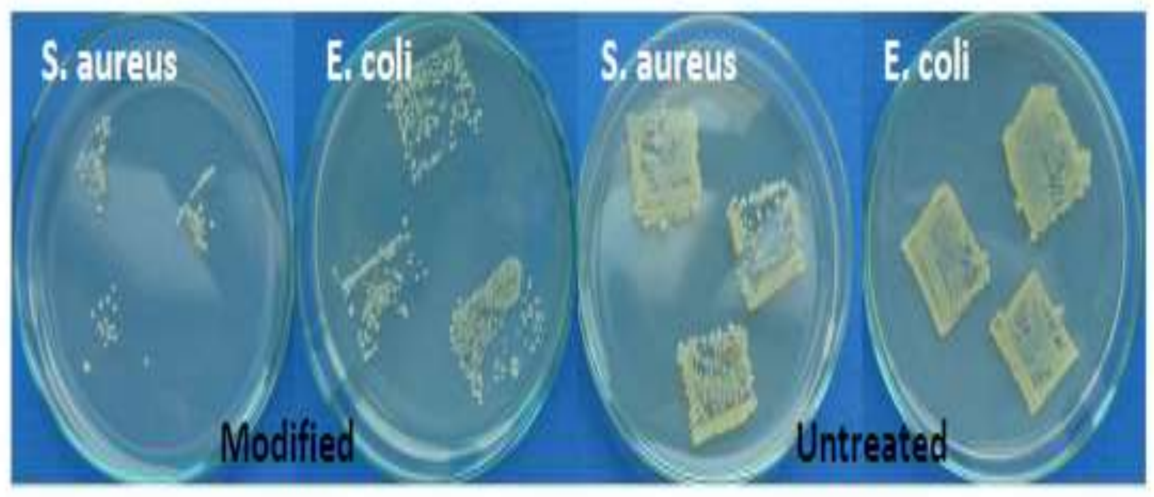


Figure2: Example of total microbial counts on plate count agar.

Table 1: Antimicrobial activity:

Sample	Increase in bacterial colonies* S. aureus	Increase in bacterial colonies* E. coli
untreated	4 , 4-5	4, 4-5
treated	5 , 5	5 , 5
ASA grafted	0 , 1	4 , 4-5

The scale for assessing the growth of bacterial colonies: 0 – without growth, 1 – detectable amount (single colony), 2 – detectable amount (combined colony), 3 – second imprint - distinguishable colonies, third imprint can be detected, 4 – third imprint - distinguishable colonies, 5 – overgrown - continuous growth

a) b)

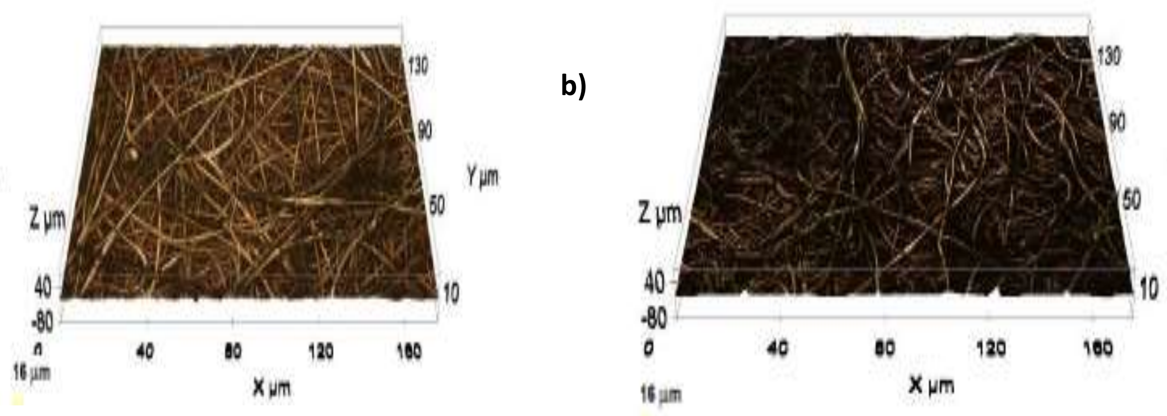


Figure3: Profilometry images of PLA fiber mats: a) 10 % w/v plasma treated (Sa = 2.0 µm), b) 10 % w/ ASA grafted (Sa = 3.3 µm)

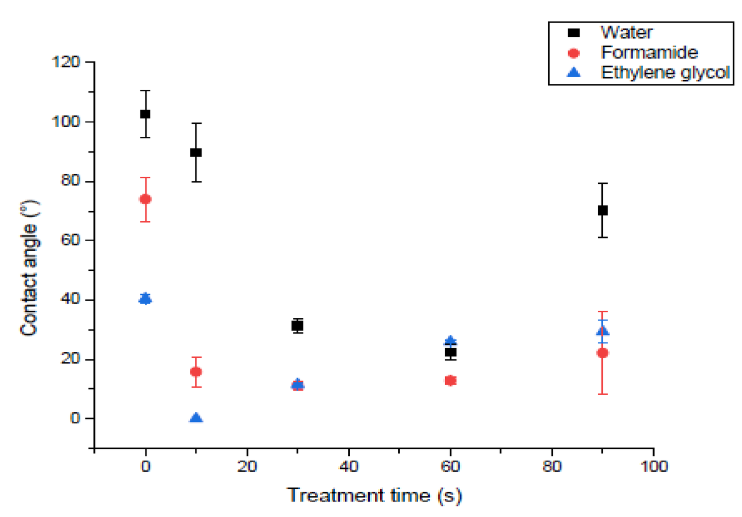


Figure4: Contact angle of (10% w/v) PLA vs. treatment time.

a) b)

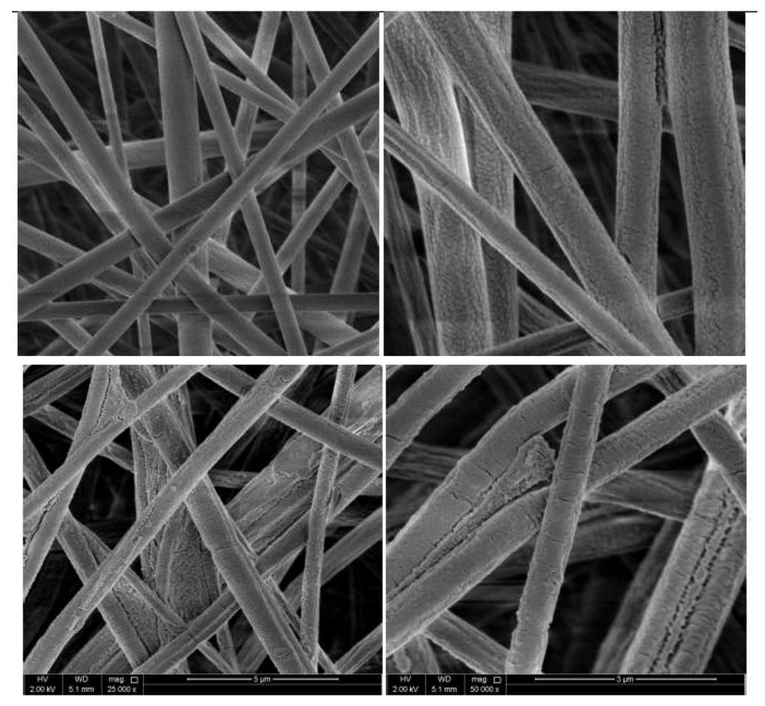


Figure5: SEM images of PLA fiber mats: a) 10 % w/v, plasma treated, b) 10 % w/v ASA grafted

a) b)

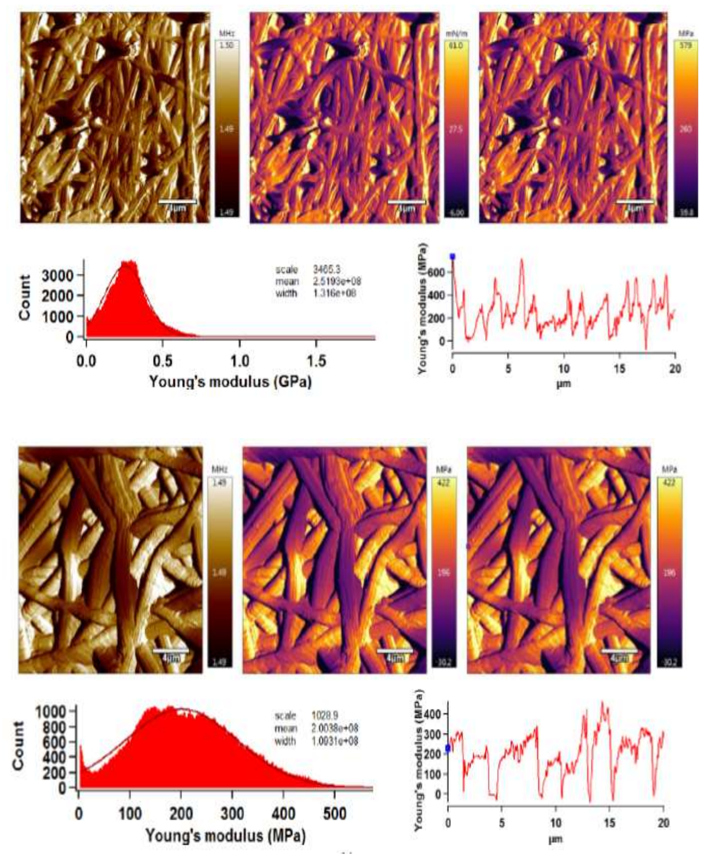


Figure6: AFM image histograms of PLA fiber mats (from left to right frequency, stiffness, Young 'smodulus; bellow and line profile. a) 10 % w/v 60s plasma treated, b) 10 % w/v ASA grafted.

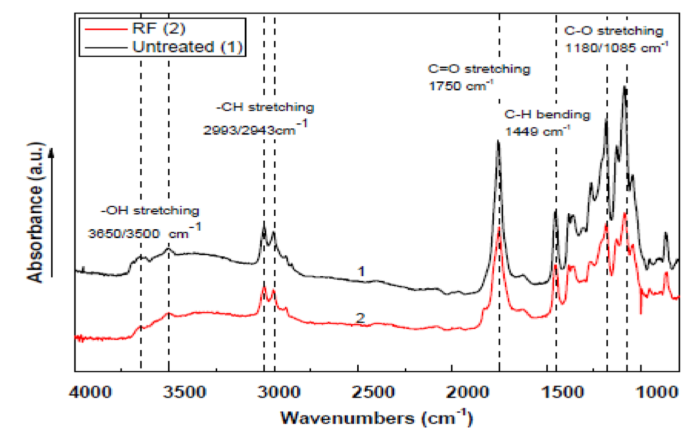


Figure7: FTIR-ATR spectra of untreated and plasma treated PLA (10 % w/v) fiber mats

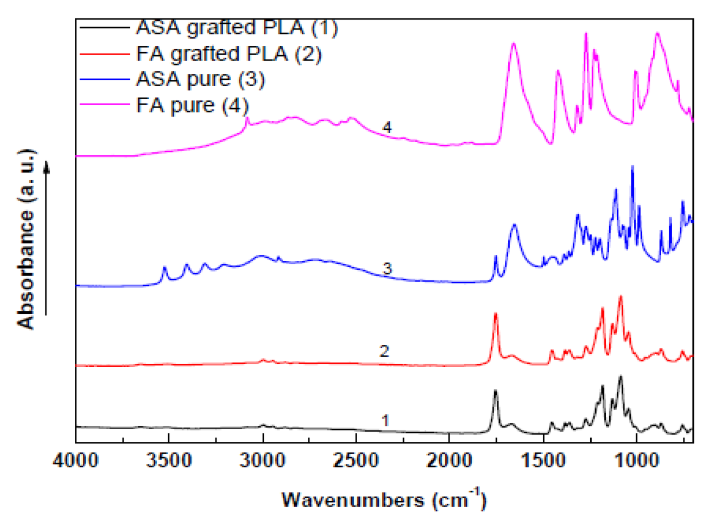


Figure8: FTIR-ATR spectra of modified PLA (10 % w/v) fiber mats and pure ASA and FA.

Conclusion

- we utilized electrospinning techniques to fabricate PLA into nanofibers mats for future application as a medical scaffold.
- PLA fiber mats prepared from 10 % w/v DCM/DMF (70:30) solution was found that it's the most optimum in terms of surface and mechanical properties, which were studied through AM-AFM.
- the surface of the nanofibers was modified through the incorporation of ascorbic acid (ASA) representing antimicrobial agent.and it was found out that incorporation of ASA into the surface of the PLA fiber mats was successful through plasma treatment. These modifications resulted in antimicrobial effect, especially against gram-positive S. aureus bacterium.

References

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