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Adapting Taylor-Aris Dispersion Analysis to nanoparticle characterization and characterizing nanoparticles in complex physiological environments

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The fascinating properties of nanoparticles (NPs) are most often caused by their specific size, and therefore a thorough analysis of their size is necessary to ensure their functionality. The rising interest in the application of NPs in the medical field has additionally made it increasingly important to be able to characterize NPs in complex physiological fluids, which is often the limit for nanoparticle sizing techniques.
In this thesis, we aimed to develop Taylor-Aris Dispersion Analysis (TDA) as an analytical technique to determine nanoparticle sizes, especially in complex physiological fluids. Since previous literature has mainly focused on using this technique to analyze polymers, proteins, and small molecules, we initially aimed to develop a method to measure a wide variety of nanoparticle materials and sizes.
After successfully establishing a standard measurement setup capable of measuring all our nanoparticle samples, we focused on exploring the possibility of measuring highly polydisperse nanoparticle systems, since NPs produced on a large scale often show high heterogeneity, and aggregation processes can cause initially monodisperse NP systems to become polydisperse. The results showed that the measurement of highly polydisperse systems is possible, however the data analysis needed to be adapted in order to analyze the strongly distorted signals. By adapting the analysis of the measurement to a model-independent analysis, using statistical moments, we showed that TDA is suitable for measuring these types of systems.
In our final study, we applied our developed system to measuring NPs in complex physiological environments. The incubation of gold nanoparticles, coated with differently charged polymers, in a variety of complex fluids, including supplemented cell culture media, showed that TDA is able to accurately determine the sizes of NPs. Our system was capable of filtering out possible interference caused by components of the complex solutions, and shows great promise to be used for other NP systems. The research showed, however, that highly positively charged NPs are challenging to measure, due to their interaction with the capillary wall. By adapting the measurement technique from a plug injection to a front injection, we were able to show that even these challenging particles can be measured accurately by TDA.

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