



*Supplement of*

**Measurement report: Effects of transition metal ions on the optical properties of humic-like substances (HULIS) reveal a structural preference – a case study of PM<sub>2.5</sub> in Beijing, China**

**Juanjuan Qin et al.**

*Correspondence to:* Jihua Tan (tanjh@ucas.ac.cn) and Xinming Wang (wangxm@gig.ac.cn)

The copyright of individual parts of the supplement might differ from the article licence.

## Summary of figures and tables

**Figure S1** The ratio spectra of mass absorption efficiency (MAE) for winter humic-like substances (HULIS) with addition of four transition metal ions under acidic, weakly acidic and neutral environment.

Page 2

5 **Figure S2** The ratio spectra of MAE for summer HULIS with addition of four transition metal ions under acidic, weakly acidic and neutral environment.

Page 2

**Figure S3** The excitation-emission matrix spectra of winter HULIS with addition of 0-500  $\mu\text{M}$   $\text{Cu}^{2+}$  under three acidity conditions.

10

Page 3

**Figure S4** The excitation-emission matrix spectra of summer HULIS with addition of 0-500  $\mu\text{M}$   $\text{Cu}^{2+}$  under three acidity conditions.

Page 3

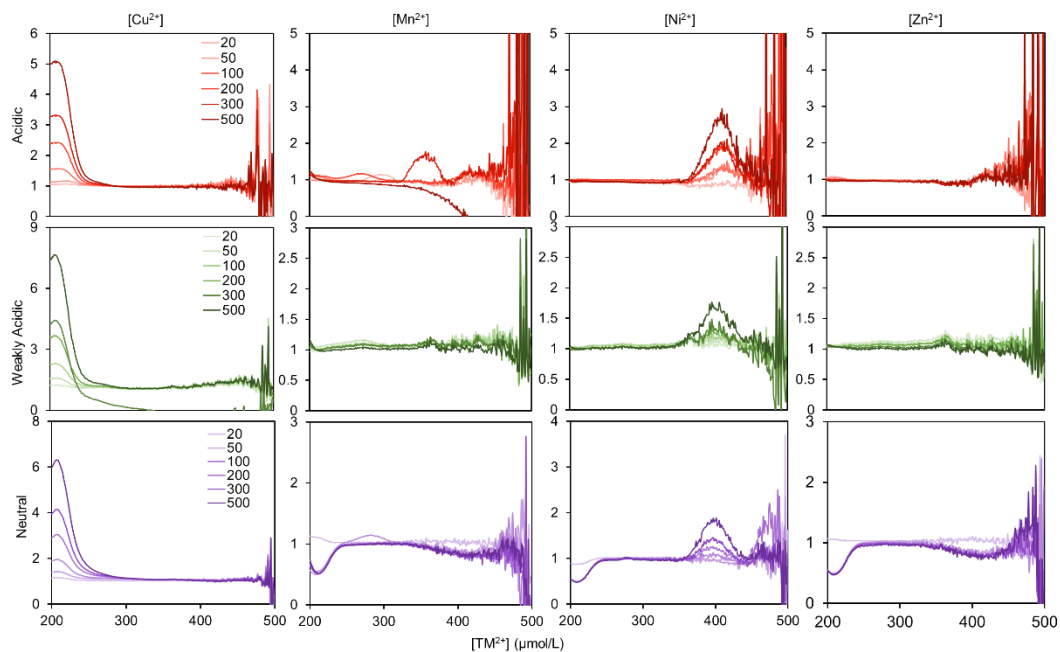
**Table S1** The Stern-volmer results for the PARAFAC results of TMs and winter HULIS.

15

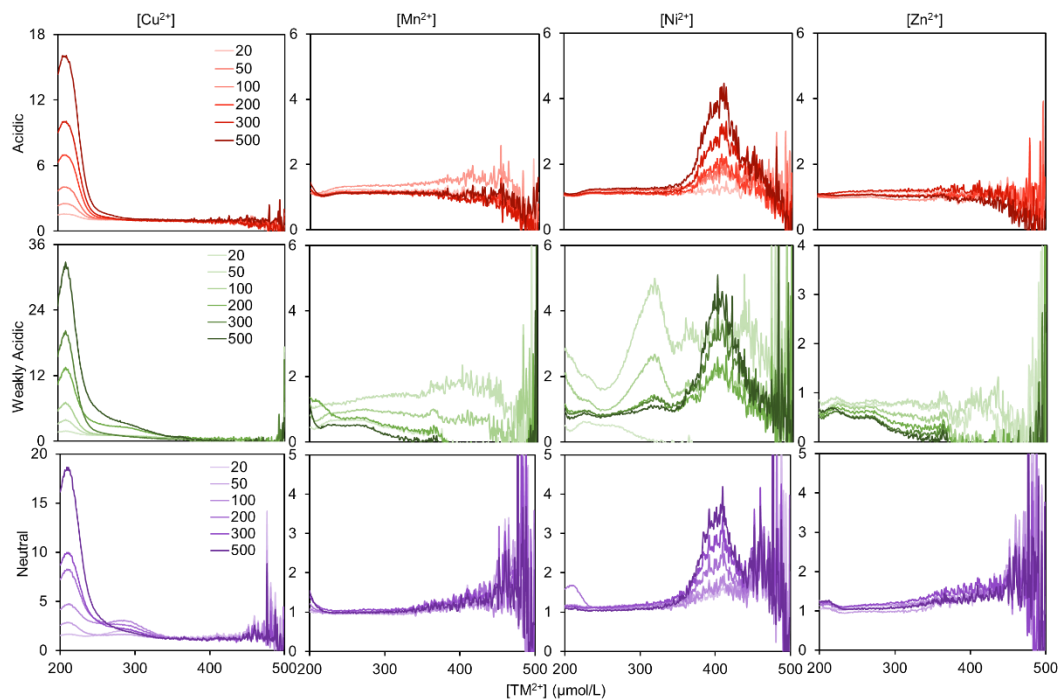
Page 4

**Table S2** The Stern-volmer results for the PARAFAC results of TMs and summer HULIS.

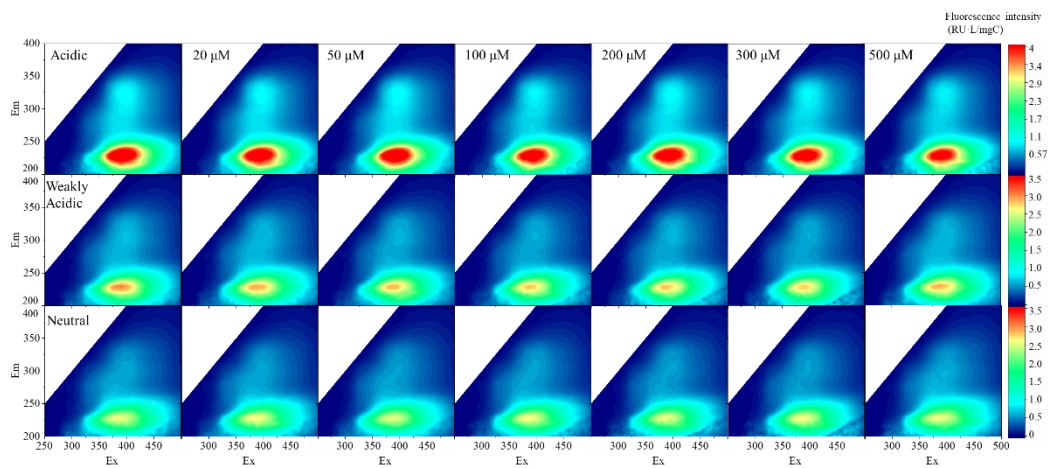
Page 4



20 **Figure S1** The ratio spectra of mass absorption efficiency (MAE) for winter humic-like substances (HULIS) with addition of four transition metal ions under acidic, weakly acidic and neutral conditions.

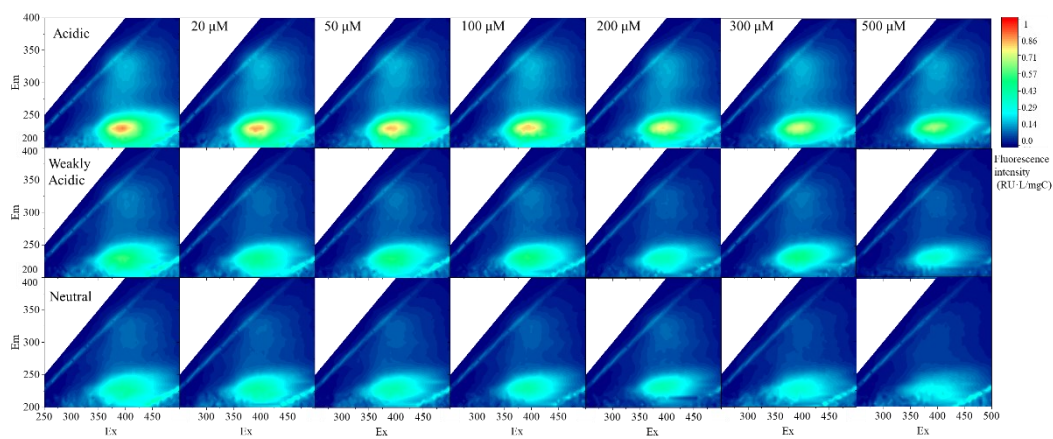


**Figure S2** The ratio spectra of MAE for summer HULIS with addition of four transition metal ions under acidic, weakly acidic and neutral conditions.



25

**Figure S3** The excitation-emission matrix spectra of winter HULIS with addition of 0-500  $\mu\text{M}$   $\text{Cu}^{2+}$  under three acidity conditions.



**Figure S4** The excitation-emission matrix spectra of summer HULIS with addition of 0-500  $\mu\text{M}$   $\text{Cu}^{2+}$  under three acidity conditions.

30

**Table S1 The Stern-volmer results for the PARAFAC results of TMs and winter HULIS.**

Acidity	Components	Cu <sup>2+</sup>		Mn <sup>2+</sup>		Ni <sup>2+</sup>		Zn <sup>2+</sup>	
		<i>k</i> ·10 <sup>3</sup>	<i>R</i> <sup>2</sup>	<i>k</i> ·10 <sup>3</sup>	<i>R</i> <sup>2</sup>	<i>k</i> ·10 <sup>3</sup>	<i>R</i> <sup>2</sup>	<i>k</i> ·10 <sup>3</sup>	<i>R</i> <sup>2</sup>
Acidic	C1	0.60	0.98	0.08	0.94	0.09	0.97	0.10	0.87
	C2	-0.04	0.11	0.10	0.72	0.07	0.63	0.04	0.47
	C3	-0.30	0.99	0.09	0.88	0.10	0.97	0.03	0.52
	C4	1.90	0.97	0.10	0.43	0.10	0.33	0.40	0.69
Weakly Acidic	C1	0.04	0.12	-0.05	0.15	0.03	0.05	0.01	0.02
	C2	0.20	0.84	0.20	0.93	0.10	0.98	0.05	0.73
	C3	0.30	0.83	0.10	0.96	0.20	0.98	0.07	0.68
	C4	0.20	0.27	0.03	0.05	0.09	0.48	0.10	0.64
Neutral	C1	0.50	0.99	0.10	0.58	0.20	0.48	0.10	0.64
	C2	0.30	0.94	0.08	0.55	0.09	0.55	0.08	0.36
	C3	0.01	0.01	0.10	0.73	0.20	0.88	0.06	0.44
	C4	1.50	0.97	0.10	0.62	0.20	0.57	0.09	0.76

**Table S2 The Stern-volmer results for the PARAFAC results of TMs and summer HULIS.**

Acidity	Components	Cu <sup>2+</sup>		Mn <sup>2+</sup>		Ni <sup>2+</sup>		Zn <sup>2+</sup>	
		<i>k</i> ·10 <sup>3</sup>	<i>R</i> <sup>2</sup>	<i>k</i> ·10 <sup>3</sup>	<i>R</i> <sup>2</sup>	<i>k</i> ·10 <sup>3</sup>	<i>R</i> <sup>2</sup>	<i>k</i> ·10 <sup>3</sup>	<i>R</i> <sup>2</sup>
Acidic	C1	0.60	0.98	0.10	0.38	0.01	0.01	-0.20	0.09
	C2	1.30	0.98	0.20	0.18	0.50	0.16	-0.40	0.58
	C3	0.70	0.99	0.10	0.73	0.09	0.15	-0.06	0.01
	C4	-0.90	0.95	0.05	0.00	1.60	0.81	0.10	0.04
Weakly Acidic	C1	1.00	0.72	0.10	0.01	-0.8	0.58	-0.40	0.07
	C2	1.20	0.92	0.06	0.13	0.05	0.03	-0.10	0.65
	C3	0.60	0.73	0.10	0.04	-0.10	0.29	-0.20	0.11
	C4	-0.30	0.56	0.05	0.08	0.20	0.71	0.04	0.23
Neutral	C1	0.40	0.33	0.03	0.01	-0.10	0.05	-0.60	0.12
	C2	1.20	0.95	0.10	0.49	-0.01	0.01	0.20	0.19
	C3	0.30	0.61	-0.02	0.01	0.20	0.68	-0.40	0.39
	C4	-0.50	0.97	-0.05	0.00	0.10	0.43	-0.20	0.36