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Microfluidic Droplet Dehydration for Concentrating Processes in Biomolecules

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Droplets in microfluidic devices have proven useful as picoliter reactors for biochemical processing operations such as polymerase chain reaction, protein crystallization, and the study of enzyme kinetics. Although droplets are typically considered to be self-contained, constant volume reactors, there can be significant transport between the dispersed and continuous phases depending on solubility and other factors. In the present talk, we show that water droplets trapped within a microfluidic device for tens of hours slowly dehydrate, concentrating the contents encapsulated within. We use this slow dehydration along with control of the initial droplet composition to influence gellation, crystallization, and phase separation processes. By examining these concentrating processes in many trapped drops at once we gain insight into the stochastic nature of the events. In one example, we show that dehydration rate impacts the probability of forming a specific crystal habit in a crystallizing amino acid. In another example, we phase separate a common aqueous two-phase system within droplets and use the ensuing two phases to separate DNA from an initial mixture. We further influence wetting conditions between the two aqueous polymer phases and the continuous oil, promoting complete de-wetting and physical separation of the polymer phases. Thus, controlled dehydration of droplets allows for concentration, separation, and purification of important biomolecules on a chip.