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

Action number: CA20129

Grantee name: Jaspar Burg

Details of the STSM

Title: STSM dual function metal nanoparticles

Start and end date: 01/06/2025 to 22/06/2025

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)

The synthesis of all 8 noble metals via one universal cold-atmospheric pressure (CAP) method was successfully carried out. The effect that both treatment time and metal precursor concentrations have on the final nanoparticles produced were investigated extensively and systematically. Multi angle dynamic light scattering (MADLS), particle concentration measurements, optical imaging, scanning electron microscopy (SEM), transmission electron microscopy (TEM), UV-Vis spectroscopy and X-ray photoelectron spectroscopy (XPS) were all carried out on all samples in order to allow for a quantitative analysis of their properties. Furthermore, plasma specific characteristics, namely power, voltage and current waveforms as well optical emission spectra (OES) were recorded to allow for the characterisation of the plasma conditions themselves. The plasma induced changes of the liquid chemistry were also investigated via the quantification of select key chemical species (namely •OH, H_2O_2, NO_2^- & NO_3^-) as well as the oxidation-reduction potential (ORP) of plasma treated water after various time points.

As for the investigation of the theranostic capabilities of these nanoparticles the results were less extensive due to experimental challenges and resulting time constraints. A working method for the separation of specific nanoparticle shapes from solution relying on a combination of density gradient centrifugation (DGC) and dialysis was developed. This allowed to tailor the absorbance of the produced nanoparticles and their concentration in solution in order to optimize both their sensing and antimicrobial potential. A photothermal treatment method based on the irradiation of bacterial and fungal samples preimpregnated with these nanoparticles was put in place. Finding a suitable substrate compatible with

[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.

the employed laser as well as following biological assays and surface-enhanced Raman spectroscopy proved significantly more challenging than expected fundamentally halting further progress on this part of the project until new substrates and or methods have been identified.

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)

The systematic investigation of both the plasma characteristic, resulting liquid chemistry as well as very thorough characterisation of the nanomaterials themselves will allow for a comprehensive insight into the irradiation-driven chemical transformations at play furthering the aims of WG3. These very promising results on a CAP based method for the synthesis of noble metal nanoparticles should be sufficient for a publication on its own.

Furthermore, a great foundation for further collaboration on the actual sensing and antimicrobial application of these nanoparticles was laid. Once a suitable solution to the above described challenges has been identified, the part of the project focused on the theranostic application can be continued possibly resulting in another separate publication.

The resultant dissemination of the obtained knowledge through the publishing of the data aligns directly with the activity of WG4. Moreover, these results are to be presented at a conference that is still to be determined once they have been published. The benefit of this STSM to my early career was even more substantial than predicted due to both the vast nature of gained knowledge and formed connections within the plasma research community (WG4).

A lot of work remains to be done on both parts of this project. Most of the data that has already been obtained on the noble metal nanoparticle synthesis still needs to be analysed appropriately over the coming weeks. Following this the actual manuscript needs to be drafted, reviewed and published.

For the investigation of the theranostic applicability of these nanoparticles, the most appropriate plasma conditions for each metal need to be selected once the data analysis has been completed. Then hese nanoparticles need to be synthesised once again and added to biological samples grown on appropriate substrates. The photothermally induced cell death of these samples needs be systematically explored in a similar fashion as for the already completed research.