PROTON-GAMMA INDUCED PEAK IN METALS AND ORGANIC COMPUNDS FOR DOSIMETRY IN RADIOTEHRAPY

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Background & Rationale: Proton beams are used to deliver a confined dose to tumours in radiotherapy. Proton dose is mainly generated via ionisation of target atoms and to a lesser extend through its nuclear interactions with the target atomic-nuclei and hence causing activation of the targets. These activated nuclei emit induced gamma radiations, which have been utilised lately for target imaging via PET scanning. However, prompt gammas are used which limits its values due to host of technical challenges. This investigation was focused on introducing a simple yet reliable method for extraction of the proton induced gamma rays and utilise it for estimation of the energy deposited by such beams. Among the materials studied included water molecules, metallic nanoparticles and alanine "as amino acid molecules" pallets.

Materials & Methods: The induced gamma from the oxygen in the water or alanine molecules was measured by a scintillator with a multichannel analyser "MCA". The proton beam of the Hyogo centre in Japan was used. Small volumes of water (around 20 mL) were exposed to set dose 'in the Bragg peak'values and then measure immediately the gamma rays emitted via positron emission from the proton oxygen nuclear reaction. The area under this peak is related to the proton flux and so does the dose. Hence the two parameters (gamma peak and the dose) can be correlated and that is what this work has proven empirically. This procedure was repeated using solid gold and gold nanoparticles. Also this technique was extended on alanine pallets which are compounds made mainly of carbon, oxygen, and hydrogen. These are known dosimeters but in this work they have used in different way extending their sensitivity to radiations.

Results & Discussion: A typical oxygen peak obtained from 2 Gy of 170 MeV proton beam and the energy-spectrum are depicted in Fig.1. The gamma peak is at 511 keV as anticipated from the activation of the oxygen by protons of energy above the threshold. This was repeated at various doses and the peak area is then determined and plotted against the dose. Linear correlation between the area under the peak of oxygen 511 keV peak with the proton dose is obtained. This correlation shows potential for ample applications in the dosimetry of proton radiotherapy. Gamma peak of pure solid gold "prostate markers" is also obtained which indicates potential application for target delineation and treatment validation. Moreover, also gold peaks from the gold atoms inside gold-nanoparticles were also extracted and plotted against dose. Similar gamma peak is obtained from activation of alanine pellets of the type used in dosimetry. And a linear relationship between the peak area and the nominal dose is also observed. This could make these dosimeters which are only viable at very high doses to be suitable for measuring doses at all levels.

Conclusion: In conclusion, this gamma activation induced by proton radiotherapy beams can be utilised to validate proton ranges, dosimetry and treatment delivery through QA procedures employing simple set up of scintillator with an MCA.

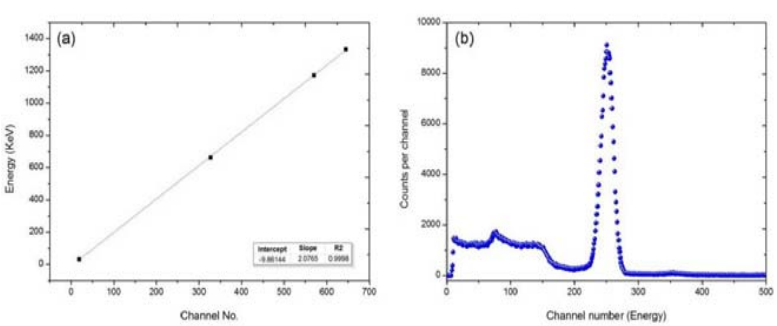

Figure 1: a. Energy calibration curve for the scintillation-MCA system and b. is a typical 511 keV oxygen gamma photo-peak.