NDnano
Notre Dame Nanoscience and Technology

NDnano Summer Undergraduate Research 2023 Project Summary

1. Student name & home university:

Kevin Armknecht, University of Notre Dame

2. ND faculty name & department:

Prakash Nallathamby, Aerospace and Mechanical Engineering

3. Summer project title:

Magneto-silica nanoparticles (MagSiNs) for combinatorial chemotherapeutics and gene delivery against metastatic cancers

4. Briefly describe new skills you acquired during your summer research:

New skill I acquired include different types of microscopy. Firstly, I learned how to prepare and image bacteria and nanoparticles using red and green fluorescent channels on our microscope. Also, I prepared and imaged these samples using dark field imaging to visualize the interaction of these nanoparticles and particular bacteria.

5. Briefly share a practical application/end use of your research:

The practical application in my nanoparticles testing is to replace current antibiotics as anti-infective agents due to a rise in antibiotics evolving resistance to many bacteria. This has become a very large issue, as multiple bacterial infections are now multi-drug resistant, so an alternative treatment is more necessary than ever.

6. 50- to 75-word abstract of your project:

Antibiotic resistance is a rapidly expanding problem faced in healthcare today as bacteria have evolved resistance to commonly used antibiotics. Data from Minimum Inhibitory Concentration (MIC) and Zone of Inhibition studies are valuable in determining the increased efficiency of nanoparticles in comparison to antibiotics versus drug-resistant bacteria. The Evolution of Resistance project I completed can provide further insight to whether nanoparticles are a viable alternative to currently used antibiotics.

7. References for papers, posters, or presentations of your research:

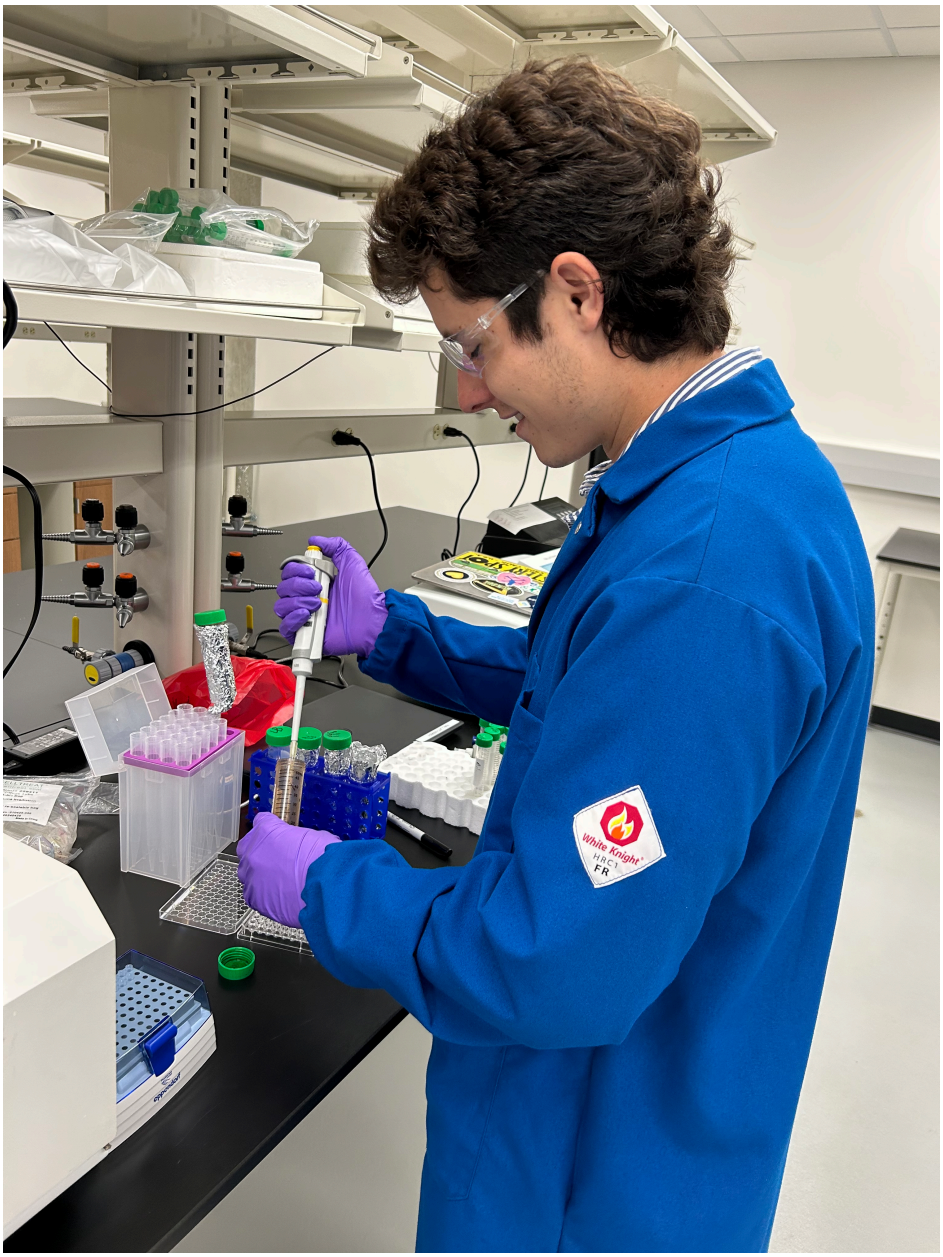
Phage-mimicking antibacterial core–shell nanoparticles
Nanoscale Advances, 2019, 1, 4812–4826
Juliane Hopf, Margo Waters, Veronica Kalwajtys, Katelyn E. Carothers, Ryan K. Roeder, Joshua D. Shrout, Shaun W. Lee and Prakash D. Nallathamby
doi: 10.1039/C9NA00461K (IF = 5.598)

One-page project summary that describes problem, project goal and your activities / results:

There are many challenges faced by cancer patients with infection as a result of their treatment protocols. Ways to reduce these challenges include improved chemotherapeutics and more efficient anti-infective agents. My work primarily focuses on the efficiency of new anti-infective agents, specifically silica-core nanoparticles. Nanoparticles are very promising for the future of anti-infective agents, as they are both less toxic and broader in which bacteria they are used to treat.

The leading cause of hospital-acquired infections globally are a group of bacteria known as ESKAPE pathogens- Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacter spp. The bacteria included in my project this summer- Pseudomonas aeruginosa, Acinetobacter baumannii, Staphylococcus aureus, Klebsiella pneumoniae, Streptococcus pyogenes, Corynebacterium striatum, and Enterococcus faecalis- are all clinically relevant, with 4 of them being multi-drug resistant pathogens. To test the efficiency of nanoparticles against these bacteria, I completed Zone of Inhibition, Minimum Inhibitory Concentration (MIC), and Evolution of Resistance experiments.

Zone of Inhibition measures the radius around our nanoparticles that inhibits bacterial growth, which allows comparison with known inhibition zones of antibiotics. MIC is the lowest concentration of nanoparticles that inhibits bacterial growth by a certain percentage. This was completed via serial dilutions in a 96 well plate and a 24 hour plate reader which measured the OD600 of each dilution throughout. From this data, a concentration versus growth rate plot was found allowing for a line of best fit and extrapolation of the MIC50, MIC90, and 2MIC90. The MIC50 measures the concentration of nanoparticles required to inhibit the growth of bacteria by 50%, while MIC90 correlates with 90%. This data is valuable to compare with the MIC's of antibiotics when they were first used and currently, after bacteria have evolved resistance. Finally, Evolution of Resistance involves growing bacteria in MIC50, MIC90, and 2MIC90 concentrations of nanoparticles for 4 weeks to determine if the bacteria evolve resistance to nanoparticles like they have for antibiotics. As antibiotic resistance continues to spread rampantly, nanoparticles appear to be the future of anti-infective agents.



Working in the lab on the Evolution of Resistance project, transferring different concentrations of nanoparticles into tubes with *S. Pyogenes*.