Supplemental Material for

Magnetic nanostructures functionalized with a derived lysine coating applied to simultaneously remove heavy metal pollutants from environmental systems

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Details of chemicals and reagents used:

$FeSO_4$ $7H_2O$, NaOH (> 98%), NH_4OH (25% aqueous solution) and acetone (≥ 99.5%) were obtained from Honeywell (Seelze, Germany). $Fe_2(SO_4)_3$ $7H_2O$, tetraethylorthosilicate (TEOS, ≥98%), HCl (≥ 37%), L-lysine crystallized (≥98%) and 3-glycidoxypropyltrimethoxysilane (GOPTS, 98%) were ordered from Sigma-Aldrich (Taufkirchen, Germany). Citric acid (≥ 99.5%, water free) was purchased from Roth (Karlsruhe, Germany) and absolute EtOH (anhydrous) was obtained from CarloErba (Val de Reuil, France). All reagents were used as received, without additional purification. Ultrapure water (sourced from Milli-Q, Millipore Corporation, Massachusetts, USA, with a resistivity of 18.2 MΩ cm) was used in all experiments.

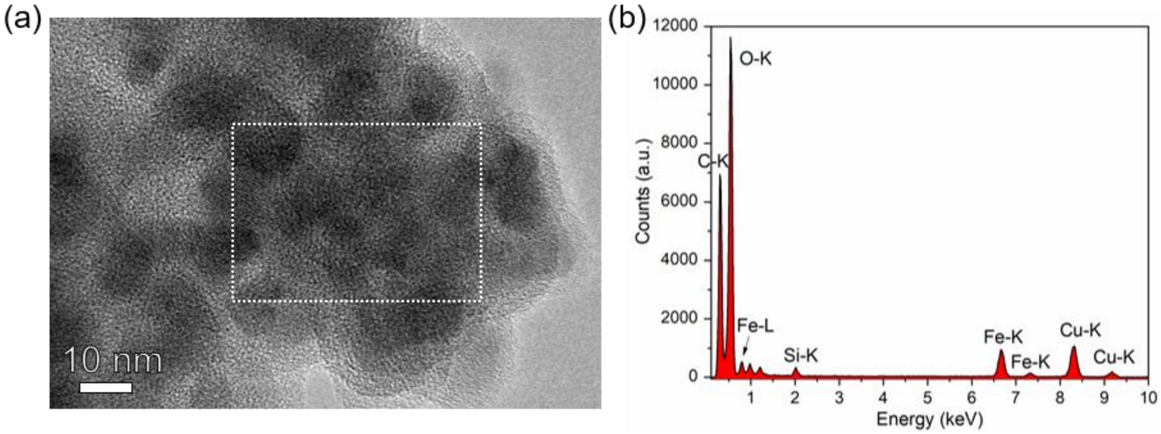

Figure S1: TEM image of MNPs@SiO2@GOPTS-Lys with white square (a) enclosed, indicating where the corresponding EDXS was acquired, and the results of this are shown in (b). The presence of Cu is due to a Cu-supported film.

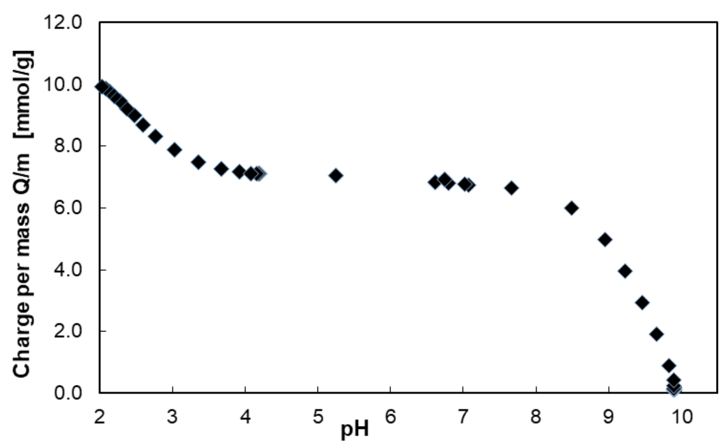

Figure S2: Potentiometric titration curve of derivatised lysine.

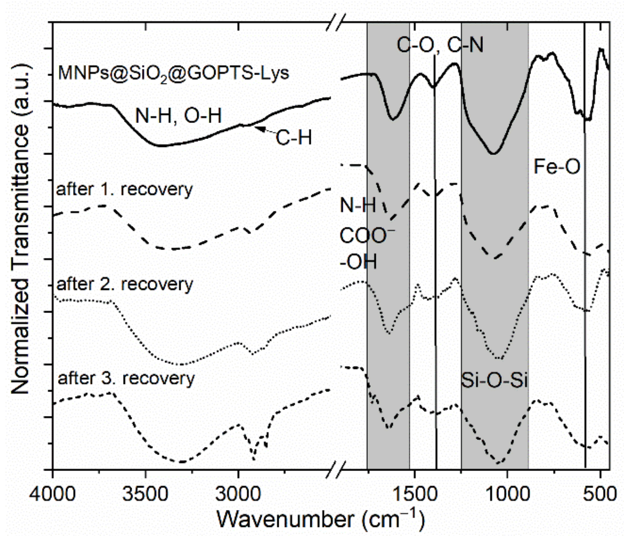

Figure S3: ATR-FTIR spectrum of the initial MNP@SiO_2@GOPTS-Lys and its comparison after different recovery/regeneration steps.

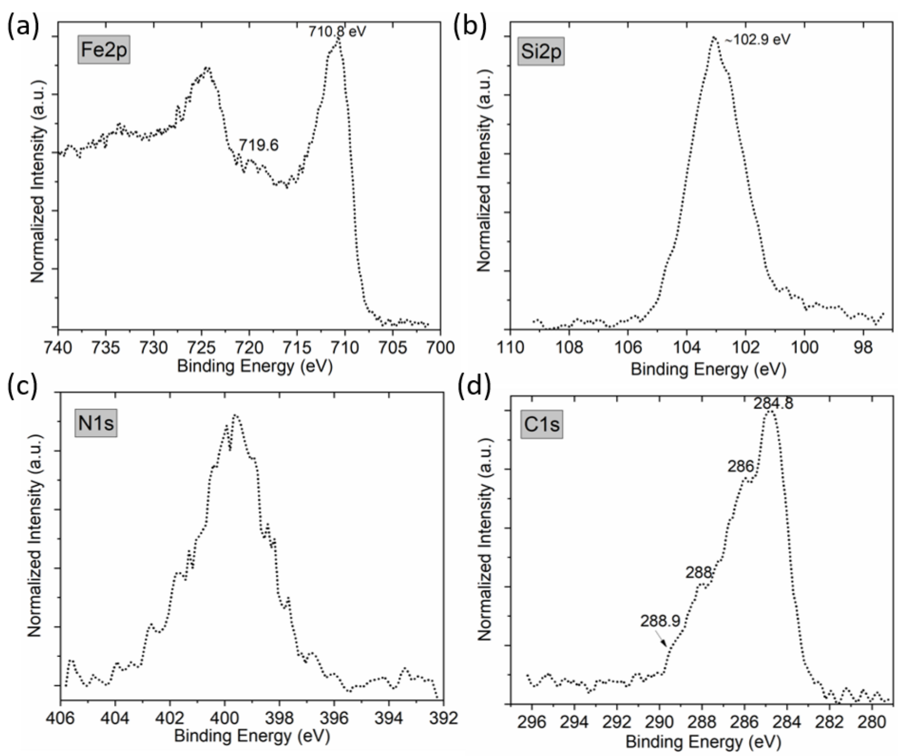

Figure S4: High-resolution spectra of a) Fe 2p b) Si 2p, c) N 1s and d) C 1s of MNPs@SiO_2@GOPTS-Lys.

Table S1. Comparison of MNPs@SiO_2@GOPTS-Lys adsorption capacities to other Zn, Cu and Cr adsorbents removal.

Adsorbent materials	pH of adsorption	Real/model system	Adsorption capacity (mg/g)				References
			Zn	**Cu**	**Cr**	**Σmetals**	
Crosslinked chitosan with epichlorohydrin	7	Model individual metal aqueous system	10.2	35.5	NR	/	[1]
Fe_3O_4/MnO_2	6.3	Model individual metal aqueous system	8.1	9.8	NR	/	[2]
Potato peel charcoal	6	Model individual metal aqueous system	NR	0.39	NR	/	[3]
MWCNTs	9	Model individual metal aqueous system	NR	3.49	NR	/	[4]
Mesoporous magnetic carbon nanocomposite fabrics	7	Model individual metal aqueous system	NR	NR	3.74	/	[5]
Magnetic Graphene nanocomposites decorated with core@double-shell nanoparticles	7	Model individual metal aqueous system	NR	NR	1.03	/	[6]
Xanthate-modified magnetic chitosan	5	Ternary metal system in model aqueous solution	7.6	26.3	NR	62.5	[7]
Micron Fe	3	Heavily contaminated groundwater and	NR	NR	1.33-2.16	/	[8]

		chromium ore processing residue samples					
Micron Fe	3	Heavily contaminated groundwater	NR	NR	1.53-1.75	/	[8]
C-phenylcalix[4]pyrogallolarene	5	Model individual metal aqueous system	NR	8.140	16.86	/	[9]
Magnetic-chitosan nanoparticles	10-11	Simultaneous removal from real sludge suspension	96.2	10.1	NR	134.7	[10]
nZVI-Fe_3O_4	3	Model individual metal aqueous system	NR	NR	100	NR	[11]
Nanoscale Zero-Valent Iron (nZVI) assembled on magnetic Fe_3O_4/graphene	8	Model individual metal aqueous system	NR	NR	66.2	NR	[12]
MNPs@SiO_2@GOPTS-Lys	**10.7**	**Simultaneous removal from real sludge suspension**	**17.2**	**4.8**	**3.9**	**24.5**	**This work**

Supplemental References

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