CO7-1 A Fundamental Experiment for the Measure Against the Activation of the Irradiation-room Concrete at BNCT facility (II)

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INTRODUCTION: At present time, the research and development into several types of accelerator-based neutron sources for boron neutron capture therapy (BNCT) are underway by several research groups in the world, with Cyclotron-based BNCT Epi-thermal Neutron Source (C-BENS) at the head of the list [1]. In near future, BNCT using the accelerator-based neutron sources may be carried out at several places in the world. Unlike the facilities for radiation therapy and charged-particle therapy, the neutron yield is larger at BNCT facility. Then, the activation of concrete, which is a main structure of the irradiation room, is larger. The use of low-activation concrete is prefer in the viewpoints of the decrease of exposure under the work in the irradiation room, the decommissioning of the irradiation room, etc.. This research is intended to perform the characteristic estimation for low-activation concrete and confirm its usability at BNCT facility. In 2015, Kyoto University Reactor (KUR) was not operated. Then, a characteristic estimation was performed for the measure against the activation due to a neutron shield for concrete using an Am-Be neutron source, as the same manner in 2014.

METHODS: A characteristic estimation was performed for two kinds of resins such as Resin A and Resin B, and also Resin A containing B_4C, which are under development. As nine resin sheets of 10-cm side, 10-cm long and 2-mm thickness were stacked on the concrete surface, the shielding performance against the Am-Be neutron source was estimated by foil activation method. Indium foil was used as an activation foil. The shielding characteristic for fast neutrons was estimated by the activity change for In-113(n,n')In-113m reaction, and the generating characteristic for the secondary thermal neutrons was estimated by the activity change for In-115(n,γ)In-116m reaction.

RESULTS: Figure 1 shows the radioactivity changes dependent on the neutron-shield thickness for the In-113(n,n')In-113m reaction. Figure 2 shows the radioactivity changes dependent on the thickness for the In-115(n,γ)In-116m reaction. In these figures, the radioactivity changes for Resin A, Resin B and Resin A with B_4C are drawn. From the comparison for the radioactivity changes for the In-113(n,n')In-113m reaction, it was found that the shielding effect for fast neutrons was a little larger for Resin B than for Resin A. Also, it was found that the shielding effect for fast neutrons was a little smaller for the resin with B_4C, as its hydrogen density was smaller. From the comparison for the radioactivity changes for the In-115(n,γ)In-116m reaction, it was found that the generation of the secondary thermal neutrons was a little larger for Resin B than for Resin A. Also, it was found that the generation of the secondary thermal neutrons was decreased to almost one fifth for the resin with B_4C.

CONCLUSION: When the KUR operation is restarted, the estimations for the important characteristics of low-activation concrete are planned, such as the shielding effect for neutrons and gamma rays, the generation of the secondary gamma rays, etc., using Heavy Water Neutron Irradiation Facility [2]. Also, the estimations for the characteristics are planned for short-life activation and long-life activation using Pneumatic Tubes.

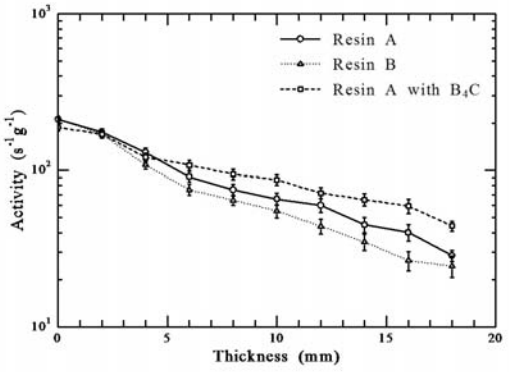

Fig. 1. Radioactivity changes dependent on the thickness for the In-113(n,n')In-113m reaction.

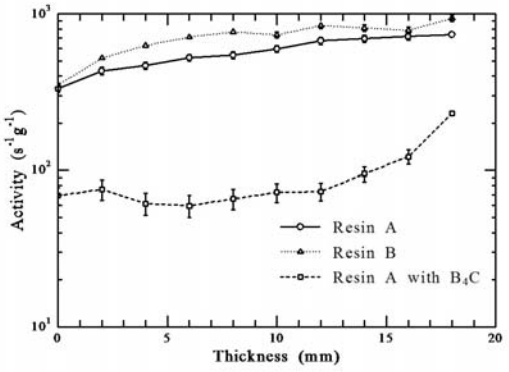

Fig. 2. Radioactivity changes dependent on the thickness for the In-115(n,γ)In-116m reaction.

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[1] H. Tanaka *et al.*, Nucl. Instr. Meth. B **267** (2009) 1970-1977.
[2] Y. Sakurai *et al.*, Nucl. Instr. Meth. A **453** (2000) 569-596.

CO7-2

Antitumor Effectivity by Gd-neutron Capture Therapy Using Gd-DTPA-incorporated Calcium Phosphate Nanoparticles

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INTRODUCTION: Gadolinium-157 has been getting attention as alternative for neutron capture therapy (NCT) agent because of its high thermal neutron cross section (255 000 barns), which the highest among all stable elements. Gadolinium neutron capture reaction (Gd-NCR) results in release of gamma rays, which reduce the localization effect of the treatment, which on the other side is increasing the possible additional effect if Gd-157 is accumulated to a bulk tumor cluster [1].

In this work, we performed histo-pathological examinations to evaluate the effects of Gd-NCT according to tumor growth suppression on multiple-injections Gd-DTPA/CaP nanoparticles in vivo.

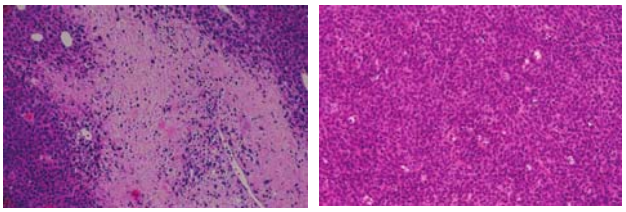
EXPERIMENTS: *In vivo* evaluation was performed on colon-26 tumor-bearing mice irradiated for 60 minutes at nuclear reactor facility of Kyoto University Research Reactor Institute with average neutron fluence of 1.8×10^{12} n/cm^2[2,3]. Antitumor effect was evaluated on the basis of the change in histopathological examinations using HE staining & TUNEL staining.

RESULTS: Tumor growth was suppressed until around four times of the non-treated group. Possibility of neutron depression for higher gadolinium concentration, there might be not sufficient amount of neutron reached deeper tumor site. Higher accumulation of gadolinium on tumor surface might reduce cancer cells killing effect at the tumor core[2,3].

Multiple-injection irradiated of bare Gd-DTPA group shows slightly better tumor growth suppression compared to control irradiated group. This proves low toxicity of Gd-DTPA/CaP nanoparticles, because all mice survived for both single and multiple injection groups.

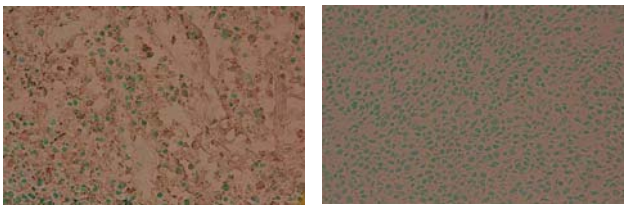
Tumor cells were destroyed after NCT and changed into granulation tissue. Number of cells killed after treatment were similar for single and multiple injection groups of Gd-DTPA/CaP nanoparticles. Non-treated group shows normal histology with clear cytoplasm and nucleus(Fig.1)[3].

Evaluation of possible apoptosis occurred on cancer cells by detecting the DNA fragmentation following GdNCT treatment. Negative control for both irradiated and non-irradiated groups was also prepared during the apoptotic assay. Number of cells undergoing stained by TUNEL, which correlates to the number of apoptosis, was higher on GdNCT treated group compared to the non-irradiated ones(Fig.2)[3].



Gd-DTPA/CaP multiple injections + Irradiation | **Gd-DTPA/CaP multiple injections**

Figure 1. Evaluation of Antitumor Effectivity (H&E Staining)



Gd-DTPA/CaP multiple injections + Irradiation | **Gd-DTPA/CaP multiple injections**

Figure 2. Evaluation of Antitumor Effectivity (TUNEL Staining)

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[1] Dewi N et al., Biomed & Pharmacother (2013) **67**:451-457.
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