Title: Real-Time Characterisation of Silver Nanoparticles

Real-Time Characterisation of Silver Nanoparticles: Development of a Compact Static Light Scattering Device for Size and Stability Analysis

Category: Material Science

Introduction and Objectives:

This study presents the development and application of a compact static light scattering device designed to characterise the size and stability of silver nanoparticles in real-time. Silver nanoparticles are widely used across materials science, biomedical research, and food safety, where precise control over size and stability is crucial for their effectiveness. For instance, in drug delivery and antimicrobial applications, nanoparticle stability directly impacts performance and safety. Our device, designed for accessibility and efficiency, incorporates a laser source, collimating slit, sample holder, and photomultiplier tube (PMT) detector, with angular measurements controlled by an Arduino-based stepper motor. Intensity data are collected via a Picoscope, enabling precise, real-time analysis of light scattering across a range of angles.

Through Guiner and Zimm analyses, we extracted critical nanoparticle parameters, revealing a radius of gyration of approximately 52 nm and a weight-average molecular weight of 60 kDa. Stability studies over periods from 10 minutes to one month showed significant variations in scattering intensity and size distribution, indicating nanoparticle aggregation over time. Comparative analysis with Transmission Electron Microscopy (TEM) validated these scattering results, showing strong agreement in size estimation and confirming the accuracy of our device.

Innovation

This innovative device offers an in-situ solution for nanoparticle characterization without the need for complex sample preparation or high-vacuum conditions, setting it apart from traditional methods. Its real-time, versatile design makes it ideal for monitoring nanoparticle behaviour in diverse applications, from healthcare to food safety. By providing quick and accessible data on nanoparticle size and stability, this device has the potential to address critical needs in fields where safety and efficacy depend on precise nanoparticle behaviour. Future developments will expand its compatibility for broader nanoparticle studies, potentially revolutionising its application in real-world challenges, such as ensuring the safety and effectiveness of nanomaterials in consumer products and environmental solutions.

Method:

• Silver nitrate ($AgNO_3$) was used as the precursor, and sodium citrate was employed as a reducing agent.

◦ Reaction: $AgNO_3 + NaBH_4 \rightarrow Ag + \frac{1}{2} H_2 + \frac{1}{2} B_2H_6 + NaNO_3$

• A 0.01 M $AgNO_3$ solution was prepared and heated to boiling. A 1% sodium citrate solution was rapidly added to the boiling $AgNO_3$ solution with continuous stirring. The mixture was allowed to boil for an additional 10 minutes until a yellowish colour, indicative of silver nanoparticle formation, appeared. The resultant suspension was cooled to room temperature and filtered to remove excess reagents.

• The synthesised silver nanoparticles were characterised using UV-Vis spectroscopy to confirm the presence of surface plasmon resonance (SPR) peaks, typically around 400-450 nm.

• The device was calibrated to ensure accurate alignment of the laser and PMT. The angular resolution was set to 1° increments for comprehensive scattering angle coverage (0° to 180°).

• A small volume (approximately 1 mL) of the freshly prepared silver nanoparticle suspension was placed in the sample holder. The system was initialised, and the PMT was rotated to collect scattering intensity data at each angle. Data acquisition was performed for intervals of 10 minutes, followed by hourly, daily, and monthly measurements to track changes in scattering intensity over time.

• The Picoscope recorded the intensity of scattered light at each angle, while the Arduino logged the corresponding angular positions. Each measurement was repeated three times to ensure reproducibility, and the average intensity values were used for analysis.

Results and Conclusions

This research contributes to the field of nanoparticle characterisation by providing a practical and effective tool for real-time monitoring of silver nanoparticles. By overcoming the limitations of traditional methods, our static light scattering device paves the way for further exploration of nanoparticle behaviour and stability, particularly in emerging applications within materials science and biomedical fields, as well as in food safety and environmental technologies.

Acknowledgements and Reference Links

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