Supplementary Information

Ternary deep eutectic solvent-modified magnetic mixed iron hydroxide@MIL-101(Cr)-NH_2 composite as a sorbent in magnetic solid phase extraction of organochlorine pesticides prior to GC–MS

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Table S1 Abbreviations of TDESs and their molar ratios.

	Abbreviation	log [P]	TDES1	TDES2	TDES3	TDES4	TDES5	TDES6
Molar ratio	Menthol	2.66	1	1	3	5	5	3
	Thymol	3.30	1	3	5	3	5	5
	Dodecanoic acid	4.48	1	1	1	1	3	5

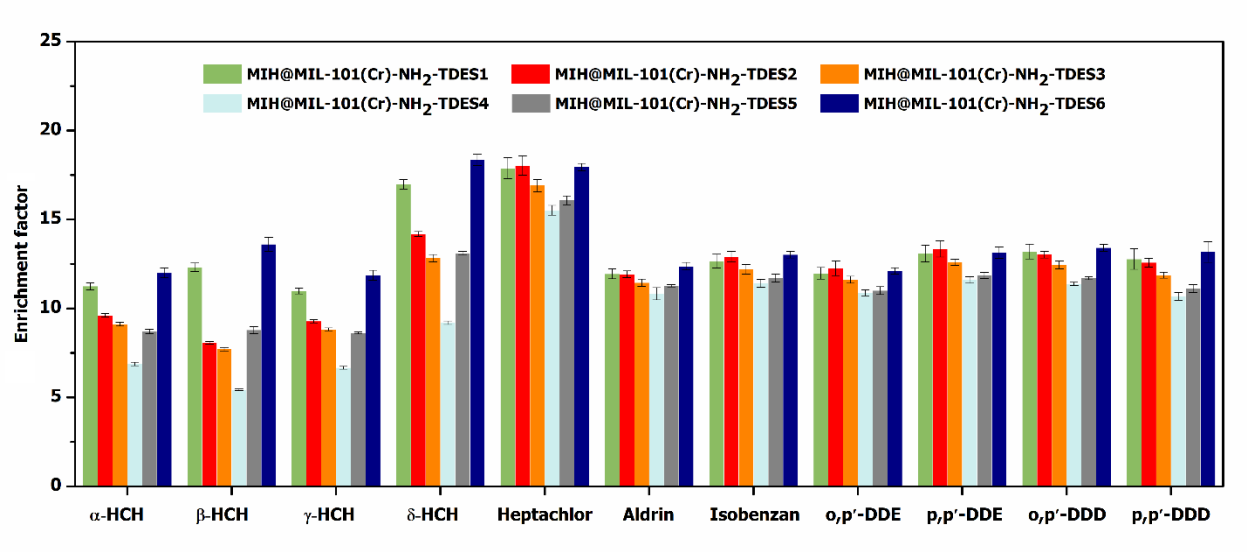

Fig. S1 Extraction efficiency of the magnetic-metal organic framework modified with different ternary deep eutectic solvents. The magnetic solid phase extraction conditions were as follows: sorbent, 30 mg; extraction/desorption time, 30 s; desorption solvent, 0.5 mL of ethyl acetate; sample volume, 10 mL containing 50 μg L^{-1} of each organochlorine pesticide.

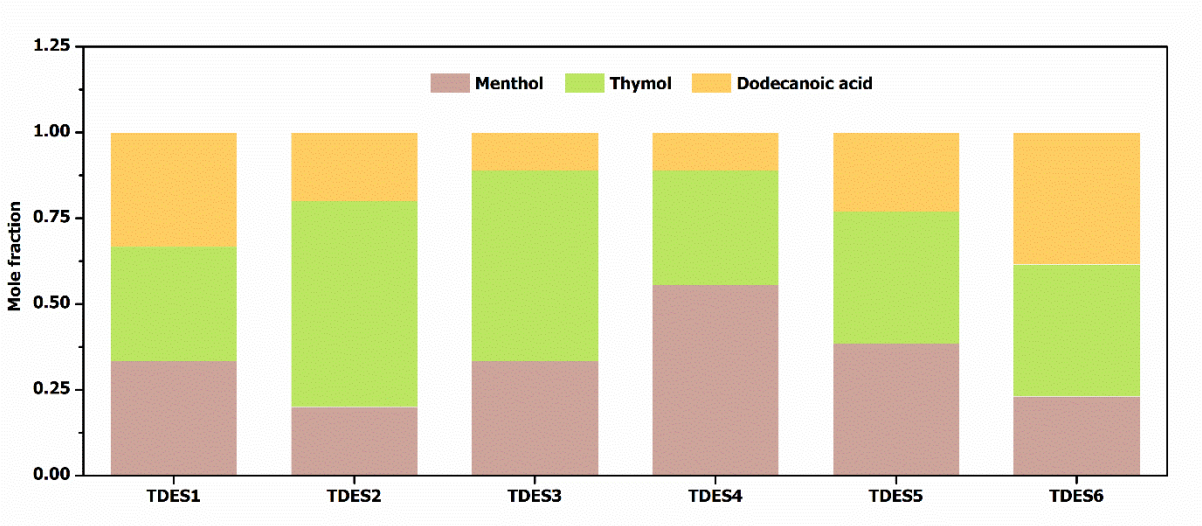

Fig. S2 Mole fraction of menthol, thymol and dodecanoic acid in the ternary deep eutectic solvents.

Table S2 Experimental factors, levels, and matrix of the Box–Behnken design for studying the synthesis conditions of MIH@MIL-101(Cr)-NH_2-TDES and the central composite design for optimizing the conditions of magnetic solid phase extraction.

Factor	Levels				
Box–Behnken design		-1	0	+1	
x_1: MOF amount (mg)		100	550	1000	
x_2: TDES volume (mL)		0.10	0.55	1.00	
x_3: Time (min)		30	60	90	
Central composite design	-2	-1	0	+1	+2
X_1: Sorbent amount (mg)	10	25	40	55	70
X_2: NaCl concentration (% w/v)	0	2.5	5.0	7.5	10.0
X_3: Extraction time (s)	10	30	50	70	90
X_4: Sample volume (mL)	10	20	30	40	50

Table S3 Experimental design of the Box–Behnken design, the central composite design, and their responses.

Run	Box–Behnken design				Central composite design				
	x_1: MOF amount (mg)	x_2: TDES volume (mL)	x_3: Time (min)	Response: Avg. of EFs	X_1: Sorbent amount (mg)	X_2: NaCl concentration (% w/v)	X_3: Extraction time (s)	X_4: Sample volume (mL)	Response: Avg. of EFs
1	100	1.00	60	20.53	55	2.5	30	20	23.01
2	550	0.55	60	25.70	25	2.5	70	20	21.80
3	550	0.10	30	5.18	55	2.5	70	20	27.49
4	100	0.55	30	17.68	55	7.5	30	40	37.06
5	100	0.55	90	19.25	40	5.0	50	30	46.82
6	550	1.00	90	28.50	25	7.5	30	20	29.55
7	1000	1.00	60	22.92	25	7.5	30	40	32.00
8	1000	0.55	30	20.61	40	5.0	10	30	46.80
9	100	0.10	60	2.42	70	5.0	50	30	37.04
10	550	0.55	60	25.02	25	7.5	70	20	32.81
11	550	1.00	30	24.16	55	7.5	70	20	37.41
12	550	0.55	60	25.78	40	10.0	50	30	31.55
13	1000	0.10	60	4.00	40	5.0	50	30	47.47
14	1000	0.55	90	20.98	25	7.5	70	40	40.93
15	550	0.10	90	10.19	25	2.5	30	40	42.81
16	-	-	-	-	55	7.5	70	40	54.30
17	-	-	-	-	40	5.0	50	50	47.55
18	-	-	-	-	40	5.0	50	10	19.84
19	-	-	-	-	10	5.0	50	30	32.24
20	-	-	-	-	55	2.5	70	40	49.22
21	-	-	-	-	40	5.0	90	30	49.59
22	-	-	-	-	40	5.0	50	30	47.08
23	-	-	-	-	25	2.5	70	40	38.83
24	-	-	-	-	40	5.0	50	30	46.15
25	-	-	-	-	40	5.0	50	30	46.66
26	-	-	-	-	55	7.5	30	20	28.00
27	-	-	-	-	40	0.0	50	30	26.42
28	-	-	-	-	25	2.5	30	20	30.07
29	-	-	-	-	40	5.0	50	30	49.07
30	-	-	-	-	55	2.5	30	40	46.13

Table S4 ANOVA for the quadratic model of Box–Behnken design and central composite design.

Source	Sum of Squares	df	Mean Square	F value	p value	
Box–Behnken design						
Model	1021.50	9	113.50	77.95	< 0.0001	significant
x_1: MOF amount	9.31	1	9.31	6.39	0.0526	
x_2: TDES volume	690.43	1	690.43	474.18	< 0.0001	
x_3: Time	15.93	1	15.93	10.94	0.0213	
$x_1 x_2$	0.1640	1	0.1640	0.1127	0.7508	
$x_1 x_3$	0.3600	1	0.3600	0.2472	0.6401	
$x_2 x_3$	0.1122	1	0.1122	0.0771	0.7924	
x_1^2	100.03	1	100.03	68.70	0.0004	
x_2^2	226.23	1	226.23	155.37	< 0.0001	
x_3^2	1.63	1	1.63	1.12	0.3381	
Residual	7.28	5	1.46			
Lack of Fit	6.93	3	2.31	13.25	0.0710	not significant
Pure Error	0.3488	2	0.1744			
Cor Total	1028.78	14				
Central composite design						
Model	2703.82	14	193.13	76.90	< 0.0001	significant
X_1: Sorbent amount	78.55	1	78.55	31.28	< 0.0001	
X_2: NaCl concentration	21.97	1	21.97	8.75	0.0098	
X_3: Extraction time	65.80	1	65.80	26.20	0.0001	
X_4: Sample volume	1155.93	1	1155.93	460.28	< 0.0001	
X_1X_2	5.22	1	5.22	2.08	0.1699	
X_1X_3	73.44	1	73.44	29.25	< 0.0001	
X_1X_4	57.99	1	57.99	23.09	0.0002	
X_2X_3	118.37	1	118.37	47.14	< 0.0001	
X_2X_4	90.73	1	90.73	36.13	< 0.0001	
X_3X_4	16.81	1	16.81	6.69	0.0206	
X_1^2	290.23	1	290.23	115.57	< 0.0001	
X_2^2	597.33	1	597.33	237.85	< 0.0001	
X_3^2	0.5061	1	0.5061	0.2015	0.6599	
X_4^2	333.92	1	333.92	132.97	< 0.0001	
Residual	37.67	15	2.51			
Lack of Fit	32.55	10	3.25	3.18	0.1070	not significant
Pure Error	5.12	5	1.02			

Cor Total	2741.49	29

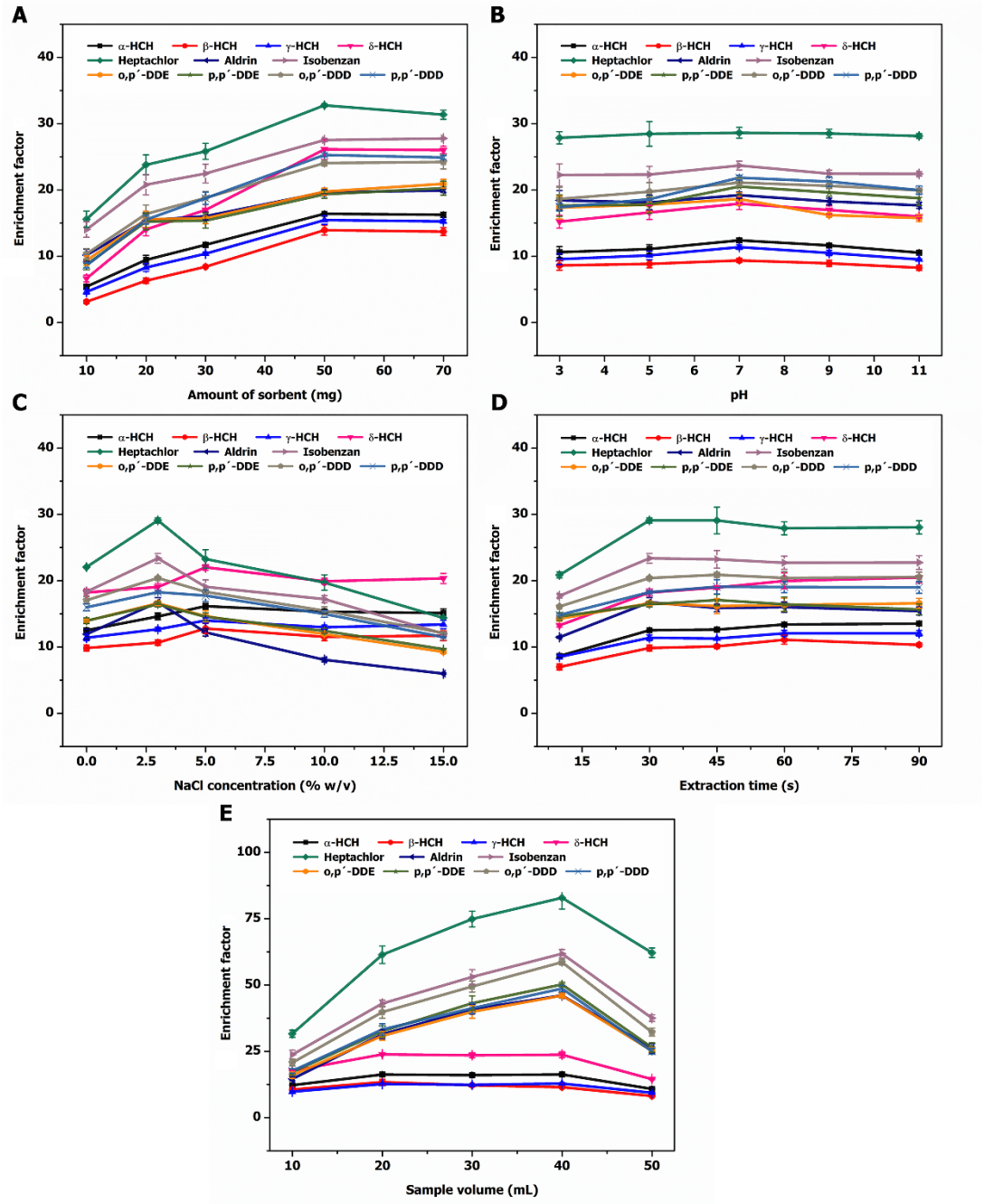

Fig. S3 Effect of (A) sorbent amount, (B) pH of sample solution, (C) salt addition, (D) extraction time, and (E) sample volume. The magnetic solid phase extraction conditions were as follows: amount of sorbent, 30 mg; extraction/desorption time, 30 s; desorption solvent, 500 µL; and sample volume, 20 mL, containing 5 µg L^{-1} of each OCP.

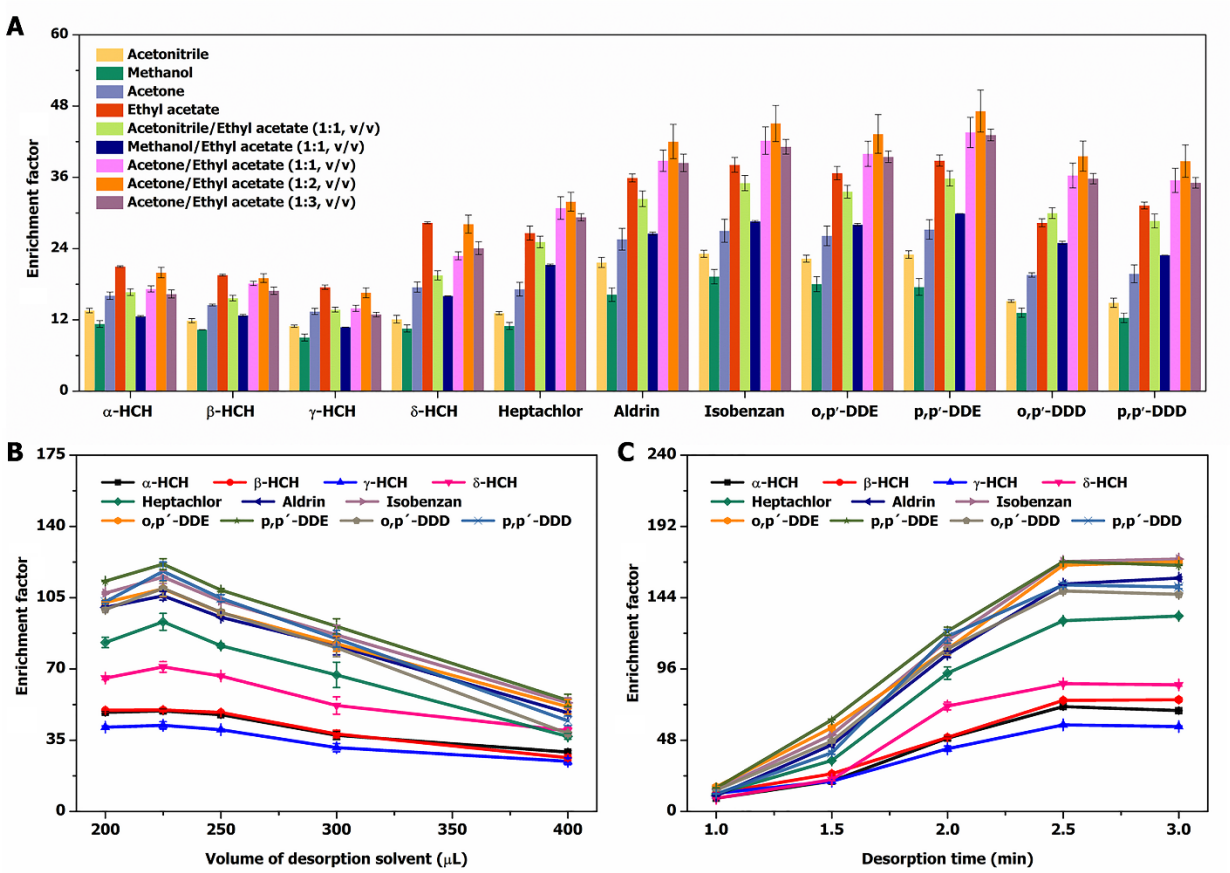

Fig. S4 Effect of (A) desorption solvent, (B) desorption solvent volume, and (C) desorption time. The magnetic solid phase extraction conditions were as follows: sorbent, 45 mg; extraction time, 70 s; and sample volume, 40 mL containing 5% (w/v) sodium chloride.

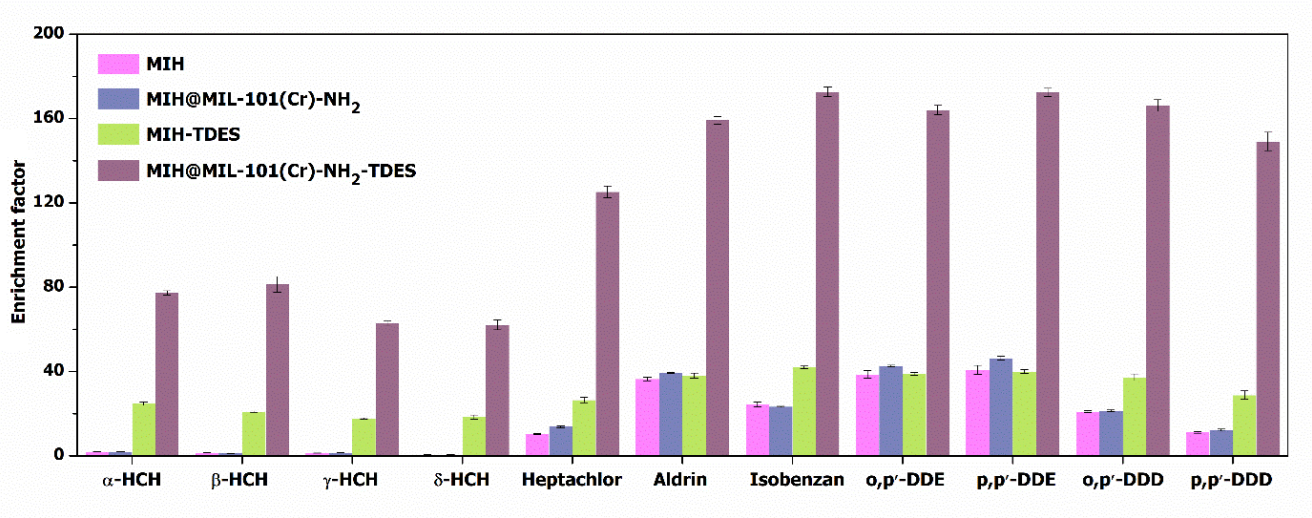

Fig. S5 Extraction efficiencies of various sorbents. The magnetic solid phase extraction conditions were as follows: sorbent, 45 mg; extraction time, 70 s; desorption time, 2.5 min; desorption solvent, 225 μL of acetone/ethyl acetate (1:2, v/v); and sample solution, 40 mL of OCP solution (5 μg L^{-1} of each) containing 5% (w/v) sodium chloride.

Table S5 Analytical performance for the determination of OCPs in honey and tea samples.

Matrix	Analyte	Linear range ($ng \cdot g^{-1}$)	R^2	LODs ($ng \cdot g^{-1}$)	LOQs ($ng \cdot g^{-1}$)	RSDs[a]	
						Intraday (n = 5)	Interday (n = 5x3)
Honey	α-HCH	0.80–1000	0.9993	0.50	0.80	4.5	5.2
	β-HCH	1.0–1000	0.9996	0.70	1.00	3.7	3.1
	γ-HCH	1.0–1000	0.9998	0.70	1.00	1.9	7.9
	δ-HCH	1.0–1000	0.9963	0.80	1.00	4.2	5.2
	Heptachlor	0.40–1000	0.9979	0.25	0.40	6.3	5.1
	Aldrin	0.50–1000	0.9967	0.30	0.50	6.9	6.6
	Isobenzan	0.50–1000	0.9976	0.30	0.50	5.5	6.0
	o,p′-DDE	0.10–1000	0.9946	0.07	0.10	7.6	7.0
	p,p′-DDE	0.10–1000	0.9945	0.07	0.10	7.4	7.4
	o,p′-DDD	0.30–1000	0.9951	0.15	0.30	5.4	4.1
	p,p′-DDD	0.50–1000	0.9970	0.25	0.50	4.1	6.3
Tea leaves	α-HCH	4.0–2500	0.9956	3.0	4.0	3.1	6.5
	β-HCH	1.5–2500	0.9980	1.0	1.5	3.5	4.9
	γ-HCH	5.0–2500	0.9977	3.0	5.0	3.6	5.3
	δ-HCH	10.0–2500	0.9977	8.5	10.0	4.3	5.1
	Heptachlor	4.0–2500	0.9997	2.5	4.0	2.8	4.9
	Aldrin	4.0–2500	0.9982	2.5	4.0	1.5	6.9
	Isobenzan	4.0–2500	0.9980	2.5	4.0	1.8	7.4
	o,p′-DDE	1.0–2500	0.9982	0.7	1.0	3.8	5.9
	p,p′-DDE	1.0–2500	0.9974	0.7	1.0	3.7	4.9
	o,p′-DDD	2.0–2500	0.9995	1.5	2.0	6.2	8.2
	p,p′-DDD	10.0–2500	0.9983	8.5	10.0	7.7	7.4

[a]Spiked at 20 $ng \cdot g^{-1}$ and 100 $ng \cdot g^{-1}$ of each OCP in honey and tea samples, respectively.

Table S6 Matrix effects of each real sample.

Analyte	ME (%)[a]					
	Honey1	Honey2	Honey3	Wulong tea	Biluochun tea	Longjing tea
α-HCH	-7.8	-11.2	-24.6	-30.1	-31.5	-20.9
β-HCH	-19.6	-20.9	-15.6	-9.3	-3.7	-10.7
γ-HCH	-29.8	-21.9	-6.5	-0.4	-12.1	-5.6
δ-HCH	-67.8	-82.5	-45.3	-40.3	-39.9	-30.6
Heptachlor	-50.7	-60.1	-71.0	-50.8	-32.5	-38.3
Aldrin	-49.4	-48.1	-15.1	-10.9	-5.9	-7.7
Isobenzan	-50.2	-37.3	-19.0	-19.4	-21.5	-18.3
o,p′-DDE	-53.5	-47.9	-29.2	-22.5	-9.4	-20.1
p,p′-DDE	-52.0	-47.9	-27.8	-17.6	-6.8	-15.9
o,p′-DDD	-36.6	-40.7	-19.1	-1.6	-9.4	-10.0
p,p′-DDD	-16.4	-21.7	-41.3	-27.2	-11.7	-22.3

[a] Matrix effect

Table S7 Recoveries of the spiked honey samples.

Analyte	Added ($ng \cdot g^{-1}$)	Honey1		Honey2		Honey3	
		Found ($ng \cdot g^{-1}$)	R[a] ± RSD[b] (%)	Found ($ng \cdot g^{-1}$)	R ± RSD (%)	Found ($ng \cdot g^{-1}$)	R ± RSD (%)
α-HCH	-	N.D.[c]	-	N.D.	-	N.D.	-
	1.00	0.91	90.9 ± 5.3	0.95	94.7 ± 6.7	1.05	104.8 ± 1.0
	2.00	2.01	100.3 ± 1.6	2.09	104.4 ± 1.2	1.86	92.9 ± 6.8
	4.00	3.96	98.9 ± 5.9	3.97	99.1 ± 2.9	3.97	99.2 ± 3.4
β-HCH	-	N.D.	-	N.D.	-	N.D.	-
	1.00	0.87	86.7 ± 5.8	0.94	94.3 ± 7.8	1.01	100.7 ± 0.7
	2.00	2.07	103.3 ± 1.0	1.96	98.0 ± 0.6	2.12	106.1 ± 1.8
	4.00	4.14	103.5 ± 2.0	3.93	98.1 ± 1.0	3.62	90.5 ± 1.5
γ-HCH	-	N.D.	-	N.D.	-	N.D.	-
	1.00	0.86	85.8 ± 5.4	0.93	92.9 ± 4.8	1.09	109.2 ± 2.3
	2.00	2.02	101.2 ± 7.0	1.83	91.7 ± 0.9	1.83	91.5 ± 4.4
	4.00	3.96	99.1 ± 7.7	3.91	97.7 ± 2.8	3.88	96.9 ± 3.1
δ-HCH	-	N.D.	-	N.D.	-	N.D.	-
	1.00	1.07	107.3 ± 2.2	0.92	91.8 ± 1.8	0.91	90.7 ± 2.1
	2.00	1.82	91.2 ± 8.8	1.80	89.8 ± 3.3	1.72	86.0 ± 2.2
	4.00	3.97	99.2 ± 7.1	3.93	98.4 ± 3.0	3.89	97.4 ± 5.5
Heptachlor	-	N.D.	-	N.D.	-	N.D.	-
	1.00	0.91	91.2 ± 4.1	0.91	90.7 ± 4.6	1.02	102.4 ± 0.1
	2.00	2.03	101.5 ± 9.6	2.06	102.8 ± 0.9	1.88	94.2 ± 2.8
	4.00	3.80	95.0 ± 7.7	4.07	101.7 ± 2.7	3.52	88.1 ± 4.3
Aldrin	-	N.D.	-	N.D.	-	N.D.	-
	1.00	0.89	88.8 ± 2.0	0.89	89.2 ± 1.4	0.99	98.8 ± 0.2
	2.00	2.15	107.3 ± 2.7	1.98	98.9 ± 0.4	1.96	98.0 ± 5.4
	4.00	3.75	93.6 ± 6.4	4.15	103.9 ± 0.8	3.58	89.6 ± 2.7
Isobenzan	-	N.D.	-	N.D.	-	N.D.	-
	1.00	0.85	85.2 ± 2.9	0.85	85.4 ± 7.0	0.96	96.0 ± 0.7
	2.00	2.10	105.0 ± 0.8	1.95	97.4 ± 1.0	2.01	100.7 ± 1.0
	4.00	3.78	94.5 ± 5.7	3.45	86.2 ± 1.2	3.54	88.5 ± 2.2
o,p′-DDE	-	N.D.	-	N.D.	-	N.D.	-
	1.00	0.95	95.3 ± 3.2	1.00	100.3 ± 6.6	0.93	92.9 ± 1.9
	2.00	2.11	105.6 ± 3.3	1.83	91.6 ± 0.8	2.02	101.1 ± 0.2
	4.00	3.77	94.4 ± 5.1	4.03	100.6 ± 0.7	3.62	90.5 ± 1.8
p,p′-DDE	-	N.D.	-	N.D.	-	N.D.	-
	1.00	0.97	97.1 ± 3.5	0.85	84.8 ± 1.1	0.87	87.5 ± 1.1
	2.00	2.11	105.7 ± 7.8	1.80	90.0 ± 0.7	1.99	99.5 ± 0.7
	4.00	3.78	94.4 ± 5.9	4.20	105.0 ± 0.9	3.72	93.0 ± 2.5
o,p′-DDD	-	N.D.	-	N.D.	-	N.D.	-
	1.00	0.82	81.7 ± 0.7	0.93	93.4 ± 3.9	1.04	103.7 ± 2.5
	2.00	1.97	98.6 ± 3.2	1.85	92.5 ± 0.7	2.15	107.5 ± 6.4
	4.00	3.67	91.7 ± 6.2	5.30	88.4 ± 0.8	3.36	84.0 ± 3.1
p,p′-DDD	-	N.D.	-	N.D.	-	N.D.	-
	1.00	0.86	85.7 ± 0.3	0.98	97.8 ± 1.1	1.00	100.4 ± 0.4
	2.00	1.75	87.4 ± 1.6	1.98	98.8 ± 0.5	1.93	96.3 ± 3.5
	4.00	4.04	101.0 ± 4.3	3.59	89.8 ± 1.0	3.41	85.3 ± 5.1

[a] Recovery, [b] Relative standard deviation, [c] Not detected

Table S8 Recoveries of the spiked tea samples.

Analyte	Added ($ng \cdot g^{-1}$)	Wulong tea		Biluochun tea		Longjing tea	
		Found ($ng \cdot g^{-1}$)	R[a] ± RSD[b] (%)	Found ($ng \cdot g^{-1}$)	R ± RSD (%)	Found ($ng \cdot g^{-1}$)	R ± RSD (%)
α-HCH	-	N.D.[c]	-	N.D.	-	N.D.	-
	10.0	9.5	95.5 ± 2.3	10.4	104.0 ± 0.4	10.2	102.4 ± 0.5
	15.0	15.5	103.6 ± 6.7	14.6	97.6 ± 0.3	15.1	100.5 ± 3.1
	20.0	21.9	109.3 ± 1.4	20.3	101.6 ± 2.4	20.5	102.4 ± 2.0
β-HCH	-	N.D.	-	N.D.	-	N.D.	-
	10.0	9.2	92.2 ± 6.0	10.1	100.7 ± 5.0	9.7	96.8 ± 5.5
	15.0	14.8	98.7 ± 4.8	14.9	99.6 ± 2.2	14.7	97.8 ± 2.5
	20.0	21.3	106.6 ± 4.4	19.5	97.7 ± 1.1	19.7	98.3 ± 1.0
γ-HCH	-	N.D.	-	N.D.	-	N.D.	-
	10.0	9.7	97.3 ± 5.5	8.5	85.4 ± 2.9	8.7	87.5 ± 1.7
	15.0	16.3	108.7 ± 4.3	14.4	96.1 ± 1.8	14.8	98.6 ± 1.0
	20.0	20.8	103.8 ± 3.8	20.4	102.2 ± 0.7	21.2	106.2 ± 3.3
δ-HCH	-	N.D.	-	N.D.	-	N.D.	-
	10.0	9.9	99.1 ± 3.9	10.3	102.7 ± 5.6	9.7	96.6 ± 4.9
	15.0	13.1	87.5 ± 3.4	14.6	97.1 ± 0.4	15.5	103.5 ± 5.1
	20.0	21.3	106.5 ± 0.8	20.0	99.9 ± 2.1	19.8	99.1 ± 2.1
Heptachlor	-	N.D.	-	N.D.	-	N.D.	-
	10.0	9.5	94.6 ± 5.0	9.5	95.4 ± 0.7	9.7	97.0 ± 2.8
	15.0	13.2	88.1 ± 1.6	14.7	98.1 ± 1.1	14.7	98.1 ± 2.0
	20.0	20.3	101.5 ± 0.5	20.0	100.1 ± 2.7	20.3	101.4 ± 3.6
Aldrin	-	N.D.	-	N.D.	-	N.D.	-
	10.0	9.5	94.7 ± 2.9	9.8	98.2 ± 1.3	10.0	99.6 ± 1.8
	15.0	15.3	101.7 ± 3.8	14.7	98.0 ± 0.2	14.7	98.2 ± 1.9
	20.0	21.2	105.8 ± 0.9	20.0	100.0 ± 0.5	19.8	98.8 ± 5.6
Isobenzan	-	N.D.	-	N.D.	-	N.D.	-
	10.0	9.6	95.5 ± 5.5	9.7	97.1 ± 1.6	9.6	96.1 ± 1.3
	15.0	15.2	101.1 ± 6.6	15.0	99.9 ± 0.7	15.1	100.5 ± 2.4
	20.0	21.2	106.2 ± 1.3	20.0	100.0 ± 1.1	19.7	98.5 ± 4.4
o,p′-DDE	-	N.D.	-	N.D.	-	N.D.	-
	10.0	10.5	105.3 ± 8.1	9.9	99.1 ± 0.7	9.9	99.1 ± 3.4
	15.0	15.3	101.8 ± 7.0	14.6	97.6 ± 0.3	14.5	96.6 ± 4.0
	20.0	21.1	105.7 ± 1.2	20.0	99.9 ± 0.6	20.6	103.1 ± 2.8
p,p′-DDE	-	N.D.	-	N.D.	-	N.D.	-
	10.0	9.7	97.2 ± 4.1	10.0	99.5 ± 0.1	9.8	97.6 ± 1.7
	15.0	14.8	98.5 ± 4.0	14.5	96.4 ± 0.4	15.0	100.2 ± 3.3
	20.0	21.5	107.3 ± 2.1	20.0	99.9 ± 0.2	20.6	102.9 ± 3.7
o,p′-DDD	-	N.D.	-	N.D.	-	N.D.	-
	10.0	9.2	92.5 ± 0.7	10.2	101.9 ± 1.3	10.1	101.1 ± 4.1
	15.0	15.8	105.1 ± 2.4	13.5	89.7 ± 1.7	13.8	92.3 ± 3.2
	20.0	20.1	100.6 ± 1.5	20.0	99.9 ± 0.5	20.3	101.5 ± 4.3
p,p′-DDD	-	N.D.	-	N.D.	-	N.D.	-
	10.0	9.0	90.2 ± 7.6	9.8	98.1 ± 4.4	9.9	99.1 ± 4.7
	15.0	13.9	92.4 ± 1.7	14.5	96.9 ± 0.2	14.7	98.0 ± 1.7
	20.0	21.2	106.2 ± 0.9	20.1	100.6 ± 1.9	19.3	96.6 ± 4.7

[a] Recovery, [b] Relative standard deviation, [c] Not detected

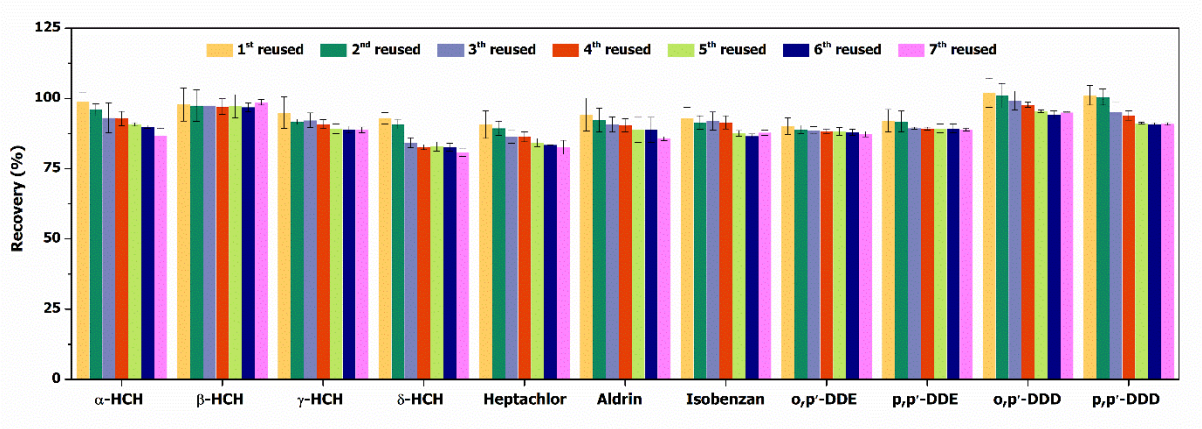

Fig. S6 Reusability of the sorbent MIH@MIL-101(Cr)-NH_2-TDES for the enrichment of organochlorine pesticides. The magnetic solid phase extraction conditions were as follows: sorbent, 45 mg; extraction time, 70 s; desorption time, 2.5 min; desorption solvent, 225 μL of acetone/ethyl acetate (1:2, v/v); and sample solution, 40 mL of OCP solution (1 μg L^{-1} of each) containing 5% (w/v) sodium chloride.

Table S9 Comparison of the proposed MSPE/GC–MS with other methods for the determination of OCPs.

Extractants[Ref.]	Method	Number of analytes	Matrix	Extraction time	Linear range	LODs	Recoveries (%)	RSDs (%)
CD-MOF/TiO_2[3]	D-SPE/GC–MS/MS	14	Honeys	5 min	1–500 ng·g^{-1}	0.01–0.04 ng g^{-1}	76.4–114.3	< 11.3
MFCNTs[4]	MSPE/GC-ECD	8	Honeys	40 min	0.02–80 μg·L^{-1}	1.3–3.6 ng L^{-1}	83.2–128.7	< 6.4
			Tea leaves				72.6–111.0	< 6.8
Porous polypropylene membrane[7]	UAE/GC–MS	13	Tea leaves	60 min	5–500 ng·g^{-1}	1.4–7.2 ng g^{-1}	86.1–100.3	< 16
Fe_3O_4@MIL-100 (Fe)[8]	MCMSPE/GC–MS	5	Tea leaves	40 s	13–2130 ng·g^{-1}	0.62–3.92 ng g^{-1}	81.5–113.6	< 9.9
Fe_3O_4-NH_2@MIL-101(Cr)[18]	MAE-MSPE/GC-ECD	8	Soils	5 min	0.50–80 ng·g^{-1}	0.15–0.28 ng·g^{-1}	71.2–102.4	< 4.9
M-M-ZIF-67[28]	MSPE/GC–MS/MS	9	Agricultural irrigation water	20 min	1–200 μg·L^{-1}	0.07–1.03 μg·L^{-1}	74.9–116.3	< 8.5
Fe_3O_4@PDA@Zr-SO_3H[29]	MSPE/GC-ECD	8	Environmental water	8 min	0.05–300 μg·L^{-1}	0.005–0.016 μg·L^{-1}	82–118	< 7.7
MIH@MIL-101(Cr)-NH_2-TDES[This study]	MSPE/GC–MS	11	Honey	70 s	0.1–1000 ng·g^{-1}	0.07–0.80 ng·g^{-1}	81.7–107.3	< 7.9
			Tea leaves		1.0–2500 ng·g^{-1}	0.7–8.5 ng·g^{-1}	85.4–109.3	< 8.2

CD-MOF/TiO_2: β- Cyclodextrin/metal organic framework grafted onto titanium dioxide
MFCNTs: Magnetic cobalt ferrite-filled carbon nanotubes
M-M-ZIF-67: Zeolitic imidazolate framework based on magnetic multiwalled carbon nanotubes
Fe_3O_4@PDA@Zr-SO_3H: metal organic framework functionalized with sulfonic acid combined with magnetic nanoparticles
D-SPE: dispersive solid phase extraction
MSPE: Magnetic solid phase extraction
UAE: Ultrasound-assisted extraction
MCMSPE: Mechanochemical magnetic solid phase extraction
MAE-MSPE: Microwave-assisted magnetic solid phase extraction