FABRICATION OF NONWOVEN NANOFIBER MATS THROUGH SOLUTION BLOW SPINNING FOR BIOSENSING OF WOUND VIRULENCE FACTORS

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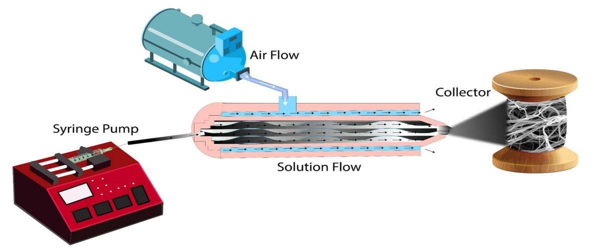
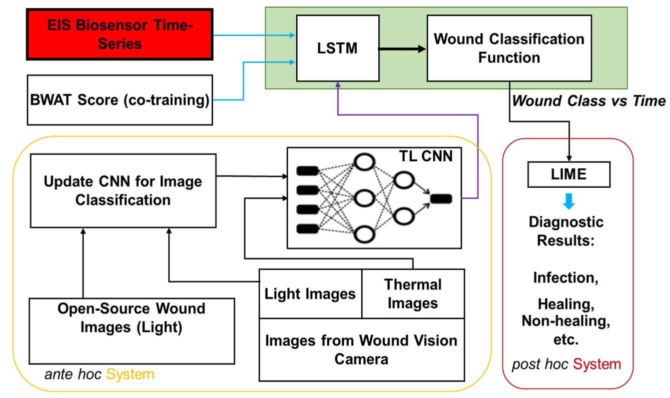
INTRODUCTION

Solution blow spinning (SBS) is an emerging nonwoven nanofibers fabrication technique with several advantages over other spinning methods (electrospinning, melt spinning, wet spinning, etc.) [1]. These nonwoven mats are constituted by the entanglement of individual nanofibers with tens of nanometers to a few micrometers [2]. High surface area, breathability, soft texture and ubiquitous pores favor encapsulation of drugs, biomarkers, antimicrobial agents, etc. required for diversified biomedical applications, especially wound care [3,4,5]. This work focuses on the effect of polymer molecular weight on SBS mats properties and their feasibility for 3D printing of biosensors for real-time virulence factors monitoring.



Schematic diagram of solution blow spinning

The biosensors designed here are especially suited for the chronic wound environment and will be combined with thermal and light imaging to comprise an explainable AI framework for chronic wound diagnosis.



EIS Biosensor Time-Series

METHODS

Fabrication

- Polylactide (PLA) pellets of two different molecular weights, 75000 (LMPLA) and 196000 (HMPLA), have been used for this study (Jam plastics Inc, MA, USA).
- The pellets (6%) were dissolved with chloroform (Fisher scientific, PA, USA) at room temperature for continuous stirring at 200 rpm for 2 hours on a magnetic stirrer plate (Fisher scientific, PA, USA).
- 20 ml solution was taken to a plastic syringe ((Fisher scientific, PA, USA) and ejected through an airbrush (Paasche airbrush company, WI, USA) having inner diameter of 1.1 mm. Continuous movement (40 mm/sec) of the airbrush was controlled by a dispensing robot (Fisnar, NJ, USA). A controlled flow rate of 40 ml/hr was maintained with a syringe pump (KD scientific, MA, USA).
- High pressurized nitrogen gas (50 psi) was supplied through the concentric nozzle to drive the polymer jet to the collector.
- The distance between the nozzle and collector was 12 cm.
- 3D printed spool was used as a collector and driven by a motor at 850 rpm.

Characterization

- For SEM imaging (Hitachi regulus 8230, Tokyo, Japan), samples were sputtered (Hummer 6.2 sputtering system, NV, USA) with platinum for 2 mins.
- Tensile strength and Young's modulus were tested with ASTM D5035 standard by Instron universal testing system 5944, MA, USA.
- Surface hydrophobicity (contact angles) were analyzed by DSA-25S Drop shape analyzer, Hamburg, Germany. Sessile drop test (2 μL) method used as the standard.
- SEM images were utilized to analyze nanofiber diameter distributions through ImageJ and OriginPro software.
- SEM images were analyzed with ImageJ software to measure porosity.

Solution blow spinning unit

RESULTS

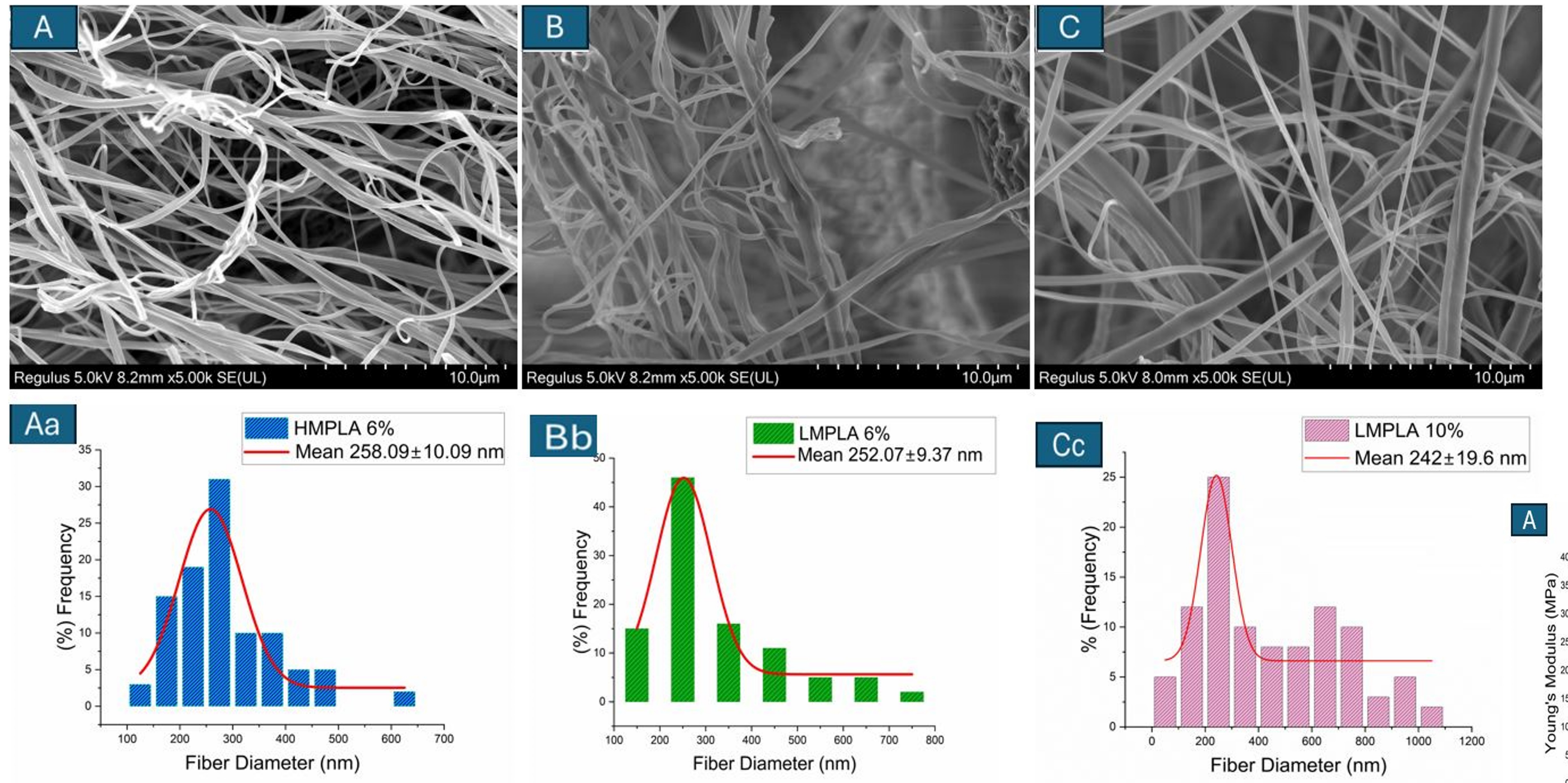


Figure 1: SEM images (5K magnification) and diameter distributions (n=100) of SBS nanofibers obtained from different concentrations (w/v) of HMPLA and LMPLA; (A and Aa) 6% HMPLA, (B and Bb) 6% LMPLA and (C and Cc) 10% LMPLA for the SEM image and fiber diameter distributions respectively.

Figure 2: 3D printed conductive sensors from Graphene on 10% LMPLA nonwoven mat.

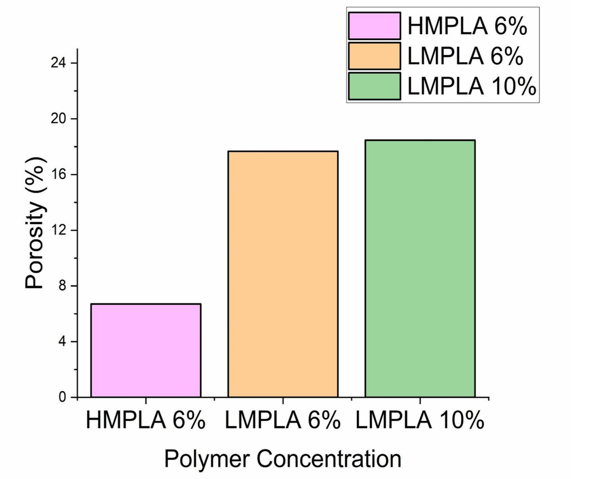


Figure 3: Porosity of LMPLA and LMPLA nonwoven mats.

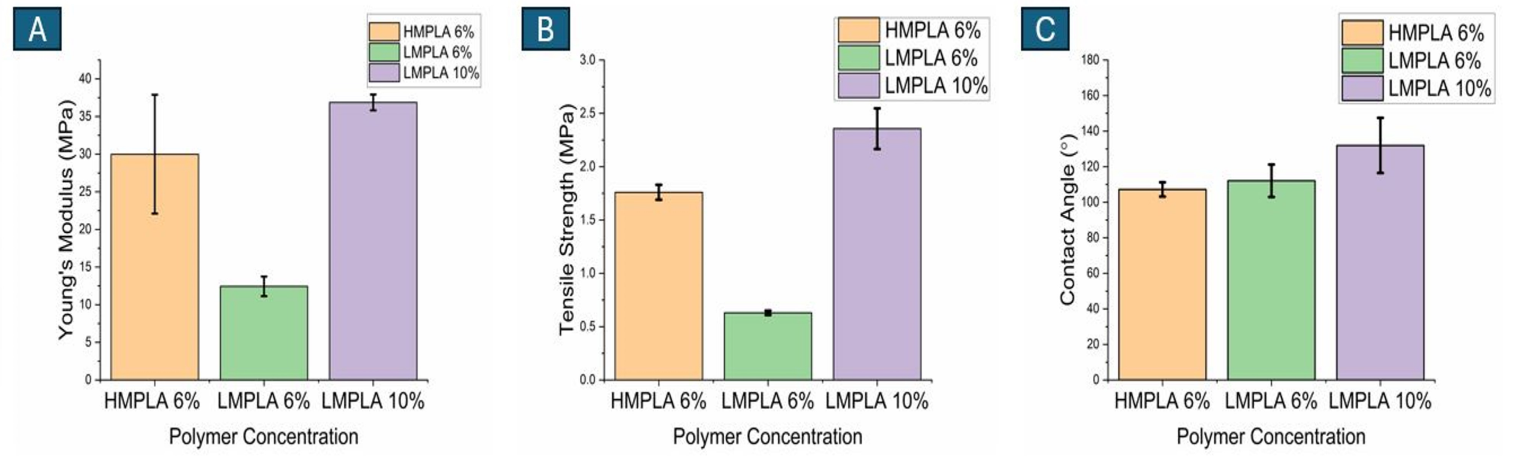


Figure 4: (A) Young's modulus (n=3), (B) Tensile strength (n=3) and (C) Contact angle (n=3) of SB spun nanofibers obtained from different concentrations (w/v) of HMPLA and LMPLA respectively.

DISCUSSION AND CONCLUSION

- Fibers oriented in HMPLA synthesized mat looks compact compared to LMPLA in same concentration.
- Because of packed fiber orientation, HMPLA mat has less porosity compared to LMPLA.
- In same concentration, HMPLA mat has higher tensile strength and Young's modulus compared to LMPLA.
- All mats shows hydrophobic characteristics (Contact angle>90°).
- Nonwoven mat surface is feasible for sensor printing.
- 3D printed Graphene sensors shows consistent shape and conductivity.

FUTURE DIRECTION

- Usage of conductive polymer and nanoparticles may allow us to make the mat conductive to act as a transducer.
- Conductivity of sensors can be increased with the incorporation of nanosilver ink.
- Immobilizing biomarkers (i.e; Integrin CD11b) on the electrodes will allow target binding of virulence molecules (i.e; Leukocidin AB) from wound bed.
- Testing the biosensor against polymicrobial communities will further validate its ability for real-time detection of virulence factors using a portable LCR meter.
- The fabricated biosensor will be combined with images from Chronic Wounds to enable a AI driven chronic wound diagnostic tool

REFERENCES AND ACKNOWLEDGMENTS

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