

Single-platform, attomolar detection of multiple biomarkers by flexible SERS sensor



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1. Introduction:

- Misfolded proteins accumulation in brain results in Alzheimer's and Parkinson's disease.¹
- Identification of early stage disease biomarker can aid in monitoring and treatability of the disease.
- At present, ELISA and other imaging techniques are sophisticated, expensive, time consuming and have low sensitivity.²
- In present study, flexible SERS sensor for detection of β -Amyloid Peptide biomarker of Alzheimer's disease has been developed.³

2. Principle of Surface Enhanced Raman Scattering (SERS):

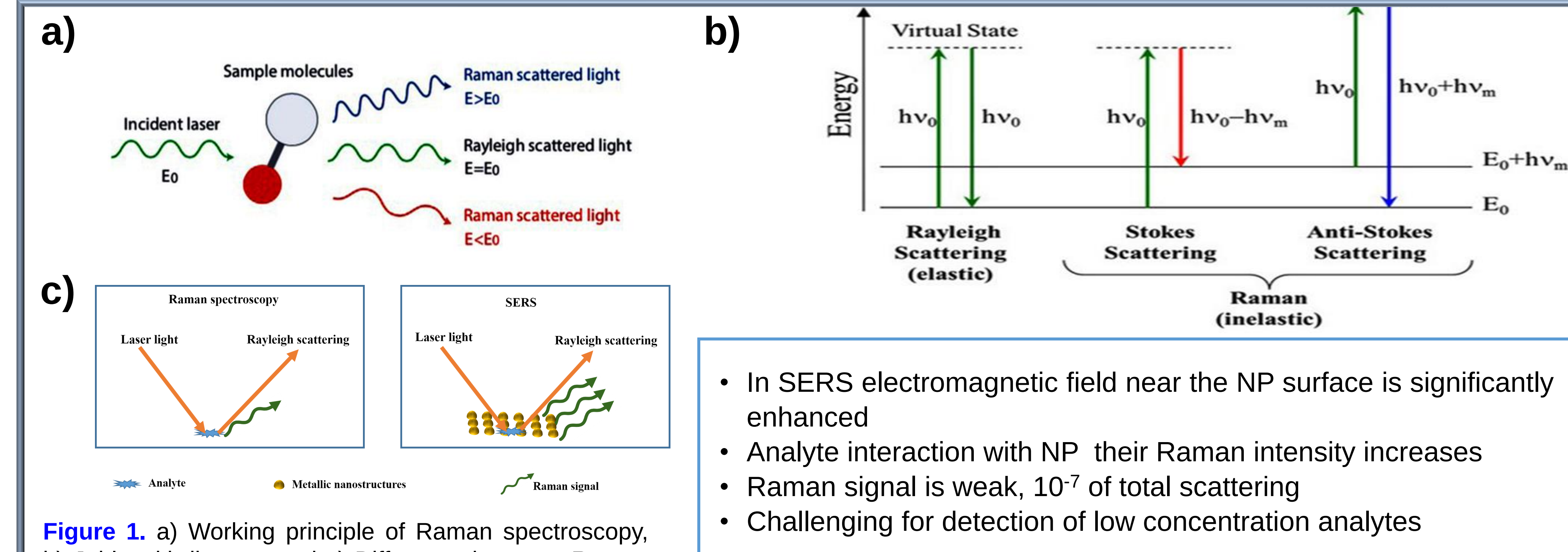


Figure 1. a) Working principle of Raman spectroscopy, b) Jablonski diagram and c) Difference between Raman and SERS.

3. Fabrication and detection method of SERS sensor:

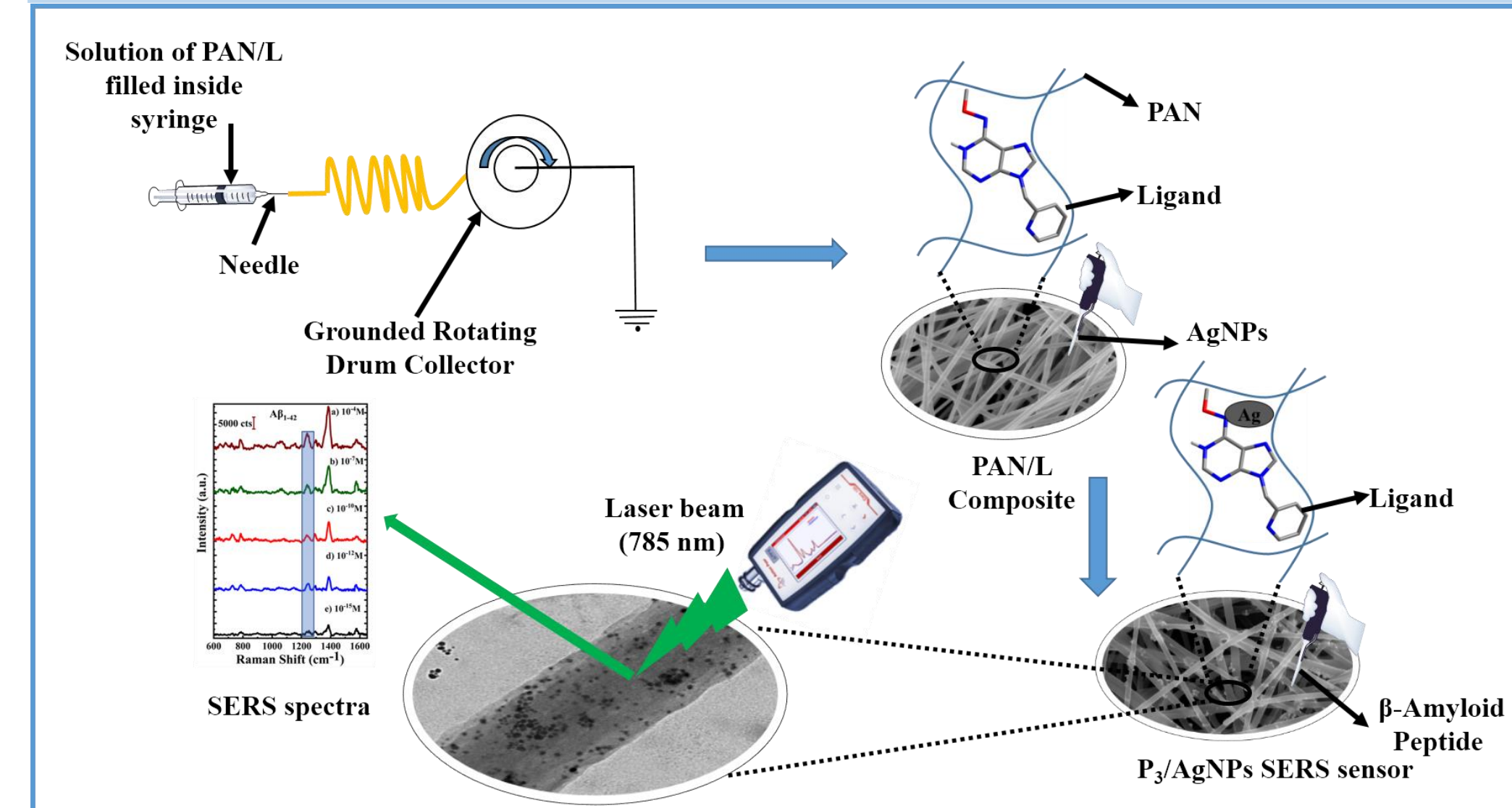


Figure 2. Fabrication and detection scheme of purine-based SERS sensor.

4. Synthesis of PAN nanofiber mat at different loadings of L:

- P₁ → PAN nanofiber mat without purine ligand
- P₂ → PAN nanofiber mat with 50 mg of purine ligand
- P₃ → PAN nanofiber mat with 100 mg of purine ligand

6. Characterization of SERS sensor:

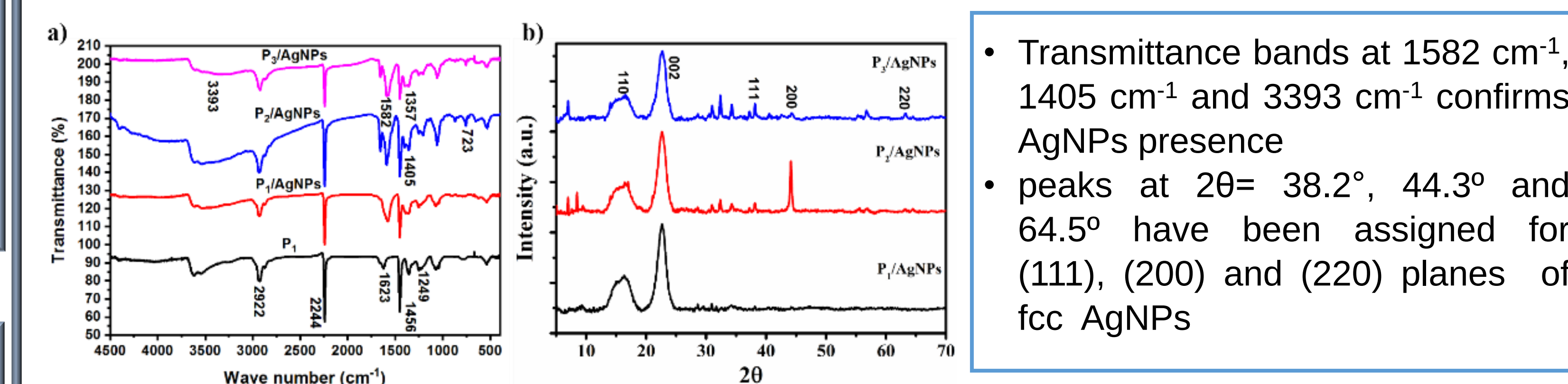


Figure 5. a) FTIR and b) XRD spectra of SERS sensors (P₁/AgNPs, P₂/AgNPs and P₃/AgNPs).

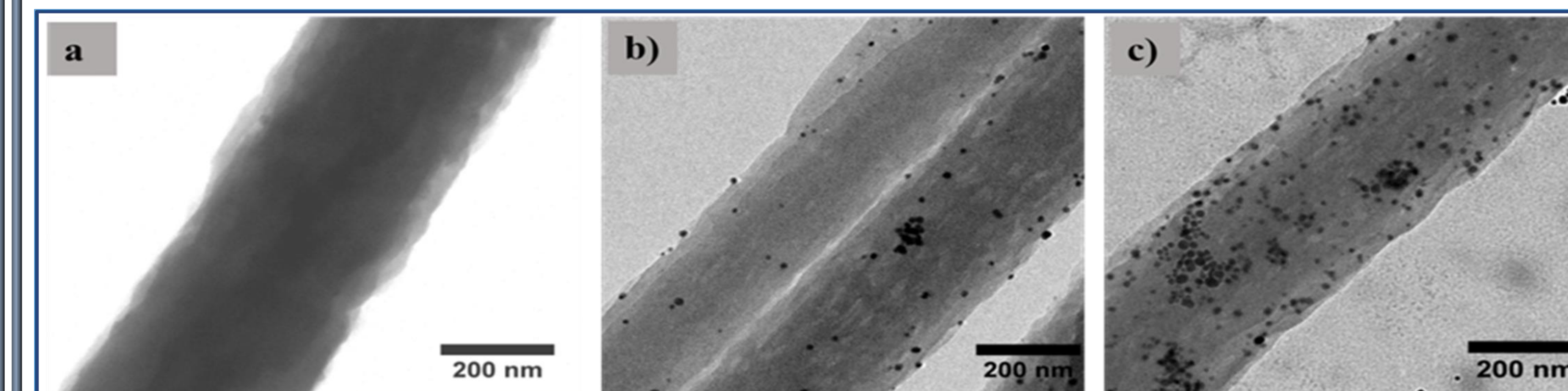


Figure 6. HRTEM images of electrospun SERS sensors a) (P₁/AgNPs) b) (P₂/AgNPs), and c) P₃/AgNPs.

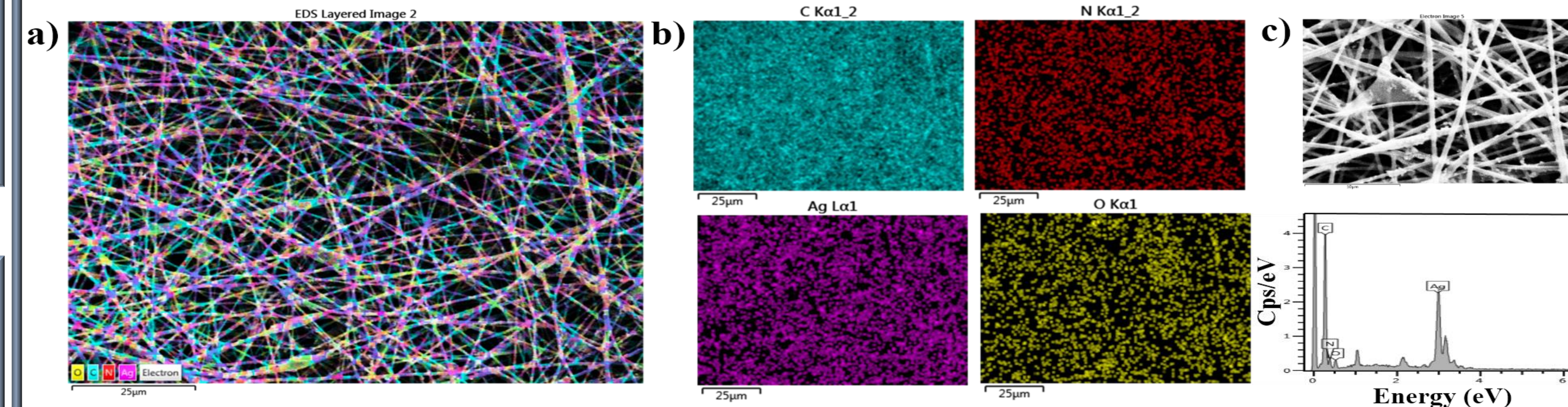


Figure 7. a) EDAX of PAN/L nanofiber mat with AgNPs (P₃/AgNPs) SERS sensor, and b) Elemental mapping of carbon (43.3 %), nitrogen (30.9 %), silver (10.5 %) and oxygen (7.9 %) elements in the fabricated SERS sensor and c) Point EDAX of P₃/AgNPs SERS sensor containing carbon (29.44 %), nitrogen (15.31 %), oxygen (6.99 %) and silver (48.27 %).

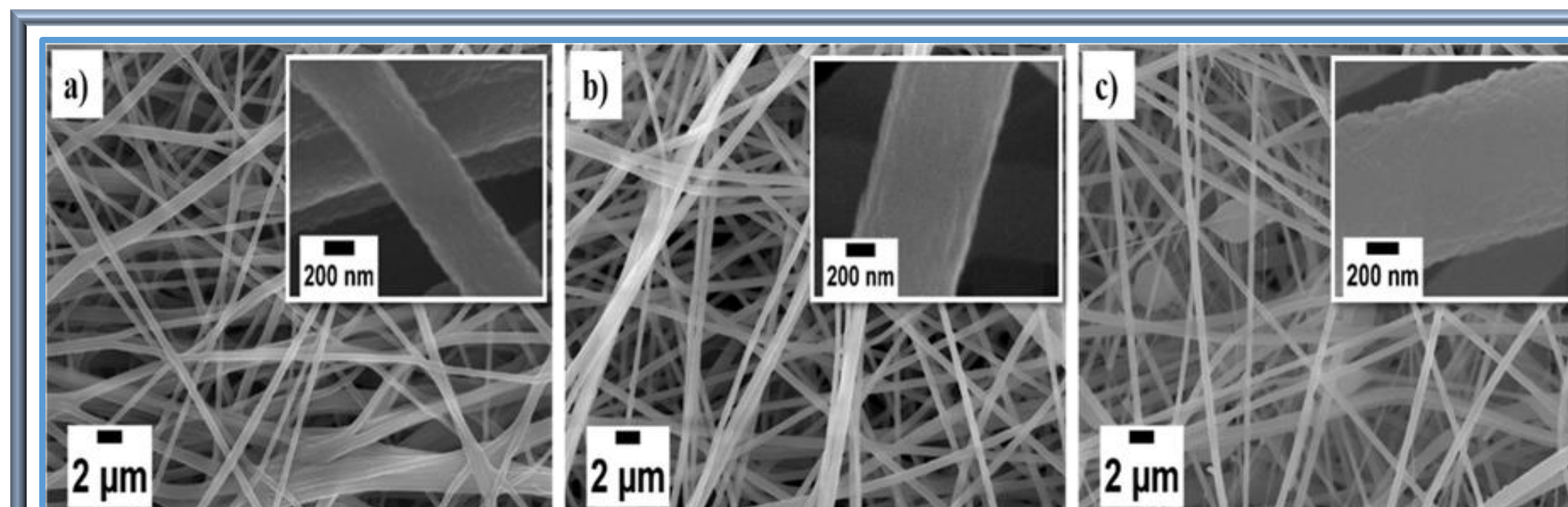


Figure 3. FESEM images of PAN/L nanofiber mats a) P₁, b) P₂ and c) P₃.

5. Fabrication of PAN/L/AgNPs SERS sensors:

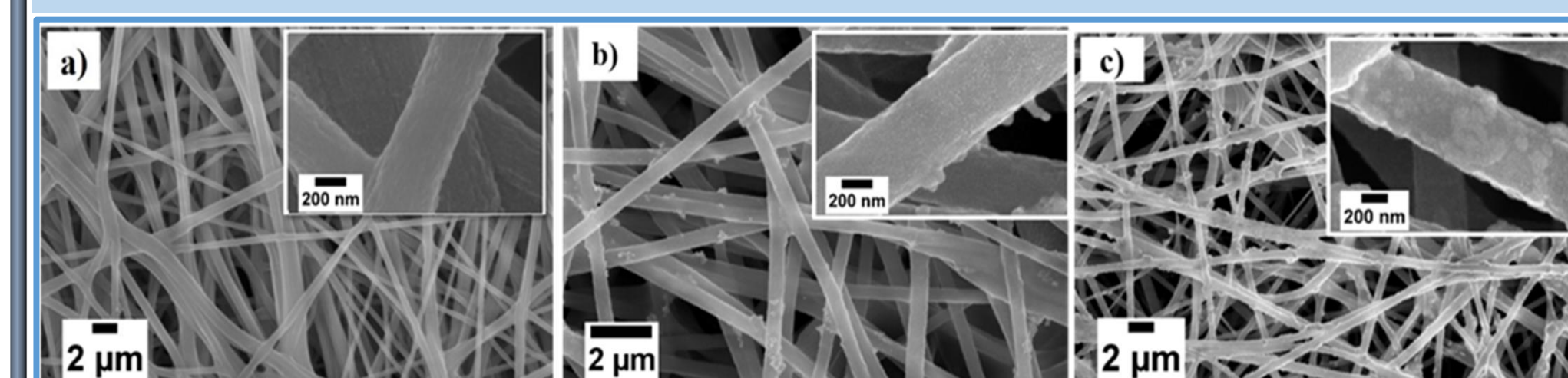


Figure 4. FESEM images of electrospun SERS sensors a) P₁/AgNPs, b) P₂/AgNPs and c) P₃/AgNPs inset show single strand of P₁ with very few AgNPs.

7. Optimization and SERS detection:

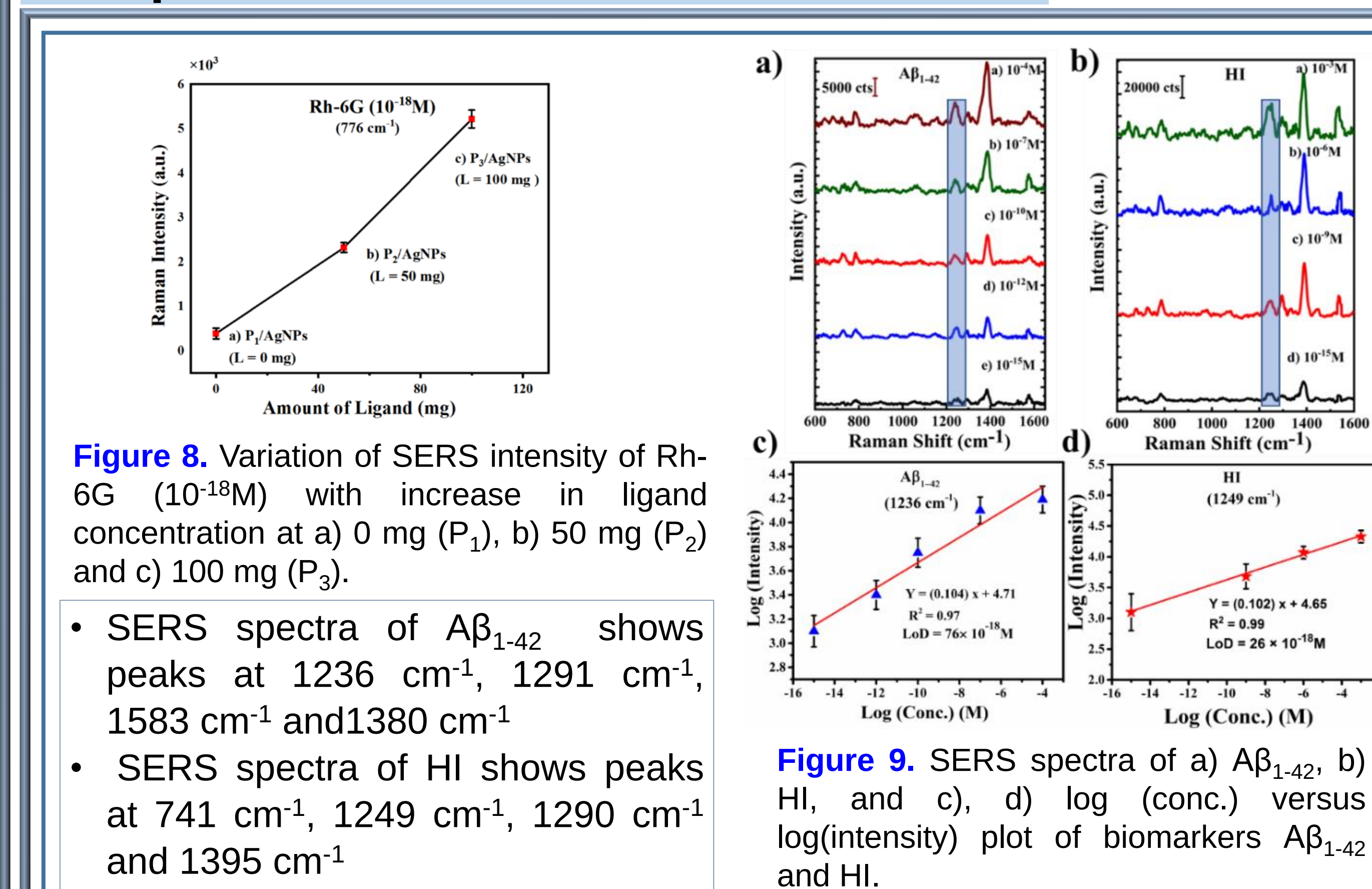


Figure 8. Variation of SERS intensity of Rh-6G (10^{-18} M) with increase in ligand concentration at a) 0 mg (P₁), b) 50 mg (P₂) and c) 100 mg (P₃).

- SERS spectra of $\text{A}\beta_{1-42}$ shows peaks at 1236 cm^{-1} , 1291 cm^{-1} , 1583 cm^{-1} and 1380 cm^{-1}
- SERS spectra of HI shows peaks at 741 cm^{-1} , 1249 cm^{-1} , 1290 cm^{-1} and 1395 cm^{-1}

Figure 9. SERS spectra of a) $\text{A}\beta_{1-42}$, b) HI, and c), d) log (conc.) versus log(intensity) plot of biomarkers $\text{A}\beta_{1-42}$ and HI.

8. Performance Evaluation of SERS sensor:

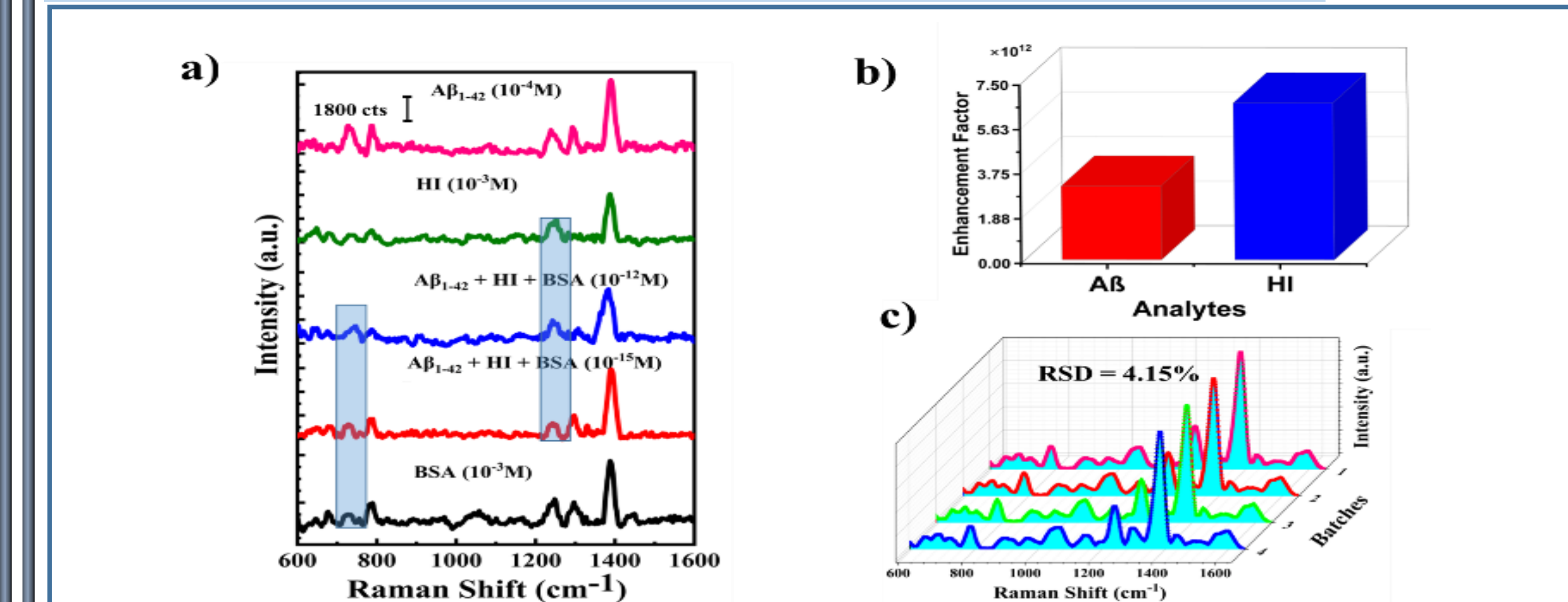


Figure 10. a) SERS spectrum of simulated cerebrospinal fluid for selectivity test, b) Enhancement factor of $\text{A}\beta_{1-42}$ and HI and c) Uniformity plot for $\text{A}\beta_{1-42}$.

Conclusions:

- Sensor developed in this study was demonstrated to be highly sensitive, selective, flexible reproducible and stable.
- The enhancement factor (EF) and limit of detection (LoD) for $\text{A}\beta_{1-42}$ and HI were 3.1×10^{12} , 6.6×10^{12} and 76×10^{-18} M, 26×10^{-18} M, respectively.
- Sensor has the potential to be developed into a wearable sensing device for preventive healthcare applications.

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References:

- X. Zhang, S. Liu, X. Song, H. Wang, J. Wang, Y. Wang, J. Huang and J. Yu, *ACS Sensors*, **2019**, 4, 2140–2149..
- W.-H. Sung, J.-T. Hung, Y.-J. Lu and C.-M. Cheng, *Diagnostics*, **2020**, 10, 272.
- Jaiswal, A. Naqvi, T. K. Dwivedi, P.K. Verma, S. *Chem. – An Asian J.* **2023**, 18, 1-7.