Electron Transfer in Alkali-Biomolecule Reactions

EIPAM Grant Final Report:

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Introduction

Many of the advances in modern medicine and the related field of radiation biology involve the understanding and characterization of the interaction between ionising radiation and tissue. DNA damage is still not well understood on a molecular level. One of the goals of this research program is to investigate these processes by observing the effects of electron transfer processes with the constituent molecules of DNA using potassium molecule collisions.

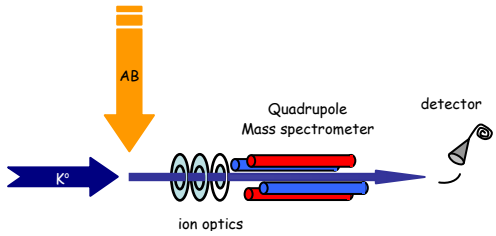

Fig 1. Schematic of the apparatus

Fig 2. Photo of the apparatus

Project Report – Current Status

The ultimate goal of the research grant proposal is the study of Electron induced damage in DNA and its constituents by the use of simple Electron Transfer in Alkali-Biomolecule reactions. Our chosen experimental system consists of a vacuum chamber capable of a base pressure of 10^{-6} mbar. (Fig 2) A schematic of the experiment is shown in Fig 1. The chamber is constructed in two sections connected by a gate valve. The first section consists of a potassium ion source. Potassium is an alkali atom having a low ionization potential making it an excellent electron donor. Potassium ions are generated in situ. Atomic K^+ ions obtained by surface ionization are accelerated through the primary chamber containing potassium vapour where charge transfer occurs. The energy of the resultant potassium neutral beam is

controlled by the initial acceleration of the ions, as this is a resonant charge exchange process. After the charge exchange those ions that have not been neutralised are removed by electrostatic fields, the resulting potassium molecular beam is now comprised of two components, a 'hyperthermal' beam and an 'effusive thermal energy' beam. The potassium beam is then directed into the second chamber where we monitor the reaction with the bio molecule using quadrupole mass spectrometer.

Work Performed.

The purpose of the visit to Portugal was to begin preliminary work on the chamber and potassium source, in particular the quadrupole mass spectrometer and arrange for the computer control of the mass spectrometer and associated components. The mass spectrometer used is a HAL model 301/S (purchased 1989) Residual Gas Analyser manufactured by Hiden Analytical (England). This particular model is controlled by an interface panel on the main controller rather than directly by software as with the later versions of this quadrupole. In order to control the mass spectrometer we have created a custom Labview package. This allows data to be transferred from the spectrometer and saved in the form of an ASCII text file. The Labview program also allows for the simple display and manipulation of the data. In the future it is planned for a wider integration of the Labview system, allowing for the automatic control of potentials and turbo molecular pumps. Following the integration of the mass spectrometer with Labview we have been able to perform a simple RGA (Residual Gas analysis) of the chamber. However by its nature the quadrupole works on the detection of positive ions. Our proposed experiments rely on the detection of negative ion fragments. In order to do this we are in the process of modifying the quadrupole to allow this. The quadrupole must scan without the ionising filament on and the lens potentials need to be adjusted accordingly. We are currently in contact with Hiden Analytical to discuss this modification. A portion of my visit has also been connected with the instruction of the students in the laboratory on the use of a quadrupole and the new computer control system. I have also been investigating the possibility of suitable data acquisition equipment for future time of flight experiments.

In summary during the time of my visit to the host institution we have successfully constructed and aligned the two chambers necessary for the ion source. The

quadrupole has been proven to work and a computer interface and data collection package has been designed and tested.

Future collaboration with the host institution in Portugal would be advantageous in order to

1) Complete the modifications on the quadrupole and to run the first preliminary tests to detect negative ions
2) Begin the first experiments on the new system. We expect that now that the initial time consuming steps of setting up the quadrupole and bio-molecules oven and aligning the equipment is nearly completed that results should be swiftly and easily obtained, now that we are confident we have a working detection system.