Light Activated Drug Delivery from Electrospun Bandages Using Plasmonic Dopants

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Incorporation of gold nanoparticles (GNPs) into electrospun (ES) fibers can enable efficient light activated drug delivery.[1,2] In the presence of light, GNPs experience a plasmonic effect, whereby, incoming optical energy interacts with the particle surface and is converted to thermal energy in the surrounding medium. Heat generated from the plasmonic response allows melting of polymer fibers and treatment release. Preceding hypotheses express that GNPs with diameters above 2 nm are capable of light-to-heat conversion efficiencies approaching 100 %.[3] In previous work, mathematical models were used to estimate the melt sphere surrounding each GNP in polymer. Results showed that photothermal heating from a GNP with a ~3 nm diameter causes polymer around the GNP to melt a 20 nm diameter sphere with an associated bulk temperature change in the polymer bandage of only 0.2 °C.[2]

Core-shell electrospinning was used to fabricate antibiotic bandages containing fibers with a fluidic, vancomycin antibiotic core surrounded by a GNP-doped polycaprolactone (PCL) shell, Figure 1. PCL was used due to its biocompatibility and hydrophobicity. In the preparation method used, GNPs (0.02 g/mL, 15-nm diameter) in water were added to fluid PCL dissolved in cyclohexanone. The high boiling point of cyclohexanone allowed the water from the GNPs to quickly boil off, while the remaining polymer solution did not boil. Antibiotic/PCL+GNP bandages were distributed onto an agar plate containing a film of *Staphylococcus aureus*. Under illumination with a 532 nm-wavelength laser (GNP maximum resonance ≅ 520 nm) melting and antibiotic release occurred, Figure 2A. Without illumination, the same bandage did not release the antibiotic, Figure 2B.

In our previous work, the melt sphere surrounding individual GNPs modelled better predict the size GNP required for adequate melting of a polymer fiber shell with specific thickness, Figure 3.[2] In this work, we will dope our PCL materials with several concentrations of GNPs and examine plasmonic coupling effects between the particles that may also impact the observed bulk heating. Using several concentrations of GNPs in polymer, we will examine bulk heating by FLIR heat mapping, determine how concentration impacts specific heat of the materials, study how concentration may alter absorption due to plasmonic coupling on UV-Vis spectroscopy, provide complex optical properties of the materials by spectroscopic ellipsometry, and test spectrally-selective melting on bacteria *in vitro*.

[1]Andriolo, J.M., et al., 2019. *MRS Advances* 31-32, 4(31-32).
[2]Andriolo, J.M., et al., 2019. *Journal of Vacuum Science and Technology B*, 37(6).
[3]Amendola, V., et al., 2017. *Journal of Physics: Condensed Matter*, 29(20).

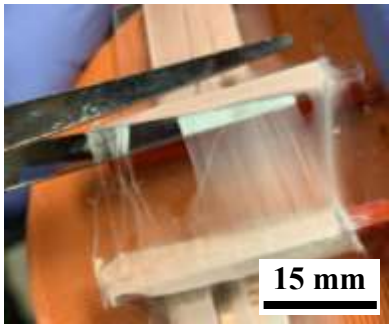

Figure 1: ES vancomycin/PCL+GNP core-shell fibers. Electrospinning was performed with passive alignment electrodes held at ~8 kV. Fibers are shown being lifted with metal tweezers for subsequent redeposition.

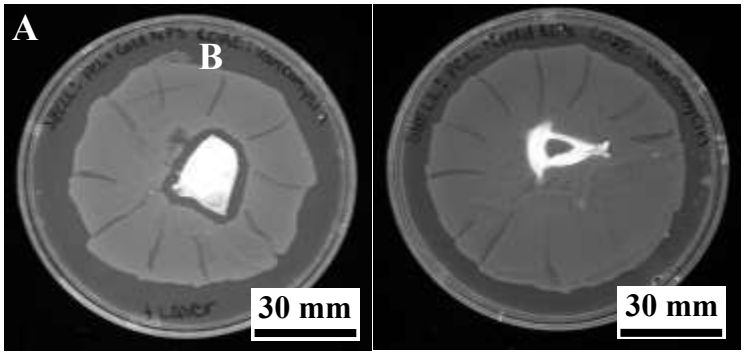

Figure 2: **A** ES vancomycin/PCL+GNP core-shell fiber bandage dropped onto a *S. aureus* film and illuminated at 532 nm to melt fibers and release antibiotic. A bacterial death zone surrounds the bandage. **B** ES vancomycin/PCL+GNP core-shell nanofiber bandage dropped onto a *S. aureus* film but not illuminated. Bacterial growth can be seen right up to the edges of the antibiotic bandage.

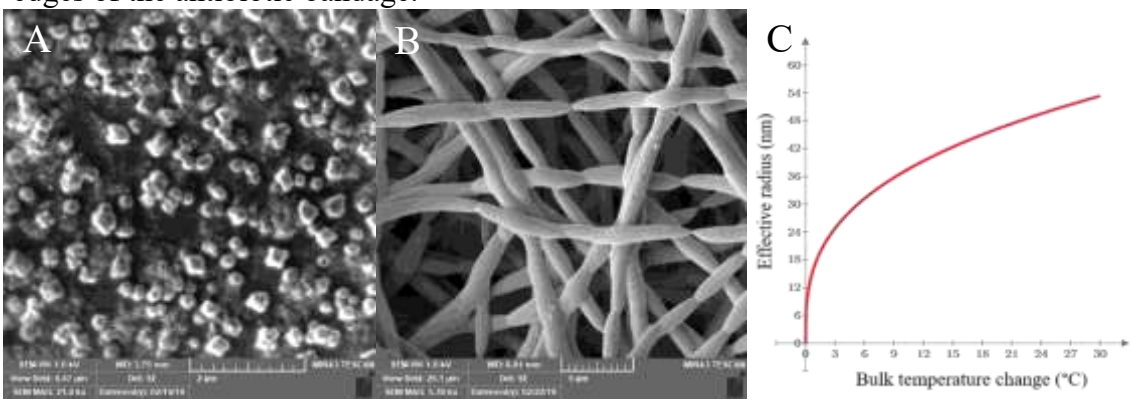

Figure 3: **A** Gold NPs used in our previous work where the melt-sphere (effective radius) was determined. Scale bar is 2 µm. **B** PEO/PEG blend fibers were used in our previous work based on the ease at which these materials melted and allowed study of how the effective radii of the GNPs affected bulk heating **C.** Scale bar in **B** is 5 µm. In the work presented for this abstract, GNPs have been placed in PCL, which is a hydrophobic polymer that will not dissolve/release medication unless illuminated, thereby allowing storage and activation when required.