Electronic Supplementary Material (ESI) for Analyst.

Supporting information for

Spherical Covalent-Organic Framework for Enhancing Laser Desorption/Ionization Mass Spectrometry of Small Molecules

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EXPERIMENTAL SECTION

Material and reagents. Trifluoroacetic acid (TFA), amino acids (tryptophan (Trp, MW=204.23), tyrosine (Tyr, MW=181.19), arginine (Arg, MW=174.20), phenylalanine (Phe, MW=165.19), histidine (His, MW=155.15), and glutamine (Gln, MW=146.14)), and nucleobases (guanine (G, MW=151.13), adenine (A, MW=135.13), thymine (T, MW=126.11), uracil (U, MW=112.09), and cytosine (C, MW=111.10)) were the products of Sigma-Aldrich (St. Louis, MO). Unsaturated fatty acids including paullinic acid (C20:1, MW=310.51), oleic acid (C18:1, MW=282.45), linoleic acid (C18:2, MW=280.44), linolenic acid (C18:3, MW=278.43) and 2-hexadecenoic acid (C16:1, MW=254.41) were obtained from Acros Organics (New Jersey). Five peptides (FGFGFGF (MW=777.87), GGFGFGG (MW=597.63), FGFGF (MW=573.65), FGFG (MW=425.47), and GGFGG (MW=393.40)) were supplied by Shanghai Apeptide Co. Ltd (Shanghai, China). Estrogens (ethinyloestradiol (EE2, MW=296.40), estriol (E3, MW=288.38), estradiol (E2, MW=272.38), estrone (E1, MW=270.37), diethylstilbestrol (DES, MW=268.35), dienestrol (DIS, MW=266.33)), and sulfonamides (sulfadlmethoxine (SM2, MW=310.33), sulfisoxazole (SIZ, MW=267.30), sulfamerazine (SMR, MW=264.30), sulfadiazine (SDZ, MW=250.28), and sulfapyridine (SASP,MW=249.29)) were supplied by Aladdin Chemistry Co. Ltd (Shanghai, China). Bisphenols (bisphenol BP (BPBP, MW=352.23), bisphenol S (BPS, MW=249.29), bisphenol B (BPB, MW=242.31), bisphenol A (BPA, MW=228.29), and bisphenol F (BPF, MW=200.23)) were supplied by Alfa Aesar (Ward Hill, MA, USA).

Preparation of matrix solution. CHCA (10 mg/mL) matrix was dissolved in acetonitrile containing 0.1% TFA at a ratio of 2:1. 9-AA (10 mg/mL) matrix was dispersed in a methanol/water solution (9:1, v/v). The spherical COF-V solution and bulk COF-V solution (1 mg/mL) were prepared individually in ethanol/water (1:1, v/v) and sonicated for 30s before use. Afterward, 1 μL of substrate was spotted and air-dried on the target (Bruker, Germany), followed by 1 μL analyte was applied onto the surface of substrate.

Preparation of sample solution. Arginine (Arg), phenylalanine (Phe), histidine (His), and glutamine (Gln) were respectively dissolved in water at a concentration of 10 mM as stock solutions. Tyrosine (Tyr) and tryptophan (Try) were dissolved in water/formic acid (1:1, v/v) at a concentration of 10 mM at stock solution. Five nucleobases were dissolved in hot water at a concentration of 10 mM as stock solutions. Unsaturated fatty acids of C16:1, C18:1, C18:2, C18:3 and C20:1 were dissolved in anhydrous ethanol at a concentration of 10 mM as stock solutions. All of peptides were respectively dissolved in water/MeOH (1:1, v/v) at a concentration of 10 mM as stock solution. Estrogens were dissolved in MeOH at a concentration of 10 mM as stock solutions. Sulfonamides and BPs were dissolved in ACN at a concentration of 10 mM as stock solutions. Saccharides were dissolved in water at a concentration of 1 mM as stock solutions. All analyte solutions were stored at 4 ℃ for use.

Apparatus. Scanning electron microscopy (SEM) images were collected on a FEI Emission Scanning Electron Microscope (SU8020, Hitachi, Japan). Transmission electron microscopy (TEM) images were taken with a Hitachi HT7700. The Fourier

transform infrared (FT-IR) experiments were carried out on a Nicolet 6700 spectrometer (Thermo Fisher, USA) in KBr pellets, scanning from 4000 to 400 cm^{-1} at room temperature. X-ray diffraction (XRD) patterns were acquired on a X'Pert-Pro MPD (Philips, Holland) power diffractometer. The gas adsorption and desorption isotherms were obtained from a surface area analyzer (Micromeritics ASAP2020, USA). The N_2 sorption isotherms were measured at 77 K. The size distribution analyses of the spherical COF-V were performed on a dynamic light scattering (DLS, Zetasizer NanoZS90, Malvern Instruments Ltd, UK). All the UV-vis adsorption data were carried on a Shimadzu UV-2550 spectrometer.

Supporting Information-Figures

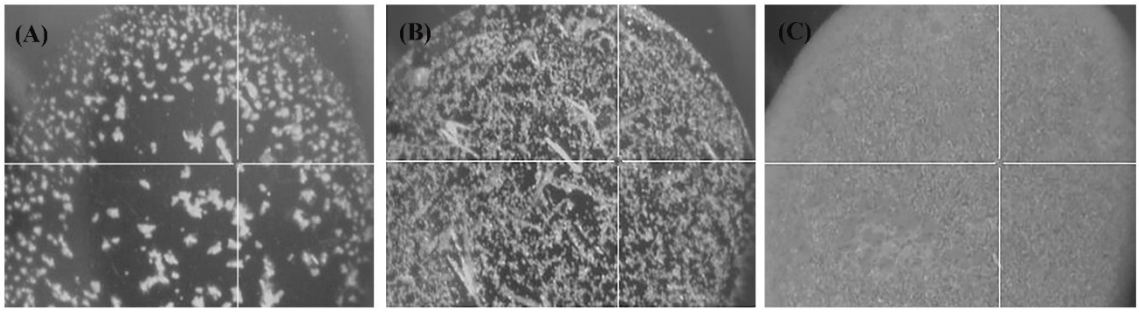

Figure S1 Optical images of (A) CHCA, (B) 9-AA, and (C) spherical COF-V dispersed on the stainless-steel target. Matrix concentration: CHCA (10 mg/mL), 9-AA (10 mg/mL) and spherical COF-V (1 mg/mL).

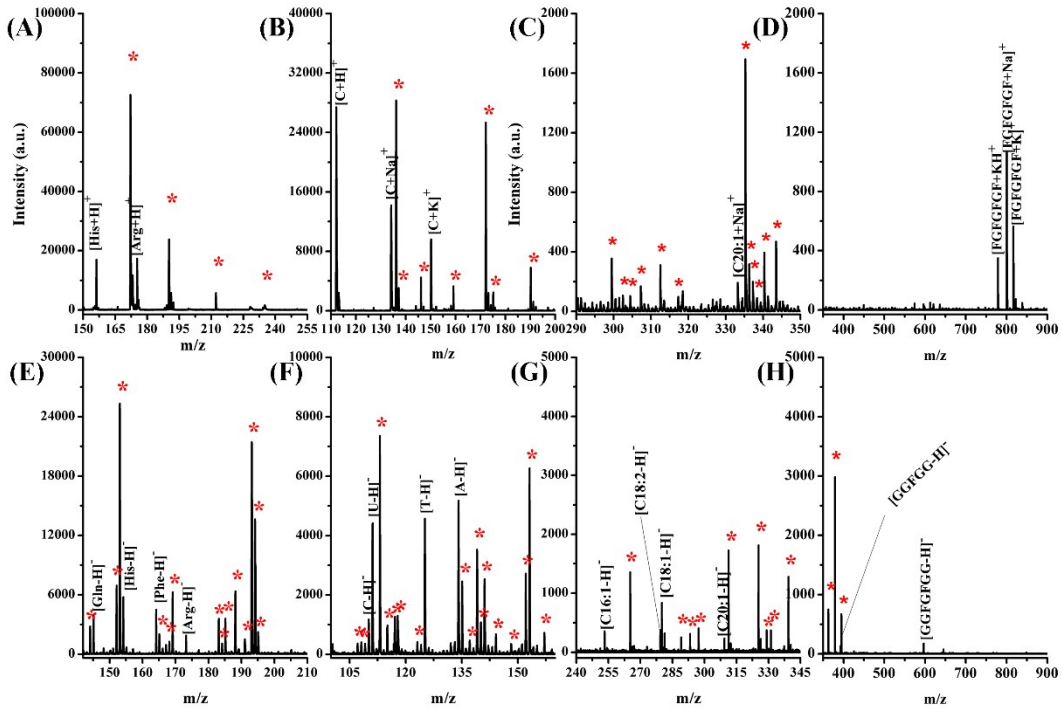

Figure S2 Mass spectra of (A) six amino acids (1 mM), (B) five nucleobases (2 mM), (C) five unsaturated fatty acids (0.5 mM) and (D) five peptides (2 mM) using CHCA in positive mode; (E) six amino acids (1 mM), (F) five nucleobases (2 mM), (G) five unsaturated fatty acids and (H) five peptides using 9-AA in negative mode.

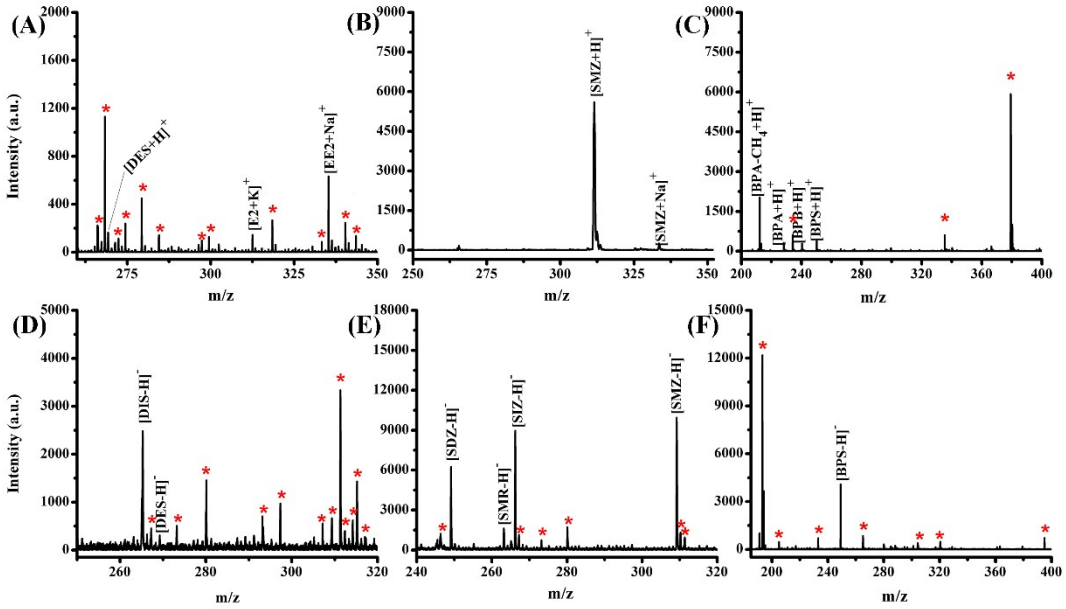

Figure S3 Mass spectra of (A) six kinds of 1 mM estrogens, (B) five kinds of 2 mM sulfonamides and (C) five bisphenols using CHCA in positive ion mode; (D) six kinds of 1 mM estrogens, (E) five kinds of 2 mM sulfonamides and (F) five bisphenols using 9-AA in negative ion mode. Analyte concentration: BPF, 2 mM; BPA, 1.5 mM; BPB, 1.5 mM; BPS, 0.5 mM; and BPBP, 0.8 mM.

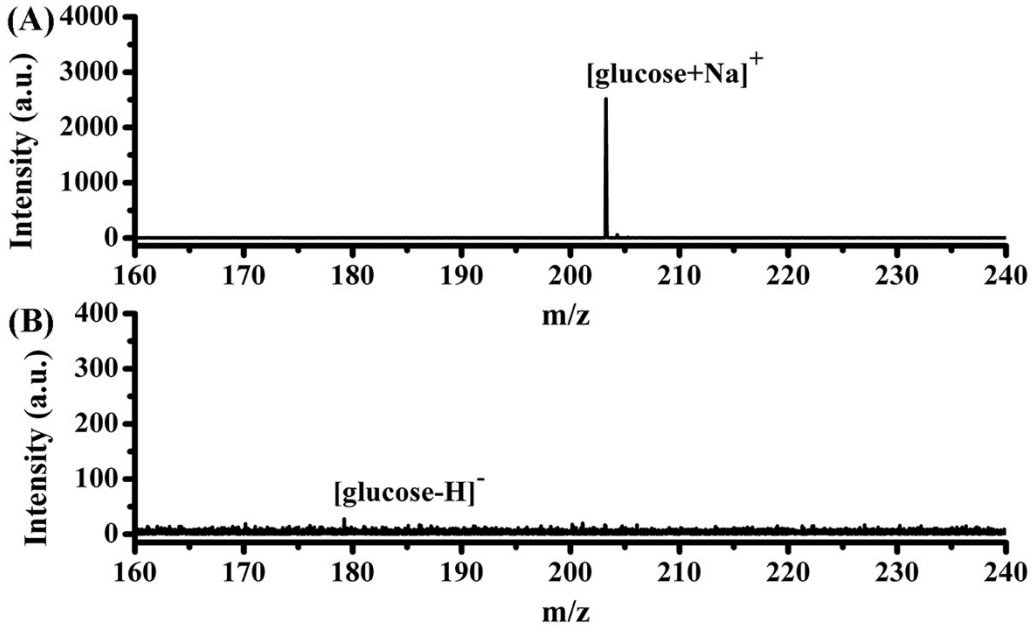

Figure S4 Mass spectra of glucose by using spherical COF-V (A) in positive ion mode, (B) in negative ion mode. The concentration of glucose was set as 1mM.

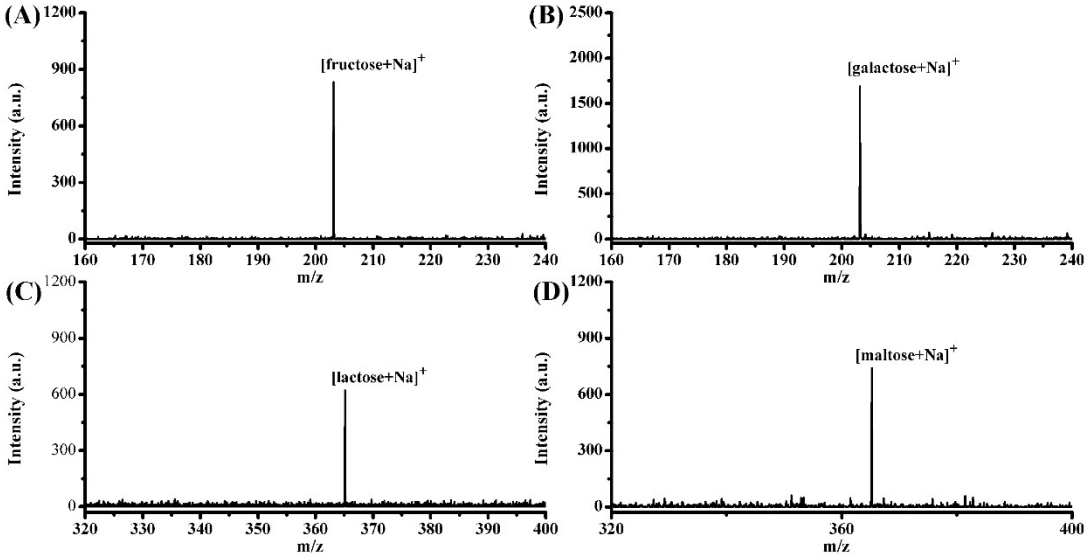

Figure S5 Mass spectra of four kinds of 1mM saccharides by using spherical COF-V in positive ion mode: (A) fructose; (B) galactose; (C) lactose; (D) maltose.

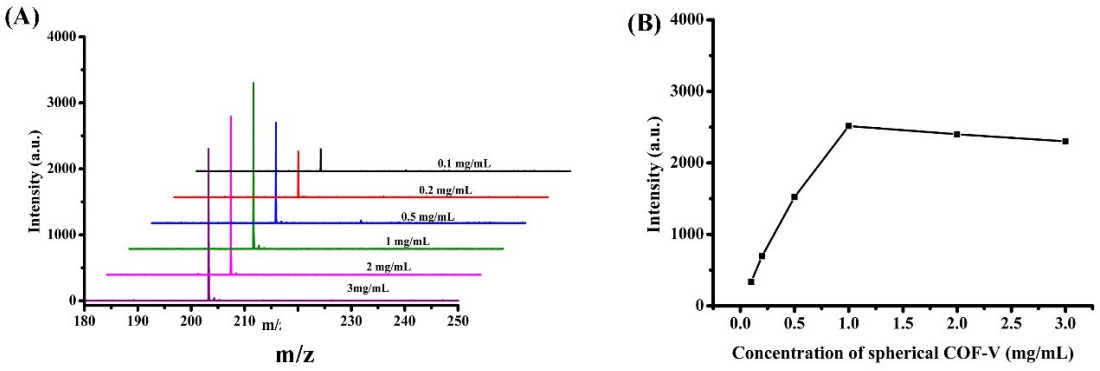

Figure S6 (A) mass spectra of glucose by using spherical COF-V with different concentration as substrate in positive ion mode. (B) optimization curve of spherical COF-V concentration. The concentration of glucose was set as 1mM.

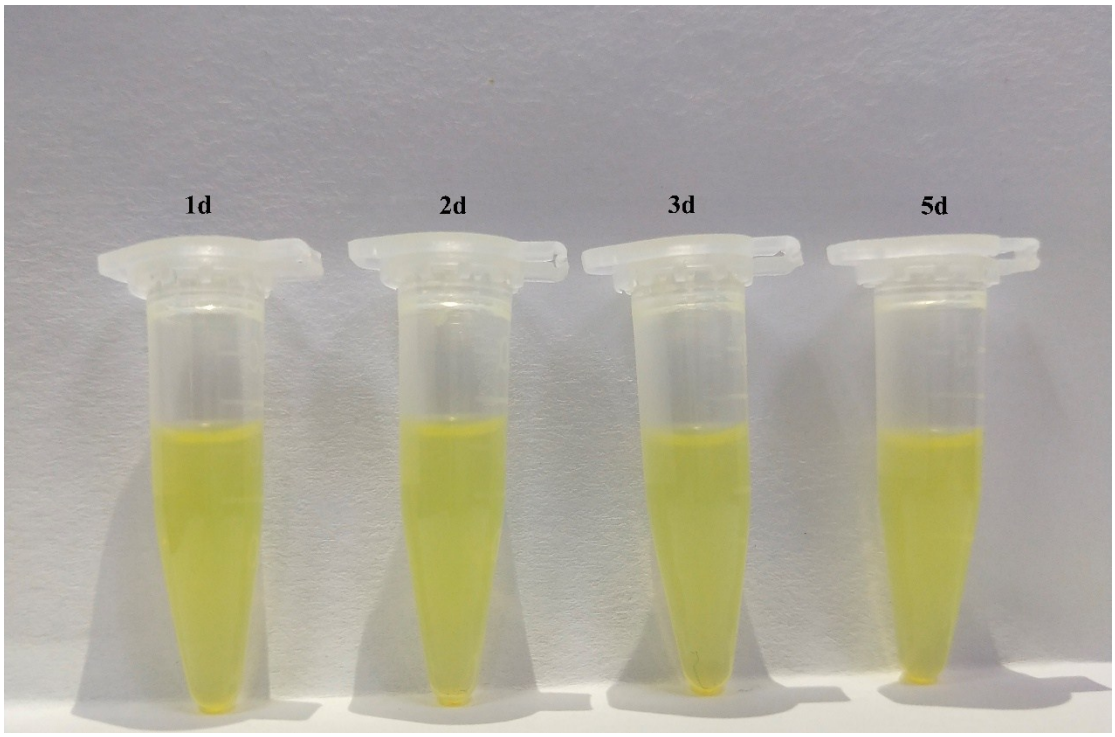

Figure S7 The stability of spherical COF-V suspension after 1 d, 2 d, 3 d and 5 d, respectively.

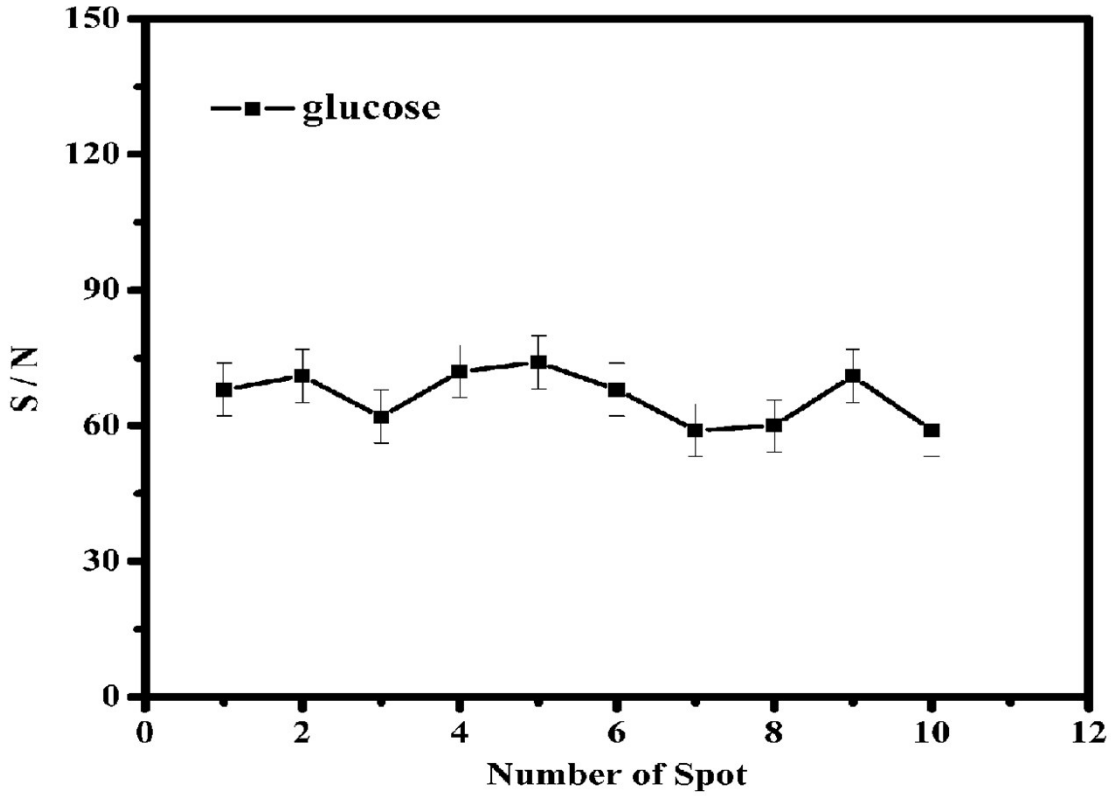

Figure S8 The signal-to-noise ratio (S/N) of glucose repeatedly acquired from 10 different sample spots by using spherical COF-V substrate in positive ion mode. The concentration of glucose was 0.1 mM.

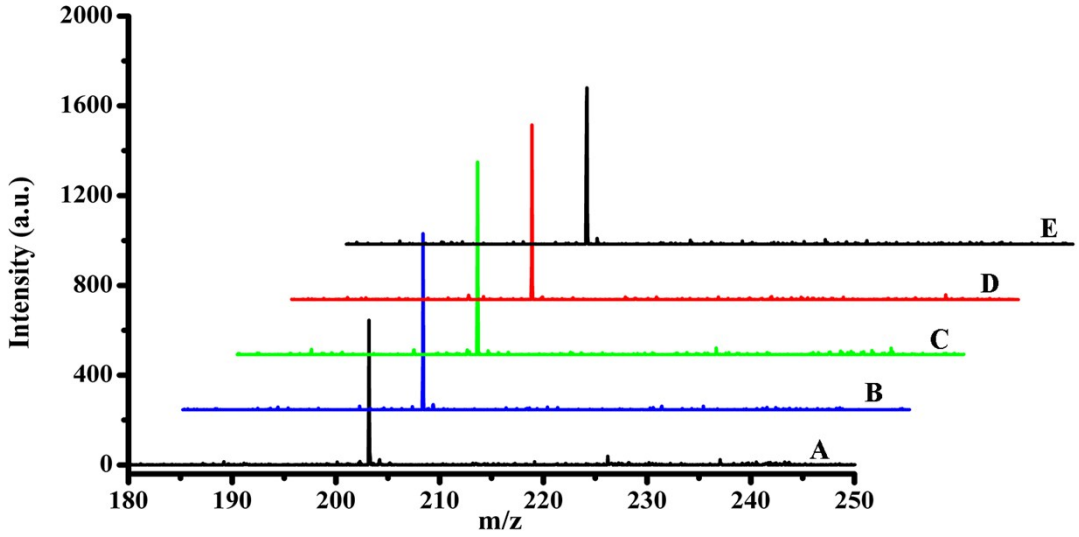

Figure S9 Mass spectra of glucose by using spherical COF-V in positive ion mode with (A) no additional salt; (B) 10 mM NaCl; (C) 100 mM NaCl; (D) 500 mM NaCl; (E) 1000 mM NaCl. The concentration of glucose was 0.1 mM.

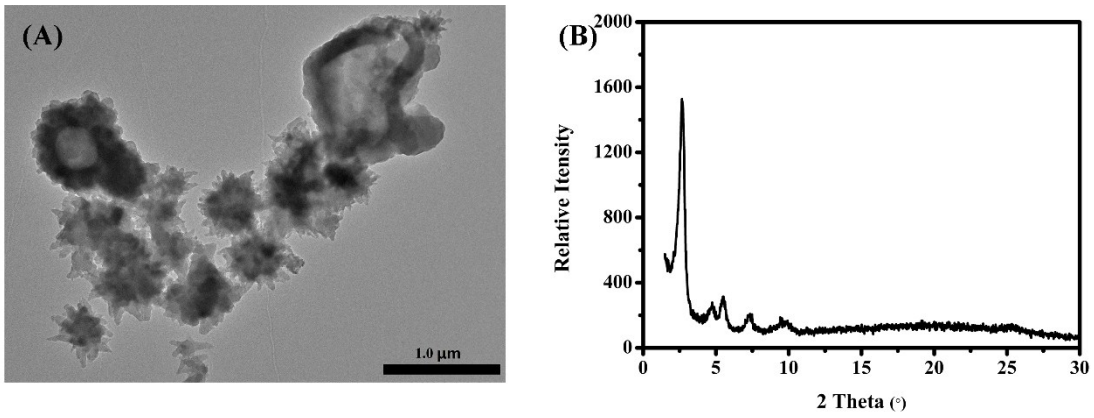

Figure S10 (A) TEM image of bulk COF-V and (B) XRD pattern of bulk COF-V.

The TEM of Figure S10A showed the non-spherical morphology of bulk COF-V, in addition, the particle size was not uniform and was easy to aggregate. The XRD pattern was used to investigate crystal of bulk COF-V in Figure S10B, which demonstrating the successful synthesis of COF-V. However, compared to the spherical COF-V, the crystal form of bulk COF-V was far less than that of the spherical COF-V.