Electron emission in ionization of bromouracil by fast bare carbon ions

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Synopsis Double differential cross sections (DDCS) of the secondary electrons emitted from a vapor jet of bromouracil in collision with 42 MeV bare carbon ions have been measured for different forward and backward emission angles over a wide energy range. The DDCS for bromouracil were compared with that of uracil measure earlier. An unusually large increase in electron emission cross section have been observed for bromouracil.

Hadron therapy using mainly protons and carbon ions have gained immense importance in cancer treatment in last several years. The advantage of ions compared to photons lies in their selective dose depth penetration, which results in negligible damage to the healthy cells surrounding the tumors. The low energy secondary electrons produced along the ion track causes strand breaks of the DNA/RNA [1]. The efficiency of damage thus depends on the amount of secondary electrons produced during irradiation by ions.

Radiosensitizers are agents well known for increasing the killing efficiency of malignant cells in presence of ion beams. Inserting a high-Z element (Au, Pt, Gd) into the DNA and further exposure to ion beams, results in the production of cascade of low energy electrons which cause strand breaks of DNA/RNA. Several breaks when strongly localized results in cell death, preventing the malignant cells from multiplying further in the body. Earlier studies have shown that with the insertion of nanoparticle, the amount of single and double strand breaks increases in DNA [2]. Halouracils are also known to exhibit radiosensitizing effects. These molecules are commercially available, where, the hydrogen at the 5^{th} place of carbon in uracil, is replaced by a halogen. Different experiments and theoretical studies are being performed for halouracils, most of which deal with the different fragmentation channels of such molecules.

We present a quantitative measurement of the amount of enhancement in low energy electron production from bromouracil by comparing it with the existing data of uracil [3]. The DDCS of electrons emitted from bromouracil in collision with 42 MeV bare carbon ions have been measured using a hemispherical electrostatic analyzer followed by a channel electron multiplier for different angles ranging between 20^0 and 160^0. The vapor jet of bromouracil was obtained by heating the powder in an oven for approximately 24 hrs. The heating was done slowly to avoid any clogging in the jet nozzle. A quartz crystal based thickness monitor was used to monitor the rate of deposition of the vapor to ensure a uniform flow. Extreme care was taken for the measurement of low energy electrons, which could otherwise get affected by the field created due to the static charge build up by the deposition of the vapor inside the chamber. A comparison of the DDCS at each individual angle between uracil and bromouracil showed an increase in electron production from bromouracil for all angles. This large enhancement in the electron production cannot be attributed only by scaling with the total number of electrons in bromouracil compared to that in uracil. The production of low energy electrons from bromouracil may be explained by the mechanism of plasmon excitation or Auger cascade, though a clear understanding is not available.

The present measurement for bromouracil is the first of it's kind and provides an important information about the enhancement in low energy electron production, explaining the radiosensitizing properties of halouracils.

References

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