

## REFERENCES

- Bellamy et al. Treatment of VOC-contaminated groundwater by hydrogen peroxide and ozone oxidation. Research Journal WPCF 63 (1991) : 120-127.
- Bhattacharyya D., et al. Two-phase ozonation of chlorinated organics J. Hazardous Materials 41 (1995): 73-93.
- Chainarong Thakulsukanant . Adsolubilization and stability characterizations of hydrocarbon aggregates chemically bonded to porous silica. Master's Thesis, The Petroleum and Petrochemical College, Chulalongkorn University, 1997.
- Colin, H. and Guiochon ,G. Introduction to reversed-phase high-performance liquid chromatography. Journal of Chromatography 141 (1977) : 289-312.
- Donald Boyd Peterson JR. Ozonation of effluent from surfactant based seperation processes. Master's Thesis ,Oklahoma University, 1989
- Dunn,R. O., et al. Use of micellar - enhanced ultrafiltration to remove dissolved organics from aqueous stream. J. Sep. Sci. Techol. 20 (1985) : 257-284.
- Eschweiler H., et al. Radiation - induced OH radical generation and its use for groundwater remediation J. Phys. Chem. 42 (1993): 711-714.
- Glaze, W.H. and Kang, J. W. Advanced oxidation processes for treating groundwater contaminated with TCE and PCE: Laboratory studies. Journal AWWA. 1 (1988) : 57-63.

- Harwell, J.H., Hoskins, J. C., Schechter, R. S. and Wade, W. H. Pseudophase separation model for surfactant adsorption: Isomerically pure surfactant. Langmuir (1985) : 251-262.
- Hennion, M.C., Picard, C., Caude, M. Influence of the number and length of alkyl chains on the chromatographic properties of hydrocarbonaceous bonded phases. Journal of chromatography 166 (197) : 21-35.
- Hogine, J. and Badder, H. Ozone initiated oxidations of solutes in wastewater: a reaction kinetic approach. Prog. Wat. Tech. 10 (1978) :657-671.
- Hogine, J. and Badder, H. The role of hydroxy radical reactions in ozonation processes in aqueous solutions. Wat. Res. 10 (1976) : 277-288.
- Karch, K., Sebastian, I., Halasz, I. Preparation and properties of reversed phases. Journal of chromatography 122 (1976) : 3-16.
- Kusakabe et al. Destruction rate of volatile organochlorine compounds in water by ozonation with ultraviolet-radiation. Wat. Res. 25 (1991) : 1199-1203.
- Lee, et.al Substituent group effects on the solubilization of polar aromatic solutes ( Phenols, Anilines, and Benzaldehydes) by N-Hexadecylpyridinium Chloride. J. Phys. Chem. 95 (1991) : 360-365.
- Levitz, P. and Van Damme, H. and Keravis, D. Fluorescence decay study of the adsorption of nonionic surfactant at the solid-liquid interface.1. Structure of the adsorption layer on a hydrophilic Solid. J. Phys. Chem. 88 (1984) : 2228-2235.
- Levitz, P. and Van Damme, H. Fluorescence decay study of the adsorption of nonionic surfactant at the solid-liquid interface.2. Influence of polar chain length. J. Phys. Chem. 90 (1986) : 1302-1310.

- Never, N. D. Air pollution control engineering. Singapore: McGraw-Hill Book Co.,1995.
- Nunn, C.C., Schechter, R.S., and Wade, H.W. Visual evidence regarding the nature of hemmicelles through surface solubilization of pinacynaol chloride. J. Phys. Chem. 86 (1982) : 3271-3272.
- O'Rear et al. Formation of Poly(tetrafluoroethylene) Thin films on alumina by admicellar polymerization. Langmuir 11 (1995) : 905-911.
- Ogawa, H., Koh, T., Taya, K. and Chihara, T. Catalysis at the toluene/water interface: Octadecyl immobilized H-ZSM-5 catalyst promoted hydrolysis of water-insoluble esters. Journal of catalysis 148 (1994) : 493-500.
- Peterson, D.B. Ozonation of effluent from surfactant-based separation processes. Master's Thesis, University of Oklahoma.
- Rosen M.J. Surfactants and interfacial phenomena 2 nd ed. New York: John Willy and Sons Co.,1989.
- Scamehorn, et al. Adsorption of surfactants on mineral oxide surfaces from aqueous solution I. Isomerically pure anionic surfactants . J. Colloid Interface Sci. 85 (1982) : 463-478.
- Scamehorn, J.F. and Harwell, J.H. Surfactants and chemical engineering, New York: Marcell Dekker Book Co., 1986.
- Shambaugh, R.L. and Melnyk, P.B. The influence of spontaneous decomposition and mass transfer upon soluble ozone concentration. Proceedings of the International Ozone Institute's Forum on Ozone Disinfection, Chicago.
- Somasundarun, P. and Fuerstenau, D. W. Mechanism of Alkyl Sulfonate at the alumina-water interface. J. Phys. Chem. 79 (1966) : 90-96.

- Yu, C.C. and Lobban, L.L. Catalysis by surfactant aggregates adsorbed on mineral oxide surfaces. Ph.D. Dissertation, University of Oklahoma.
- Yurteri, C. and Gurol, M.D. Ozone consumption in natural water: Effects of background organic matter, pH and carbonate species. Journal of Ozone Science Engineering. 10 (1988) : 277.

## APPENDIX

**Table A-1** External limitation at 550 rpm

Data : Initial TCE concentration 400 ppm

Ozone concentration 50 g/m<sup>3</sup>

Flow rate 50 ml/min

25 g of catalyst

Temperature 20 °C

time (min)	TCE (mol/l)	d[C]/dt (gmol/min)	rate (gmole/g.l.min)
0	1.8151	0.0262	-0.0010
2	1.8788	0.0136	-0.0005
4	1.8671	0.0028	-0.0001
6	1.8445	-0.0060	0.0002
8	1.8343	-0.0128	0.0005
10	1.9297	-0.0178	0.0007
12	1.7635	-0.0208	0.0008
14	1.7041	-0.0220	0.0009
16	1.7097	-0.0212	0.0008
18	1.6494	-0.0184	0.0007
20	1.6340	-0.0138	0.0006
22	1.5986	-0.0072	0.0003

time (min)	TCE (mol/l)	$d[C]/dt$ (gmol/min)	rate (gmole/g.l.min)
24	1.7356	0.0012	0.0000
26	1.6162	0.0116	-0.0005
28	1.6970	0.0240	-0.0010

**Table A-2** External limitation at 750 rpm

Data : Initial TCE concentration 400 ppm

Ozone concentration 50 g/m<sup>3</sup>

Flow rate 50 ml/min

25 g of catalyst

Temperature 20 °C

time (min)	TCE (mol/l)	d[C]/dt (gmol/min)	rate (gmole/g.l.min)
0	1.8151	-0.0021	0.0001
2	1.8595	-0.0110	0.0004
4	1.9083	-0.0184	0.0007
6	1.6913	-0.0244	0.0010
8	1.7095	-0.0290	0.0012
10	1.7276	-0.0321	0.0013
12	1.4730	-0.0338	0.0014
14	1.4679	-0.0340	0.0014
16	1.4628	-0.0328	0.0013
18	1.4149	-0.0302	0.0012
20	1.3097	-0.0261	0.0010
22	1.2847	-0.0206	0.0008
24	1.1581	-0.0136	0.0005
26	1.1604	-0.0052	0.0002
28	1.1674	0.0046	-0.0002

**Table A-3** External limitation at 900 rpm

Data : Initial TCE concentration 400 ppm

Ozone concentration 50 g/m<sup>3</sup>

Flow rate 50 ml/min

25 g of catalyst

Temperature 20 °C

time (min)	TCE (mol/l)	d[C]/dt (gmol/min)	rate(gmole/g.l.min)
0	1.8151	-0.0347	0.0014
2	1.8334	-0.0373	0.0015
4	1.7343	-0.0393	0.0016
6	1.5635	-0.0409	0.0016
8	1.5334	-0.0421	0.0017
10	1.4893	-0.0427	0.0017
12	1.3663	-0.0429	0.0017
14	1.2709	-0.0425	0.0017
16	1.2181	-0.0417	0.0017
18	1.1652	-0.0405	0.0016
20	1.0440	-0.0387	0.0015
22	0.9897	-0.0365	0.0015
24	0.9324	-0.0337	0.0013
26	0.9552	-0.0305	0.0012
28	0.8244	-0.0269	0.0011



**Table A-4** External limitation at 1,000 rpm

Data : Initial TCE concentration 400 ppm

Ozone concentration 50 g/m<sup>3</sup>

Flow rate 50 ml/min

25 g of catalyst

Temperature 20 °C

time (min)	TCE (mol/l)	d[C]/dt (gmol/min)	rate (gmole/g.l.min)
0	1.8151	0.0262	-0.0010
2	1.8788	0.0136	-0.0005
4	1.8671	0.0028	-0.0001
6	1.8445	-0.0060	0.0002
8	1.8343	-0.0128	0.0005
10	1.9297	-0.0178	0.0007
12	1.7635	-0.0208	0.0008
14	1.7041	-0.0220	0.0009
16	1.7097	-0.0212	0.0008
18	1.6494	-0.0184	0.0007
20	1.6340	-0.0138	0.0006
22	1.5986	-0.0072	0.0003
24	1.7356	0.0012	0.0000
26	1.6162	0.0116	-0.0005
28	1.6970	0.0240	-0.0010

**Table A-5** Effectiveness of catalyst

Data : Initial TCE concentration 400 ppm

Ozone concentration 130 g/m<sup>3</sup>

Flow rate 50 ml/min

Temperature 20 °C

time (min)	Conversion		
	no catalyst	10.2 g catalyst	25 g catalyst
0	0	0	0
5	0.2545	0.3234	0.4068
10	0.6137	0.7064	0.8590
15	0.8053	0.8573	0.9360
20	0.9467	0.9449	0.9980
25	0.9915	0.98667	1
30	0.9972	0.9938	1

**Table A-6** Adsolubilization curve

Data : 25 g of catalyst

Temperature 20 °C

Stirring speed 550 rpm

Equilibrium time 2 hrs.

TCE initial (ppm)	TCE in aqueous (ppm)		TCE in admicelle (ppm)
	equilibrium	adsolubilize	
140	80.671	31.953	48.719
240	140.926	56.089	84.837
340	213.687	87.716	125.971
440	270.487	106.709	163.778

## CURRICULUM VITAE

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