Report on the outcomes of a Short-Term Scientific Mission[1]

Action number: CA20129

Grantee name: Marta Berholts

Details of the STSM

Title: Photodissociation dynamics of iodine-enhanced DNA chains following hard x-ray irradiation

Start and end date: 09/12/2022 to 19/12/2022

Description of the work carried out during the STSM

The STSM mission went according to the initial working plan and no significant deviations took place. The preparation time before the beamtime was efficiently used to install the setup to the beamline, align it to the photon beam, prepare the stock solutions of the samples, and optimize experimental parameters of the electrospray ionization source and the ion guides for each sample. The experimental team managed to run the experiments smoothly working 24h per day in three shifts during the duration of the beamtime. We measured the mass spectra of 9 single-stranded DNA oligomers doped with iodine at three photon energies of 4500, 4630, and 4900 eV to accumulate the data below, at, and above the I 2p threshold. For all the samples to guarantee the comparability of the results, the same ion trap parameters were applied. Firstly, we measured the following sequences: UC, UCA, UCAG, and UCAGT, where U is uracil, C is cytosine, A is adenine, G is guanine, and T is thymine. The nucleobases were connected to the phosphate-deoxyribose backbone. The aim here is to understand the extent of the fragmentation spread from the primary ionization site located at the iodine atom that is always connected to the uracil base upon the increasing length of the oligomer. Unfortunately, we could not achieve measurable conditions with the non-iodinated uracil molecule due to its high instability. Then, we measured CAU, CUA, and AUC that with the UCA from the first dataset form an excellent set to explore the effect of the iodinated uracil position on the fragmentation of the oligomer. After that, we measured CAUGT and CUAGT to again probe the effect of the ionization site position on the fragmentation but in this case in a longer, more complicated sequence. Lastly, at the very end of the beamtime, we had enough time left to measure the effect of water addition on the fragmentation of the potential radiosensitizer molecule, 2-bromo-5-iodo-4-nitroimidazole (backup sample brought by the applicant), as a separate project which was not mentioned in the initial working plan. We were able to generate water-molecule dimers in an electrospray ionization source using an appropriate concentration of the solution and solvent ratios. We recorded mass spectra of the molecule+water vs just molecule guiding one or another to the ion trap. The samples were irradiated below and above the I 2p threshold at 4.5 keV and 4.9 keV, respectively.

[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the GH for payment of the Grant.

When beamtime was finished, we disconnected the experimental setup from the beamline and packed it for transportation back to the home laboratory.

Description of the STSM main achievements and planned follow-up activities

The goal of this STSM was to perform a mass spectrometric experiment on the iodine-enhanced DNA oligomers at the PETRA III synchrotron facility (Hamburg, Germany) using the P01 beamline equipped with the ion trap setup of the Sadia Bari research group. The beamtime was granted 13-19.12.2022. The rich experimental program planned for that beamtime involved measurements of various DNA oligomers at different photon energies. This mission was successfully accomplished and even further extended to the measurements of the backup sample. As a result, instead of one, we obtained two projects as outcomes from this STSM. The first project relates to the investigation of the fragmentation dynamics of iodinated DNA oligomers. Here, we will analyze the measured data to understand how the position of the initial ionization site (iodine) affects the fragmentation of DNA oligomers of various lengths and configurations upon absorption of hard x-rays. In the second project, we will study the influence of nanosolvation of a nitroimidazole-based radiosensitizer by one water molecule on the fragmentation dynamics through a direct comparison with its non-hydrated reference. We will shortly start working on the analysis of the experimental data and the theoretical support for both projects as a follow-up collaboration with our international group of researchers from Sweden (Carl Calleman, Olle Björneholm, etc.), Hamburg (Sadia Bari, Lucas Schwob, etc.), and Estonia (the applicant). We plan to summarize the results of the described experiments in two scientific papers that will be published preferably in open-access journals for more visibility and hence better dissemination of the results.