

Supporting Information

A pyrazine structured metal-organic framework for selective removal of copper
from strongly acidic solutions

Key Laboratory of Jiangxi Province for Persistent Pollutants Control and Resources Recycle,
National-Local Joint Engineering Research Center of Heavy Metals Pollutants Control and
Resource utilization, Nanchang Hangkong University, Nanchang 330063, China

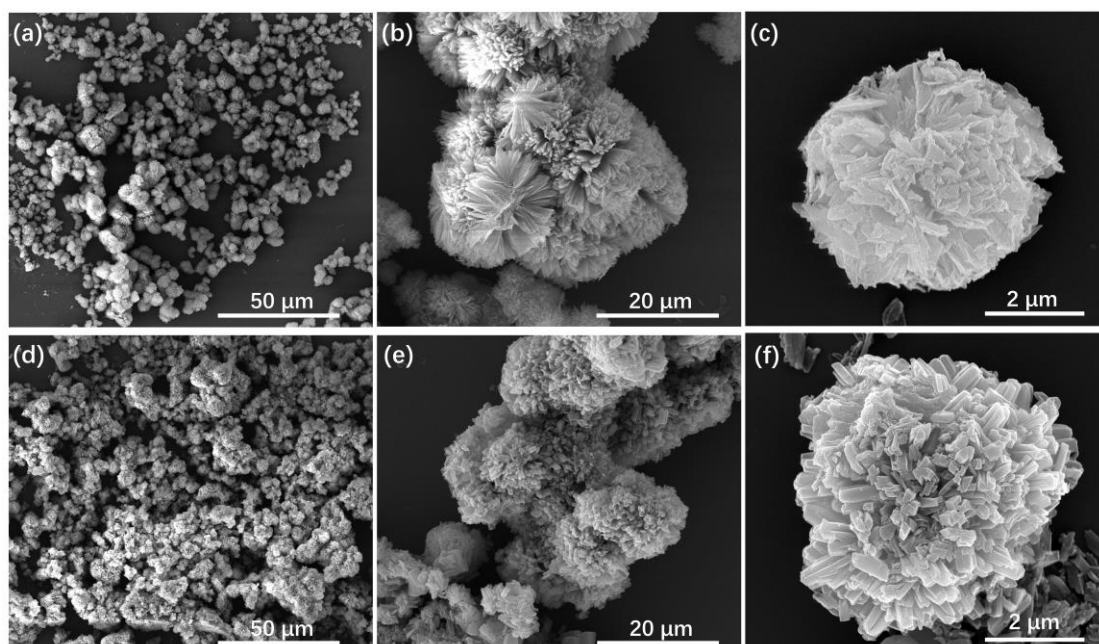


Fig. S1 SEM images of (a-c) pz-UiO-66 and (e-f) pz-UiO-66-Cu at different magnifications.

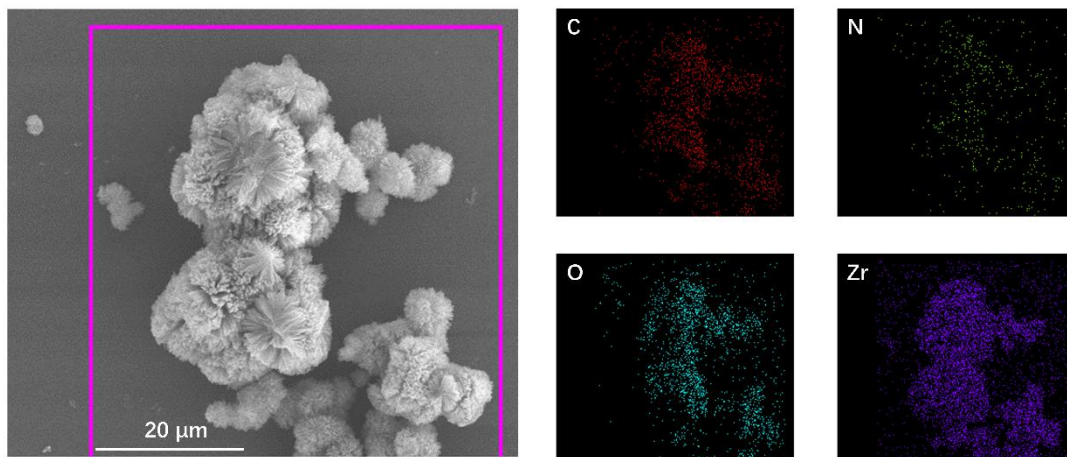


Fig. S2 The expanded SEM image and energy-dispersive X-ray spectroscopy (EDS) analyses with area-scan on pz-UiO-66.

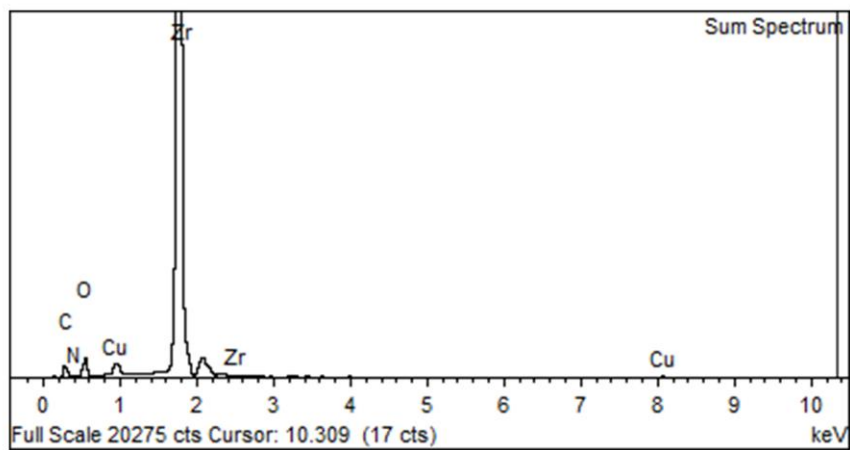


Fig. S3 EDS imagine of pz-UiO-66-Cu.

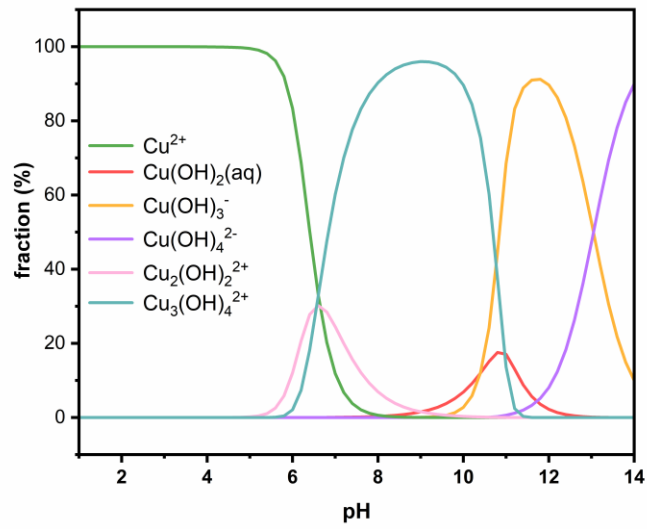


Fig. S4 Morphological distribution of Cu(II) in water under different pH conditions

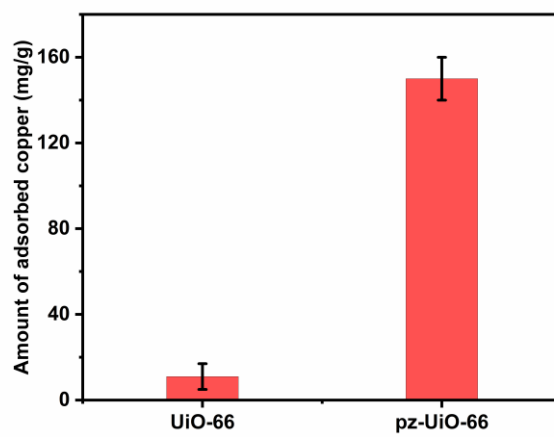


Fig. S5 Adsorption capacity of UiO-66 and pz-UiO-66 for copper

Table S1 EDS element analysis of pz-UiO-66-Cu.

Element	Weight (%)	Atomic (%)
C	27.43	45.86
N	7.26	10.41
O	27.36	34.34
Cu	10.90	3.45
Zr	27.04	5.95
Totals	100	

Physicochemical characteristics of adsorbents in this work

Table S2 Physicochemical characteristics of pz-UiO-66.

Adsorbent	BET (m ² /g)	Pore Volume (cm ³ /g)	Pore Size (nm)
pz-UiO-66	149.63	0.1943	0.4875

Table S3 Adsorption isotherm parameters for adsorption of Cu²⁺ onto pz-UiO-66.

Adsorbent	Langmuir			Freundlich		
	Q_m	K_L	R^2	n	K_F	R^2
pz-UiO-66	247	0.00446	0.982	2.904	169.63	0.955

Table S4 Comparison of the maximum adsorption capacity of Cu²⁺ with the adsorbents reported in the literature.

Adsorbents	Q_m (mg/g)	pH	Ref.
CEAD	111.8	4	(Chen et al., 2013)
D001-PEI	99	5	(Chen et al., 2010)
PLLA nanofibers	111.7	7	(Zia et al., 2020)
EDTB	110.4	4	(Zhu et al., 2015)
Si-AMP-M-H	49.6	4	(Bai et al., 2012)
NFC/PEI	175.4	5	(Li et al., 2018)
M4195	56.66	2	(Kołodźńska et al., 2014)
TP-220	94.20	2	
CNP	62.3	1	(Wang et al., 2020)
pz-UiO-66	247	1	This work

Table S5 Adsorption kinetic parameters for adsorption of Cu²⁺ onto pz-UiO-66.

Adsorbent	Pseudo-first-order			Pseudo-second-order			
	Q_m	K_1	R^2	Q_m	K_2	R^2	h_0
pz-UiO-66	112.5	0.0946	0.972	125.8	9.877×10^{-4}	0.996	15.63

Thermodynamic investigations

20 mg pz-UiO-66 was added to a 100 mL conical flask containing 50 mL of 200 mg/L Cu^{2+} solution and shaken for 2 h at the 298 K, 308 K and 318 K.

Table S6 Thermodynamic parameters of the adsorption for Cu^{2+} onto CEAD.

Metal ion	ΔH° (kJ/mol)	ΔS° (J/K/mol)	ΔG° (kJ/mol)		
			298 K	308 K	318 K
Cu^{2+}	15.28	108.66	-17.09	-18.18	-19.26

References

Bai L, Hu H, Zhang W, Fu J, Lu Z, Liu M, Jiang H, Zhang L, Chen Q, Tan P (2012). Amine/acid catalyzed synthesis of a new silica-aminomethyl pyridine material as a selective adsorbent of copper. *Journal of Materials Chemistry*, 22(33): 17293-17301

Chen T, Liu F, Ling C, Gao J, Xu C, Li L, Li A (2013). Insight into highly efficient coremoval of copper and p-nitrophenol by a newly synthesized polyamine chelating resin from aqueous media: competition and enhancement effect upon site recognition. *Environmental Science & Technology*, 47(23): 13652-13660

Chen Y, Pan B, Li H, Zhang W, Lv L, Wu J (2010). Selective removal of Cu (II) ions by using cation-exchange resin-supported polyethyleneimine (PEI) nanoclusters. *Environmental Science & Technology*, 44(9): 3508-3513

Kołodzyńska D, Sofińska-Chmiel W, Mendyk E, Hubicki Z (2014). DOWEX M 4195 and LEWATIT®MonoPlus TP 220 in Heavy Metal Ions Removal from Acidic Streams. *Separation Science and Technology*, 49(13): 2003-2015

Li J, Zuo K, Wu W, Xu Z, Yi Y, Jing Y, Dai H, Fang G (2018). Shape memory aerogels from nanocellulose and polyethyleneimine as a novel adsorbent for removal of Cu(II) and Pb(II). *Carbohydr Polym*, 196: 376-384

Wang L L, Ling C, Li B S, Zhang D S, Li C, Zhang X P, Shi Z F (2020). Highly efficient removal of Cu(ii) by novel dendritic polyamine-pyridine-grafted chitosan beads from complicated salty and acidic wastewaters. *RSC Adv*, 10(34): 19943-19951

Zhu C, Liu F, Xu C, Gao J, Chen D, Li A (2015). Enhanced removal of Cu(II) and Ni(II) from saline solution by novel dual-primary-amine chelating resin based on anion-synergism. *J Hazard Mater*, 287: 234-242

Zia Q, Tabassum M, Lu Z, Khawar M T, Song J, Gong H, Meng J, Li Z, Li J (2020). Porous poly(L-lactic acid)/chitosan nanofibres for copper ion adsorption. *Carbohydr Polym*, 227: 115343