

Supporting Information

Coordination Interaction of Gd Metal–Organic Frameworks and Bismuth Halides for Efficient X-ray Shielding

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This supplementary information includes:

- A. Gd-MOF synthesis schematic
- B. Scheme of coin-making process
- C. Hardening issues to add a large amount of Gd-MOF
- D. Gd-MOF nanostructure
- E. Pure PDMS sponge morphology
- F. Element mapping of pure PDMS coin with EDX
- G. PDMS/Gd-MOF PDMS sponge morphology
- H. Element mapping of PDMS/Gd-MOF coin with EDX
- I. PDMS/Gd-MOF/BiI₃ sponge morphology

- J. Element mapping of PDMS/Gd-MOF/BiI₃ coin with EDX
- K. Solid state detector image
- L. Gd-MOF/BiI₃ and BiI₃ XPS peak shifting
- M. Gd-MOF/BiI₃ and BiI₃ Raman peak shifting
- N. Performance comparison table between Pb plate & S4
- O. Shielding Measurement at 60 kV by Si based solid-state detector
- P. Shielding Measurement at 100 kV by Si based solid-state detector
- Q. LAC, MAC, MFP, HVL, TVL data prepared sponges at 60kV
- R. LAC, MAC, MFP, HVL, TVL data prepared sponges at 100kV
- S. Shieling ratio of S1, S2, S3, S4 & Pb rubber at 60, 70, 80, 90, 100kV

Figures S1 to S12

Table S1 to S6

A. Gd-MOF synthesis schematic

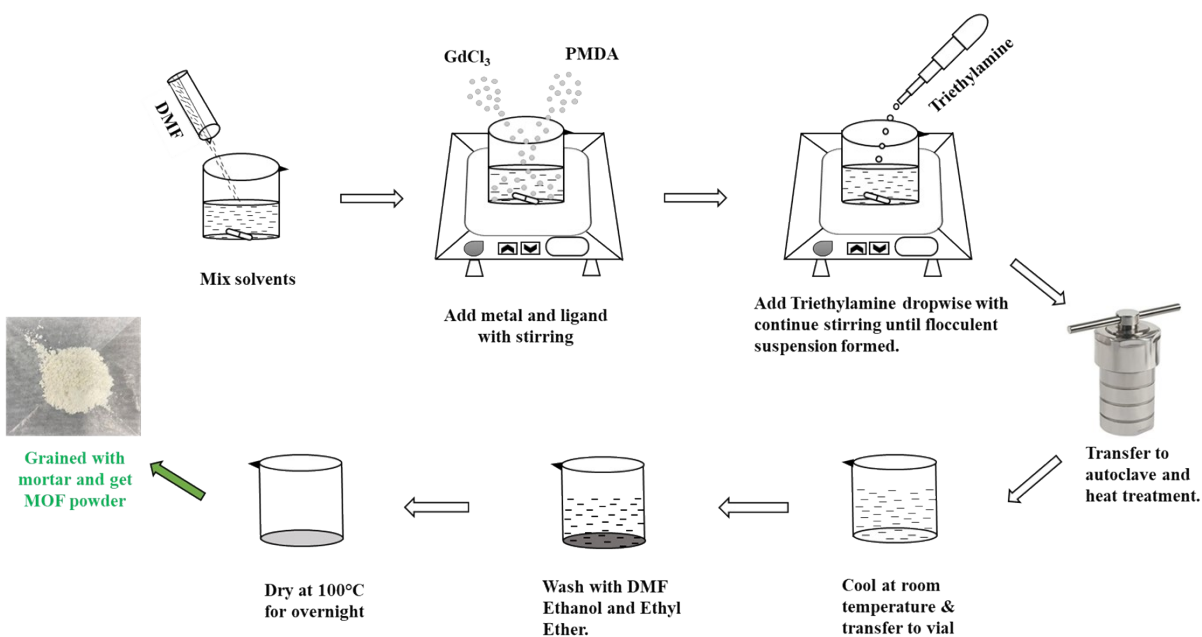


Figure S1. Gd-MOF nano powder preparation followed by hydrothermal method.

B. Scheme of coin-making process

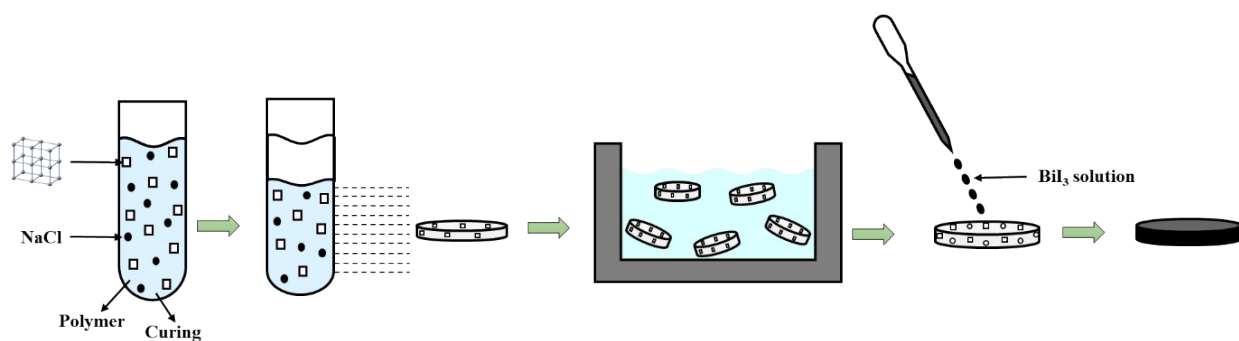


Figure S2. Sponge preparation and load bismuth halides.

C. Hardening issues to add a large amount of Gd-MOF

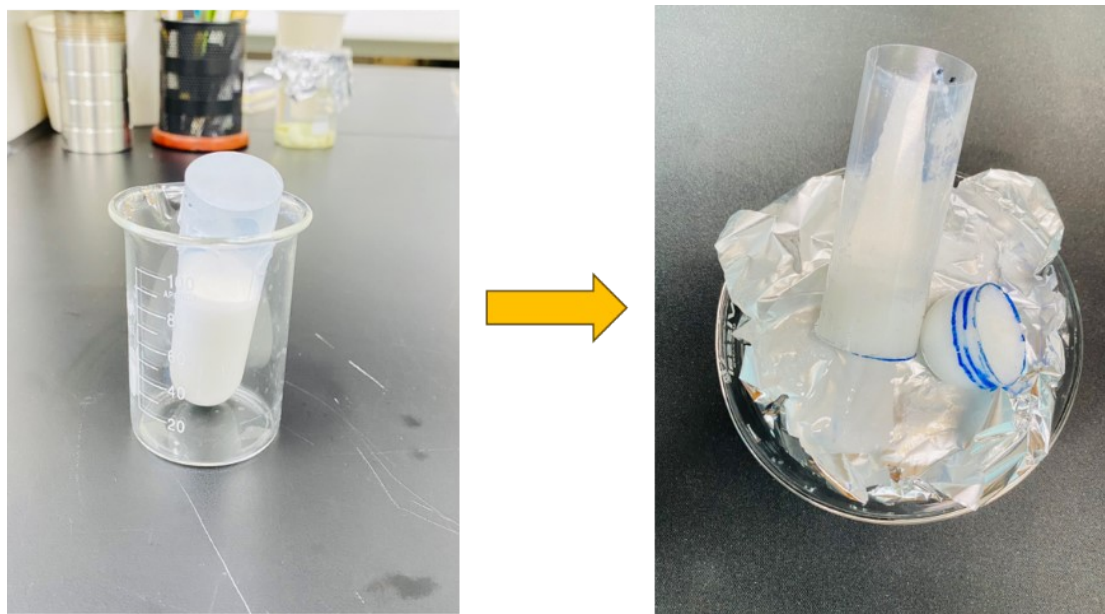


Figure S3. hardening problem when Gd-MOF add more than 0.7g.

D. Gd-MOF nanostructure

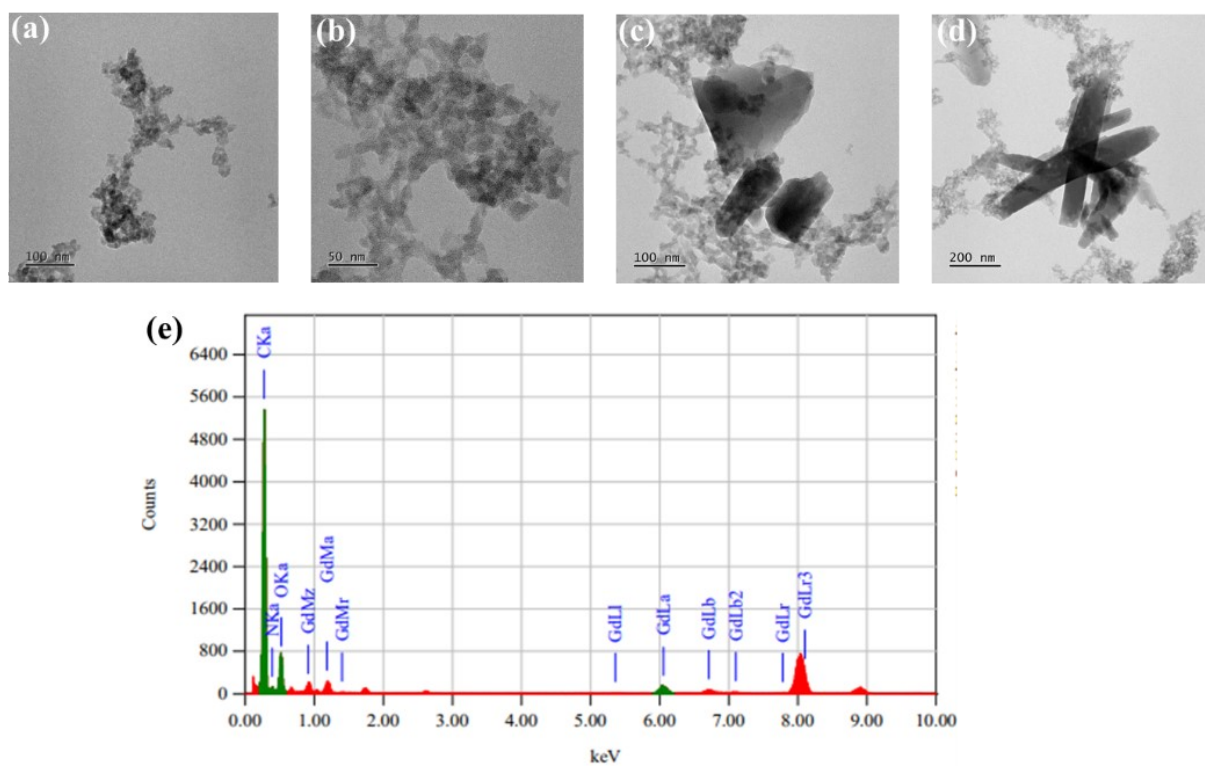


Figure S4. Gd-MOF TEM images and EDX mapping.

E. Pure PDMS sponge morphology

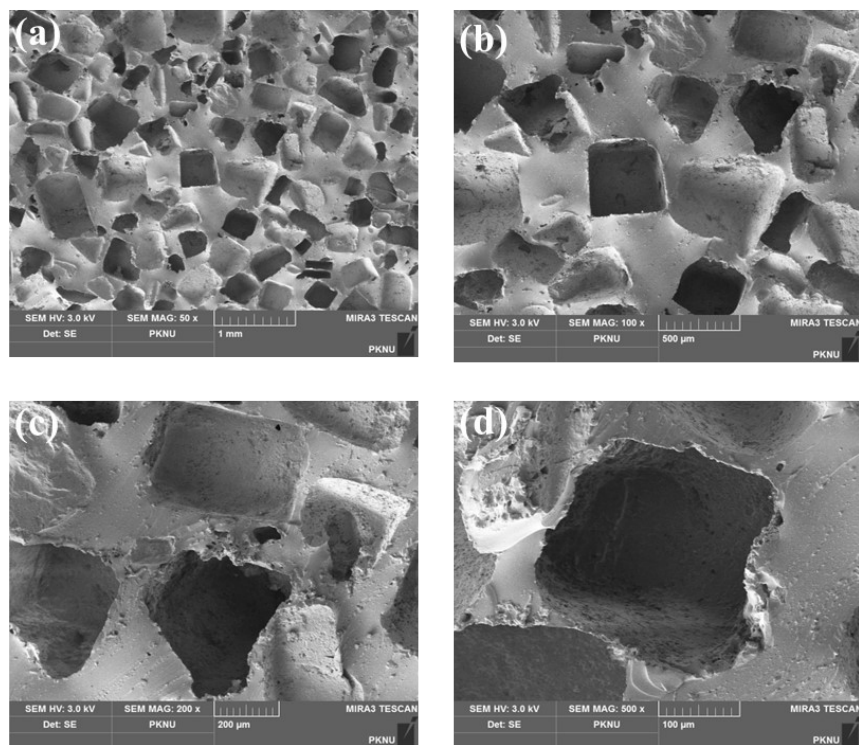


Figure S5. Pure PDMS SEM images.

F. Element mapping of pure PDMS coin with EDX

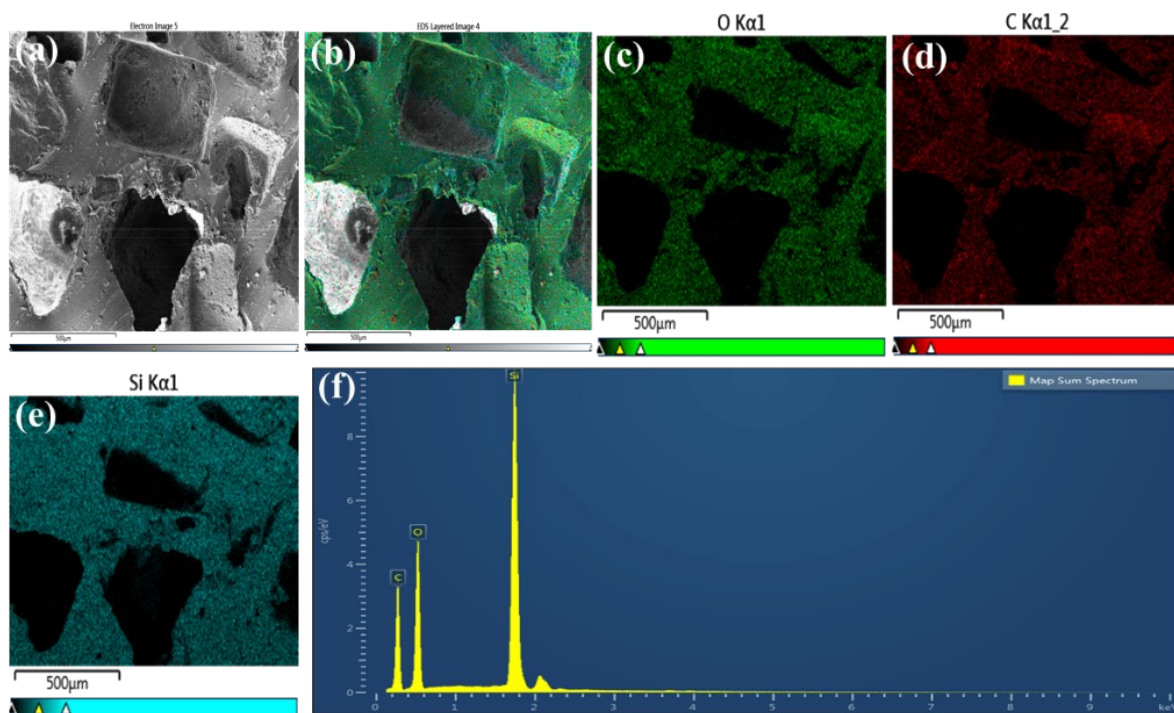


Figure S6. Pure PDMS sponge element mapping with EDX.

G. PDMS/Gd-MOF PDMS sponge morphology

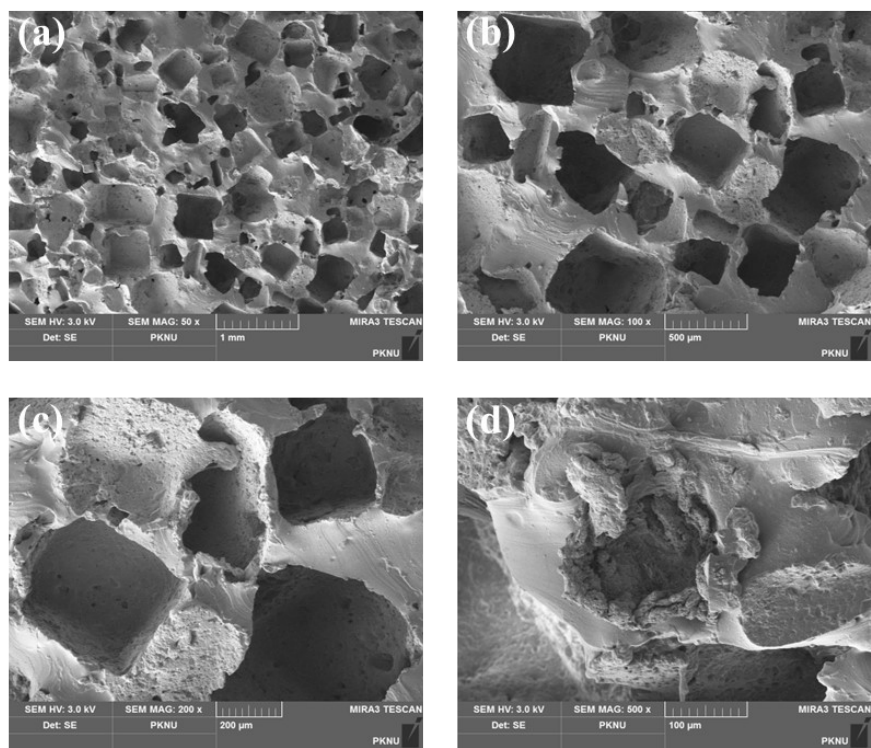


Figure S7, PDMS/Gd-MOF SEM images.

H. Element mapping of PDMS/Gd-MOF coin with EDX

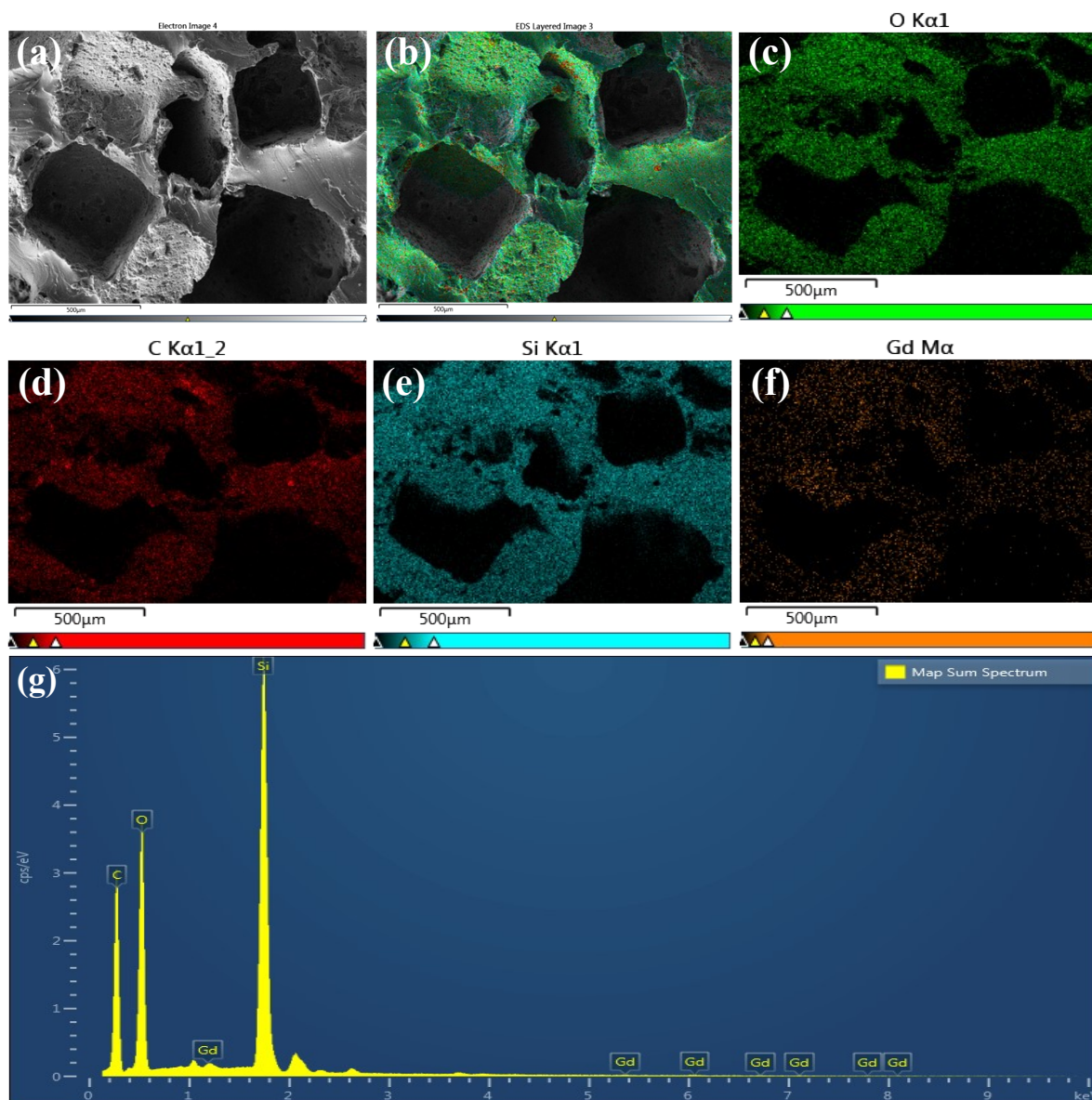


Figure S8. PDMS/Gd-MOF sponge element mapping with EDX.

I. PDMS/Gd-MOF/ BiI_3 sponge morphology

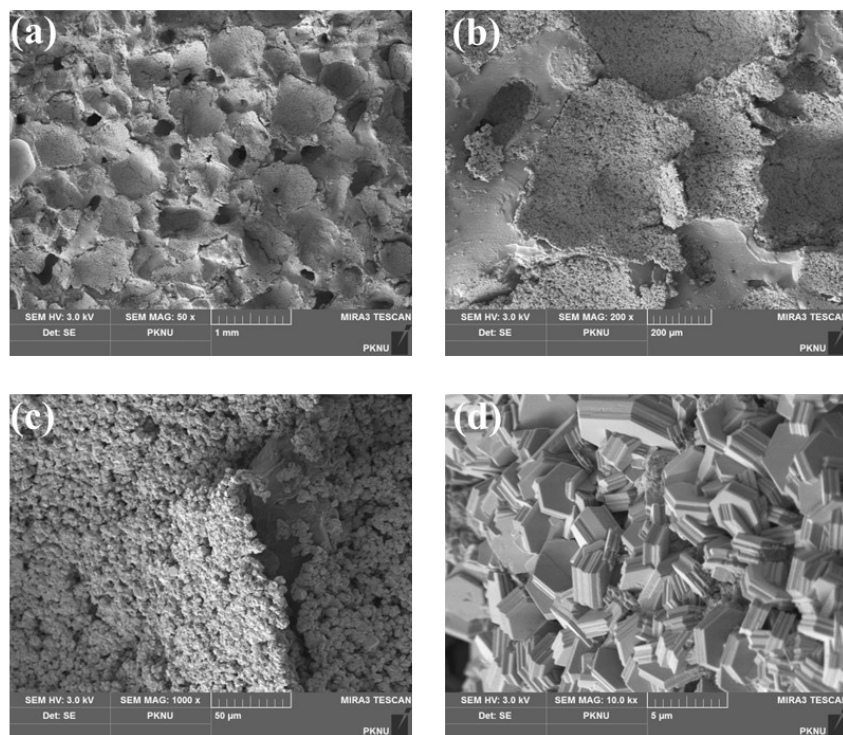


Figure-S9. PDMS/Gd-MOF/ BiI_3 SEM images.

J. Element mapping of PDMS/Gd-MOF/BiI₃ coin with EDX

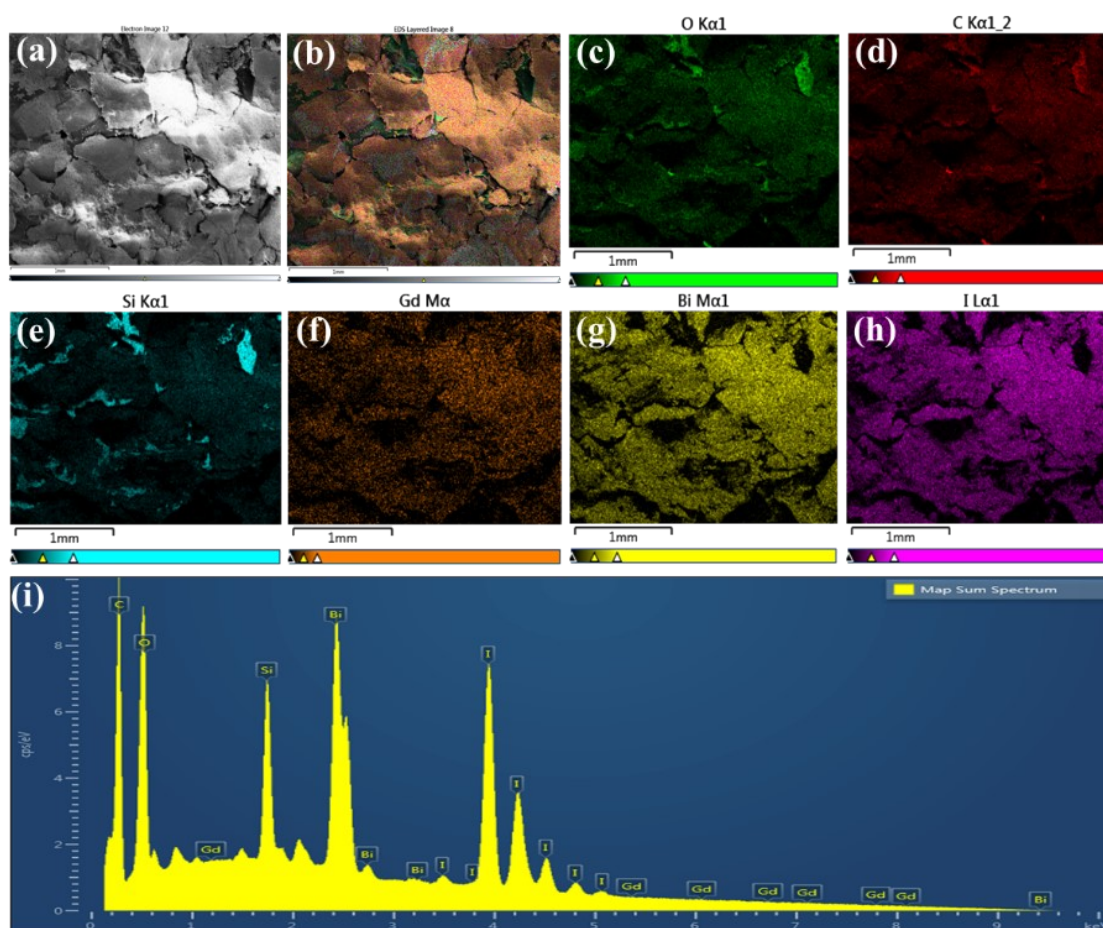


Figure-S10. PDMS/Gd-MOF/BiI₃ sponge element mapping with EDX.

K. Solid state detector image



Figure-S11. Photograph image of Si bases solid detector for cross checking.

L. Gd-MOF/ BiI_3 and BiI_3 XPS peak shifting

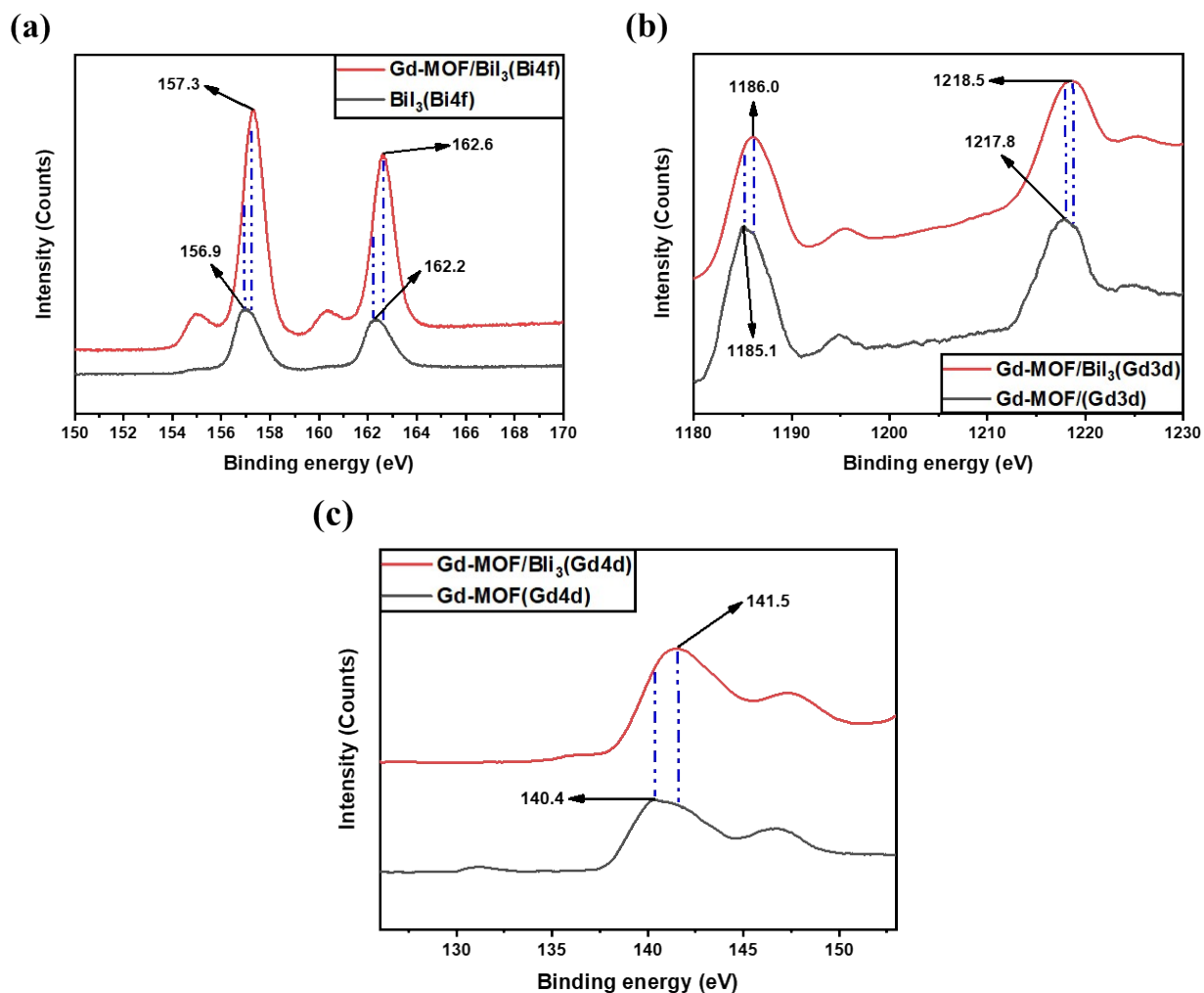


Figure-S12. Peak shifting (a) Bi4f of BiI_3 and Gd-MOF/ BiI_3 , (b) Gd3d of Gd-MOF and Gd-MOF/ BiI_3 , (c) Gd4d of Gd-MOF and Gd-MOF/ BiI_3 .

M. Gd-MOF/ BiI_3 and BiI_3 Raman peak shifting

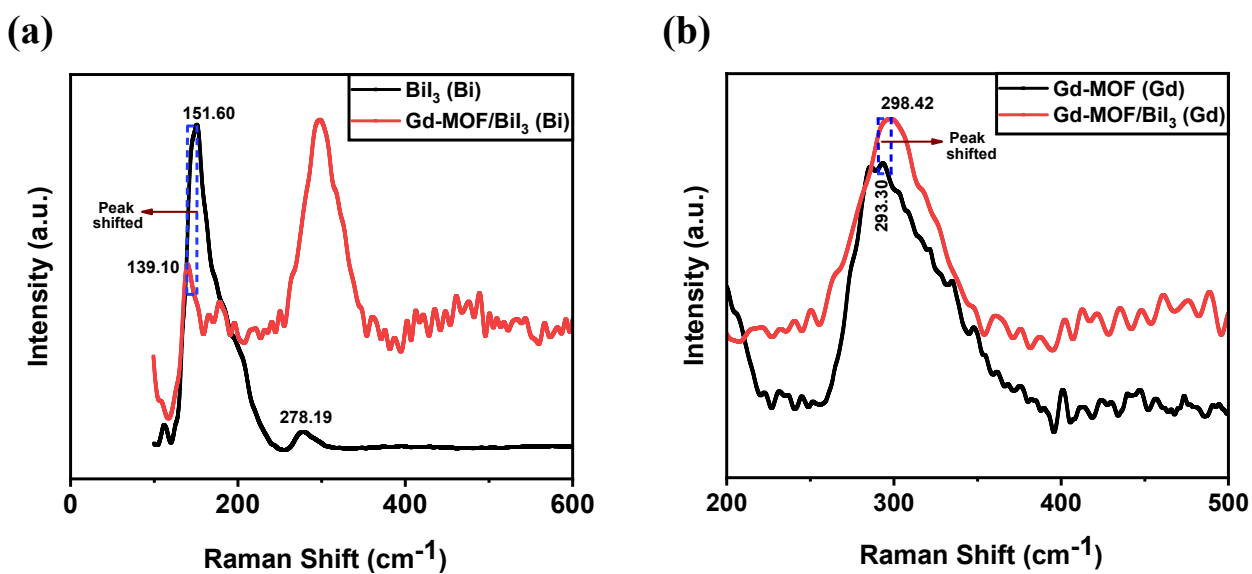


Figure-S13. Peak shifting (a) Bi peak (red shift) in BiI_3 and Gd-MOF/ BiI_3 , (b) Gd peak (blue shift) in Gd-MOF and Gd-MOF/ BiI_3 .

N. Performance comparison table between Pb plate & S4

Table S1. Performance comparison table between Pb plate & PDMS/Gd-MOF/BiI₃ sponge.

Sample	Shielding rate	LAC	Thickness	Diameter	Weight	X-ray energy
Pb plate	98.51%	38.156	1.07mm	25mm	5.18g	100 kV
S4	77.98%	5.044	3mm		2.18g	

By using this formula,

$$X_{\text{Pb}} : E_{\text{Pb}} = X_{\text{eqv.Pb}} : E_{\text{s}}$$

[X_{Pb} = Pb plate thickness; E_{Pb} = Pb plate shielding efficiency; $X_{\text{eqv.Pb}}$ = equivalent thickness of Lead plate; E_{s} = Our sample shielding efficiency.

So, our sample performance is equivalent to 0.84mm thickness of Pb plate under 100 kV X-ray energy. The 0.84 mm (equivalent thickness) of the Pb plate ($R=1.25$ mm) has a weight of 4.68 g, which is higher than our sample (2g).

O. Shielding Measurement at 60 kV by Si based solid-state detector

Table S2. Shielding Measurement at 60 kV by Si based solid-state detector.

Samples	Dose 1	Dose 2	Dose 3	Dose 4	Average Dose		Shielding Performance	
					Dose rate	STDEV	Shielding Ratio (%)	STDEV
Without sample	5.668 μ Gy	5.663 μ Gy	5.689 μ Gy	5.626 μ Gy	5.66 μ Gy	0.02		
S4-1	439.8 nGy	461.1 nGy	454.0 nGy	503.7 nGy	464.65 nGy	27.50	91.79	0.52
S4-2	461.1 nGy	503.7 nGy	397.3 nGy	482.4 nGy	461.12 nGy	45.97	91.85	0.83
S4-3	439.8 nGy	383.1 nGy	461.1 nGy	496.6 nGy	445.15 nGy	47.54	92.14	0.85
S4-4	277.0 nGy	276.7 nGy	297.7 nGy	241.2 nGy	273.15 nGy	23.46	95.18	0.39
S4-5	432.7 nGy	567.5 nGy	532.1 nGy	404.4 nGy	484.17 nGy	78.00	91.45	1.35

[S4-1 ~ S4-5 are different sample in same condition (PDMS/0.7 g Gd-MOF/BiI₃)



*Average Dose: = average of 4 dose values

*STDEV: Standard deviation 4 dose values

**Shielding Rate & STDEV: Calculated values using 4 dose values of each sample and without sample.

P. Shielding Measurement at 100 kV by Si based solid-state detector

Table S3. Shielding Measurement at 100 kV by Si based solid-state detector.

Samples	Dose 1	Dose 2	Dose 3	Dose 4	Average Dose		Shielding Performance	
					Dose rate	STDEV	Shielding Rate (%)	STDEV
Without sample	18.94 μ Gy	19.13 μ Gy	19.10 μ Gy	19.13 μ Gy	19.07 μ Gy	0.09		
S4-1	8.05 μ Gy	8.05 μ Gy	8.05 μ Gy	8.06 μ Gy	8.05 μ Gy	0.005	57.78	0.19
S4-2	8.54 μ Gy	8.69 μ Gy	8.65 μ Gy	8.55 μ Gy	8.60 μ Gy	0.07	54.88	0.32
S4-3	6.72 μ Gy	6.78 μ Gy	6.79 μ Gy	6.86 μ Gy	6.79 μ Gy	0.06	64.42	0.19
S4-4	5.20 μ Gy	5.18 μ Gy	5.22 μ Gy	5.17 μ Gy	5.19 μ Gy	0.02	72.78	0.20
S4-5	7.90 μ Gy	7.96 μ Gy	7.88 μ Gy	7.86 μ Gy	7.90 μ Gy	0.04	58.58	0.29

[S4-1 ~ S4-5 are different sample in same condition (PDMS/0.7g Gd-MOF/BiI₃)



*Average Dose: = average of 4 dose values
 *STDEV: Standard deviation 4 dose values
 **Shielding Rate & STDEV: Calculated values using 4 dose values of each sample and without sample.

Q. LAC, MAC, MFP, HVL, TVL data prepared sponges at 60kV

Table S4. LAC, MAC, MFP, HVL, TVL data prepared sponges at 60kV.

Name	LAC (cm⁻¹)	MAC (cm²/g)	MFP (cm)	HVL (cm)	TVL (cm)
PDMS/BiI₃	6.358	6.573	0.164	0.114	0.379
0.3g Gd- MOF/PDMS/BiI₃	7.569	6.476	0.135	0.093	0.310
0.5g Gd- MOF/PDMS/BiI₃	7.749	6.470	0.129	0.09	0.298
0.7g Gd- MOF/PDMS/BiI₃	9.497	7.842	0.107	0.074	0.246

R. LAC, MAC, MFP, HVL, TVL data prepared sponges at 100kV**Table S5.** LAC, MAC, MFP, HVL, TVL data prepared sponges at 100kV.

Name		LAC (cm ⁻¹)	MAC (cm ² /g)	MFP (cm)	HVL (cm)	TVL (cm)
PDMS/BiI3		4.112	4.252	0.261	0.181	0.600
0.3g	Gd-	4.375	3.743	0.229	0.159	0.527
MOF/PDMS/BiI₃						
0.5g	Gd-	4.428	3.697	0.228	0.158	0.524
MOF/PDMS/BiI₃						
0.7g	Gd-	5.071	4.188	0.199	0.137	0.377
MOF/PDMS/BiI₃						

S. Shielding ratio of S1, S2, S3, S4 & Pb plate at 60, 70, 80, 90, 100 kV

Table S6. Shielding performance table of S1 (Pure PDMS/BiI₃), S2 (Pure PDMS/0.3g Gd-MOF/BiI₃), S3 (Pure PDMS/0.5g Gd-MOF/BiI₃), S4 (Pure PDMS/0.7g Gd-MOF/BiI₃) & Pure Pb plate (thickness: 1.07 mm) at 60, 70, 80, 90 & 100 kV.

Sample type	Shielding ratio									
	60 kV		70 kV		80 kV		90 kV		100 kV	
	Shielding rate (%)	SE*	Shielding rate (%)	SE*	Shielding rate (%)	SE*	Shielding rate (%)	SE*	Shielding rate (%)	SE*
S1	83.95	0.41	79.78	2.54	73.38	2.06	71.22	1.31	69.26	1.34
S2	89.14	0.37	84.96	0.16	77.04	0.04	74.28	2.20	73.03	1.24
S3	90.16	0.33	87.30	0.34	81.37	0.27	75.25	0.66	73.33	1.48
S4	93.88	0.19	90.08	0.10	83.707	0.17	80.63	0.03	77.98	0.49
Pure Pb plate									98.52	0.23

SE* = Standard Error = Standard deviation / root (measurement number)