

Supplementary Material

Chlorpyrifos and its metabolites were determined by Agilent 1290 Infinity UPLC liquid chromatography system and Agilent 6550 iFunnel Q-TOF mass spectrometry. The total running time of liquid chromatography was 15 min, the injection volume was 5 μ L, and the flow rate was 0.3ml/min. A Waters BEH C18 2.1 \times 50mm (1.7 μ m) column was used for separation. The analyte was ionized by dynamic multiple reaction monitoring (MRM) using an electrospray ionization source. The MS parameters were set as follows: sheath temperature was 350°C and sheath gas flow rate was 12 L/min; The ESI+ mode voltage is 4000V, and the ESI- mode voltage is 3200V. Ms scanning range: m/z = 50-600. The gradient leaching procedure is shown in **Table S1**.

Table S1. Gradient drenching scheme

Time (min)	Phase A (%)	Phase B (%)
	0.1% Formic Acid in Ultrapure water	Methanol
0	95	5
1	95	5
9	0	100
13	0	100
14	95	5
15	95	5

Table S2. The location and assignments of FT-IR peaks.

Number	Location (cm ⁻¹)	Assignments	References
1	3000~3500	-OH deformation band	(M. Yang et al., 2021; Zhu et al., 2019)
2	1645	C=O stretching vibration	Elzinga et al., 2012
3	1360-1450	$\nu_{\text{S}}(\text{-COO})$	Elzinga et al., 2012
4	1051	C-OH, C-O-C, and C-C vibrations of polysaccharides	Elzinga et al., 2012
5	891	σ -OH	Oliveira et al., 2008
6	796	γ -OH	Oliveira et al., 2008
7	637	Fe-O	Oliveira et al., 2008

Table S3. XPS C1s fitting parameters of goethite before and after reactions.

Degradation stage		C-C/C=C	C-OH	C=O	O-C=O
2 Day	B. E. (eV)	284.64	285.63	287.02	288.80
	Per. (%)	33.49	21.28	5.71	1.81
10 Day	B. E. (eV)	283.82	285.40	287.00	/
	Per. (%)	8.55	7.47	2.89	/

Table S4. XPS O1s fitting parameters of Goethite before and after reactions.

Degradation stage		Fe-O	Fe-OH	H ₂ O
2 Day	B. E. (eV)	529.86	531.73	533.48
	Per. (%)	2.77	15.17	5.03
10 Day	B. E. (eV)	530.36	529.06	531.73
	Per. (%)	26.29	15.82	10.89

Table S5. XPS Fe (III) fitting parameters of goethite before and after reactions.

Degradation stage		Fe (III)					
		Fe 2p _{3/2}	Fe 2p _{1/2}	Fe 2p _{3/2}	Fe 2p _{1/2}	Satellite 1	Satellite 2
2 Day	B. E. (eV)	710.88	724.18	712.78	725.62	719.88	/
	Per. (%)	0.70	0.41	0.43	0.43	0.06	/
10 Day	B. E. (eV)	710.85	724.33	713.41	726.39	718.68	732.37
	Per. (%)	3.66	4.90	3.26	3.24	1.61	0.21

Table S6. XPS Fe (II) fitting parameters of goethite before and after reactions.

Degradation stage		Fe (II)					
		Fe 2p _{3/2}	Fe 2p _{1/2}	Fe 2p _{3/2}	Fe 2p _{1/2}	Satellite 1	Satellite 2
2 Day	B. E. (eV)	/	/	/	/	719.88	/
	Per. (%)	/	/	/	/	0.06	/
10 Day	B. E. (eV)	709.54	722.75	/	/	718.68	732.37
	Per. (%)	3.94	3.03	/	/	1.61	0.21