

The Effects of Compaction Pressure, Sintering Temperature and Time on the Fabrication of Simulated Fuel

150

1670 , 1730 , 1780 , 4 , 8 , 24 가 가 가 1 ton/cm² 4 ton/cm², 1.3444 g/cm³ , tubular 2.3352 g/cm³ 가 CANDU 1730 , 3 ton/cm², 4 가

Abstract

In this study, the effects of the variables on sintering of simulated fuel to simulate the spent fuel are described. Mainly, the effects of compaction pressure, sintering temperature and sintering time on the density of pellet are described. The experimental is performed with compaction pressure of 1 ton/cm² 4 ton/cm², sintering temperature of 1670 , 1730 and 1780 and sintering time of 4 hr, 8hr and 24hr. Sintered density and grain size is increased with these variables. Apparent densities of the powders after wet milling and grinding in tubular are 1.3444 g/cm³ and 2.3352 g/cm³, respectively. Optimum condition of simulated fuel fabrication is 1730 in sintering temperature, 3 ton/cm² in compaction pressure and 4 hours in sinterin time to satisfy the criteria of the pellet density of CANDU fuel.

1.

DUPIC(Direct Use of Spent PWR Fuel in CANDU Reactors)

가

. 1993
of Oxide fuel)가 가

OREOX(Oxidation and Reduction

[1] OREOX

. DUPIC

DUPIC (lattice
property)

CPPF

DUPIC (Reference Simulated DUPIC Fuel) U-235 Pu-239

1.0 % 0.45 % .[2] DUPIC 가

가

DUPIC

DUPIC

가

DUPIC

/

DUPIC

.[3]

- matrix : Sr, Zr, Nb, Y, La, Ce, Pr, Nd, Pm, Sm;

- : Mo, Tc, Ru, Rh, Pd, Ag, Cd, In, Sb, Te;

- : Ba, Zr, Nb, Mo, (Rb, Cs, Te);

- : Kr, Xe, Br, I, (Rb, Cs, Te).

DUPIC

DUPIC

가

,[3-5]

matrix

[6-8]

potential [9]

[10,11]

, simulated mixed (U, Th)O₂

[12- 14] UO₂ [15- 18]

가 [15,18,19]

DUPIC

DUPIC

가

1 ton/cm² 4 ton/cm²,

4 , 8 24 , 1670 , 1730 1780

2.

2.1

(UO₂) ADU (ammonium
 diuranate) ORIGEN-2
 18
 가 Pr, Sm Nd , Pu Ce , Tc
 Ru , Am La 가 , 가 1

2.2

가 UO₂

UO₂ tubular mixer 24 attrition miller
 5 , 40 5
 tubular 5 35 sieve
 0.2 % (0.4 g) 가 tubular 1 Zn stearate

mixing UO₂ and F.P. : mixing UO₂ and F.P. for 24 hrs. in tubular

milling : milling mixed powder with methyl alcohol for 24 hrs in attrition miller

dry : dry milled powder at 40 in oven for 5 days

granulation : shift sieve No. 35 and rotating for 5 hrs in tubular

lubricant : mixing granulated powder and Zn stearate(0.2 %) for 1 hrs in tubular

1. UO₂ 가

element	chemical form	weight	contents (g)	% of element	Weight of Oxide	weight of U 100 g	% of element
Rb	Rb ₂ O ₃	85.5	278.6	0.02811	356.83	0.03174	0.0308761
Sr	SrO	87.6	541.7	0.05465	640.62	0.05697	0.0554318
Y	Y ₂ O ₃	88.9	355.0	0.03582	450.84	0.04010	0.0390104
Zr	ZrO ₂	91.2	2888.4	0.29142	3901.65	0.34700	0.3376048
Mo	MoO ₃	96.0	2636.7	0.26602	3955.05	0.35175	0.3422253
Tc	RuO ₂	99.0	612.0	0.06175	822.61	0.07316	0.0711798
Ru	RuO ₂	101.1	1724.5	0.17399	2270.50	0.20193	0.1964632
Rh	Rh ₂ O ₃	102.9	330.0	0.03329	406.97	0.03619	0.0352144
Pd	PdO	106.4	1109.3	0.11192	1276.11	0.11349	0.1104203
Te	TeO ₂	127.6	379.6	0.03830	474.80	0.04223	0.0410836
Ba	BaCO ₃	137.3	1493.2	0.15065	2145.70	0.19083	0.185665
La	La ₂ O ₃	138.9	957.7	0.09662	1123.18	0.09989	0.0971871
Ce	CeO ₂	140.1	1854.6	0.18712	2278.15	0.20261	0.197125
Pr	Nd ₂ O ₃	140.9	877.6	0.08854	1047.81	0.09319	0.0906659
Nd	Nd ₂ O ₃	144.2	3157.2	0.31854	3682.52	0.32751	0.318644
Sm	Nd ₂ O ₃	150.4	693.0	0.06992	775.41	0.06896	0.067095
Th		232.0	396.6	0.04001		0.00000	0
U	UO ₂	238.0	991154	100.000	1124402.5	100.00000	97.29308
Np		237.0	354.7	0.03579		0.00000	0
Pu(Ce)	CeO ₂	244.0	7361.9	0.74276	5193.16	0.46186	0.4493571
Am	La ₂ O ₃	243.0	720.1	0.07265	482.73	0.04293	0.0417703

2.3

10 ton

10 mm

1.0 ton/cm²

4.0 ton/cm²

1999

, 1670 , 1730 1780 4 , 8 24

2.4

tubular

(scanning electron

microscopy, SEM) , laser-light

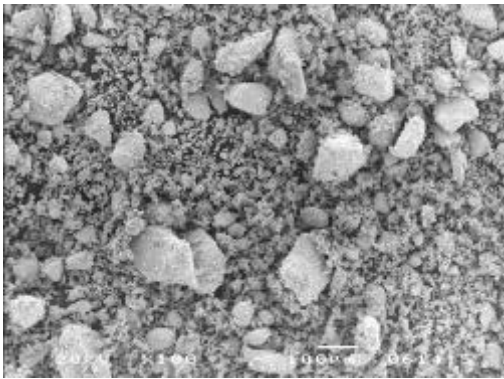
scattering method B.E.T ,

(immersion method) , linear intercept

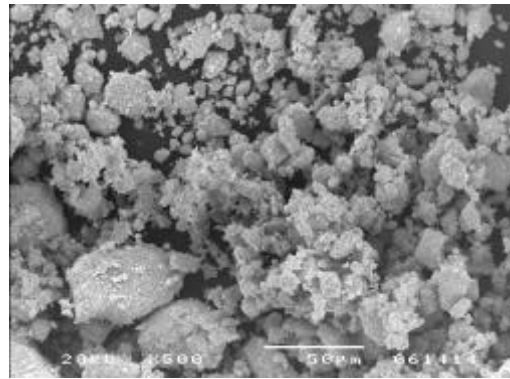
3.

3.1

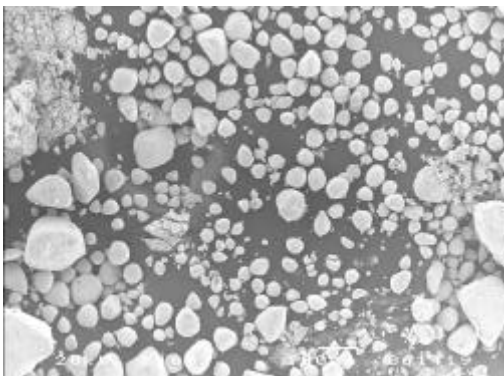
24 , 40 5 . 1
 , 35 . 4 .
 tubular 4 tubular .
 1 tubular .
 가 tubular
 tubular (apparent density)
 가 1.3444 g/cm³ , tubular 2.3352 g/cm³
 (granulation)
 tubular
 tubular 3.28 μm, 0.45 μm 0.37 μm ,
 tubular 가 .



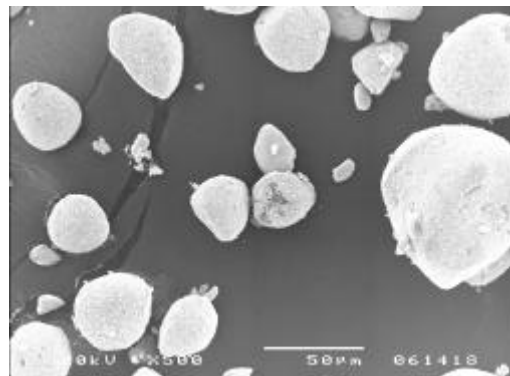
a) after wet milling x 100



b) after wet milling x 500



c) after tubular grinding x 100



d) after tubular grinding x 500

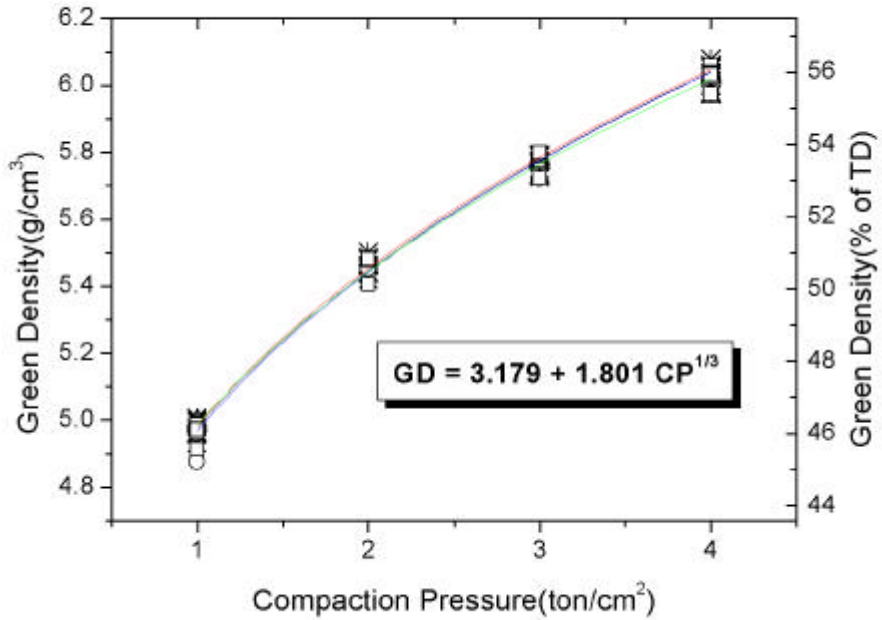
1. SEM a, b)
 c, d) tubular

3.2

1 ton/cm² 4 ton/cm² 가
 27 4.95 g/cm³
 1 ton/cm² 4 ton/cm² 가
 (45.9 % of TD) 6.04 g/cm³ (56.0 % of TD) 가
 가

$$= 3.179 + 1.801 P^{1/3} \quad (1)$$

K (), P A, B



2.

3.3

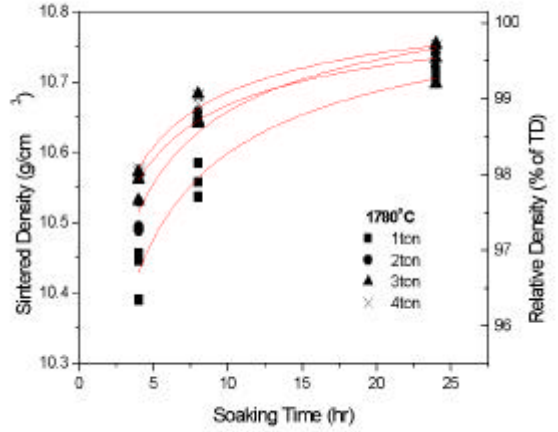
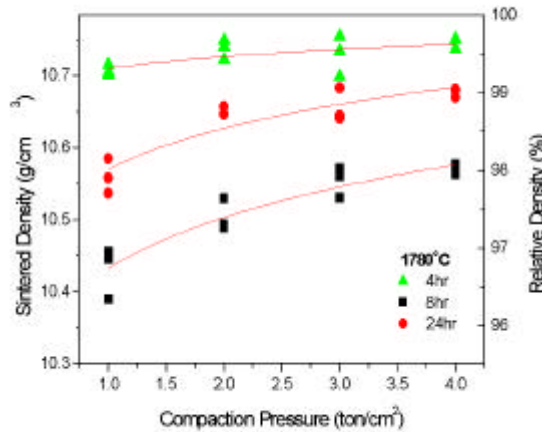
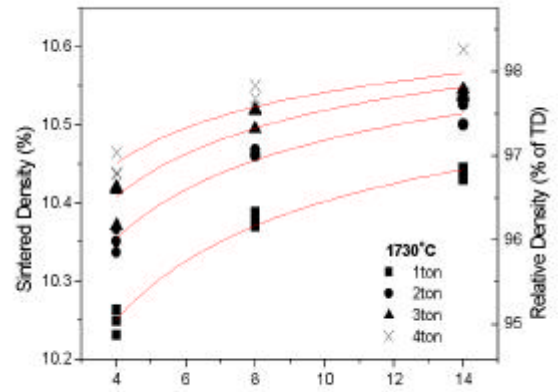
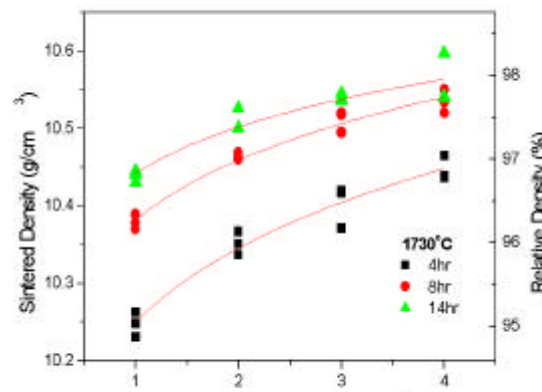
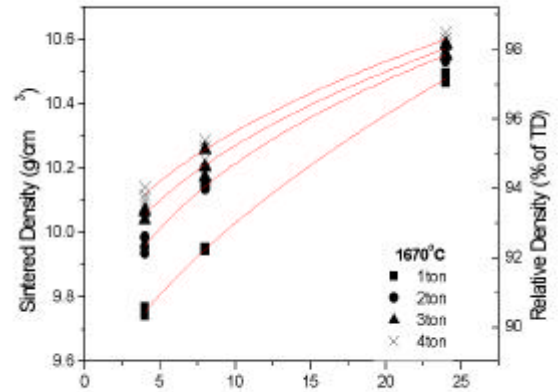
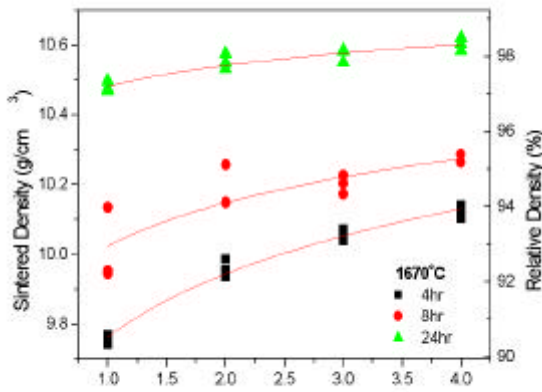
1 ton/cm² 4 ton/cm² , 1670 , 1730 1780
 4 8 24 (1730 14)
 2 3 , 가 가
 가
 1670
 9.754 g/cm³ (90.452 % of TD) 10.602 g/cm³ (98.314 % of TD) 가

1730, 10.248 g/cm³ (95.025 % of TD) 10.559
 g/cm³ (97.915 % of TD) 가 , 1780 10.443
 g/cm³ (96.838 % of TD) 10.746 g/cm³ (99.648 % of TD) 가 . CANDU

10.3 g/cm³ 10.6 g/cm³ 1670
 1 ton/cm² 3 ton/cm² 24 . 1730

. 1780 4

. 1730 가



2. ,

Soaking Temp ()	Soaking Time(hrs)	Sintered Density (g/cm ³)()			
		1(ton/cm ²)	2(ton/cm ²)	3(ton/cm ²)	4(ton/cm ²)
1670	4	9.754(90.452)	9.959(92.348)	10.057(93.262)	10.121(93.851)
	8	9.948(92.244)	10.144(94.063)	10.211(94.682)	10.259(95.128)
	24	10.479(97.175)	10.552(97.854)	10.572(98.039)	10.602(98.314)
1730	4	10.248(95.025)	10.352(95.993)	10.403(96.465)	10.447(96.874)
	8	10.379(96.246)	10.464(97.033)	10.511(97.467)	10.535(97.686)
	14	10.438(96.759)	10.509(97.449)	10.539(97.730)	10.559(97.915)
1780	4	10.443(96.838)	10.536(97.695)	10.563(97.954)	10.582(98.120)
	8	10.560(97.923)	10.650(98.759)	10.656(98.816)	10.677(99.006)
	24	10.710(99.286)	10.737(99.564)	10.729(99.487)	10.746(99.648)

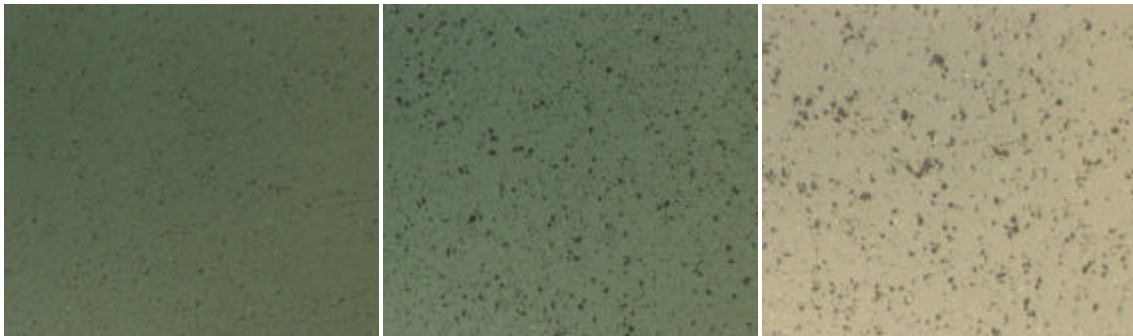
3.3

4 1670

(2 ton/cm²)

(4 ton/cm²)

.[22]



1670 4hrs, 2ton, x500

1670 8hrs, 2ton, x500

1670 24hrs, 2ton, x500

4.

5

1670 , 1730 1780

8

4 , 8 , 24

1780

8

1670

1780 가

2.299 μm

4.598 μm 가

1780

4

24

가

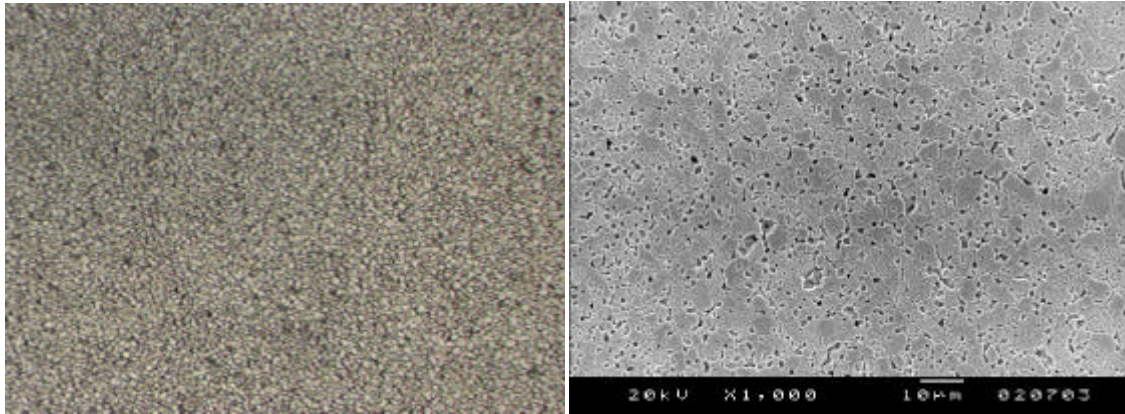
3.605 μm 5.287 μm 가

6

.[21]

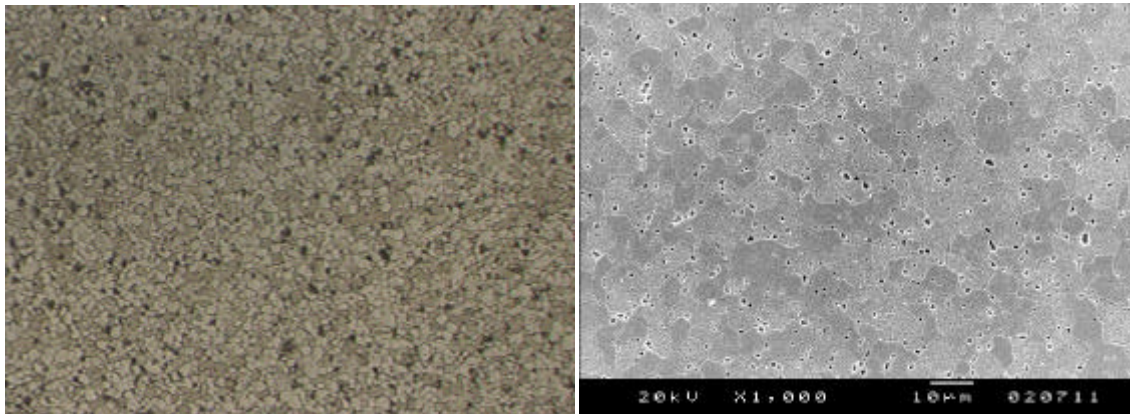
$$d^n - d_0^n = C_1 \exp\left(-\frac{Q}{RT}\right) \cdot \Delta t \quad (2)$$

d , d_0 , T , t , Q , R , n , C_1 .



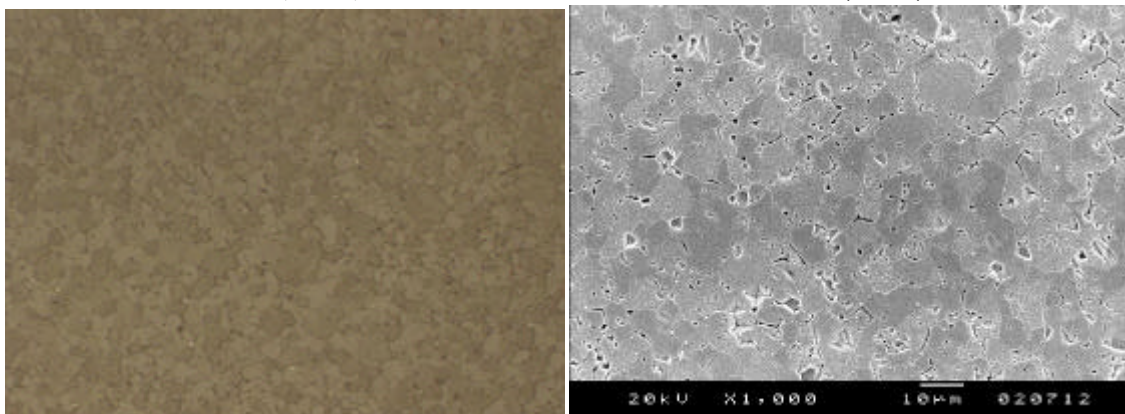
1670 8hrs, 2ton, x500

1780 4hrs, 2ton, x1000



1730 8hrs, 2ton, x500

1780 8hrs, 2ton, x1000



1780 8hrs, 2ton, x500

1780 24hrs, 2ton, x1000

UO₂

1550

2000

n 2.5 가

$$d = 1.086 + 0.568t^{0.4} \quad (T = 1670 \text{ }) \quad (3)$$

$$d = 1.852 + 0.587t^{0.4} \quad (T = 1730 \text{ }) \quad (4)$$

$$d = 2.325 + 0.857t^{0.4} \quad (T = 1780 \text{ }) \quad (5)$$

7 1780

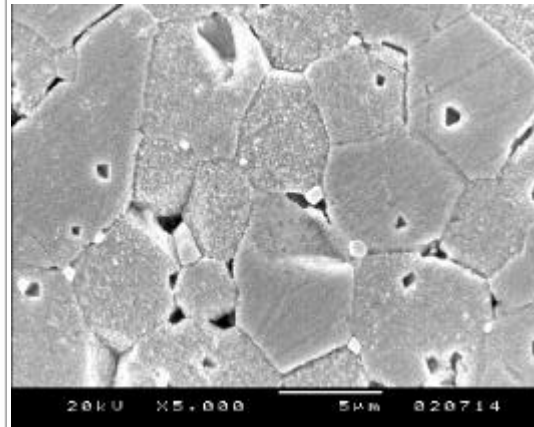
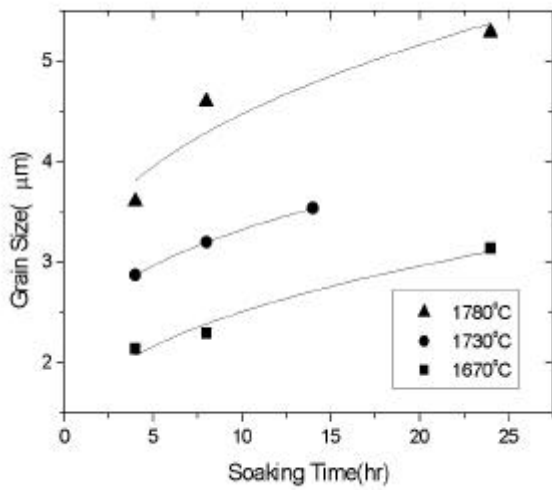
4

5000

Mo-Ru-Rh-Pd

[22]

BaZrO₃ perovskite



7.

(1780 , 4)

6.

4.

1. 가

tubular

1.3444 g/cm³

, tubular

(apparent density)

2.3352 g/cm³

(granulation)

가

tubular

2. tubular 3.28 μm ,
 0.45 μm 0.37 μm , tubular 가

3.

$$= 3.179 + 1.801 P^{1/3}$$

K , 0 (), P , 0 A, B

4. 가 . CANDU
 (10.3 g/cm^3 10.6 g/cm^3)

1730

5.

$$d = 1.086 + 0.568t^{0.4} \quad (T = 1670 \text{)}$$

$$d = 1.852 + 0.587t^{0.4} \quad (T = 1730 \text{)}$$

$$d = 2.325 + 0.857t^{0.4} \quad (T = 1780 \text{)}$$

d , t

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