Supporting Information

Bio-Mass Derived Functionalized-Graphene-Aerogel: A Sustainable Approach for the Removal of Multiple Organic Dyes and their Mixtures

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Table S1: EDX elemental compositing of GA.

Element	Weight%	Atomic%
C K	90.79	92.92
O K	9.21	7.08
Total	100.00	100.00

Table S2: EDX elemental compositing of f-GA.

Element	Weight%	Atomic%
C K	64.11	70.41
O K	35.89	29.59
Total	100.00	100.00

Batch Adsorption Experiments

For the kinetic and isotherm studies of dyes adsorption, 50 mL of dyes solution (CV, MB and RhB) were prepared with different concentrations (10-250) mg L^{-1} with f-GA dosage of 0.16 mg mL^{-1} in a 100 mL conical flask. After 2 min of sonication, the solutions were placed on a magnetic stirrer and stirred continuously for 73 min. From these solutions, 1 mL was taken out at various time intervals from (0-75) min. The concentrations of all the three dyes were estimated by applying universal Beer Lambert's Law at wavelengths corresponding to the respective maximum absorbance (589 nm for CV, 664 nm for MB, and 554 nm for RhB) spectrophotometrically using UV-Vis spectrometer. Maximum equilibrium adsorption capacity (q$_e$) was calculated by using the following **Eq. S1**

$$q_e = \frac{(C_0 - C_e).V}{m} \qquad (S1)$$

The effect of varying concentrations (10-250) mg L^{-1} of all the three tested dyes were investigated at a constant adsorbent (f-GA) dose of 8 mg in 50 mL dye's solutions. The effect of adsorbent doses was investigated at different adsorbent amounts, respectively (4, 8, 12, 16, 20) mg in 50 mL at constant concentration (100 mg L^{-1}) of dyes, while other parameters were kept constant. The effect of temperature was investigated with 200 mg L^{-1} and 8 mg 50 ml^{-1} of f-GA loading at 293, 303, 313, and 323 K, while other parameters were constant.

The pH studies were performed by checking the adsorption capacity of f-GA at varying solution pH (dyes + f-GA) from 2 to 10 using 0.1 M HCl and 0.1 M NaOH solution with the help of a calibrated pH meter. For this purpose, 100 mg L^{-1} dye adsorbed by 0.16 mg mL^{-1} f-GA

loading, was separated from the solution phase via centrifugation and dried at room temperature. As the results obtained from the pH study, basic pH was chosen for desorption study. So, the dyes (CV, MB and RhB) loaded f-GA were separately immersed in 0.01 M 50 mL NaOH solution and stirred for 75 minutes. Afterward, 1 mL of these solutions were taken out at various time intervals and centrifuged for 2 minutes (10000 rpm). The same process was repeated 5 times to check the reusability. The resultant supernatant was analyzed by UV-Vis spectrophotometer and % desorption was plotted against the time.

The comparative studies of GA, AC and f-GA were performed at different dyes concentration of 50 and 100 mg L^{-1} with the adsorbent loading of 0.16 mg mL^{-1}. For the analysis of dyes mixture, 50 mg L^{-1} of CV, MB and RhB was mixed and 50 mL of this mixed solution was then treated with GA and f-GA with a loading of 0.16 mg mL^{-1}. Industrial wastewater samples were collected from the Sanganer textile industry, Jaipur, India. Then 50 mg L^{-1} individual dyes were spiked externally in the industrial sample and 0.16 mg mL^{-1} of GA and f-GA was supplied to it for treatment.
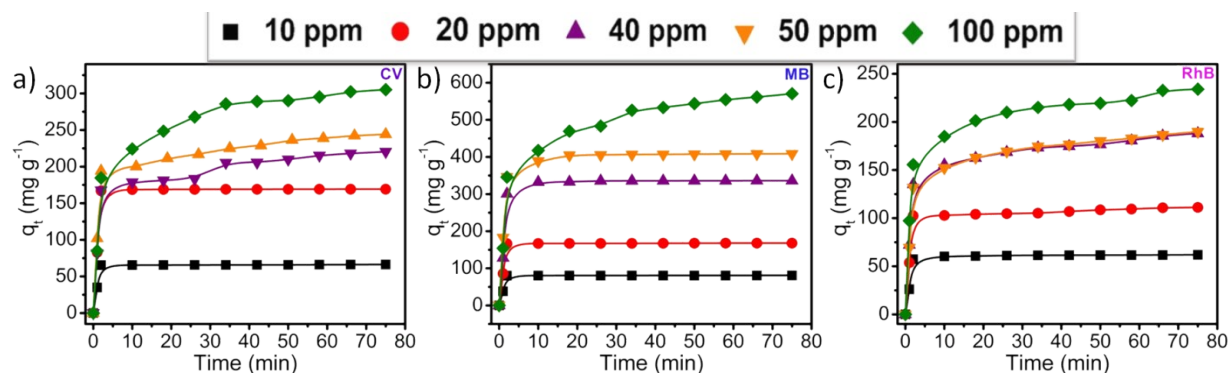

Figure S1. Plot of adsorption capacity (q_t) vs time (t) with different initial dyes concentrations 10, 20, 40, 50, 100 ppm; **(a)** CV; **(b)** MB; and **(c)** RhB (Dyes concentration (10-100) mg L^{-1}; f-GA loading 0.16 mg mL^{-1}).

Table S3: Comparative data table for the Pseudo first order and Pseudo second-order model.

Dye	Conc. (ppm)	q_e (experimental) (mg g^{-1})	Pseudo-first order kinetics			Pseudo-second order kinetics		
			q_e(graphical) (mg g^{-1})	K_1 (min^{-1})	R^2	q_e(graphical) (mg g^{-1})	K_2 (mg^{-1}g min^{-1})	R^2

Dye								
CV	10	66.21	5.73	0.0577	0.4833	66.40	0.0505	0.9999
	20	168.19	9.43	0.0933	0.6213	169.78	0.0241	0.9998
	40	242.36	113.33	0.0567	0.9163	245.10	0.0022	0.9974
	50	218.07	110.87	0.0543	0.9108	221.73	0.0020	0.9955
	100	302.29	168.42	0.0535	0.9353	309.60	0.0012	0.9969
MB	10	81.03	5.61	0.0556	0.3986	81.23	0.0408	0.9999
	20	167.87	15.22	0.0966	0.6997	168.63	0.0228	0.9999
	40	336.21	58.15	0.1193	0.8359	338.98	0.0065	0.9997
	50	408.44	99.57	0.1022	0.8776	411.52	0.0050	0.9999
	100	570.31	347.29	0.0547	0.9601	578.03	0.0006	0.9967
RhB	10	61.93	10.54	0.0682	0.7158	62.23	0.0334	0.9998
	20	111.14	32.32	0.0573	0.7623	111.23	0.0097	0.9993
	40	187.98	87.38	0.0486	0.8711	187.62	0.0029	0.9977
	50	189.86	92.20	0.0489	0.9065	190.11	0.0027	0.9978
	100	234.01	123.96	0.0539	0.8396	233.64	0.0022	0.9972

Table S4: Parameters of Intra Particle Diffusion (IPD) model at different concentrations.

| Dye	Conc. (ppm)	k_1 (mg g^{-1}min$^{-1/2}$)	R^2	k_2 (mg g^{-1}min$^{-1/2}$)	c_2	R^2
CV	10	44.15	0.9247	0.11	65.13	0.8593
	20	111.62	0.8875	0.25	167.43	0.8462
	40	130.88	0.9167	7.69	179.08	0.9743
	50	111.88	0.8788	8.05	152.32	0.9206
	100	122.06	0.8467	17.43	170.28	0.9456
MB	10	53.30	0.8644	0.09	80.04	0.8262
	20	111.79	0.9069	0.20	166.14	0.9553
	40	197.09	0.8023	3.53	311.42	0.8926
	50	233.53	0.9183	6.77	360.09	0.9067
	100	227.73	0.8284	30.82	322.76	0.9565
RhB	10	37.87	0.8414	0.52	57.87	0.7648
	20	68.98	0.9157	1.34	98.88	0.895
	40	91.27	0.9247	6.73	131.25	0.9625
	50	88.68	0.9187	7.59	126.91	0.9637
	100	107.68	0.9834	10.01	151.6	0.935
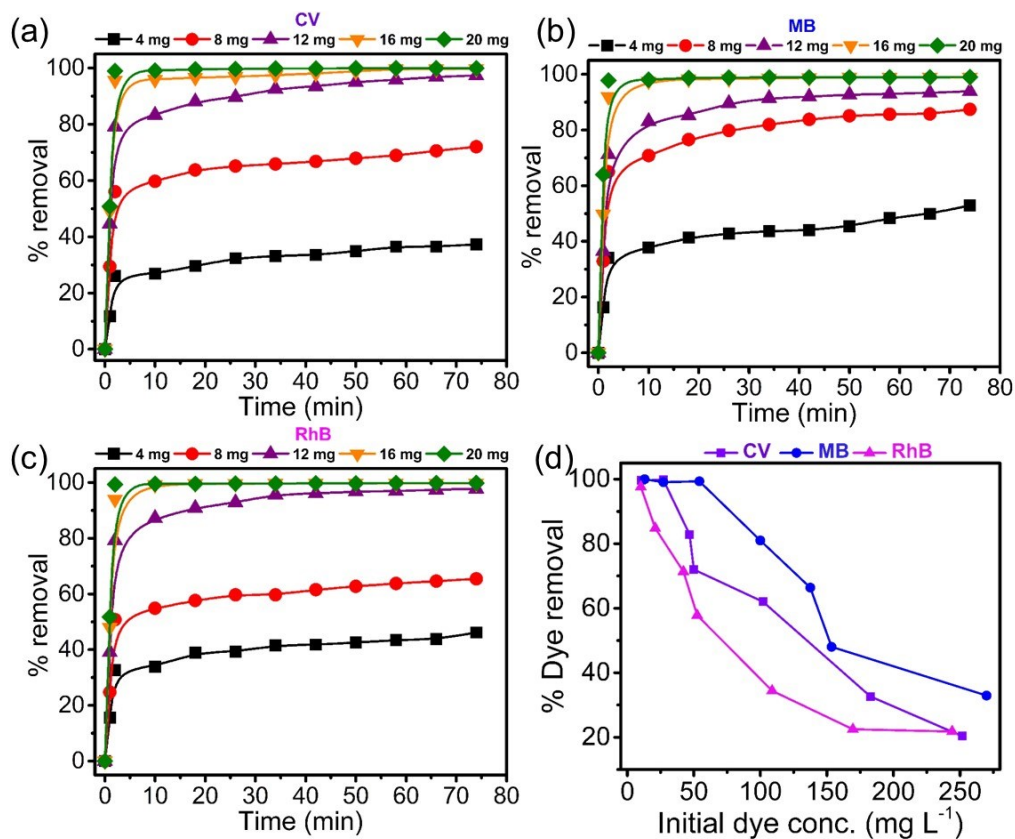
Figure S2. Effect of f-GA loading (4-20 mg/50 ml) on percentage removal of 100 mg L^{-1} **(a)** CV; **(b)** MB; **(c)** RhB; and **(d)** effect of varying initial concentration on % dye removal for 75 minutes (Dyes concentration (10-250) mg L^{-1}; f-GA loading 0.16 mg mL^{-1}).