

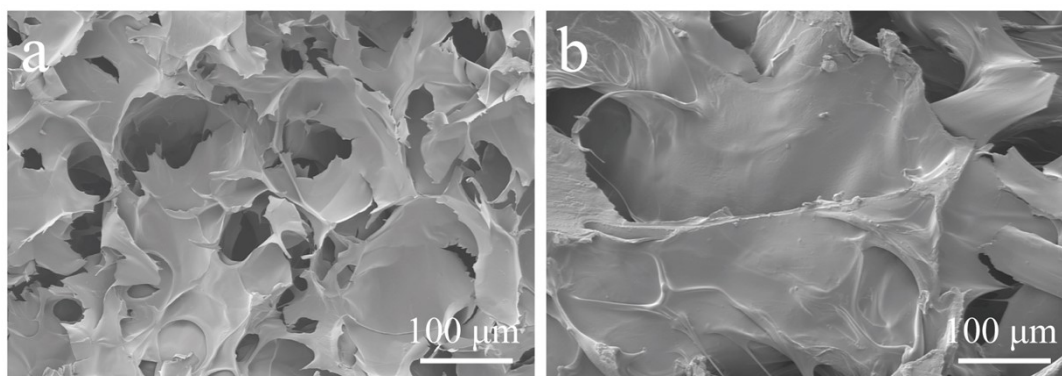
## Supplementary Information

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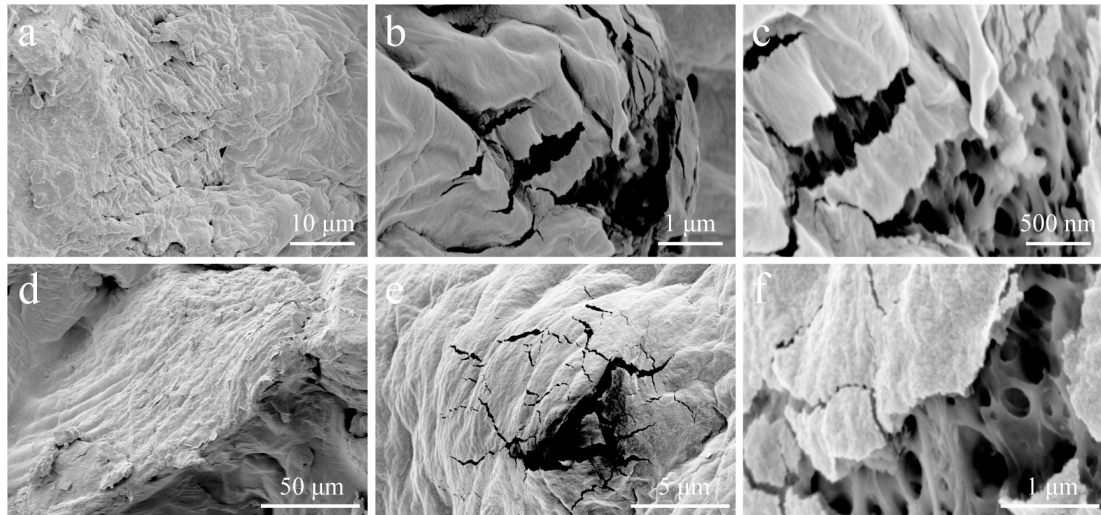
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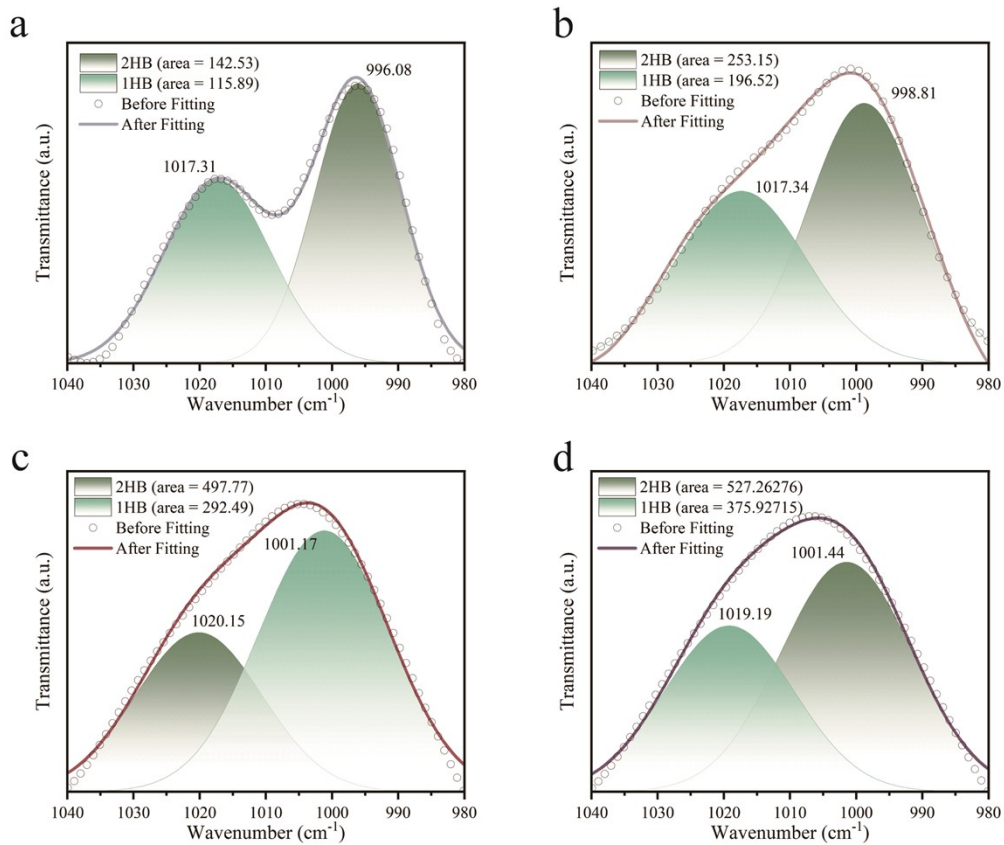
\*Corresponding author.



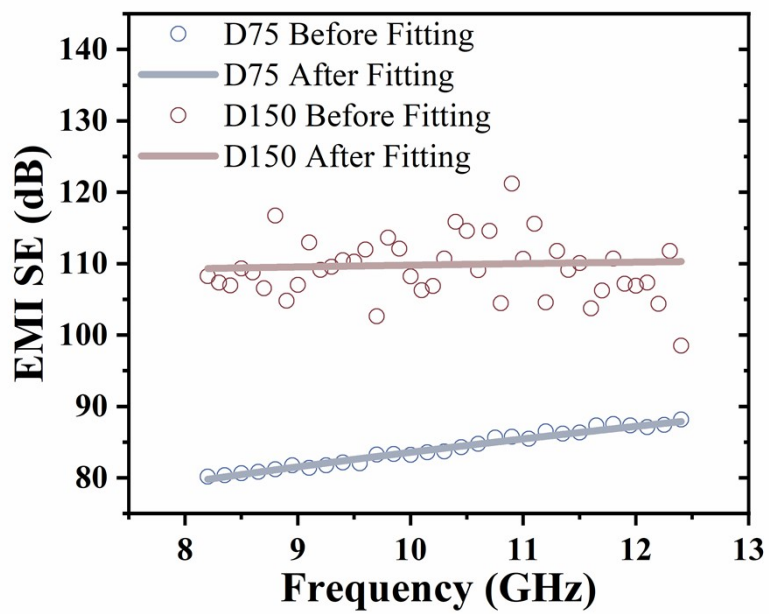
**Fig. S1.** SEM images of internal structure of (a) D0 and (b) D75.



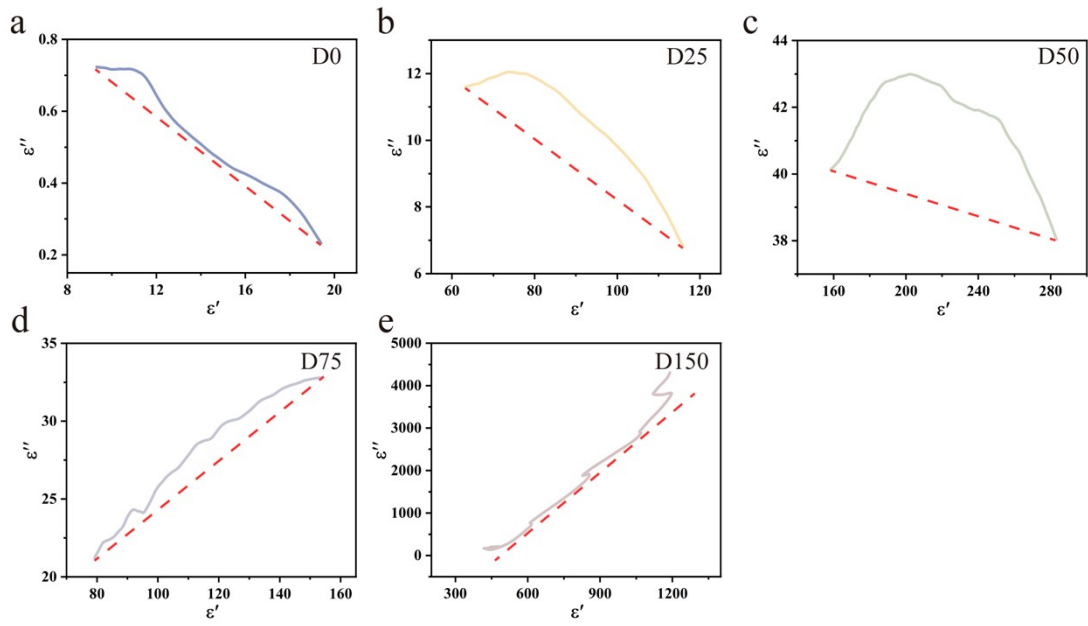
**Fig. S2.** Detailed appearance of electron beams at 15 kV smashing the external membrane of PPK sponges' structure units, (a), (b), (c) for first spot, and (d), (e), (f) for second spot.



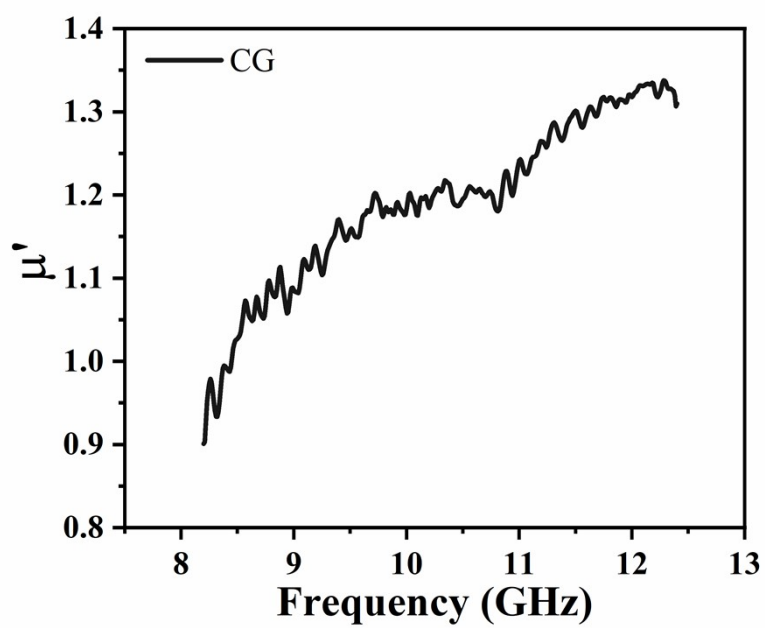
**Fig. S3.** Curve-fitting results of FTIR spectra in the range of 1040~980  $\text{cm}^{-1}$  of (a)D75, (b)D150, (c)D300, (d)D500.



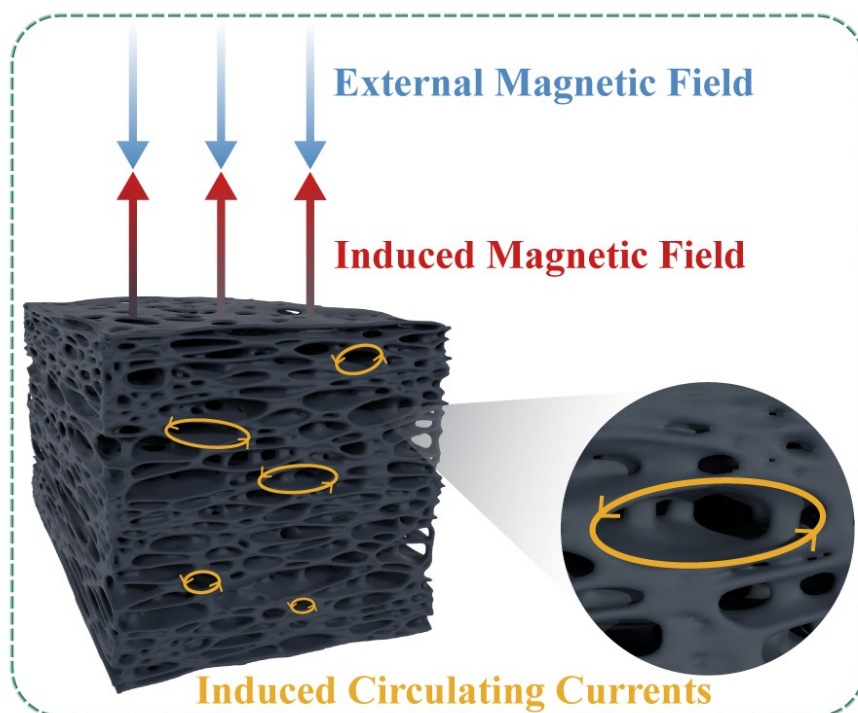
**Fig. S4.** Fitting of EMI SE of D75 and D150.



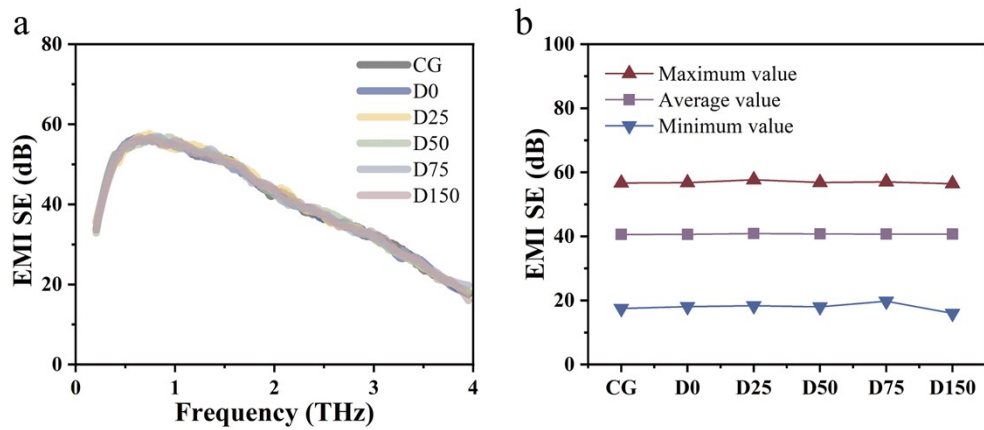
**Fig. S5.** Cole-Cole curves of the PPK sponges.



**Fig. S6.** The real part of permeability of CG in GHz band.



**Fig. S7.** Induced circulating currents in PPK sponges.



**Fig. S8.** EMI SE of CG and PPK sponges in THz band.



**Table S1.** EMI SE values of PPK sponges and control group.

<b>Sample</b>	<b>Thickness (mm)</b>	<b>Apparent density (g/cm<sup>3</sup>)</b>	<b>Electrical conductivity (S/cm)</b>	<b>SE<sub>total</sub> (dB)</b>	<b>SSE<sub>total</sub> (dB·cm<sup>3</sup>/g)</b>
<b>CG</b>	<b>0.132</b>	<b>1.591</b>	<b>15.038</b>	<b>46.505</b>	<b>29.232</b>
<b>D0</b>	<b>5.809</b>	<b>0.067</b>	<b>0.241</b>	<b>55.116</b>	<b>819.916</b>
<b>D25</b>	<b>4.787</b>	<b>0.126</b>	<b>0.302</b>	<b>58.744</b>	<b>465.009</b>
<b>D50</b>	<b>3.559</b>	<b>0.161</b>	<b>0.432</b>	<b>64.958</b>	<b>403.401</b>
<b>D75</b>	<b>2.744</b>	<b>0.327</b>	<b>1.161</b>	<b>84.047</b>	<b>256.722</b>
<b>D150</b>	<b>1.635</b>	<b>1.040</b>	<b>3.831</b>	<b>109.841</b>	<b>105.597</b>

**Table S2.** Direct comparison of THz EMI shielding performance of PPK sponges in this work with reported materials.

<b>Ref.</b>	<b>Form</b>	<b>Shielding filler</b>	<b>Qualified band (THz)</b>	<b>Qualified bandidth</b>	<b>Max EMI SE (dB)</b>
<b>1</b>	<b>Film</b>	<b>MXene</b>	<b>0.2~1.6</b>	<b>37.93%</b>	<b>64.9</b>
<b>2</b>	<b>Film</b>	<b>MXene</b>	<b>0.2~1.6</b>	<b>37.93%</b>	<b>52.7</b>
<b>3</b>	<b>Film</b>	<b>Fe<sub>3</sub>O<sub>4</sub>/CNF</b>	<b>0.2~1.2</b>	<b>27.09%</b>	<b>60.0</b>
<b>4</b>	<b>Film</b>	<b>MXene/GO/metalion</b>	<b>0.2~2.0</b>	<b>48.77%</b>	<b>51.0</b>
<b>5</b>	<b>Film</b>	<b>MXene/rGO</b>	<b>0.4~2.0</b>	<b>44.16%</b>	<b>54.2</b>
<b>6</b>	<b>Film</b>	<b>CNF</b>	<b>0.3~1.2</b>	<b>24.38%</b>	<b>44.0</b>
<b>7</b>	<b>Sponge</b>	<b>MXene</b>	<b>0.3~1.7</b>	<b>36.58%</b>	<b>65.0</b>
<b>8</b>	<b>Sponge</b>	<b>GO/CNF</b>	<b>0.3~1.5</b>	<b>32.51%</b>	<b>34.0</b>
<b>9</b>	<b>Sponge</b>	<b>Carbon</b>	<b>0.4~2.0</b>	<b>43.35%</b>	<b>70.0</b>
<b>10</b>	<b>Sponge</b>	<b>GO</b>	<b>0.2~1.2</b>	<b>27.09%</b>	<b>40.7</b>
<b>11</b>	<b>Sponge</b>	<b>MXene</b>	<b>0.5~3.0</b>	<b>67.73%</b>	<b>57.5</b>
<b>12</b>	<b>Sponge</b>	<b>GaN</b>	<b>0.3~1.2</b>	<b>24.38%</b>	<b>44.0</b>
<b>This work</b>	<b>Sponge</b>	<b>PEDOT:PSS</b>	<b>0.2~3.9</b>	<b>100%</b>	<b>57.7</b>

**Table S3.** Composition of PPK sponges and control group.

<b>Composition Sample</b>	<b>PEDOT:PSS (ml)</b>	<b>H<sub>2</sub>O (ml)</b>	<b>DMSO (ml)</b>	<b>KGM (g)</b>
<b>CG</b>	<b>10</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>D0</b>	<b>10</b>	<b>5</b>	<b>0</b>	<b>0.4</b>
<b>D25</b>	<b>10</b>	<b>4.75</b>	<b>0.25</b>	<b>0.4</b>
<b>D50</b>	<b>10</b>	<b>4.5</b>	<b>0.5</b>	<b>0.4</b>
<b>D75</b>	<b>10</b>	<b>4.25</b>	<b>0.75</b>	<b>0.4</b>
<b>D150</b>	<b>10</b>	<b>3.5</b>	<b>1.5</b>	<b>0.4</b>
<b>D300</b>	<b>10</b>	<b>2</b>	<b>3</b>	<b>0.4</b>
<b>D500</b>	<b>10</b>	<b>0</b>	<b>5</b>	<b>0.4</b>

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