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A Silver Trimesate Organic Framework As An Ultrasensitive Surface-enhanced Raman Scattering Substrate For Detection Of Various Organic Pollutants

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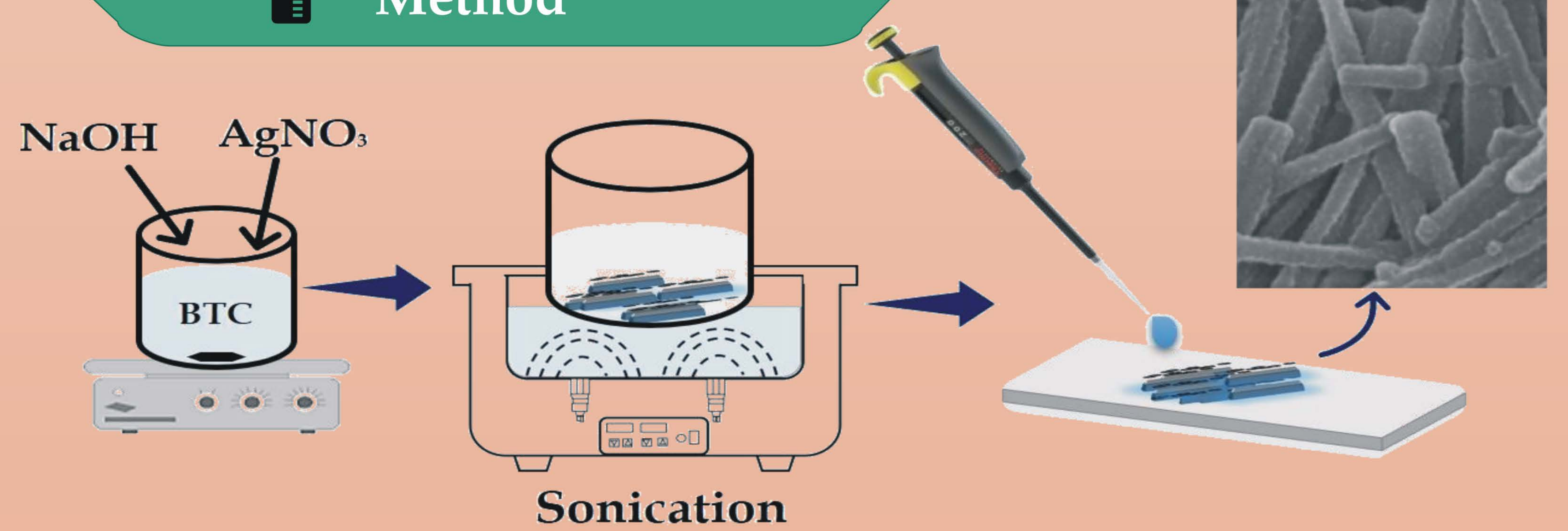
Abstract

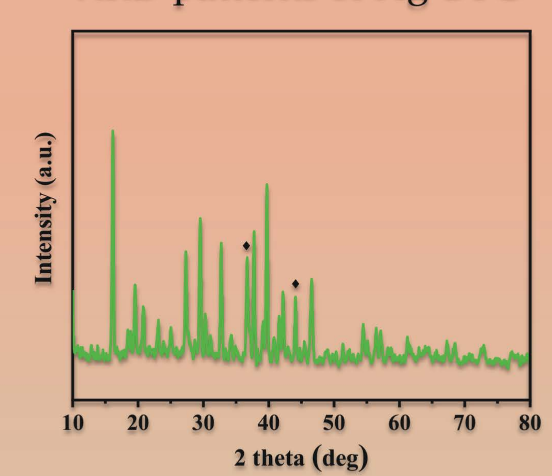
Recently, there has been an outburst of research in the field of surface enhanced Raman spectroscopy for detecting trace-level molecules. Metal-organic frameworks (MOFs) are nanoporous hybrid organic-inorganic material, with flexible structures via coordination bonds made up of metal clusters and organic linkers. MOFs are fantastic materials and deserves thorough investigations for SERS applications due to its active metal sites, large surface area, lower densities, porosity, chemical stability, and adsorption performance. Herein, a facile, efficient and sensitive a silver trimesate organic framework [{$Ag(H_2btc)$}{$Ag_2(Hbtc)$}]n (H_3btc = 1,3,5-trimesic acid) (Ag-BTC) substrate used for the detection of Rhodamine 6G (R6G), Rhodamine B(RB) and Methylene Blue (MB). The incorporation of plasmonic metal (Ag) in an organic framework offers a remarkable structural versatility with high selectivity, adsorption and stability as a SERS substrate.

Method

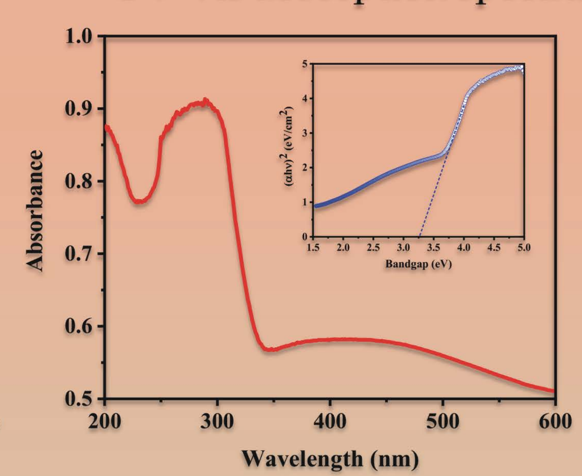


Characterisation

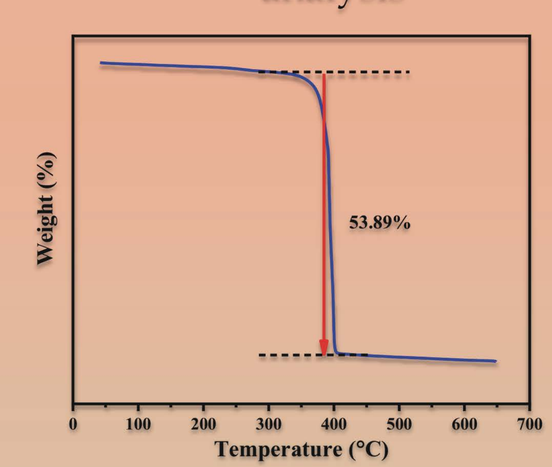
XRD patterns of Ag-BTC



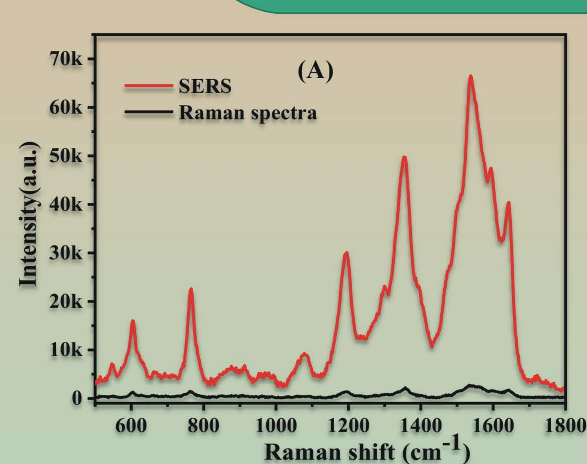
UV-Vis absorption spectra

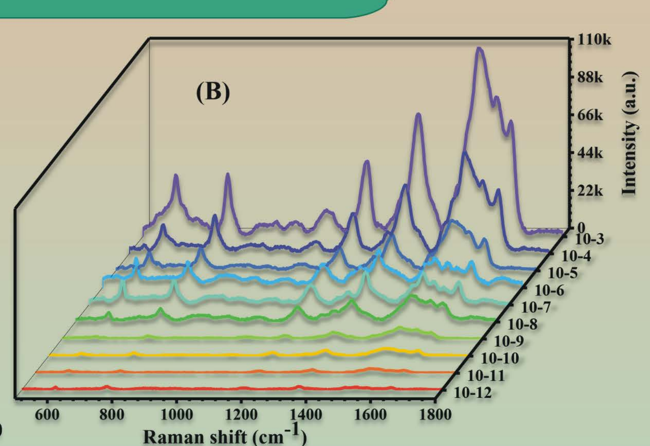


Thermogravimetric analysis



Results





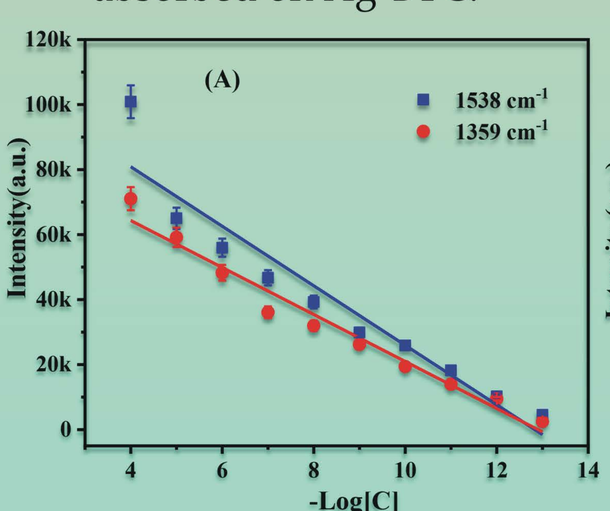
(A)Comparison spectra of SERS and normal Raman;

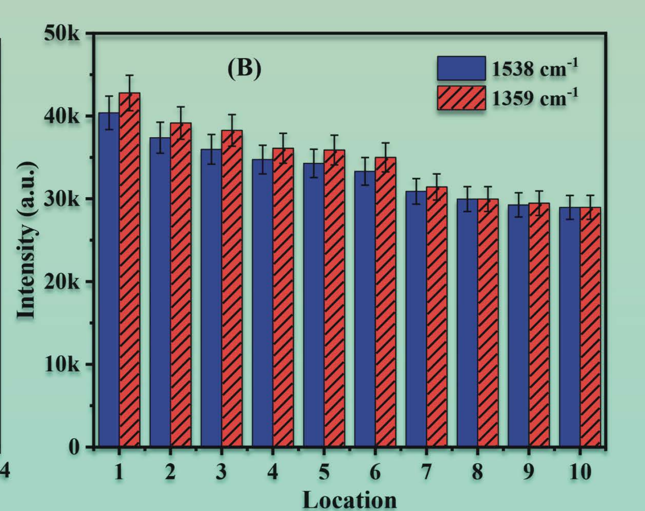
(B) SERS spectra of different concentration(10^{-4} M to 10^{-13} M) of R6G absorbed on Ag-BTC.

The analytical enhancement factor (*AEF*) values were calculated using the following equation:

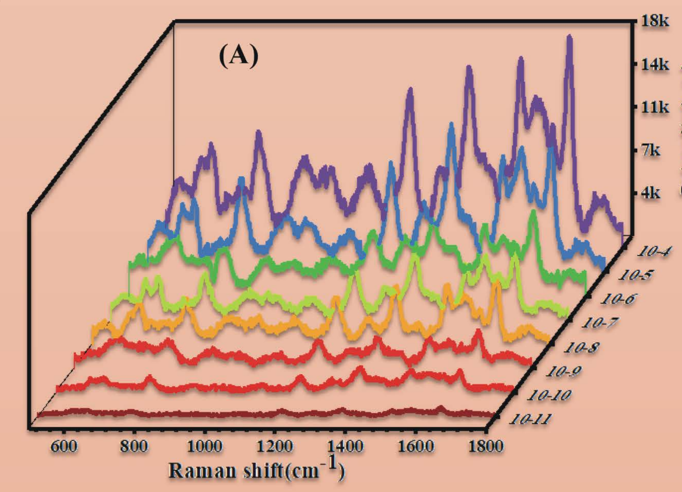
$$AEF = \frac{I_{SERS} \times C_0}{I_0 \times C_{SERS}}$$

The EF value for the main peaks was as up to 5.85 x 10^7 for R6G, providing an improved SERS sensitivity.





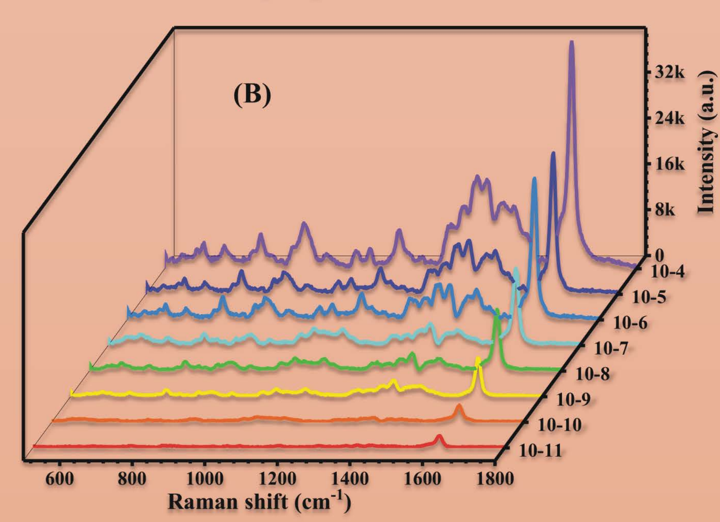
(A) Calibration plot ; (B) SERS spectra of R6G (10^{-8} M) obtained from 10 random locations.



SERS spectra of different concentration (10^{-4} M to 10^{-11} M) of RB

Summary of the parameter for different dyes

Dye	Peaks (cm^{-1})	AEF	R^2	RSD%
R6G	1538	5.85 x 10^7	0.9731	9.77
	1359	5.45 x 10^7	0.97149	11.45
	762	5.49 x 10^7	0.97876	14.41
	608	5.85 x 10^7	0.96089	13.85
RB	1654	4.85 x 10^6	0.93555	10.80
	1511	4.65 x 10^6	0.96584	14.64
	1367	4.59 x 10^6	0.97805	12.55
MB	1624	7.51 x 10^5	0.9740	5.58
	1354	7.11 x 10^5	0.9875	1.09



SERS spectra of different concentration (10^{-4} M to 10^{-11} M) of MB

Conclusion

- A silver trimesate organic framework (Ag-BTC) was fabricated by a simple co-precipitation method and investigated for the SERS activity.
- The characterization studies showed that the Ag particles were decorated uniformly on the organic framework creating a synergistic effect which aids to an increased amount of local field hotspots and increased Raman intensity.
- The prominent peaks were observable even concentration down to 10^{-13} M (R6G) and 10^{-11} M (RB and MB) indicating a noticeable enhancement of SERS signals exhibited by Ag-BTC.
- The *AEF* value for the main peaks was as around ~10^6, providing an improved SERS sensitivity. Furthermore, the substrate also exhibited excellent uniformity.
- The Ag-BTC displayed great potential as SERS substrates for rapid detection of environmental pollutants.

References

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