Supplementary Data

Electromagnetic shielding performance of polyaniline-nanorod/graphene-nanoflake hybrid films in the S- and X- bands

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Synthesis of PANI-graphene hybrids

Aniline monomer (4.5 mL) and 1M HCl 50 mL) is mixed with chloroform in the ratio 1:2 (v:v). 1M ammonium persulphate (11.2 mL) was added dropwise to this mixture while stirring. It is stirred for 6 hours in an ice bath and the green PANI dispersion is filtered and washed using distilled water and acetone to remove oligomers and excess acid. The sample is then dried at 50 °C in a vacuum oven overnight. The doped, green powder of PANI thus obtained is then finely ground and deprotonated using 1M ammonia solution for the preparation of the hybrid samples.
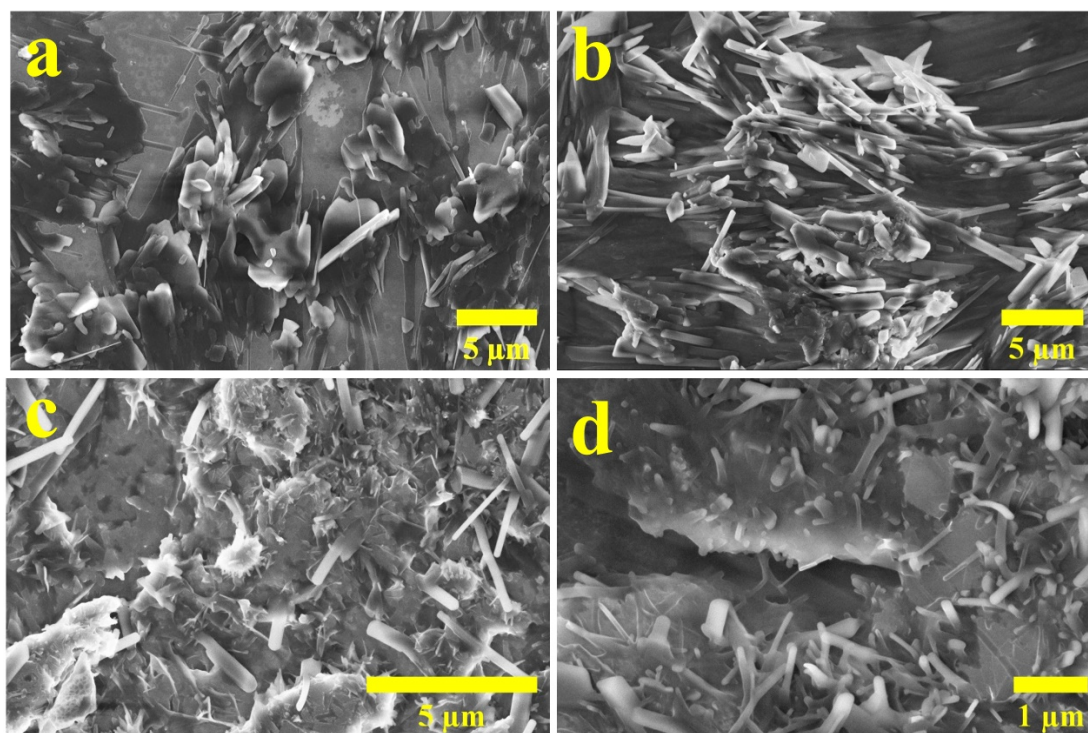
Scanning Electron Microscopy Analysis

Figure S1. SEM micrographs of PANI-nanorod/graphene-nanoflake hybrid films

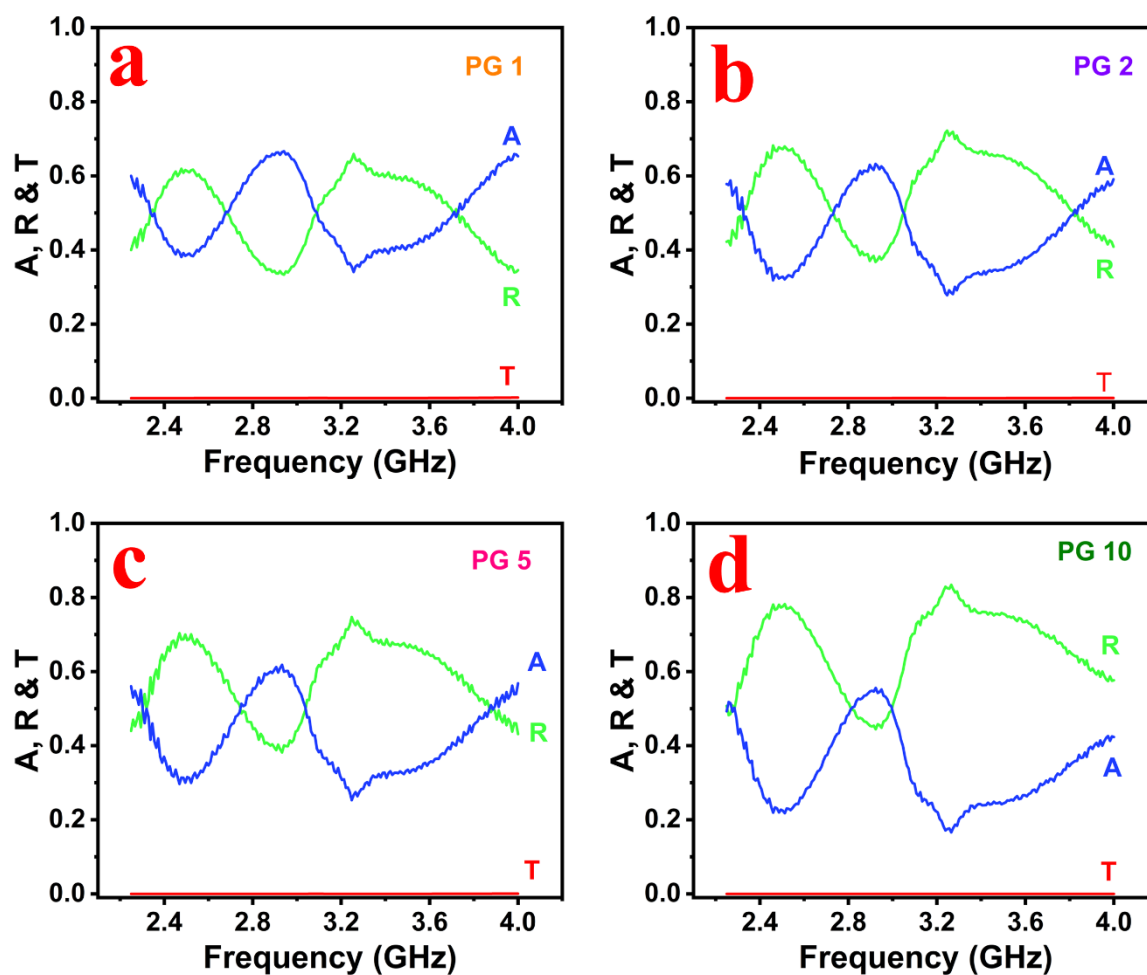**Absorption, Reflection and Transmission Coefficients**

Figure S2. Absorption, reflection and transmission coefficients of the PANI-nanorod/graphene-nanoflake hybrid films in the S-band
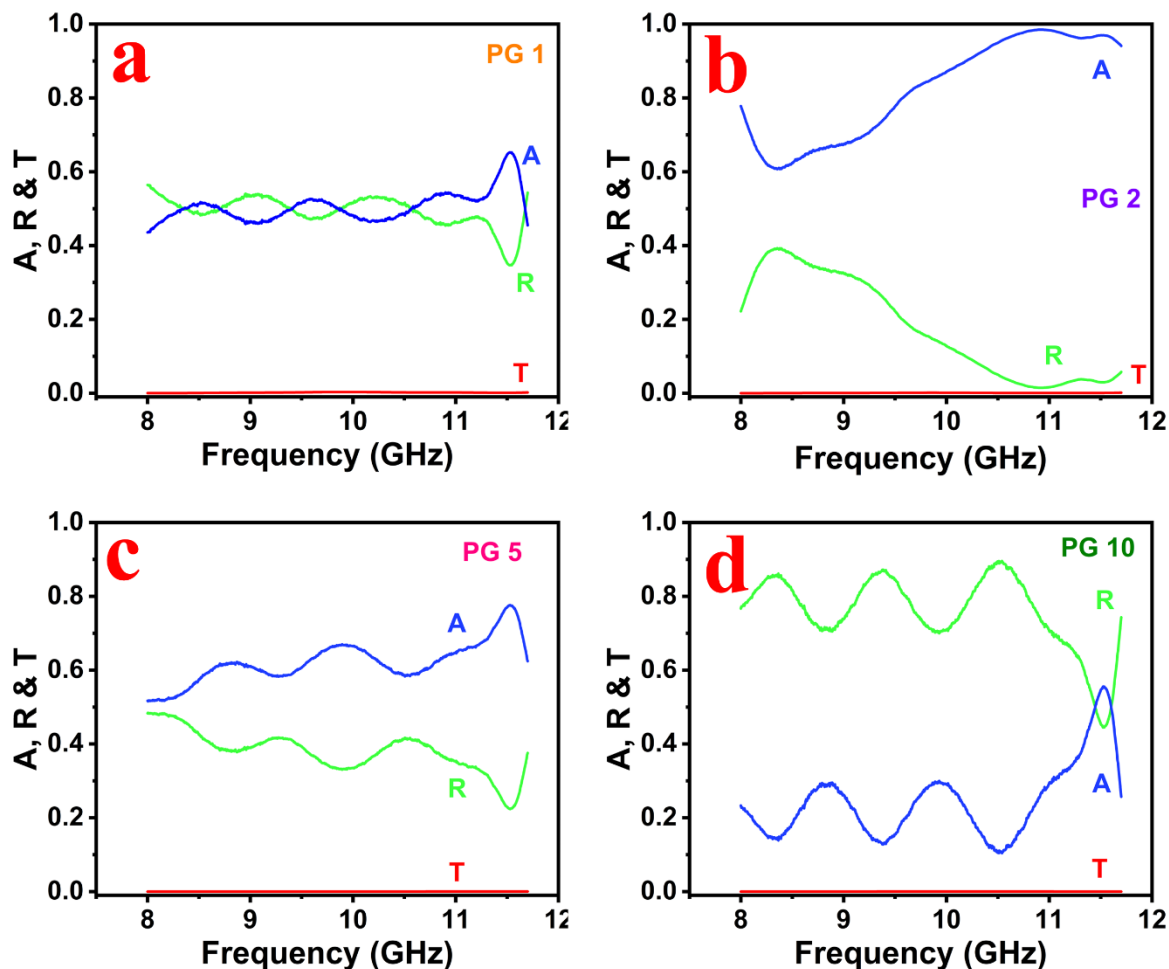
Figure S3. Absorption, reflection and transmission coefficients of the PANI-nanorod/graphene-nanoflake hybrid films in the X-band
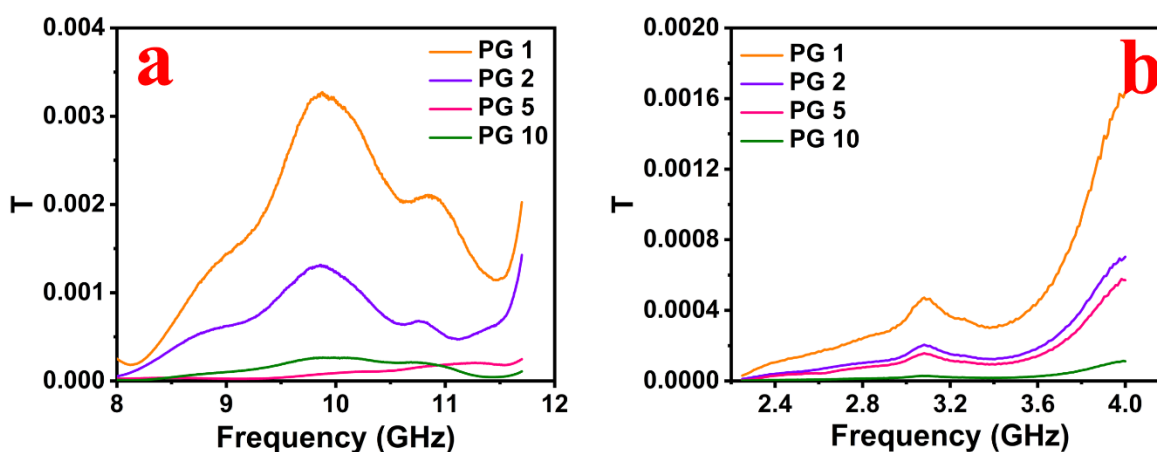

Figure S4. Comparison of transmission coefficients of the PANI-nanorod/graphene-nanoflake hybrid films in the S- and X-bands

Calculation of absolute shielding effectiveness and comparison with other materials

Table S1: Comparison of thickness, density, mass, total shielding effectiveness and Absolute Shielding Effectiveness (A.SE) of ours with different samples reported in the literature

Samples	T (cm)	D (g cm^3)	Mass** (g)	SE$_{Total}$ (dB)	A.SE*** (dB cm^2 g^{-1})	Ref.
Dense Cu foil	0.0032	6.944	0.711	46.3 (1.5 GHz-10 GHz)	2084.38	[1]
TiO$_2$/SiO$_2$@PPy@rGO	0.026	0.089	0.074	<30 (X-band)	~13829	[2]
Nano CuO embedded PANI films (PC 10)	0.00102	3.21	0.105	83 (S-band) 74 (X-band)	25349.70 22600.94	[3]
Thermoplastic polyurethane nanocomposites with Zn^{2+}-substituted CoFe$_2$O$_4$ nanoparticles and Reduced Graphene Oxide	0.08	0.80-1.17	-	67.8 (X-band)	668-963	[4]
GNP-Fe$_3$O$_4$-epoxy nanocomposites (solid)	0.2	0.73	-	28.30 (X-band)		[5]
GNP-Fe$_3$O$_4$-epoxy nanocomposites (porous)	0.2	0.34	-	37.03 (X-band)		[5]
MXene graphene coated fabric	0.35	0.77	-	38.99 (X-band)	11405.3	[6]
MXene graphene composite	0.35	0.77	-	53.89 (X-band)	1944.3	[6]
MXene graphene oxide composite	0.35	0.77	-	44.10 (X-band)	2996.2	[6]
Porous polyimide composites containing PANI modified graphene oxide and MWCNT hybrid fillers	0.2	0.56	-	28.2 (X-band)	251.78	[7]
PG 1	0.001	1.58	0.050	45 (S-band), 42 (X-band)	28481, 26582	†
PG 2	0.001	1.58	0.051	49 (S-band), 37 (X-band)	31012, 23417	†
PG 5	0.001	1.58	0.052	53 (S-band), 46 (X-band)	33544, 29113	†
PG 10	0.001	1.58	0.055	57 (S-band), 49 (X-band)	36075, 31012	†

*T = Thickness; D = density; SE~Total~ = Total Shielding Effectiveness, ^†^**Our sample**

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** *Mass for the volume (8 cm × 4 cm × T cm)*

***The absolute shielding effectiveness of the samples were calculated using the relation [6]:

$$A.SE = \frac{SSE}{T} \text{---------------- (1)}$$

where,

$$Specific\ Shielding\ Effectiveness,\ SSE = \frac{SE_T}{D} \text{---------------- (2)}$$

Magnetic Studies: M-H Curve

The magnetic studies of the hybrid films at room temperature were evaluated using Vibrating Sample Magnetometer (VSM, Quantum design, Versa lab mini PPMS with cylindrical magnet). PG10 with appreciable CuO NP loading was selected as the representative sample. The samples were placed in an out-of-plane direction (perpendicular to the direction of the magnetic field) in the sample holder. The magnetization vs magnetic field (M-H) graph shows the diamagnetic nature of the sample under test (figure S5) [3]. As PG 10 is diamagnetic in nature, other samples may also be considered to be diamagnetic and any magnetic attributes can thus be neglected.
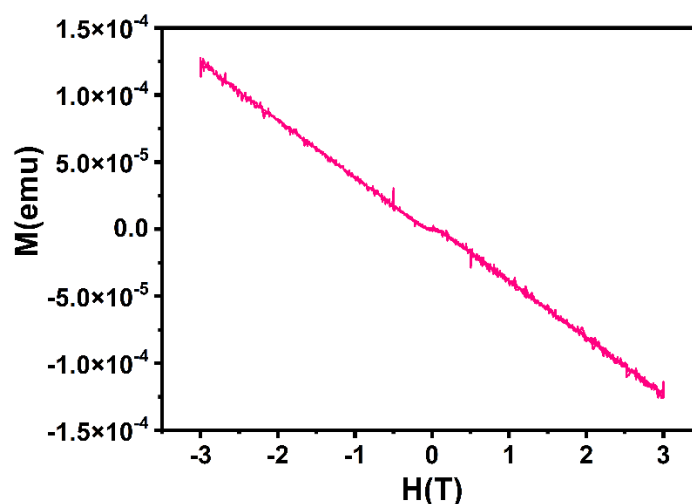

Figure S5. M-H curve of PANI nanorod/graphene nanoflake hybrid film

References

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