RADIOACTIVE NANODIAMONDS

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Abstract – In the given work a possibility of obtaining radioactive nanodiamonds was shown. The possibility is stipulated by not production of radioactive isotopes of carbon but by obtaining of radionuclides from non-removable, basically, metal-containing impurities during irradiation in an industrial nuclear reactor.

Purpose of the present work is obtaining the radioactive nanodiamonds (R-ND) necessary for diagnostics of their allocation in a living organism (medicine), in polymer chemistry (additional polymer cross-linking, in different composites).

As carbon in diamond is practically impossible to transform into radioactive one having an acceptable half-life [1], then to give radioactivity to nanodiamonds (ND) we have tried to create radioactive zones in ND by transformation of non-removable metal-containing impurities into radionuclides.

Detonation nanodiamonds (DND) contain from ~0,05 to 2,5 wt.% metal-containing impurities, static synthesis ND (ND-ASM) contain also up to 2,5 wt. % [2].

Ampoules with DND-powder were irradiated in an industrial reactor of the 4th energetic block of AES, t.Sosnoviy bor, Russia in a special cooling channel.

Nanodiamonds were placed into glass ampoules and bombarded by neutrons in an industrial nuclear reactor with neutron fluence of 1-2 $\cdot 10^{19}$ cm^{-2}. Average power in the immediate surroundings of an irradiating channel was 2,35 MW.

The obtained R-ND have radioactivity with a dose rate of γ-radiation no more than 180,0 μSv/h and a dose rate of γ+β-radiation no more than 720,0 μSv/h.

TABLE 1 – A dose rate of radiation

19 days storage after radiation termination				
Diamond kind and its producer	Incombustible impurities, wt. %	A dose rate of γ-radiation, μSv/h (average)	% of γ-radiation of sum γ+β–radiation	A dose rate of γ+β–radiation, μSv/h (average)
DND, FGUP «SCTB Technolog» (Russia)	0,07	13,68	43	31,86
DND, JSC «ALIT» (Ukraine)	0,34	14,22	38	37,08
DND, produced by Prof. E.Osawa (Japan)	0,79	124,2	30	410,4
ND-ASM (0,1/0), company «SAKID» (Russia)	0,85	160,2	35	459,0
117 days storage after radiation termination				
DND, FGUP «SCTB Technolog» (Russia)	0,07	3,24	72	4,50
DND, JSC «ALIT» (Ukraine)	0,34	4,68	76,5	6,12
DND, produced by Prof. E.Osawa (Japan)	0,79	30,24	64,6	40,68
ND-ASM (0,1/0), company «SAKID» (Russia)	0,85	32,4	54	60,12
227 days storage after radiation termination				
DND, FGUP «SCTB Technolog» (Russia)	0,07	0,61	70,8	0,86
DND, JSC «ALIT» (Ukraine)	0,34	1,22	73,0	1,66
DND, produced by Prof. E.Osawa (Japan)	0,79	7,74	74,1	10,44
ND-ASM (0,1/0), company «SAKID» (Russia)	0,85	11,20	64,8	17,28

Spectroscopic study of ampoules with DND-powders (production of “Elektrokhimpribor”) on the 13^{th} day after two-day irradiation showed that there is Cr-51 (basic radionuclide), Hf-181 (detected with high confidence), and - Sb-122, Sb-124, Zr-95 (detected with 50% probability).

An source of formation of a Cr-51- radionuclide is a Cr-50-isotope (content of 4,35 % in elemental Chrome); for Hf-181-radionuclide – a stable Hf-180-isotope (content of 35,10 % in elemental Hafnium, being a chemical analogue of Titanium); as well the rest of chemical impurities - Iron, Titanium, Aluminium can form long-lived radionuclide such as Fe-59, Sc-46, Co-60.

Date for samples R-DND and R-ND-ASM are presented in Table 1.

Arising radioactivity of DND and ND-ASM after irradiation by neutrons can be related to radionuclides formed from Na, Ca, Ti, Fe, Al, W, V, Cu.

Radioactive ND can turn out an convenient instrument for studying their behaviour in different objects and composites.

REFERENCES

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