Surface Enhanced Raman Scattering of Electrospun Nanofibers Embedded with Silver Nanoparticles

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Introduction

- Surface Enhanced Raman Scattering (SERS) is a very sensitive detection technique (Figure 1)
- Silver nanoparticles were used to create effective and robust substrates that have SERS capabilities
- This method will allow for greater detection abilities for use in anti-counterfeit technologies.

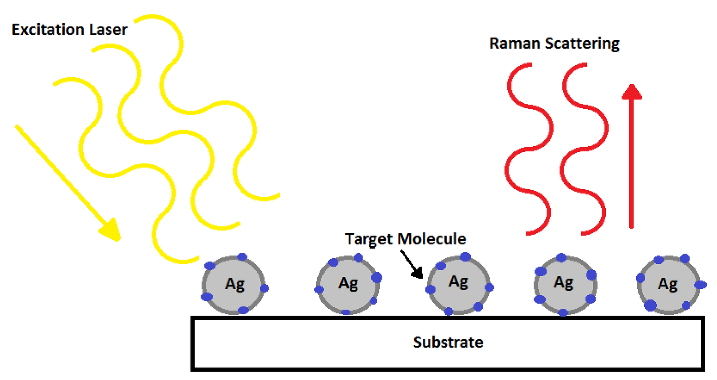

Figure 1: SERS diagram

Research Objectives

- Produce electrospun nanofibers embedded with silver nanoparticles in a manner of controlled nanoscale structures for effective and robust substrates for SERS applications.

Procedure

Electrospinning poly(methyl methacrylate) (PMMA)

- Prepare PMMA solutions using different solvents and weight percentages
- Vary experimental parameters such as pumping rate, voltage, distance between needle and ground, and needle gauge (Figure 2)

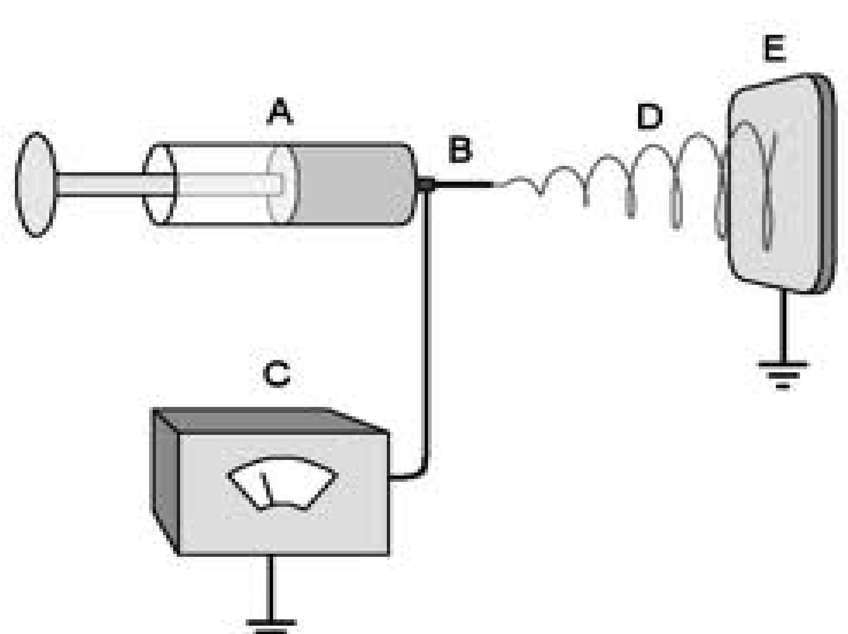

Figure 2: Electrospinning apparatus consisting of syringe (A), needle (B), voltage source (C), fiber (D), ground (E).

Ag Nanoparticle (NP) Synthesis

- Preform reduction method synthesis with PVP, NaCl, $AgNO_3$, and $NaBH_4$ at an elevated temperature.

Electrospinning PMMA/Ag NP Nanofibers

- Prepare/electrospin composite substrate and test SERS activity

Results and Discussion

Electrospinning PMMA Nanofibers

- Electrospinning parameters that yield fibers less than 500nm and no beading in highlighted yellow (Table 1 & Figure 3)

Polymer	Polymer wt %	Solvent 1	Solvent 2	Observations
PMMA	3%	$CHCl_3$	DMF	Thin Diameter < 1µm, Uncontinuous
PMMA	5%	$CHCl_3$	DMF	Thin Diameter < 1µm
PMMA	6%	$CHCl_3$	DMF	Large Diameter
PMMA	6%	TCE	DMF	Beads, Large Diameter
PMMA	6%	TCE	DMF	Beads, Uncontinuous Fibers
PMMA	7%	TCE	DMF	Beads, Thin Diameter < 1µm
PMMA	7%	TCE	DMF	Minimal Beads, Thin Diameter
PMMA	7%	TCE	DMF	Beads, Thin Diameter
PMMA	8%	TCE	DMF	Minimal Beads, Holes, Thin
PMMA	12%	TCE	DMF	Minimal Beads, Large Diameter
PMMA	14%	TCE	DMF	Large Diameter

Table 1: Electrospun polymer table

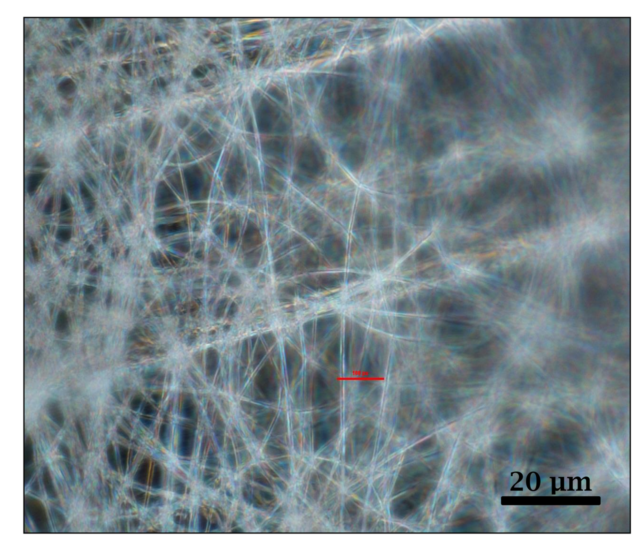

Figure 3: Dark Field 100x Optical Microscope image of nanofibers

Ag Nanoparticle (NPs) Synthesis

- Consistent UV-Vis and minimal silver aggregation (Figure 4 & 5)

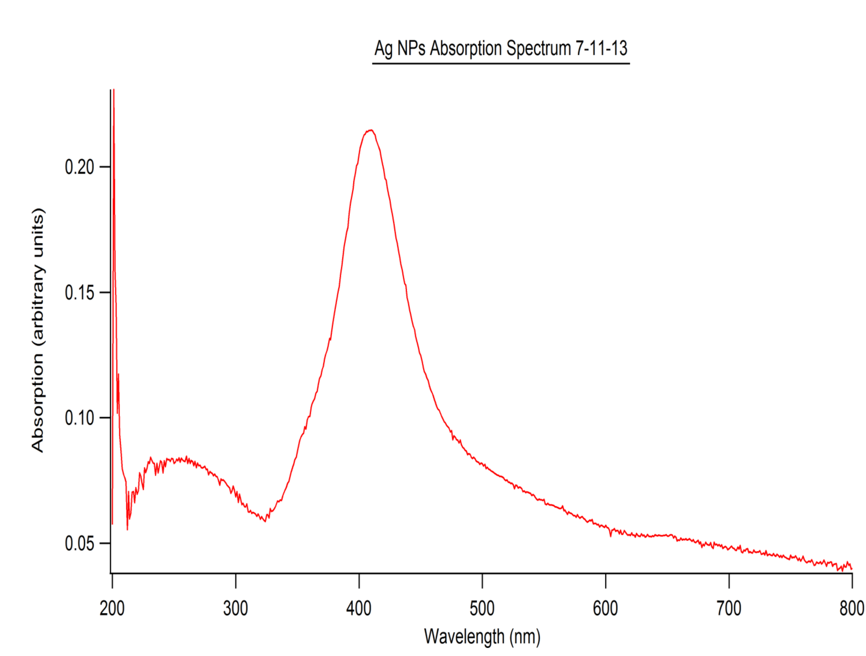

Figure 4: Absorption Spectra of Ag NPs, with peak around 410 nm

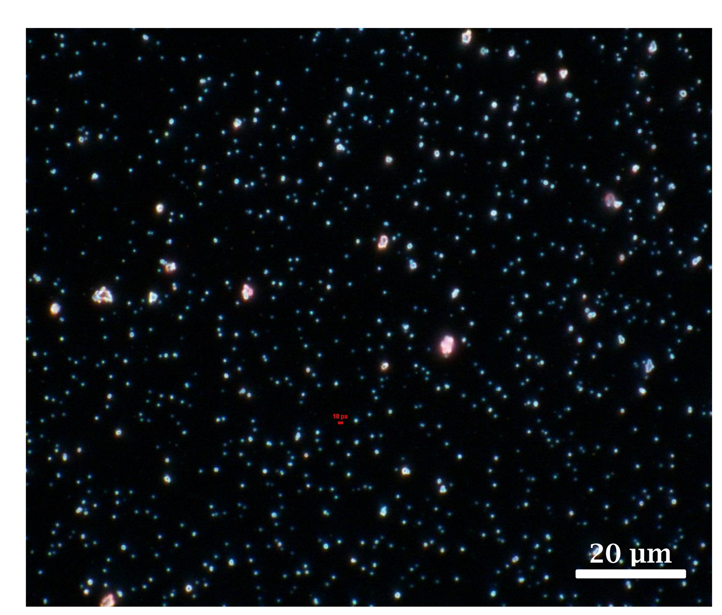

Figure 5: Dark Field 100x Optical Microscope image of Ag NPs

Electrospinning Composite/SERS Testing

- Optimized parameters of PMMA nanofibers with Ag NPs (Figure 6)
- Plotted SERS spectra of 4-mercaptobenzoic acid on electrospun nanofibers (Figure 7)

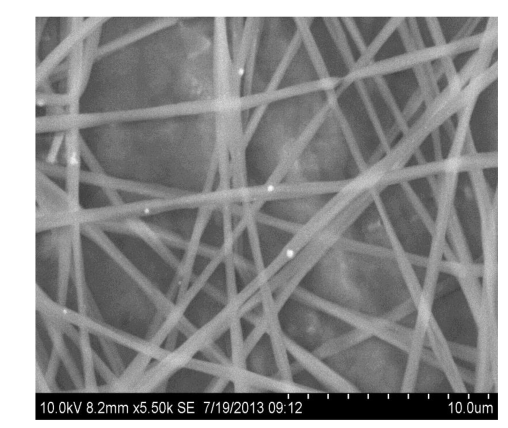

Figure 6: Scanning Electron Microscopy (SEM) image of optimized nanofibers

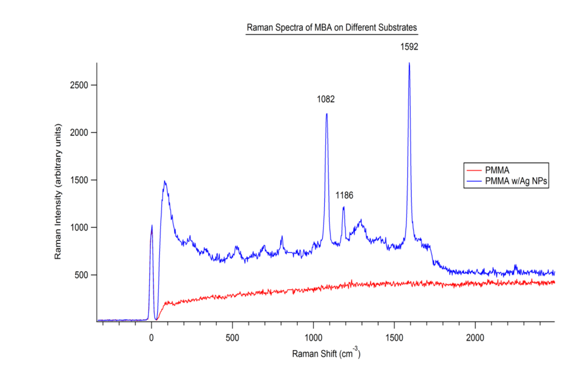

Figure 7: SERS spectra of 4-MBA on PMMA with and without Ag NPs

Conclusions

- 5% PMMA with chloroform yielded optimum fibers (i.e. < 500 nm, no beading, continuous)
- Prevalent SERS activity in nanofibers with Ag NPs
- Poor Ag NP dispersion in nanofibers

Future Work

- Vary concentration of Ag NPs in nanofibers (increase weight percentage)
- Study effect of different NP size/ composition on SERS activity

References

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Acknowledgements

Thanks to the National Science Foundation grant # EEC-1263343, Dr. Chaoyang Jiang, Dr. Stanley P. May, Dr. Alfred Boysen, CY Group members, SPACT Faculty.

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