

## ESI

# Chiral Induced Synthesis of Helical Polypyrrole (PPy) Nano-Structures: A Lightweight and High-Performance Material against Electromagnetic Pollution

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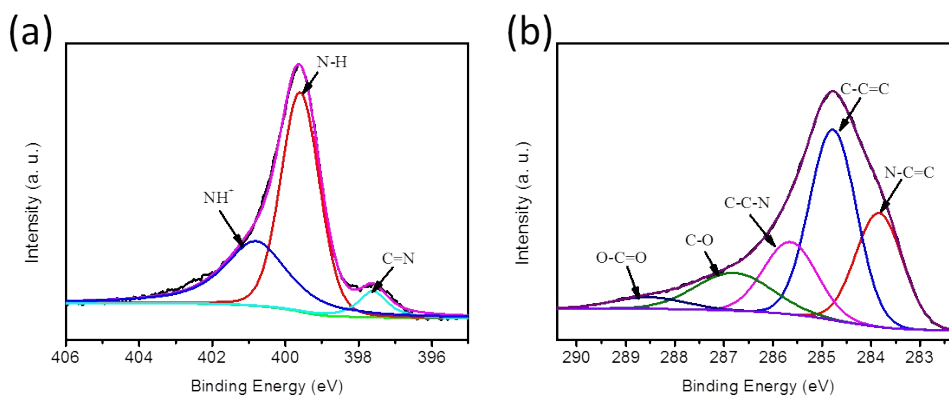
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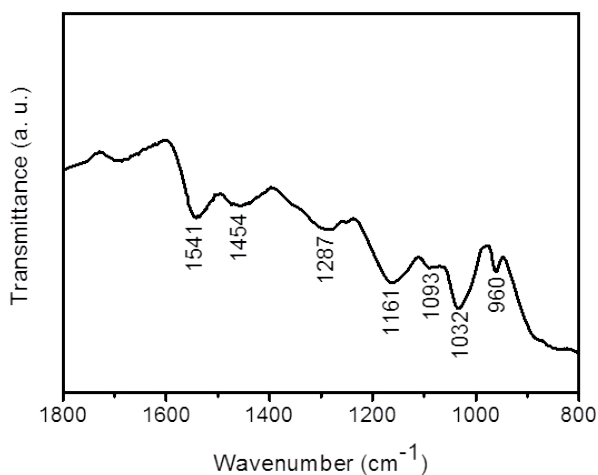
Figure S1 shows the X-ray photoelectron spectroscopy (XPS) of LHC-PPy nano-fiber. The N 1s peaks were reasonably decomposed into three Gaussian peaks with 400.86, 399.61 and 397.61 eV, respectively, which was corresponded to positively charged nitrogen atoms (NH<sup>+</sup>), secondary amine-like structure (NH), and imine-like structure (C=N) of pyrrole ring (Figure S1a).<sup>1</sup> The C 1s peaks can be resolved into five rational Gaussian peaks at 283.86, 284.81, 285.66, 286.81 and 288.56 eV, which can be

assigned to the structures of N-C=C, C-C=C, C-C-N, C-O, and O-C=O, indicating the existence of carbonyl defects in PPy (Figure S1b).<sup>2-4</sup>



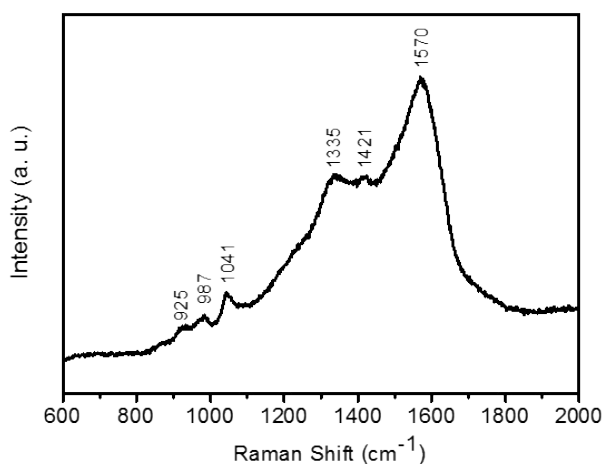
**Figure S1.** XPS core level spectra of N 1s (a) and C 1s (b) of LHC-PPy.

The structure of the LHC-PPy was characterized by Fourier-transform Infrared (FT-IR) detections (Figure S2). The peaks at  $1541\text{ cm}^{-1}$  is corresponded to the pyrrole ring vibration. The bands at  $1454\text{ cm}^{-1}$  is assigned to the =CH in-plane vibration of the pyrrole ring and the peaks at  $1032\text{ cm}^{-1}$  and  $960\text{ cm}^{-1}$  are owing to the =CH out-of-plane vibration. The bands at  $1287\text{ cm}^{-1}$  and  $1161\text{ cm}^{-1}$  corresponds to the stretching vibration of C-N bonds and the C-C stretching, respectively. The band at  $1093\text{ cm}^{-1}$  is related to in-plane deformation of C-H and N-H bonds of pyrrole ring. It is confirmed that the chemical structure of LHC-PPy is consistent with the PPy particles or PPy aerogel.<sup>5</sup>



**Figure S2.** FT-IR spectrum of LHC-PPy.

In Figure S3, the Raman spectra of LHC-PPy shows the bands at 925 and 1041 cm<sup>-1</sup> were due to the symmetrical C-H out of plane and in-plane bending, respectively.<sup>5</sup> The peak at 987 cm<sup>-1</sup> was associated with the ring deformation of pyrrole. The C-N stretching aroused the Raman bands at 1335 and 1421 cm<sup>-1</sup>. The C=C stretching shows a strong band at 1570 cm<sup>-1</sup>.



**Figure S3.** Raman spectrum of LHC-PPy.

**Scheme S1** gives the illustration of the mechanisms of EMA and EMI shielding.

***The principle for EMA characterization.*** The test process of EMA can be concluded as:

(1) The electromagnetic waves were generated from an emitter. (2) Due to mismatch between the absorber and free space, some electromagnetic waves were reflected and others entered into the absorber vertically. (3) When the electromagnetic waves transmitted in the absorber, some of them were attenuated and transformed to internal energy. (4 and 5) The rest of electromagnetic waves were reflected on the surface of metal backplane, and complicated synergetic enhancement and decrease would be aroused in the reflected electromagnetic waves, due to the resonance at  $1/4$  wavelength. (6 and 7) Before the reflected electromagnetic waves came back to the free space, partial electromagnetic energy was absorbed in the absorber again.

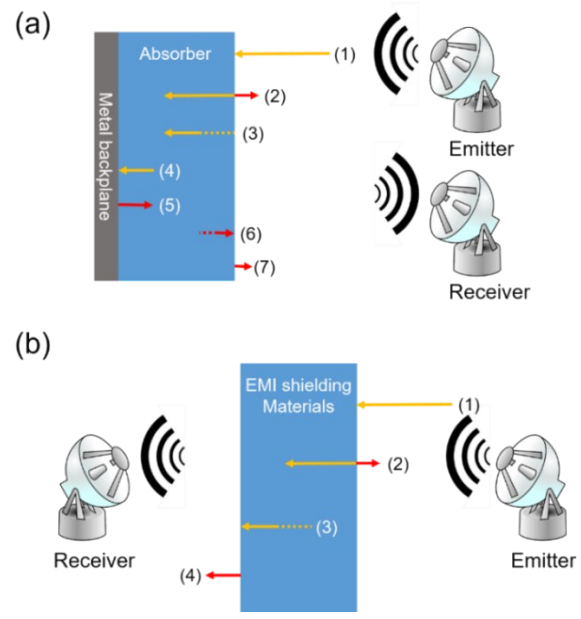
***The principle for EMI shielding characterization.*** The test process of EMI shielding can be concluded as:

(1 and 2) The first two steps are the same as EMA. (3 and 4) When the electromagnetic waves transmitted in the absorber, some of them were attenuated and transformed to internal energy. The others came through the shielding material.

EMA is essentially different from EMI shielding. EMA measures the

difference of energy between the incident and reflected electromagnetic wave while EMI shielding characterizes the difference of energy between the incident and transmitted electromagnetic radiation.

**Scheme S1.** Illustration of the principle for EMA (a) and EMI shielding (b) characterization.



**Table S1. EMA Performance of Typical Materials Reported in This work and Recent Literatures.** (RGO: reduced graphene oxide; PEDOT: poly(3,4-ethylenedioxythiophene); CNCs: Carbon nanocoil; PVDF: polyvinylidene fluoride; PANi: polyaniline; SCI: spherical carbonyl iron; PDA: polydopamine)

Filler	Matrix	Loading ratio (wt. %)	Efficient EMA bandwidth (GHz)	Thickness (mm)	Ref.
DHC-PPy nano-fibers	Wax	7	7.04	2.4	This work
LHC-PPy nano-fibers	Wax	4	6.12	2.4	This work
3D-PPy aerogel	Wax	7	6.20	3	5
3D-PPy/RGO aerogel	Wax	10	6.76	3	6
3D-PPy/PEDOT aerogel	Wax	10	6.28	2.5	7
PANi/Fe <sub>3</sub> O <sub>4</sub> /CNTs	Wax	16	7.00	4	8
Ni/Al <sub>2</sub> O <sub>3</sub> /CNCs	Wax	25	3.60	1.5	9
Porous carbon	Wax	5	4.50	2	10

Fe <sub>3</sub> O <sub>4</sub> /graphene	Wax	10	4.50	1.5	11
Rugby-shaped CoFe <sub>2</sub> O <sub>4</sub>	Wax	50	2.60	2.5	12
Porous Co/C	Wax	40	5.80	2.5	13
SnO <sub>2</sub> foams	Wax	30	5.60	2.0	14
CuS hollow microspheres	Wax	30	3.60	1.8	15
CuS/RGO	Wax	20	4.50	2.5	16
Hollow Fe <sub>3</sub> O <sub>4</sub> -Fe/RGO	Wax	18	6.20	2.0	17
MoS <sub>2</sub> /RGO	Wax	10	5.72	2.0	18
γ-Fe <sub>2</sub> O <sub>3</sub> /RGO	Wax	45	3.00	2.5	19
PEDOT/RGO/Co <sub>3</sub> O <sub>4</sub>	Wax	50	3.10	2.0	20
RGO@hematite	PVDF	5	5.76	2.0	21
RGO/PANi	Wax	10	5.30	3.5	22
RGO/ZnO hollow spheres	Wax	50	3.30	2.2	23

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CNTs/RGO	Wax	5	3.50	2.75	24
RGO/MnFe <sub>2</sub> O <sub>4</sub>	Wax	5	4.88	3.0	25
RGO-SCI	Wax	60	4.19	3.0	26
RGO/CNTs	Wax	5	3.30	3.0	27
ZnO@Ni	Wax	60	5.30	1.5	28
RGO/Fe <sub>3</sub> O <sub>4</sub>	Wax	10	5.80	3.0	29
RGO/ $\alpha$ -Fe <sub>2</sub> O <sub>3</sub>	Wax	8	6.40	3.0	30
RGO/ZnO	Wax	10	6.40	2.5	31
PPy@PANi	Wax	50	4.70	2.0	32
Ni/SnO <sub>2</sub>	Wax	50	3.80	1.8	33
Hollow PDA@ $\alpha$ -MnO <sub>2</sub>	Epoxy	17	3.30	3.0	34
MoS <sub>2</sub> nano-sheets	Wax	60	4.10	2.4	35
ZnO/ZnAl <sub>2</sub> O <sub>4</sub>	Wax	40	4.20	2.86	36

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CoO nano-flowers	Epoxy	17	6.00	2.0	37
CF@G@PPy	Wax	20	4.10	2.5	38
Hollow carbon nanosphere	Wax	20	4.8	1.9	39
RGO/ZnO	Wax	20	6.7	2.4	40

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**Table S2. EMI SE of composites loaded with LHC and DHC -PPy nano-fibers.**

Fillers	Matrix	Loading ratio (wt. %)	Test frequency range (GHz)	Best EMI SE (dB)	Thickness (mm)
LHC-PPy nano-fibers	Wax	16	2-18	21.82	1
				30.66	2
				43.12	3
				54.72	4
				66.42	5
				78.15	6
DHC-PPy nano-fibers	Wax	16	2-18	17.87	1
				23.18	2
				31.91	3
				40.62	4
				48.64	5
				57.19	6

**Table S3. EMI SE of Typical Materials Reported in Recent Literatures.** (PMMA: polymethylmethacrylate; WPU: water-borne polyurethane; PEI: polyetherimide; PVDF: poly(vinylidene fluoride); PLLA: poly (*L*-lactic acid))

Fillers	Matrix	Loading ratio	Test frequency range (GHz)	Best EMI SE (dB)	Thickness (mm)	Ref.
Porous carbon	Wax	20 wt. %	2-18	50	2.0	10
RGO	PMMA	1.8 vol. %	8-12	<20	4.0	41
RGO	PMMA	4.2 vol. %	8-12	30	3.4	42
RGO	WPU	7.7 wt. %	8.2-12.4	32	2.0	43
RGO	PEI	10 wt. %	8-12	<25	2.3	44
RGO@Fe <sub>3</sub> O <sub>4</sub>	PEI	10 wt. %	8-12	<20	2.5	45
RGO/carbonyl iron	Epoxy	5 wt. %	8-12	<35	2.5	46
CNTs sponge	Epoxy	2 wt. %	8-12	40	2.0	47
RGO	BaTiO <sub>3</sub>	4 wt. %	8.2-12.4	40	1.5	48

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CNTs	PVDF	15 wt. %	8-12	57	2.0	49
CNTs	WPU	76 wt. %	8.2-12.4	80	0.8	50
RGO-foam	-	100 wt. %	8-12	25.2	0.3	51
CNTs	PLLA	10 wt. %	8.2-12.4	23	2.5	52
RGO	PU sponge	10 wt. %	8-12	57.7	60	53

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