Diagnosis plays a very crucial role in medicine and health care, which makes biosensors extremely important in modern technological context. Till date, various types of biosensors have been developed that are capable of detecting a wide range of biologically important species with great sensitivity and selectivity. However, most of these sensing units require highly sophisticated instrumentations and often lack the desired portability. Liquid crystal (LC) droplets, on the other hand, are a new type of functional material that are finding increasing research attention as a new sensing unit due to their tunable optical property, high surface area, portability and cost-effectiveness.

In this dissertation, chemically functionalized LC droplets dispersed in aqueous solution were prepared by the self-assembly of amphiphilical molecules at the aqueous/LC interface. The chemically functionalized LC droplets showed a well-defined director configuration and a specific optical pattern when observed with a polarizing light microscope. It was discovered that the interaction between chemically functionalized LC droplets with an analyte triggers transition of the director configuration of the LC within the droplets, providing a simple and unique optical sign for the detection of the analyte. Moreover, the director configuration transition happened in a concentration dependent manner, allowing both qualitative and quantitative detection of the analyte. The sensitivity of chemically functionalized LC droplets depends on not only the nature of amphiphilical molecules but also the size and number of the droplets.

The dissertation essentially deals with the application of chemically functionalized LC droplets in detecting several biologically important species. We found that the adsorption of charged macromolecules (dendrimers, proteins, and viruses) on polyelectrolyte functionalized LC droplets triggered a bipolar-to-radial configuration transition based on the polar verses non-polar interaction. By using a simple optical microscope, we were able to detect microgram per milliliter concentrations of bovine serum albumin, cowpea mosaic virus, and tobacco mosaic virus in aqueous solution. The detection limit of mastoparan X polypeptide decorated LC droplets in detecting Escherichia coli could reach to approximately 10 bacteria per milliliter. In this case, the high affinity of the polypeptide towards the bacterial causes the former to detach from the LC droplets, triggering the director configuration transition of the LC inside the droplets. Finally, we used surfactant decorated LC droplets to detect lithocholic acid (LCA), a toxic bile acid used as a specific biomarker for colon cancers. In this case, the director configuration transition of the LC inside the droplets is a result of the replacement of the surfactant from the aqueous/LC interface by LCA. The microgram per milliliter concentration of LCA, a clinically significant concentration, could be easily detected by changing the length of surfactants.

Our studies hence highlight the novel use of surface functionalized LC droplets to detect biologically important species. Thus, due to the tunable optical property, coupled with high surface area and portability, we believe that, surface functionalized LC droplets have great potentials in the design of next generation biosensors.

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