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(HBTC)][Ag(HBTC)])In (H₄BTC = 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

NaOH AgNO₃

Sonication

Characterisation

XRD patterns of Ag-BTC

UV-Vis absorption spectra

Thermogravimetric analysis

Results

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

\[ \text{AEF} = \frac{I_{\text{Ag-BTC}}}{I_{\text{Ag-BTC}}} \times C_{\text{Ag-BTC}} \]

The EF value for the main peaks was as up to 5.85 x 10⁶ for R6G, providing an improved SERS sensitivity.

SERS spectra of different concentration (10⁻⁴ M to 10⁻¹³ M) of MB

SERS spectra of different concentration (10⁻⁴ M to 10⁻¹¹ M) of RB

Summary of the parameter for different dyes

<table>
<thead>
<tr>
<th>Dye</th>
<th>Peaks (cm⁻¹)</th>
<th>AEF</th>
<th>S%</th>
<th>RSD%</th>
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</thead>
<tbody>
<tr>
<td>R6G</td>
<td>1359 5.45 x 10⁶</td>
<td>0.9714</td>
<td>9.72</td>
<td>11.45</td>
</tr>
<tr>
<td>R6G</td>
<td>1359 5.45 x 10⁶</td>
<td>0.9714</td>
<td>11.45</td>
<td></td>
</tr>
<tr>
<td>762 5.85 x 10⁶</td>
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<tr>
<td>408 5.85 x 10⁶</td>
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<tr>
<td>1154 4.85 x 10⁶</td>
<td>0.9555</td>
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<tr>
<td>1151 4.85 x 10⁶</td>
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<td>1367 4.59 x 10⁶</td>
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<tr>
<td>1364 7.51 x 10⁶</td>
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<td>1354 7.11 x 10⁶</td>
<td>0.9875</td>
<td>1.09</td>
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</table>

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 ~10⁶, 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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