Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

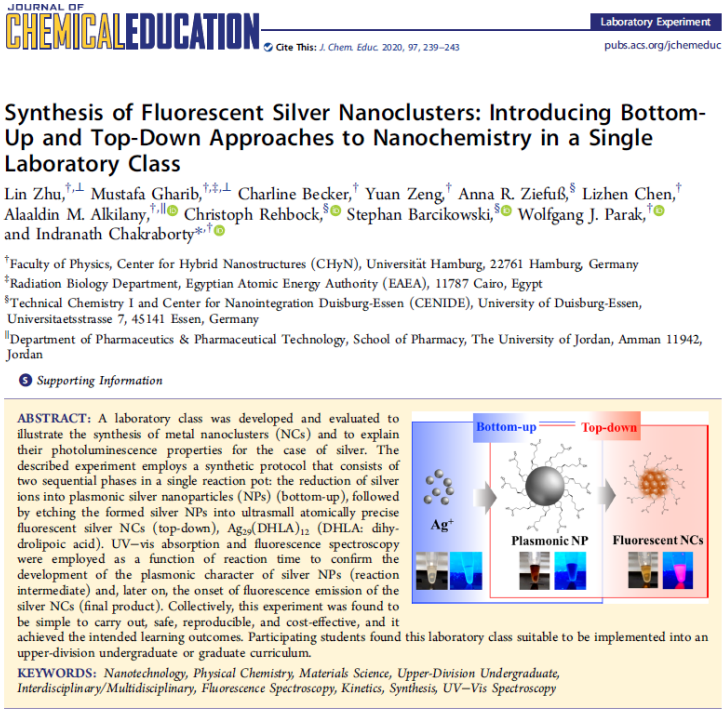
INF20: Synthesis and characterization of fluorescent silver nanoclusters

Aim of the experiment:

Practical aspects:
- synthesis
- spectroscopy

Theory/background:
- optical properties of nanomaterials
- reaction kinetics
- spectroscopy

Strong focus on practical aspects:
What do I do in the lab ←→ interpretation



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Laboratory Experiment
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Synthesis of Fluorescent Silver Nanoclusters: Introducing Bottom-Up and Top-Down Approaches to Nanochemistry in a Single Laboratory Class

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Supporting Information

ABSTRACT: A laboratory class was developed and evaluated to illustrate the synthesis of metal nanoclusters (NCs) and to explain their photoluminescence properties for the case of silver. The described experiment employs a synthetic protocol that consists of two sequential phases in a single reaction pot: the reduction of silver ions into plasmonic silver nanoparticles (NPs) (bottom-up), followed by etching the formed silver NPs into ultrasmall atomically precise fluorescent silver NCs (top-down), $Ag_{29}(DHLA)_{12}$ (DHLA: dihydrolipoic acid). UV−vis absorption and fluorescence spectroscopy were employed as a function of reaction time to confirm the development of the plasmonic character of silver NPs (reaction intermediate) and, later on, the onset of fluorescence emission of the silver NCs (final product). Collectively, this experiment was found to be simple to carry out, safe, reproducible, and cost-effective, and it achieved the intended learning outcomes. Participating students found this laboratory class suitable to be implemented into an upper-division undergraduate or graduate curriculum.

KEYWORDS: *Nanotechnology, Physical Chemistry, Materials Science, Upper-Division Undergraduate, Interdisciplinary/Multidisciplinary, Fluorescence Spectroscopy, Kinetics, Synthesis, UV−Vis Spectroscopy*

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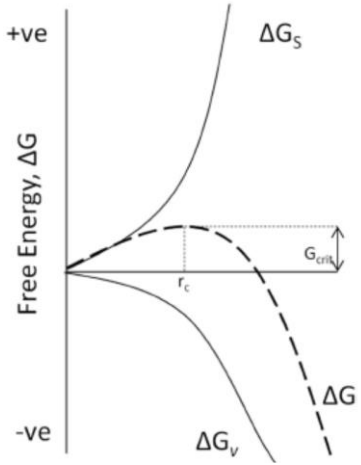
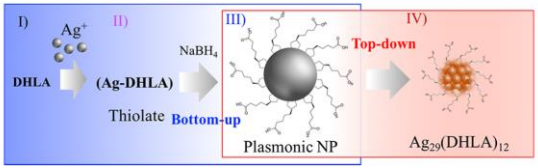
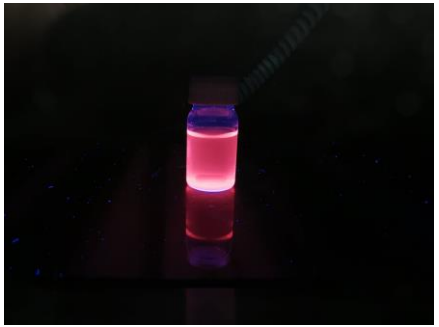
synthesis



Take home message: what kind of „magic“ happens in the flask, and can we understand it?

→ basics of nucleation and growth (minimized chemistry aspects)





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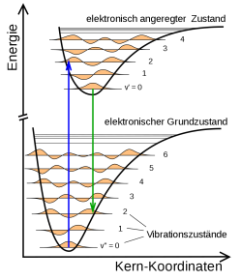
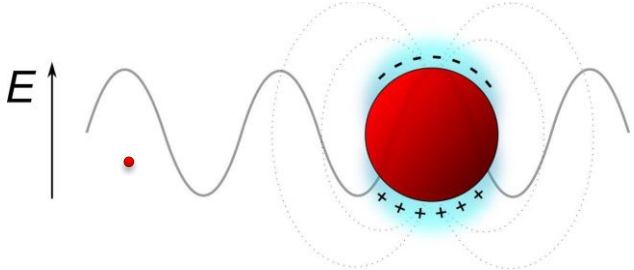
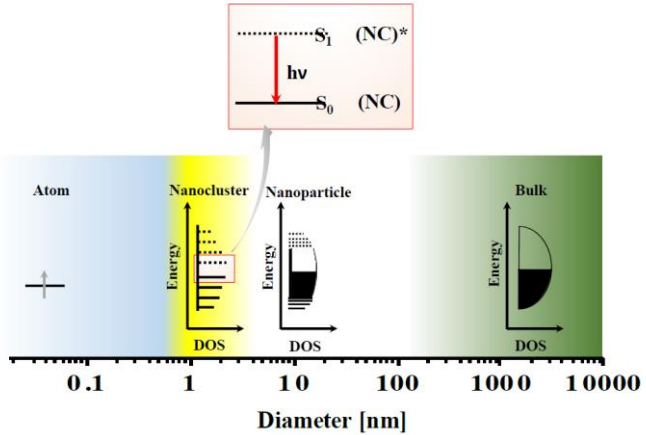
spectroscopy



Main focus of the experiment, fluorescence and UV/vis spectroscopy

- practical aspects
- theory
- linking the measured data to the interpretation





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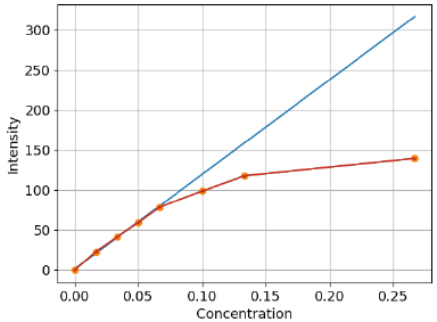

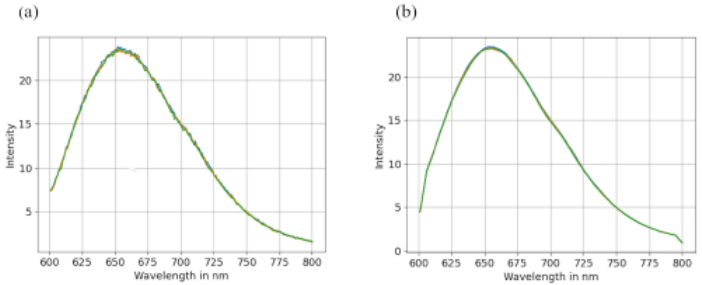

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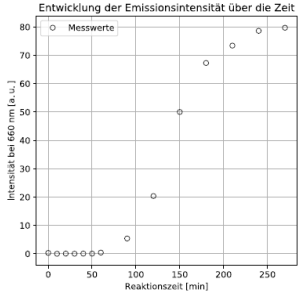

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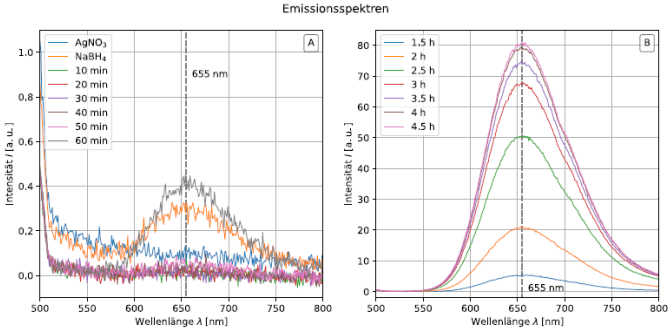

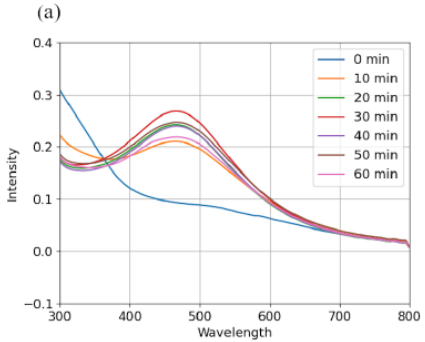

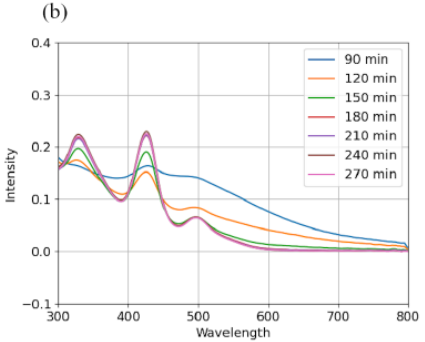

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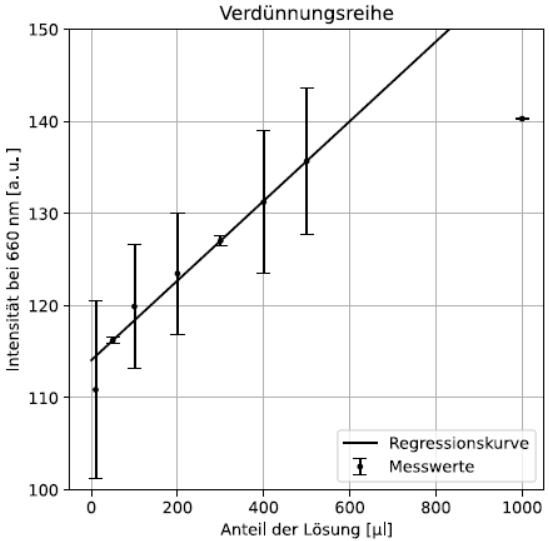
spectroscopy

Thinking about errors: which errors are relevant and how can I test it?



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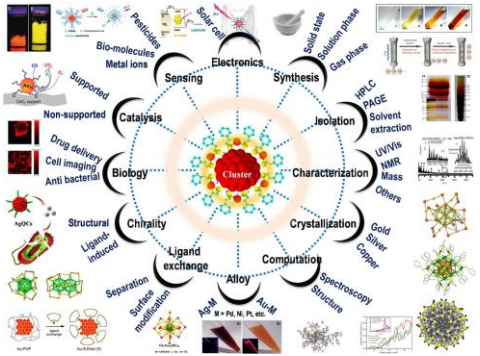
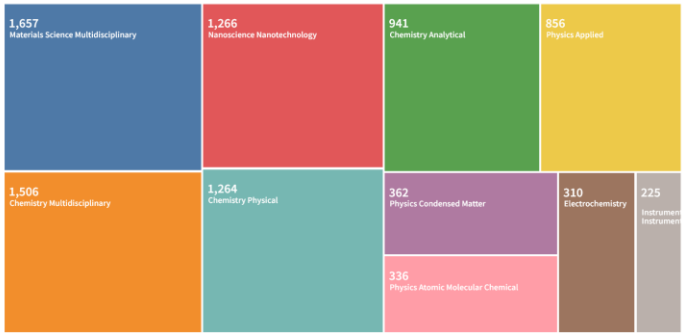
Link to modern research in the physics department
(if applicable links to clusters of excellence)

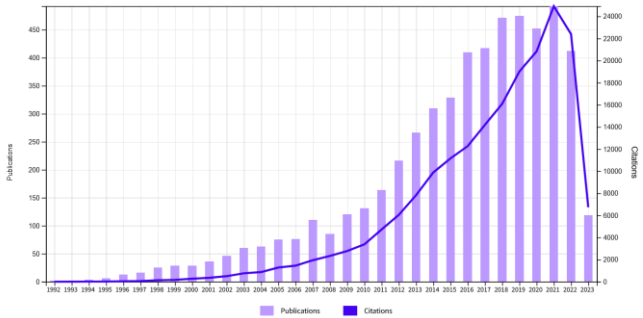
- What is the modern application of this technologies / experimental methods
- In which group are these technologies / experimental methods applied
- What skills do the students gain which can be used in the research group?
- What is the difference between state of the art equipment and the F-praktikum setup?



Chem. Rev. 2017, 117, 12, 8208–8271

Web of Science, search term „silver nanoclusters“





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Experimental aspects of optical spectroscopy

→ Lab skills
→ Writing skills!
→ Critical thinking/scientific method

A Materials and devices

Agilent Cary 60 UV Vis
Agilent Eclipse Fluorescence Spectrometer
(7.3 ± 0.2) mg + (10.4 ± 0.2) mg $NaBH_4$
(19.3 ± 0.2) mg LA
700 µl of 25 mM $AgNO_3$ solution

Table 3: The devices and materials used in this experiment.

References

[1] Chakraborty, I., Synthesis of Fluorescent Silver Nanoclusters: Introducing Bottom-Up and Top-Down Approaches to Nanochemistry in a Single Laboratory Class - Supporting Information: Instructor Lab Manual & Templates (2019).

[2] Schulz, F., Methods in nanobiotechnology II: Nanoparticle synthesis.

[3] Schulz, F., Plasmonic nanoparticles.

[4] Chakraborty, I., Synthesis of Fluorescent Silver Nanoclusters: Introducing Bottom-Up and Top-Down Approaches to Nanochemistry in a Single Laboratory Class (2019).

Grade your experiment

Complexity of the various aspects of your experiment (1 is high and 5 low)

Theory / preparation	Setup / experimental	Data taking	Analysis	Protokol
1-2	3	4	4	1-2

Usually the most challenging: correct interpretation and discussion of the experiment and data and correct scientific writing