

Supporting Information

Chemical deposition of Ag nanostructures on polypyrrole films as active SERS substrates

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Experiment section

Reagents

Pyrrole ($\geq 98.0\%$, National medicine group chemical reagent co., LTD) was distilled and stored at low temperature under nitrogen protection. AgNO_3 (99.9999%, Aldrich), sulfosalicylic acid, mandelic acid and methylene blue (MB, Aldrich 90%) were used as received.

Fabrication of PPy Films

The electrochemical polymerization of polypyrrole (PPy) on stainless steel sheets was carried out using a typical two-electrode setup at a constant potential of 1.50 V in a 20 mL 0.5 M pyrrole aqueous solution containing 0.5 M sulfosalicylic acid. The thickness of PPy films was controlled by changing the electrodeposition time. The resulting PPy films doped with sulfosalicylic acid can be peeled off from the stainless steel sheets after a reaction time of 1 h. The PPy films were then cut into 5 mm $\times$ 5 mm pieces. Next, the small PPy pieces were dedoped in 0.1 M ammonia solution for 30 min before being used for Ag growth.

Growth of Ag Nanostructures on PPy Films

The typical reaction are as follows: the doped PPy films treated with ammonia water were rinsed repeatedly with H_2O and then immersed in a mixture solution of 0.5 mL of 0.1 M AgNO_3 and 0.05 mL of 0.5 M mandelic acid for 30 s, 1 min, 2 min, 5 min, 10 min, respectively. After Ag growth, the PPy films were rinsed with water thoroughly to remove surface residuals and then dried in a vacuum drier.

Characterization

Scanning electron microscopy (SEM) images were recorded on a S-4800 (Hitachi) electron microscope. The characteristics of the crystallite structure of the prepared samples were collected using an XRD-6000 X-ray diffractometer (Shimadzu) with a Cu K α radiation source ($\lambda=1.5405 \text{ \AA}$, 40.0 kV, and 30.0 mA). For SERS measurement, the PPy films after Ag growth were immersed in MB aqueous solutions of different concentrations for 30 min, and then washed with distilled water thoroughly. The Raman spectra were determined on a Renishaw in Via micro Raman spectroscopy system, using the TE air-cooled 576 $\times$ 400 CCD array in a confocal Raman system (wavelength: 633 nm). The incident laser power was kept at 0.1 mW, $\times 100$ objective and an integration times of 5 s were employed.

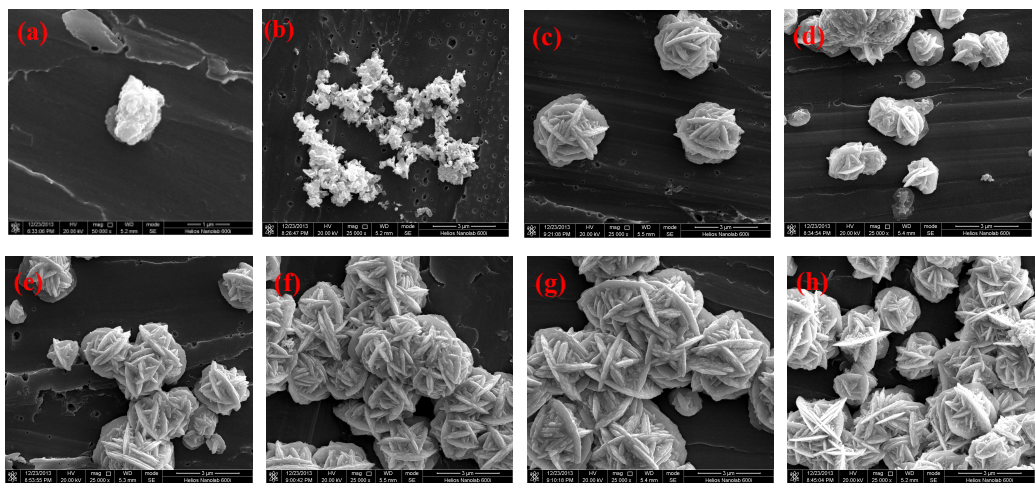


Figure S1 SEM image of Ag nanostructures deposited on PPy films for different reaction time in 0.1 M AgNO₃ solution. (a) 6 h; (b) 12 h; (c) 18 h; (d) 24 h; (e) 30 h; (f) 36 h; (g) 42 h; (h) 48 h.

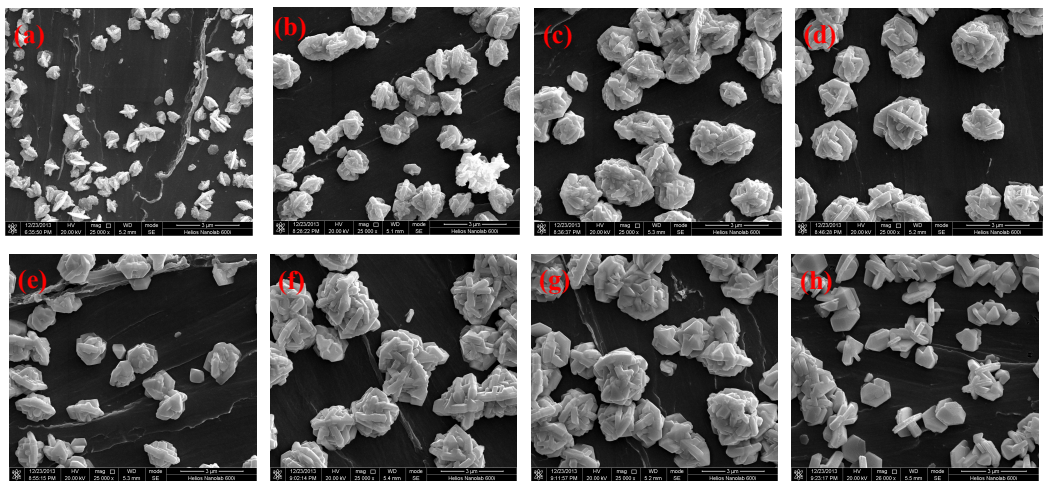


Figure S2 SEM image of Ag nanostructures deposited on PPy films treated with ammonia solution for different reaction time in 0.1 M AgNO₃ solution. (a) 6 h; (b) 12 h; (c) 18 h; (d) 24 h; (e) 30 h; (f) 36 h; (g) 42 h; (h) 48 h.

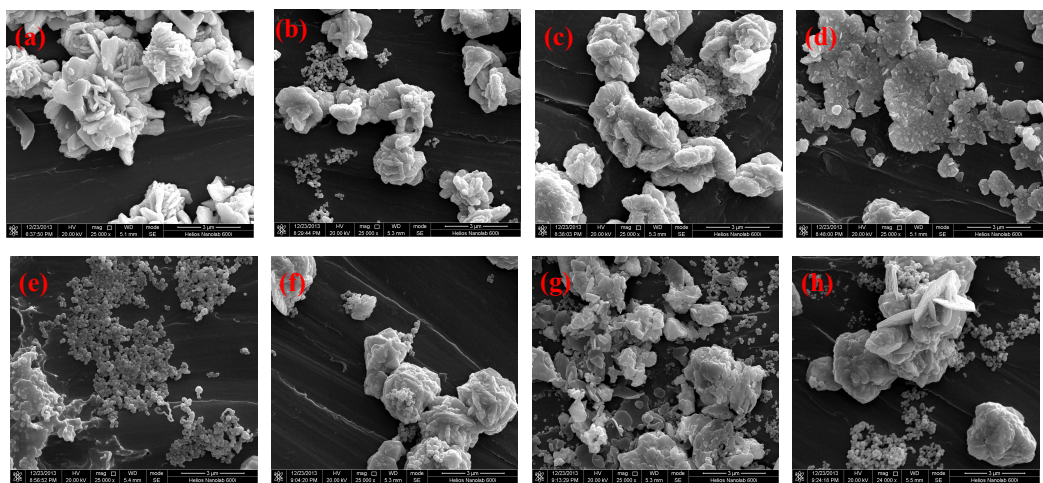


Figure S3 SEM image of Ag nanostructures deposited on PPy films for different reaction time in 0.1 M AgNO₃ solution with the presence of 0.5 M mandelic acid. (a) 6 h; (b) 12 h; (c) 18 h; (d) 24 h; (e) 30 h; (f) 36 h; (g) 42 h; (h) 48 h.

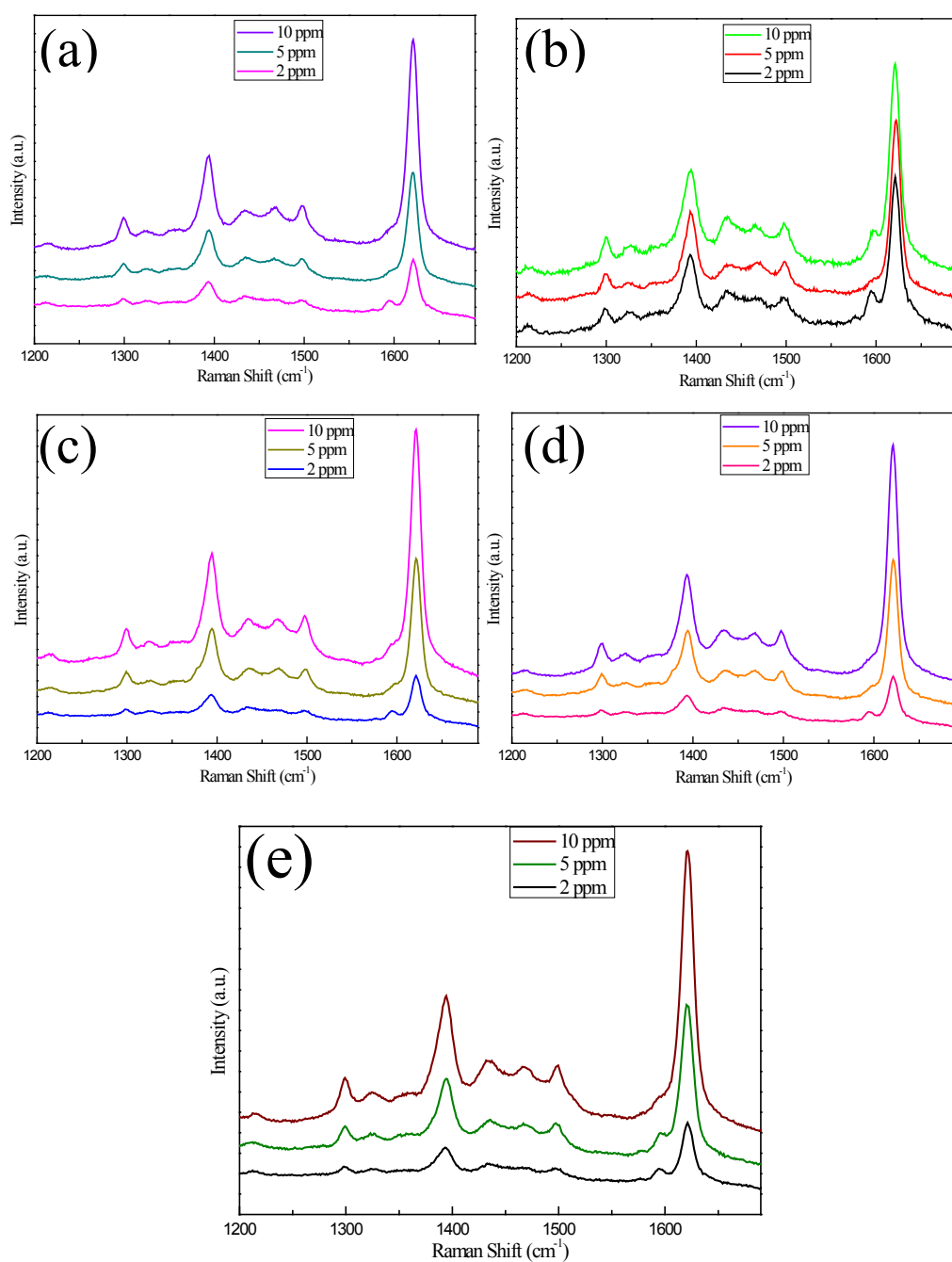


Figure S4 SERS spectra of Different concentrations of MB taken from the Ag nanostructures for different reaction time (a) 30 s; (b) 1 min; (c) 2 min; (d) 5 min and (e) 10 min produced on the treated PPy films, with mandelic acid present in the AgNO_3 solution.

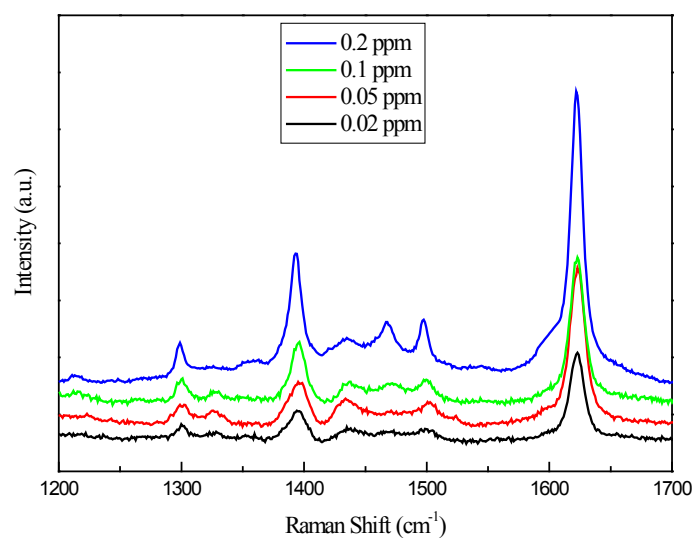


Figure S5 SERS spectra of different concentration of MB taken from the Ag nanostructures for 10 min produced on the treated PPy films, with mandelic acid present in the AgNO₃ solution.