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STRUCTURAL PHASIC CHARACTERISTICS OF NANOPARTICLES OXIDES SAMARIUM-153 BY INFLUENCE GAMMA ACTIVATION

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The isotope ^{153}Sm ($T_{1/2}$ = 46.3 h, E = 810 keV) which emit is both therapeutic beta and diagnostic gamma energies and it is ideal for therapy plus diagnostic application. The specific activity of ^{153}Sm was increased by using the Szilard-Chalmers reaction and nanoparticles Sm_2O_3 after gamma activation on LAE. It is shown that the isotope ^{153}Sm after gamma activation there are no radioactive impurities and no changes of chemical and phasic structure.

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INTRODUCTION

Samarium-153 (^{153}Sm) has radiation characteristics such as the medium-energy beta particle emission (E_{max} = 810 keV) which is profitable for treatmen, the medium-energy gamma quantum (103 keV) which is suitable for imaging, and the short half-life (46.3 h). Isotopes which emit therapeutic beta and diagnostic gamma energies would be ideal for application – "theranostic". An ideal theranostic radionuclide should has optium physical half-life, necessary liner energy and range in tissues (1 cm), high ratio of non-penetrating to penetrating, short lived or stable daughter, good and selective concentration with prolonged retention in tumor, and minimum uptake by normal tissue [1].

Samarium-153 is potential suitable as an alternative to ^{90}Y, ^{32}P, ^{90}Sr in different cancer treatment. It has been widely used for palliative pain treatment bone metastatic patients but its therapeutic potential has not been fully utilised for others cases. The imaging properties of ^{153}Sm has been proved effective for gastrointestinal scintigraphy [2].

The main advantages of ^{153}Sm are the important features for transarterial radioembolization. ^{153}Sm is the major therapeutic agent wich is widely used in the world just for various bone pain palliative therapy [3].

One of the important features of radioembolic agent is the particle size. Nowadays the particular attention give to the particles size especially nanoparticles in range between 40…80 nm. The nanoparticles may pass in the tumour capillaries and reach the such parenchymatous organs such as lungs, kidneys, liver [4].

Nanoparticles with resistivity to physical heat and body chemicals, biocompatible, non-biodegradable and easily labelled with radionuclides are highly preference.

Decay properties such as half-life and particles energy play significant roles in clinical characteristics, for example, duration of palliative effects and degree of and time to recovery from myelosuppression.

The particles emissions from ^{32}P and ^{89}Sr in bone and soft tissue are much greater than those of ^{153}Sm. High energy particles are associated with greater marrow toxicity as result of the larger volumes of marrow exposed to radiation. The shoter physical half-life of ^{153}Sm (1.9 days) results in more rapid delivery of radiation than either ^{32}P (14.3 days) or ^{89}Sr (50.5 days). For example, delivery of 90% of the total dose of radiation requires approximately 3.5 half-lives of decay, a time interval of approximately 1 week for ^{153}Sm.

The purpose of our study was to evaluate for each sample ^{153}Sm the presence of radionuclide impurities, especially the long-lived radionuclides and comparison of IR spectra nanoparticles initial Sm_2O_3 and ^{153}Sm on the water content before and after gamma activation.

1. MATERIALS AND METHODS

Gamma-activation method used for production ^{153}Sm with high specific activity that can be increased in many cases by using the Szilard-Chalmers process [5–7].

In that experiment the nanoparticles (50…80 nm) Sm_2O_3 and clinoptilolite (80 nm) used. On LAE with E = 23 MeV and curent 700 μA it is possible to produce 1 Ci ^{153}Sm during day by using of Sm_2O_3 (40 g) of natural isotope composition.

The activity of ^{153}Sm obtained in nuclear reaction ^{154}Sm(γ,n)^{153}Sm measured by Ge(Li)-detector with volume 50 cm^3 and with energy resolution 3.2 keV in the area of 1332 . To reduce the influence of backgrond, the detector is equipped with a three-layer Pb-Cu-Al protection.

Nanoparticles Sm_2O_3 and clinoptilolite used as donor and acceptor, respectively. For the concentration of recoil nucleir in among donor, nanoparticles sizes Sm_2O_3, containing an activatable element, must be less than or equal to the range of racoil nuclei.

The structure and phase composition of nanoparticles Sm_2O_3 and ^{153}Sm investigated by infrared (IR) spectrophotometer "Specord-75" in the frequency 600…4000 cm^{-1} on the compressed tablets from mixture KBr (100 mg sample) [8].

2. RESULTS AND DISCUSSION

Gamma ray spectrum of ^{153}Sm is shown in Fig. 1.

The most dominant peaks observed were at 103 and 69.5 keV and two other significant peaks were 41 and 45 keV. These peaks resulted from K-shell characteristic X-ray following radioactive decay. There are not radionuclide impurity in the ^{153}Sm sample.

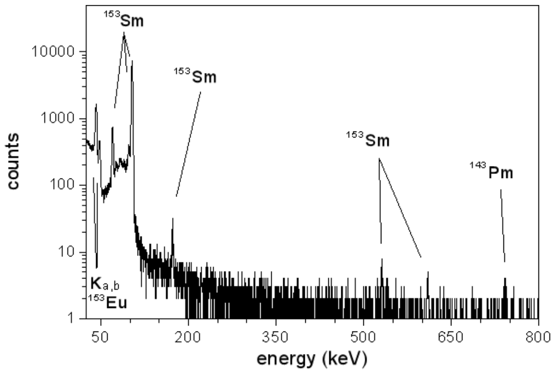

Fig. 1. Gamma ray spectrum of natural Sm after activation bremsstruhlung energy 11.5 MeV

Gamma ray spectrum of native non activate clinoptilolite as acceptor for ^{153}Sm is shown in Fig. 2.

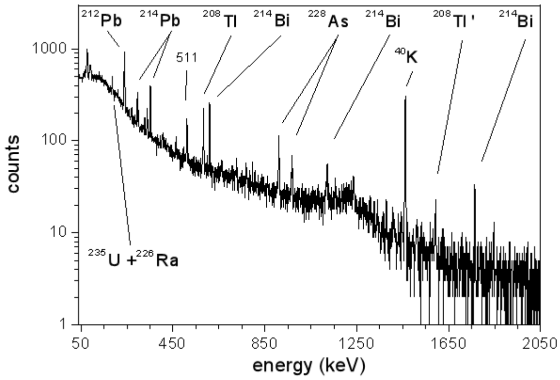

Fig. 2. Gamma ray spectrum of natural clinoptilolite

The measurement of gamma spectra of natural clinoptilolite gamma spectrum was shown the folllowing gamma lines of ^{228}Ac and ^{40}K for ^{214}Pb, ^{214}Bi, ^{212}Pb, ^{208}Tl. The content of Th, U was conformed with distribution theirs in earth`scrust (Th ~ 1.0 $10^{-5}$, U ~ 3.6 $10^{-6}$ g/g). The ratio Th/U was 3.87 for natural clinoptilolite sample and for earth`scrust of average value – 2.78.

IR spectrum of the nanoparticle sample Sm_2O_3 was compared to IR spectrum of the same sample after activation by bremsstruhlung energy 11.5 MeV. As shown in Figs. 3 and 4. IR spectra of samples before and after activation are nearly identical. Gamma activation did not destroy the chemical structure and the functional groups. The intensity bands 3200 and 3400 cm^{-1} also indicated that the water content during gamma activation of samples was not changed.

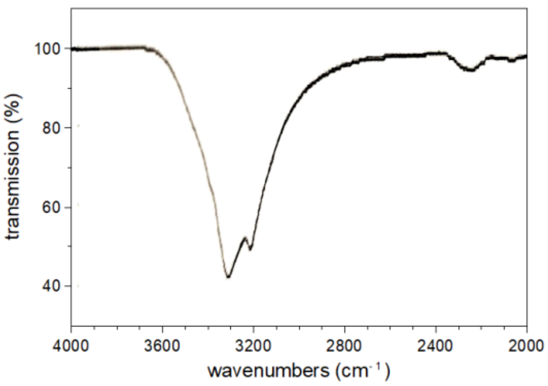

Fig. 3. IR spectra of nanoparticles Sm_2O_3 before activation bremsstruhlung energy 11.5 MeV

The presence in the IR spectrum of absorption bands of medium intensity in the frequency range of 2000 and 2800 cm^{-1} small peaks which is associated with an impurity OH^{-1} groups.

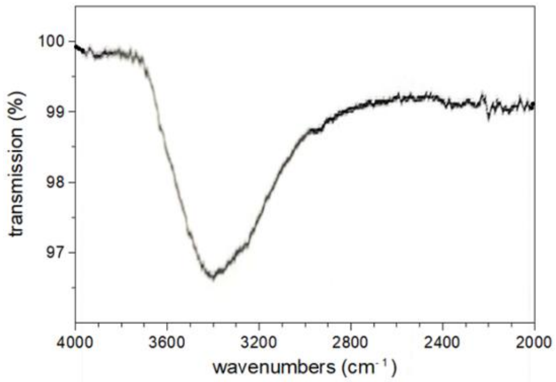

Fig. 4. IR spectra of nanoparticles Sm_2O_3 after activation bremsstruhlung energy 11.5 MeV

CONCLUSIONS

Photo-nuclear technology for produce isotopes ^{153}Sm with high specific activity by using the Szilard-Chalmers process and nanoparticles Sm_2O_3 was elaborated. Elemental analysis and method of infrared spectrocopy showed no radioactive impurities and no major differences observed between chemical structure, functional groups and water content after gamma activation of nanoparticles Sm_2O_3.

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ВПЛИВ ГАММА-АКТИВАЦІЇ НА СТРУКТУРНО-ФАЗОВІ ХАРАКТЕРИСТИКИ НАНОЧАСТИНОК ^{153}Sm

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Ізотоп ^{153}Sm ($T_{1/2}$ = 46.3 год, E = 810 кеВ) являється ідеальним емітером для проведення бета-терапії та гамма-діагностики. Питома активність ^{153}Sm була підвищена завдяки використанню реакції Сціларда-Чалмерса та наночастинок Sm_2O_3 після гамма-активації на лінійному прискорювачі електронів. Показано, що ізотоп ^{153}Sm після гамма-активації не містить радіонуклідних домішок та не втрачає хімічну та фазову структури.