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

Action number: CA20129

Grantee name: Sara Alexandra Carvalho Lopes de Freitas

Details of the STSM

Title: Synergistic effect between photothermal and radiotherapy using plasmonic nanoparticles as photo-absorbing agents and radiosensitizers toward higher-efficiency colorectal cancer treatments

Start and end date: 29/02/2024 to 29/03/2024

Description of the work carried out during the STSM

Description of the activities carried out during the STSM. Any deviations from the initial working plan shall also be described in this section.

(max. 500 words)

During my monthly stay at Universidad Autónoma in Madrid, I engaged in an extensive research project focusing on the effect of photothermal and proton therapy on a colorectal cancer cell line (HCT116), taking advantage of the possible treatment enhancement coming from the presence of gold nanorods (AuNRs) in the system. The research encompassed several key areas:

1) Characterization of Gold Nanorods: The AuNRs utilized in our study were thoroughly characterized using UV-visible spectroscopy (UV-vis) and scanning electron microscopy (SEM).

2) Study of the behavior of AuNRs dispersed in water, under continuous wave laser irradiation (operating at 800 nm), considering the influence of different experimental parameters including laser output power and nanoparticle concentration. Three concentrations were evaluated (25, 75 and 200 ug/mL) with an increasing applied laser output power. The lower concentration showed the most promising results in terms of nanoparticle heating efficiency. The latter was evaluated and compared using the figure of merit SAR (Specific Absorption Rate) through the Box-Lucas method, as suggested in the literature.

3) Cell manipulation and culture techniques: A comprehensive and hands-on training program was undertaken to acquire the necessary skills and knowledge for cell manipulation and cell culture in the laboratory. This included techniques for aseptic handling, cell culture maintenance, media preparation, and cell passaging, among others.

[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.

4) Study of the influence of gold AuNRs in a Colorectal Cancer Cell Line (Phototherapy): Building upon the previous experiments, we explored the behavior of gold nanowires under 800 nm laser irradiation in direct contact with colorectal cancer cells on an adequate plate. The chosen concentration was 25 ug/mL. The laser fluence was in the 0.4 – 1 W/cm^2 range.

5) Proton Therapy Investigation: Another aspect of our research involved studying the effects of proton therapy on cancer cells. Here different doses were applied (1-15 Gy) on the same cancer cell line.

6) Cell viability assessment: Following photothermal and proton irradiation, the cell viability was assessed through clonogenic and Alarmar Blue viability studies.

Overall, my time at Universidad Autónoma in Madrid was dedicated to advancing our understanding of the interactions between gold nanorods and biological systems, as well as exploring innovative approaches to cancer therapy using proton irradiation. Despite being a highly productive month in terms of experimental work, it is necessary to note that due to unforeseen circumstances, the planned aspect of the research involving ionizing radiation with X-rays could not be carried out. While this unforeseen limitation posed a challenge to the full execution of the research plan, the insights gained from the conducted experiments still provided valuable contributions to the overall understanding of the targeted research areas.

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

Description and assessment of whether the STSM achieved its planned goals and expected outcomes, including specific contribution to Action objective and deliverables, or publications resulting from the STSM. Agreed plans for future follow-up collaborations shall also be described in this section.

(max. 500 words)

As mentioned in the Application Form, I believe that the proposed experiments align with the objectives outlined by the Action Cost, particularly within the domains of radiosensitising properties of metal-based nanoparticles exposed to radiation and the development of novel treatment protocols, predicted in the main objectives of MultIChem COST Action. In this context, the convergence of nanotechnology, cellular biology, and radiation sciences employed in this research mission exemplifies a synergistic approach that can contribute to several WG in the MultIChem COST Action; Particularly to the WG3 regarding the inclusion of the radiation-driven nanoscale effects into the existing treatment plans based on macroscale dose delivery to facilitate technological advances (Tasks 1 and 3).

Considering specifically the experimental results, they seem to indicate that both in phototherapy and proton therapy, the effects are more observable after 48 or 72 hours, suggesting a potential time-dependent response in cellular behavior to the treatments. The effects were more pronounced at higher laser power levels (in the case of photothermal therapy) and concentrations. These findings underscore the importance of long-term observation periods in assessing the efficacy and impact of these therapeutic modalities on cellular systems. Although these results provide promising insights into the influence of gold nanorods on treatments, additional studies are crucial. Not only should the number of experiments under the same conditions be increased to enhance statistical significance and reduce error bars, and therefore enable more concise conclusions, but the study should also be complemented with other forms of treatment (such as radiotherapy with X-ray treatments). For future work, it would also be essential to functionalize the NPs to promote their internalization and conduct comparative studies with the current ones. Additionally, further studies are needed to identify the type of cell death present in the cells. In conclusion, it is important to emphasize that these were the initial steps of a highly complex study with many stages that should be continued and is worth to be investigated.