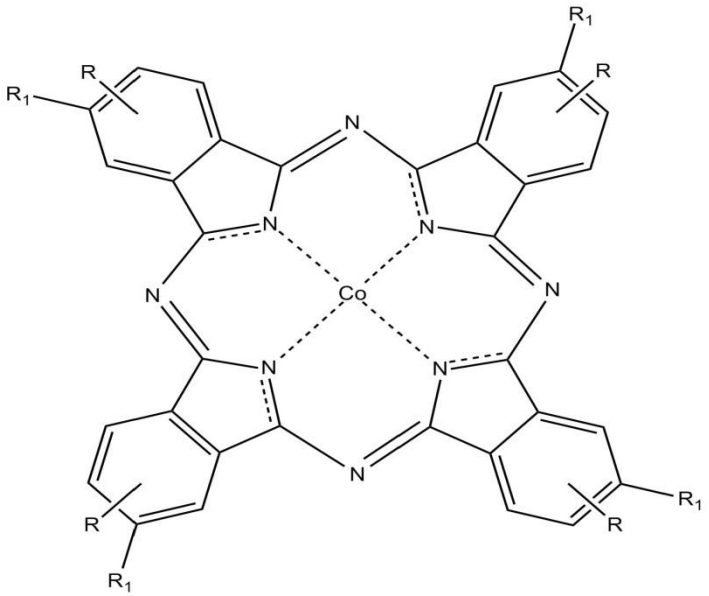
Supplementary Materials



R: SO_3H^-, Cl^-, OH^-, Br^-

R_1: $PhCH_2^-$, NO_2^-, NH_2^-

Fig. S1. Molecular structure of Europhtal, LCPS30.

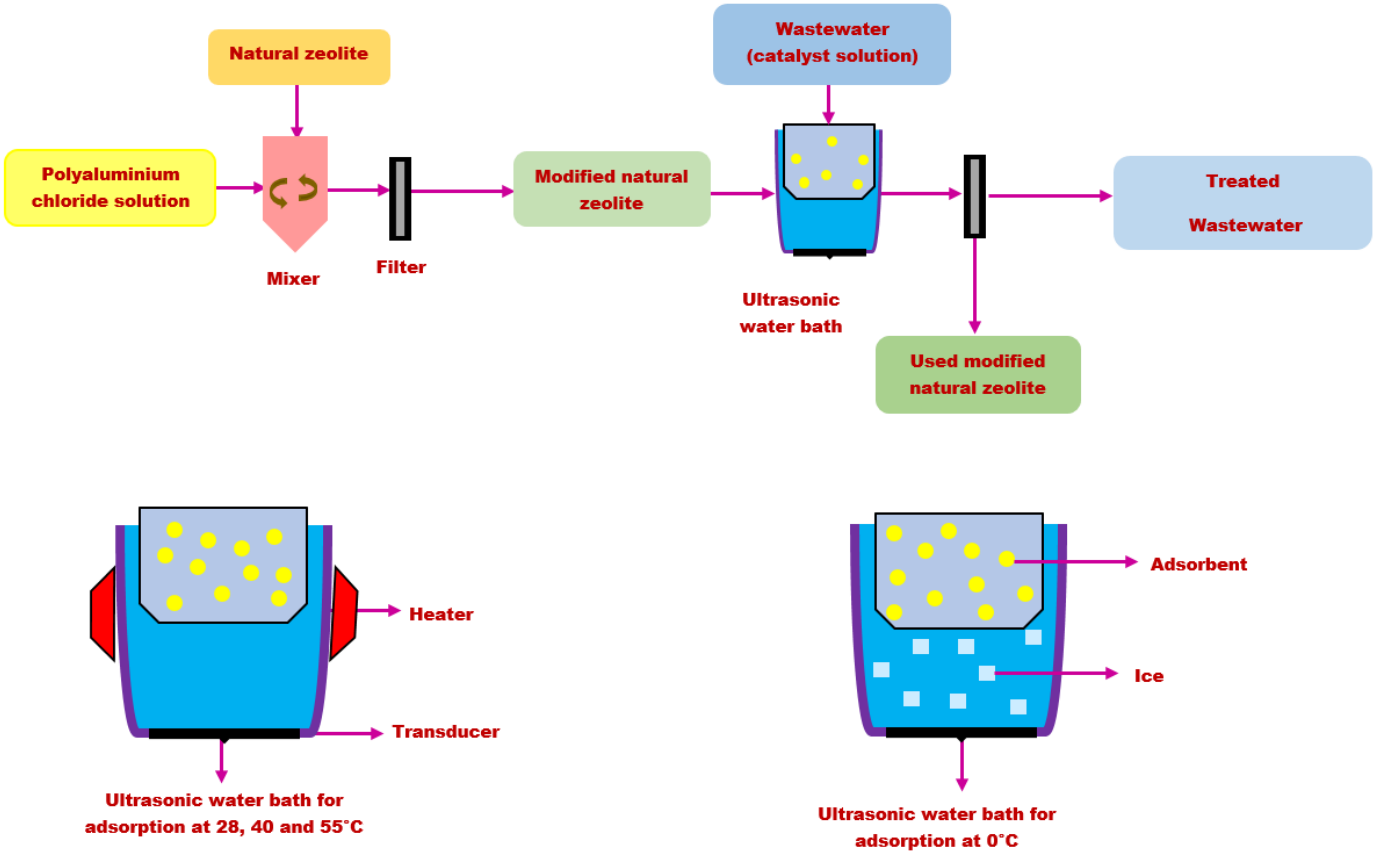


Fig. S2. Schematic of the experimental setup.

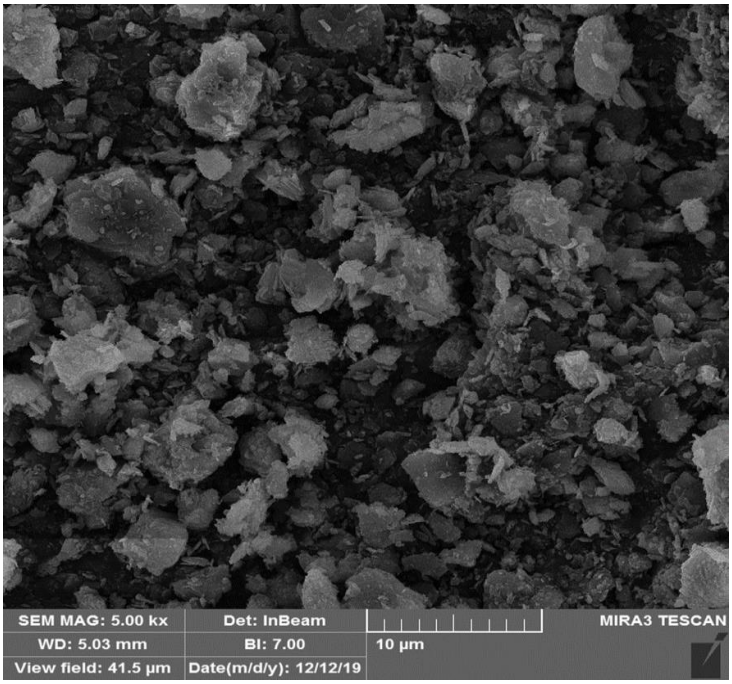


Fig. S3. SEM images of clinoptilolite type natural zeolite particles.

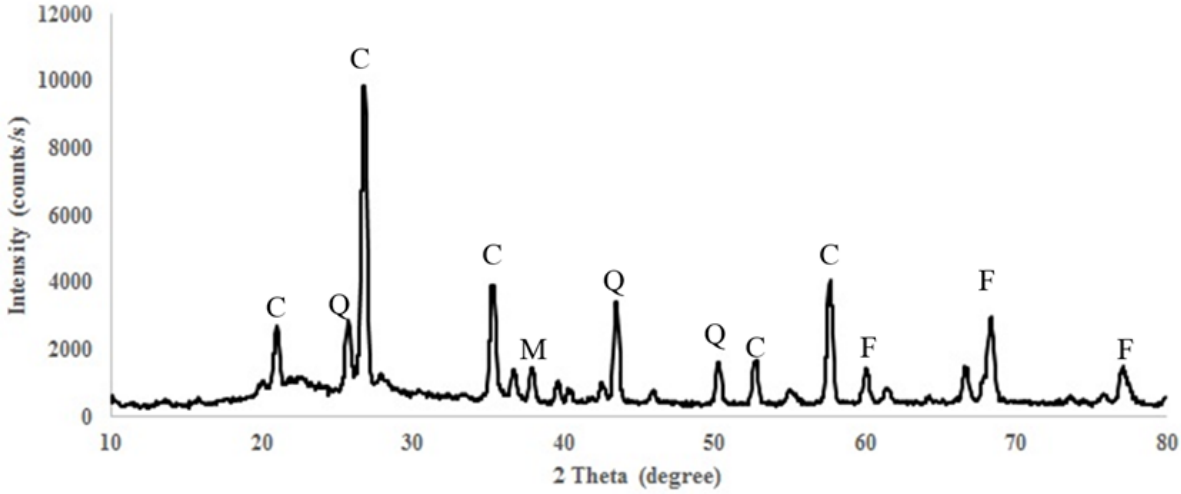


Fig. S4. XRD analysis of clinoptilolite type natural zeolite particles.

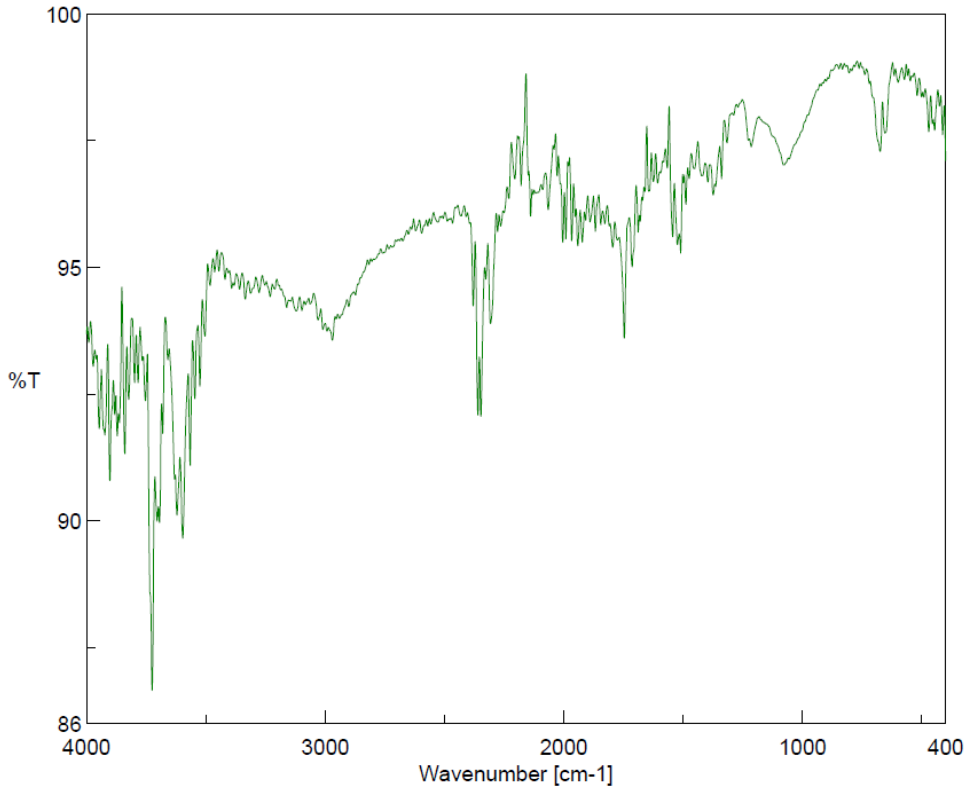


Fig. S5. FT-IR analysis of natural zeolite particles.

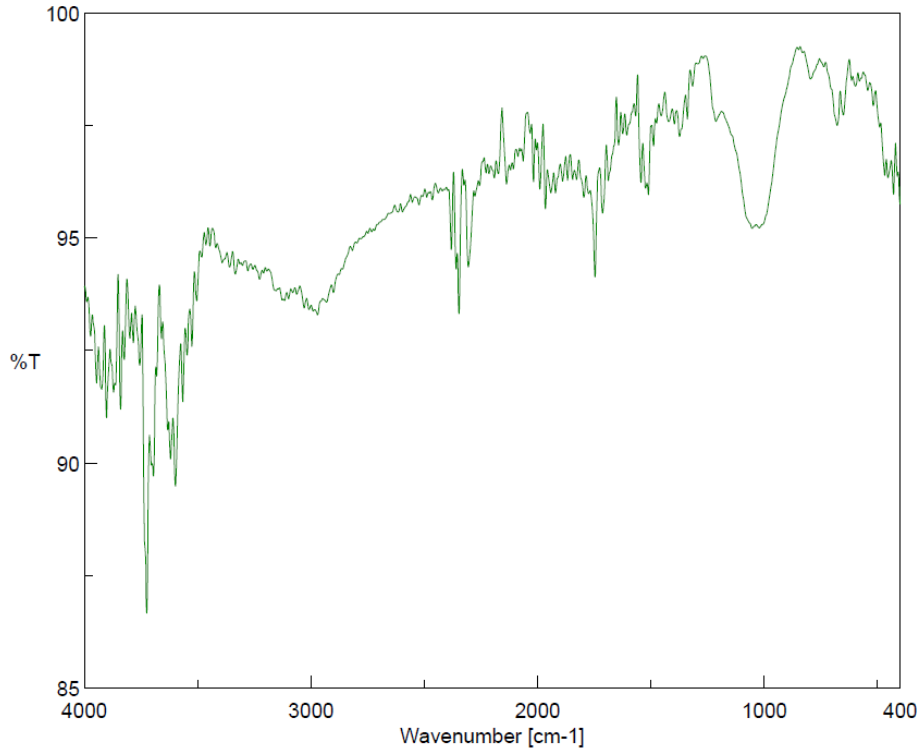


Fig. S6. FT-IR analysis of modified natural zeolite particles.

Table S1. The Characteristics of Catalyst

Product Identification	
Trade Name	Europhtal Additive 802
Appearance	Blue Liquid Solution
Chemical Name	Sulfonated Cobalt Phthalocyanine (Sodium salt)
Chemical Formula	C32H16-i N8Co(SO3Na)i
CAS Number	90294-83-0
EINECS Number	290-971-9
shelf life	Not limited when stored in normal conditions: (Temperature: 5 to 40℃; relative humidity: less than 90%)
Maximum wavelength (λmax), nm	664 nm

USES	Desulphuration Catalyst for oils
pH	7.0 to 9.0
Decomposition temperature	> 300°
Relative density (Water)	1,15
Solubility	Soluble in water
Acute toxicity	LD 50 > 2,000 mg/kg (oral rat)
Hazardous reaction with	None under normal conditions of use

Table S2. Specification of the Real Wastewater

Parameters	**Value**
Daily Volume (m^3/24 h)	24
Flow (m^3/h)	1
Available water pressure (bar g)	2
pH	13
Water Temperature, C	40
COD (ppm)	12,440
H_2S (ppm)	490
RSNa (ppm)	2,000
Na_2S (ppm)	2,800
Total Alkalify (ppm $CaCO_3$)	127.5
TSS (ppm)	20
TDS (ppm)	290,000
Conductivity (jumbos/20°C)	391,000

Table S3. Isotherm Models for the Adsorption of Europhtal on Modified Zeolite

Model	Equation
Langmuir	$\frac{C_e}{q_e} = \frac{1}{q_m K_l} + \frac{C_e}{q_m}$
Freundlich	$q_e = K_f C_e^{\frac{1}{n}}$
Tempkin-Payzhev	$q_e = \frac{RT}{b}(ln\, K_T C_e)$
Dubinin–Radushkevich	$q_e = q_m \exp(-\beta\varepsilon^2)$

Table S4. Kinetic Models for the Adsorption of Europhtal on Modified Zeolite

Model	Equation
Pseudo first order	$\frac{dq}{dt} = K_1(q_e - q)$
Pseudo second order	$\frac{dq}{dt} = K_2(q_e - q)^2$
Intraparticle diffusion	$q_t = k_{ip} t^{0.5} + C$
Elovich	$\frac{dq_t}{dt} = \alpha \exp(-\beta q_t)$

Table S5. Experimental Runs and Values of Responses Obtained through the CCD for Removal of Europhtal Using Modified Zeolite

Run Order	X_1	X_2	X_3	X_4	R%
1	8.75	3.5	0.0125	10.5	92.94
2	6.50	5.0	0.0350	17.0	96.80
3	2.00	5.0	0.0200	17.0	70.81
4	4.25	6.5	0.0275	10.5	96.62

5	4.25	6.5	0.0275	23.5	85.40
6	8.75	3.5	0.0275	10.5	90.00
7	6.50	5.0	0.0200	17.0	98.31
8	6.50	5.0	0.0200	17.0	97.69
9	4.25	3.5	0.0125	10.5	88.65
10	8.75	6.5	0.0275	10.5	90.96
11	4.25	3.5	0.0275	23.5	96.10
12	8.75	6.5	0.0125	23.5	92.96
13	4.25	3.5	0.0275	10.5	97.11
14	6.50	5.0	0.0200	17.0	90.96
15	6.50	5.0	0.0200	4.0	95.67
16	8.75	6.5	0.0125	10.5	90.00
17	6.50	2.0	0.0200	17.0	98.03
18	8.75	3.5	0.0275	23.5	97.77
19	11.00	5.0	0.0200	17.0	70.42
20	8.75	6.5	0.0275	23.5	96.10
21	4.25	6.5	0.0125	10.5	95.78
22	6.50	5.0	0.0200	17.0	96.77
23	6.50	5.0	0.0200	17.0	95.10
24	6.50	8.0	0.0200	17.0	99.78
25	8.75	3.5	0.0125	23.5	97.17
26	6.50	5.0	0.0050	17.0	90.24
27	4.25	3.5	0.0125	23.5	90.33
28	4.25	6.5	0.0125	23.5	95.56
29	6.50	5.0	0.0200	17.0	89.54
30	6.50	5.0	0.0200	17.0	99.98
31	6.50	5.0	0.0200	30.0	86.45

Table S6. Specific Surface Area, Average Pore Diameter, and Specific Pore Volume for Natural Zeolite Particles

Parameter	Specific pore volume (cm^3/g)	Average pore diameter (nm)	Specific surface area (m^2/g)
Natural zeolite	0.107	12.8	25.7

Table S7. XRF Analysis of Natural Zeolite Particles

Component	% w/w	Component	% w/w
SiO_2	68.5	Na_2O	3.8
Al_2O_3	11.0	K_2O	4.4
Fe_2O_3	0.9	SO_3	0.1
MgO	1.37	Loss of ignition (L.O.I)	10.3
CaO	0.6		

Table S8. XRF Analysis of Modified Natural Zeolite Particles

Component	% w/w	Component	% w/w
Na_2O	0.6	Al_2O_3	16.91
SO_3	2.37	K_2O	3.87
TiO_2	0.18	SiO_2	54.37
MgO	0.7	CaO	1.64
Cl	0.08	Loss of ignition (L.O.I)	17.68
Fe_2O_3	1.6	La & Lu	< 1

Table S9. Analyze of Variance for Europhtal Removal Utilizing Modified Zeolite

Source of variation	df (degree of freedom)	Sum of square (SS)	Mean square (MS)	F-value	P- value
X_1	1	0.25	0.25	0.09	0.768
X_2	1	5.56	5.56	2.00	0.176
X_3	1	0.73	0.73	0.26	0.615
X_4	1	65.37	65.37	23.52	0.000
X_1^2	1	1,148.16	1,148.16	413.08	0.000
X_2^2	1	15.49	15.49	5.57	0.031

X_3^2	1	1.87	1.87	0.67	0.424
X_4^2	1	6.21	6.21	2.23	0.154
X_1X_2	1	4.25	4.25	1.53	0.234
X_1X_3	1	6.16	6.16	2.22	0.156
X_1X_4	1	2.44	2.44	0.88	0.363
X_2X_3	1	20.00	20.00	7.20	0.016
X_2X_4	1	20.50	20.50	7.37	0.015
X_3X_4	1	41.89	41.89	15.07	0.001
Lack of fit	10	38.34	3.83	3.76	0.059

Table S10. The Comparison between the Performance of Modified Natural Zeolite and Modified Activated Carbon

Parameter	**Europhtal concentration (mg/L)**	**Adsorbent amount (g)**	**Time (min)**	**pH**	**Removal percentage (%)**	**Maximum adsorption capacity (mg/g)**
Modified natural zeolite	30	0.035	8	6.7	99.9	687.51
AC-M	30	0.03	2		> 98.8	56.69
AC-SCH-4	30	0.03	5		> 98.8	17.84