Organic field-effect transistors (OFETs) are unique platforms for the detection of chemical and biological species. Such sensors are able to directly transduce an analyte-binding event into an electrical signal, making them highly compatible with sensing platforms requiring a digital readout. In particular, the detection of biologically relevant molecules lends itself to this detection platform because of the inherent charge associated with many biomolecules, which can be detected by the OFET. Additionally, OFETs are more biocompatible than their inorganic counterparts, facilitating their use as biosensors.

OFET sensor applications have historically been limited to the detection of small molecules in the vapor phase, due to the incompatibility of many organic semiconductors with water. Our group first demonstrated the real-time detection of several chemical species in aqueous media using an inherently water-stable organic semiconductor. These sensors were capable of low-voltage operation due to the incorporation of an ultrathin polymer dielectric layer, and were shown to be highly stable operating in aqueous conditions. However, while the limit of detection of these sensors has been demonstrated down to the part-per-billion (ppb) level, the response of the sensors was nonspecific, as the active layer itself displayed a serendipitous sensitivity to a number of small-molecule analytes.

In order to define sensitivity for a particular molecule of interest, a receptor group must be integrated into the device’s architecture, preferably by a method that does not damage the OFET itself. We recently developed a novel OFET sensor platform that is capable of stable operation in an aqueous environment while also allowing for the selective detection of a user-defined analyte. Sensitivity for the targeted analyte is engineered by virtue of the ordered array of AuNPs that decorates the OFET’s surface. This highly versatile platform is compatible with a large number of available, thiolated receptor groups that can be used to functionalize the AuNPs through the well-known gold-thiol (Au-S) linkage.

We have previously used this platform to demonstrate the highly selective detection of mercury (II) in solution. We have now expanded the sensing capabilities of this platform by demonstrating the selective detection of thrombin to 100 pM. Additionally, using this model system, we systematically investigated the effect of varying the ionic strength and pH of the buffer, as well as the average center-to-center distance between the receptor sites in order to form a more comprehensive picture of biodetection with OFETs. Using these parameters, we have devised a method to tune the dynamic range of our sensors in order to match that necessary for the particular application for which they will be used.