

Enhanced reduction of COD in water associated with natural gas production using iron-based nanoparticles

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Supporting Information

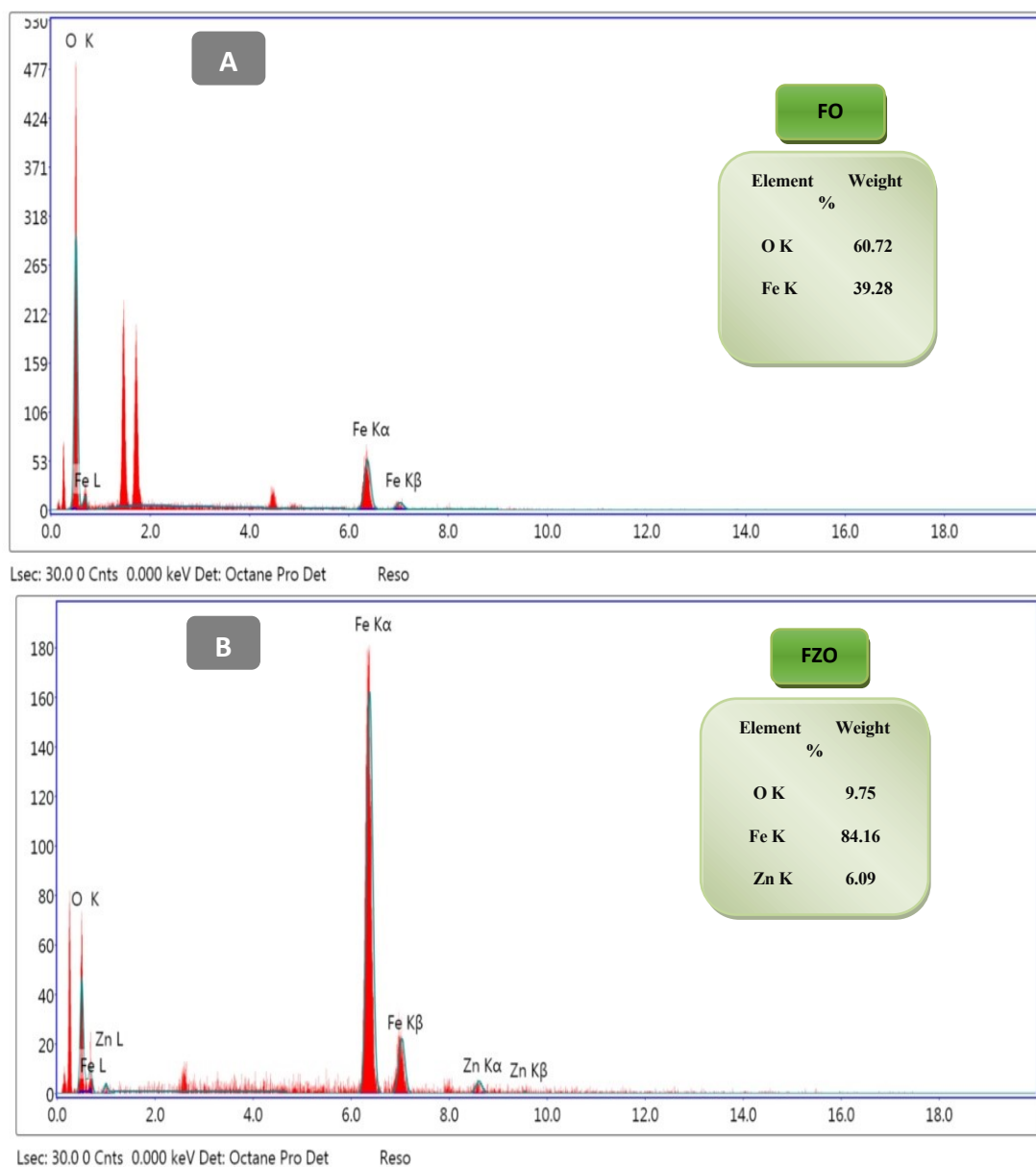


Figure S1: EDX analysis of iron oxide (FO) (A), and iron zinc oxide (FZO) (B).

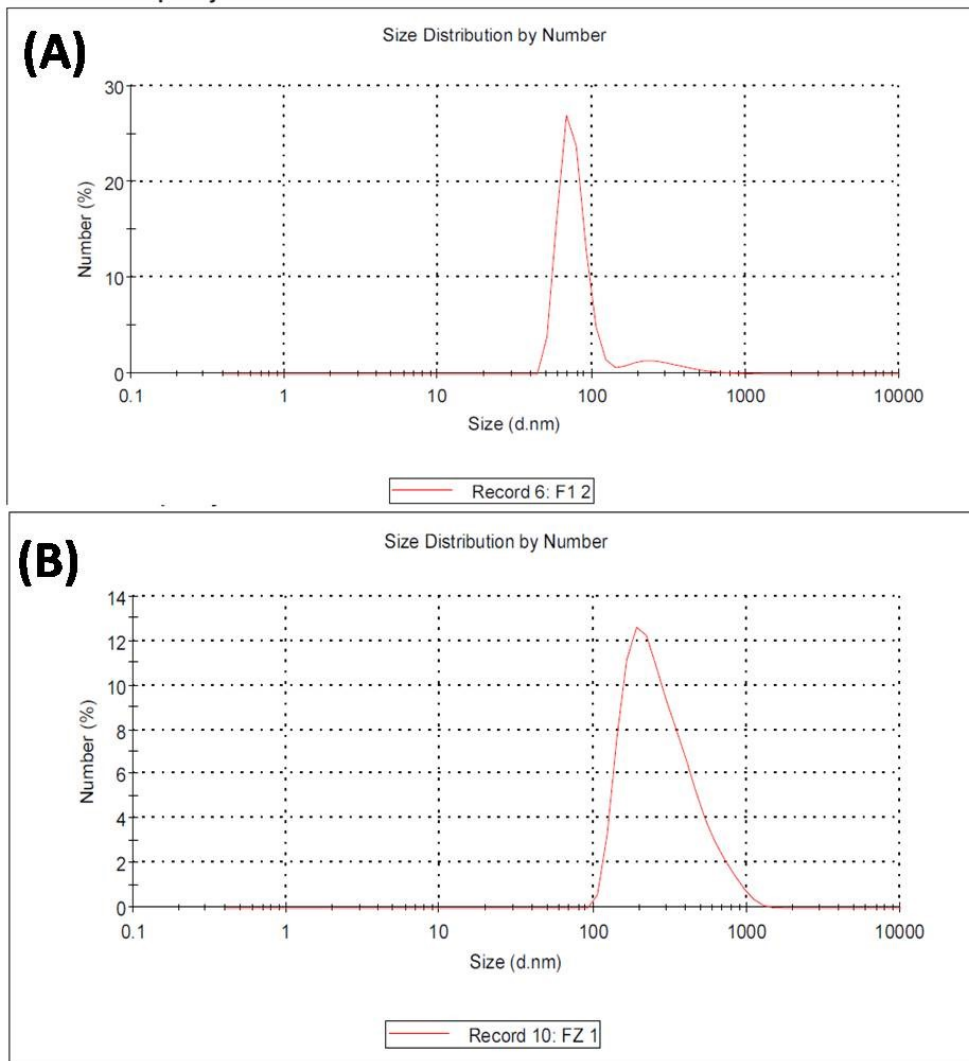


Figure S2: DLS analysis of iron oxide (FO) (A), and iron zinc oxide (FZO) (B).

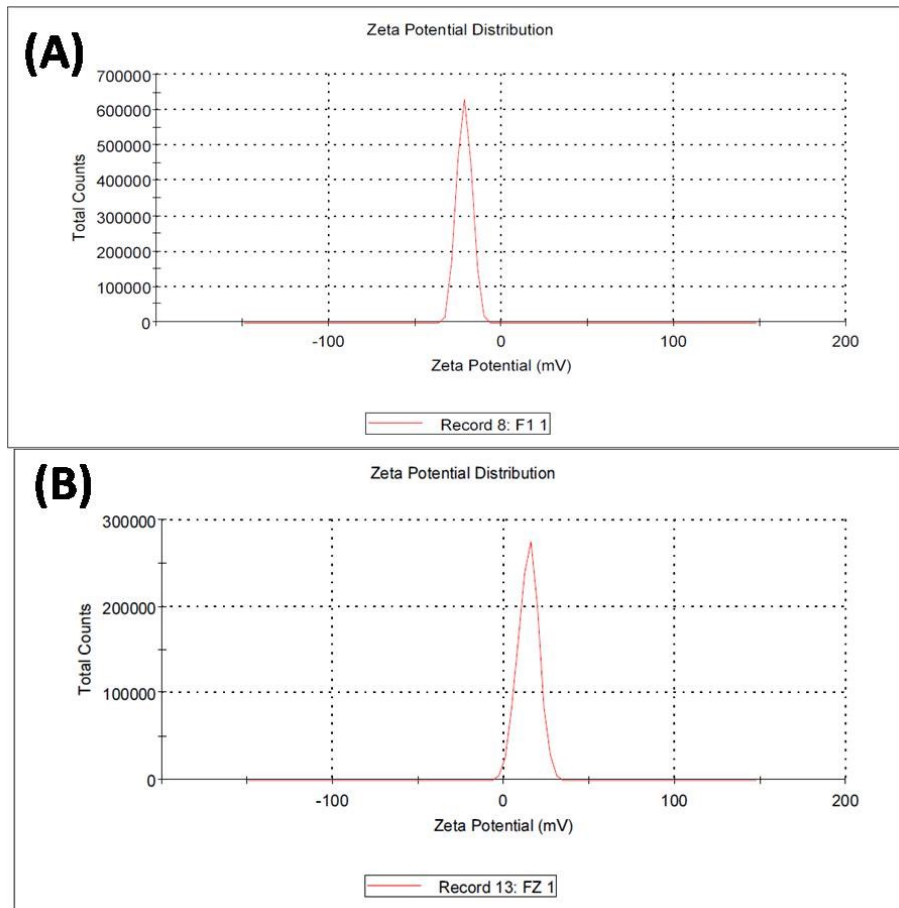


Figure S3: Zeta potential analysis of iron oxide (FO) (A), and iron zinc oxide (FZO) (B).

Table S1: The effect of pH upon %COD reduction at different dosage (1.5 g/L, 3 g/L, 4.5 g/L) of nanoparticles.

Dose (g/l)	Samples	pH (3)		pH (4)		pH (6)		pH (8)		pH (10)	
		COD (ppm)	Removal %	COD (ppm)	Removal %	COD (ppm)	Removal %	COD (ppm)	Removal %	COD (ppm)	Removal %
Blank		3,547		3,547		4,732		3,547		3,547	
1.5 g/l	<u>FO</u>	3,208	9.55	3,168	10.69	4,118	12.97	3,068	13.51	3,049	14.04
	<u>FZO</u>	3,217	9.30	3,077	13.24	3,986	21.13	2,921	17.66	3,044	14.18
	<u>FVO</u>	3,509	1.07	3,006	15.25	3,448	27.14	2,899	18.27	3,213	9.40
Blank		3,547		3,547		4,732		3,547		3,547	
3 g/l	<u>FO</u>	2,865	19.23	2,820	20.50	3,497	26.10	2,601	26.66	2,582	27.20
	<u>FZO</u>	2,909	17.99	2,756	22.29	3,047	35.61	2,694	24.06	2,936	17.23
	<u>FVO</u>	2,878	18.86	2,621	26.10	2,736	42.18	2,409	32.07	2,768	21.96
Blank		3,547		3,547		4,732		3,547		3,547	
4.5 g/l	<u>FO</u>	2,686	24.27	2,742	22.70	3,719	19.70	2,698	23.92	2,549	28.13
	<u>FZO</u>	2,532	28.62	2,449	30.95	3,270	30.89	2,328	34.36	2,374	33.10
	<u>FVO</u>	2,831	20.19	2,641	25.53	3,816	19.35	2,683	24.35	2,506	29.34

Table S2: The effect of nanomaterials dosage (1.5, 3, 4.5 g/L) upon %COD reduction at pH 6.

Dose (g/L)	Samples	pH (6)	
		COD (ppm)	Removal %
Blank		4,732	
1.5	<u>FO</u>	4,118	12.97
	<u>FZO</u>	3,986	21.13
	<u>FVO</u>	3,448	27.14
Blank		4,732	
3	<u>FO</u>	3,497	26.10
	<u>FZO</u>	3,047	35.61
	<u>FVO</u>	2,736	42.18
Blank		4,732	
4.5	<u>FO</u>	3,719	19.70
	<u>FZO</u>	3,270	30.89
	<u>FVO</u>	3,816	19.35

Table S3: The effect of temperatures (25 °C, 30°C, 40°C, 50°C and 60 °C) upon %COD reduction at dose (3 g/L) of nanomaterials

Dose (g/l)	Samples	25 °C		30 °C		40 °C		50 °C		60 °C	
		COD (ppm)	Removal %	COD (ppm)	Removal %	COD (ppm)	Removal %	COD (ppm)	Removal %	COD (ppm)	Removal %
Blank		4,732		3,547							
3 g/l	<u>FO</u>	3,497	26.10	2,784	22.06	2,825	20.36	2,847	19.73	3,062	13.67
	<u>FZO</u>	3,047	35.61	2,610	26.41	2,929	17.42	2,997	15.51	3,107	12.40
	<u>FVO</u>	2,736	42.18	2,366	33.29	2,997	15.50	3,109	12.35	3,221	9.19

Table S4: The effect of different commercial products upon %COD reduction at doses (1.5, 3.0, 4.5, 100.0, 200.0, 300 g/L)

Materials	Substance (RedOxy)	Substance (Oxy)
Dosage (g/L)	Removal %	Removal %
Blank	4,732	
1.5	<u>0</u>	<u>0</u>
3.0	<u>0</u>	<u>0</u>
4.5	<u>0</u>	<u>0</u>
100.0	<u>15.17</u>	<u>0</u>
200.0	<u>22.66</u>	<u>0</u>
300.0	<u>22.12</u>	<u>0</u>

Table S5: The components of oilfield water

Analysis	unit	Results	Analysis	unit	Results	Constituents	unit	Results	Constituents	unit	Results
TDS	(mg/l)	30655	TSS HCl%	(mg/l)	13.2 % organic	Lithium	(mg/l)	0.41	Fluoride	(mg/l)	53.77
					86.7 % inorganic						
Salinity		28723	Density		1.01139	Sodium		10480.2	Chloride		17407.86
Alkalinity		417.8	SP Gr		1.01239	Ammonium		169.12	Bromide		195.98
Total hardness		2327.5	PH		6	Potassium		179.92	Nitrate		97.45
DO		3.68	Conductivity		(mohs/cm) 4.6 x 10 ⁻²	Magnesium		229.7	Nitrite		Nil
BOD		346.4	Resistivity	(ohm-m) 0.2174	Calcium	553.29		Phosphate	Nil		
TSS		65.34	COD	(mg/l)	Strontium	13.28		Sulfate	703.38		
Total BTX		11.209	Toluene		3.429	Barium		2.71	Hydroxide		Nil
Benzene		5.22	Xylenes		0.55	Iron		29.9	Carbonate		Nil
Ethyl Benzene		0.63	p, m-xylene		1.38	Copper		0.06	Bicarbonate		509.55
Oil Content		15.5									

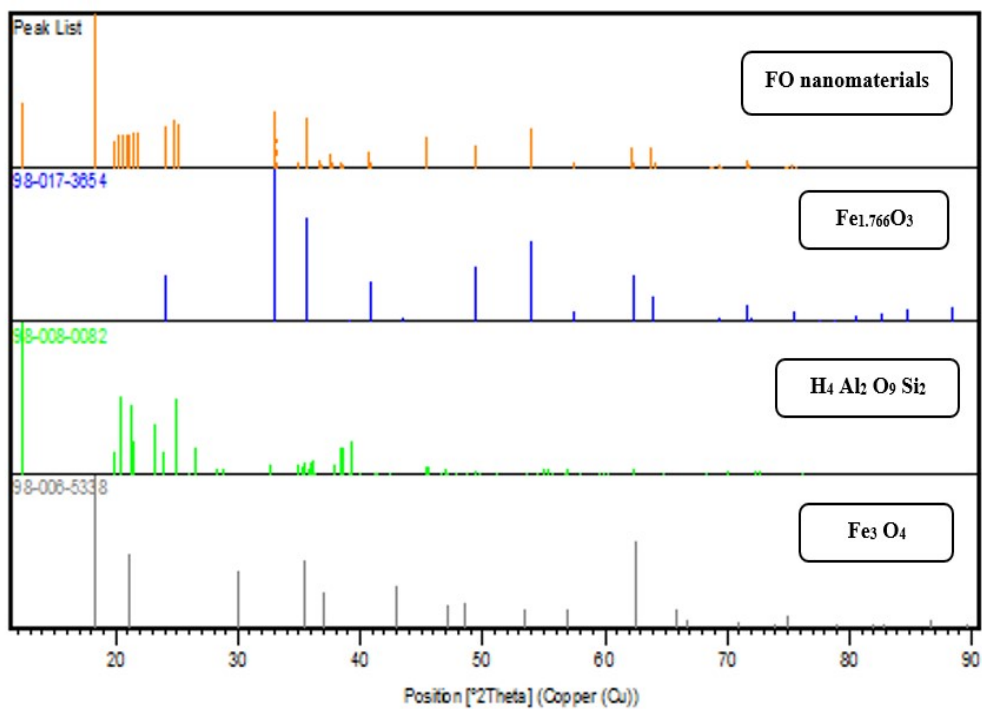


Figure S4: The ICSD of compounds existed in FO nanomaterials

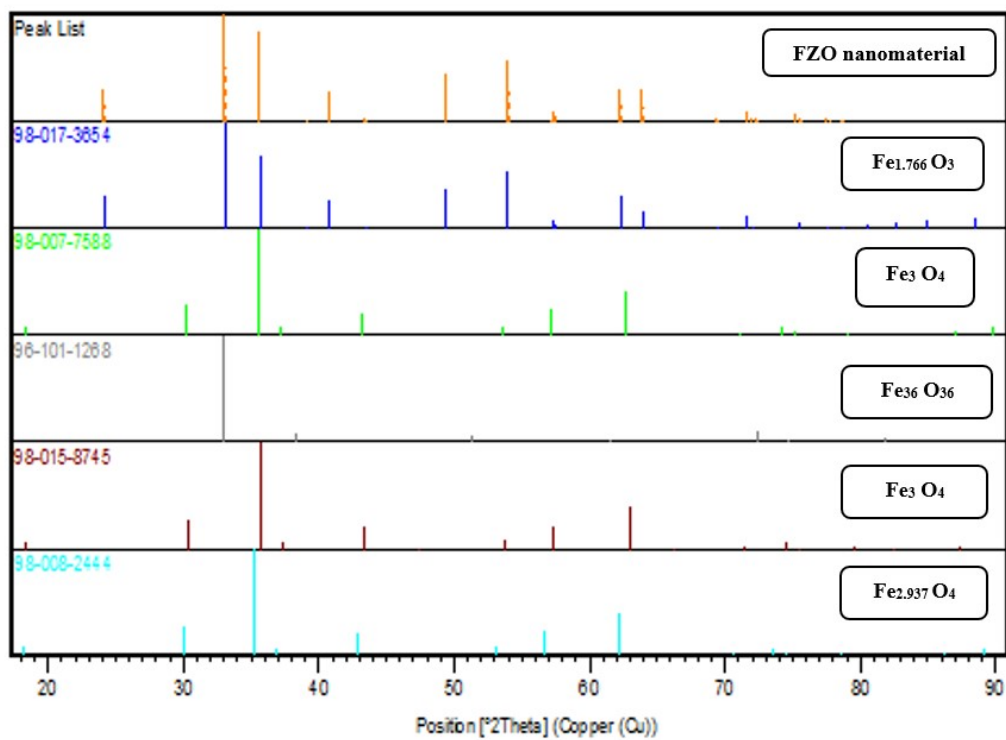


Figure S5: The ICSD of compounds existed in FZO nanomaterials

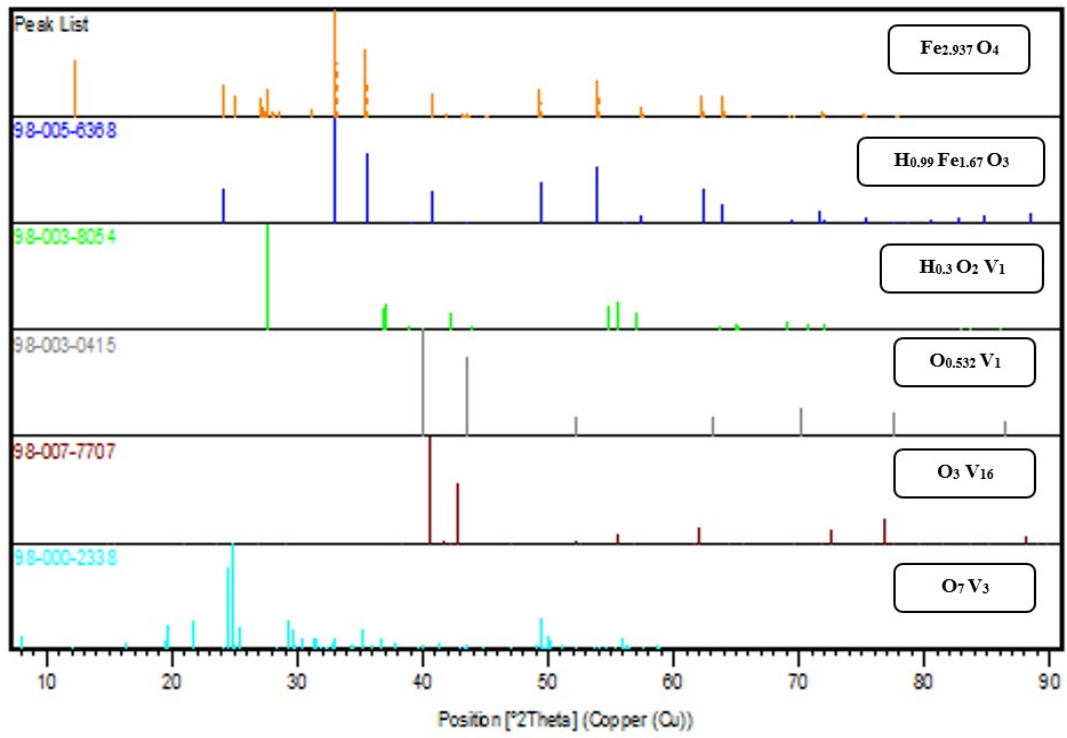


Figure S6: The ICSD of compounds existed in FZO nanomaterials