Anders Snell

Från:	Jacinto Sá <jacinto.sa@kemi.uu.se>
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Ämne:	Submission of Åforsk Grant Report (No. 23-268)
Bifogade filer:	ÅForsk - 23-268_Scientific report.pdf; ÅForsk - 23-268_Redovisning.xlsx

Gusta

Dear Anders,

I hope this email finds you well.

I am reaching out to inquire about the next steps for submitting the report for Åforsk Grant No. 23-268. We have prepared both the scientific and financial reports (attached). Could you please advise on the proper procedure for filing these reports and securing the remaining 100,000 SEK installment payment?

We would appreciate your guidance and look forward to your response at your earliest convenience.

Best regards,
Jacinto

Jacinto Sá
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"The secret of getting ahead is getting started"

- Mark Twain

Scientific report of the project 23-268 - "Discovery, optimization and standardization of nanomaterial synthesis protocols through machine learning-driven microfluidics"

Project goals:

Develop a compact and versatile microfluidic system integrated with machine learning to revolutionize the discovery, optimization, and standardization of optically active nanomaterial synthesis. The system should enable the production of high-quality nanomaterials - such as quantum dots and plasmonic structures - with precise morphology, even without prior knowledge. Additionally, the developed synthesis protocols should be easily transferable to other laboratories and facilities, paving the way for the establishment of Nanomaterials as a Service (NaaS) business models.

Project outcomes:

As part of our efforts to develop a compact and versatile microfluidic system integrated with machine learning, we achieved the following key milestones:

1. **System Upgrade at Uppsala University**
   We enhanced the existing microfluidic system at Uppsala University by integrating a novel optimization algorithm - specifically, Bayesian optimization with Gaussian processes. This upgrade significantly reduced optimization time, improved reproducibility, and minimized the impact of hardware degradation. As a result, we successfully demonstrated the discovery, optimization, and standardization of plasmonic nanoparticles and Prussian blue nanomaterials for battery applications, leading to two peer-reviewed scientific publications.

2. **Construction of an Advanced Robotic System at the University of Groningen**
   Building on insights from the first system, we developed a more advanced robotic system for the University of Groningen, Netherlands. This system incorporates commercially available reactor hardware (VapourTech) and rapid analytics (Ocean Optics). Key features include:
   - Six independently controlled pumps
   - Up to two independently heated reactors

- Customizable geometry to accommodate a wide variety of chemical synthesis processes

The synthesis optimization process leverages Bayesian optimization with Gaussian processes, while the learning process can be fed into an Artificial Neural Network (ANN), transforming the system into an AI-driven platform with broad applications. The system was successfully commissioned and installed at the University of Groningen on January 30, 2025.

3. **Scalability and the Nanomaterials as a Service (NaaS) Model**
   The optimized reactor design and component settings serve as a blueprint for scalable nanomaterial synthesis. By enabling parallelization and transferability, we laid the foundation for a Nanomaterials as a Service (NaaS) business model, as detailed in our scientific publication in Nanoscale Horizons.

Conclusion:

This project has been a resounding success. We developed a next-generation robotic system with machine learning capabilities, significantly expanding the possibilities for material synthesis. Moreover, we demonstrated the feasibility of converting this concept into a NaaS business model, addressing a major bottleneck in scaling up the production of high-quality nanomaterials.

Scientific publications:

1. S. Kioumourtzoglou, S. Hof, C. Kalk, V. Toth, M. Görlin, J. Nováková, J. Sá, *'Nanomaterials as a Service (NaaS) concept: on-demand protocols for volume synthesis of nanomaterials'*, **Nanoscale Horizons** 9 (2024) 1364.
2. S. Hof, S. Kioumourtzoglou, J. Nováková, M. Görlin, J. Sá, *'Continuous Flow Synthesis of Prussian Blue and Analogues Assisted by AI'*, **Advanced Materials Technology** (2024) 2401566.