Nuclear Physics Approach

Possibility of Radioactive Waste Utilization in Terms of the Erzion Model

Yu.N.Bazhutov, V.P.Koretsky

Erzion Center, P.O.Box 169, 105077 Moscow, Russia

Abstract

The possibility of transmutation of twenty six elements which form the main part of radioactive wastes is analysed in terms of the Erzion Model. The final products of the transmutation reactions are examined. It is concluded that practically all of the radio nuclides may be utilized.

The Erzion Model of catalytic nuclear transmutation can predict the possibility of radioactive waste utilization. Transmutation of some isotopes, which form a part of nuclear reactor wastes, was analysed earlier [1, 2]. It was shown that transmutation can be initiated with a lot of radioactive isotopes on the following two conditions:

1. A definite ratio of donor-nuclei (transmutation catalyst carriers) to fuel-nuclei has to exist.
2. Initiation mechanism of the reactions must be effective. Natural radiation of wastes can be used for this purpose.

Possible procedure of waste treatment was discussed earlier [2]. The detailed method of burning away of one long-lived isotope - Cesium-137 - was proposed as well. The aim of present paper is the analysis of other radio nuclides burning away possibility.

It is known that the main sources of environment radioactive pollutants are: the natural radioactivity; the nuclear weapon treatment; the natural uranium mining; the nuclear station operation; the nuclear fuel processing; the nuclear emergencies. The radioactive composition of these pollutants was analysed [3]. The final products of exothermic reactions with catalyst particles - enion $Э_N$ and erzions $Э^0$ and $Э^-$ were defined for each radio nuclide [4]. The examples of such reactions for isotopes ^{137}Cs and ^{99}Tc are as follows:

$^{137}Cs(Э_N,Э^-)^{138}\underline{Ba}$ + 1,20 MeV;
$^{137}Cs(Э^-,Э_N)^{136}\underline{Xe}$ + 0,38 MeV;
$^{99}Tc(Э_N,Э^-)^{100}\underline{Ru}$ + 1,38 MeV;
$^{99}Tc(Э^-,Э_N)^{98}\underline{Mo}$ + 1,30 MeV;
$^{99}Tc(Э_N,Э^0)^{100}Tc$ + 0,61 MeV; 16s.: β^-: γ;
$^{99}Tc(Э^-,Э^0)^{99}Mo$ + 1,08 MeV; 66hr: β^-: γ;

These reactions can proceed validly as a catalytic particle ($Э_N$, $Э^0$ or $Э^-$) appears in each channel.

Nuclear Physics Approach

The results are presented in Tables 1 and 2 for fusion and transuranium products correspondingly. Some first isotopes in each Table bounded by double line are in decreasing order of their radiation danger [5]. The other isotopes are in decreasing order of half-life period.

Table 1.

Transmutation reactions for fusion products

Initial isotope	Half-life period	Final isotope	Half-life period
^{137}Cs	30y.	^{136}Xe	stable
		^{138}Ba	stable
^{99}Tc	$2{,}1\cdot10^{5}$y.	^{98}Mo	stable
		^{99}Mo	66hr
		^{100}Tc	16s.
		^{100}Ru	stable
^{107}Pd	$6{,}5\cdot10^{6}$y.	^{107}Ru	22min.
		^{108}Pd	stable
^{129}I	$1{,}6\cdot10^{7}$y.	^{128}Te	stable
		^{129}Te	70min.
		^{130}I	12,4hr
		^{130}Xe	stable
^{147}Pm	2,6y.	^{146}Nd	stable
		^{147}Nd	11d.
^{154}Eu	8,8y.	^{153}Sm	47hr
		^{154}Sm	stable
		^{155}Eu	5y.
^{40}K	$1{,}3\cdot10^{6}$y.	^{39}Ar	2,7y.
		^{40}Ar	stable
		^{41}K	stable
		^{41}Ca	$1{,}4\cdot10^{5}$y.
^{126}Sn	$1\cdot10^{5}$y.	^{127}Sb	3,85d.
^{79}Se	$6{,}5\cdot10^{4}$y.	^{79}As	9min.
		^{80}Se	stable
^{210}Pb	22,3y.	^{210}Pb	3,25hr
^{60}Co	5,27y.	^{60}Fe	$3\cdot10^{5}$y.
		^{60}Ni	stable
		^{61}Ni	stable
		^{61}Co	1,7hr
^{106}Ru	372d.	^{107}Rh	21,7min.
^{54}Mn	312d.	^{53}Cr	stable
		^{54}Cr	stable
		^{55}Fe	2,7y.
		^{55}Mn	stable
^{57}Co	271d.	^{56}Fe	stable
		^{57}Fe	stable
		^{58}Co	71d.
		^{58}Ni	stable
^{103}Ru	39d.	^{104}Ru	stable

Table 2.

Transmutation reactions for transuranium elements

Initial isotope	Half-life period	Final isotope	Half-life period
^{239}Pu	$2{,}4 \cdot 10^{4}$y.	^{238}Np	2.12d.
		^{239}Np	2.35d.
		^{238}Pu	88y.
		^{240}Pu	$6{,}5 \cdot 10^{3}$y.
^{240}Pu	6537y.	^{239}Np	2.35d.
		^{240}Np	65min.
^{241}Pu	1.44y.	^{240}Np	65min
		^{241}Np	16min.
		^{240}Pu	$6{,}5 \cdot 10^{3}$y.
		^{242}Pu	$3{,}8 \cdot 10^{5}$y.
^{241}Am	432y.	^{240}Pu	$6{,}5 \cdot 10^{3}$y.
		^{241}Pu	14.4y.
^{232}Th	$1{,}4 \cdot 10^{10}$y.	^{231}Ac	7.5min.
^{238}U	$4{,}5 \cdot 10^{9}$y.	^{237}Pa	8.7min.
^{237}Np	$2{,}1 \cdot 10^{6}$y.	^{236}U	$2{,}3 \cdot 10^{7}$y.
		^{237}U	6.8d.
^{243}Am	7380y.	^{242}Pu	$3{,}8 \cdot 10^{5}$y.
		^{243}Pu	5hr
^{226}Ra	1600y.	^{225}F	3.9min.
^{244}Cm	18.1y.	^{243}Am	7380y.
		^{244}Am	10.1hr

As Table 1 illustrates, stable ore short-lived isotopes appear as a result of most reactions with radio nuclides. More long-lived isotopes can appear for three isotopes only (^{60}Co, ^{106}Rh and ^{54}Mn). But each such long-lived isotope can enter to transmutation reaction with enions and erzions and create new isotopes [5] - ^{61}Co (with 1,6 hr life time); ^{107}Rh (22 min.) and ^{108}Pd (stable); ^{55}Mn (stable) and ^{56}Fe (stable) correspondingly. One of the main fusion products ^{90}Sr is absent in the Table 1 because all six possible erzion transmutation reactions are endothermic if some model parameters are true. But some of this reactions can be exothermic if such parameters will be changed during the future investigations. In this case the generation of some other isotopes is possible [5] - rubidium, strontium or yttrium with maximum life time 59d. (^{91}Y). This suggests the possibility of ^{90}Sr transmutation in terms of the Erzion Model.

The more long-lived isotopes ($^{240,242}Pu$, ^{236}U and ^{243}Am) may appear for some transuranium radio nuclides also. But as seen from Table 2, two of them (^{240}Pu and ^{243}Am) may be transmuted into more short-lived ones on the next steps of transmutation. The Erzion Model also predicts transmutation of remaining two isotopes into short-lived isotopes [5] - ^{241}Np (16 min.) and ^{235}Pa (24 min.).

So if the Erzion Model is true, it predicts the transmutation possibility for, actually, all radio nuclides that occur in the composition of all kinds of radioactive wastes.

Nuclear Physics Approach

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