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Supporting information

Response surface methodology approach for optimization of simultaneous dyes and metal ions ultrasound-assisted adsorption onto Mn doped Fe_3O_4-NPs loaded on AC: Kinetic and isotherm study

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Abstract

In the present work, the usefulness of ultrasonic power as dispersion and mixing tool to accelerate the adsorption of Safranin O (SO), Methylene blue (MB), Pb^{2+} ions and Cr^{3+} ions onto novel composite of Fe_3O_4-NPs-AC as adsorbent was investigated. This new material extensively were characterized and analyzed by different techniques such as XRD, FESEM, Raman spectroscopy and FT-IR. The Central Composite Design (CCD) based on designed runs reveal that adsorbent mass, sonication time, MB concentration, SO concentration, Pb^{2+} ions and Cr^{3+} ions concentration and some of their interactions have significant contribution on the target compounds removal percentages. The combination of response surface methodology and Design-Expert software used to qualify and estimates the influence and magnitude of each term contribution on response. The optimization over following investigated interval of effective variables, adsorbent mass (0.01-0.03 g), sonication time (2-6 min), initial dyes concentration (5-25 mg L^{-1}), initial metal ions concentration (20-60 mg L^{-1}) reveal that fixing the experimental variables at 0.025 g of Mn-Fe_3O_4-NPs-AC, 3 min sonication time, 20 mg L^{-1} of MB, 10 mg L^{-1} of SO, 38 mg L^{-1} of Pb^{2+} ions and 42 mg L^{-1} of Cr^{3+} ions at room temperature lead to achievement of best characteristics performance. Conduction of 32 experiments according to limitation of CCD and their subsequent analysis of variance (ANOVA) gives useful information about significant and also approximate contribution of each term (main and interaction of

variables) in empirical equation on expected response. The results indicate that the R^2 values are more than 0.988 and adjusted R^2 are in a reasonable agreement with R^2. Under the optimal conditions, the MB, SO, Pb^{2+} ions and Cr^{3+} ions removal efficiency reached 99.54%, 98.87%, 80.25% and 99.54% after 3 min, while their equilibrium data with high performance can be represented with Langmuir isotherm and a pseudo second-order kinetic model. The maximum adsorption capacity in single component system, 229.4 mg g^{-1} for MB, 159.7 mg g^{-1} for SO, 139.5 mg g^{-1} for Pb^{2+} ions and 267.4 mg g^{-1} for Cr^{3+} ions support high efficiency of Mn-Fe_3O_4-NPs-AC as new adsorbent.

Keywords: Adsorption, Dyes, Heavy metals, Mn-Fe_3O_4-NPs-AC, Nanoparticles, Response surface methodology, Ultrasound-assisted removal.

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Table. S1. Quality of quadratic model based on R^2, CV% and standard deviation.

Response	MB	SO	Pb^{2+}	Cr^{3+}
Coefficient of variation (CV %)	0.609908	1.753726	3.221253	3.067336
Standard deviation (SD)	0.595587	1.56356	2.206575	2.789185
Adequate precision (AP)	17.64543	34.24239	16.35126	22.20737
Mean	97.65186	89.15648	68.50052	90.93186
R^2	0.988661	0.997201	0.991109	0.994591
Adjusted-R^2	0.912122	0.978309	0.931094	0.958083

Table. S2. Optimum conditions derived by RSM design for removal dyes and ions (N=5).

Optimal conditions							R%	
Response	A	B	C	D	E	F	Experimental value [a]	Predicted value [b]
MB	0.025	3.000	20.000	10.000	38.000	42.000	99.540±1.068	99.500
SO	0.025	3.000	20.000	10.000	38.000	42.000	98.876±1.381	101.100
Pb^{2+}	0.025	3.000	20.000	10.000	38.000	42.000	80.245±1.986	82.900
Cr^{3+}	0.025	3.000	20.000	10.000	38.000	42.000	99.542±1.052	100.000

[a] Experimental values of response.

[b] Predicted values of response by RSM proposed model.

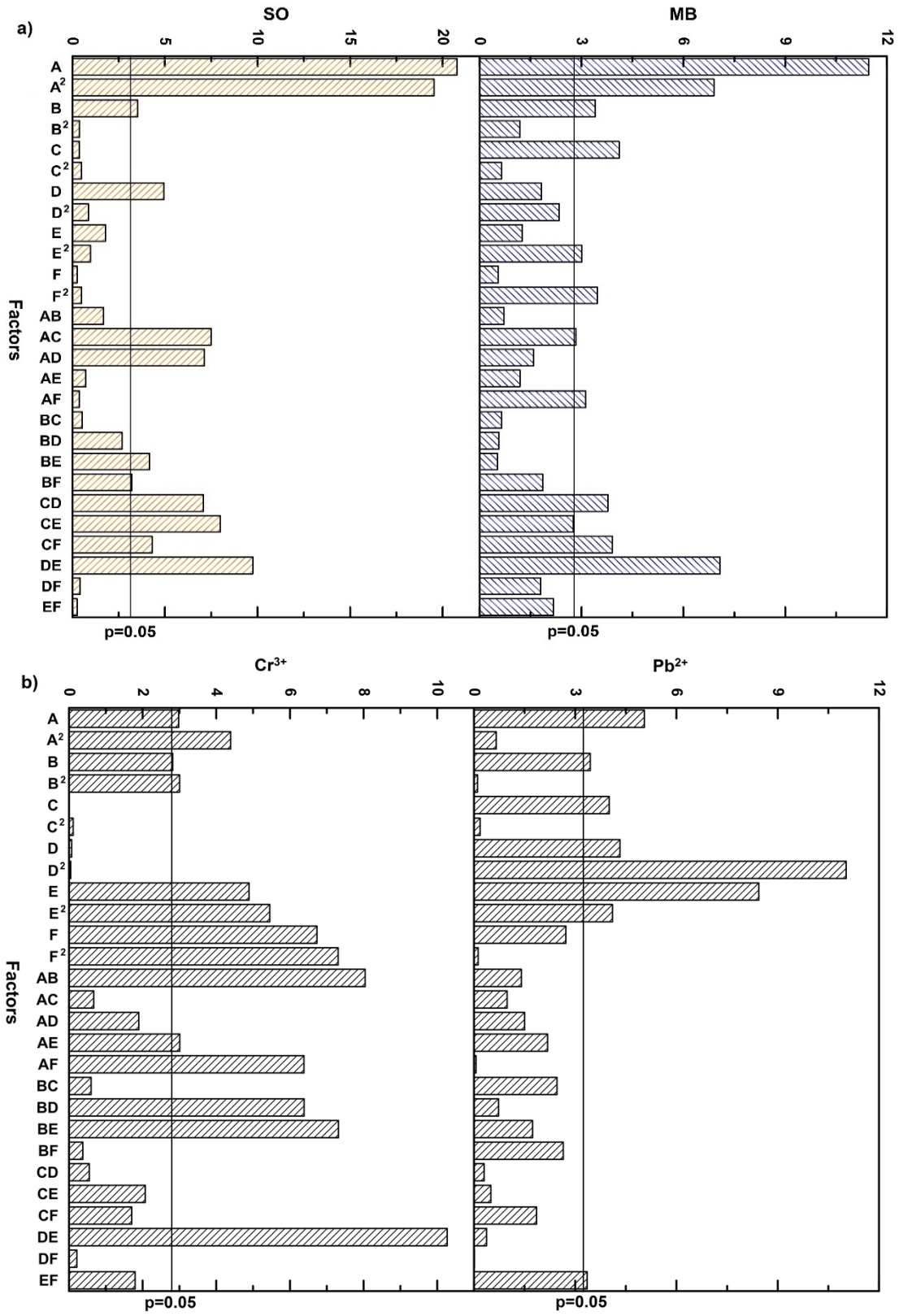

Fig. S1. Standardized main effect Pareto chart for the Central Composite Design of removal of dyes **(a)**, and ions **(b)**.