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Appendices

ศูนย์วิทยทรัพยากร  
จุฬาลงกรณ์มหาวิทยาลัย



Appendix A

ศูนย์วิทยทรัพยากร  
จุฬาลงกรณ์มหาวิทยาลัย



48-0132		Wavelength = 1.5418				
Mg <sub>0.26</sub> Pb <sub>0.95</sub> Zr <sub>0.03</sub> Nb <sub>0.60</sub> O <sub>2.78</sub>		2 $\theta$	Int	h	k	l
Magnesium Lead Zirconium Niobium Oxide		21.927	22	1	0	0
		31.241	100	1	1	0
		38.504	16	1	1	1
		44.753	24	2	0	0
Rad. CuK $\alpha$ $\lambda$ 1.5418 Filter Graph Mono d sp: Diff.		50.378	5	2	1	0
Cut off Int. Diffract. I/cor.		55.579	22	2	1	1
		65.131	7	2	2	0
Ref. Nijmeijer, A., Bocijsma, J., Kruidhof, H. Powder Diffraction, 11, 85 (1996)		69.627	1	3	0	0
		73.997	5	3	1	0
		78.272	1	3	1	1
		82.473	2	2	2	2
Sys. Cubic S.G. Pm $\bar{3}$ m (221)		86.663	<1	3	2	0
a 4.0508(1) b c A C:		90.798	4	3	2	1
$\alpha$ $\beta$ $\gamma$ Z: 1 mp:		99.133	<1	4	0	0
Ref. Ibid		103.388	<1	4	1	0
		107.668	2	4	1	1
		112.105	<1	3	3	1
		116.636	1	4	2	0
Dx 7.647 Dm 7.600 SS/FOM: F <sub>21</sub> = 102(.0098 . 21)		121.421	<1	4	2	1
		126.419	<1	3	3	2
		137.585	<1	4	2	2
Color Orange yellow						
Mg Nb <sub>2</sub> O <sub>6</sub> , yellow Pb O, Zr O <sub>2</sub> and Mg O were milled for 16 hours in isopropanol, then calcined at 750 C for 10 hours. The product was reground, pressed and fired at 950 C for 10 hours under lead zirconate vapor. Silicon used as an internal stand. PSC: cP4.62. To replace 27-1199. Mwt: 306.12 Volume[CD]: 66.47.						

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40-0831		Wavelength = 1.5418				
Pb <sub>2.5</sub> Nb <sub>2.07.5</sub>		2 $\theta$	Int	h	k	l
Lead Niobium Oxide		27.791	25	0	0	6
		29.183	100	2	0	2
		33.447	50	0	2	4
		47.137	20	2	0	8
Rad. $\alpha$ Filter d sp.		55.597	10	0	2	10
Cut off Int. I/cor.		56.717	30	3	1	5
Ref. Saine, M., Gasperin, M., Brussel II Rev. Chim. Miner., 18, 587 (1981)		57.178	25	2	2	6
		57.964	15	0	4	2
		60.555	15	4	0	4
Sys. Rhombohedral S.G. R						
a 7.452(2) b c 19.24(1) A C: 2.5819						
$\alpha$ $\beta$ $\gamma$ Z mp:						
Ref. Ibid						
Dx Dm SS/FOM: F <sub>g</sub> = 17(.0126 . 43)						
Degradation product from pyrochlore structure of PbO Nb <sub>2</sub> O <sub>3</sub> system. Small solution range. Product of crystals with periodic shear. PSC: hR? Mwt: 823.81. Volume[CD]: 925.30.						

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89-1280		Wavelength= 1.54060						C			
Pb(ZrO 601Ti0.399)O3		2 $\theta$	Int	h	k	l	2 $\theta$	Int	h	k	l
Lead Zirconium Titanium Oxide		21.708	417	0	1	2	81.613	42	4	0	4
		30.801	970	1	0	4	85.249	34	2	1	10
		30.976	999*	1	1	0	85.793	7	2	3	2
		37.850	98	0	0	6	89.092	46	1	1	12
Rad: CuK $\alpha$ $\lambda$ : 1.54060 Filter: d-sp: Calculated		38.144	211	2	0	2	89.544	47	3	1	8
Cut off 17.7 Int.: Calculated I/lor.: 9.10		44.247	458	0	2	4	89.904	77	4	1	0
Ref: Calculated from ICSD using POWD-12++		49.685	125	1	1	6					
Ref: Corker, D.L. et al., J. Phys.: Condens. Matter, 10, 6251 (1998)		49.921	71	1	2	2					
		54.659	149	0	1	8					
		54.980	303	2	1	4					
		55.100	257	3	0	0					
Sys: Rhombohedral S.G.: R3c (161)		58.592	1	1	2	5					
a: 5.7692(1) b: c: 14.2501(2) A: C: 2.4700		64.162	104	2	0	8					
		64.563	113	2	2	0					
$\alpha$ : $\beta$ : $\gamma$ : Z: 6 mp:		66.404	40	1	0	10					
Ref: Ibid.		68.792	36	0	3	6					
		68.985	35	3	1	2					
		72.950	93	1	2	8					
Dx: 7.983 Dm		73.233	106	1	3	4					
		76.971	29	0	2	10					
		77.341	34	2	2	6					
Peak height intensity, R-factor: 0.038 PSC: hR10 At least one TF implausible. Mwt: 329.13 Volume[CD]: 410.75		77.526	24	0	4	2					
		80.883	13	0	0	12					

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75-0438		Wavelength= 1.54060						C			
PbTiO3		2 $\theta$	Int	h	k	l	2 $\theta$	Int	h	k	l
Lead Titanium Oxide		21.499	220	0	0	1					
		22.842	375	1	0	0					
Macedonite, syn		31.570	999*	1	0	1					
Rad: CuK $\alpha$ $\lambda$ : 1.54060 Filter: d-sp: Calculated		32.526	457	1	1	0					
Cut off 17.7 Int.: Calculated I/lor.: 11.20		39.324	379	1	1	1					
Ref: Calculated from ICSD using POWD-12++ (1997)		43.805	146	0	0	2					
Ref: Naray-Szabo, S., Naturwissenschaften, 31, 466 (1943)		46.662	236	2	0	0					
		49.963	80	1	0	2					
		51.922	71	2	0	1					
		52.564	68	2	1	0					
Sys: Tetragonal S.G.: P4/mmm (123)		55.608	159	1	1	2					
a: 3.89 b: c: 4.13 A: C: 1.0617		57.432	283	2	1	1					
$\alpha$ : $\beta$ : $\gamma$ : Z: 1 mp:		65.920	126	2	0	2					
Ref: Ibid.		68.124	57	2	2	0					
		70.757	49	2	1	2					
		72.360	23	2	2	1					
		72.818	62	1	0	3					
Dx: 6.053 Dm		77.020	48	3	0	1					
		77.540	57	1	1	3					
		77.540	3	1	0						
		81.594	52	3	1	1					
Peak height intensity, PSC: IP5. See PDF 6-452 No R value given. At least one TF missing. Calc. density unusual but tolerable. Mwt: 303.10. Volume[CD]: 62.50		84.589	49	2	2	2					
		86.552	12	2	0	3					
		89.090	11	3	0	2					

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34-0398		Wavelength= 1.5418				
Fe-Cr		2 $\theta$	Int	h	k	l
Iron Chromium		44.521	100	1	1	0
		64.836	20	2	0	0
		82.063	50	2	1	1
		98.579	18	2	2	0
		115.905	30	3	1	0
		136.426	12	2	2	2
Rad: CuK $\alpha$	$\lambda$ 1.5418	Filter: Mono	d-sp. Diff			
Cut off	Int. Diffract.	1/isor 0.59				
Ref: Pfoertsch et al., Penn State Univ., University Park, PA, USA, ICDD Grant-in-Aid, (1983)						
Sys: Cubic	S.G. $Im\bar{3}m$ (229)					
a 2.8760(1)	b	c	A	C		
$\alpha$	$\beta$	$\gamma$	Z: 1	mp:		
Ref: Ibid.						
Dx 7.727	Dm	SS/FOM F <sub>6</sub> = 70(0144 . 6)				
Color: Black						
Spectroscopic analysis (wt.%): Fe 80.10, Cr 11.70, Si 0.59, Mn 0.09, Ag 0.01, Mo 1.39, Ni 0.33, P 0.01, plus trace elements, W type.						
Also called: 434-L stainless steel. Silicon used as an external stand PSC: c12. Mwt: 110.89 Volume[CD]: 23.79.						

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06-0696		Wavelength= 1.5405				
Fe		2 $\theta$	Int	h	k	l
Iron		44.671	100	1	1	0
		65.018	20	2	0	0
		82.329	30	2	1	1
Iron, syn		98.940	10	2	2	0
		116.378	12	3	1	0
		137.125	6	2	2	2
Rad: CuK $\alpha$	$\lambda$ 1.5405	Filter: Ni	Beta	d-sp.		
Cut off	Int. Diffract.	1/isor				
Ref: Swanson et al., Natl. Bur. Stand. (U.S.), Circ. 539, IV, 3 (1955)						
Sys: Cubic	S.G. $Im\bar{3}m$ (229)					
a 2.8664	b	c	A	C		
$\alpha$	$\beta$	$\gamma$	Z: 2	mp:		
Ref: Ibid.						
Dx 7.875	Dm	SS/FOM F <sub>6</sub> = 225(0044 . 6)				
Color: Gray, light gray metallic						
Pattern taken at 25 C. CAS #: 7439-89-6. The iron used was an exceptionally pure rolled sheet prepared at the NBS, Gaithersburg, Maryland, USA, [Moore, G., J. Met., 5 1443 (1953)]. It was annealed in an H <sub>2</sub> atmosphere for 3 days at 1100 C and slowly cooled in a He atmosphere. Total impurities of sample <0.0013% each metals and non-metals. $\gamma$ -Fe (fcc)-(1390 C) $\delta$ -Fe (bcc). Opaque mineral optical data on specimen from Meteorite: RR2Re= 57.7, Disp.=16, VHN=158 (mean at 100, 200, 300), Color values-.311, .316, 57.9, Ref.: IMA Commission on Ore Microscopy QDF, W type, Iron SuperGroup, IC-disordered Group. Also called: ferrite, PSC: c12. See ICSD 64795 (PDF 85-1410). Mwt: 55.85. Volume[CD]: 23.55.						

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33-0664		Wavelength= 1.540598									
Fe2O3		2 $\theta$	Int	h	k	l	2 $\theta$	Int	h	k	l
Iron Oxide		24.138	30	0	1	2	122.431	6	4	1	6
		33.153	100	1	0	4	125.929	1	2	3	8
		35.612	70	1	1	0	128.758	3	4	0	10
Hematite, syn		39.277	3	0	0	6	131.877	5	1	2	14
Rad. CuK $\alpha$ $\lambda$ 1.540598 Filter Mono d-sp: Diff		40.855	20	1	1	3	133.241	3	3	3	0
Cut off: Int: Diffract: I/ cor.: 2.4		43.519	3	2	0	2	144.456	4	3	2	10
Ref: Natl. Bur. Stand. (U.S.) Monogr. 25, 18, 37 (1981)		49.480	40	0	2	4	147.971	4	2	4	4
		54.091	45	1	1	6					
		56.152	1	2	1	1					
		57.429	5	1	2	2					
		57.590	10	0	1	8					
Sys. Rhombohedral S.G. R $\bar{3}c$ (167)		62.451	30	2	1	4					
a 5.0356(1) b c 13.7489(7) A. C. 2.7303		63.991	30	3	0	0					
$\alpha$ $\beta$ $\gamma$ Z 6 mp: 1350 1360		66.028	<1	1	2	5					
Ref: Ibid.		69.601	3	2	0	8					
		71.937	10	1	0	10					
		72.262	6	1	1	9					
		75.430	8	2	2	0					
Dx: 5.270 Dm: 5.260 SS/FOM: F <sub>30</sub> = 69(0.111, 39)		77.729	4	3	0	6					
		78.760	2	2	2	3					
mz: 2.94 $\eta$ : 0.22 $\mu$ : Sign: 2V		80.711	5	1	2	8					
Ref: Dana's System of Mineralogy, 7th Ed., 1, 529 (1944)		82.939	5	0	2	10					
		84.916	7	1	3	4					
		88.542	7	2	2	6					
Color: Dark reddish brown		91.345	2	0	4	2					
Pattern taken at 25 C. Sample from Pfizer, Inc., New York, USA,		93.715	7	2	1	10					
heated at 800 C for 3 days. CAS #: 1309-37-1. Opaque mineral		95.239	<1	1	1	12					
optical data on specimen from Elba, R1R0=30.2, RR2Re=26.1,		95.663	3	4	0	4					
Disp.=16. VHN=1038 (mean at 100, 200, 300). Color values=1 .299,		102.285	4	3	1	8					
.309, 29.8, 2 .299, .309, 25.7. Pattern reviewed by Syvinski, W.,		104.914	<1	2	2	9					
McCarthy, G., North Dakota State Univ., Fargo, North Dakota, USA,		106.623	5	3	2	4					
ICDD Grant-in-Aid (1990). Agress well with experimental and		107.025	4	0	1	14					
calculated patterns. Additional weak reflection [indicated by		108.090	5	4	1	0					
brackets] was observed. All 03 type. Corundum SuperGroup,		111.518	2	4	1	3					
corundum Group. Also called: burnt ochre, colcothar, rouge,		113.594	2	0	4	6					
Fe2 O3.Silver used as an internal stand. PSC: hR10. To replace		116.044	5	1	3	10					
13-534 and validated by calculated pattern 24-72. See ICSD 64599		117.758	1	3	0	12					
(PDF 79-7). Mwt: 159.69 Volume[CD]: 301.93.		118.697	3	2	0	14					

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33-1381		Wavelength= 0.710688									
TiO2		2 $\theta$	Int	h	k	l	2 $\theta$	Int	h	k	l
Titanium Oxide		14.427	5	0	0	2					
		15.313	100	2	1	1					
		15.313		3	0	0					
		16.958	10	3	0	1					
Rad.: MoK $\alpha$ $\lambda$ 0.710688 Filter: d-sp:		17.760	20	2	2	0					
Cut off: Int: Estimation: I/ cor.:		24.661	30	4	1	1					
Ref: Liu, L., Science, 199, 422 (1978)		25.518	5	2	1	3					
		27.222	5	4	2	0					
		28.984	10	0	0	4					
		29.865	5	4	0	3					
Sys. Hexagonal S.G. P6 <sub>3</sub> (173)											
a: 9.22(1) b c: 5.685(6) A: C. 0.6166											
$\alpha$ $\beta$ $\gamma$ Z: 16 mp:											
Ref: Ibid.											
Dx: 5.072 Dm: SS/FOM: F <sub>9</sub> = 5(0.037, 49)											

X-ray diffraction patterns obtained in situ in a diamond-anvil pressure cell after laser heating and quenching. Z-tentative assignment, made on the basis of volume changes. On release of pressure, transition to  $\alpha$ -Pb O<sub>2</sub> form results in 8.5% volume change. a and c measured at room temperature, approximately 250 kbar. PSC: hP48 Mwt: 79.90 Volume[CD]: 418.53

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2θ-0530		Wavelength- 1.5405									
PbS <sub>2</sub> CrO <sub>5</sub>		2θ	Int	h	k	l	2θ	Int	h	k	l
Lead Chromium Oxide											
		13.717	14	1	0	1	42.736	10	1	2	0
		14.00	16	2	0	0	43.959	18	2	2	2
		14.851	10	1	0	1	44.947	2	2	1	3
Phoenicochroite, syn											
		17.136	2	1	1	0	45.495	6	3	0	3
Rad. CuKα1	λ 1.5405	19.980	14	0	1	1	46.532	4	6	1	1
	Filter: Mono	23.490	8	3	0	1	48.538	4	4	1	3
	d sp. Gummier 1146	23.809	4	2	1	1	48.732	18	4	2	2
Cut off	Int. Diffract	25.127	6	2	1	1	48.955	4	5	2	1
	1/teor	26.282	100	3	1	0	49.812	2	0	3	1
Ref: Technisch Physische Dienst, Delft, Netherlands, ICDD Grant-in-Aid, (1976)											
		27.618	12	2	0	2	50.134	2	1	2	3
		29.897	80	2	0	2	50.852	2	7	0	1
Svs. Monocline S.G. 12/m (12)											
		31.003	20	1	1	2	51.343	8	0	0	4
		31.473	35	0	2	0	51.592	8	4	2	2
a 12.722	b 5.676	c 7.139	A 22414	C 1.2578			33.795	2	4	1	1
			Z 4	mp.			34.602	4	2	2	0
	p 95-19						34.950	4	1	2	1
Ref: Ibid.											
		35.727	12	4	1	1	54.090	6	6	2	0
		36.204	14	1	0	2	55.112	10	1	3	2
		36.493	6	5	0	1	55.766	2	1	3	2
Dx 7.069	Dm	37.898	8	1	0	3	56.399	2	3	2	3
	SS/FOM F <sub>30</sub> = 43( 0145 , 46)	38.868	8	5	1	0	56.665	6	3	1	4
Color: Orange-red											
Compound is isomorphous with PbO, PbS <sub>2</sub> O <sub>4</sub> (lanarkite) PSC mC32. To replace 8-437, 21-946 and 29-769 Deleted by 29-768.											
		41.243	6	0	1	3	58.111	2	6	1	3
		42.358	6	2	2	2	58.843	2	4	3	1

2θ	Int	h	k	l
60.498	8	3	1	4
60.894	6	8	1	1
61.567	8	7	0	3
61.749	8	7	1	2
62.209	2	2	2	4
63.247	8	7	2	1
63.683	2	6	1	3
65.751	6	0	4	0

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Appendix B

ศูนย์วิทยทรัพยากร  
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Table B-1 Thickness of films in various formulas measure by reflected light microscope

Paste formula	Firing condition	Film thickness ( $\mu\text{m}$ )
APA	750°C, 1 h	19.79 $\pm$ 1.52
APB	750°C, 1 h	11.83 $\pm$ 1.92
APC	750°C, 1 h	12.39 $\pm$ 1.59
UPA	750°C, 1 h	17.69 $\pm$ 0.63
UPB	750°C, 1 h	14.33 $\pm$ 0.18
UPC	750°C, 1 h	10.18 $\pm$ 0.99
UPA1	750°C, 1 h	14.02 $\pm$ 0.66
UPB8	750°C, 1 h	15.72 $\pm$ 1.01
UPB8E	750°C, 1 h	20.33 $\pm$ 0.38
UPB8F	750°C, 1 h	15.55 $\pm$ 2.35
UPB8EF1	680°C, 1 h	14.49 $\pm$ 0.29
	750°C, 1 h	16.77 $\pm$ 0.58
	800°C, 1 h	12.73 $\pm$ 0.58
	850°C, 1 h	14.39 $\pm$ 0.45

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Table B-2 Capacitance of ferroelectric thick films

Paste formula	Firing condition	Gold-coated (sec)	Frequency			
			1 kHz	10 kHz	100 kHz	1 MHz
APA	750°C, 1 h	120	6.78 ± 0.56	6.39 ± 0.41	6.17 ± 0.43	5.94 ± 0.41
APB	750°C, 1 h	120	7.58 ± 1.14	7.02 ± 0.92	6.74 ± 0.84	6.49 ± 0.80
APC	750°C, 1 h	120	5.80 ± 0.46	5.42 ± 0.53	5.22 ± 0.53	5.01 ± 0.52
UPA	750°C, 1 h	120	11.50 ± 0.60	10.73 ± 0.52	10.19 ± 0.39	9.83 ± 0.34
UPB	750°C, 1 h	120	13.15 ± 1.83	11.40 ± 1.09	10.38 ± 0.83	9.84 ± 0.69
UPC	750°C, 1 h	120	12.73 ± 1.13	10.56 ± 0.35	9.71 ± 0.20	9.17 ± 0.24
UPA1	750°C, 1 h	120	12.31 ± 0.31	10.76 ± 0.12	10.01 ± 0.10	9.54 ± 0.06
UPB8	750°C, 1 h	120	15.64 ± 0.89	12.89 ± 0.10	11.73 ± 0.31	11.10 ± 0.42
UPB8	750°C, 1 h	150	23.89 ± 2.77	18.14 ± 1.82	14.70 ± 1.32	12.82 ± 1.63
UPB8E	750°C, 1 h	150	39.18 ± 3.21	29.88 ± 1.22	22.82 ± 1.17	17.75 ± 1.15
UPB8F	750°C, 1 h	150	40.01 ± 1.73	32.79 ± 1.41	28.62 ± 1.21	25.79 ± 1.20
UPB8EF1	680°C, 1 h	150	39.39 ± 0.96	33.37 ± 1.35	28.41 ± 1.70	23.64 ± 1.84
UPB8EF1	750°C, 1 h	150	52.37 ± 0.94	44.92 ± 0.69	39.79 ± 0.53	35.89 ± 0.80
UPB8EF1	800°C, 1 h	150	53.46 ± 1.61	42.28 ± 1.44	35.04 ± 1.02	30.99 ± 0.84
UPB8EF1	850°C, 1 h	150	20.21 ± 0.45	13.73 ± 0.58	10.85 ± 0.46	9.38 ± 0.44

Table B-3 Dielectric constant of ferroelectric thick films

Paste formula	Firing condition	Gold-coated (sec)	Frequency			
			1 kHz	10 kHz	100 kHz	1 MHz
APA	750°C, 1 h	120	53.58 ± 3.89	50.55 ± 1.61	48.76 ± 0.94	46.93 ± 0.75
APB	750°C, 1 h	120	35.43 ± 2.68	32.93 ± 3.29	31.65 ± 3.23	30.47 ± 3.21
APC	750°C, 1 h	120	28.85 ± 5.13	27.02 ± 5.27	26.00 ± 5.05	24.96 ± 4.92
UPA	750°C, 1 h	120	81.46 ± 4.41	76.03 ± 3.98	72.21 ± 3.22	69.61 ± 2.68
UPB	750°C, 1 h	120	75.36 ± 9.59	65.39 ± 5.42	59.52 ± 4.04	56.44 ± 3.27
UPC	750°C, 1 h	120	51.67 ± 3.72	42.96 ± 2.86	39.51 ± 3.19	37.36 ± 3.48
UPA1	750°C, 1 h	120	69.07 ± 2.28	60.37 ± 2.25	56.19 ± 2.28	53.54 ± 2.25
UPB8	750°C, 1 h	120	98.35 ± 10.29	81.16 ± 8.77	73.86 ± 7.85	69.91 ± 7.64
UPB8	750°C, 1 h	150	150.46 ± 16.66	114.24 ± 10.91	92.57 ± 7.99	80.75 ± 10.20
UPB8E	750°C, 1 h	150	318.28 ± 22.62	242.79 ± 5.64	185.39 ± 6.15	144.22 ± 7.15
UPB8F	750°C, 1 h	150	248.02 ± 26.02	203.21 ± 21.43	177.43 ± 19.10	159.91 ± 16.67
UPB8EF1	680°C, 1 h	150	228.60 ± 9.75	193.68 ± 11.04	164.92 ± 12.20	137.17 ± 11.74
UPB8EF1	750°C, 1 h	150	351.56 ± 9.60	301.53 ± 7.90	267.13 ± 8.83	240.88 ± 3.85
UPB8EF1	800°C, 1 h	150	272.37 ± 8.18	215.38 ± 6.44	178.54 ± 6.22	157.94 ± 6.18
UPB8EF1	850°C, 1 h	150	116.42 ± 2.47	79.03 ± 1.06	62.46 ± 0.91	54.01 ± 1.24

Table B-4 Dissipation factor of ferroelectric thick films

Paste formula	Firing condition	Gold-coated (sec)	Frequency			
			1 kHz	10 kHz	100 kHz	1 MHz
APA	750°C, 1 h	120	0.086 ± 0.029	0.034 ± 0.013	0.019 ± 0.006	0.011 ± 0.004
APB	750°C, 1 h	120	0.082 ± 0.034	0.041 ± 0.012	0.024 ± 0.005	0.015 ± 0.002
APC	750°C, 1 h	120	0.066 ± 0.011	0.035 ± 0.006	0.023 ± 0.002	0.014 ± 0.0002
UPA	750°C, 1 h	120	0.072 ± 0.020	0.042 ± 0.007	0.028 ± 0.005	0.020 ± 0.001
UPB	750°C, 1 h	120	0.180 ± 0.056	0.089 ± 0.023	0.044 ± 0.011	0.027 ± 0.005
UPC	750°C, 1 h	120	0.212 ± 0.088	0.090 ± 0.032	0.050 ± 0.012	0.029 ± 0.006
UPA1	750°C, 1 h	120	0.145 ± 0.019	0.070 ± 0.009	0.042 ± 0.002	0.023 ± 0.002
UPB8	750°C, 1 h	120	0.265 ± 0.131	0.103 ± 0.033	0.054 ± 0.013	0.028 ± 0.005
UPB8	750°C, 1 h	150	0.274 ± 0.051	0.165 ± 0.011	0.123 ± 0.040	0.077 ± 0.039
UPB8E	750°C, 1 h	150	0.224 ± 0.035	0.193 ± 0.028	0.177 ± 0.013	0.167 ± 0.010
UPB8F	750°C, 1 h	150	0.195 ± 0.011	0.121 ± 0.005	0.087 ± 0.004	0.072 ± 0.003
UPB8EF1	680°C, 1 h	150	0.123 ± 0.010	0.111 ± 0.011	0.113 ± 0.014	0.140 ± 0.015
UPB8EF1	750°C, 1 h	150	0.153 ± 0.006	0.097 ± 0.007	0.079 ± 0.006	0.069 ± 0.001
UPB8EF1	800°C, 1 h	150	0.168 ± 0.006	0.147 ± 0.003	0.111 ± 0.004	0.071 ± 0.002
UPB8EF1	850°C, 1 h	150	0.409 ± 0.031	0.233 ± 0.016	0.137 ± 0.009	0.078 ± 0.007



## Biography

Miss Usa Kaeowanpen was born in Phatthalung on 29<sup>th</sup> of May 1977. After graduating with a Bachelor's Degree in Ceramic Engineering from Faculty of Engineer, Suranaree University of Technology in 2000, she worked in laboratory division of Patra Porcelain Co. Ltd., for one year. She continued a further study in Master's Degree in the field of Ceramic Technology at Chulalongkorn University in 2001 and graduated in April 2004.



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