Further developments in sample preparation strategies for nanoparticles analysis using laser ablation single particle–ICP-MS

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Nanoparticles are utilized in diverse fields, such as material manufacturing, energy production, food processing, consumer goods, and life sciences. The physicochemical properties of materials in the nanometer size range differ significantly from those of bulk materials, resulting in unique characteristics useful for various products such as medical products, catalysts, cosmetics, food technology, and household items. [1], [2] However, the widespread use of nanoparticles in consumer goods raises concerns about their impact on the environment and human health. To address this issue, single particle inductively coupled plasma mass spectrometry (SP-ICP-MS) has been developed as a powerful tool for investigating nanoparticles. [1] However, conventional SP-ICP-MS, which enables the simultaneous determination of particle size and number concentration, is limited to nanoparticles in suspension. Further limitations of this approach include difficulties in the sample storage because of the low stability of suspensions as well as limited efficiency of sample introduction and the potential negative impacts of the solvent on the quality of ICP-MS analysis.

To overcome these limitations, the measurement of solid samples is recommended. The combination of laser ablation as the sampling technique and SP-ICP-MS for the analysis was introduced to incorporate the benefits of solid sampling. [2] [3] This approach allows the sizing and counting of nanoparticles directly in a solid matrix with the advantage that embedded nanoparticles can be stored without changes in particle size. Similar to conventional SP-ICP-MS, laser ablation SP-ICP-MS (LA-SP-ICP-MS) also requires nanoparticle standards for signal evaluation. In the literature, the commercially available nanoparticle standards were prepared in a gelatine matrix and investigated with LA-SP-ICP-MS. [3] The use of gelatine is related to drawbacks such as the need for heating, which can affect the dissolved fraction of the nanoparticles. Moreover, gelatine is a natural biological substance which results in a complex sample matrix containing several nutrients and trace elements. Application of techniques for fabrication of even thin films with controllable thickness, such as spin coating, is not possible with gelatine.

In this study, dispersions of metallic nanoparticles in polymer matrices were produced by spin coating using different types of polymers. The aim was to achieve a random distribution of isolated nanoparticles within the generated polymer thin film without particle agglomeration. This spin coating approach gives the vital advantage of creating even and uniformly thin polymer films, which can be used as standards for signal evaluation if a specified quantity of solute analyte is added to them and an exact area of the film is completely ablated. The impact of the sample preparation procedures and the effect of the different polymer matrixes, as well as the influence of the laser energy in the ablation process, were investigated and compared to assist in the further development of LA-SP-ICP-MS.

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[2] S. Yamashita, Y. Yoshikuni, H. Obayashi, T. Suzuki, D. Green, and T. Hirata, “Simultaneous Determination of Size and Position of Silver and Gold Nanoparticles in Onion Cells using Laser Ablation-ICP-MS,” *Anal. Chem.*, vol. 91, no. 7, pp. 4544–4551, 2019, doi: 10.1021/acs.analchem.8b05632.

[3] D. Metarapi, M. Šala, K. Vogel-Mikuš, V. S. Šelih, and J. T. Van Elteren, “Nanoparticle Analysis in Biomaterials Using Laser Ablation-Single Particle-Inductively Coupled Plasma Mass Spectrometry,” *Anal. Chem.*, vol. 91, no. 9, pp. 6200–6205, 2019, doi: 10.1021/acs.analchem.9b00853.