Research Trip Summary Report

Task 2. Foreign mobility of WUST doctoral students

I. Data of the doctoral student

1.Full name: **Patryk Fałat**

2.Year of studies: **4**

3. Educational discipline: **Chemical Sciences**

II. Foreign research trip (research visit)

1. Research institute in which the foreign research was implemented: Utrecht University, the Netherlands

2. Name and surname of the host person (mentor): Prof. Andries Meijerink

3. Dates of the research trip: 10.09-10.12.2023

4. Title and date of a seminar delivered during the research trip: *Vis-to-UV up-conversion for biological applications*, Condensed Matter and Interfaces Group seminar, 15.11.2023.

5. Description of work carried out during the research trip:

- Pr^{3+}-based $NaYF_4$ and $LiYF_4$ nanoparticles (NPs) and microcrystals (MCs) synthesis;
- Morphology and crystal structure characterization of the obtained materials;
- Non-polar-to-polar-phase transfer *via* ligand-exchange strategy;
- NPs and MCs functionalization with organic dye molecules (Coumarin 343) in a wide dye concentration range;
- Measurements of spectroscopic features, including Vis-to-UV up-conversion spectra and fluorescence lifetimes decay curves, of the both non-functionalized and dye-decorated Pr^{3+}-based $NaYF_4$ and $LiYF_4$ NPs and MCs;
- Analysis of the data gathered during the research stay.

6. Description of the main results obtained:

Pr^{3+}-based $NaYF_4$ and $LiYF_4$ materials were successfully synthesized in the inert atmosphere *via* either thermal decomposition of corresponding precursors in the mixture of high boiling point surfactants (oleic acid and octadec-1-ene) or solid-state synthesis in a tube furnace. The resultant materials were characterized in terms of crystal structure (powder X-ray diffraction, PXRD), morphology and size distribution (transmission electron microscopy, TEM). In the following step, the colloidal suspensions were mixed with nitrosonium tetrafluoroborate ($NOBF_4$) dissolved in dichloromethane (DCM) to transfer the materials from non-polar solvent (hexane) to polar one (N,N-dimethylformamide). Such

an operation resulted in formation of stable NPs and MCs colloidal suspensions in DMF, which were ready for surface functionalization with organic dye molecules.

Coumarin 343 was chosen as the organic dye to decorate the surface of the Pr^{3+}-based materials due to broad emission band observed in the region of interest (i.e. 440-470 nm, in DMF) and ionic structure of molecule (carboxylic acid). A certain amount of the colloidal DMF suspensions was mixed with Coumarin 343 in a wide range of dye concentration for the optimized period of time. The process of functionalization was successful, since Stokes emission coming from Pr^{3+}-doped materials was observed upon dye excitation at its absorption maximum, which clearly confirms energy transfer between dye and lanthanides ions incorporated into host matrices.

The most significant part of the research was to register Vis-to-UV up-conversion spectra. The process in the investigated non-functionalized and dye-decorated Pr^{3+}-based $NaYF_4$ and $LiYF_4$ NPs and MCs is possible to be observed, as the co-doped lanthanide ions (e.g. Tm^{3+}) are excited. However, it requires tremendous amount of power for inducing, i.e. the laser operating at the maximal power and the beam focused with an optical lens. Under these conditions the dye degrades with the ease, therefore inducing Vis-to-UV up-conversion *via* dye sensitization is challenging.

7. Future collaborations (if applicable):

The in-depth data analysis of the results gathered during the research stay abroad and online discussions with the research stay supervisor are planned. Additionally, both sides express their willingness to work together on the proposal of postdoctoral research stay at Condensed Matter and Interfaces Group, which could be performed by the PhD candidate after the doctoral defense.

8. Title and date of a seminar presenting the results of the trip delivered at Wroclaw University of Science and Technology after returning from the research trip: *Studies on Vis-to-UV up-conversion emission enhancement of lanthanide-doped nanoparticles and microcrystals functionalized with organic dye molecules*, 19.12.2023.

III. Doctoral student's signature

…10.12.2023...
(Date)

…….
(doctoral student's signature)

IV. Confirmation and information from the host

1. Confirmation of compliance of the information contained in the report: **I CONFIRM** / ~~DO NOT CONFIRM~~. (*In justified cases, the confirmation of the host may be sent by e-mail to the Dean's Office of the Doctoral School email: interdocschool@pwr.edu.pl*)

2. Additional information and comments

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…10.12.2023…
(Date)

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(signature(s) of Host)