Synthesis of Sustainable Guar gum-*g*-(Acrylic Acid-*co*-Acrylamide-*co*-3-Acrylamido Propanoic Acid) Interpenetrating Polymer Network via *in situ* Attachment of 3-Acrylamido Propanoic Acid for Analyzing Superadsorption Mechanism of Pb(II)/Cd(II)/Cu(II) and Dyes: Comparative Studies of Microstructures

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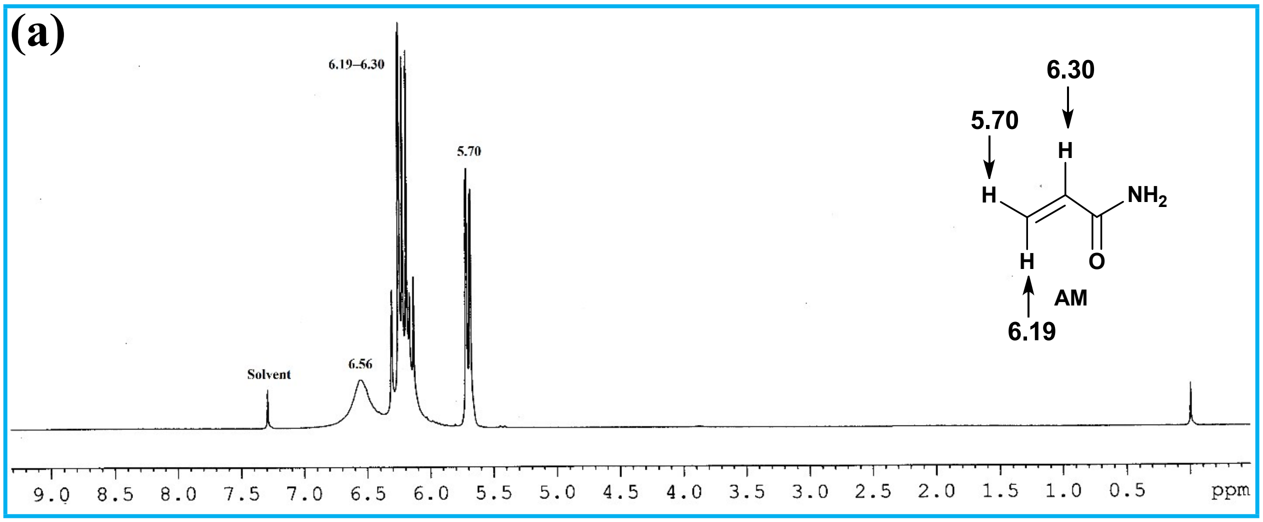

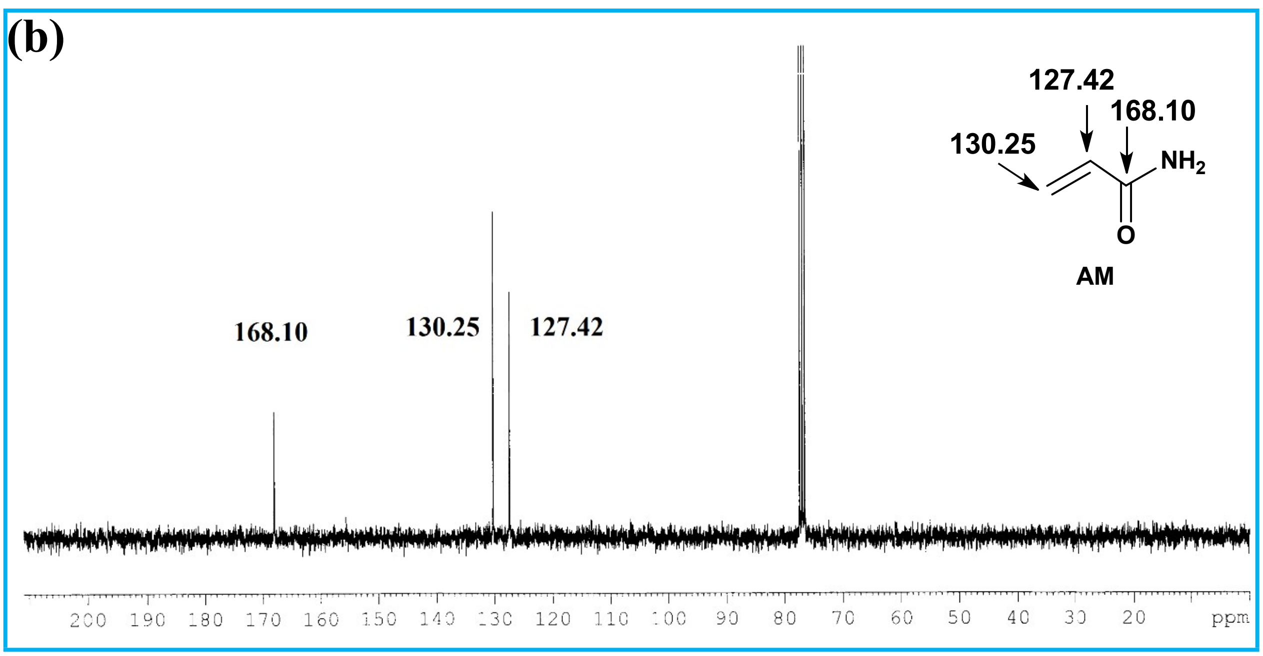

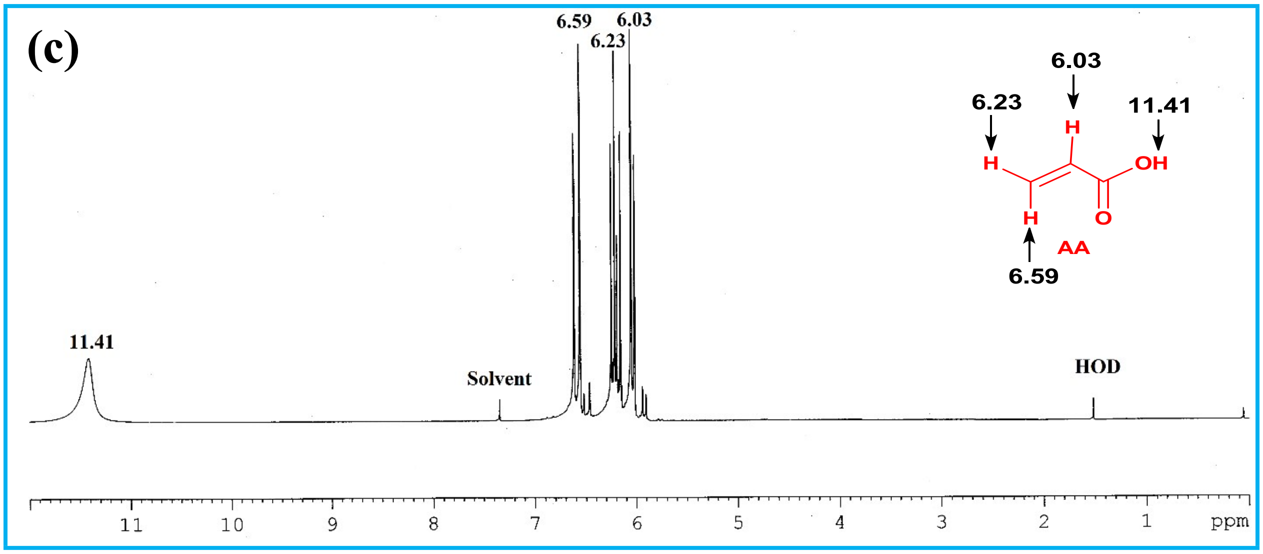
(c)
6.59
6.23
6.03
11.41
Solvent
HOD
6.23
6.03
11.41
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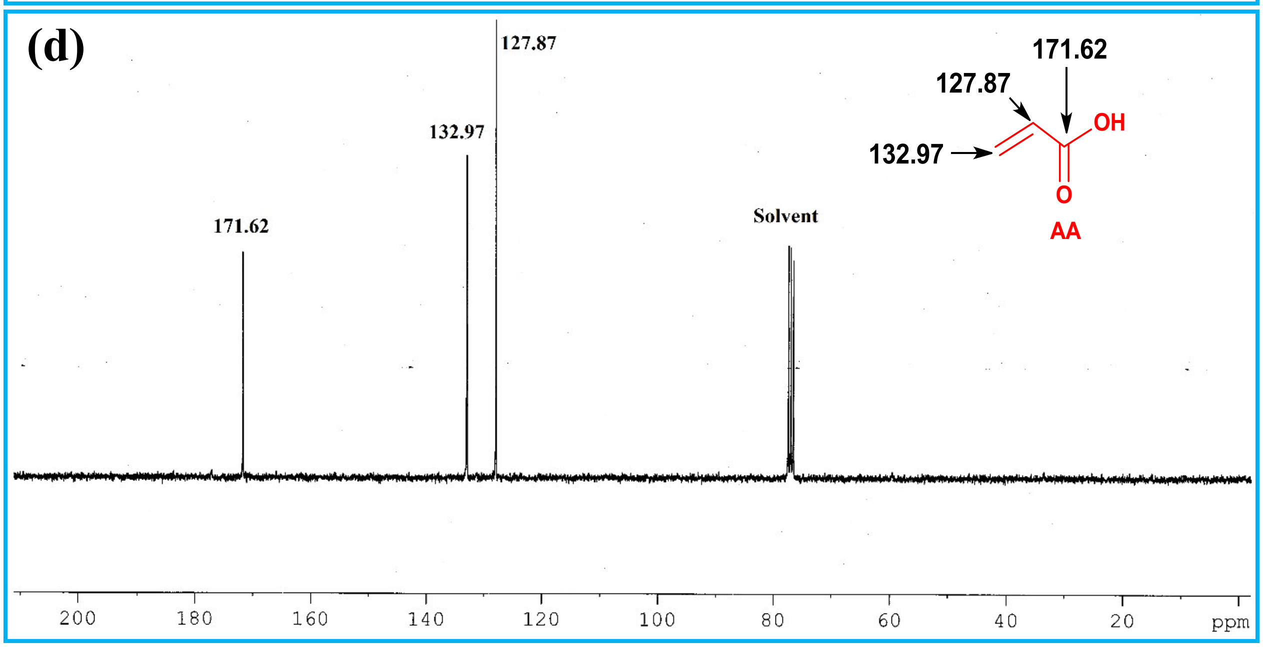
H
OH
H
O
AA
6.59
11
10
9
8
7
6
5
4
3
2
1
ppm


(d)
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132.97
171.62
Solvent
171.62
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OH
132.97
O
AA
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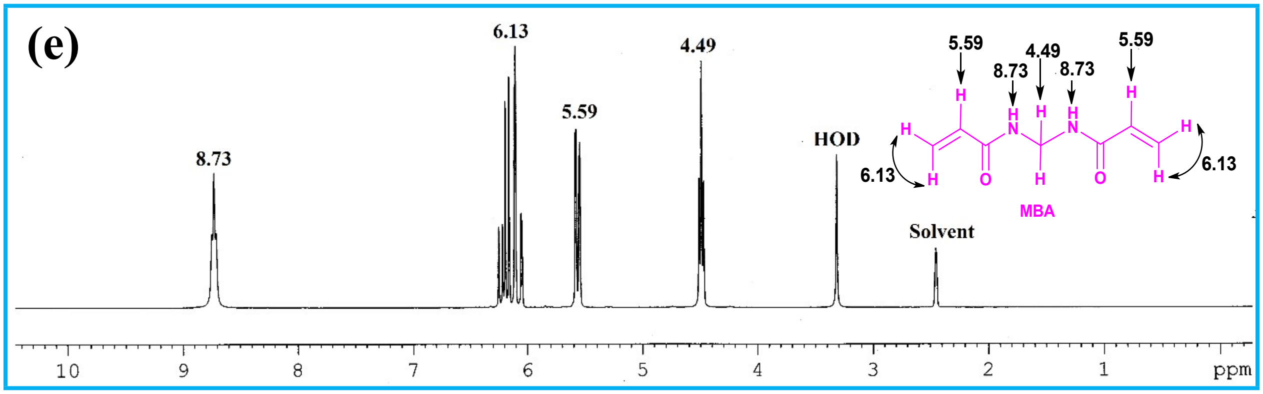
180
160
140
120
100
80
60
40
20
ppm



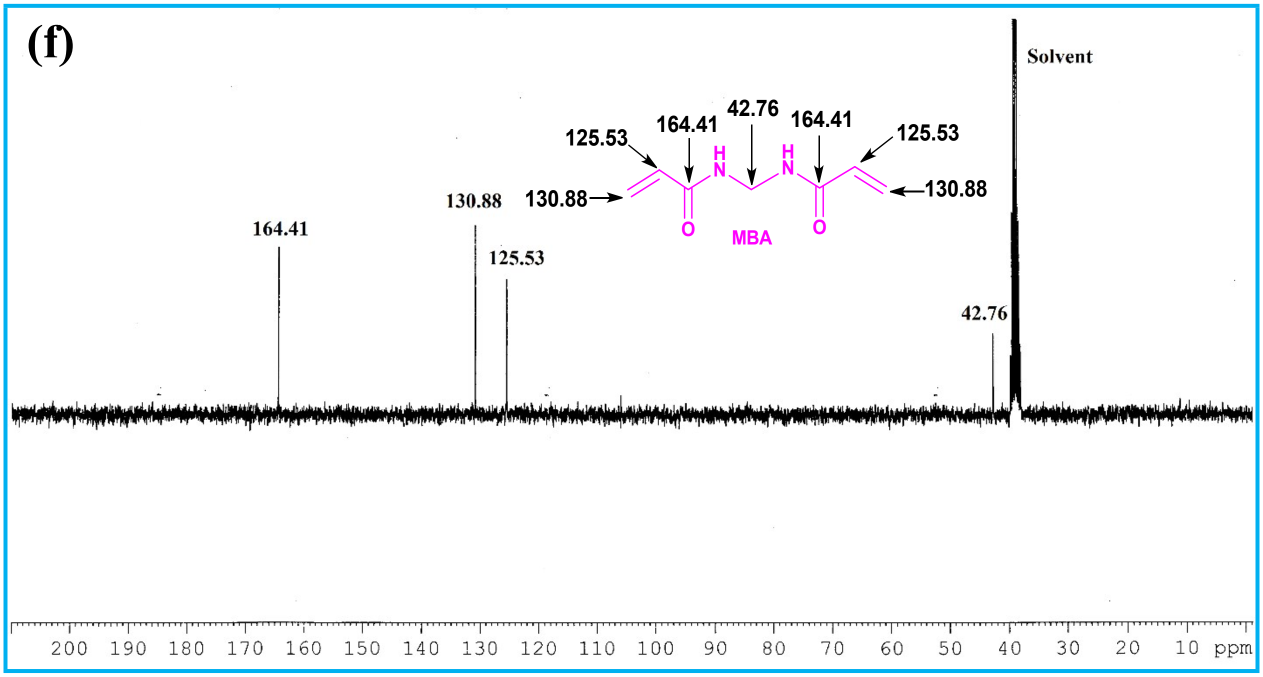


Fig. S1 ^{1}H-NMR of (a) AM, (c) AA and (e) MBA and ^{13}C-NMR of (b) AM, (d) AA and (f) MBA

Adsorption isotherm models

Adsorption isotherm data were fitted to the following isotherm models

$$q_e = q_{\max} \frac{k_L C_e}{1 + k_L C_e} \quad \text{(S1)}$$

$$q_e = k_F C_e^{1/n} \quad \text{(S2)}$$

$$q_e = q_{BET} \frac{k_1 C_e}{(1 - k_2 C_e)(1 - k_2 C_e + k_1 C_e)} \quad \text{(S3)}$$

Here, k_L, k_F, k_1 and k_2 are the corresponding isotherm constants and q_{max}, n and q_{BET} are the corresponding isotherm parameters.

Adsorption kinetics study

Adsorption kinetics data were fitted to the following pseudosecond and pseudofirst order kinetics models.

$$q_t = q_e \left(1 - \frac{1}{1 + k_2 q_e t} \right) \quad \text{(S4)}$$

$$q_t = q_e [1 - \exp(-k_1 t)] \quad \text{(S5)}$$

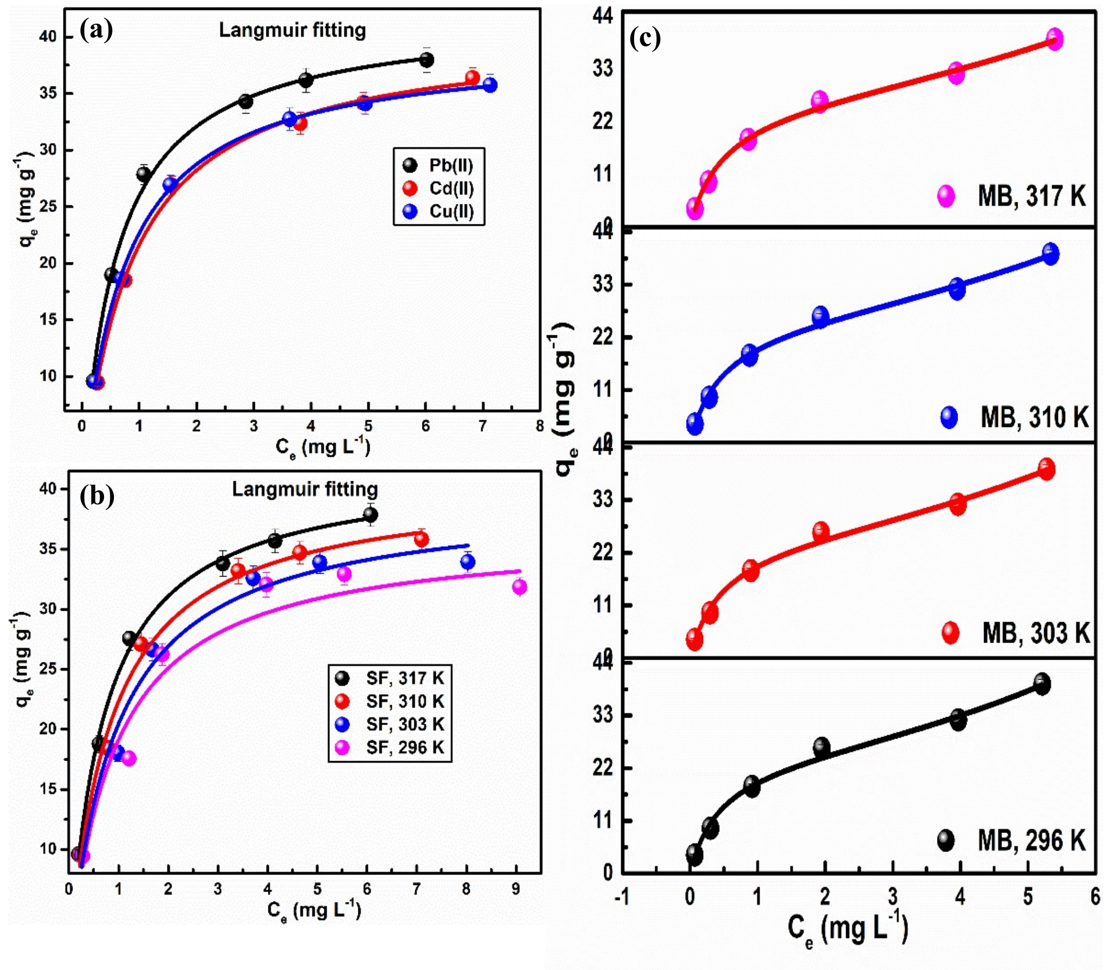


Fig. S2 (a) Langmuir fitting for Pb(II), Cd(II), Cu(II) and (b) SF and (c) BET isotherm fitting for MB

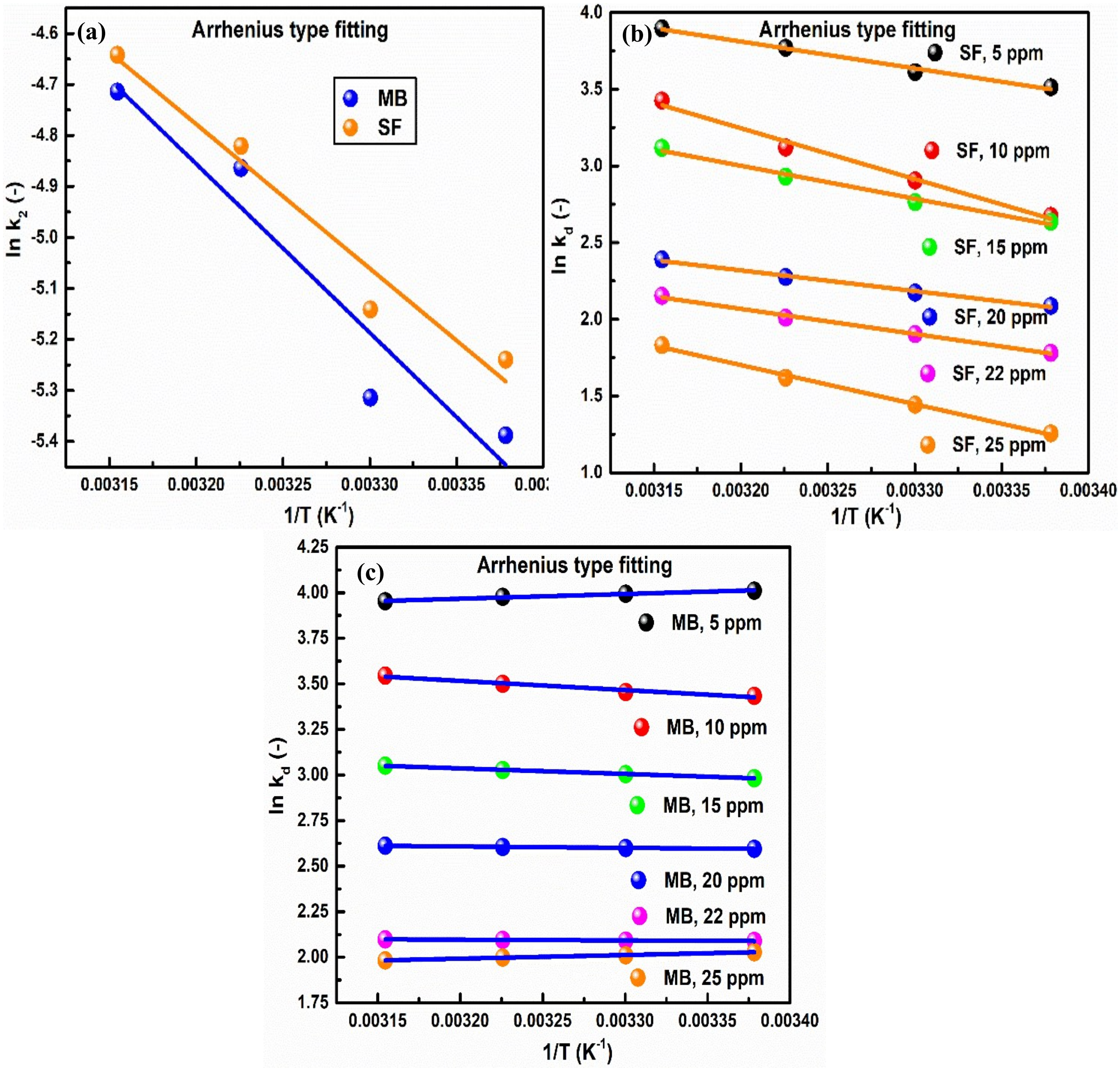


Fig. S3 ln k_2 vs. 1/T for (a) MB and SF and ln k_d vs. 1/T plots for (b) SF and (c) MB

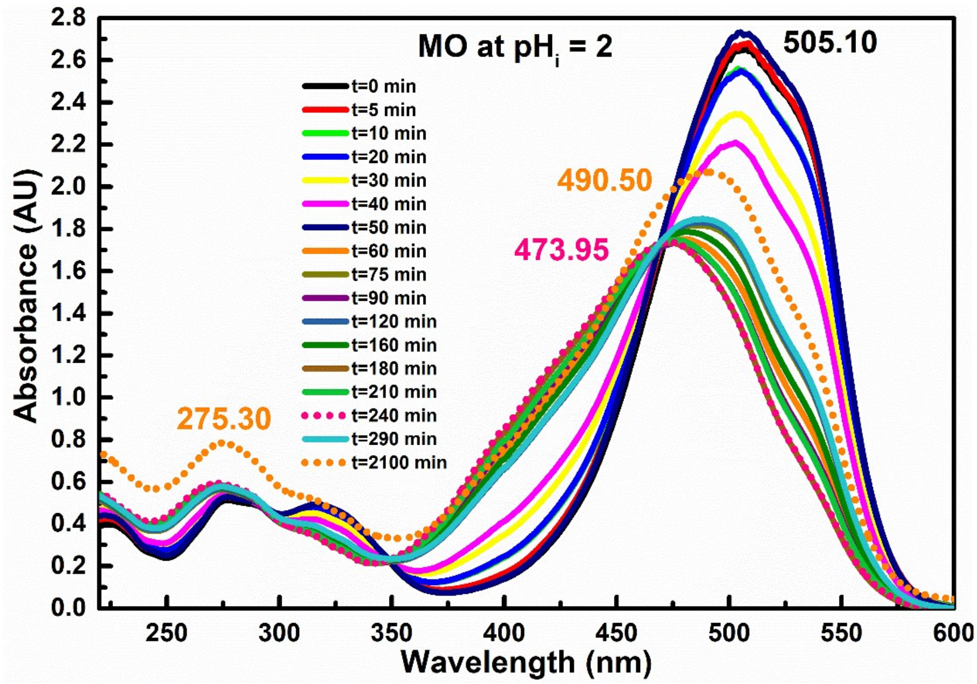


Fig. S4 Full scan kinetics data of MO adsorption at pH_i = 2

Table S1. Comparison of the results

Dyes/M(II)	Name of the adsorbents	Adsorption capacities (mg g^{-1}) /pH/C_0 (mg L^{-1})/temperature (K)	Ref.
MB	PNIPAAm[a]	8.50/6.5–6.7/10–50/298	S1
	PNIPAAm/IA[b]	17.52/6.5–6.7/10–50/298	S1
	PNIPAAm/IA/pumice	22.18/6.5–6.7/10–50/298	S1
	Cu-BTC[c]	15.28*/7.0/1–10#/298	S2
	BC-PM[d] microparticles	25/6.5/500/298	S3
	IPNS[e]	16.97/11.0/5–30/303	S4
	IPNS[e]	137.43/11.0/200–300/303	S4
	MIL-53(A1)-NH_2[f]	45.20/7.0/5/–	S5
	Br/Mo heterostructures	54.82/4.0/30–70/–	S6
	MCGO[g]	70.03/1.5–12.0/70/298	S7
	h-XG/SiO_2[h]	497.50/8.0/400/323	S8
	GGAAAMAPA[i]	**27.06/9.0/5–25/303**	**TS^**
SF	AC[j]	1.32/5.0/25/298	S9
	Hydrogels prepared with sodium polyacrylate and 6 wt. % of CM	9.45/–/10/–	S10
	CO_2 neutralized activated red mud	9.77/8.3/37.3/302	S11
	Native SBP[k]	17.90/10.0/100/293	S12
	AC[j]	19.01/6.0/10/–	S13
	Pinapple peels	21.70/6.0/60/302	S14
	Cu-NWs-AC[l]	34.00/5.5/15/–	S15
	NaOH-treated rice husk	37.97/8.0/10/303	S16
	CuO-NPs[m]	53.67/12.0/154/303	S17
	PDA@SBP[n]	54.00/10.0/100/293	S12
	HDTMA[o]-modified Spirulina sp.	54.05/2.0/300/–	S18
	MIL-101(Cr)-SO_3H	70.80/6.2/50/–	S19
	Al-Mont-EnPILC[p]	76.13/10.0/100/295	S20
	SDS/RM[q]	89.40/4.0/50/308	S21
	MDMLG[r]	137.53/12.0/105/–	S22
	GGAAAMAPA[i]	**39.35/9.0/5–25/303**	**TS^**
Pb(II)	Bare Malachite Nanoparticle	7.2/5.0–6.0/10–100/–	S23
	Kaolinite	11.50/5.7/10–50/303	S24
	Jordanian kaolinite	13.32/5.0/50–400/295	S25
	Montmorillonite	31.10/5.7/10–50/303	S24
	Lemon peel	37.87/5.0/100–300/301	S26
	IPNS[e]	54.86/7.0/5–30/303	S4
	APAN[s]	60.6/4.0/40–1000/303	S27
	GGAAAMAPA[i]	**41.98/7.0/5–25/303**	**TS^**
Cd(II)	RGO[t]-Fe(O)/Fe_3O_4	1.91/7.0/2–6/298	S28
	Dithiocarbamated-sporopollenin	7.09/7.0/15/293	S29
	Dead T. viride	10.95/6.0/26/320	S30
	BiOBr microsphere	11.70/7.0/29/298	S31
	Polyaniline grafted chitosan	12.87/6.0/20–40/303	S32
	GO[u]	14.90/5.6/–/–	S33
	Garden grass	17.60/4.0/50/303	S34
	Functionalized graphene (GNS[C8P])	30.05/6.2/–/–	S35
	Si-DTC[v]	43.47/7.0/100/298	S36
	GO-TiO_2	72.80/5.6/–/–	S33

	Functionalized graphene (GNS^{PF6})	73.42/6.2/–/–	S35
	Dithiocarbamate-anchored polymer/organosmectite composites	82.20/7.0/50/293	S37
	MGO[w]	91.29/6.0/200/298	S38
	Biomass of nonliving, dried brown marine algae *Sargassum natans*, *Fucus vesiculosus*, and *Ascophyllum nodosum*	100.00/3.5/100/–	S39
	Polyvinyl alcohol-chelating sponge	125.11/5.5/560/293	S40
	CS-co-MMB-co-PAA[x]	135.51/4.5–5.5/300/–	S41
	GO[u]	167.50/6.0/–/333	S42
	Mesoporous MCM-41	210.96/7.0/250/298	S43
	ANMP derived from PCBs[y]	230.06/3.5/450/293	S44
	GGAAAMAPA[i]	**40.55/7.0/5–25/303**	**TS^**
Cu(II)	Copper-imprinted polymethacrylate porous beads	2.00/6.5/5–100/298	S45
	Bare Malachite Nanoparticle	3.20/5.0–6.0/10–100/–	S23
	Cu(II) ion-imprinted poly(methacrylic acid/vinyl pyridine) micro-particles	15.04/6.2/10/–	S46
	P(NIPAM-MA-VI)[z]	21.10/5.0/–/333	S47
	Cu(II)-imprinted poly(methacrylic acid/vinyl pyridine) polymer	22.40/7.0/2.5–70/298	S48
	Fe_3O_4@SiO_2-Cu(II)-imprinted polymer	24.20/7.0/80/298	S49
	Cu(II)-imprinted poly(chitosan/attapulgite)	35.20/1.0–6.0/40/298	S50
	IPNS[e]	53.86/7.0/5–30/303	S4
	Lemon peel	70.92/5.0/100–300/301	S26
	GGAAAMAPA[i]	**39.42/7.0/5–25/303**	**TS^**

[a]poly(N-isopropylacrylamide) hydrogel, [b]poly (N-isopropylacrylamide)/itaconic acid composite hydrogel, [c]metal-organic framework (MOF) based on copper-benzenetricarboxylate, [d]biochar microparticles derived from pig manure, [e]metal-organic framework, [f]interpenetrating network superadsorbent, [g]magnetic cellulose/graphene oxide composite, [h]Hydrolyzed polyacrylamide grafted xanthan gum and its nanosilica composite, [i]guar gum-g-(acrylic acid-co-acrylamide-co-3-acrylamido propanoic acid)[j]activated carbon, [k]sea buckthornbranchpowder, [l]copper nanowires loaded on activated carbon, [m]sodium dodecyl sulphate/red mud, [n]polydopamine coated sea buckthornbranch powder, [o]hexadecyltrimethylammonium bromide, [p]Multi-walled carbon nanotubes, [q]sodium dodecyl sulphate/red mud, [r]MgO decked multi-layered graphene, [s]aminated polyacrylonitrile, [t]reduced graphene oxide, [u]graphene oxide, [v]silica-supported dithiocarbamate adsorbent, [w]Magnetic graphene oxide, [x]a chitosan-based hydrogel, [y]activated non-metallic Powder derived from printed circuit boards, [z]poly(N-isopropylacrylamide-*co*-maleic acid-*co*-1-vinylimidazole), [#]μ mol L^{-1}, [*]μ mol g^{-1} and [^]this study.

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