Electronic Supplementary Information

Bimetallic ZIF-derived conductive network of Co-Zn@NPC@MWCNT nanocomposites for efficient electromagnetic wave absorption in the whole X-band

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1. Experimental section

1.1. Materials

Methanol (CH_3OH, 99%), ethanol (C_2H_6O, 99%), cobalt nitrate hexahydrate and ($Co(NO_3)_2 \cdot 6H_2O$, 99%) and Zinc nitrate hex hydrate ($Zn(NO_3)_2 \cdot 6H_2O$, 99%) were purchased from Sinopharm Chemical Reagent Co., Ltd. Polyvinylpyrrolidone K30 (PVP) and 2-methylimidazole (2-MeIm, 98%) were procured from Shanghai Aladdin Bio-Chem Technology Co., Ltd. MWCNTs was obtained from Nanjing XFNANO Materials Technology Co., Ltd.

1.2. Synthesis of Co-Zn-ZIFs@MWCNTs

Firstly, 250mg, 300mg and 350mg MWCNTs were separately dissolved with 250 ml methanol, then added 1g, 1.5 g and 2 g PVP into the above solutions. After ultrasonic treated for 4 hours, solution A, solution B and solution C were formed. Secondly, three copies of 5.821g cobalt nitrate hexahydrate and 2.975g zinc nitrate hexahydrate in 100 mL methanol were added into the above solutions, respectively, and stirred magnetically at room temperature for 6 hours. Thirdly, three parts of 9.852 g 2-MeIm with 150 ml methanol were rapidly poured into the above mixed solutions and stirred for 24 hours. Lastly, the black compounds were gathered by centrifugation, washed several times with ethanol, then under a vacuum dried at 70 °C for 24 hours. The attained resultants were all Co-Zn-ZIFs@MWCNTs, named as samples S1, S2 and S3, separately.

1.3. Synthesis of Co-Zn@NPC@MWCNTs

The above samples were calcined at 600 °C, 700 °C, 800 °C and 900 °C. Argon acted as a protective gas in the process of calcination. The annealing time lasted 5 hours and the heating rate was 3 °C/min. The black products were called samples S600-*x*, S700-*x*, S800-*x* and S900-*x* (*x*=1,2,3), respectively.

1.4 Characterization

X-ray diffraction (XRD) patterns were examined using X-ray diffractometer (DX-2700) equipped with Cu Kα radiation (λ=1.5406 Å). Raman spectra were carried out inVia-Reflex MicroRaman Sepctrometer. X-ray photoelectron spectroscopy (XPS) was recorded on a Scaning X-ray Microprobe (ESCSLAB 250Xi). Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) images were obtained using a Field Emission Scanning Electron microscope (Regulus) and JEM 2100 microscope with an accelerating voltage of 100 kV, respectively. The N_2 sorption isotherm is measured to evaluate the specific surface area (ASAP 2460).

The electromagnetic parameters of samples were measured using a vector network analyzer (VNA, AV3629D) in the frequency range of 2-18 GHz with coaxial method. The measured samples were prepared by uniformly mixing 15 wt % of the sample with a paraffin matrix. The mixture was then pressed into a toroidal shaped sample with an outer diameter of 7.00 mm and inner diameter of 3.04 mm.

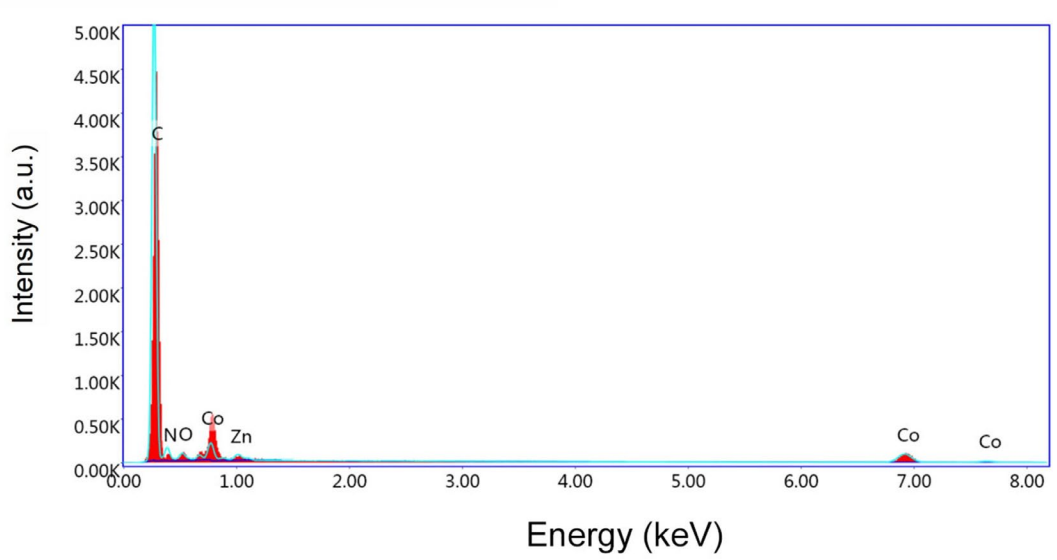

Fig. S1. Energy disperse spectrum of Co-Zn@NPC@MWCNTs for the sample S800-3.

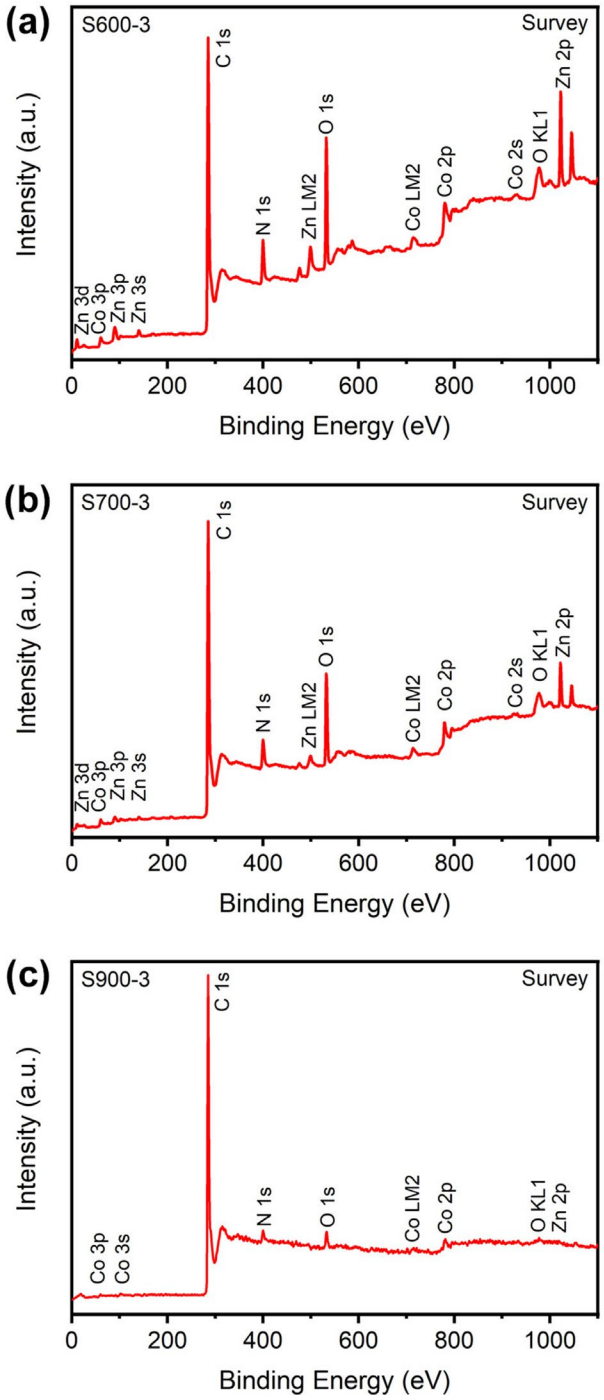

Fig. S2. Survey spectra of Samples S600-3 (a), S700-3 (b) and S900-3 (c).

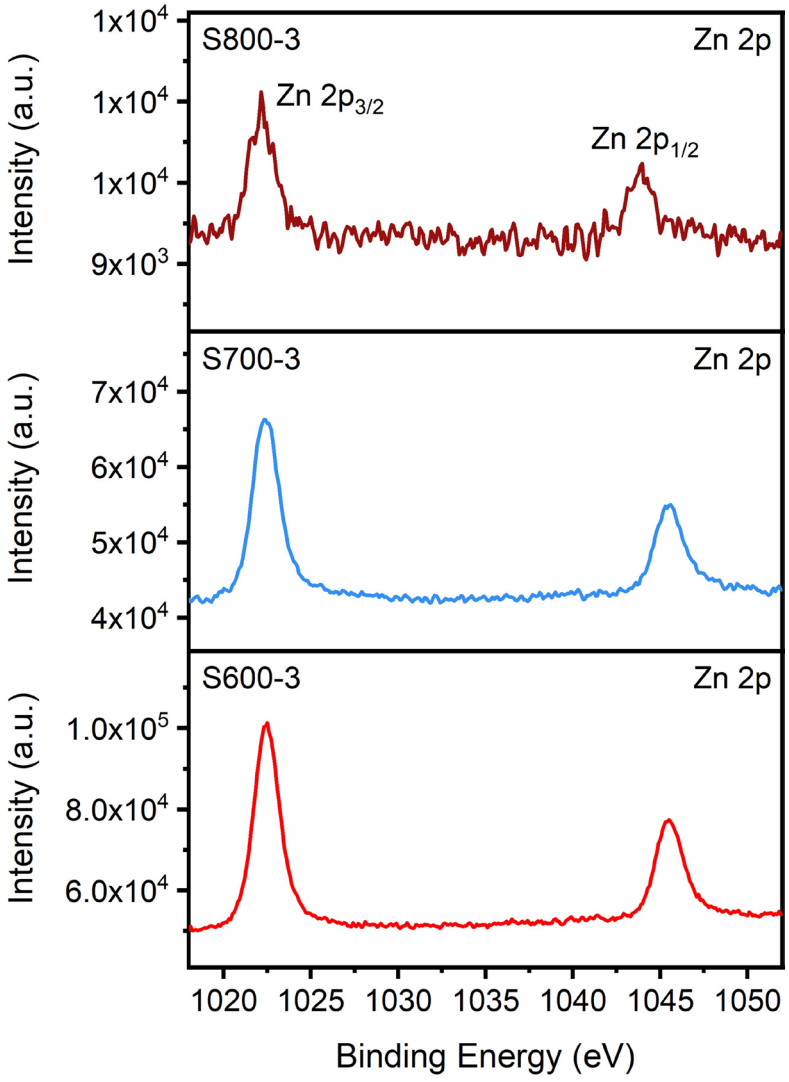

Fig. S3. Zn 2p spectra of samples S600-3, S700-3 and S800-3.

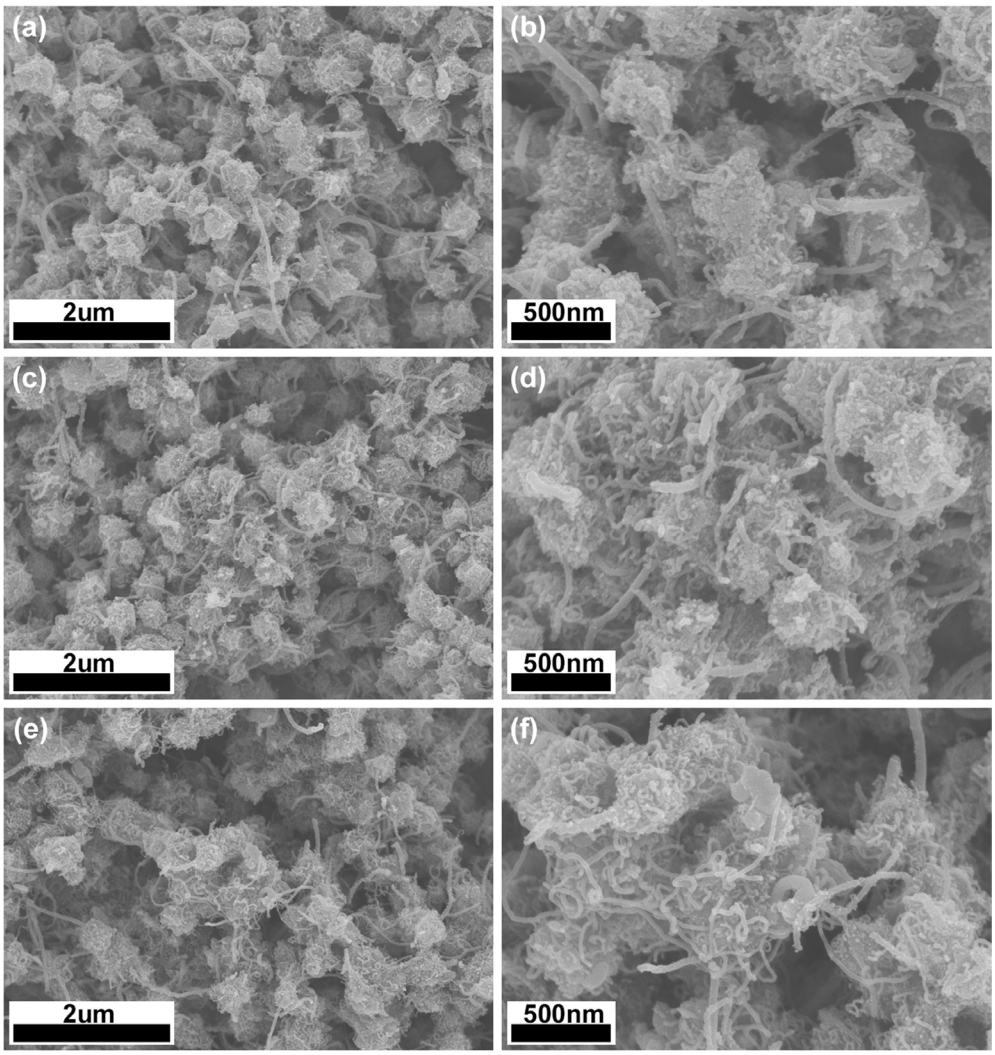

Fig. S4. SEM images of S600-3 (a) and (b), S700-3 (c) and (d), S900-3 (e) and (f).

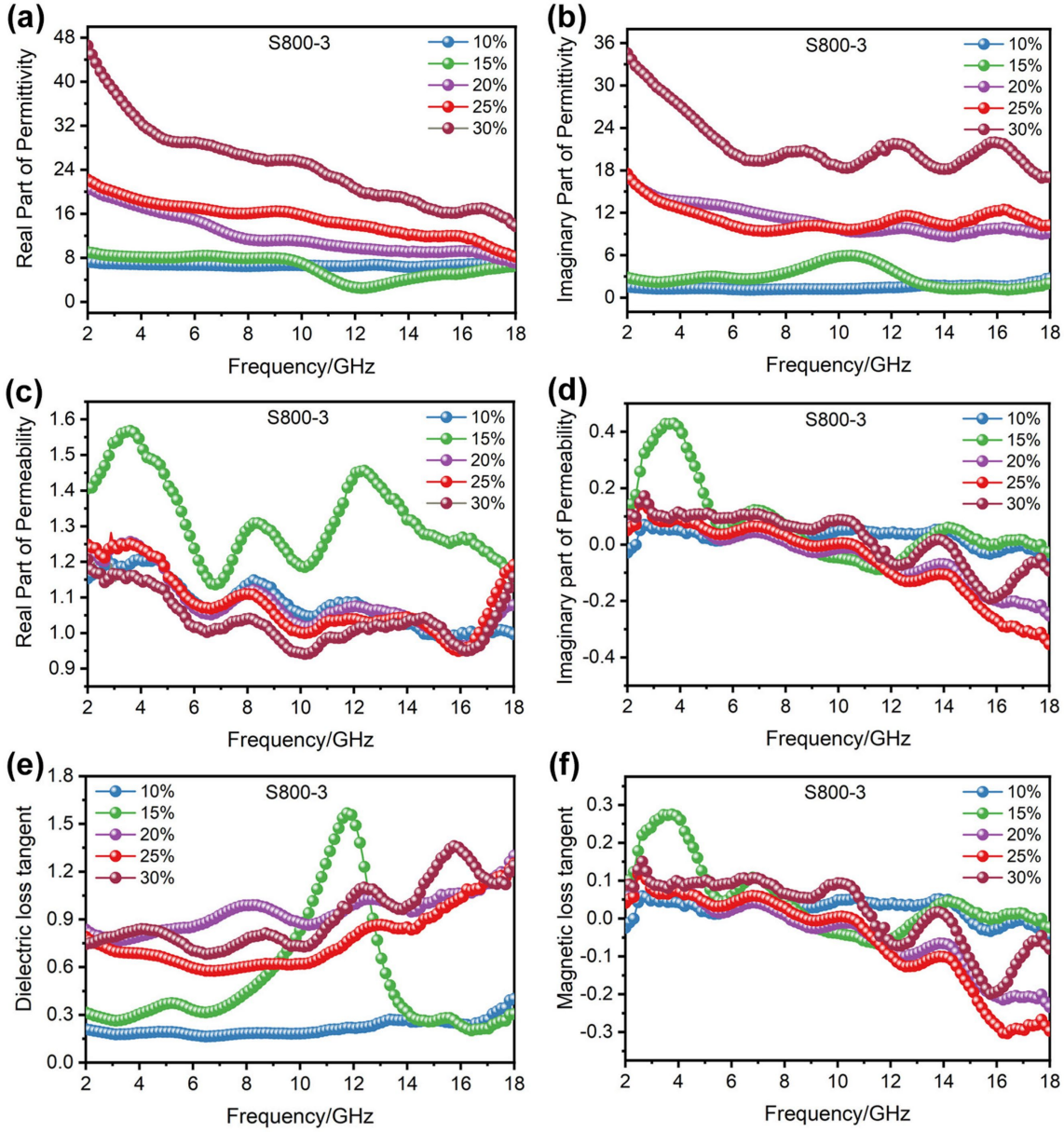

Fig. S5. Frequency dependences of electromagnetic parameters of samples S800-3 with different filling loader 10%, 15%, 20%, 25% and 30%. (a) the real part ε' and (b) imaginary part ε'' of complex permittivity, (c) the real part μ' and μ'' of complex permeability, (e) the dieletric loss tanget and (f) the magnetic loss tanget.