

Supplementary Materials

# Co-Action of Ionic Liquids with Alternative Sorbents for Removal of Reactive Azo Dyes from Polluted Wastewater Streams

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**Number of pages:** 9

**Number of Tables:** 1

**Number of Schemes:** 2

**Number of Figures:** 8

## Report of Elemental Analysis

Date of analysis: 15. 12. 2023, 15:03

Sample: Hr Cr

Equipment settings: EDXRF ElvaX, Rh X-ray tube – Light elements 12kV, 8  $\mu$ A, spectrum acquisition 90s; Heavy elements – 35 kV, 6  $\mu$ A, , spectrum acquisition 90s

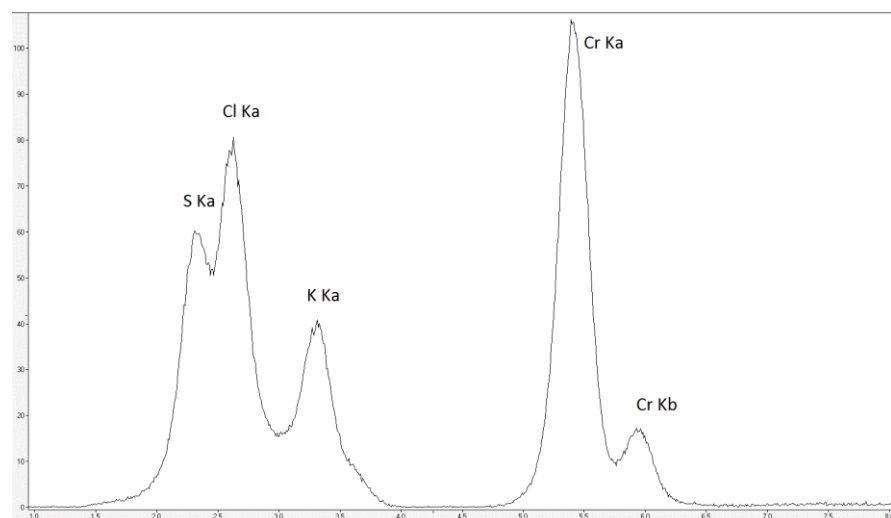
Composition calculation: General standard-less FPM method without correction – the gross mistake can occur namely in LE calculation due to incompatibility sample matrix composition with model matrix

## Elemental Composition

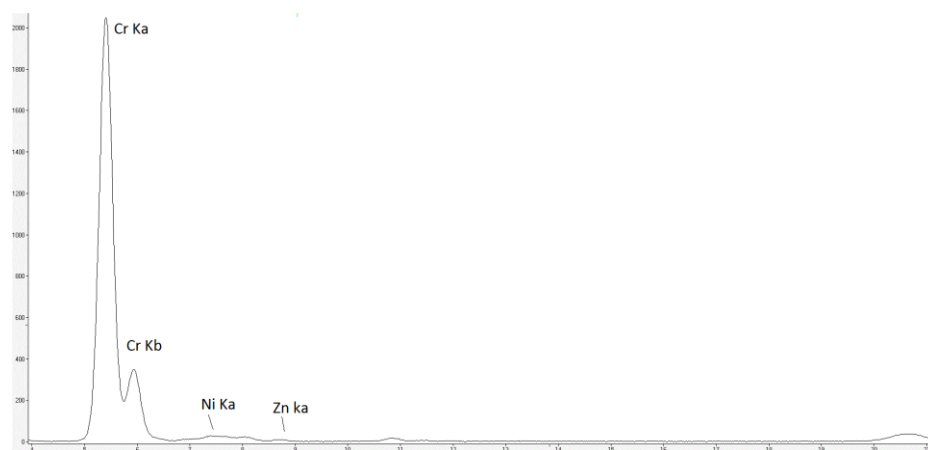
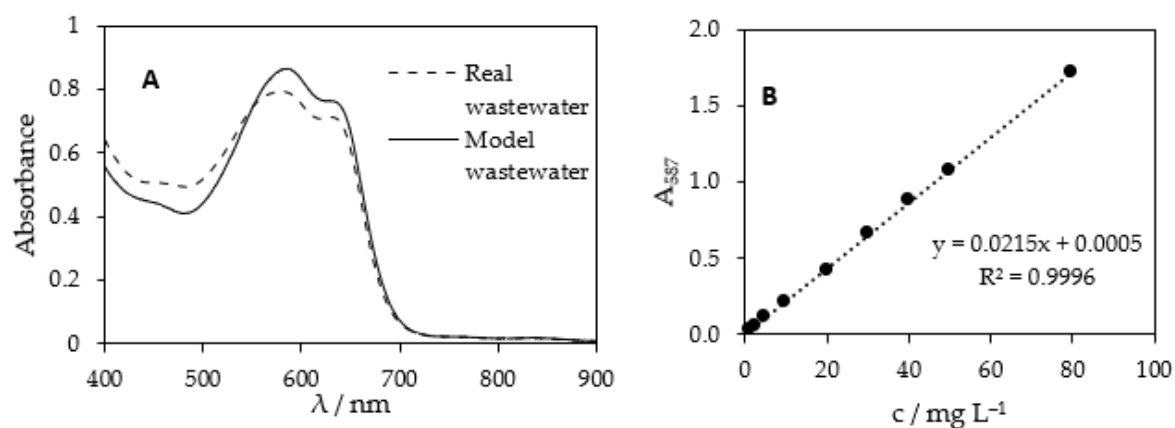
Atomic	Element	Series	Intensity	Concentration
	LE*		4056116	59.5392 $\pm$ 0.0659%
16	S	K	109707	11.2667 $\pm$ 0.1309%
17	Cl	K	148693	14.2230 $\pm$ 0.1212%
19	K	K	529668	7.9292 $\pm$ 0.0340%
20	Ca	K	31026	0.3836 $\pm$ 0.0257%
24	Cr	K	2099395	6.6572 $\pm$ 0.0136%
37	Rb	K	2147	0.0003 $\pm$ 0.0002%
38	Sr	K	1568	0.0002 $\pm$ 0.0002%
83	Bi	L	2600	0.0007 $\pm$ 0.0004%

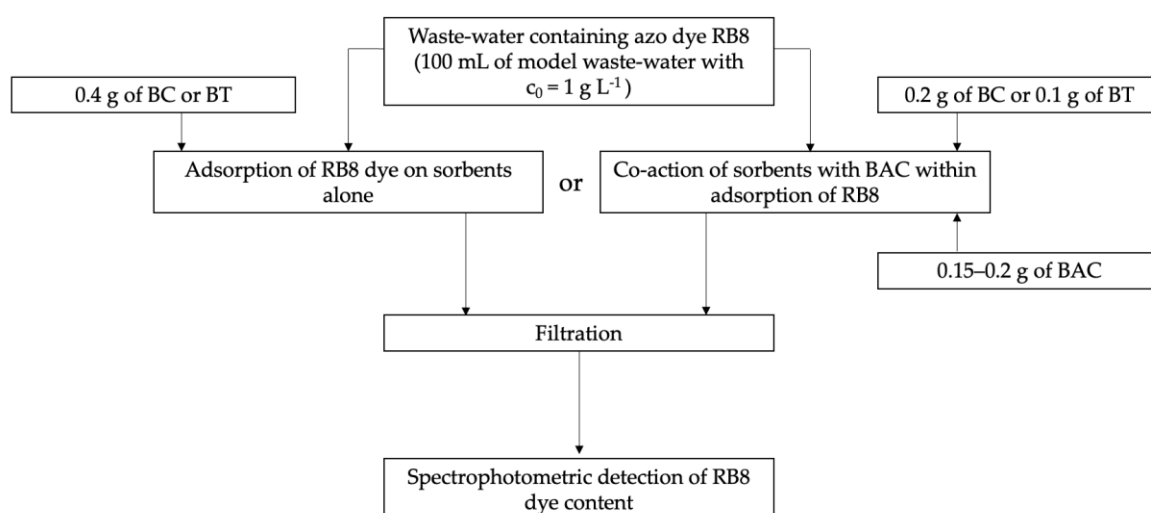
\*LE – light elements – recalculation of non-detectable light elements using backscattering intensity (theoretical mean atomic weight of light elements is 13 g/mol)

Spectrum – Sample Hr-Cr – Light elements (Al – Fe)

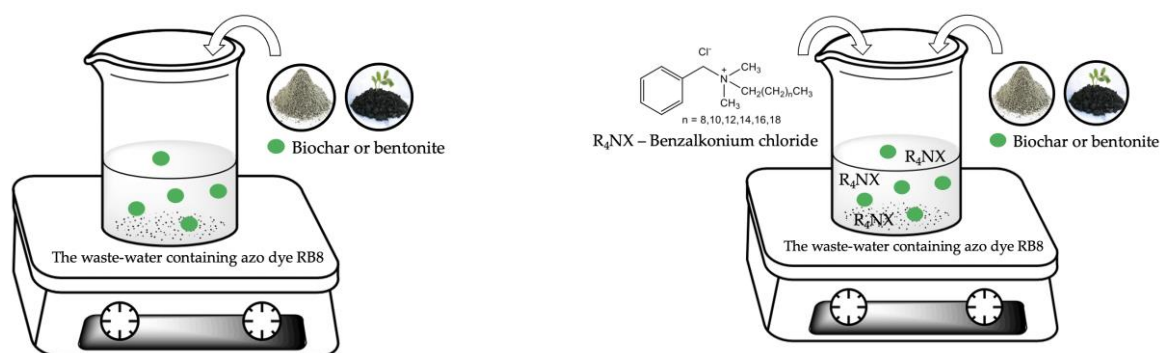


Spectrum – Sample Hr-Cr– Heavy elements (V – U)

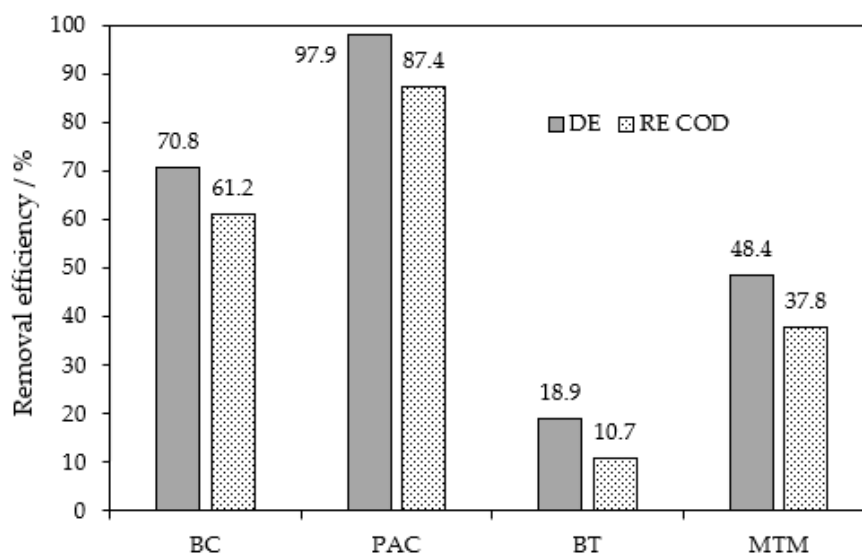
**Figure S1.** Report from EDXRF analysis of commercial RB8 sample.**Figure S2.** Absorption spectrum of RB8 in model and real wastewater (A) and calibration curve of model aq. solutions of RB8 (B).



**Scheme S1.** The experimental scope of RB8 separation using alternative sorbents with presence/absence of benzalkonium chloride.



**Figure S3.** The experimental layout of the RB8 separation using alternative sorbents with presence/absence of benzalkonium chloride.



**Figure S4.** Comparison of decolorization efficiency and COD removal of RB8 dye using PAC and MTM (40 g L<sup>-1</sup>) and alternative sorbents BC or BT (each of them 40 g L<sup>-1</sup>) after 5 hours of action.

### Report of Elemental Analysis

Date of analysis: 15. 12. 2023, 15:23

Sample: Bk1

Equipment settings: EDXRF ElvaX, Rh X-ray tube – Light elements 12kV, 8 μA, spectrum acquisition 90s; Heavy elements – 35 kV, 6 μA, , spectrum acquisition 90s

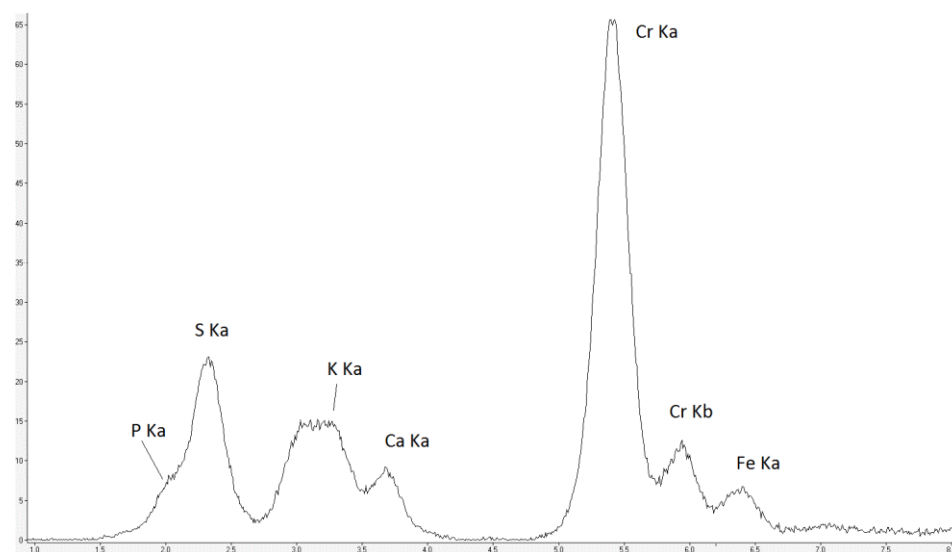
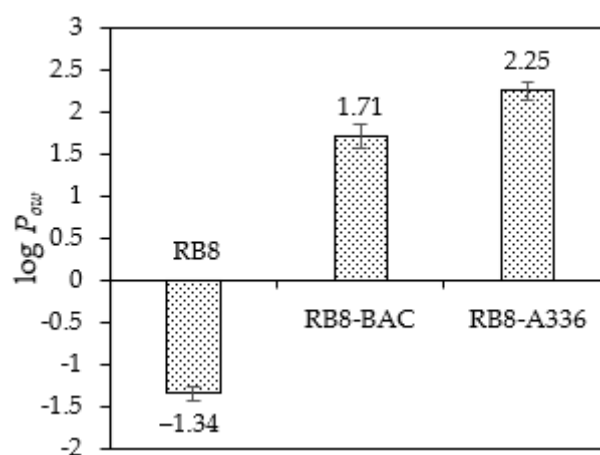
Composition calculation: General standard-less FPM method without correction – the gross mistake can occur namely in LE calculation due to incompatibility sample matrix composition with model matrix

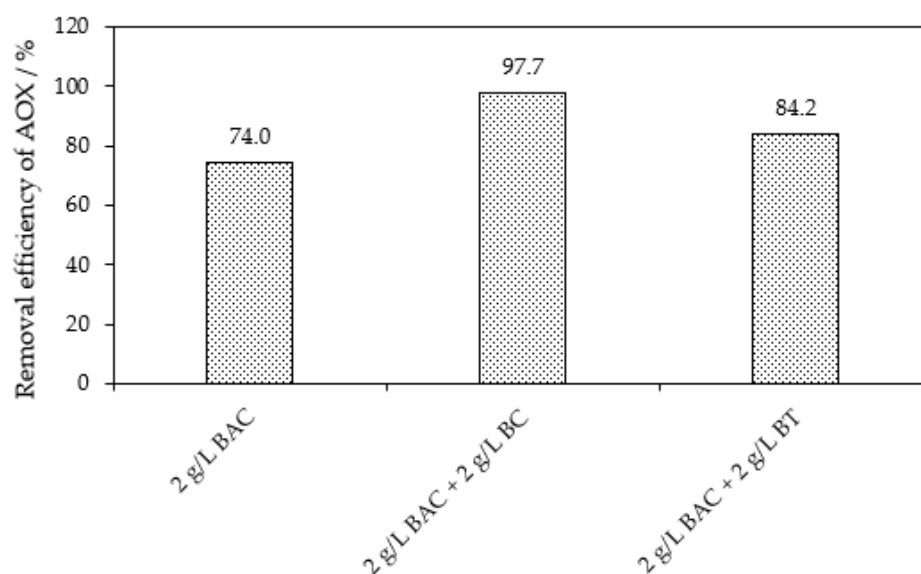
### Elemental Composition

Atomic	Element	Series	Intensity	Concentration
	LE*		4782583	81.6922 ± 0.0662%
15	P	K	10200	2.2197 ± 0.1618%
16	S	K	46738	6.8314 ± 0.0905%
19	K	K	167601	2.9455 ± 0.0322%
20	Ca	K	108822	1.4602 ± 0.0198%
24	Cr	K	1301024	4.4879 ± 0.0105%
26	Fe	K	154010	0.2687 ± 0.0032%
28	Ni	K	27206	0.0227 ± 0.0014%
29	Cu	K	17300	0.0107 ± 0.0010%
30	Zn	K	133698	0.0597 ± 0.0008%
38	Sr	K	10020	0.0013 ± 0.0002%

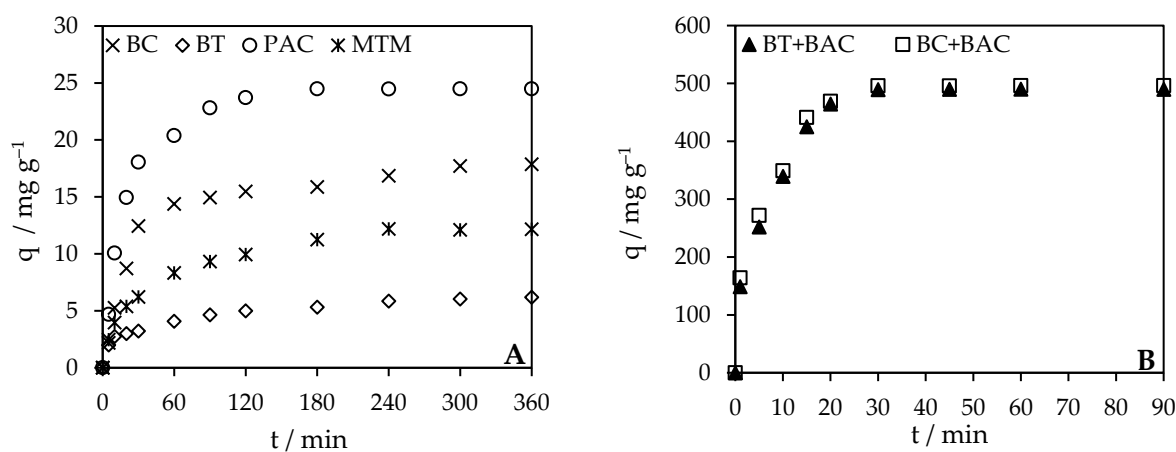
\*LE – light elements – recalculation of non-detectable light elements using backscattering intensity (theoretical mean atomic weight of light elements is 13 g/mol)

Spectrum – Sample Bk1 – Light elements (Al – Fe)

**Figure S5.** Report from EDXRF analysis of alternative BC sorbent saturated with RB8 dye.**Figure S6.** Comparison of the octan-1-ol/water partition coefficients ( $\log P_{ow}$ ) for the RB8 dye and RB8-based ion-pairs RB8-IL.



**Figure S7.** Removal of AOX from model aq. solutions of RB8 ( $1 \text{ g L}^{-1}$  aq. model solution) using optimal doses of BAC and BC or BT after 30 minutes of action.



**Figure S8.** Dependencies of adsorption capacity on time within the sorption of RB8 ( $1 \text{ g L}^{-1}$  aq. model solution) on (A) different sorbents ( $40 \text{ g L}^{-1}$ ) and (B) co-action of BC ( $2 \text{ g L}^{-1}$ ) with BAC ( $1.5 \text{ g L}^{-1}$ ) or BT ( $2 \text{ g L}^{-1}$ ) with BAC ( $2 \text{ g L}^{-1}$ ).

## Report of Elemental Analysis

Date of analysis: 15. 12. 2023, 15:12

Sample: Bk2

Equipment settings: EDXRF ElvaX, Rh X-ray tube – Light elements 12kV, 8  $\mu$ A, spectrum acquisition 90s; Heavy elements – 35 kV, 6  $\mu$ A, , spectrum acquisition 90s

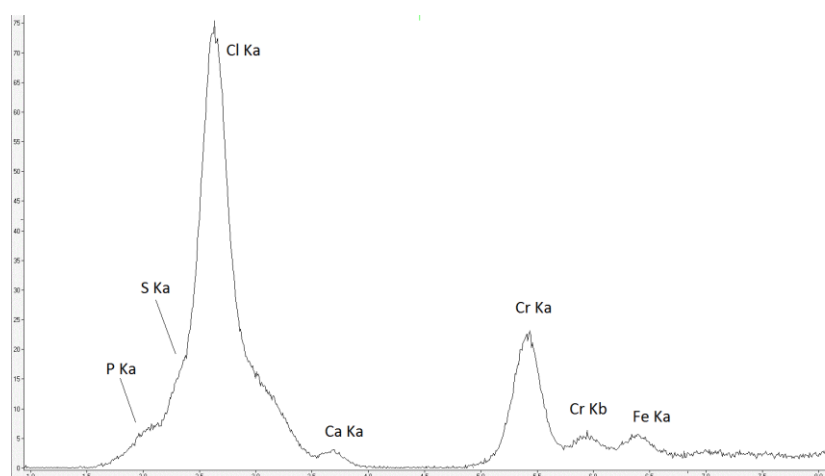
Composition calculation: General standard-less FPM method without correction – the gross mistake can occur namely in LE calculation due to incompatibility sample matrix composition with model matrix

## Elemental Composition

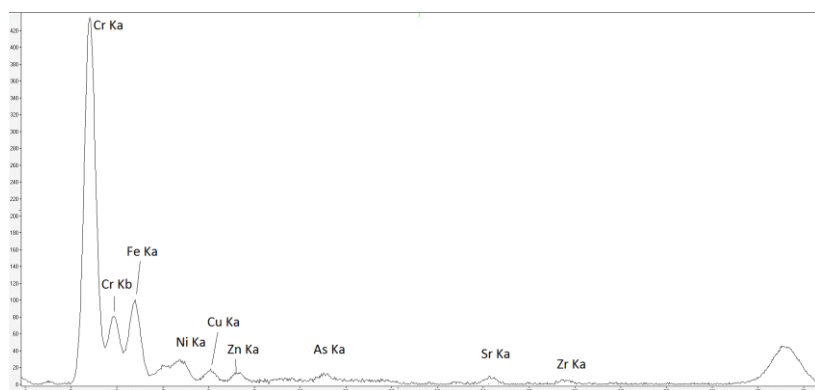
Atomic	Element	Series	Intensity	Concentration
	LE*		5570360	78.9944 $\pm$ 0.0735%
16	S	K	23991	3.0065 $\pm$ 0.1477%
17	Cl	K	149268	15.9255 $\pm$ 0.0993%
20	Ca	K	48569	0.5964 $\pm$ 0.0124%
24	Cr	K	440142	1.3190 $\pm$ 0.0058%
26	Fe	K	104340	0.1417 $\pm$ 0.0022%
29	Cu	K	15856	0.0076 $\pm$ 0.0008%
30	Zn	K	14661	0.0051 $\pm$ 0.0006%
33	As	K	14613	0.0024 $\pm$ 0.0003%
38	Sr	K	9340	0.0009 $\pm$ 0.0002%
39	Y	K	984	< 0.0001%
40	Zr	K	4196	0.0004 $\pm$ 0.0001%

\*LE – light elements – recalculation of non-detectable light elements using backscattering intensity (theoretical mean atomic weight of light elements is 13 g/mol)

Spectrum – Sample Bk2 – Light elements (Al – Fe)



Spectrum – Sample Bk1 – Heavy elements (V – U)



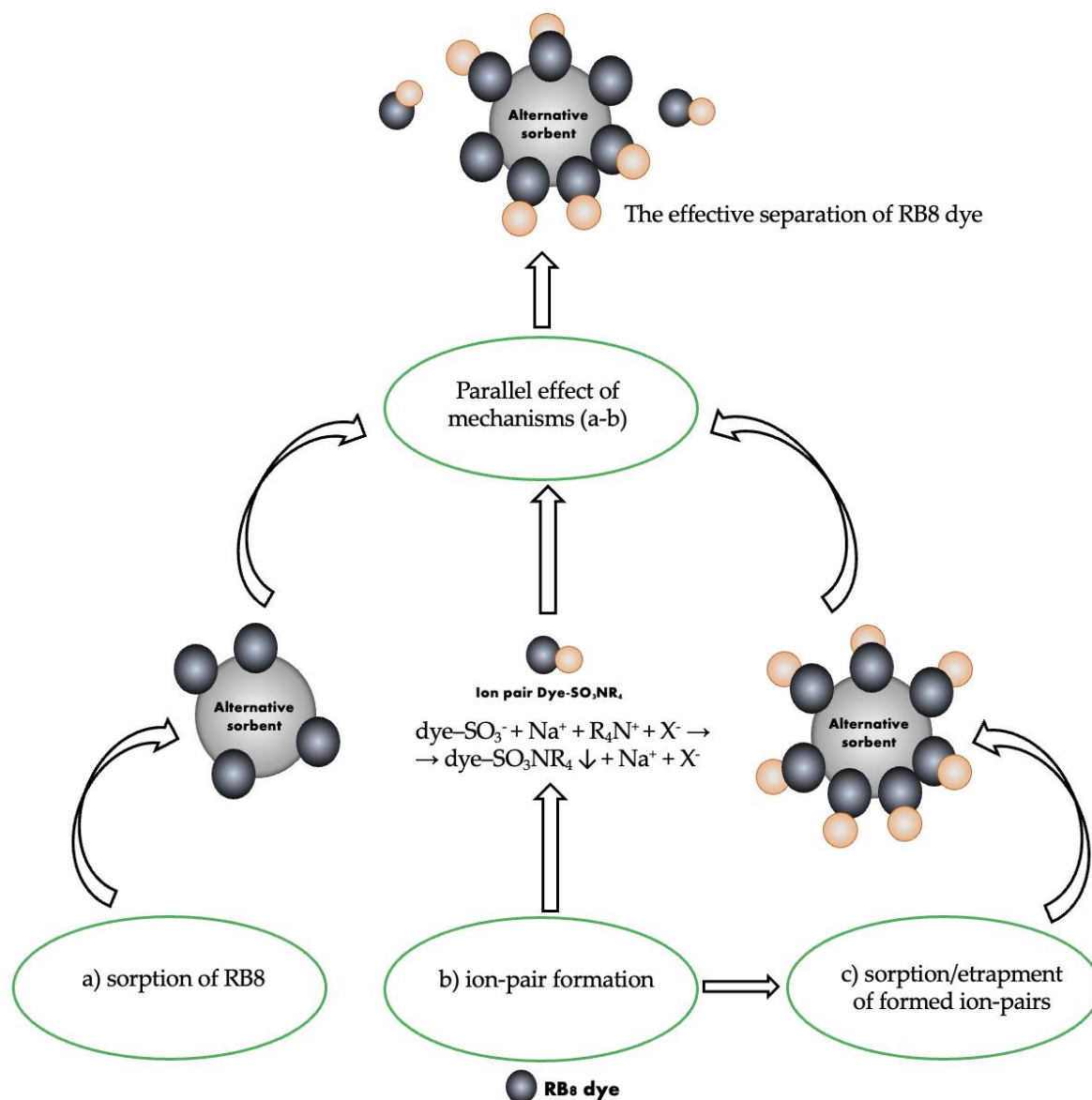
**Figure S9.** Report from EDXRF analysis of alternative BC sorbent saturated with (BAC)<sub>4</sub>RB8 ion pair.

**Table S1.** A comparison of economic costs of tested separation methods of RB8 dye from model (1 g L<sup>-1</sup>) or real (7 g L<sup>-1</sup>) wastewater.

Method	Type of wastewater	Quantity of used reagents per gram of OB dye	Reaction time	Efficiency of decolorization	Price for optimized dosages per kilogram of RB8 *
Ion exchange <i>via</i> IL	Model	2 g BAC	30 min.	99.1%	39.6 \$
Ion exchange <i>via</i> IL	Model	6 g A336	30 min.	98.9%	130 \$
Adsorption	Model	40 g PAC	180 min.	97.9%	260 \$
Adsorption	Model	40 g BC	300 min.	70.8%	30 \$
Adsorption	Model	40 g BT	300 min.	18.9%	3.8 \$
<b>Co-action of sorbent and IL</b>	<b>Model</b>	<b>2 g BC + 1.5 g BAC</b>	<b>30 min.</b>	<b>99%</b>	<b>31.2 \$</b>
<b>Co-action of sorbent and IL</b>	<b>Model</b>	<b>1 g BT + 2 g BAC</b>	<b>30 min.</b>	<b>98.2%</b>	<b>39.7 \$</b>
Ion exchange <i>via</i> IL	Real	2 g BAC	30 min.	86.3%	39.6 \$
Adsorption	Real	40 g BC	300 min.	51.2%	30 \$
Adsorption	Real	40 g PAC	300 min.	92.6%	260 \$
Adsorption	Real	40 g BT	300 min.	18.6%	3.8 \$
<b>Co-action of sorbent and IL</b>	<b>Real</b>	<b>8 g BC + 4 g BAC</b>	<b>90 min.</b>	<b>98.6%</b>	<b>85.2 \$</b>
<b>Co-action of sorbent and IL</b>	<b>Real</b>	<b>4 g BT + 2.9 g BAC</b>	<b>60 min.</b>	<b>96.1%</b>	<b>57.8 \$</b>

\* Note: Prices according to Global Trade Magazine (<https://www.globaltrademag.com>) and ref. [56].





**Scheme S2.** The proposed mechanisms of separation of RB8 dye from waste-waters.