Liquid crystal (LC) droplets show great potential as an optical probe for sensor applications due to their large surface areas and stimuli-response director configurations. Bile acids with amphipathic properties, which are formed in liver and secreted into the small intestine, play an important role in the digestion of fats and fat-soluble vitamins. After the digestion process, most of bile acids are recycled back to the liver and ready for the next digestion. Only a few of them are excreted into body fluids. However, there is significant increases in the concentration level of bile acids in body fluids for patients with liver and intestinal diseases, which makes bile acids a biomarker for the early diagnosis of liver and intestinal diseases. Chromatography-mass spectrometry and electrochemical sensors are common methods for the detection of bile acids. However, these methods are time consuming, require relatively large sample volumes, and expensive instruments. To date, there is still a demand in the development of simple and low-cost sensing platforms for the rapid detection of bile acids in clinical settings.

In this dissertation, two simple LC droplet-based sensing platforms were developed for the rapid and real-time detection of bile acids with a small sample volume. First, a miniaturized LC droplet-based sensor platform was designed and fabricated by the integration of polyelectrolytes/surfactant/sulfate β-cyclodextrin (β-CD) complex-stabilized LC droplets into a microfluidic channel for the real-time and selective detection of bile acids in a small amount of solution, in which the β-CD immobilized at the surface of the LC droplets acts as a selective barricade and the director configuration of the LC droplets serves as an optical probe. Second, a flexible LC droplet-based sensor platform was formed by the integration of surfactant-stabilized LC droplets in biopolymer hydrogel films. The LC droplet-based hydrogel film was cut into small sheets for the real-time detection of bile acids in a small amount of solution, in which the configuration transition of LC droplets induced by the interaction of bile acids with the surfactants absorbing on the surface of LC droplets serves as an optical probe.

Cholic acid (CA) and deoxycholic acid (DCA), which are the most related to the liver and intestinal diseases, were detected in phosphate buffered saline (PBS) solution in the presence of the interference species of uric acid and ascorbic acid in this dissertation. These miniaturized LC droplet-based sensor platforms can be used to selectively detect CA and DCA in the presence of UA and AA. The detection limit of these sensor platforms for CA and DCA can be tuned by the number of LC droplets and the nature of surfactants. Furthermore, we find that these sensor platforms are more sensitive for DCA with the shorter response time and lower detection limit over CA due to their difference in hydrophobicity.

These miniaturized 5CB droplet-based sensor platforms are easily handed, allowing the rapid and real-time detection of bile acids in a small sample volume in the presence of interference species, which are highly desirable for the "point-of-care" analysis of bile acids.

Major: Materials Science and Engineering

Educational Career:
Bachelor’s of Materials Science & Engineering, BS, 2010, Beihang University, China

Committee in Charge:
Jiyu Fang, Chair, Materials Science & Engineering
Shin-Tson Wu, The College of Optics & Photonics
Linan An, Materials Science & Engineering
Quanfang Chen, Materials Science & Engineering