Electron interactions with DNA Bases at intermediate impact energies.

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Introduction

The genotoxic effects of ionising radiation (alpha, beta, gamma rays and ions) in living cells are well known. In exploring the effect of radiation on genetic material in general and in the structure of DNA in particular several key questions remain unanswered;

What levels of exposure to radiation is 'safe'?

Are long term exposures to low levels of radiation as harmful as short term exposures to higher levels?

How can we destroy DNA in cancer cells without damaging DNA in the healthy cells ?

In order to address any of these questions it is necessary to understand the mechanisms of DNA damage and answer the key question; what are the mechanisms of DNA damage and how does this lead to mutation in the cell?

Project Report - Current Status

In simple terms the project consists of an interaction region where a beam of electrons of varying kinetic energy interacting with a heated beam of bio-molecules produced in an oven resulting in the ionization of the bio-molecule. The resulting positive ions produced are then deflected with an electric potential to be collected on a collection plate, while the electrons are collected in a faraday cup.

Work Performed.

During the visit with the direction of Prof Gustavo Garcia we initially concentrated on improving the current experimental system. The current electron gun system / interaction region was modelled with SimIon and tests were performed using water and air as a medium.

Unavoidable experimental problems and breakages have slowed the work considerably. We have benefited though from a long initial testing period of the electron optics trying to model the behaviour of the electrons and optimising potentials. The installation of new power supplies and an alterative electron gun have helped slightly. We have taken preliminary measurements on the cross section of water to compliment previous measurements taken by Prof. Garcia. The experimental system is capable of producing a stable beam of electron with energies from ~300 to 3000 eV. The high energy cross sections in particular have not been measured before and provide a good comparison with theoretical work. Our preliminary work has highlighted a number of issues namely the experimental difficulties associated with obtaining these cross sectional measurements. We have refitted pressure gauges to try to obtain an accurate pressure in the interaction region but this may not prove possible. We also identified the dosing system as a source of weakness as obtaining a constant flow of water / molecules into the interaction region can be difficult. Water can be introduced into the system purely from its vapour pressure. Biomolecules are generally in power form requiring heating to vaporise them. Both water and biomolecules condense in the system preventing a constant flow in the interaction region and making cross section measurements difficult. The addition of heating tape could help reduce this problem.

Work has also been performed on the computer control of the system and the readings from the ion extraction plates have been successfully integrated from the electrometer to the computer. In preparation for the introduction of biomolecules into the interaction region and time of flight measurements we have also investigated methods of pulsing the beam. The beam can be pulsed by either a simple mechanical 555 timer system or Labview DAQ card method. We have elected to use a 555 timer method and work for this is currently underway.

In summary we have thoroughly tested and modified the system based on the data obtained from measuring water cross sections. We have used this information to highlight the experimental problems in the system in preparation for the bio molecule irradiation. Work on pulsing the beam is underway and the electronics have been successfully integrated into the computer.