

## APPENDIX A

### Standard Calibration Curve of the chlorophenols

#### A.1 Calibration Curve for 2-chlorophenol

Table A.1 The response (area) at  $\lambda$  216 nm with the concentration of 2-chlorophenol from 0.1 ppm to 1.0 ppm

Concentration(ppm) prepared of 2-chlorophenol	Response (area)
0.3	19844073
0.4	24106123
0.5	27093346
0.8	38528926
0.9	39642420

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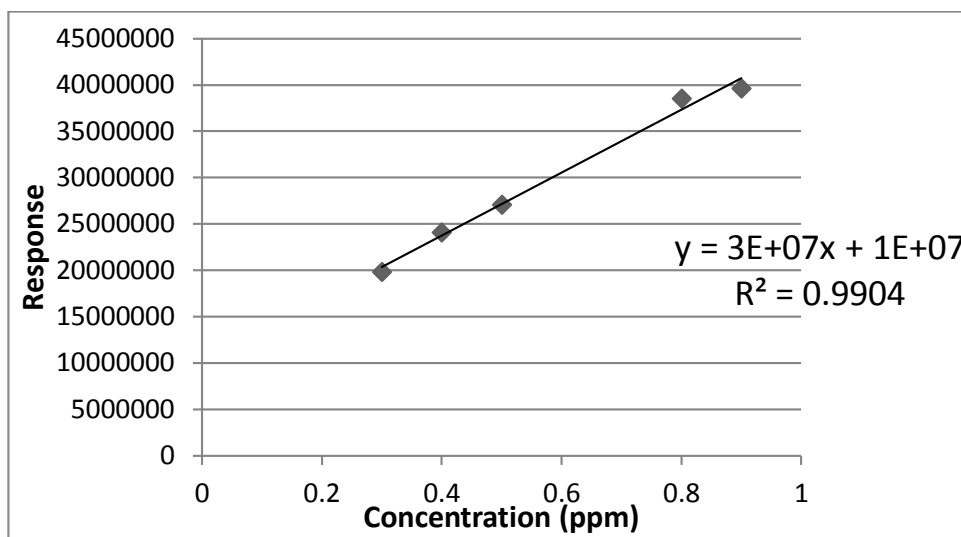


Figure A.1 relationship between response (peak area) with the concentration of 2-chlorophenol at various concentrations

The standard curve is shown in Figure A.1. The y-axis is the Area peak and x is the concentration of 2-chlorophenol. The standard curve plot of The relationship between response (peak area) with the concentration of 2-chlorophenol at various concentrations. Found that when the concentration of 2-chlorophenol increases the absorption is increased too. Coefficient of Determination ( $R^2$ ) was 0.9904. Thus, this standard curve was suitable for determination the degradation of 2-Chlorophenol at different times.

## APPENDIX B

### Residual 2-chlorophenol concentration data and calculation

Table B.1 Effect of the amount of dopant on 2-chlorophenol oxidation

Time	0.07 %mol Ce		0.14 %mol Ce		0.21 %mol Ce	
	%dagrads	C/C <sub>0</sub>	%dagrads	C/C <sub>0</sub>	%dagrads	C/C <sub>0</sub>
0	0.0003	1.0000	0.0002	1.0000	0.0000	1.0000
60	14.9124	0.8509	16.6379	0.8336	27.6534	0.7235
120	25.8699	0.7413	37.7006	0.6230	48.0611	0.5194
180	39.8025	0.6020	59.9554	0.4004	73.3272	0.2667
240	57.0973	0.4290	74.0297	0.2597	92.9923	0.0701

Time	0.28 %mol Ce		0.35 %mol Ce	
	%dagrads	C/C <sub>0</sub>	%dagrads	C/ C <sub>0</sub>
0	0.0003	1.0000	0.0001	1.0000
60	40.1024	0.5990	35.1825	0.6482
120	74.0813	0.2592	59.6864	0.4031
180	84.6332	0.1537	81.9460	0.1805
240	99.1147	0.0089	97.8660	0.0213

Table B.2. Effect of calcinations temperature on 2-chlorophenol oxidation

Time	200 °C		300 °C		400 °C	
	%dagrads	C/C <sub>0</sub>	%dagrads	C/C <sub>0</sub>	%dagrads	C/C <sub>0</sub>
0	0.0003	1.0000	0.0002	1.0000	0.0001	1.0000
60	10.6831	0.8932	13.1414	0.8686	15.1682	0.8483
120	25.7843	0.7422	30.1698	0.6983	36.5450	0.6346
180	42.0240	0.5798	43.8266	0.5617	59.9330	0.4007
240	53.2350	0.4677	58.3067	0.4169	70.7471	0.2925
Time	500 °C		600 °C			
	%dagrads	C/C <sub>0</sub>	%dagrads	C/ C <sub>0</sub>		
0	0.0002	1.0000	-0.0003	1.0000		
60	21.4807	0.7852	40.1024	0.5990		
120	57.9265	0.4207	74.0813	0.2592		
180	83.3506	0.1665	84.6332	0.1537		
240	95.1502	0.0485	99.1147	0.0089		

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Table B.3 Effect of amount of catalyst on 2-chlorophenol oxidation

Time	1 g/L		2 g/L		3 g/L	
	% dagrađ	C/C <sub>0</sub>	% dagrađ	C/C <sub>0</sub>	% dagrađ	C/C <sub>0</sub>
0	0.0001	1.0000	0.0004	1.0000	0.0001	1.0000
60	14.9691	0.8503	20.5425	0.7946	46.5000	0.5350
120	39.4683	0.6053	57.7928	0.4221	80.8126	0.1919
180	60.7084	0.3929	71.5702	0.2843	91.6745	0.0833
240	66.6791	0.3332	85.2355	0.1476	98.9718	0.0103
Time	4 g/L		5 g/L			
	% dagrađ	C/C <sub>0</sub>	% dagrađ	C/ C <sub>0</sub>		
0	0.0002	1.0000	0.0000	1.0000		
60	35.5587	0.6444	9.7333	0.9027		
120	70.8463	0.2915	40.6260	0.5937		
180	85.2421	0.1476	52.6407	0.4736		
240	96.9330	0.0307	69.3918	0.3061		

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Table B.4 Effect of the pH on 2-chlorophenol oxidation

Time	pH 2		pH 3		pH 5.5	
	% dagraad	C/C <sub>0</sub>	% dagraad	C/C <sub>0</sub>	% dagraad	C/C <sub>0</sub>
0	0.0002	1.0000	-0.0002	1.0000	0.0003	1.0000
60	32.2517	0.6775	23.3889	0.7661	40.1024	0.5990
120	64.8653	0.3513	62.1475	0.3785	74.0813	0.2592
180	77.7505	0.2225	80.3799	0.1962	84.6332	0.1537
240	85.7865	0.1421	83.8798	0.1612	99.1147	0.0089
Time	pH 7		pH 9			
	% dagraad	C/C <sub>0</sub>	% dagraad	C/ C <sub>0</sub>		
0	0.0001	1.0000	0.0004	1.0000		
60	46.5000	0.5350	13.1103	0.8689		
120	80.8126	0.1919	33.9309	0.6607		
180	91.6745	0.0833	47.7197	0.5228		
240	98.9718	0.0103	67.0812	0.3292		

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Table B.5 Effect of the initial 2-chlorophenol concentration

Time	10 ppm		20 ppm		30 ppm	
	%dagrads	C/C <sub>0</sub>	%dagrads	C/C <sub>0</sub>	%dagrads	C/C <sub>0</sub>
0	-0.0002	1.0000	0.0001	1.0000	0.0001	1.0000
60	54.8277	0.4517	46.5000	0.5350	31.7600	0.6824
120	90.5042	0.0950	80.8126	0.1919	60.5575	0.3944
180	97.0634	0.0294	91.6745	0.0833	77.0937	0.2291
210	99.1736	0.0083	96.0787	0.0392	85.3774	0.1462
240	99.1736	0.0083	98.9718	0.0103	90.7729	0.0923
Time	40 ppm		50 ppm			
	%dagrads	C/C <sub>0</sub>	%dagrads	C/ C <sub>0</sub>		
0	0.0002	1.0000	0.0002	1.0000		
60	26.1634	0.7384	10.7230	0.8928		
120	47.2196	0.5278	22.3444	0.7766		
180	64.5849	0.3542	37.9138	0.6209		
210	69.3639	0.3064	43.9637	0.5604		
240	72.1721	0.2783	53.0974	0.4690		

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Table B.6 the control parameter

Time	TiO <sub>2</sub> /Ce & LED		TiO <sub>2</sub> /Ce only		LED only	
	%dgrad	C/C <sub>0</sub>	%dgrad	C/C <sub>0</sub>	%dgrad	C/C <sub>0</sub>
0	0.0003	1.0000	0.0001	1.0000	0.0002	1.0000
60	40.1024	1.4784	3.8764	0.9612	1.6589	0.9834
120	74.0813	3.4187	5.8147	0.9419	3.0990	0.9690
180	84.6332	11.7436	6.9985	0.9300	4.4079	0.9559
240	99.1147	92.8685	9.1090	0.9089	4.2222	0.9578

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Table B.7 Comparison between various doped TiO<sub>2</sub>

Time	undoped TiO <sub>2</sub> with Sol-gel		undoped TiO <sub>2</sub> with hydrothermal	
	%dgrad	C/C <sub>0</sub>	%dgrad	C/C <sub>0</sub>
0	0.0002	1.0000	0.0001	1.0000
60	26.2338	0.7377	35.7382	0.6426
180	48.5137	0.5149	57.1284	0.4287
300	66.3176	0.3368	78.2771	0.2172
360	85.4700	0.1453	87.6693	0.1233
420	88.7879	0.1121	93.0656	0.0693
Time	P25		Cerium 0.28%mol doped TiO <sub>2</sub> with hydrothermal process	
	%dgrad	C/C <sub>0</sub>	%dgrad	C/C <sub>0</sub>
0	0.0003	1.0000	0.0003	1.0000
60	9.7487	0.9025	40.1024	0.5990
180	23.9394	0.7606	74.0813	0.2592
300	34.3441	0.6566	99.1147	0.0089
360	35.5968	0.6440	99.1147	0.0089
420	37.9584	0.6204	99.1147	0.0089

## APPENDIX C

### Crystal structures

These lattice point arrangements are called the Bravais lattices. In three dimensional crystal structures composed of constants, the three lattices ( $a$ ,  $b$ ,  $c$ ) and three angles ( $\alpha$ ,  $\beta$ ,  $\gamma$ ). Table C-1 shows the seven different crystal class or structures indicating their respective axis. Crystals consists of planes of atoms that are spaced a distance apart but can be resolved into many atomic planes with different d-spacing (Brundle et al., 1992). If the difference between reflections on neighbouring planes is equal to the whole number of wavelengths, then the phase difference is zero throughout the crystal. Thus, using the angle ( $\theta$ ), the maximum amplitude of the reflected wave can be obtained. Now when there is constructive interference from X-rays scattered by the atomic planes in a crystal, a diffraction peak is observed ( Brundle et al., 1992). The X-ray signal corresponds to consistent reflection on the plane of crystal. This reflection is called Bragg reflection (Poole, Jr. and Owens, 2003). Every crystallographic planes has three indices ( $h,k,l$ ). Such that d-spacing ( $d_{hkl}$ ) can be determined using the Bragg's law.

$$2d_{hkl} \sin\theta = n\lambda \quad (\text{eq. C} - 1)$$

Where:  $d_{hkl}$  is the spacing between the planes

$\theta$  is the angle that the X-ray beam makes with respect to the plane

$\lambda$  is the wavelength of the X-rays

$n = 1,2,3,\dots$  is an integer normally has the value  $n = 1$

Table C.1 Different crystal class/structures and systems.

Crystal Class	Axis System
Cubic	$a = b = c, \alpha = \beta = \gamma = 90^\circ$
Tetragonal	$a = b \neq c, \alpha = \beta = \gamma = 90^\circ$
Hexagonal	$a = b \neq c, \alpha = \beta = 90^\circ, \gamma = 120^\circ$
Rhombohedral	$a = b = c, \alpha = \beta = \gamma \neq 90^\circ$
Orthorhombic	$a \neq b \neq c, \alpha = \beta = \gamma = 90^\circ$
Monoclinic	$a \neq b \neq c, \alpha = \gamma = 90^\circ, \beta \neq 90^\circ$
triclinic	$a \neq b \neq c, \alpha \neq \beta \neq \gamma \neq 90^\circ$

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