Application of solid sampling high-resolution-continuum source atomic absorption spectrometry for the detection of silver nanoparticles in food samples

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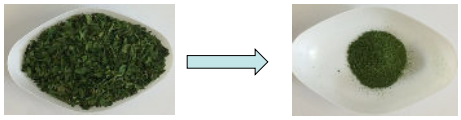
1. Introduction

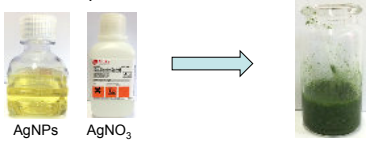
Silver nanoparticles (AgNPs) found massive applications in food industry and research due to their antimicrobial properties. Therefore, the risk of AgNPs entering human food is inevitable, which could be proved by e.g. Huang et al. [1], investigating the migration of AgNPs from fresh food containers into simulated food solutions. However, the toxicity comparing ionic and nanoparticulate silver differ with potential higher effects caused by AgNPs. Hence, the distinction of ionic silver and silver nanoparticles is meaningful. Most of the conventional analytical techniques for the detection of silver in food samples are elaborative and time-consuming. Especially in food analysis with large sample series fast and easy detection techniques are required. Therefore, we developed a method for the direct detection of silver nanoparticles in biological samples [2]. Here, AgNP-spiked parsley was used as exemplary food sample, which was investigated by application of solid sampling high-resolution-continuum source atomic absorption spectrometry.

2. Sample preparation

1. Homogenization of commercially available parsley by milling



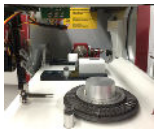
2. Addition of silver nanoparticles and/or silver nitrate and mixing of the suspension



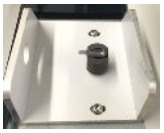
3. Drying of the suspension at 80°C in the drying furnace until complete dehydration
4. Homogenization in an agate mortar

3. Measurement procedure

Investigation of parsley either spiked with AgNPs or $AgNO_3$ by direct solid sampling high-resolution continuum source graphite furnace atomic absorption spectrometry

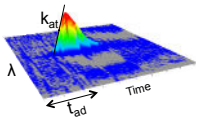


Application of the dried sample onto a graphite sample carrier



Automatic weighing of the sample carrier

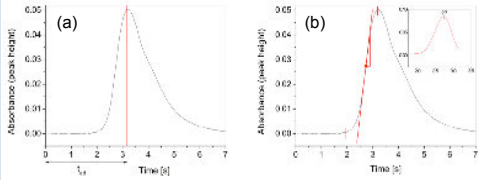
Transportation of the sample carrier into the graphite furnace



Absorbance measurement after an optimized furnace program (see below)

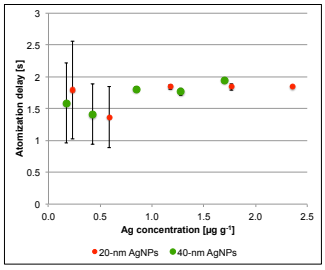
Step	*Temperature [°C]*	*Heating rate [°C s^{-1}]*	*Hold time [s]*
Drying I	80	5	20
Drying II	130	10	20
Pyrolysis	300	300	20
Gas adjustement	300	0	5
Atomization	1800	1700	7
Cleaning	2500	500	4

4. Evaluation strategy



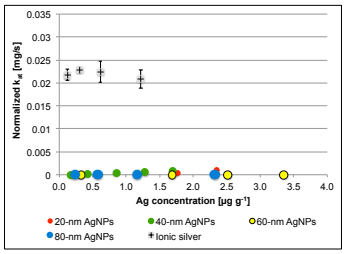
Criteria for evaluation of the received absorbance signals:
(a) Atomisation delay (t_{ad})
(b) Atomisation rate (k_{at})

5. Dependence of t_{ad} on silver concentration

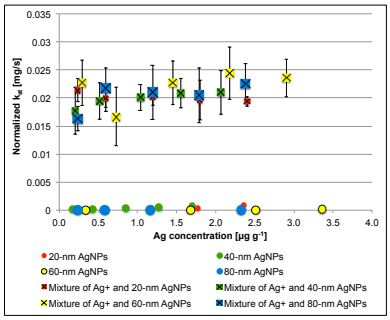


- Measurements were performed with 20-nm and 40-nm spiked parsley samples at five different concentrations (0.170 – 2.354 mg g^{-1})
- No significant concentration dependent effects on atomization delays for both spiked samples
- Atomization delays varied between 1.37 – 1.98 s

6. Dependence of k_{at} on silver concentration



- Normalization of the k_{at}-values to the ratio of peak area and sample weight
- Significant difference between samples spiked with ionic silver and AgNPs at all observed concentrations



- Comparison of samples spiked with a mixture of AgNP&Ag^+ or AgNPs only in similar concentration ranges show different atomization rates
- Differentiation over the entire examined concentration range possible

6. Conclusion and Outlook

We were able to directly detect silver nanoparticles in biological samples. The received absorbance signals were evaluated according to the atomization delays for the assessment on the presence or absence of AgNPs in the parsley samples. Samples containing AgNPs showed higher time delays compared to samples containing ionic silver. Further experiments on food samples should prove this new approach on direct detection of AgNPs.

7. References

[1] Huang, Y.; Chen, S.; Bing, X.; Gao, C.; Wang, T.; Yuan, B. *Packag. Technol. Sci.* **2011**, 24, 291-297.

[2] Feichtmeier, N.S.; Leopold, K. *Anal. Bioanal. Chem.* **2014**, 406, 3887-3894.

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