Supporting Information

Waste activated sludge disintegration and dewaterability by hydroxyl and sulfate radical-based oxidations: A comparative study

Hanife Sari Erkan

Yildiz Technical University, Civil Engineering Faculty, Environmental Engineering Department, 34220 Davutpasa, Esenler, Istanbul, Turkey

Tel.: +90 212 383 5383, Fax: +90 212 383 5358,

e-mail address: hsari@yildiz.edu.tr

(Total 5 tables and 3 figures)

Table S1. Experimental design matrix and levels of the sludge conditioning parameters for hydroxyl and sulfate radical oxidation

Factors	Ranges and levels		
	-1	0	1
X_1: Oxidant dosage (mmol/g SS)	0.5	1.25	2
X_2: Initial pH of WAS	2	6 (3 for HP)	10 (4 for HP)
X_3: Fe^{2+}/oxidant dosage	0.5	1.25	2

Table S2. Experimental conditions in hydroxyl and sulfate radical oxidation process and results of responses

	X_1	X_2	X_2	X_3	HP	CHC	PMS	PDS
Run	Oxidant dosage	Initial pH for HP	Initial pH for CHC, PMS and PDS	Fe^{2+}/oxidant ratio	DD_{COD}, %	DD_{COD}, %	DD_{COD}, %	DD_{COD}, %
1	2	4	10	1.25	1.35	6.63	6.31	4.26
2	1.25	3	6	1.25	2.51	0.58	6.50	2.42
3	1.25	2	2	0.5	3.89	6.46	7.08	4.61
4	1.25	3	6	1.25	2.41	0.78	6.22	2.47
5	1.25	4	10	2	1.23	4.28	6.15	3.29
6	2	3	6	0.5	2.51	1.01	7.30	3.47
7	2	2	2	1.25	4.44	6.80	9.21	5.06
8	1.25	4	10	0.5	1.46	8.18	7.49	3.92
9	0.5	4	10	1.25	1.86	6.37	7.03	2.32
10	0.5	2	2	1.25	3.99	6.85	5.27	3.67
11	1.25	2	2	2	4.04	7.49	7.88	4.81
12	0.5	3	6	0.5	2.51	0.62	5.32	1.37
13	1.25	3	6	1.25	2.51	0.79	6.57	2.52
14	1.25	3	6	1.25	2.47	0.58	6.61	2.72
15	1.25	3	6	1.25	2.46	0.73	6.82	2.62
16	2	3	6	2	2.33	0.32	8.29	3.02
17	0.5	3	6	2	2.66	0.58	5.16	1.47

Table S3. ANOVA of DD_{COD} for hydroxyl based oxidants

Response 1:DD_{COD} for HP treatment					
Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F
Model	14.78	9	1.64	598.04	**< 0.0001**
X_1-Oxidant dosage	0.018	1	0.018	6.55	**0.0375**
X_2-Initial pH	13.99	1	13.99	5093.03	**< 0.0001**
X_3-Fe^{2+}/oxidant ratio	7.774E-005	1	7.774E-005	0.028	0.8712
X_1X_2	0.23	1	0.23	82.67	**< 0.0001**
X_1X_3	0.026	1	0.026	9.57	**0.0175**
X_2X_3	0.016	1	0.016	5.66	**0.0489**
X_1^2	0.11	1	0.11	38.29	**0.0005**
X_2^2	0.34	1	0.34	122.54	**< 0.0001**
X_3^2	0.068	1	0.068	24.87	**0.0016**
Residual	0.019	7	2.747E-003		
Lack of Fit	0.012	3	4.112E-003	2.39	0.2098
Pure Error	6.892E-003	4	1.723E-003		
Cor Total	14.80	16			
R^2	0.9987				
Adj R^2	0.9970				
Response 2: DD_{COD} for CHC treatment					
Model	159.26	9	17.70	177.03	**< 0.0001**
X_1-Oxidant dosage	0.015	1	0.015	0.15	0.7115
X_2-Initial pH	0.57	1	0.57	5.68	**0.0486**
X_3-Fe^{2+}/oxidant ratio	1.62	1	1.62	16.17	**0.0051**
X_1X_2	0.023	1	0.023	0.23	0.6481
X_1X_3	0.10	1	0.10	1.04	0.3410
X_2X_3	6.08	1	6.08	60.81	**0.0001**
X_1^2	6.127E-006	1	6.127E-006	6.130E-005	0.9940
X_2^2	150.11	1	150.11	1501.83	**< 0.0001**
X_3^2	0.014	1	0.014	0.14	0.7177
Residual	0.70	7	0.100		
Lack of Fit	0.66	3	0.22	20.56	**0.0068**
Pure Error	0.043	4	0.011		
Cor Total	159.96	16			
R^2	0.9956				
Adj R^2	0.9900				

Table S4. ANOVA of DD_{COD} for sulfate radical based oxidants

Response 3:DD_{COD} for PMS treatment					
Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F
Model	17.56	9	1.95	15.68	**0.0007**
X_1-Oxidant dosage	8.66	1	8.66	69.65	**< 0.0001**
X_2-Initial pH	0.76	1	0.76	6.09	**0.0430**
X_3-Fe^{2+}/oxidant ratio	9.275E-003	1	9.275E-003	0.075	0.7927
X_1X_2	5.43	1	5.43	43.66	**0.0003**
X_1X_3	0.33	1	0.33	2.64	0.1481
X_2X_3	1.15	1	1.15	9.22	**0.0189**
X_1^2	0.050	1	0.050	0.40	0.5449
X_2^2	1.14	1	1.14	9.18	**0.0191**
X_3^2	0.029	1	0.029	0.23	0.6456
Residual	0.87	7	0.12		
Lack of Fit	0.68	3	0.23	4.85	0.0807
Pure Error	0.19	4	0.047		
Cor Total	18.43	16			
R^2	0.9527				
Adj R^2	0.8920				
Response 4:DD_{COD} for PDS treatment					
Model	19.25	9	2.14	212.96	**< 0.0001**
X_1-Oxidant dosage	6.09	1	6.09	606.81	**< 0.0001**
X_2-Initial pH	2.38	1	2.38	237.04	**< 0.0001**
X_3-Fe^{2+}/oxidant ratio	0.075	1	0.075	7.44	**0.0295**
X_1X_2	0.075	1	0.075	7.49	**0.0290**
X_1X_3	0.075	1	0.075	7.49	**0.0290**
X_2X_3	0.17	1	0.17	16.86	**0.0045**
X_1^2	0.32	1	0.32	31.40	**0.0008**
X_2^2	10.15	1	10.15	1011.09	**< 0.0001**
X_3^2	0.014	1	0.014	1.35	0.2835
Residual	0.070	7	0.010		
Lack of Fit	0.013	3	4.198E-003	0.29	0.8308
Pure Error	0.058	4	0.014		
Cor Total	19.32	16			
R^2	0.9964				
Adj R^2	0.9917				

Table S5. Floc sizes of raw WAS and disintegrated sludge samples

	Temperature (°C)	d10 (μm)	d50 (μm)	d90 (μm)
Raw WAS		6.24	19.449	51.79
After HP treatment	30	6.442	24.028	71.054
	45	5.644	18.31	56.703
	60	5.034	16.347	47.583
After CHC treatment	30	4.8	18.039	60.14
	45	4.598	17.763	60.603
	60	5.229	18.12	51.062
After PMS treatment	30	4.42	15.901	53.238
	45	4.479	15.608	45.95
	60	4.927	16.107	45.807
After PDS treatment	30	6.458	21.084	63.888
	45	6.588	20.934	56.706
	60	6.557	20.668	61.143

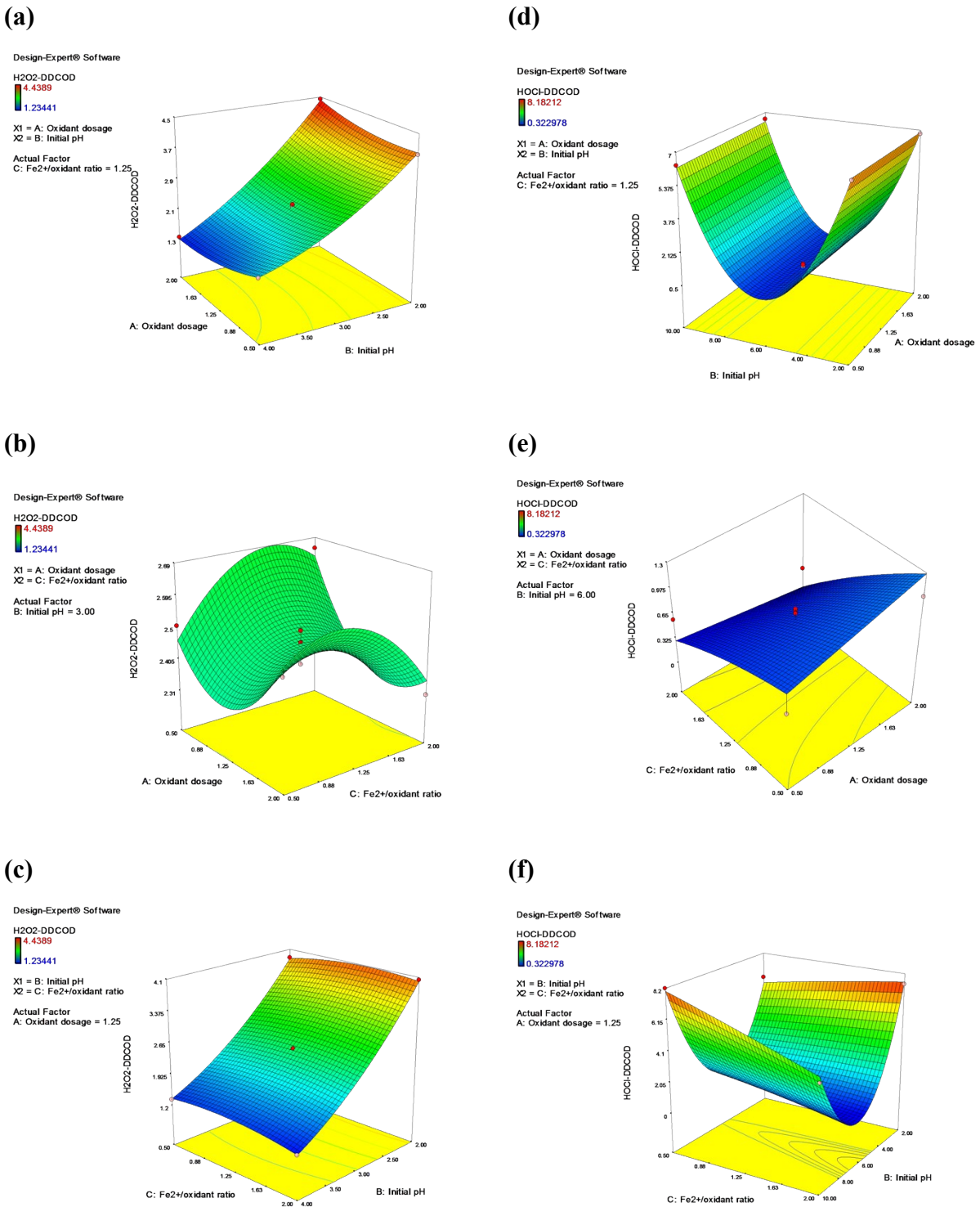


Fig S1. Response surface and contour plots for disintegration process with hydroxyl radical based oxidants; (a) HP dosage vs. initial pH, (b) HP dosage vs. Fe^{2+}/HP ratio, (c) initial pH vs. Fe^{2+}/HP ratio, (d) CHC dosage vs. initial pH, (e) CHC dosage vs. Fe^{2+}/CHC ratio, (f) initial pH vs. Fe^{2+}/CHC ratio

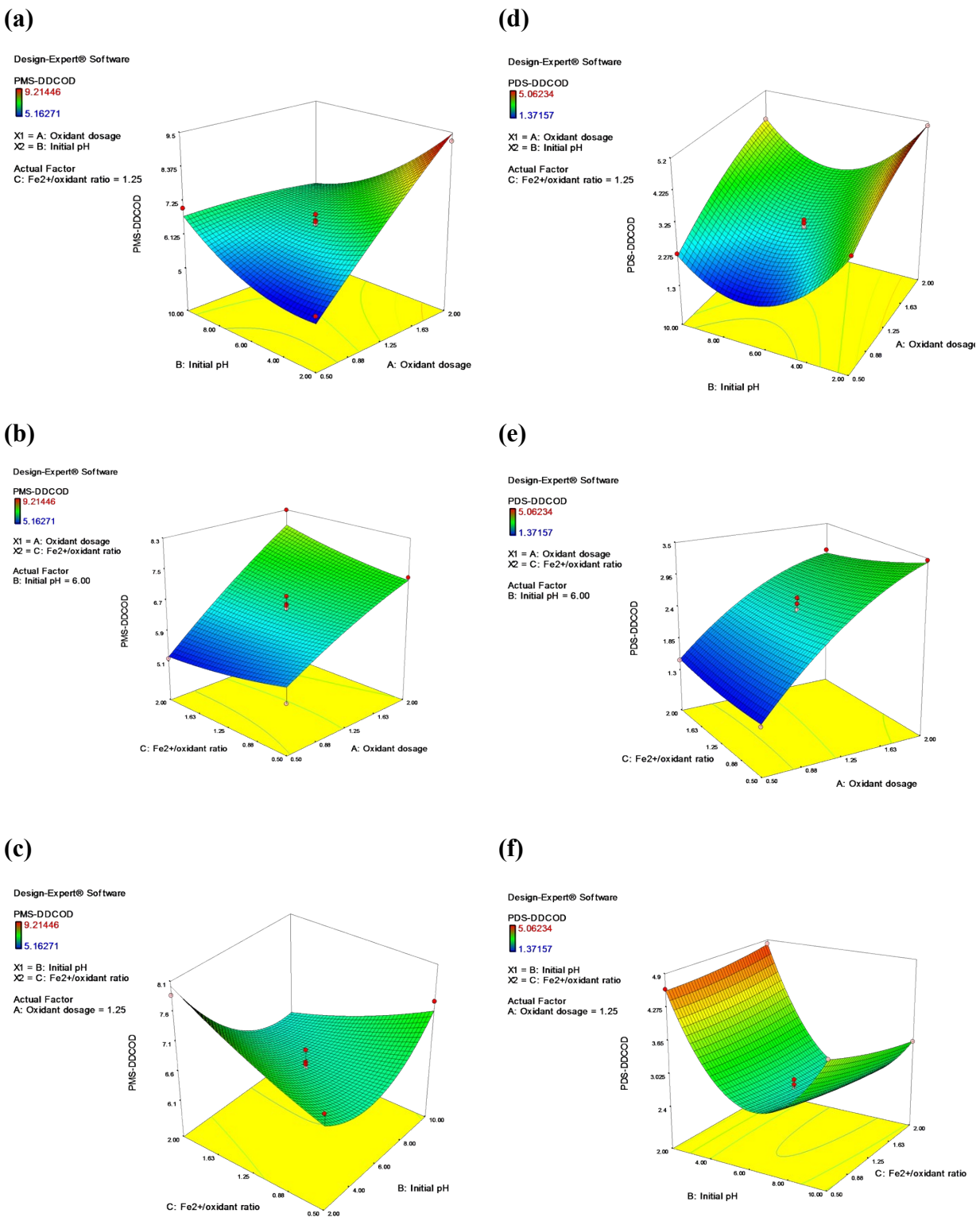
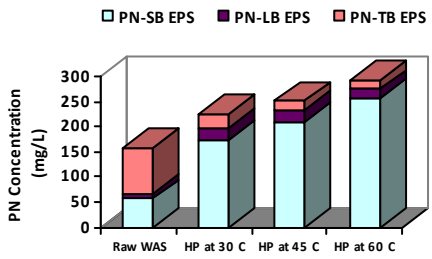


Fig S2. Response surface and contour plots for disintegration process with sulfate radical based oxidants; (a) PDS dosage vs. initial pH, (b) PDS dosage vs. Fe^{2+}/ PDS ratio, (c) initial pH vs. Fe^{2+}/ PDS ratio, (d) PMS dosage vs. initial pH, (e) PMS dosage vs. Fe^{2+}/ PMS ratio, (f) initial pH vs. Fe^{2+}/ PMS ratio

(a)



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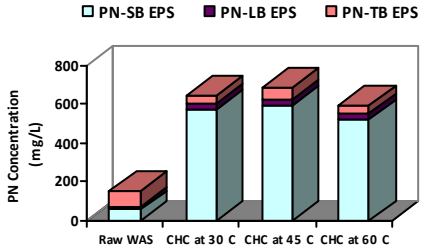

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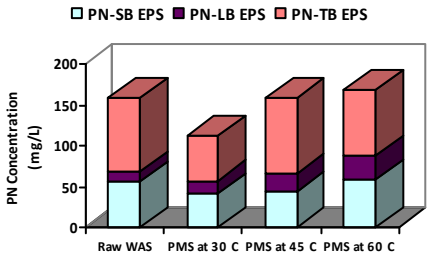

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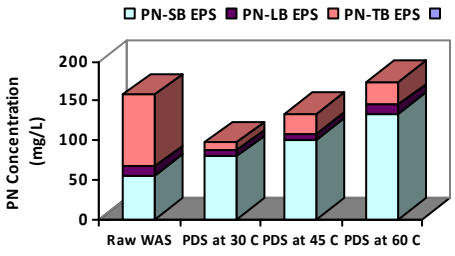

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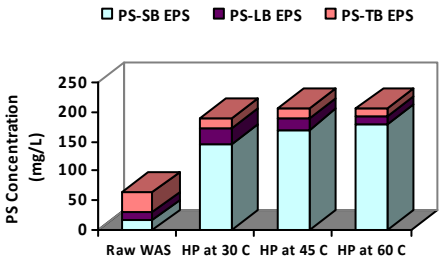

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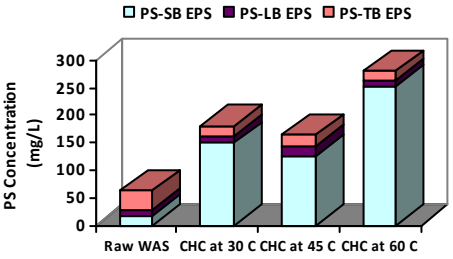

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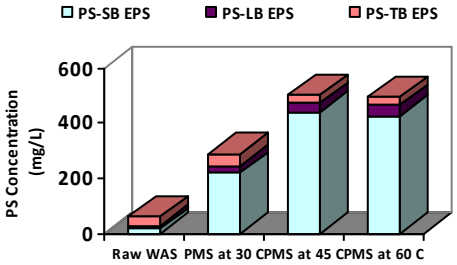

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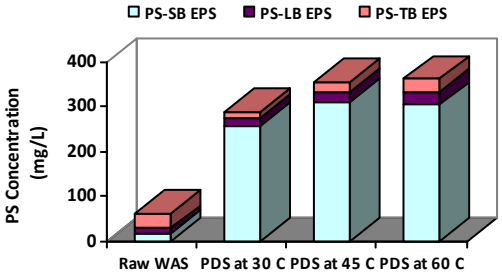

Fig S3. PN and PS fractions of EPS of raw and treated sludge at different temperatures