Antimicrobial Hernia Mesh: Plasma Activated Diallyldimethylammonium Chloride Coating

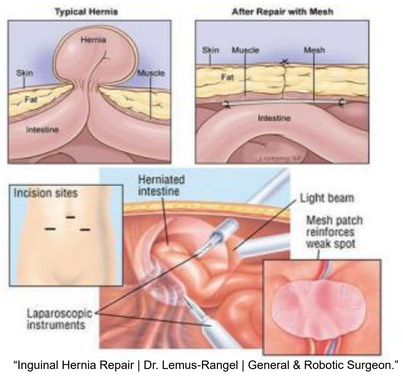
NC STATE Wilson College of Textiles
Textile Engineering, Chemistry and Science

Ziyu Wang[1*], Ahmed El-Shafei[1], Ashley C. Brown[2], Jessica M. Gluck[1], Martin W. King[1,3]
[1] Wilson College of Textiles, North Carolina State University, Raleigh, NC
[2] Joint Dept of Biomedical Engineering, UNC-Chapel Hill & NC State University, Raleigh, NC
[3]College of Textiles, Donghua University, Songjiang, Shanghai, China

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Background

More than 20,000 US hernia cases each year.
- Frequency of hernia mesh complications:
  - Inguinal repair ranges from 2.3% to 20%.
  - Femoral hernias range from 11.8% to 75%.
- Other hernia complications:
  - Seroma, persistent pain, tissue adhesions, and wound infection.
- Infection is the third major complication after hernia mesh implantation [1].



"Inguinal Hernia Repair | Dr. Lemus-Rangel | General & Robotic Surgeon."

Approach

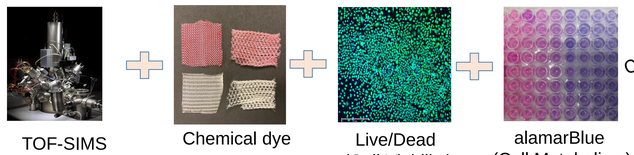
Plasma induced antibacterial hernia mesh to prevent bacterial infection.
- Radio frequency plasma activates mesh surface with diallyldimethylammonium chloride (DADMAC) and pentaerythritol tetraacrylate (PETA) crosslinker [2].
- Prevents late bacterial infection.
- Inexpensive and easy method to apply.
- Tension-free mesh helps recovery and reduces recurrence.

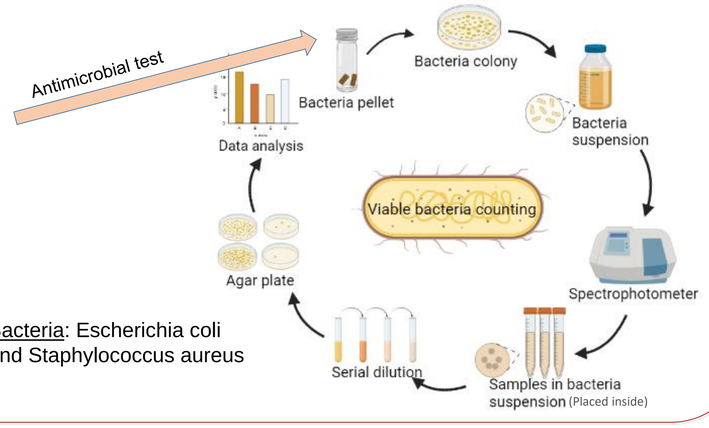
Images source: https://www.nhbr.com/hernia-mesh-litigation-mounts/

Research Plan

Polypropylene hernia mesh modification

- Polypropylene knitted mesh: C.R. Bard Inc.
- Radio frequency plasma power: 300W
- Gas: 1% oxygen and 99% helium
- DADMAC-PETA solution: 5 minutes immersion
- Post plasma treatment: 100% helium, 2 minutes

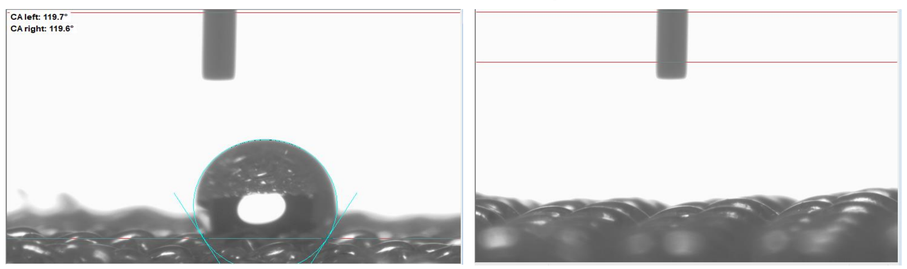




Bacteria: Escherichia coli and Staphylococcus aureus

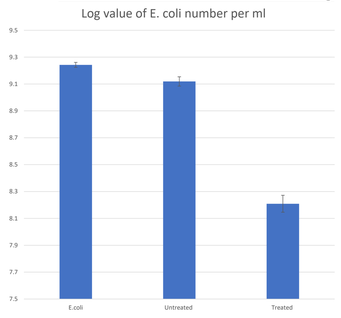
Results

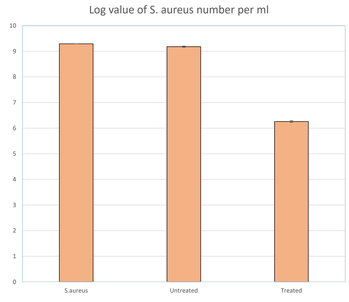
Water Contact Angle



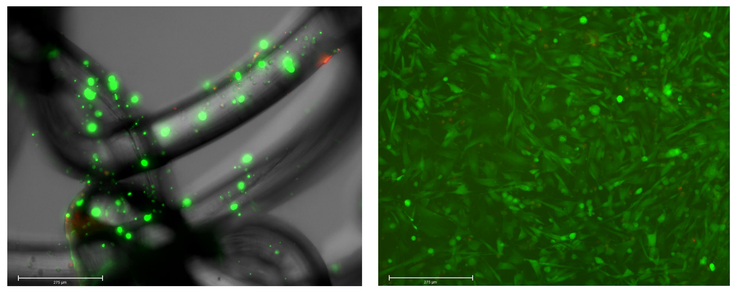
PP mesh control | DADMAC treated mesh

Effect of Antibacterial Grafting

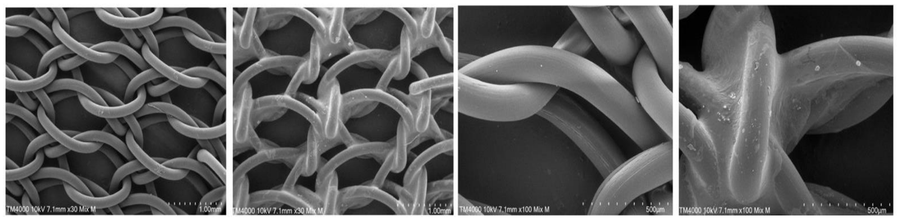




Live/Dead Day 3

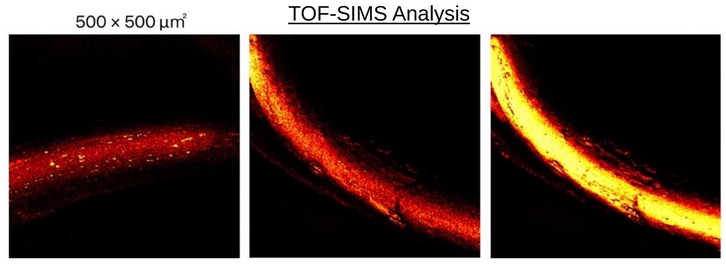


SEM Images



PP mesh control (30X) | DADMAC treated mesh (30X) | PP mesh control (100X) | DADMAC treated mesh (100X)

TOF-SIMS Analysis



PP control ($C_3H_5^+$) | DADMAC mesh ($C_3H_5^+$) | DADMAC mesh ($C_3H_8N^+$)

Conclusions and Future Work

- Successfully activated both sides of the polypropylene mesh surface by using He/O_2 radio frequency plasma.
- Successfully grafted uniform coating of DADMAC on both sides of the polypropylene mesh.
- Nitrogen positive ions were detected on the DADMAC treated mesh surface by acid dye and TOF-SIMS to confirm the presence of DADMAC coating.
- The bacteriostatic rate for DADMAC treated mesh was calculated for both E. coli (at 86.8%) and for S. aureus (at 99.9%). The DADMAC treated samples indicated significant reduction in bacteria load compared to the untreated control sample.
- In the future, optimize power level and time for the atmospheric pressure radio frequency plasma system to improve the durability of DADMAC coating.
- *In vitro* assays to evaluate cell attachment and mesh biocompatibility will be undertaken.
- *In vivo* animal trials will demonstrate clinical relevance.

References

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[2] M. Mazloumpour, P. Malshe, A. El-Shafei, P. Hauser, "Conferring durable antimicrobial properties on nonwoven polypropylene via plasma-assisted graft polymerization of DADMAC," Surface and Coatings Technology, vol. 224, pp. 1–7, 2013, doi: 10.1016/j.surfcoat.2013.02.022.

Contact Info

Ziyu Wang: zwang77@ncsu.edu
LinkedIn: Ziyu Wang