SYNTHESIS AND ANALYSIS OF NANOPARTICLES WITH THE LOW-COST MEASURING SYSTEM LABPI

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Introduction

The continuous development of new nanomaterials represents a great opportunity in tackling current and future problems of our living environment. From corona rapid tests, new approaches to combat multi-resistant germs or modern cleaners - ways are increasingly being found to implement this technology in various useful, but also questionable contexts. The reflection of this use is essential to prevent damage to humans and the environment and therefore also for the MINT lessons an outstanding topic to promote the evaluation competence on current examples [1]. For this purpose, nanomaterials and their properties can be used for many additional contexts, such as quantitative determination via spectrometry.

Didactical Reconstruction

Scientific research	chemistry education
Development of synthesises	Adaption of synthesises
Precise characterization	Low-Cost spectrometre
reasonable applications: - medical solutions - technical parts	questionable applications: - sanitary products - food storage
Context in lifeworld and everyday life	

Topic:

Quantitative analysis of silver nanoparticles in a cleanser

student lab

piloting with university students

24 students of chemistry education

Application in summer school 2021

24 high school participants

Preparation

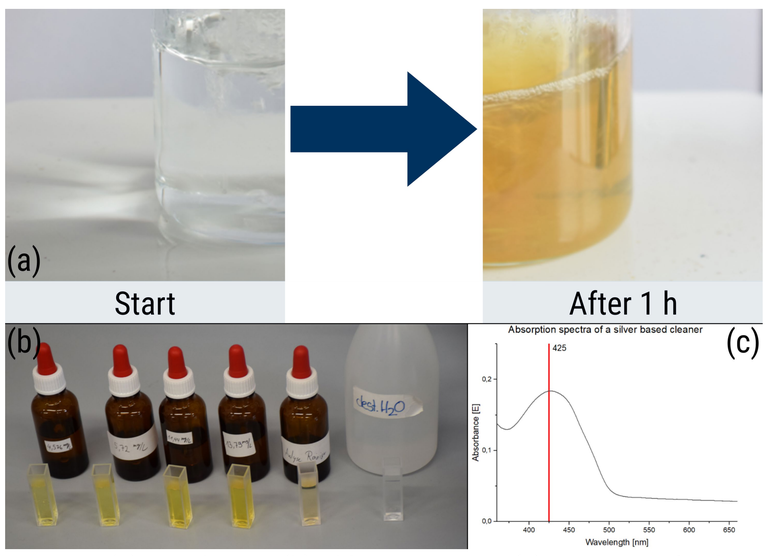

Fig. 1: (a) Synthesis, (b) dilution series, (c) Spectra of silver nanoparticles

For the synthesis of silver nanoparticles, silver nitrate was reacted with the aid of D(+)-glucose and polyvinylpyrrolidone (PVP for short) in water to form nanoparticles. In this process, the glucose and PVP are dissolved in water, heated, and mixed with silver nitrate under stirring. The mixture begins to turn yellowish/orange due to the nanoparticles formed during the process. After 60 minutes, the dispersion was cooled, and the reaction was terminated (Fig. 1). It is known from the literature that the yield of this reaction corresponds to about 1% of the silver used and the particle size is around 50 nm [2-4]. For the photometric analysis of a purifier with silver nanoparticles, spectra of cleaner, the synthesized and purchased nanoparticles were compared to check whether the size of the nanoparticles matched. Measurements were made with a self-made spectrometer for the low-cost LabPi measuring system and a laboratory spectrometer (Fig. 2) [5].

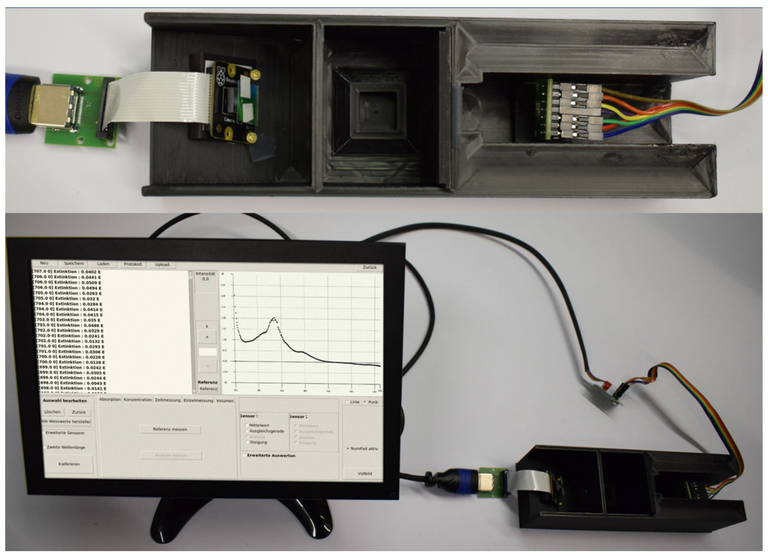

Fig. 2: Top: self-built Spectrometer, Below: LabPi Spectrometer in use with data on screen.

Analytic

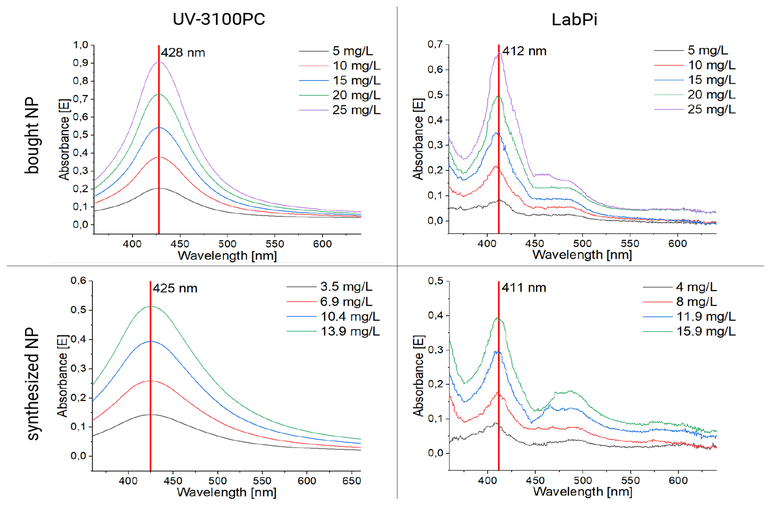

Fig. 3: Spectra of dispersions from different spectrometers

To compare the dispersions, concentration series were prepared with known mass concentration of purchased silver nanoparticles and with the dispersion obtained from the synthesis. The similarity of the absorption maxima in the spectra shows that the synthesized nanoparticles have about the same size of 50 nm (Fig. 3). To determine the actual concentration of nanomaterial in the synthesized dispersion, the undiluted solution was determined using the concentration series of the purchased nanoparticles (Fig. 4).

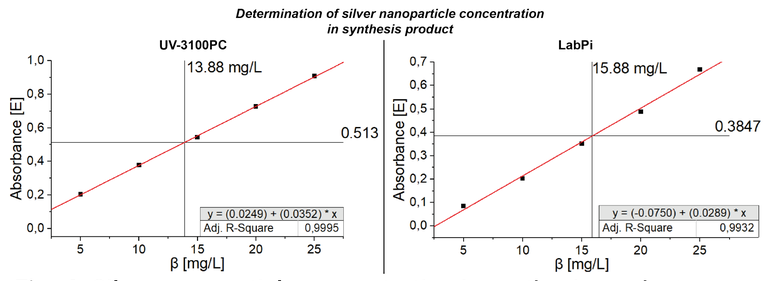

Fig. 4: Silver nanoparticle concentration in synthesis product

Using the determined concentration of the synthesized dispersion, the concentration of silver nanoparticles in a purchased cleaner was ultimately determined to be 4.6 mg/L (LabPi: 4.1 mg/L) (Fig. 5). It can be stated here that the results of the laboratory spectrometer and the self-built LabPi spectrometer led to good results and that the implementation with learning groups does not require any complex laboratory analysis.

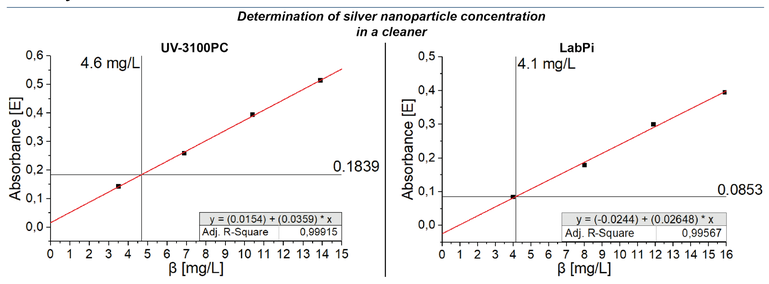

Fig. 5: Determination of silver nanoparticle concentration (cleaner)

Experiences

In a pilot with chemistry education students, silver nanoparticles were synthesized, and based on theoretical values, the concentration of nanoparticles in a cleaner was determined photometrically with LabPi. In this process, the students were very interested in the silver nanoparticles, its properties, and applications. For the photometry, they were also able to draw on their previous knowledge. The experiments were also carried out as part of a summer school for high school students about nanotechnology. The high students showed an analogous interest in nanomaterials and gained a first impression of spectroscopic methods in a research-based context.

Fig. 6: High school and chemistry education students in school lab during summer school.

References

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