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Novel Electrokinetic Approaches for Particle Separation Applied to Organelles and Microplastics

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Summary

Electrokinetic phenomena are essential elements in separation sciences, yet novel approaches are required for addressing cutting-edge analytical challenges. Among the traditional combination of electrophoretic and electroosmotic phenomena employed in the microenvironment, dielectrophoresis (DEP) has been explored either as a unique particle migration tool or in combination with other electrokinetic techniques. DEP can be induced in microfluidic devices by designing constrictions and arrays of such leading to inhomogeneous electric fields via the application of potential differences along a microchannel. We have designed microfluidic devices that allow DEP-induced separation of organelles via a unique periodic driving mechanism. We have particularly focused on mitochondria and the underlying optimization of their separation in small and large size fractions which are actively steered into opposing directions. Our latest work focused on the optimization of this ratchet-migration mechanism in the continuous separation mode with numerical methods, which are in excellent agreement with experimental observations.

Furthermore, we scout the capabilities of dielectrophoretic separation of micro- and nanoplastics (MNPs), for which implications in human health and disease are alarming. While evidence has been found that MNPs accumulate in organs, we postulate that they circulate in the blood stream in sub-µm dimensions. However, techniques to analyze and enumerate their abundance and composition in this size range are lacking. With DEP-based approaches we have started to characterize micro- and nanoplastics as they interact with blood constituents. To allow these studies, we developed protocols to generate realistic micro- and nanoplastic particles by cryo-grinding and studied their dielectrophoretic characteristics in alternating current electric fields. These studies will inform the design of microfluidic separation devices exploiting dielectrophoresis to characterize MNPs in human body fluids.