

U₃Si/Al**Analysis of the Spent U₃Si/Al Fuel Using the Heavy Atom Isotope Correlation with Burnup**

150

U₃Si/Al U, Pu
²³⁵U
 Nd-148 U Pu
²³³U and ²⁴²Pu
²³⁵U, Pu/U, ²³⁵U / , ²³⁵U,
²³⁹Pu ²⁴¹Pu
 U Pu U Pu

Abstract

The correlation of isotope composition of uranium and plutonium with the burnup in the spent U₃Si/Al fuel from Hanaro reactor has been investigated experimentally. The total and fractional(²³⁵U) burnup were determined by Nd-148 and mass spectrometric method

respectively. The contents of the U and Pu elements and their isotope compositions, after their separation from the spent fuel samples were determined by isotope dilution mass spectrometric method using ^{233}U and ^{242}Pu as spikes. The depletion of ^{235}U , the Pu/U ratio, the capture-to-fission ratio for ^{235}U , and the ratio of fission contributions for ^{235}U , ^{239}Pu and ^{241}Pu were determined. The burnup values and some parameters were expressed by the correlation with uranium and plutonium isotopes. The correlations between isotope compositions themselves were also expressed.

1.

가
 Pu
 safeguards 3가 , ,
 ,
 U, Pu, Kr, Xe, Cs, Nd, Eu,
 Ru Zr . (total burnup)
 (^{235}U burnup), ^{235}U ^{239}Pu (depletion), ^{239}Pu (buildup), Pu/U U/U₀(U₀ :
) ,

가 [1-7].

^{234}U ^{238}Pu

가

Hanaro

U₃Si/Al

가

2.

가.

U₃Si/Al hot cell
 (shielded line) [8.9].
 4 M HCl 1 가 10 M HNO₃ 90°C
 24

glove box

Fig. 1 Nd-148 U
 Pu [10-12]. U Pu ²³³U ²⁴²Pu

가

Symbol	Definition	Reference
F _T	Total burnup in atom % fission	[10,11]
F ₅	Fractional burnup(atom % fission) from fission of ²³⁵ U	[7,12]
D ₅	Depletion ($W_5^0/W_5^0 - W_5$) of ²³⁵ U in weight	[7]
₅	Capture-to-fission ratio of ²³⁵ U	[13]
Pu/U	Plutonium-to-uranium ratio in weight	[1,5-7]
N _{F235} /N _{F239} /N _{F241}	Ratio of fission contributions of ²³⁵ U, ²³⁹ Pu and ²⁴² Pu	[14]

3.

3.1.

Table 1 6 U₃Si/Al U
 (atom %) . ²³⁵U 19.95 atom % 5-14 atom %
 U Pu 가
 U Pu U
 Pu .

3.2.

Table 2 가 (F_T, F₅, D₅,
 s, Pu/U N_{F235}/N_{F239}/N_{F241} . (F_T) Nd-148 [10.11], (F₅)
 [12] 가 (7-14) .
 Pu/U U Pu ²³⁵U, ²³⁹Pu
²⁴¹Pu N_{F235}/N_{F239}/N_{F241} ²³⁸U

3.3.

3.3.1.

U 가 가 ²³⁵U ²³⁶U
²³⁸U 가 (Fig. 2). Pu
 가 가 ²³⁹Pu ²⁴⁰Pu, ²⁴¹Pu ²⁴²Pu 가
 (Fig. 3). 가 . ²³⁵U (D₅), Pu/U
 / (s) U Pu (²³⁵U/²³⁸U, ²³⁶U/²³⁸U
²⁴⁰Pu/²³⁹Pu) (Fig 4 5).

(Pu) 가 .

3.3.2.

가 . (F_T)

(F_T) ²³⁵U (D₅), / (s) Pu/U

Fig. 6 가 Pu , , Pu/U

3.3.3.

, U, Pu
²³⁶U ²³⁵U , ²³⁶U/²³⁸U
²³⁵U/²³⁸U (Fig. 7), ²³⁸U/²³⁶U ²³⁵U/²³⁶U , ²⁴¹Pu/²³⁹Pu ²⁴²Pu/²⁴⁰Pu
²³⁹Pu ²³⁵U , ²³⁵U/²³⁸U ²⁴⁰Pu/²³⁹Pu (Fig. 8)

4.

- 1) U
- 2) Pu (ng)
U 가
- 3) U₃Si/Al
, ²³⁵U ,
²³⁹Pu , , U/U₀ Pu/U , ²³⁵U / ,
- 4) U₃Si/Al

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Table 1. Burnup Parameters Determined by Chemical Methods

Parameter	Spent Fuel Sample					
	L1-M	L1-L	L1-H	L2-M	L2-L	L2-H
F_T	11.2577	9.0301	5.5145	11.4942	9.0935	5.4241
F_5	10.4497	8.3666	5.1167	10.5318	8.4868	5.0091
D_5	1.6834	2.1226	3.5130	1.6661	2.0991	3.5790
δ	0.1952	0.2070	0.2274	0.1937	0.2045	0.2300
Pu/U	4.768×10^{-3}	3.715×10^{-3}	2.294×10^{-3}	4.837×10^{-3}	3.907×10^{-3}	2.375×10^{-3}
$N_{F235}/N_{F239}/N_{F241}^*$	89.8/9.6/0.7	93.2/6.5/0.3	96.5/3.4/0.1	89.6/9.7/0.7	93.1/6.6/0.3	96.4/3.5/0.1

* : neglected the fast fissions originating in ^{238}U

Table 2. Isotopic Composition of U Separated from the Spent $\text{U}_3\text{Si}/\text{Al}$ Fuel Samples

Isotope	Atom %					
	L1-M	L1-L	L1-H	L2-M	L2-L	L2-H
U-234	0.1194	0.1468	0.1542	0.1355	0.1427	0.1500
U-235	8.1105	10.5626	14.2811	7.9874	10.4575	14.3856
U-236	2.4883	2.0623	1.3304	2.5278	2.0533	1.3220
U-238	89.2819	87.2282	84.2343	89.3493	87.3464	84.1424
Total	100.0001	99.9999	100.0000	100.0000	99.9999	100.0000

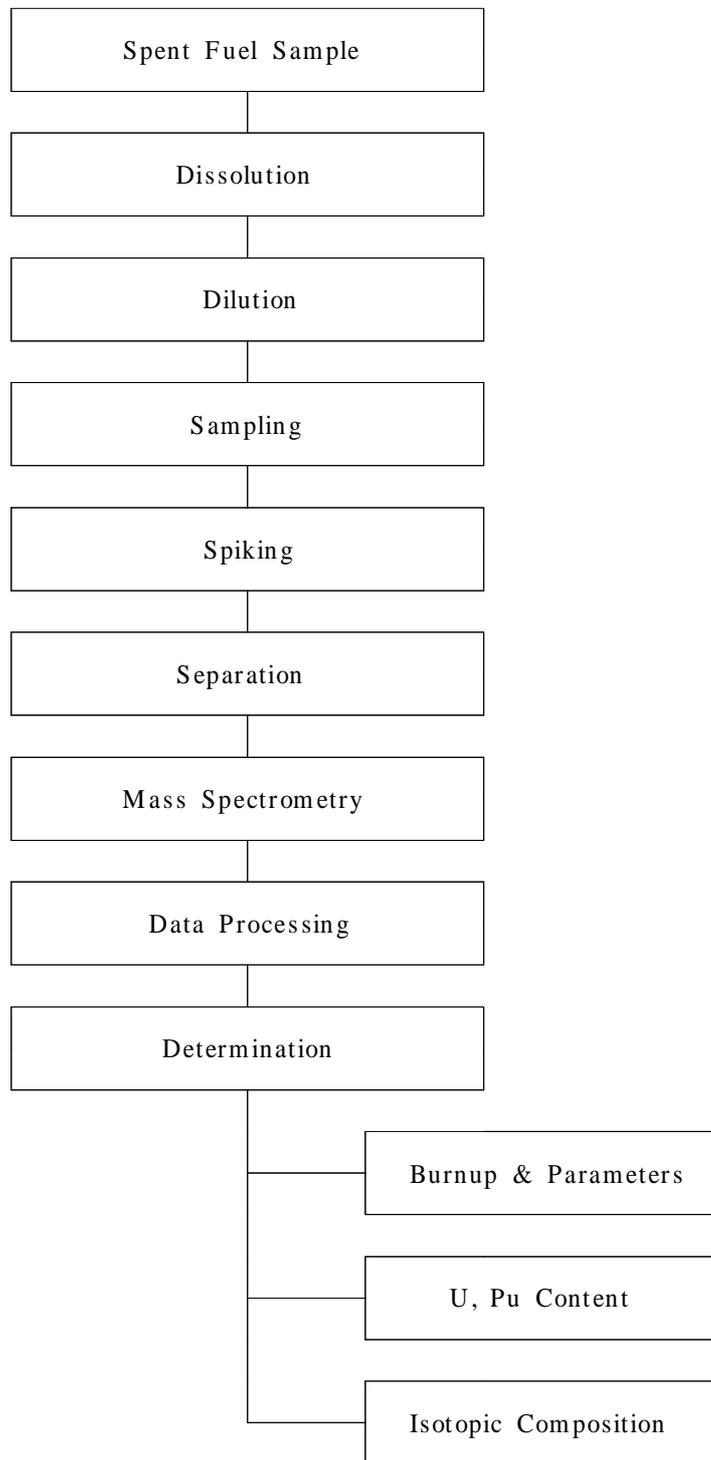


Fig. 1. Basic Processes for Isotope Correlation Study.

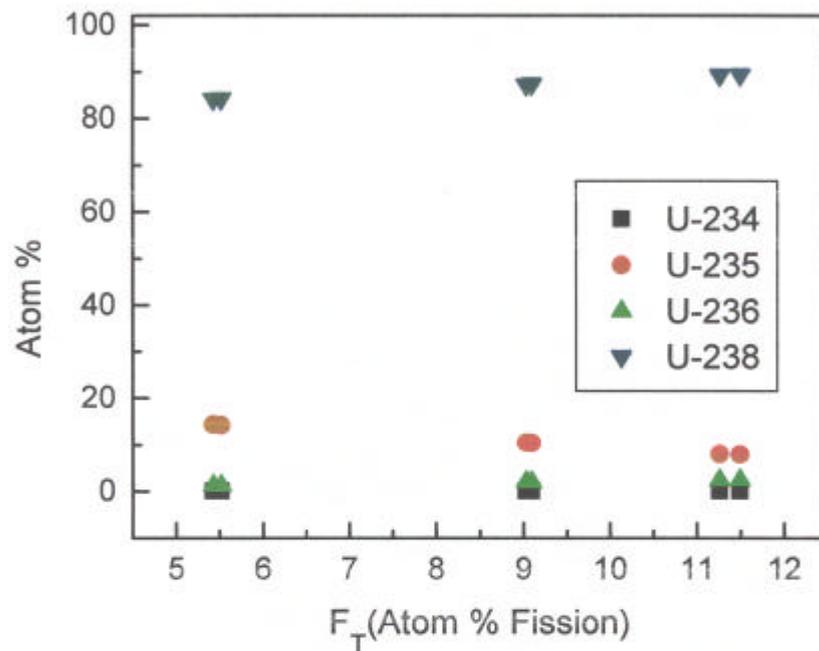


Fig.2. The Dependence of U Isotopes on Total Burnup(F_T)

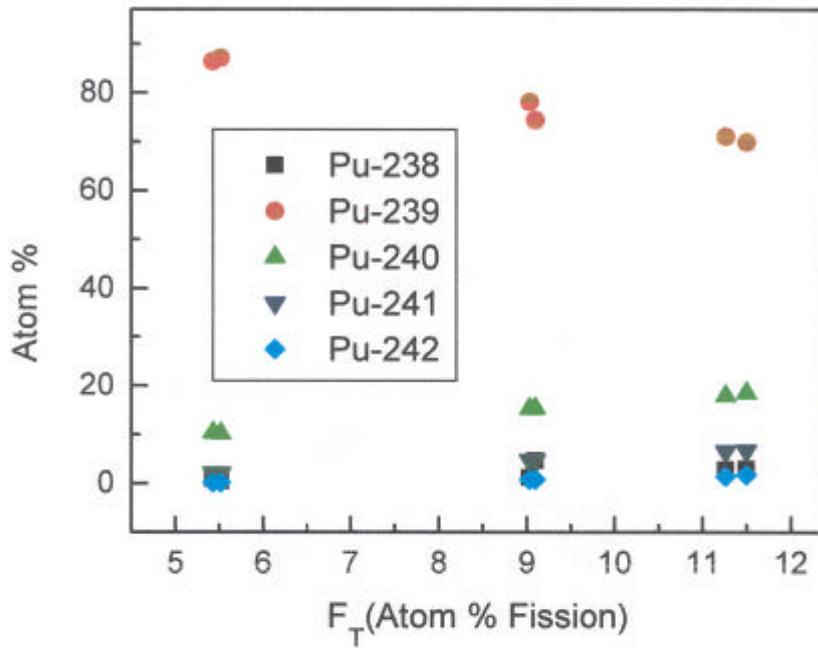


Fig. 3. The Dependence of Pu Isotopes on Total Burnup(F_T)

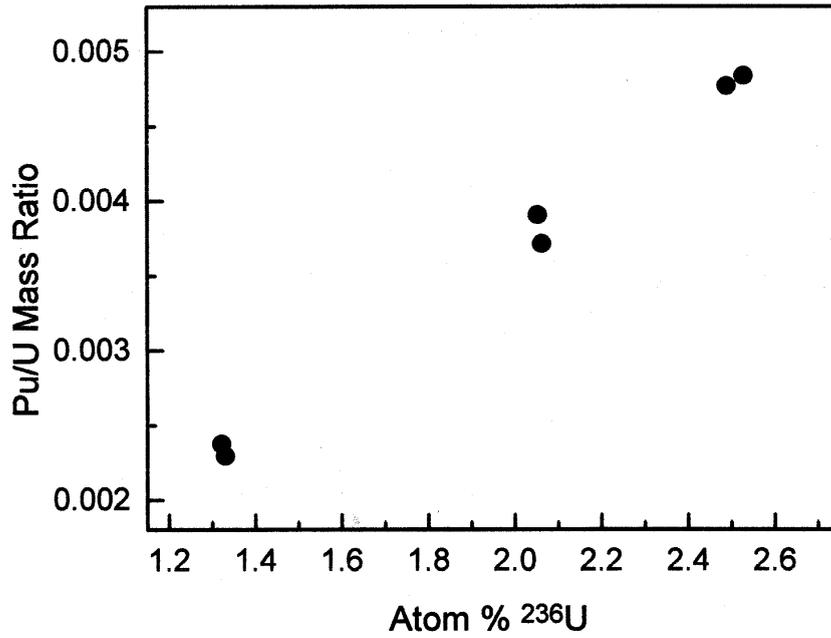


Fig. 4. Correlation between Pu/U Mass Ratio and Atom % ²³⁶U

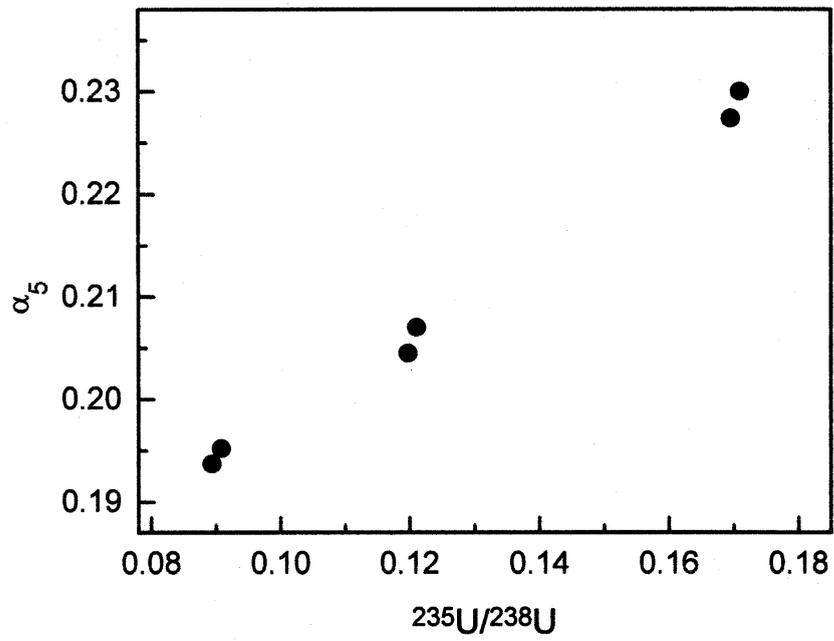


Fig. 5. Correlation between α_5 and $^{235}\text{U}/^{238}\text{U}$

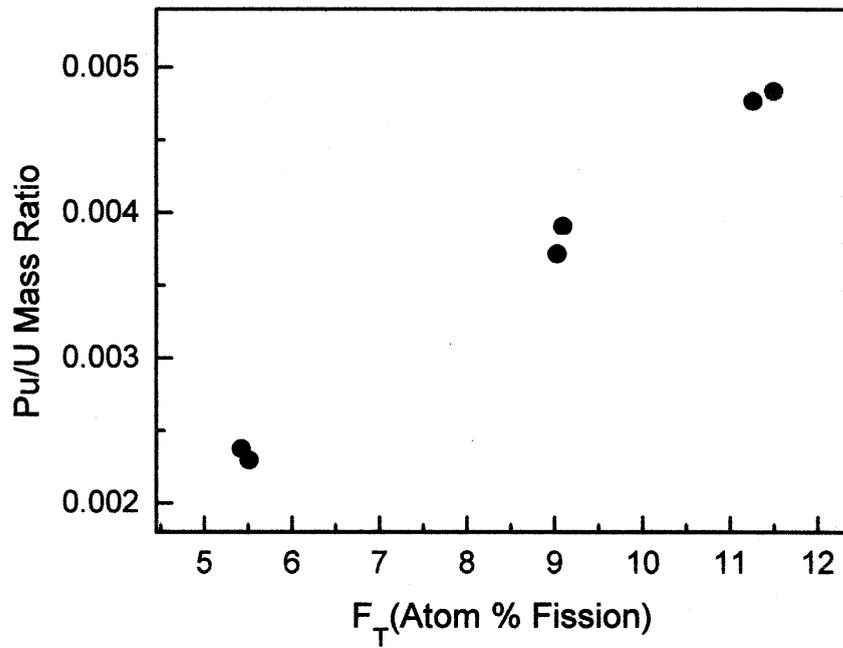


Fig. 6. Correlation between Pu/U Mass Ratio and Total Burnup(F_T)

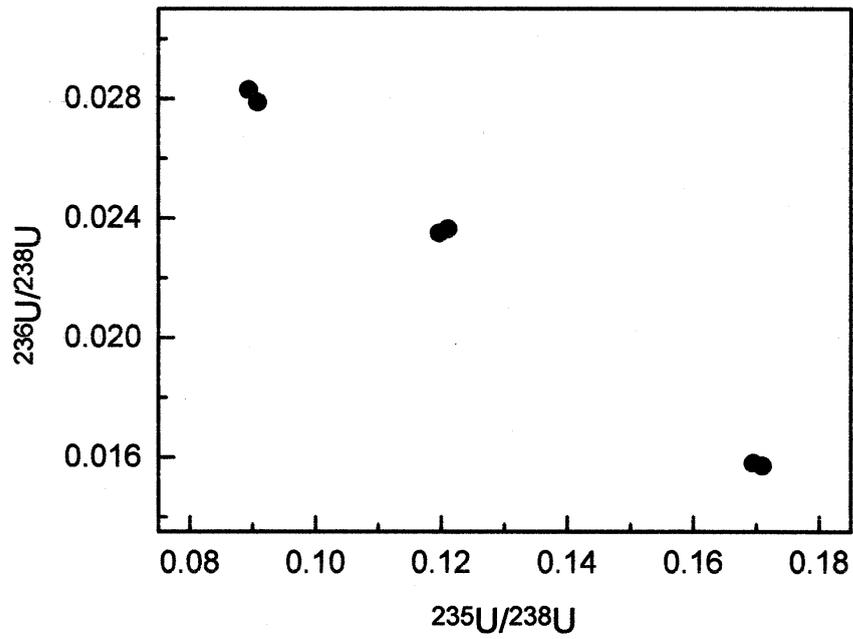


Fig. 7. Correlation between $^{236}\text{U}/^{238}\text{U}$ and $^{235}\text{U}/^{238}\text{U}$ Atom Ratio

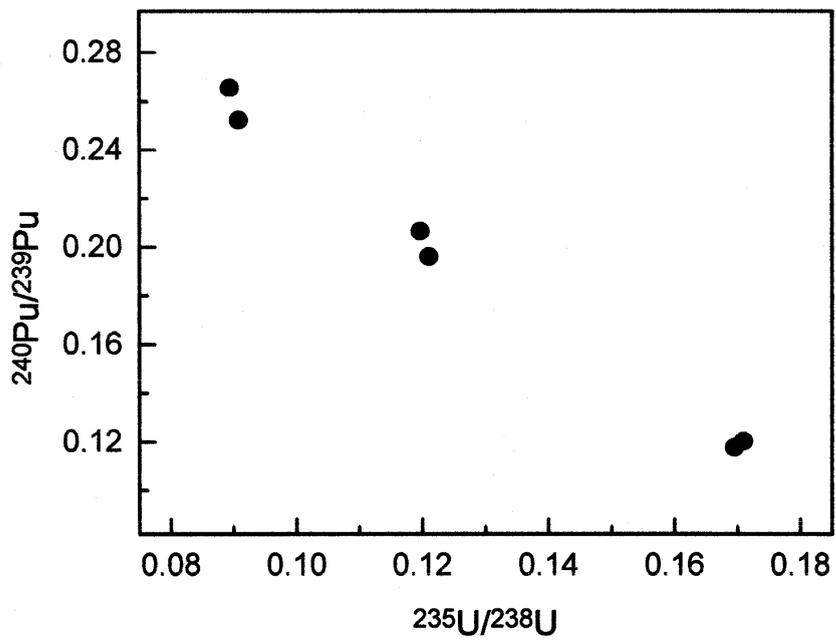


Fig. 8. Correlation between $^{240}\text{Pu}/^{239}\text{Pu}$ and $^{235}\text{U}/^{238}\text{U}$ Atom Ratio