Supplementary information

Lightweight polyimide-derived carbon foams with anisotropic porous structure prepared by microwave-assisted foaming and carbonization for thermal insulation and EMI shielding applications

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Table S1. The peak aeras of both D-band and G-band, and the intensity ratio of D-band to G-band, i.e., I_D/I_G, of PICFs.

Samples	Peak area of D-band	Peak area of G-band	Peak area ratio of D-band to G-band (I_D/I_G)
$PICF_{800}$	12309.26	5657.18	3.35
$PICF_{1000}$	29976.38	8939.80	2.72
$PICF_{1200}$	43901.88	16158.61	2.38
$PICF_{1400}$	67247.52	28247.00	1.99

The deconvolution of Raman spectral peaks of PICFs was performed using the Fourier deconvolution method, which was briefly given below: collecting data→ determination of instrument response function→ Fourier transformation→ the deconvolution of frequency domain→ inverse Fourier transformation. As tabulated in Table S1, the peak areas of the D-band and G-band were obtained by split-peak fitting of D-band and G-band using Origin software, and the peak area ratio between D-band and G-band (I_D/I_G) was used to characterize the degree of graphitization in carbon-based materials.

Table S2. The physical properties of PIF and PICFs.

Samples	Density (kg/m^3)	Volumetric shrinkage (%)	Weight loss (%)	Compressive strength (kPa)	
				Vertical	Horizontal
PIF	22.23	-	-	58.29	37.15
$PICF_{800}$	25.63	44.87	36.33	47.78	77.52
$PICF_{1000}$	25.02	47.50	41.34	55.10	88.14
$PICF_{1200}$	24.38	49.05	42.54	75.22	81.49
$PICF_{1400}$	22.90	50.24	48.17	102.96	80.34

Table S3. A comparison of density and thermal conductivity of PICFs with other porous carbon materials reported in literature.

Samples	Density（kg/ m^3）	Thermal conductivity [(W/(m·K)]	Refs
Melamine carbon foam	5.4	0.035	[1]
Graphene carbon aerogel	23.5	0.027	[2]
PI carbon foam	**25.6**	**0.0356**	**This work**
TiC-CNT/cellulose carbon aerogel	34.5	0.111	[3]
Cellulose carbon aerogel	43.8	0.043	[3]
rGO/sugarcane carbon foam	47	0.115	[4]
Cotton/sucrose carbon foam	60	0.069	[5]
PI/graphene carbon aerogel	74	0.038	[6]
Sucrose bio-carbon foam	89	0.092	[7]
PI carbon aerogel	112	0.055	[8]
Wood carbon composite	113	0.089	[9]
PDMS/PIF/Fe/CNT carbon foam	150	0.058	[10]

Table S4. A comparison of density, thickness and EMI shielding performances of PICFs with other porous (carbon) materials reported in literature.

Samples	Density（kg/m^3）	Thickness (mm)	EMI SE (dB)	EMI SSE [dB/(g/cm^2)]	Refs
CNT/graphene/PI foam	20	2	28.2	7050	[11]
PI/CNT composite foam	20.7	5	20.3	1962	[12]
PI/graphene carbon foam	22	2	63.5	14430	[13]
PI carbon foam	**22.9**	**1.9**	**53.2**	**12216**	**This work**
PI/Fe/CNT carbon foam	28.33	2	37.2	6565.5	[10]
PI carbon foam	29	1.7	22.6	4582	[14]
CNT/PI foam	32.1	2	41.1	6422	[15]
TiC-CNT/cellulose carbon aerogel	34.5	2	89.7	13000	[3]
PI carbon aerogel	34.7	1	51	14697	[16]
Cellulose carbon aerogel	43.8	2	50	5708	[3]
rGO/sugarcane carbon foam	47	2.9	53	3830	[4]
PI/graphene aerogel	74	1.9	54.6	3883	[6]
MXene@ANFs/PI hybrid foam	74.3	4	48.9	1645	[17]
PI/graphene composite aerogel	76	2.5	28.8	1518	[18]
PI carbon foam	91	2	54	2967	[19]

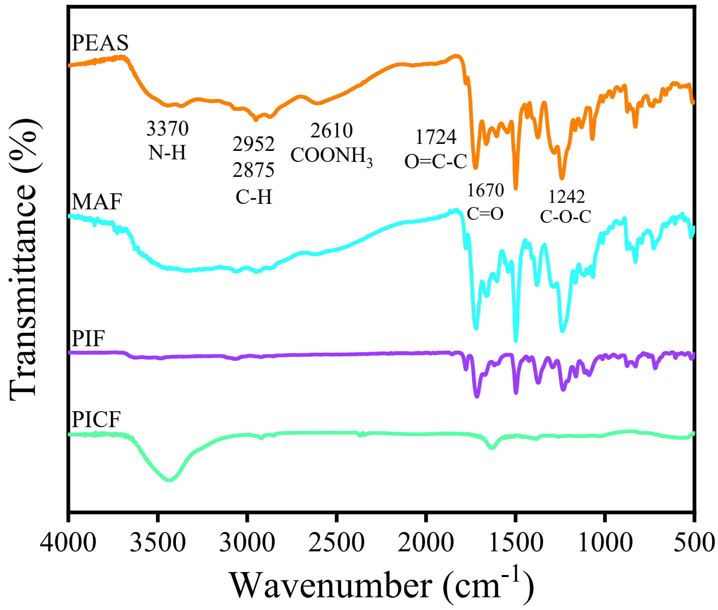

Fig. S1. FTIR spectra of PEAS, MAF, PIF and PICF.

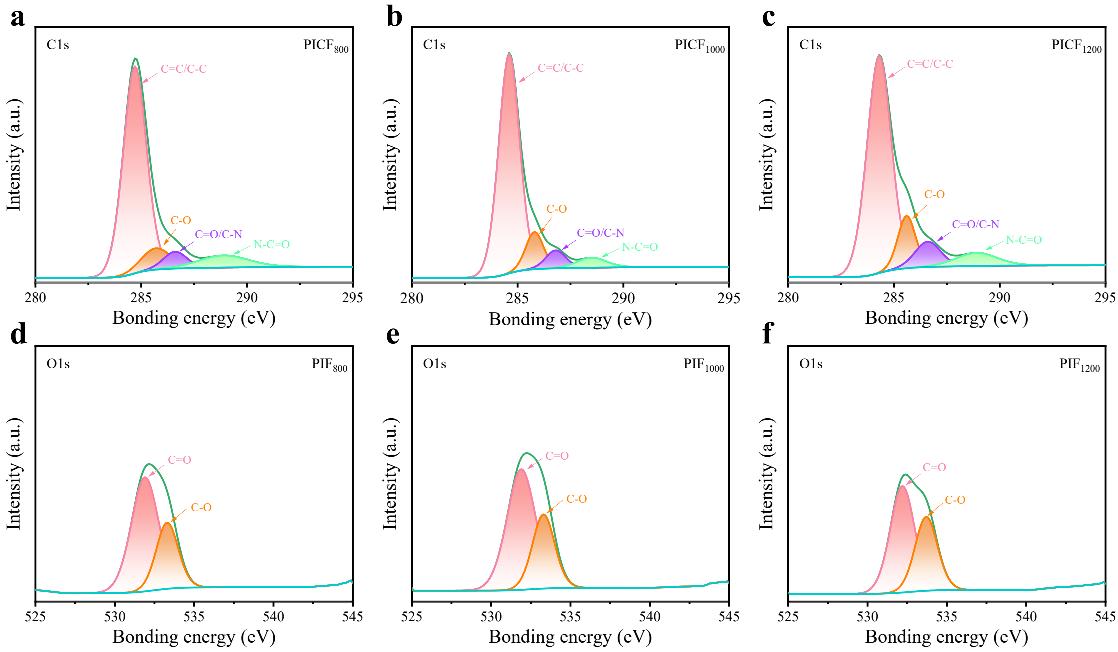

Fig. S2. (a-c) C1s and (d-f) O1s high-resolution spectra of PIF_{800}, $PICF_{1000}$ and $PICF_{1200}$.

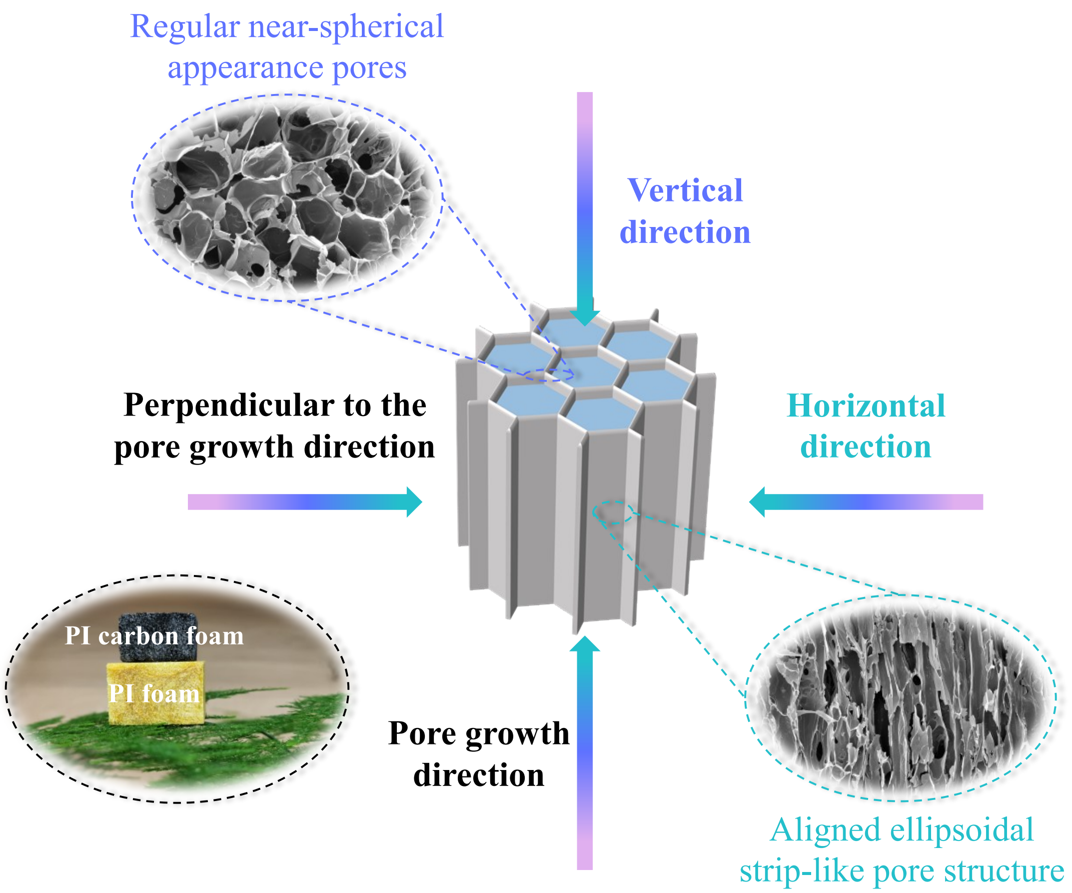

Fig. S3. Illustration of the measurement directions for SEM observation, mechanical properties, thermal insulation, volume resistance and EMI shielding performance as well as the lightweightness of PIF and PICF.

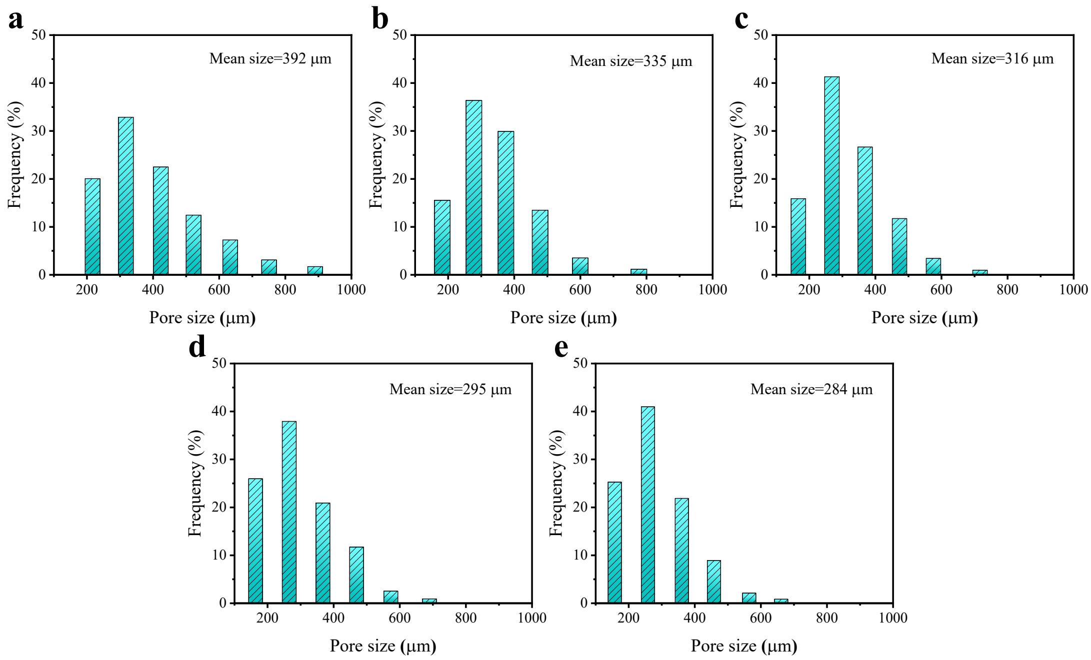

Fig. S4. Statistical distribution of pore size: (a) PIF, (b) $PICF_{800}$, (c) $PICF_{1000}$, (d) $PICF_{1200}$, (e) $PICF_{1400}$.

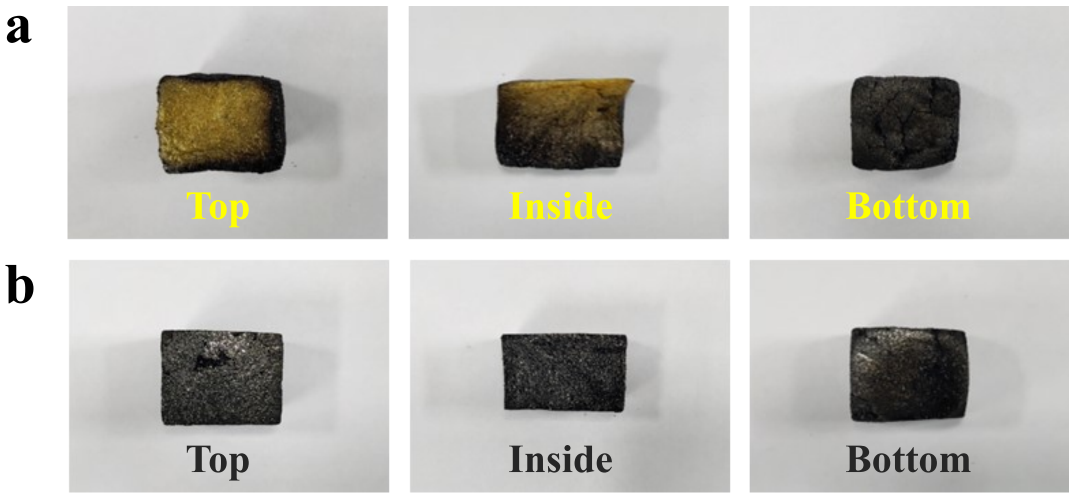

Fig. S5. The optical images of sample blocks after the direct burning test using an alcohol lamp: (a) PIF, (b) $PICF_{800}$.

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