Study of the biological effects in glioblastoma cell lines after exposure to high LET α particles appearing in BNCT therapy

M. Araszkiewicz[1,2], U. Kaźmierczak[3], A. Korgul[1], R. Kwiatkowski[2], A. Malinowska[2],
K. Maliszewska-Olejniczak[4], S. Męczyńska-Wielgosz[5], Z. Szefliński[3], and K. Tymińska[2]
[1] *Faculty of Physics, University of Warsaw, Warsaw, Poland*
[2] *National Centre for Nuclear Research, Otwock, Świerk, Poland*
[3] *Heavy Ion Laboratory at the University of Warsaw, Warsaw, Poland*
[4] *Department of Physics and Biophysics, Institute of Biology,*
Warsaw University of Life Sciences-SGGW, Warsaw, Poland and
[5] *Institute of Nuclear Chemistry and Technology, Warsaw, Poland*

The essence of Boron Neutron Capture Therapy is the reaction between ^{10}B and thermal neutrons. In such a capture reaction, high LET (Linear Energy Transfer) particles, ^{4}He and ^{7}Li, are released. However, the radiation field produced in BNCT consists of different LET components.

Charged particles like α particles passing through the matter lose energy in atomic and nuclear interaction. Maximum energy transfer and the highest dose deposition occur at the end of the range. The dense ionization along the particle track induces different types of DNA damage. Radiation represented by high LET like α particles forms more difficult to repair DNA lesions than low LET radiation (X-rays and electrons) [1]. Irradiation of cell lines with alpha particles is a good utility for research on high LET-induced DNA damages and DNA repair mechanisms.

At the Heavy Ion Laboratory at the University of Warsaw (HIL), a cell irradiation system was developed in the radiobiology laboratory. This device consists of a flat Am-241 source with activity of 1.96 MBq attached by a mylar film to the inside of a Petri dish lid [2]. Cells are seeded onto 30 mm diameter coverslips and placed in a sterile Petri dish. The cell dish is covered with the top of the α particle source dish during the irradiation.

The diameter of the active part of the source is 50 mm, and the height is 0.4 μm. The source surface is protected with a 1 μm gold layer. Am-241 emits alpha particles of energies 5388 keV, (1.7%), 5443 keV (13.1%), 5485 keV (84.8%), 5544 keV (0.4%) [3]. The source was covered with a 6 μm thick mylar foil for irradiation purposes. The experimental geometry consists of a 5.8 mm air gap between the source and the biological sample on the coverslip.

Accurate determination of the alpha particle energy loss due to the source and system geometry is crucial in radiobiological experiments. The irradiation time required to obtain the corresponding cellular α radiation doses was estimated from Monte Carlo simulations using the MCNP6.2 code [4]. Particle energy, irradiation geometry, and source activity were considered in the calculations. The simulation results were compared with experimental data.

Glioblastoma is the most common, most malignant, and difficult to treat among brain tumours [5]. Two human glioma cell lines which differed in their intrinsic sensitivity to ionizing radiation (radiosensitive M059J and radioresistant M059K) [6] were chosen for preliminary research with high LET BNCT radiation components. The next step will be a comparison of the results with data obtained after cell irradiation according to the BNCT procedure in the National Centre for Nuclear Research in Świerk where a research post for Boron Neutron Capture Therapy is already under construction.

[1] E. Sage *et al.*, Free Radic. Biol. Med. **107** (2017) 125-135.
[2] Z. Szefliński *et al.*, RAP Conference Proceedings **4** (2019) 7-9.
[3] https://www.nndc.bnl.gov/nudat3/DecayRadiationServlet?nuc=241Amunc=NDS
[4] C. J. Werner *et al.*, MCNP6.2 Release Notes, Los Alamos National Laboratory, report **LA-UR-18-20808** (2018).
[5] A. F. Tamimi *et al.*, Epidemiology and Outcome of Glioblastoma (2017) 143-153.
[6] M. J. Allalunis-Turner *et al.*, **134** (1993) 349-354.