Development of a self-assembled gold nanoparticle thin film to support field detection of trace chemicals

Taylor M. Parmer, BS; Sarah Stewart, MS; Geraldine Monjardez, PhD; Jorn (Chi-Chung) Yu, PhD, ABC-CC

Department of Forensic Science, Sam Houston State University, Huntsville, TX 77340

INTRODUCTION

With the use of many highly potent controlled substances, such as fentanyl, on the rise, it is more important than ever to be able to detect minute traces of various chemicals. In addition, field testing for chemical threats such as explosives is vital for law enforcement and security agencies.

Raman spectroscopy is a valuable tool for identifying unknown substances, but it is not effective on trace or residual amounts of substances due to the relatively weak nature of Raman scattering.

Consequently, surface-enhanced Raman scattering (SERS) has been demonstrated to amplify the Raman signal, allowing for more sensitive detection of minute traces of chemicals. This technique uses a SERS substrate, often based on metallic nanoparticles, such as gold nanoparticles (AuNP), either in solution or fixed to a solid surface.

In this work, an AuNPs self-assembled thin film was prepared on several different materials, such as filter paper, scotch tape, double-sided carbon tape, glass, and silicon chips, to serve as SERS substrates. The performance of AuNP thin films' SERS properties was evaluated using 1,2-bis(4-pyridyl)-ethylene (BPE) as the reference material.

The experimental procedures for synthesizing AuNPs, forming a thin film, transferring the film onto the desired substrate, and SERS detection using a handheld Raman spectrometer are discussed in this poster.

MATERIALS AND METHODS

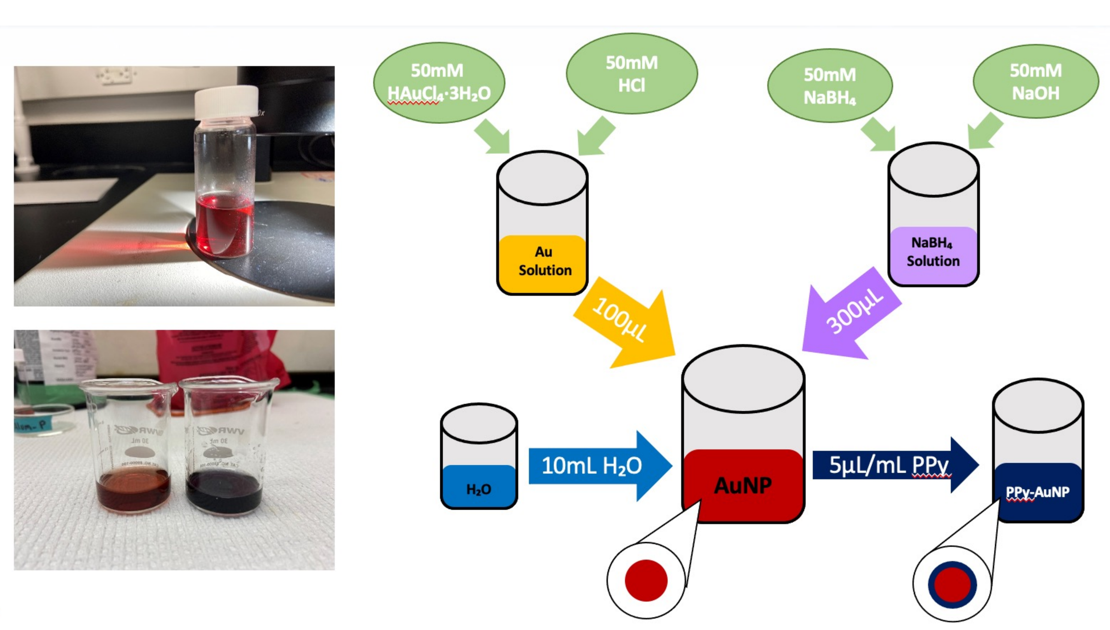

Fig. 1 a) Synthesis of gold nano particles and gold nano particles surface modification of polymer.

RESULTS AND DISCUSSION

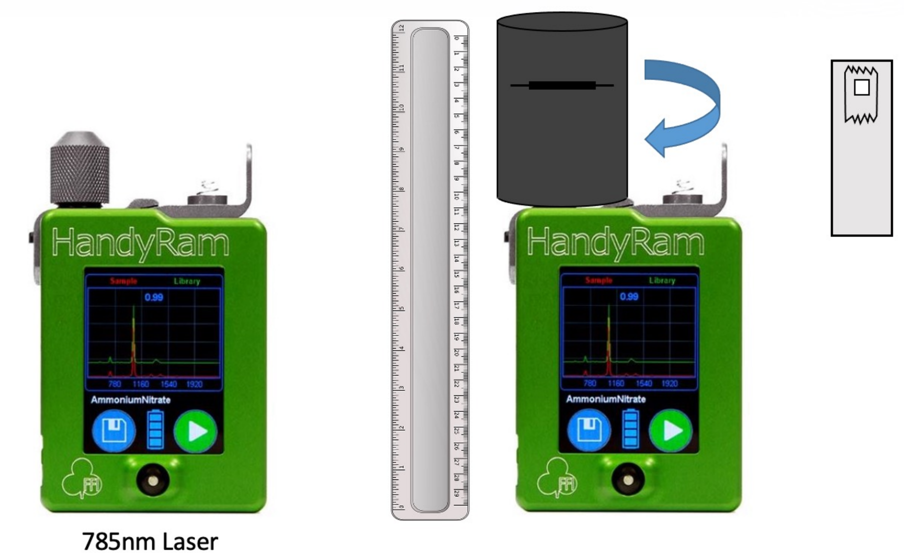

Fig. 2 Instrumental set up for SERS testing using a potable Raman spectrometer.

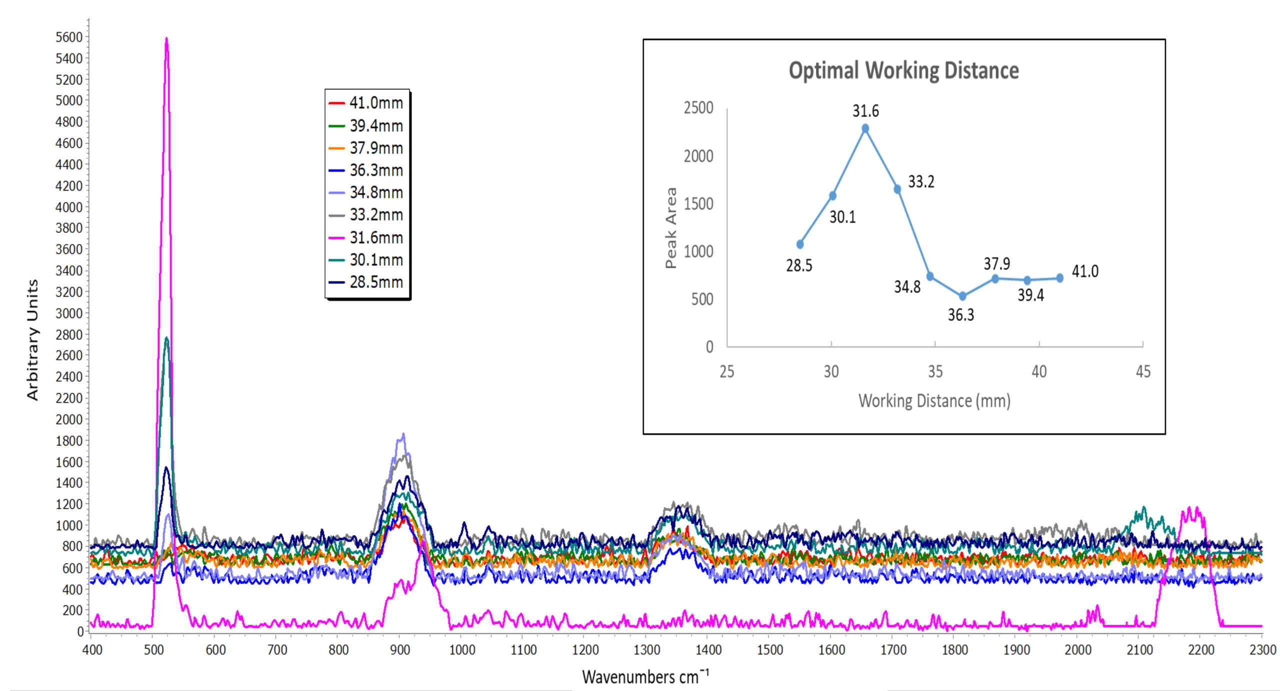

Fig. 3 a) Raman spectra of a silicon standard at various working distances ranging from 28.5mm to 41.0mm and b) plot of peak area versus working distance

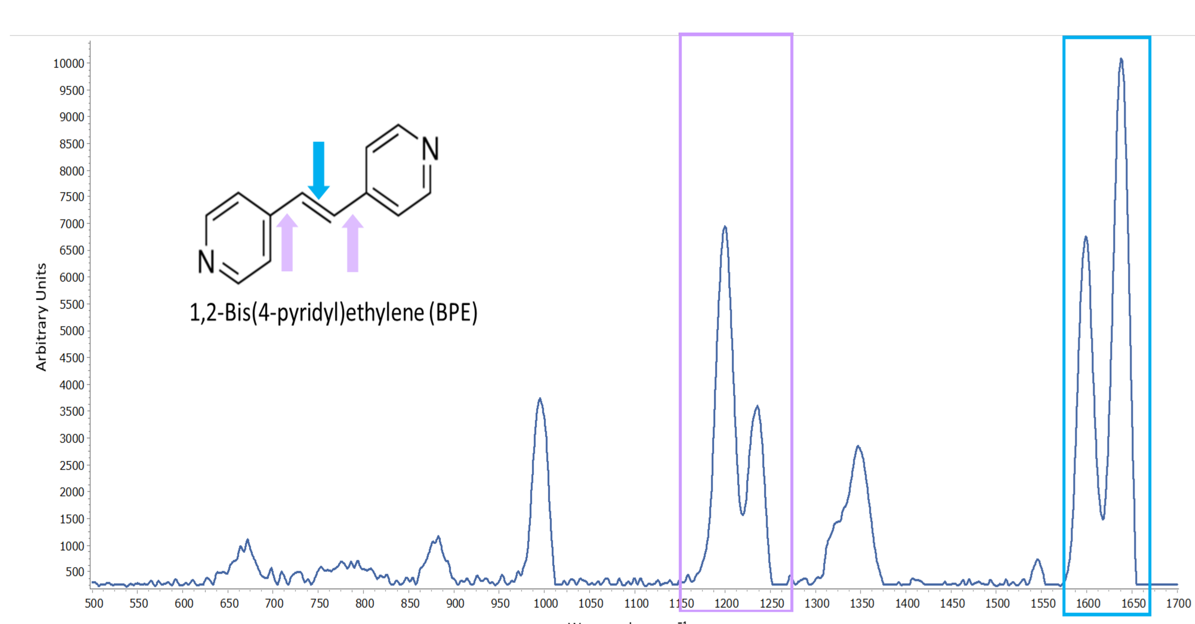

Fig. 4 Raman spectra of BPE

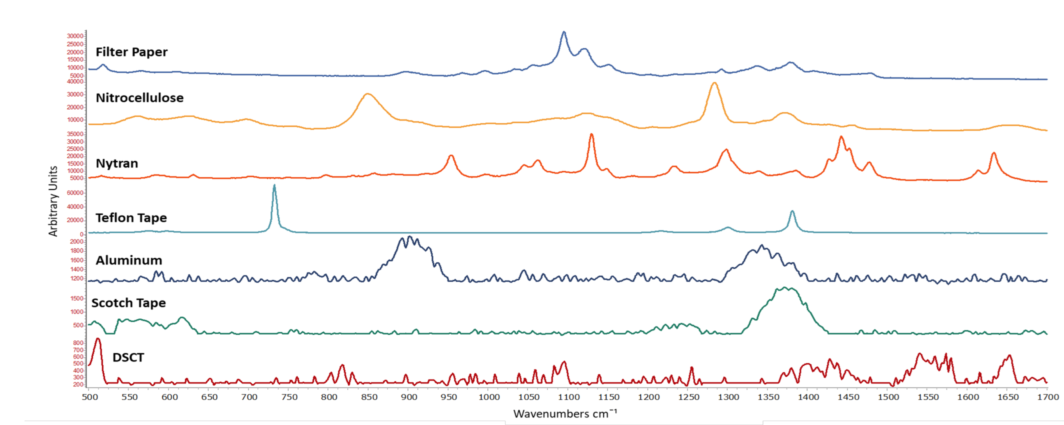

Fig. 5 Raman spectra of backing materials

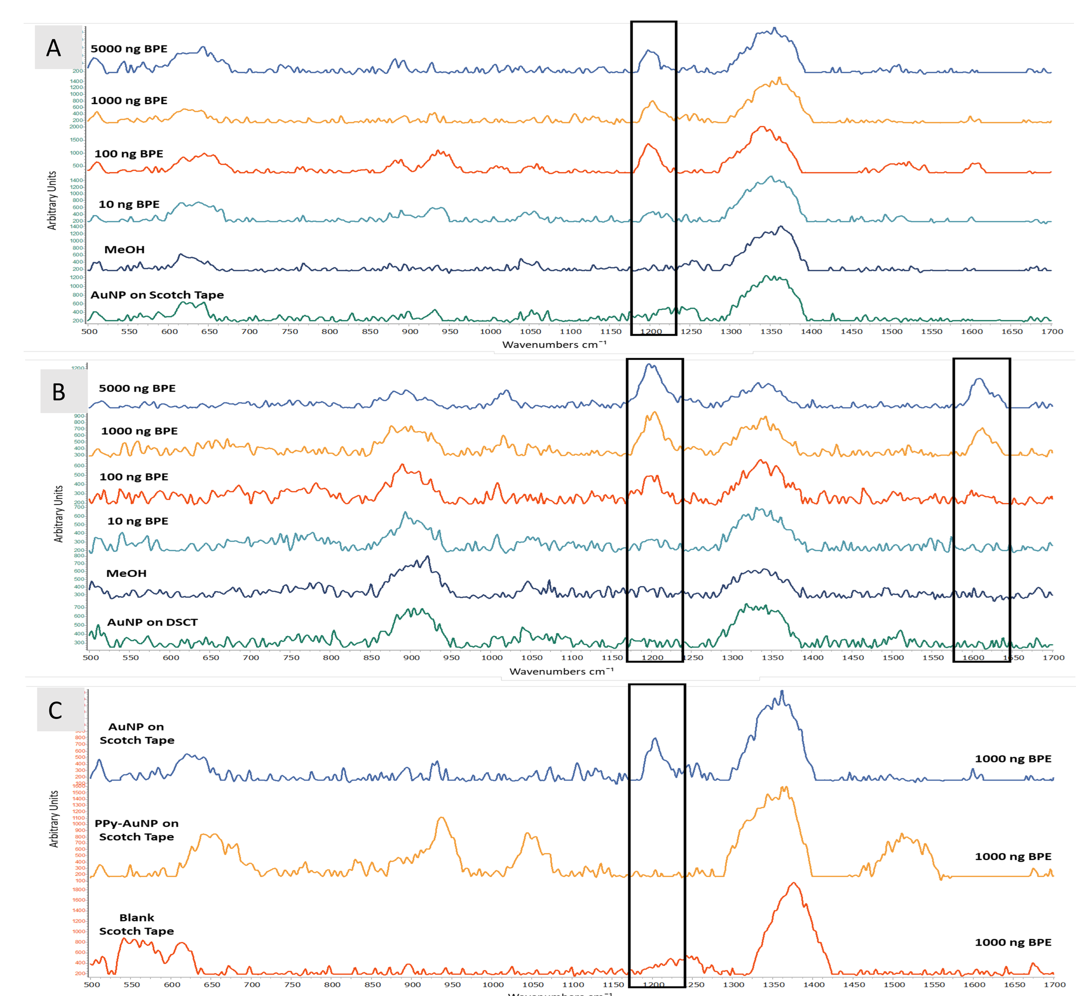

Fig. 6 SERS observation of BPE on different substrates. A) different concentrations of BPE on AuNP-Scotch tape. B) different concentrations of BPE on AuNP-double sided carbon tape. C) comparison of SERS between AuNP and Ppy-AuNP.

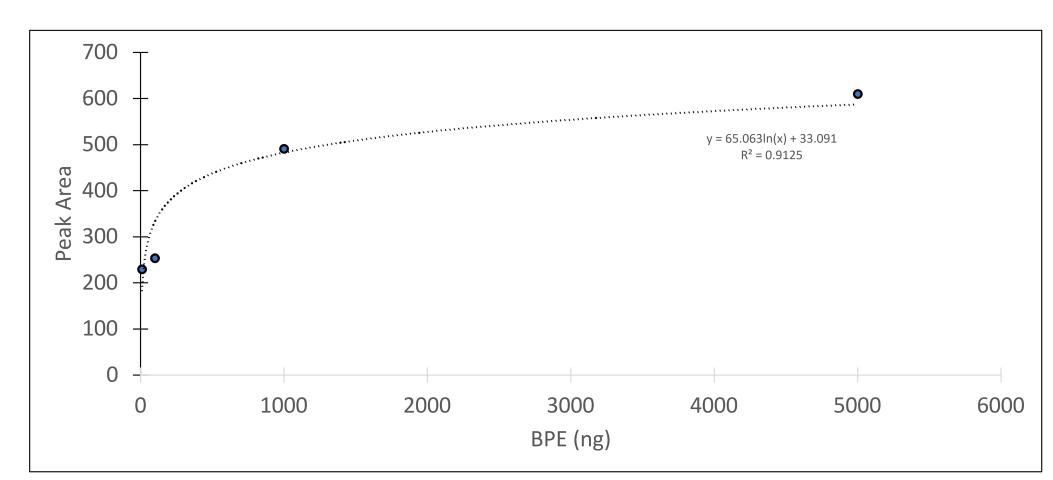

Fig. 7 Correlation between BPE concentration and peak area of 1620 cm^{-1} peak using AuNP on double sided carbon tape.

After adding BPE to the AuNP films using scotch tape as the backing material, a Raman signal enhancement was observed at 1200 cm^{-1}. When using a double-sided carbon tape as the backing material, 1200 cm^{-1} and 1620 cm^{-1} peaks attributed to the BPE were detected. These enhanced Raman scattering signals were absent from the backing materials. The detected Raman signals for BPE demonstrated that the AuNP self-assembled films exhibited SERS capabilities.

MATERIALS AND METHODS

- AuNPs were first synthesized in an aqueous solution. The size of the nanoparticles was controlled using 300 uL BH^{4-}/OH^{-} in the final synthesis step.
- The AuNP self-assembled thin film was prepared using a liquid-liquid interface approach. Five mL of AuNP solution, acetone, and hexane were added to a vial and mixed well by shaking. The solution was then poured into a small petri dish, separating the immiscible liquids into layers.
- The AuNPs were allowed to aggregate undisturbed at the interface for several minutes before being transferred to the backing materials. The transfer was done by allowing the hexane to evaporate or removing the hexane with a pipette and then using tweezers to relocate the AuNPs films onto the backing materials.

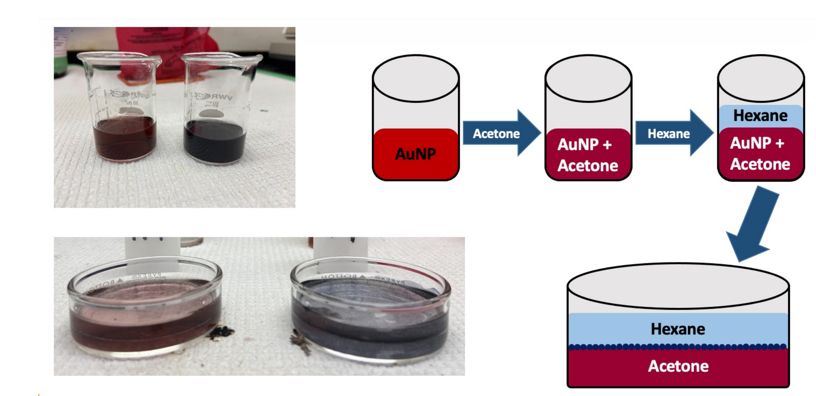

Fig. 8 Examples of liquid-liquid interface formation of AuNP thin films.

CONCLUSIONS

- Raman-based techniques can assist for the field testing of chemical chemical evidence.
- A novel SERS substrate would allow for the detection of trace chemicals.
- In this work, the AuNP self-assembled thin films provide potential SERS capabilities for trace chemical detection in forensic applications.

ACKNOWLEDGEMENTS

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