Raman Spectroscopy of Tissue Samples After Irradiation by 24 MeV Protons ◇

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Tissue samples, normal skin of outbreed female nude mice and human pancreatic adenocarcinoma (line UB 290896) transplanted subcutaneously on the right flank of the nude mice, cut into four pieces each of about 1 mm thickness and sealed in thin wrappers of plastic foil, were irradiated by 24 MeV protons from the Munich Tandem Accelerator. The plateau region of the protons traversing the samples delivered doses of 0 (reference sample), 1, 7, and 50 Gray.

The samples were analysed using the resonance Raman spectroscopy at the Institute of Chemical Technology in Prague. Resonance Raman spectra of the samples were recorded by a Dilor–Jobin Yvon–Spex resonance Raman spectrometer equipped with an Olympus BX 40 system microscope with a 100 objective. This objective is capable to provide a laser spot diameter of approximately 10 – 12 μm. An argon ion laser system with an excitation line at 487 nm and an excitation power of 2.5 mW at the sample was used in the measurements of the tissues. Exposure time was 10 – 600 s. Resonance Raman spectra were taken at 25 – 30 ^{o}C in 10 randomly chosen parts (20 accumulations per part, i.e. 200 accumulations in one site). Spectral images were recorded point by point. Spectra of all samples were normalized to the (CH_2, CH_3) peak at 1437 cm^{-1} (normal skin) or 1444 cm^{-1} (tumor tissue).

The obtained Raman spectra are presented in Fig. 1 for the normal skin and in Fig. 2 for the tumor tissue, and a change in their intensity with increasing applied dose is visible.

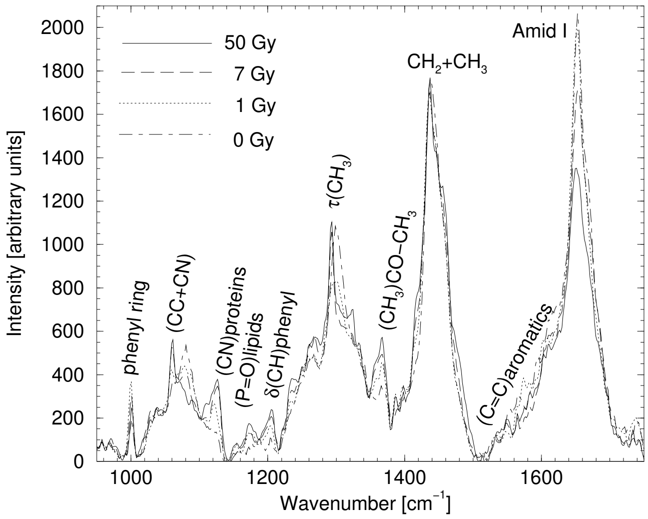

Fig. 1: Intensity of the Raman spectra of normal skin as a function of the wavenumber for different applied doses (important lines assigned).

As it can be seen from Figs. 1–2, a significant decrease with increasing dose occurs for the amid I line at 1653 cm^{-1} for the normal skin and for the same line at 1667 cm^{-1} for the tumor tissue. In the tumor tissue, the amid I line at 1667 cm^{-1} for zero dose moves with increasing dose towards 1653 cm^{-1} which corresponds to the normal skin. Similarly, aromatics dominantly present in the non–irradiated tumor tissue (see region 1540 – 1620 cm^{-1}) are destroyed during the irradiation and the Raman spectrum for the highest dose approaches that of the normal skin with less pronounced lines of aromatics (for the line assignment see e.g. [1,2,3,4]

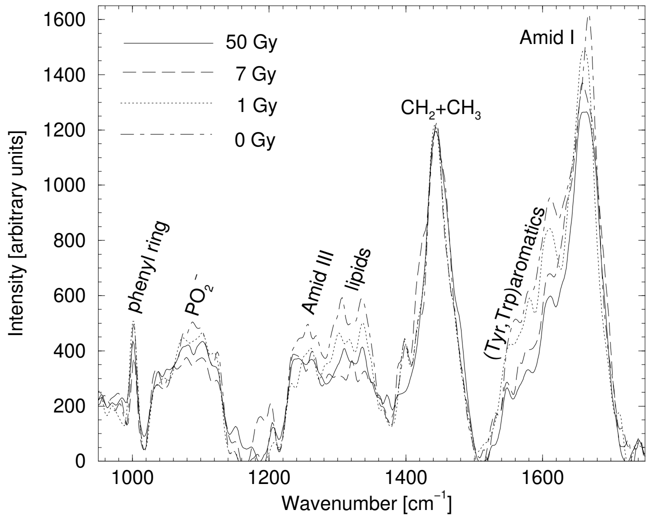

Fig. 2: Intensity of the Raman spectra of the tumor tissue as a function of the wavenumber for different applied doses (important lines assigned.

We have shown that the Resonance Raman spectroscopy can be used for the analysis of tissue samples irradiated by protons. In the future we plan to investigate both tissue samples (normal and tumor) and single organic compounds irradiated by protons as well as by gamma radiation and to compare effects induced by protons and gamma radiation.

References

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