Measurement of Electrophoretic Mobility of Coated Nanoparticles Using Electrical Asymmetrical Flow Field-Flow Fractionation

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Introduction

Industrial applications of nanoparticles have been growing immensely. Medical and healthcare, electronics and information technology, energy and environmental remediation are a few among the major industries that nanoparticles help improve or revolutionize [1]. Application of nanoparticles in medicine has produced solutions for preventing diseases, clinical diagnosis and therapy. Extensive research is being conducted in cancer treatment where the nanoparticles are utilized as drug carriers. This allows researchers to find a new kind of therapeutics which reduces the risk of damage to healthy tissue by delivering the drug directly to the cancerous cells. Nanoparticles uptake by cells is highly size and surface charge dependent [2]. That underlines the importance of size and charge characterizations of nanoparticles. Batch mode analytical techniques such as dynamic light scattering and electrophoretic light scattering are widely used to measure nanoparticles size and charge. Although they can provide fast and accurate size and charge information, their use is usually limited to monodisperse and homogeneous suspensions. Asymmetrical Flow Field-Flow Fractionation (AF4) is a well-established high resolution separation technique for characterization of nanoparticles, suitable for both mono- and polydisperse colloidal suspensions. In addition to the primary separation field (crossflow), an electrical field can also be applied to the separation channel in AF4, which enables to manipulate the elution times of the charged nanoparticles based on the charge type and strength (figure 1).

In this application note, the Electrical Asymmetrical Flow FFF (EAF4) system was used to measure the electrophoretic mobility and Zeta potential of 50 nm Ag nanoparticles (AgNPs) coated with three different coating materials, namely Citrate, Polyvinyl pyrrolidone (PVP) and Tannic acid.

How to Measure Surface Charge from EAF4?

Particles in an AF4 channel are moving toward the accumulation wall (semi permeable membrane) with the velocity induced by the separation field (crossflow), which acts perpendicular to the channel flow. The field induced migration is counterbalanced by the diffusion of the particles. The elution time of the particles is mainly related to the ratio of the field- and diffusion- induced migrations. In EAF4, in addition to the crossflow an electrical field is applied inducing a net surface charge at the accumulation wall, which shifts the elution time of a charged particle based on the direction and strength of the electrical force applied on the particle.

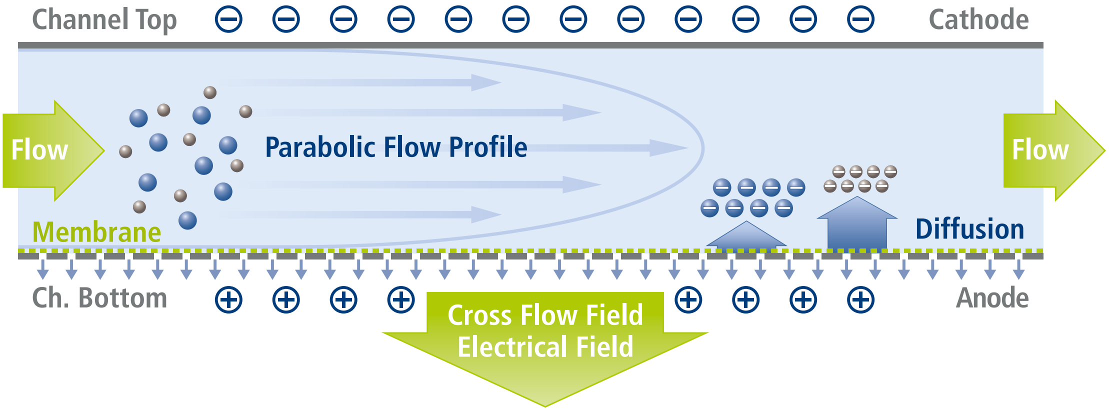

Figure 1: Schematic representation of an Electrical Asymmetrical Flow FFF channel.

The electrophoretic mobility of the particles can be calculated from the shift in the retention time when the electrical field is off and on. The analysis requires at least three runs, where the particle net drift velocity (related to the retention time shift) is plotted against the applied electrical field. The size-resolved electrophoretic mobility and Zeta Potential of the particles can now be derived from the slope of the linear regression and the application of the Smoluchowski-approximation, respectively.

Results

Figures 2a-2c illustrate the fractograms of 50 nm Ag NPs coated with Citrate, Polyvinyl pyrrolidone (PVP) and Tannic acid obtained by EAF4 at a constant crossflow field and different electrical fields.

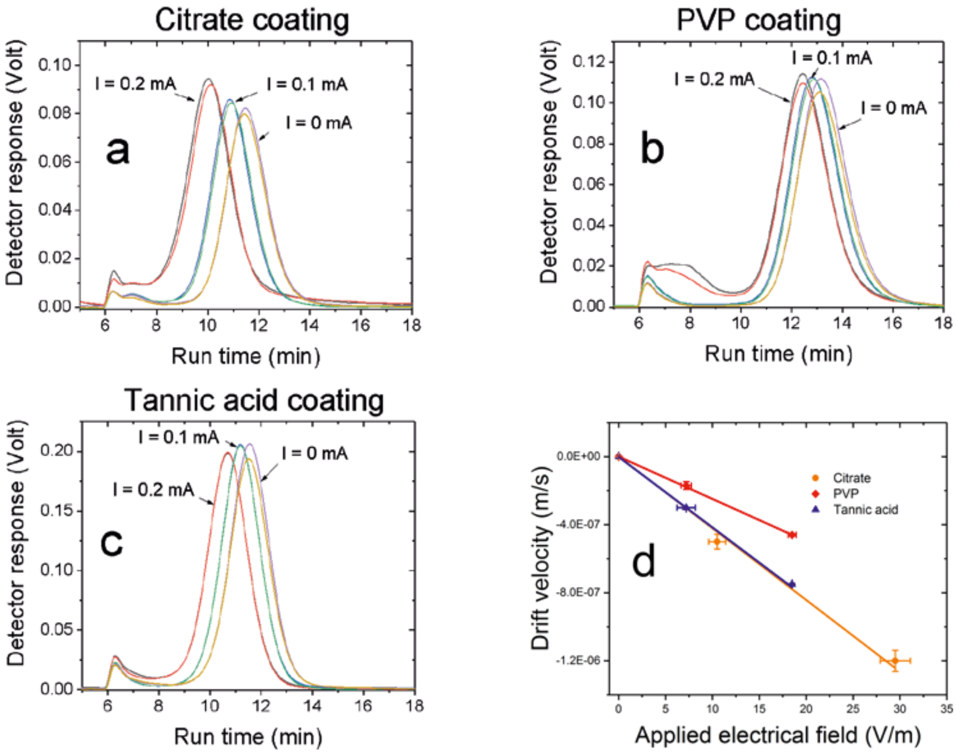

Figure 2: UV-based fractograms of 50 nm Ag NPs with different coating materials. a) Citrate coated, b) PVP coated, c) Tannic acid coated, d) plot of net drift velocity versus applied electrical field.

The shift in the retention times were used to generate the plot of net drift velocity versus applied electrical field for the three samples shown in figure 2d. The results showed that the Citrate and Tannic acid coated Ag NPs have a similar electrophoretic mobility of -3.8 μm cm V^{-1} s^{-1} whereas the PVP coated Ag NPs has a lower electrophoretic mobility of -2.37 μm cm V^{-1} s^{-1}. As these test sample NPs are reasonably monodisperse, we can, in this case, validate the accuracy of the analysis by measuring the electrophoretic mobility of the unseparated Ag NP samples using a traditional batch zeta potential analyzer (Zetasizer Nano, MalvernPanalytical, UK). Figure 3 shows the comparison of the two techniques, where the measured electrophoretic mobility values are in good agreement.

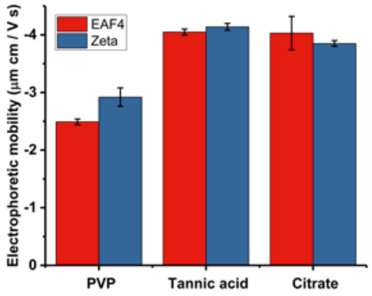

Figure 3: Comparison of the measured electrophoretic mobility values obtained from EAF4 and zeta potential analyzer.

Conclusion

The electrophoretic mobility and Zeta potential of a 50 nm Ag NP sample coated with three different coating materials were measured successfully using a combination of electrical and flow fields in the Electrical Asymmetrical Flow FFF channel. This technique is particularly useful for the characterization of polydisperse colloidal suspensions where a size-resolved determination of surface charges is required, for example in order to study interactions between nanoparticles and biological systems under native conditions to improve the efficiency of drug delivery systems.

References

[1] National Nanotechnology Intitative: https://www.nano.gov/you/nanotechnology-benefits.
[2] S Honary, F Zahir, Tropical Journal of Pharmaceutical Research, 2013, 12(2), 265-273.