Design and Characterization of Zwitterionic Antimicrobial Polymers for Biofilm Modulation: A Cu-Catalyzed Click Chemistry Approach

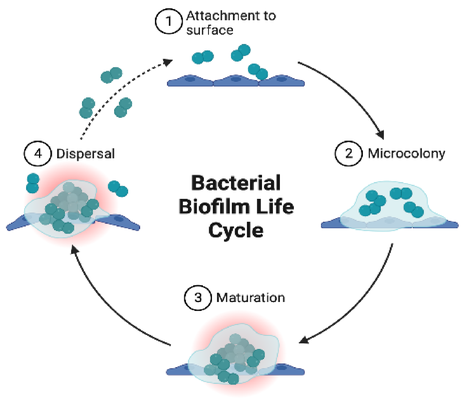
Ethan Nguyen, Md Tareque Hassan Mukut, Haritha Asokan-Sheeja, Andrew Mier, He Dong and Joseph A Buonomo*

The University of Texas at Arlington, Arlington, Texas

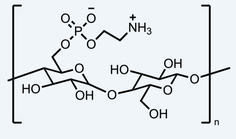
Introduction

Cellulose modified with PEtN is an integral component of *E. coli* biofilms, as bacteria adhere to modified polymers.[1] Biofilm infections are typically chronic in nature, as biofilm-residing bacteria can be resilient to both the immune system, antibiotics, and other treatments.[2] The design of antimicrobial materials heavily depends on controlling biofilm formation, as biofilms contribute to both bacterial resistance and chronic infections.

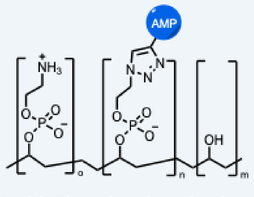
In our study, we will functionalize phospho-azide-containing polyvinyl alcohol (pN_3-PVA) with a self-assembling antimicrobial peptide (AMP). This will generate a bioactive material with zwitterionic properties,[3] designed to influence biofilm formation.



PEtN containing zwitterionic materials

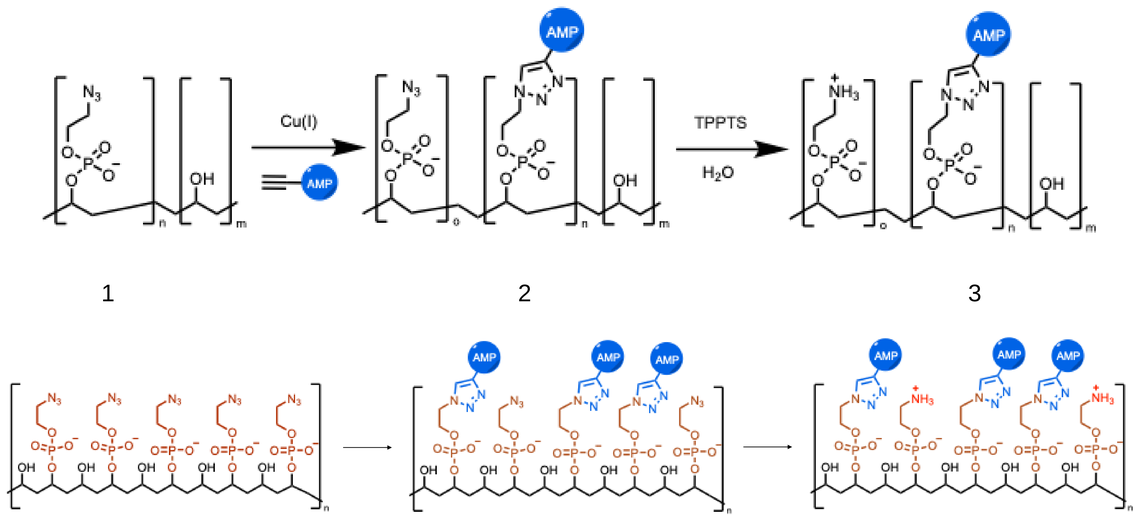


Modified cellulose with Phosphoethanolamine (pEtN) in *E. coli* biofilms

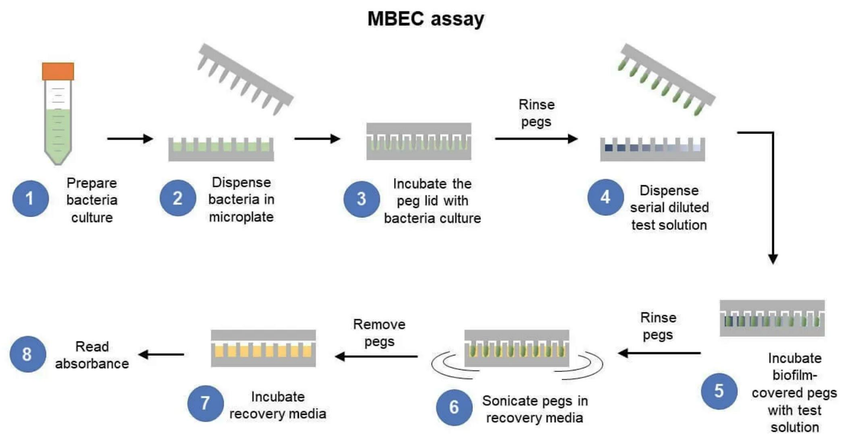


Modified PVA with Phosphoethanolamine (pEtN) and antimicrobial peptide (AMP) with zwitterionic properties

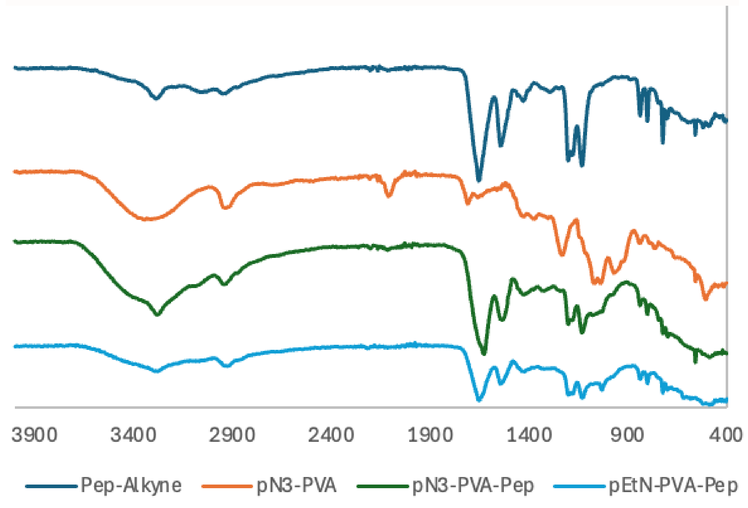
Synthetic scheme



Biofilm Assay[4]



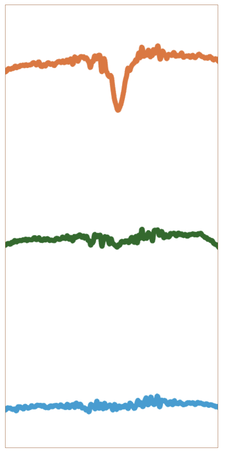
Characterization



Wavenumber (cm-1)	Alkyne-Pep	pN_3-PVA	pN_3-PVA-Pep	pEtN-PVA-Pep
2111.7223	**0.98105**	**0.91667**	**0.95823**	**0.97423**
2110.306	0.98185	0.91519	0.9584	**0.97513**
2108.8897	0.98279	0.91452	0.95962	**0.976**

Discussion

- ❑ The successful synthesis of pEtN-PVA-PEP material through Cu-catalyzed click chemistry- Around 50% of the azide group of pN3-PVA will be labeled with the antimicrobial peptide using Cu-catalyzed click chemistry, facilitating its integration onto the polymer. Following this, the remaining azide groups will be reduced to amino groups (NH_2), introducing zwitterionic characteristics into the material.
- ❑ **Advanced Characterization** – UV-Vis, FTIR, and NMR confirm modifications; microscopy visualizes biofilm effects.
- ❑ **Biofilm Assay –** Minimum Biofilm Eradication Concentration (MBEC) assay
  - *Staphylococcus aureus*
  - *Pseudomonas aeruginosa*



References

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2. Vestby, L. K.; Grønseth, T.; Simm, R.; Nesse, L. L. Bacterial Biofilm and Its Role in the Pathogenesis of Disease. Antibiotics **2020**, 9(2), 59.
3. Qu, K.; Yuan, Z.; Wang, Y.; Song, Z.; Gong, X.; Zhao, Y.; Mu, Q.; Zhan, Q.; Xu, W.; Wang, L. Structures, Properties, and Applications of Zwitterionic Polymers. *ChemPhysMater* **2022**, 1(4), 294–309.
4. emerypharma.com/solutions/cell-microbiology-services/biofilm-eradication-testing/

Abbreviations: Triphenylphosphine-3,3',3''-trisulfonic acid trisodium salt (TPPTS)
Fourier-transform Infrared Spectroscopy (FTIR), Minimum Biofilm Eradication Concentration (MBEC) assay

Acknowledgements

- ❑ Department of Chemistry and Biochemistry
- ❑ UTA Start-Up Funds
- ❑ UT System Rising STARs

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Email
ern5004@mavs.uta.edu

Lab website
www.jabuonomo.com

Applications

- ❑ **Anti-fouling coating-** to inhibit the undesirable attachment of organisms
- ❑ **Biomaterials** with anti-bacterial properties can be applied as an antimicrobial and anti-biofouling coating on medical implants, catheters, and wound dressings to reduce infection risks.