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A Novel Target for Reactor-produced ^{193m}Pt

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^{192}Pt and ^{194}Pt formed due to the β-decay of ^{192}Ir and ^{194}Ir in industrial iridium sources has been separated. According to mass spectrometric assay the separated platinum consisted in 70–79% ^{192}Pt and 20–28% ^{194}Pt. The high enrichment in ^{192}Pt makes its application for reactor production of ^{193m}Pt possible.

SINCE the discovery of ROSENBERG *et al.*[1] about the anti-tumour activity of *cis*-dichloradiammineplatinum (DDP), the application of ^{193m}Pt or ^{195m}Pt labelled *cis*-DDP in cancer chemotherapy research has been reported by several authors. The administration of radioplatinum-labelled *cis*-DDP may contribute to therapeutic management by providing information on the distribution and localization of *cis*-DDP,[2,3] while investigations on the interaction of *cis*-DDP and nucleic acids may elucidate the method of action of *cis*-DDP on tumour cells.[4,5]

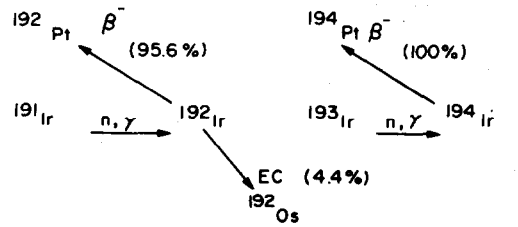
The difficulty arising when one intends to produce either of these radioplatinum isotopes by reactor irradiation with sufficiently high specific activity is the low neutron capture cross section of ^{194}Pt and/or the low abundance of ^{192}Pt. In addition, as can be seen from the data listed in Table 1, several radioplatinum isotopes besides ^{193m}Pt and ^{195m}Pt are simultaneously formed during neutron irradiation. Furthermore, the β-decay of ^{199}Pt yields ^{199}Au which has to be removed from platinum isotopes.

There are two known ways to increase the specific activity of ^{193m}Pt and/or that of ^{195m}Pt. One of them is to irradiate enriched ^{194}Pt,[1] while the other one is based on the utilization of the ^{192}Os $(\alpha, 3n)$ ^{193m}Pt nuclear reaction as performed by LANGE *et al.*[3] at the Yale Heavy Ion Accelerator.

Though the ^{193m}Pt formed in this case is a carrier-free nuclide, the necessity of using a heavy ion accelerator imposes limitations on large-scale production.

Instead of using enriched ^{192}Pt for production of ^{193m}Pt or utilizing an accelerator to initiate the ^{192}Os $(\alpha, 3n)$ ^{193m}Pt nuclear reaction, it is more economical to use a mixture of ^{192}Pt–^{194}Pt, which can be separated from spent ^{192}Ir sources, as target material for reactor irradiation.

As can be seen from the scheme below, the β-decay of reactor-activated natural iridium yields ^{192}Pt and ^{194}Pt, while the electron capture of ^{192}Ir results in ^{192}Os.



SCHEME 1.

The fraction of an iridium target converted into platinium or osmium during a 100-day irradiation at a thermal neutron flux of 10^{17} m^{-2} sec^{-1} is listed in Table 2.

It is a consequence of the 2 barn neutron capture cross section of ^{192}Pt in contrast with that of the 0.09 barn of ^{194}Pt that reactor irradiation of a ^{192}Pt-^{194}Pt

TABLE 1.[3]

Natural abundance (%)	Neutron capture cross-section (barn)	Product of the (n, γ) reaction	Half-life	Saturation activity (GBq/g)
^{190}Pt 0.0127	150	^{191}Pt	3d	0.570
^{192}Pt 0.78	2	^{193m}Pt	4.4d	0.466
^{194}Pt 32.9	0.09	^{195m}Pt	4.1d	0.089
^{195}Pt 33.7	27	^{196}Pt	Stable	—
^{196}Pt 25.2	0.9	^{197}Pt	20 h	6.67
	0.05	^{197m}Pt	80 min	0.37
^{198}Pt 7.19	4	^{199}Pt	14 s	8.70
	0.03	^{199m}Pt	20 min	0.59

* The saturation activity was calculated for a thermal neutron flux of 10^{17} m^{-2} sec^{-1}.

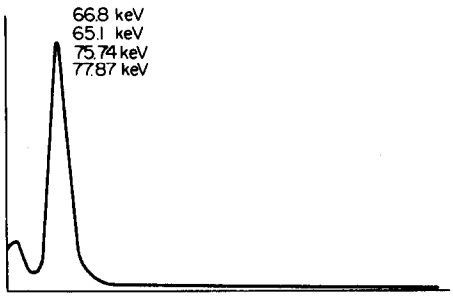


FIG. 1. NaI(Tl) γ-ray spectrum of ^{193m}Pt.

mixture—the composition of which may be ranged according to the data in Table 2 between (2.83/0.57) and (10.9/7.2) depending on the neutron spectrum of the given irradiation position—yields overwhelmingly ^{193m}Pt:99.1% in the former case and 97.1% in the latter.

The reactor irradiation of a few mg ^{192}Pt–^{194}Pt mixture separated from spent ^{192}Ir sources resulted in ^{193m}Pt containing a minute fraction of ^{195m}Pt. The

TABLE 2. Conversion of iridium into platinum and osmium calculated from:

	Neutron capture cross-section (%)	Resonance integral (%)
^{192}Pt	2.83	10.9
^{194}Pt	0.57	7.2
^{192}Os	0.15	0.6

TABLE 3. The average composition of platinum separated from spent ^{192}I sources

Isotope	Abundance (%)
^{192}Pt	70–79
^{194}Pt	20–28
^{195}Pt	0.2–0.6
^{196}Pt	0.01–0.25
^{198}Pt	0.05

γ-ray spectra, recorded by the use of a NaI(Tl) scintillation crystal and a Ge(Li) semiconductor detector, are shown in Figs 1 and 2.

These spectra are in good agreement with the internal conversion coefficients reported by LANGE *et al.*, according to which the 135 and 12.6 keV γ-photons are completely converted in the *K*, *L* and *M* shells.[6]

The single photopeak of the NaI(Tl) γ-spectrum in Fig. 1 is composed of the 65.1–66.8 and 75.7–77.8 keV platinum X-rays while in case of the Ge(Li) γ-ray spectrum, shown in Fig. 2, the 65.1–66.8 and 75.7–77.8 keV X-ray pairs result in two photopeaks. The small peaks occurring at 98.8 and 130 keV are due to ^{195m}Pt. From the data reported here the conclusion can be drawn that ^{192}Pt separated from spent ^{192}Ir sources is an ideal target material for reactor production of high specific activity ^{193m}Pt.

The abundances of the stable platinum isotopes separated from spent ^{192}Ir sources are listed in Table 3.

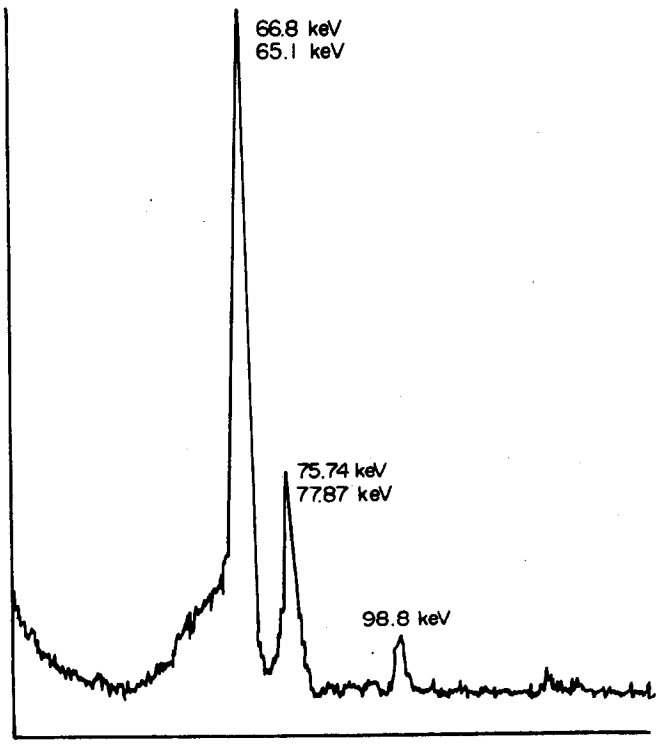


FIG. 2. Ge(Li) γ-ray spectrum of ^{193m}Pt.

The figures listed in Table 3 are from the mass spectrometric analysis of several platinum batches separated from ^{192}Ir sources produced in different reactors. The variation between the lower and upper limits is due to the difference of the neutron energy distribution of reactors used for irradiation of iridium.

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