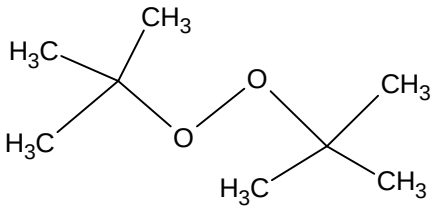
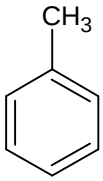
産業技術総合研究所　高エネルギー物質研究グループ
発熱分解エネルギー測定の標準化　　熱分析結果

tert-Butyl peroxide - Toluene　　$C_8H_{18}O_2 – C_6H_5CH_3$　　TBP - Toluene





ARC device: New ARC (TIAX, LLC)

Material of Bomb: Ti, Hastelloy C

Waiting & Searching Time: 15 min, 30 min

TBP Concentration: 10%, 20%, 30%

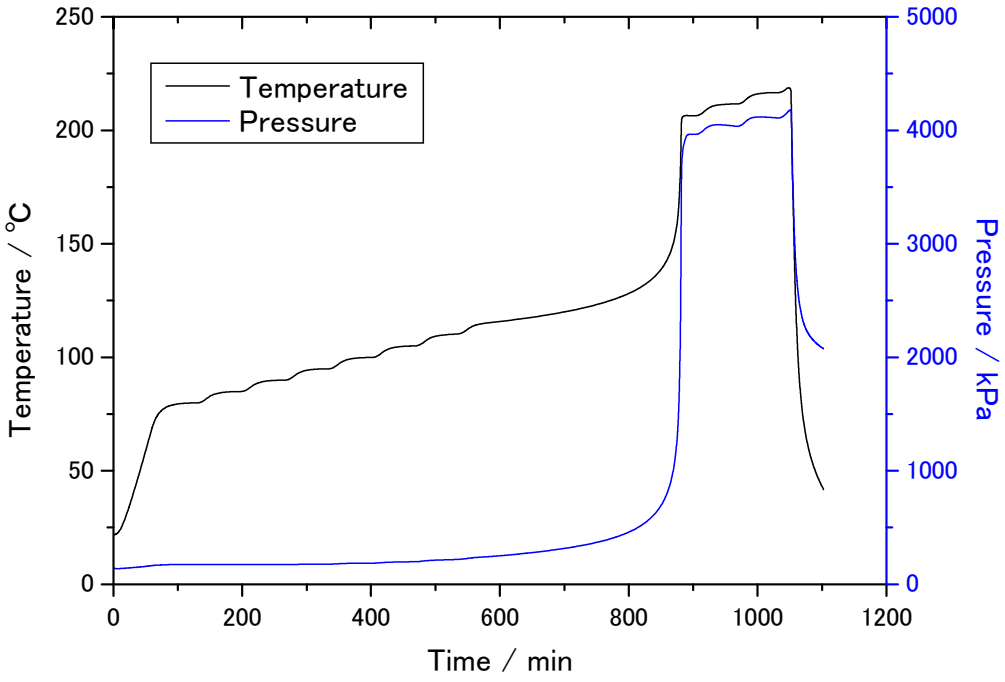
Date: 2008/12, 2009/6

Operator: Y. S.

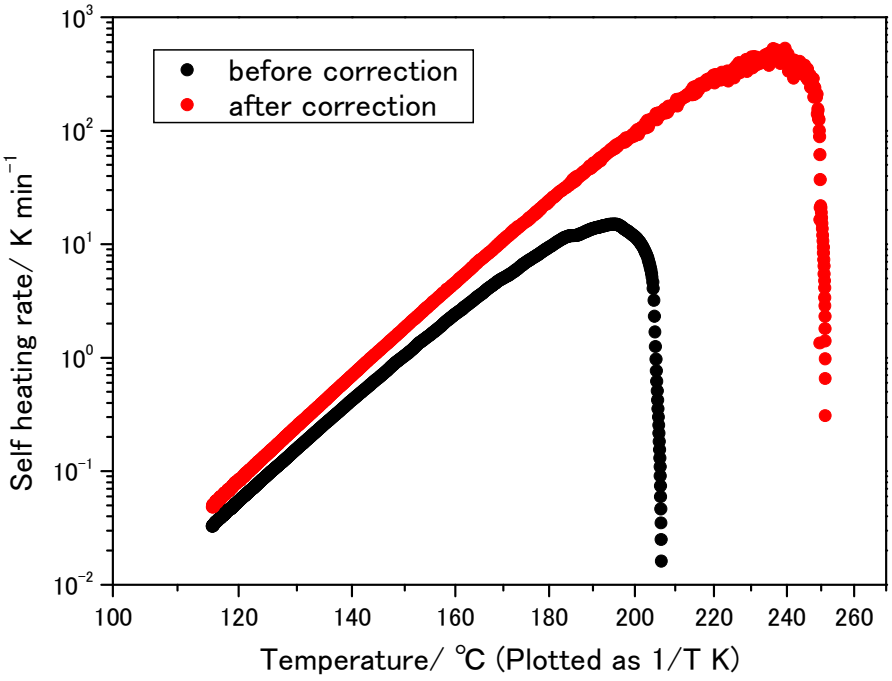
a) Material of Bomb: Hastelloy C

Waiting & Searching Time: 30 min

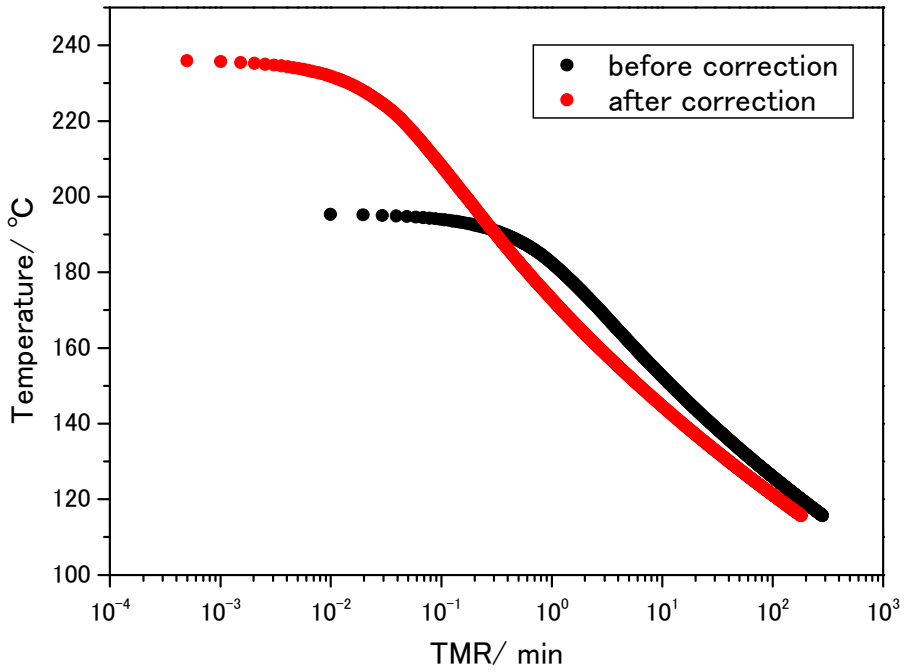
TBP Concentration: 20%



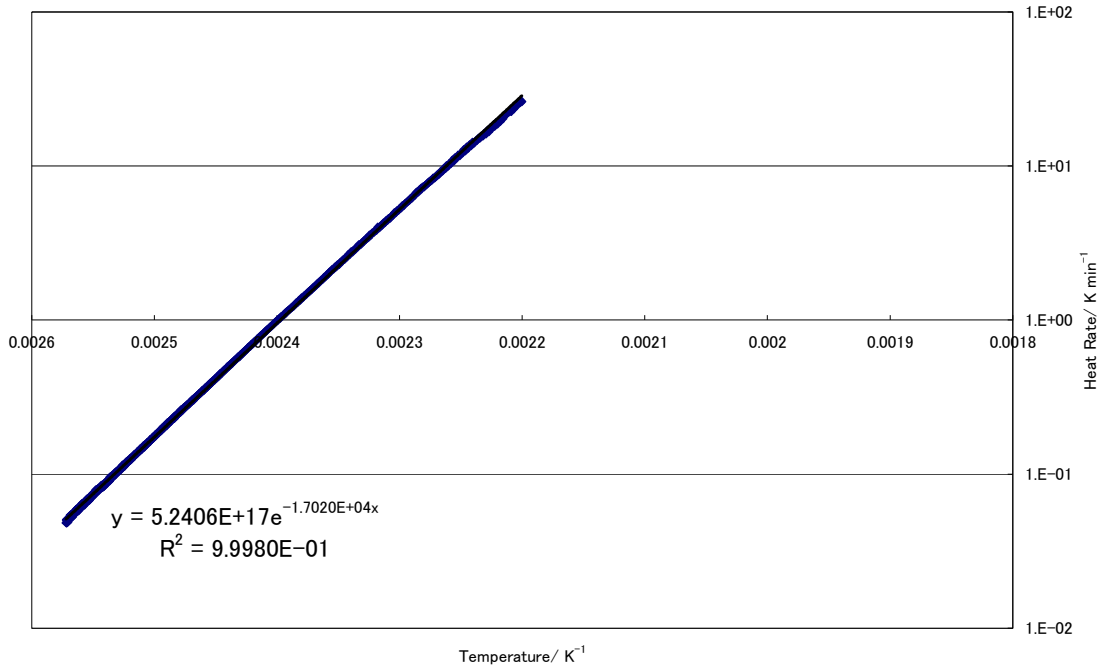
Time vs. Temperature and Pressure



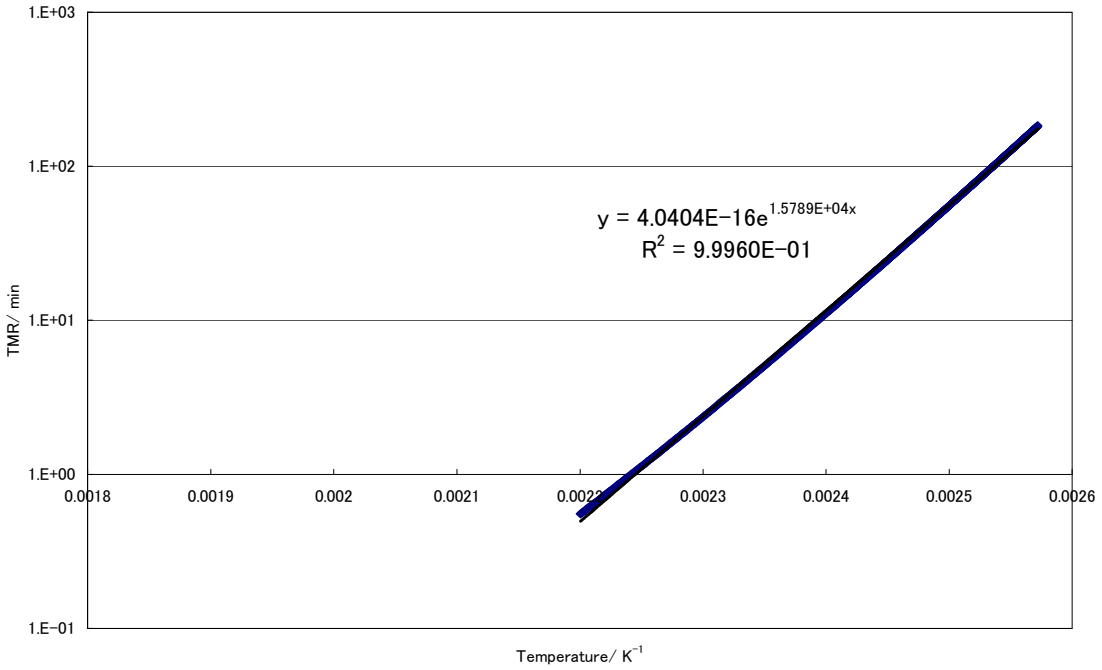
Temperature vs. Self heating rate



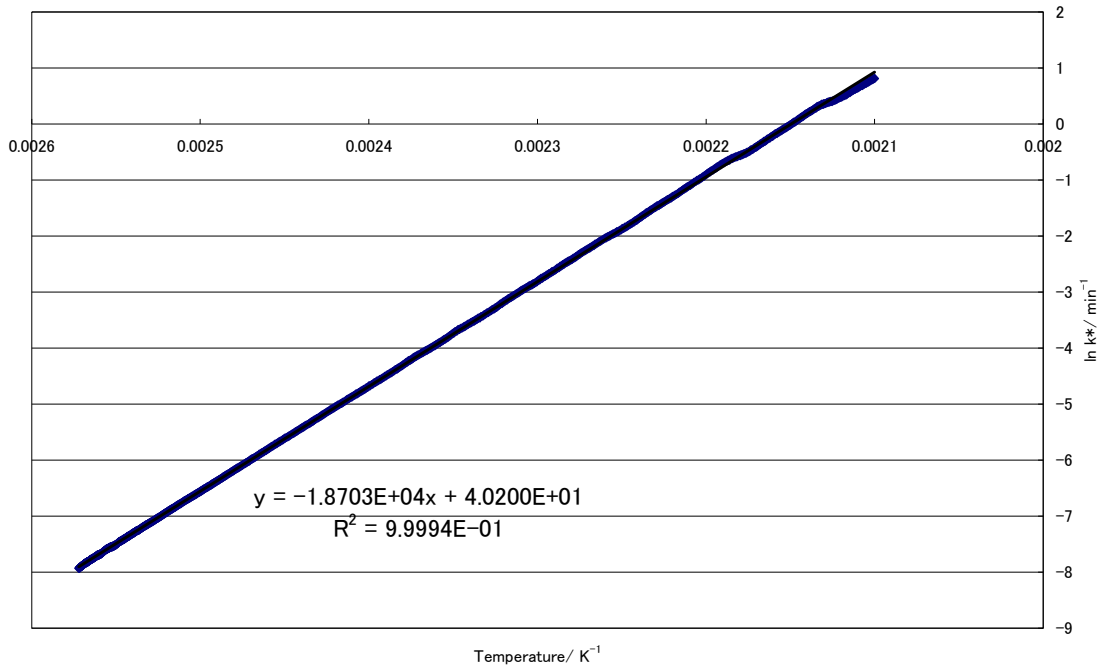
TMR vs. Temperature



Temperature vs. Self heating rate (approximate calculation)



Temperature vs. TMR (approximate calculation)

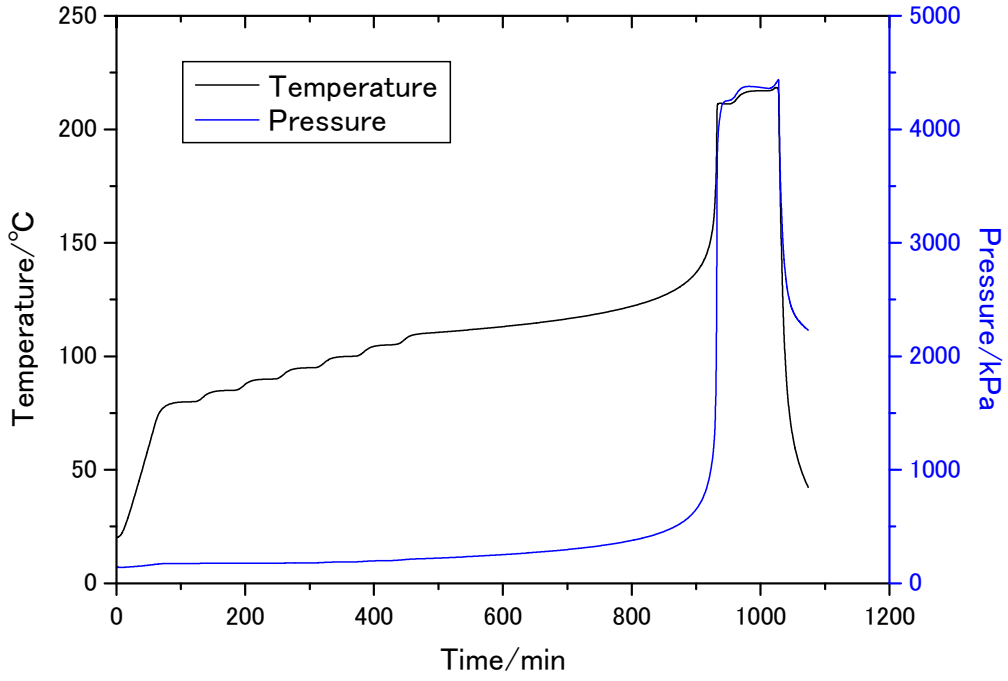


Arrhenius equation (approximate calculation)

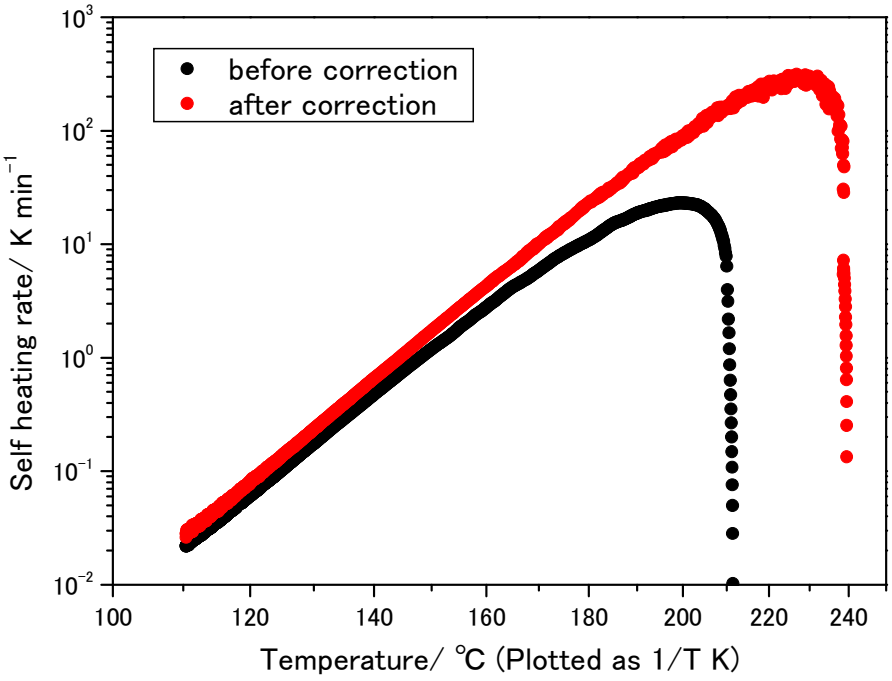
b) Material of Bomb: Ti

Waiting & Searching Time: 30 min

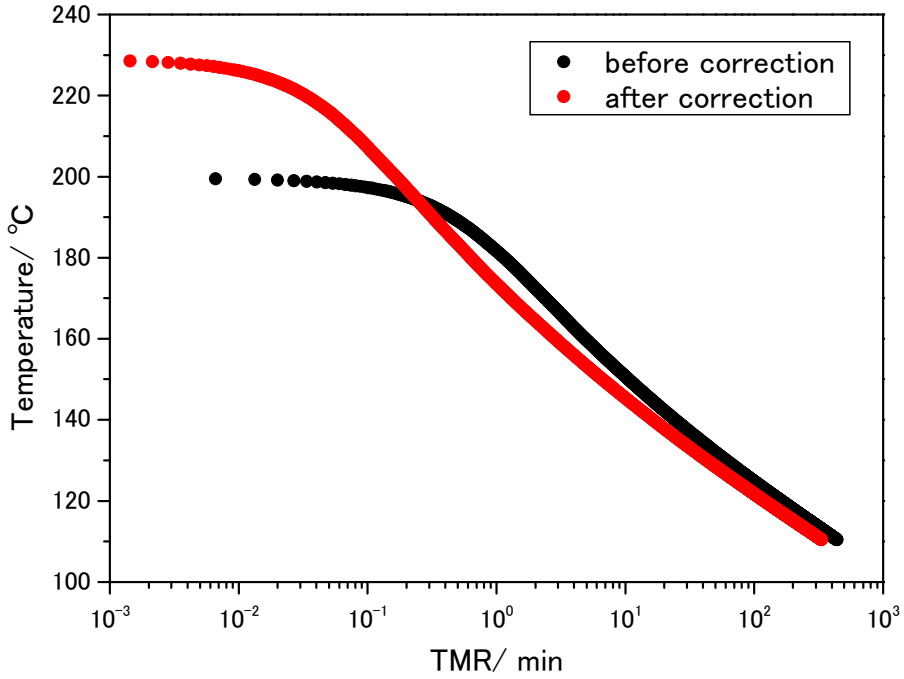
TBP Concentration: 20%



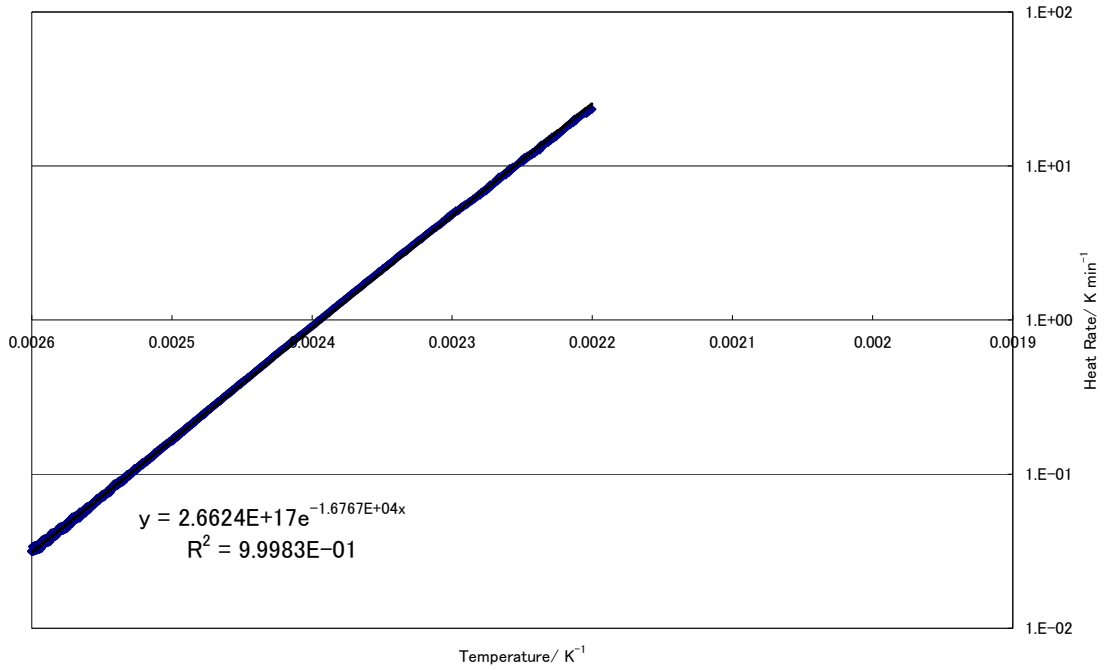
Time vs. Temperature and Pressure



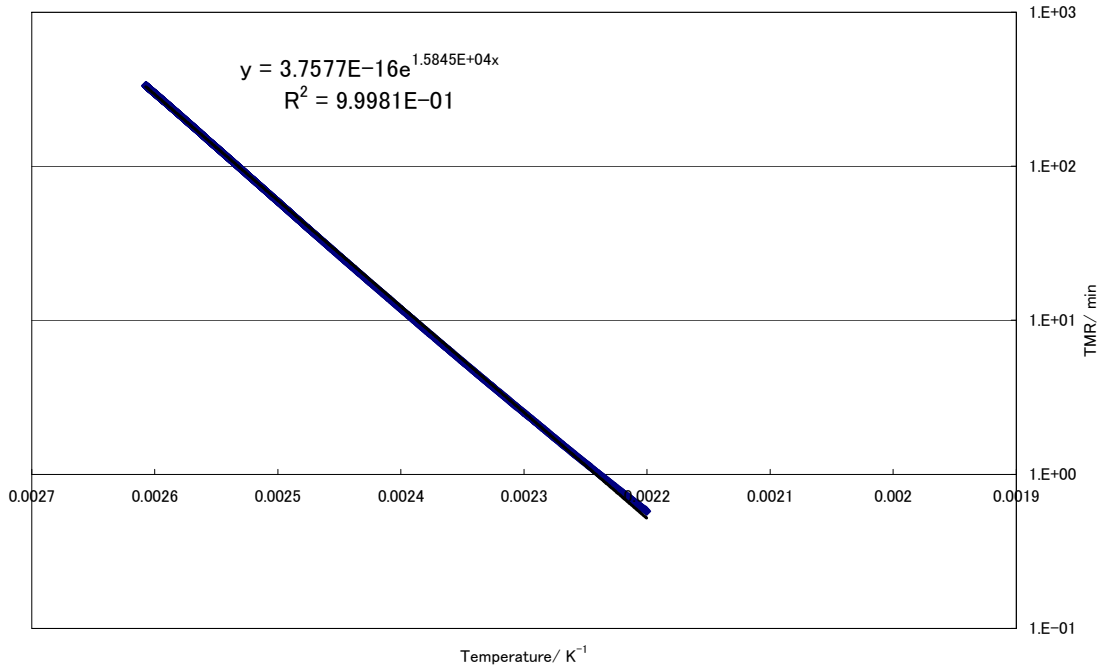
Temperature vs. Self heating rate



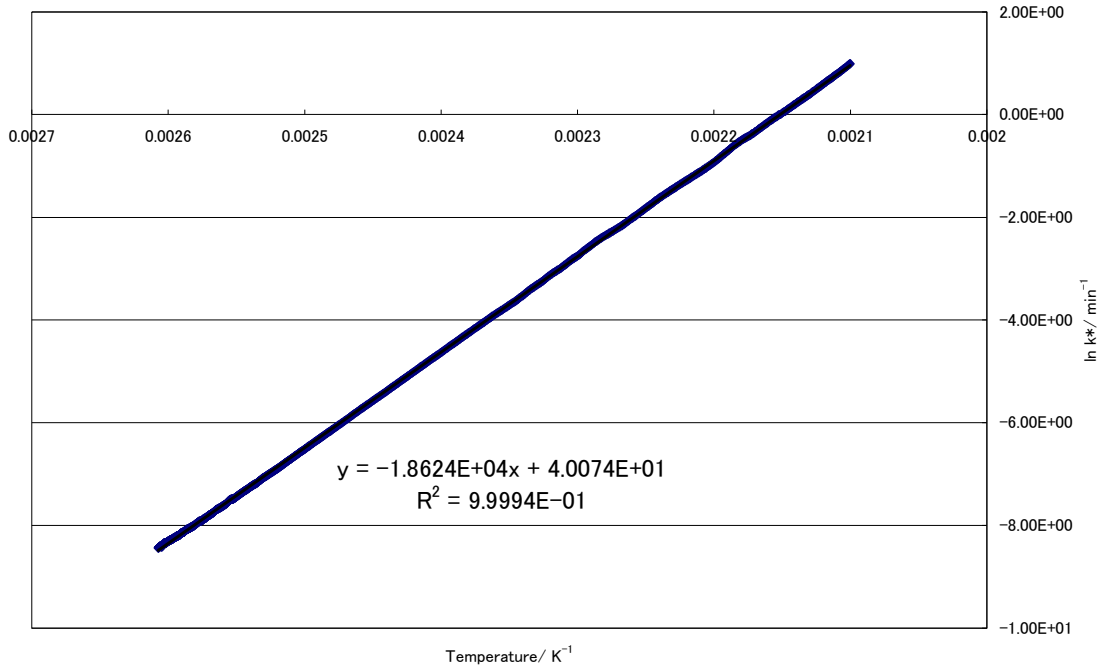
TMR vs. Temperature



Temperature vs. Self heating rate (approximate calculation)



Temperature vs. TMR (approximate calculation)

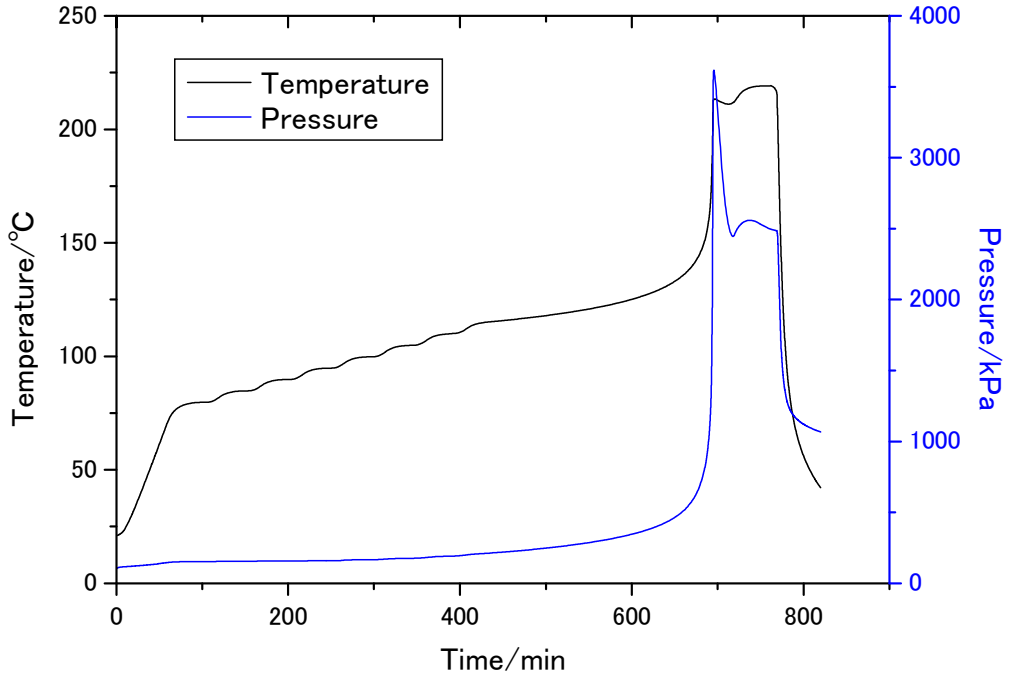


Arrhenius equation (approximate calculation)

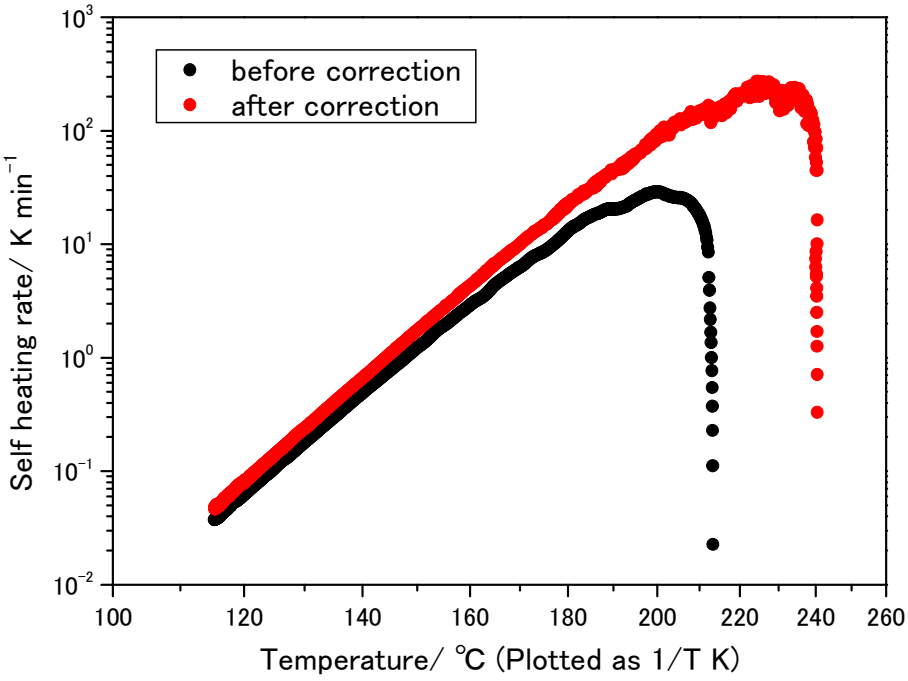
c) Material of Bomb: Ti

Waiting & Searching Time: 15 min

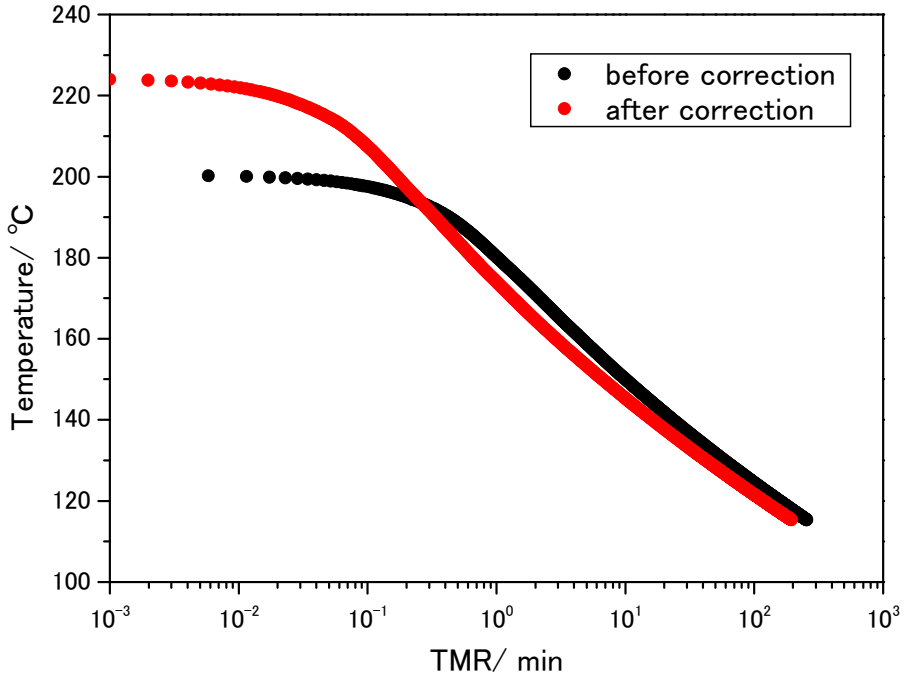
TBP Concentration: 20%



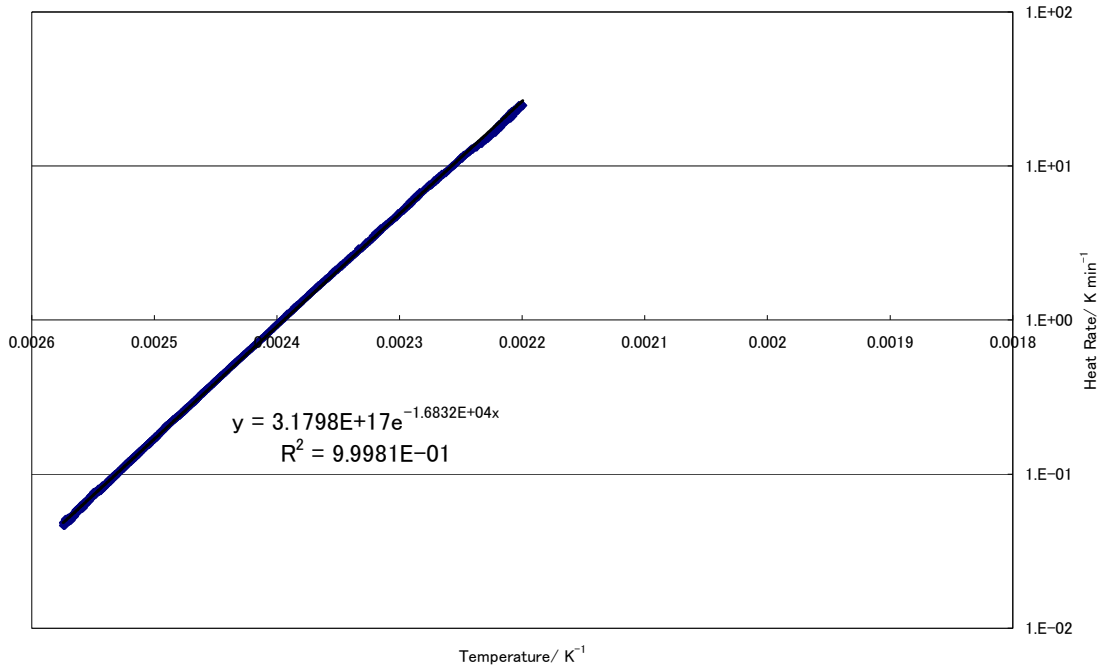
Time vs. Temperature and Pressure



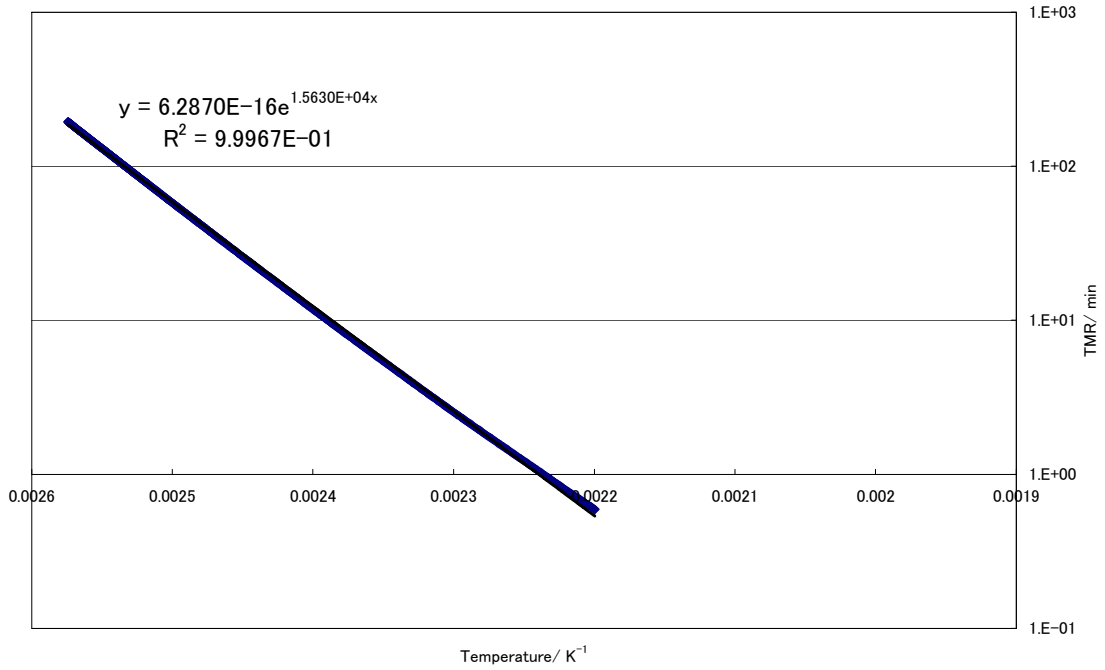
Temperature vs. Self heating rate



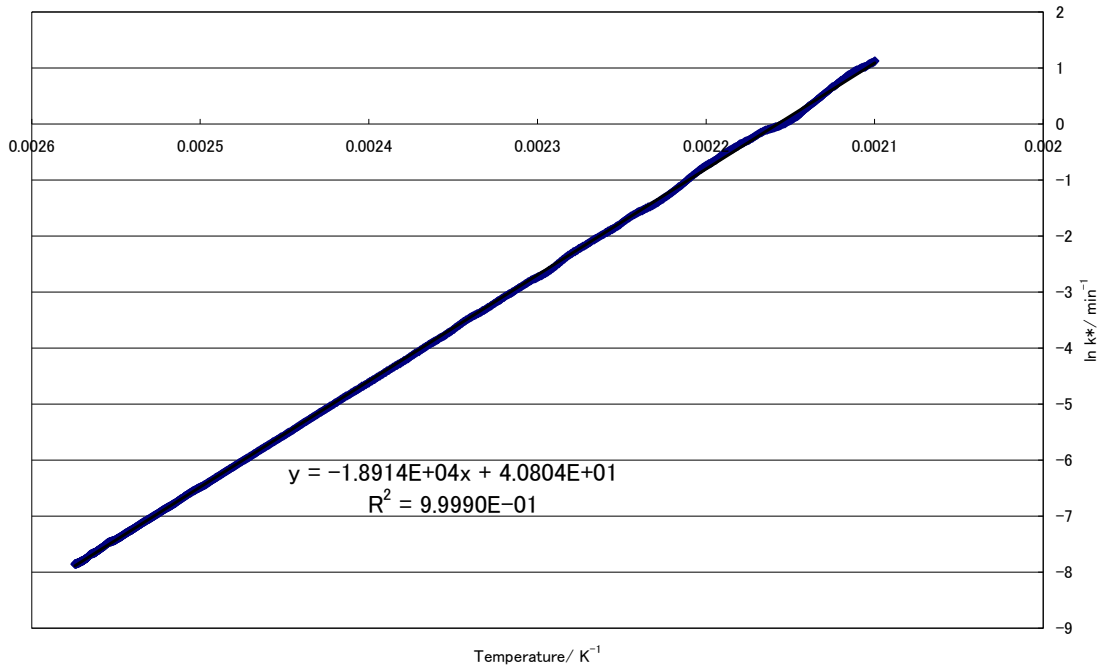
TMR vs. Temperature



Temperature vs. Self heating rate (approximate calculation)



Temperature vs. TMR (approximate calculation)

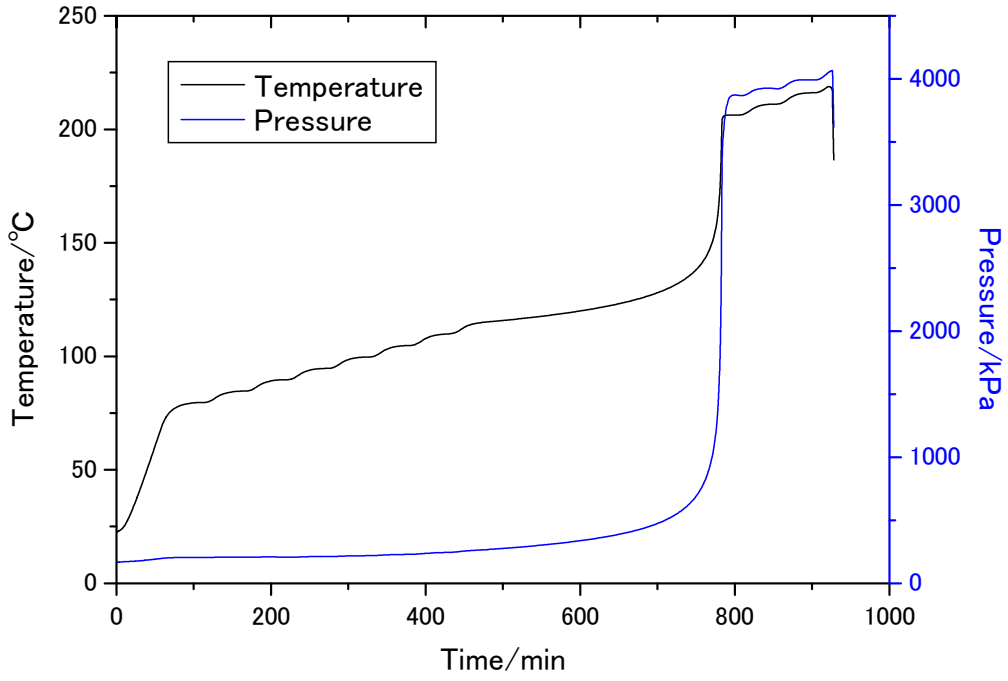


Arrhenius equation (approximate calculation)

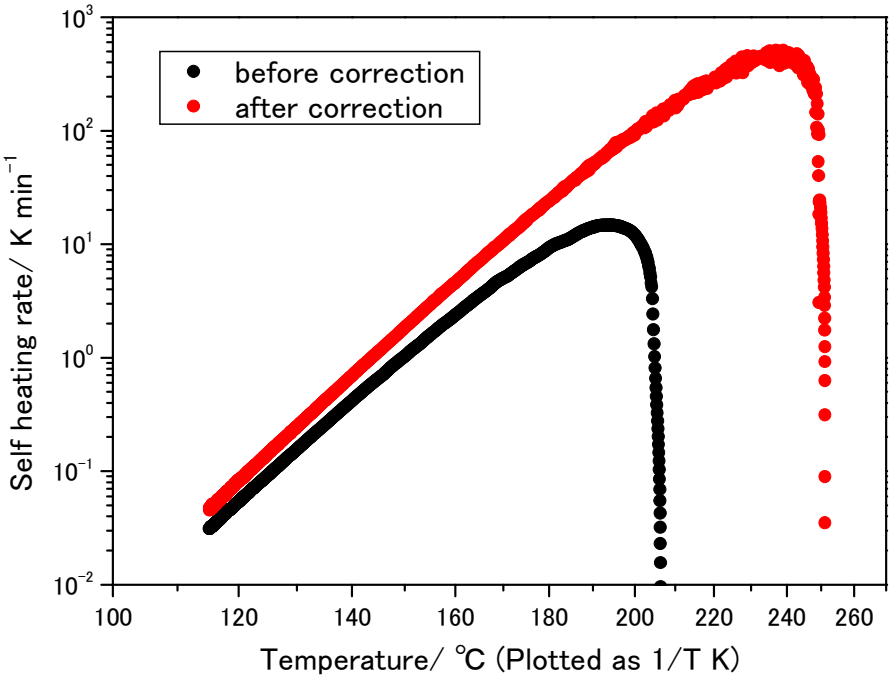
d) Material of Bomb: Hastelloy C

Waiting & Searching Time: 15 min

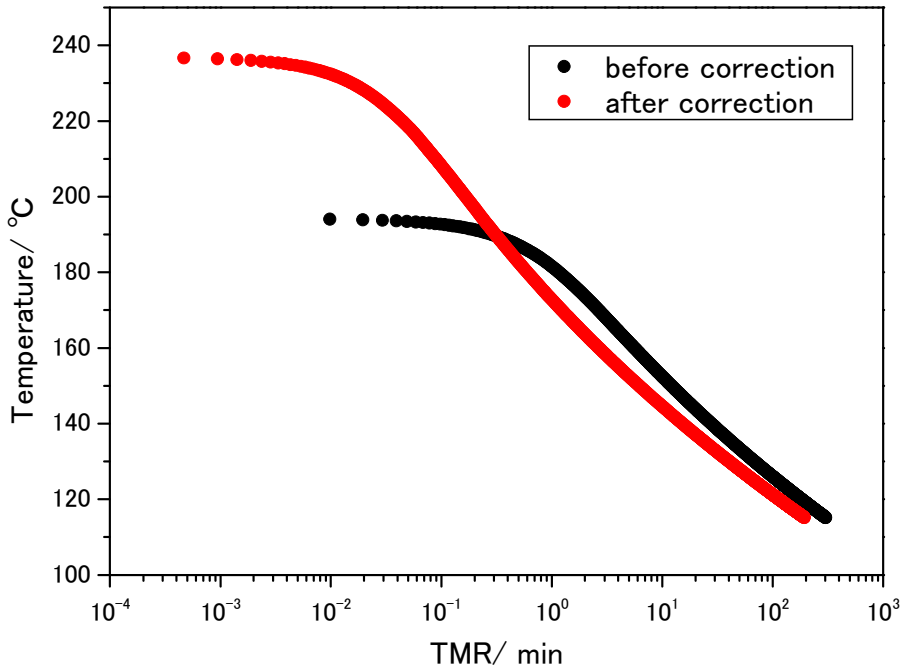
TBP Concentration: 20%



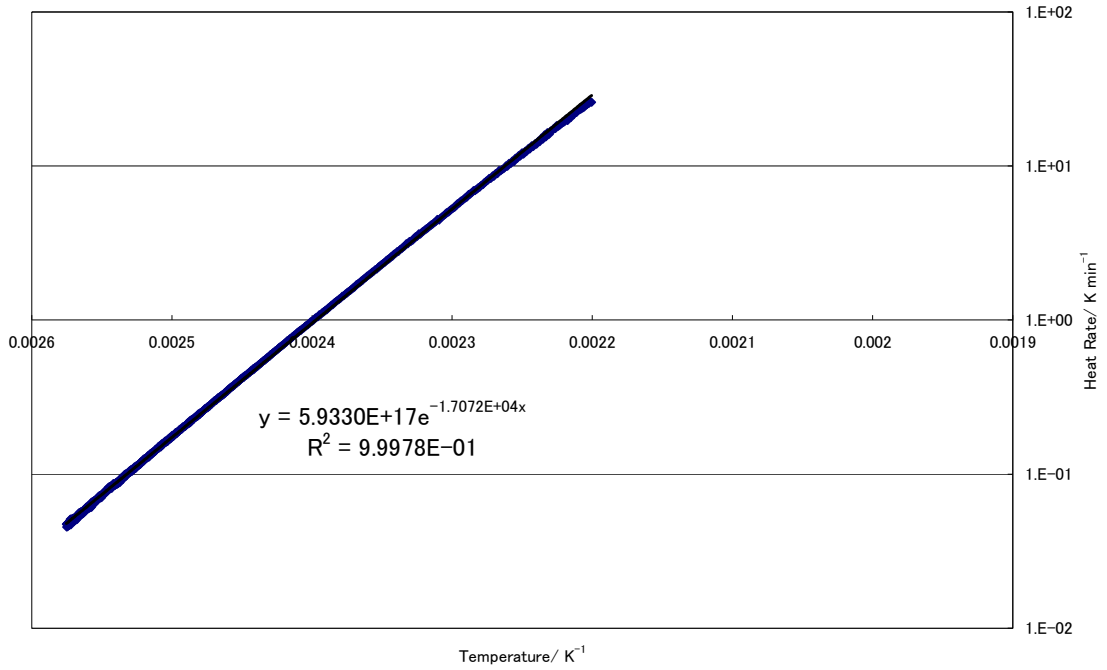
Time vs. Temperature and Pressure



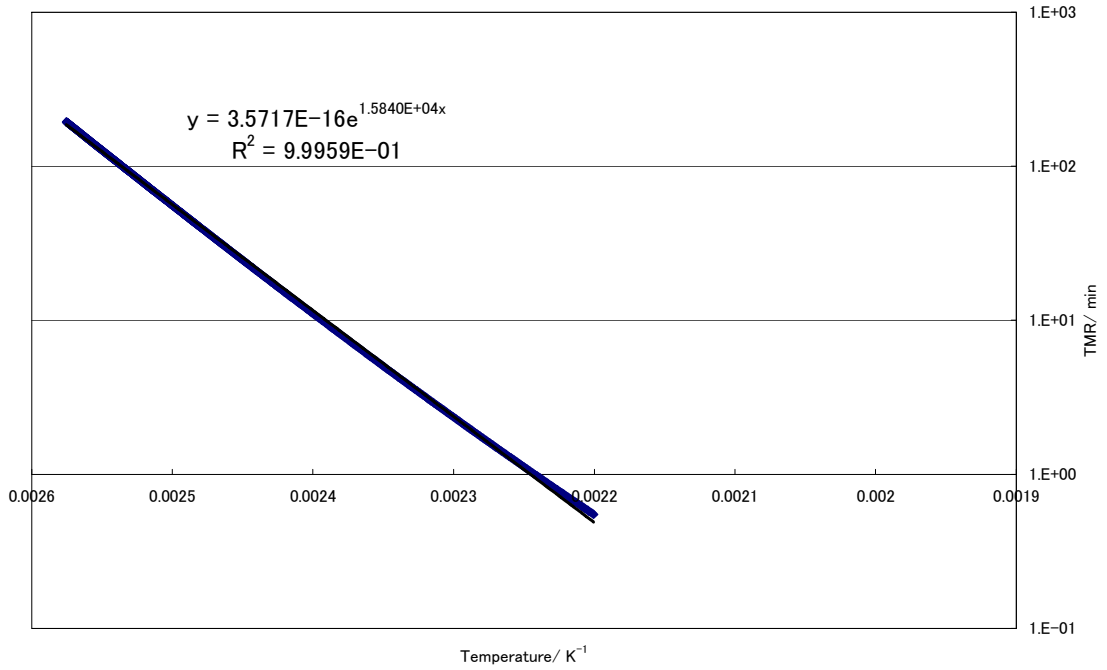
Temperature vs. Self heating rate



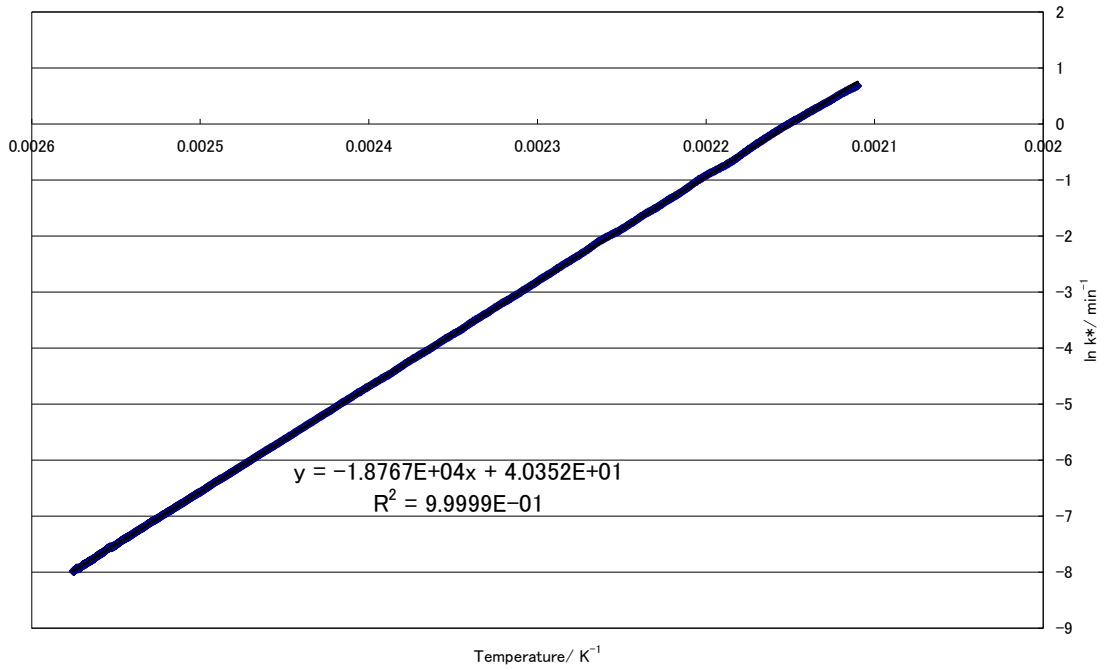
TMR vs. Temperature



Temperature vs. Self heating rate (approximate calculation)



Temperature vs. TMR (approximate calculation)

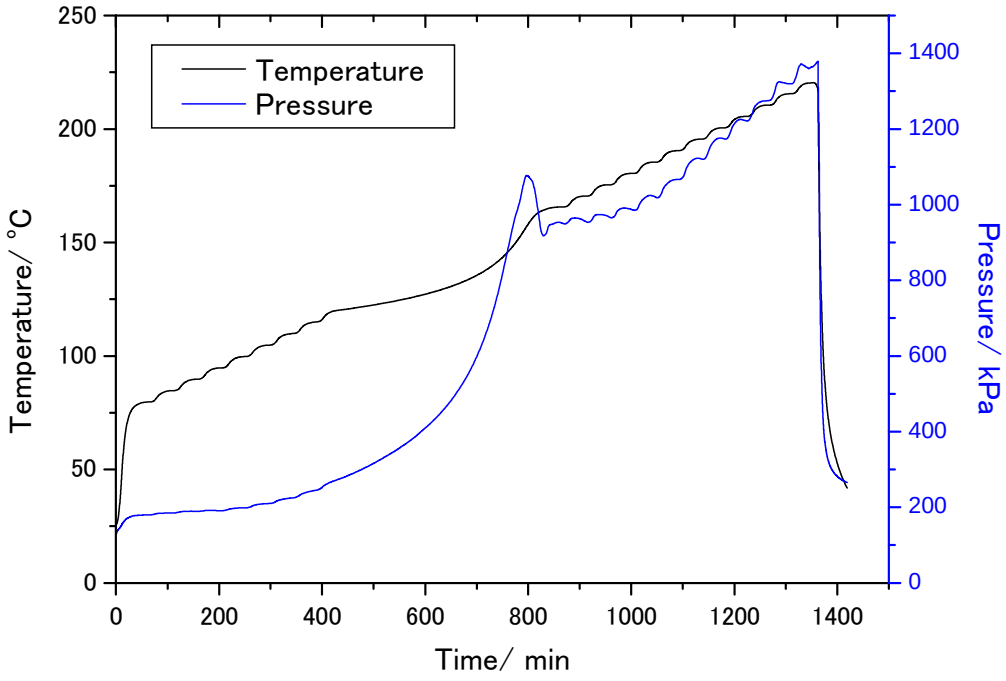


Arrhenius equation (approximate calculation)

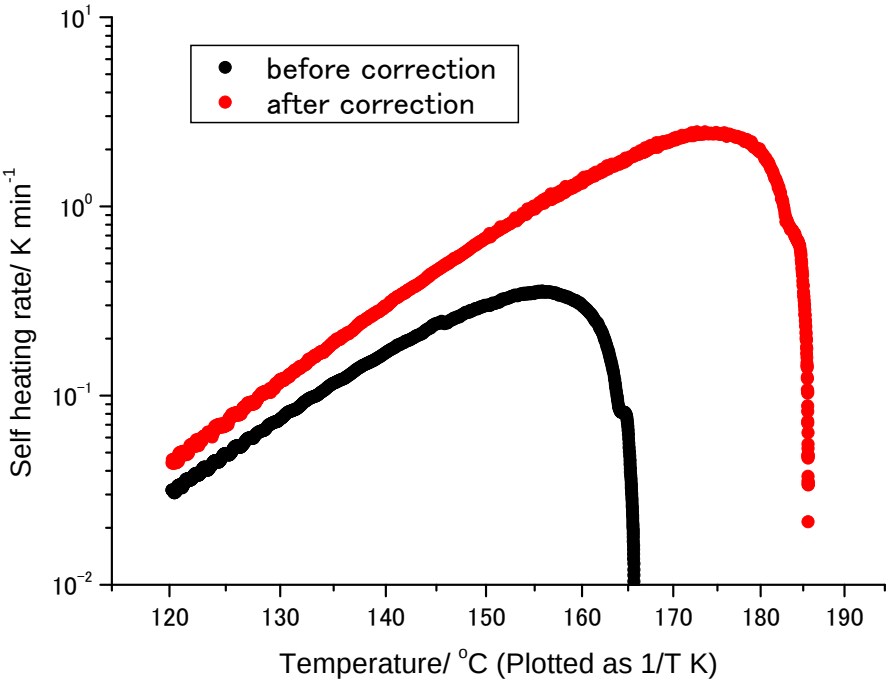
e) Material of Bomb: Hastelloy C

Waiting & Searching Time: 15 min

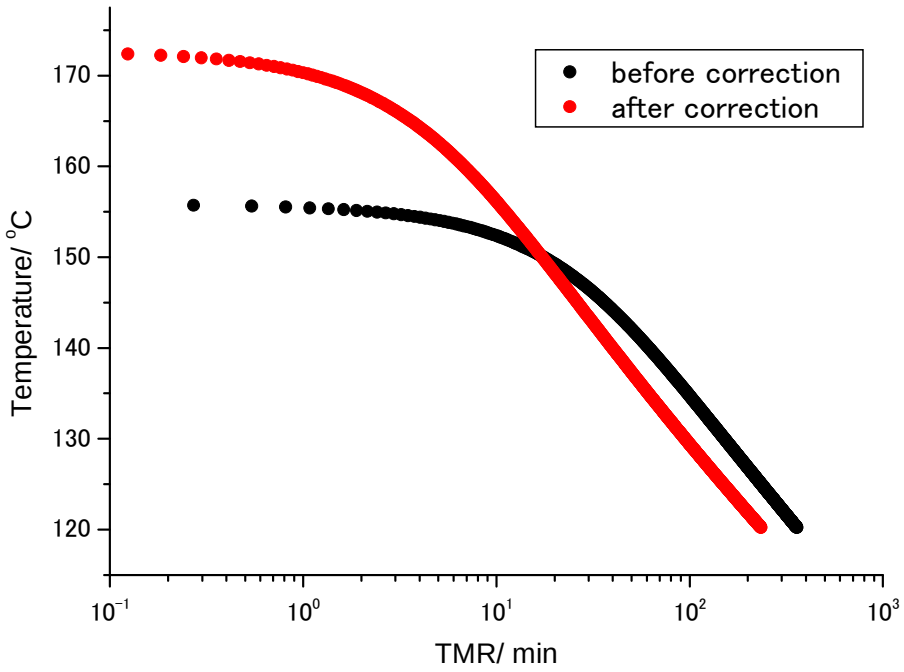
TBP Concentration: 10%



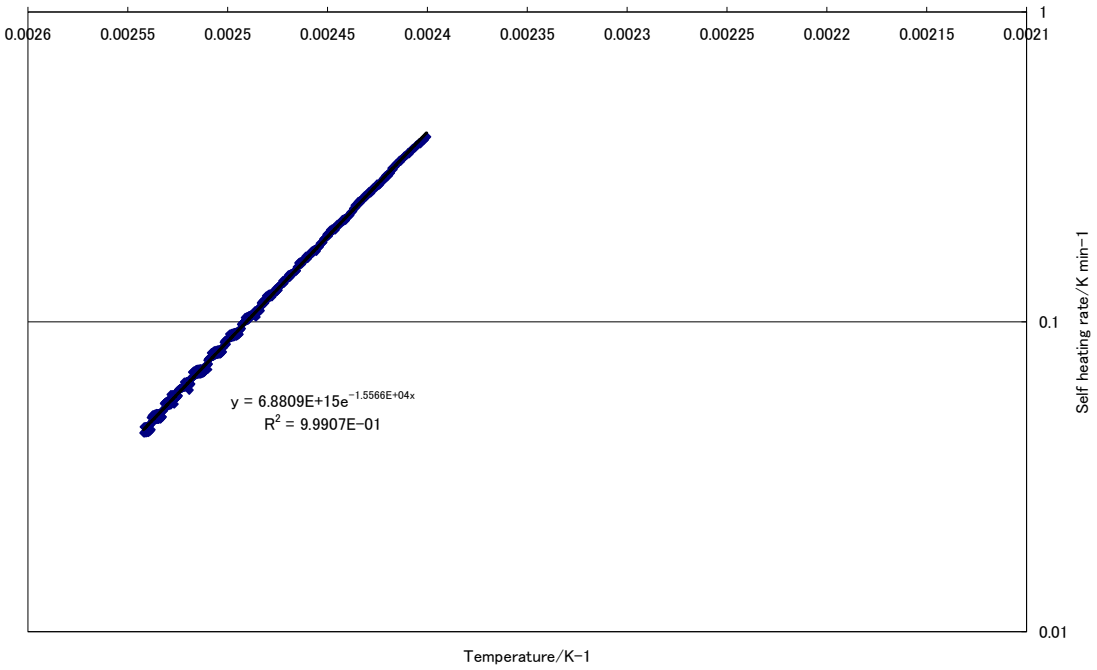
Time vs. Temperature and Pressure



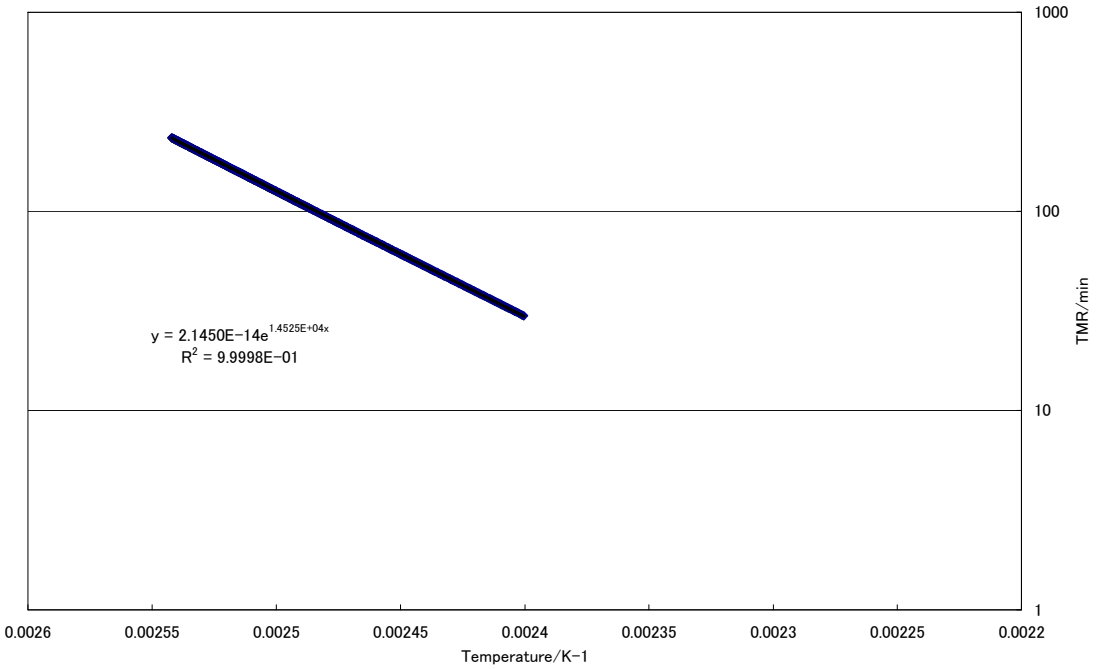
Temperature vs. Self heating rate



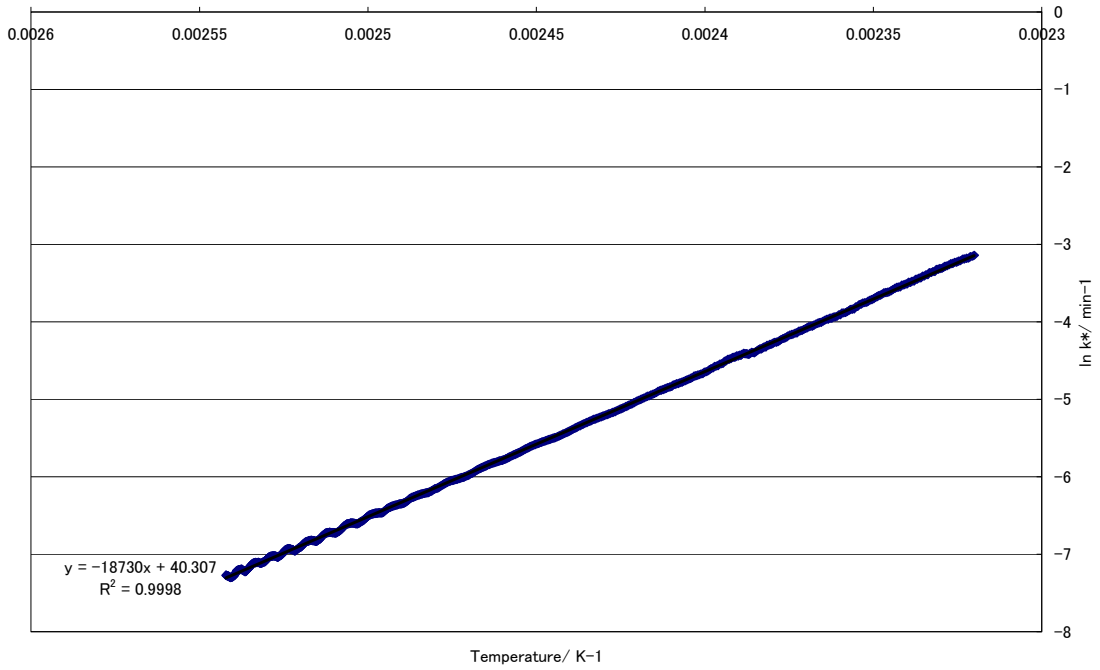
TMR vs. Temperature



Temperature vs. Self heating rate (approximate calculation)



Temperature vs. TMR (approximate calculation)

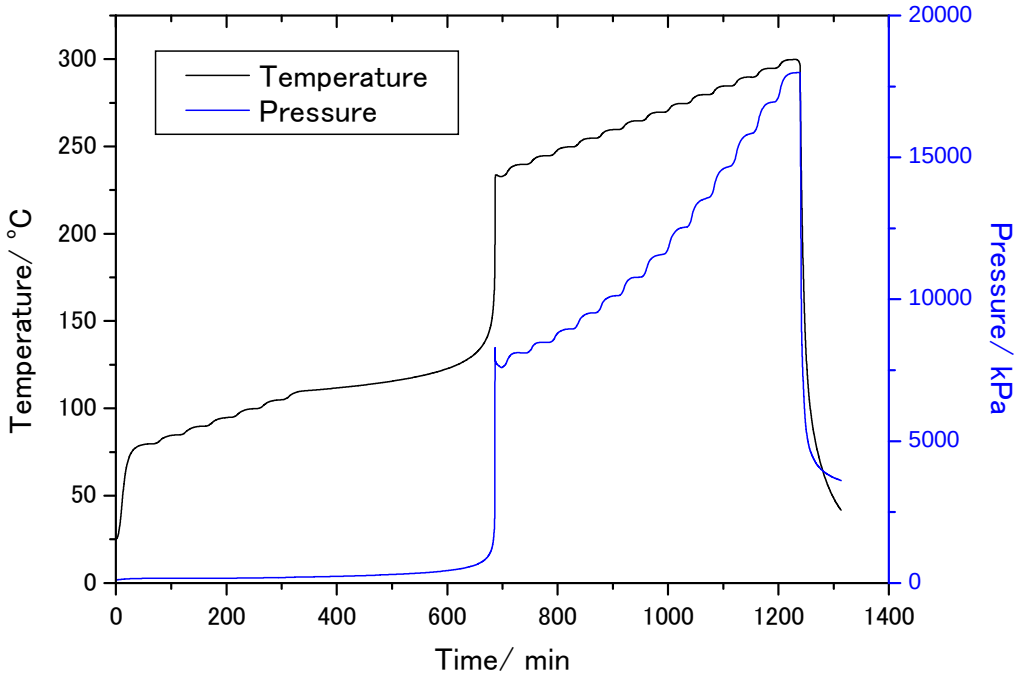


Arrhenius equation (approximate calculation)

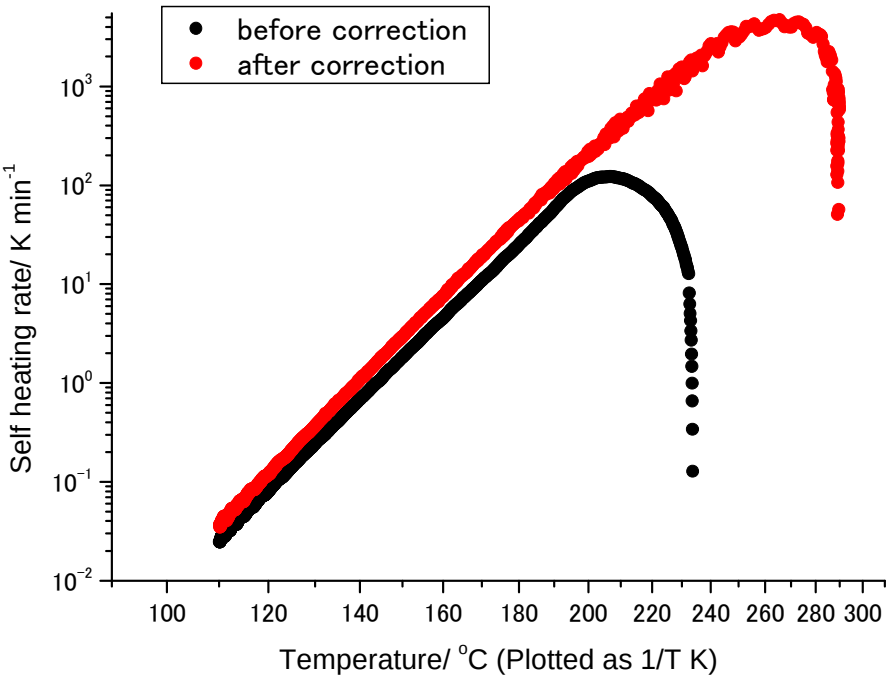
f) Material of Bomb: Hastelloy C

Waiting & Searching Time: 15 min

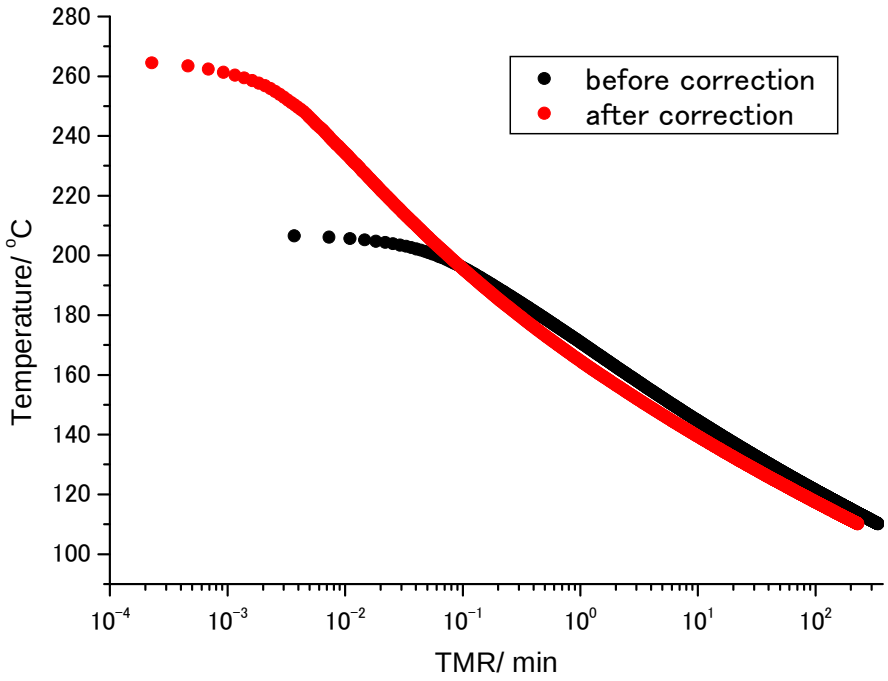
TBP Concentration: 30%



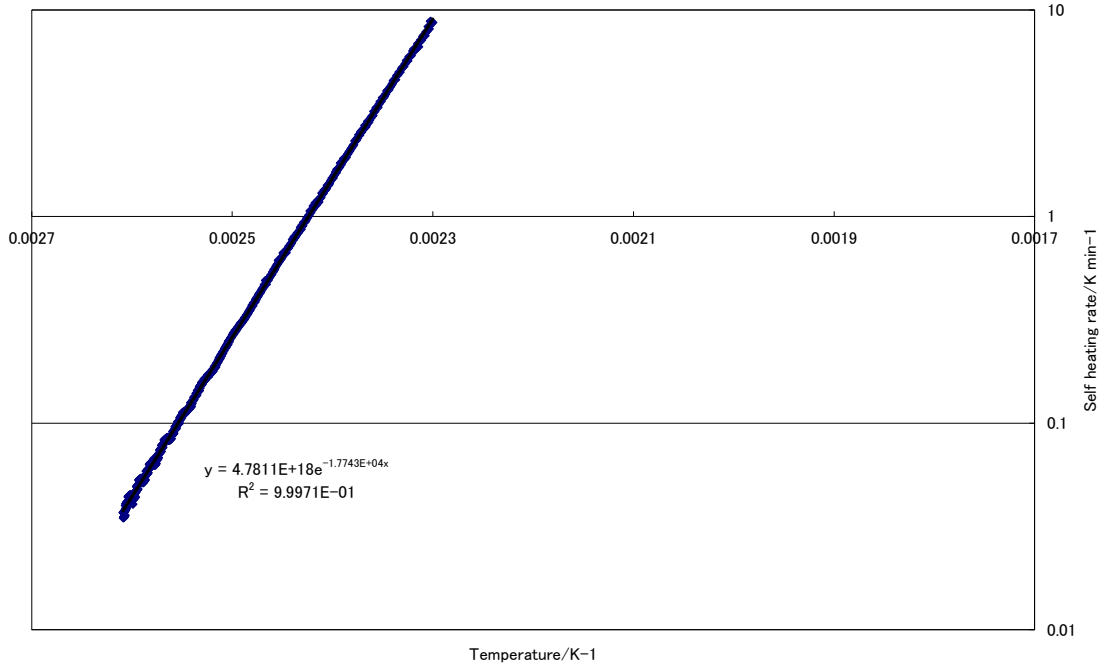
Time vs. Temperature and Pressure



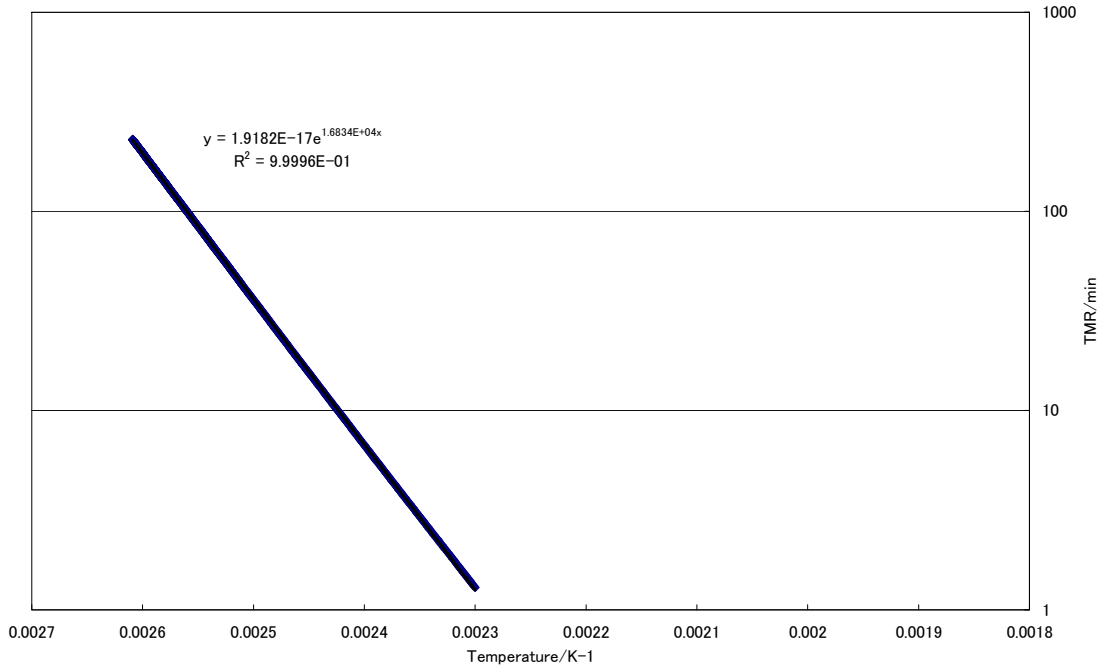
Temperature vs. Self heating rate



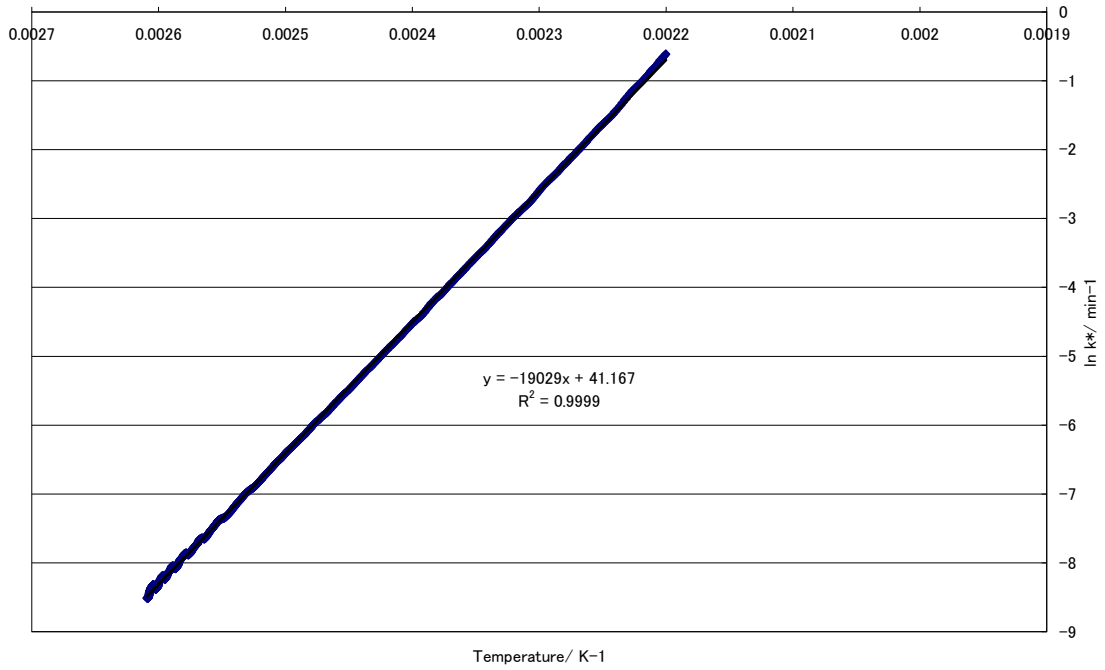
TMR vs. Temperature



Temperature vs. Self heating rate (approximate calculation)



Temperature vs. TMR (approximate calculation)



Arrhenius equation (approximate calculation)

a) Material of Bomb: Hastelloy C

Waiting & Searching Time: 30 min

TBP Concentration: 20%

	Date	2008/12/2
Measuring conditions	ARC device	NewARC (TIAX, LLC)
	Operating Institute	AIST
	Operator	Y. S.
	Material of Bomb	Hastelloy C
	Weight of Bomb (g)	14.7934
	Volume of Bomb (mL)	about 9
	Weight of sample (g)	6.0039
	Weight of residue (g)	—
	Specific heat of Bomb (J K^{-1} g^{-1})	0.419
	Specific heat of sample (J K^{-1} g^{-1})	2.093
	ϕ facotr	1.493
	Start temperature (℃)	80
	End temperature (℃)	220
	Temperature increment (K)	5
	Waiting time (min)	30

	Searching time (min)	15
	Exothermic threshold (K min^{-1})	0.02
	Logging intervals (℃)	0.15 ℃
	Pressure limit (kPa)	7000
	Atmosphere	Air, atmospheric pressure
Results	T_o, Exothermic temperature (℃)	115.65
	Self heating rate at T_o (K min^{-1})	0.033
	Pressure at T_o (kPa)	249.53
	Temperature at maximum self heating rate (℃)	195.46
	Maximum self heating rate (K min^{-1})	15.014
	Pressure at maximum self heating rate (kPa)	3001.3
	Pressure rising rate at maximum self heating rate (kPa min^{-1})	925.60
	Maximum pressure (kPa)	3966.1
	Maximum pressure rising rate (kPa min^{-1})	940.36
	Temperature at maximum pressure rising rate (℃)	197.23
	Time to maximum rate (min)	284.14
	Maximum temperature (℃)	206.47
	Adiabatic temperature rise (℃)	90.82
	Activation energy (kJ mol^{-1})	155
	Heat of decomposition (J g^{-1})	284
Corrected results	T_{ARC}, Exothermic temperature (℃)	107.50
	Time of maximum rate at T_{ARC} (min)	417.39
	Self heating rate at T_{ARC} (K min^{-1})	0.02
	Maximum self heating rate (K min^{-1})	527.33
	Maximum temperature (℃)	251.25
	Adiabatic temperature rise (℃)	143.75
	Heat of decomposition (J g^{-1})	301

b) Material of Bomb: Ti

Waiting & Searching Time: 30 min

TBP Concentration: 20%

	Date	2008/12/8
Measuring conditions	ARC device	NewARC (TIAX, LLC)
	Operating Institute	AIST
	Operator	Y. S.
	Material of Bomb	Ti
	Weight of Bomb (g)	6.4039
	Volume of Bomb (mL)	about 9
	Weight of sample (g)	6.0012
	Weight of residue (g)	—
	Specific heat of Bomb (J K^{-1} g^{-1})	0.544
	Specific heat of sample (J K^{-1} g^{-1})	2.093
	ϕ facotr	1.277
	Start temperature (℃)	80
	End temperature (℃)	220
	Temperature increment (K)	5
	Waiting time (min)	30
	Searching time (min)	15
	Exothermic threshold (K min^{-1})	0.02
	Logging intervals (℃)	0.15
	Pressure limit (kPa)	7000
	Atmosphere	Air, atmospheric pressure
Results	T_o, Exothermic temperature (℃)	110.40
	Self heating rate at T_o (K min^{-1})	0.022
	Pressure at T_o (kPa)	220.59
	Temperature at maximum self heating rate (℃)	199.59
	Maximum self heating rate (K min^{-1})	23.156
	Pressure at maximum self heating rate (kPa)	2872.4
	Pressure rising rate at maximum self heating rate (kPa min^{-1})	1637.1
	Maximum pressure (kPa)	4251.7
	Maximum pressure rising rate (kPa min^{-1})	1713.1

	Temperature at maximum pressure rising rate (℃)	200.84
	Time to maximum rate (min)	439.13
	Maximum temperature (℃)	211.21
	Adiabatic temperature rise (℃)	100.81
	Activation energy (kJ mol^{-1})	155
	Heat of decomposition (J g^{-1})	269
Corrected results	T_{ARC}, Exothermic temperature (℃)	107.67
	Time of maximum rate at T_{ARC} (min)	441.43
	Self heating rate at T_{ARC} (K min^{-1})	0.02
	Maximum self heating rate (K min^{-1})	310.54
	Maximum temperature (℃)	239.52
	Adiabatic temperature rise (℃)	131.85
	Heat of decomposition (J g^{-1})	276

c) Material of Bomb: Ti

Waiting & Searching Time: 15 min

TBP Concentration: 20%

	Date	2008/12/12
Measuring conditions	ARC device	NewARC (TIAX, LLC)
	Operating Institute	AIST
	Operator	Y. S.
	Material of Bomb	Ti
	Weight of Bomb (g)	6.3646
	Volume of Bomb (mL)	about 9
	Weight of sample (g)	6.0010
	Weight of residue (g)	—
	Specific heat of Bomb (J K^{-1} g^{-1})	0.544
	Specific heat of sample (J K^{-1} g^{-1})	2.093
	ϕ facotr	1.276
	Start temperature (℃)	80
	End temperature (℃)	220
	Temperature increment (K)	5
	Waiting time (min)	15
	Searching time (min)	15
	Exothermic threshold (K min^{-1})	0.02

	Logging intervals (℃)	0.15
	Pressure limit (kPa)	7000
	Atmosphere	Air, atmospheric pressure
Results	T_o, Exothermic temperature (℃)	115.31
	Self heating rate at T_o (K min^{-1})	0.037
	Pressure at T_o (kPa)	214.40
	Temperature at maximum self heating rate (℃)	200.34
	Maximum self heating rate (K min^{-1})	28.984
	Pressure at maximum self heating rate (kPa)	2695.9
	Pressure rising rate at maximum self heating rate (kPa min^{-1})	1838.8
	Maximum pressure (kPa)	3616.7
	Maximum pressure rising rate (kPa min^{-1})	1875.3
	Temperature at maximum pressure rising rate (℃)	202.27
	Time to maximum rate (min)	255.61
	Maximum temperature (℃)	211.65
	Adiabatic temperature rise (℃)	96.34
	Activation energy (kJ mol^{-1})	157
	Heat of decomposition (J g^{-1})	257
Corrected results	T_{ARC}, Exothermic temperature (℃)	107.55
	Time of maximum rate at T_{ARC} (min)	425.42
	Self heating rate at T_{ARC} (K min^{-1})	0.02
	Maximum self heating rate (K min^{-1})	272.58
	Maximum temperature (℃)	240.39
	Adiabatic temperature rise (℃)	132.84
	Heat of decomposition (J g^{-1})	278

d) Material of Bomb: Hastelloy C

Waiting & Searching Time: 15 min

TBP Concentration: 20%

	Date	2008/12/17
Measuring conditions	ARC device	NewARC (TIAX, LLC)
	Operating Institute	AIST

	Operator	Y. S.
	Material of Bomb	Hastelloy C
	Weight of Bomb (g)	14.7859
	Volume of Bomb (mL)	about 9
	Weight of sample (g)	6.0062
	Weight of residue (g)	—
	Specific heat of Bomb (J K^{-1} g^{-1})	0.419
	Specific heat of sample (J K^{-1} g^{-1})	2.093
	ϕ facotr	1.493
	Start temperature (℃)	80
	End temperature (℃)	220
	Temperature increment (K)	5
	Waiting time (min)	15
	Searching time (min)	15
	Exothermic threshold (K min^{-1})	0.02
	Logging intervals (℃)	0.15
	Pressure limit (kPa)	7000
	Atmosphere	Air, atmospheric pressure
Results	T_o, Exothermic temperature (℃)	115.14
	Self heating rate at T_o (K min^{-1})	0.031
	Pressure at T_o (kPa)	267.66
	Temperature at maximum self heating rate (℃)	194.15
	Maximum self heating rate (K min^{-1})	14.802
	Pressure at maximum self heating rate (kPa)	2617.3
	Pressure rising rate at maximum self heating rate (kPa min^{-1})	884.67
	Maximum pressure (kPa)	3871.9
	Maximum pressure rising rate (kPa min^{-1})	978.81
	Temperature at maximum pressure rising rate (℃)	196.19
	Time to maximum rate (min)	302.37
	Maximum temperature (℃)	206.34
	Adiabatic temperature rise (℃)	91.20
	Activation energy (kJ mol^{-1})	156

	Heat of decomposition (J g^{-1})	285
Corrected results	T_{ARC}, Exothermic temperature (℃)	107.61
	Time of maximum rate at T_{ARC} (min)	416.83
	Self heating rate at T_{ARC} (K min^{-1})	0.02
	Maximum self heating rate (K min^{-1})	513.02
	Maximum temperature (℃)	251.15
	Adiabatic temperature rise (℃)	143.54
	Heat of decomposition (J g^{-1})	300

e) Material of Bomb: Ti

Waiting & Searching Time: 15 min

TBP Concentration: 10%

	Date	2009/6/22
Measuring conditions	ARC device	NewARC (TIAX, LLC)
	Operating Institute	AIST
	Operator	Y. S.
	Material of Bomb	Hastelloy C
	Weight of Bomb (g)	10.1658
	Volume of Bomb (mL)	about 9
	Weight of sample (g)	6.0114
	Weight of residue (g)	—
	Specific heat of Bomb (J K^{-1} g^{-1})	0.544
	Specific heat of sample (J K^{-1} g^{-1})	2.093
	ϕ facotr	1.440
	Start temperature (℃)	80
	End temperature (℃)	220
	Temperature increment (K)	5
	Waiting time (min)	15
	Searching time (min)	15
	Exothermic threshold (K min^{-1})	0.02
	Logging intervals (℃)	0.15
	Pressure limit (kPa)	20000
	Atmosphere	Air, atmospheric pressure
Results	T_o, Exothermic temperature (℃)	120.22
	Self heating rate at T_o (K min^{-1})	0.032
	Pressure at T_o (kPa)	275.16

	Temperature at maximum self heating rate (℃)	155.80
	Maximum self heating rate (K min^{-1})	0.3563
	Pressure at maximum self heating rate (kPa)	1068.3
	Pressure rising rate at maximum self heating rate (kPa min^{-1})	5.1217
	Maximum pressure (kPa)	1077.0
	Maximum pressure rising rate (kPa min^{-1})	6.8837
	Temperature at maximum pressure rising rate (℃)	152.96
	Time to maximum rate (min)	434.22
	Maximum temperature (℃)	165.70
	Adiabatic temperature rise (℃)	45.48
	Activation energy (kJ mol^{-1})	156
	Heat of decomposition (J g^{-1})	137
Corrected results	T_{ARC}, Exothermic temperature (℃)	112.34
	Time of maximum rate at T_{ARC} (min)	495.84
	Self heating rate at T_{ARC} (K min^{-1})	0.02
	Maximum self heating rate (K min^{-1})	2.472
	Maximum temperature (℃)	185.64
	Adiabatic temperature rise (℃)	73.3
	Heat of decomposition (J g^{-1})	153

f) Material of Bomb: Ti

Waiting & Searching Time: 15 min

TBP Concentration: 30%

	Date	2009/6/26
Measuring conditions	ARC device	NewARC (TIAX, LLC)
	Operating Institute	AIST
	Operator	Y. S.
	Material of Bomb	Ti
	Weight of Bomb (g)	10.1759
	Volume of Bomb (mL)	about 9
	Weight of sample (g)	6.0169
	Weight of residue (g)	—

	Specific heat of Bomb (J K^{-1} g^{-1})	0.544
	Specific heat of sample (J K^{-1} g^{-1})	2.093
	ϕ facotr	1.440
	Start temperature (℃)	80
	End temperature (℃)	300
	Temperature increment (K)	5
	Waiting time (min)	15
	Searching time (min)	15
	Exothermic threshold (K min^{-1})	0.02
	Logging intervals (℃)	0.15
	Pressure limit (kPa)	20000
	Atmosphere	Air, atmospheric pressure
Results	T_o, Exothermic temperature (℃)	110.14
	Self heating rate at T_o (K min^{-1})	0.025
	Pressure at T_o (kPa)	209.89
	Temperature at maximum self heating rate (℃)	206.95
	Maximum self heating rate (K min^{-1})	122.33
	Pressure at maximum self heating rate (kPa)	8278.5
	Pressure rising rate at maximum self heating rate (kPa min^{-1})	122.33
	Maximum pressure (kPa)	8280.3
	Maximum pressure rising rate (kPa min^{-1})	38816
	Temperature at maximum pressure rising rate (℃)	191.41
	Time to maximum rate (min)	345.93
	Maximum temperature (℃)	233.76
	Adiabatic temperature rise (℃)	123.62
	Activation energy (kJ mol^{-1})	158
	Heat of decomposition (J g^{-1})	373
Corrected results	T_{ARC}, Exothermic temperature (℃)	104.98
	Time of maximum rate at T_{ARC} (min)	414.32
	Self heating rate at T_{ARC} (K min^{-1})	0.02
	Maximum self heating rate (K min^{-1})	4727.4
	Maximum temperature (℃)	290.04

	Adiabatic temperature rise (℃)	185.06
	Heat of decomposition (J g^{-1})	387