Engineering Novel Biochips for the Rapid and Sensitive Detection of Biomarkers

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Immunoassays, involving the precipitate reaction between antibodies and antigens, have wide applications for the detection of disease-related molecules in patients or contaminants in food or environment. However, traditional immunoassays are usually limited by their low sensitivity (milligram of antigen), slow detection process (hours to days) and low throughput (one sample at a time). Thus, my project aimed to optimize the immunoassays and make improvements that would decrease the reaction time, reduce the amount of sample required, improve the detection limit, and increase the throughput for simultaneous detection of multiple markers. First, I used a fluorescence-tagged antibody to increase the sensitivity of the antigen detection, achieving a detection limit of 50 ng and the detection time of 20 minutes. In addition, I decreased the thickness of the gel by 10-fold to improve the sensitivity (25 ng) and detection time (5 minutes). I then designed microchannels to limit diffusion in the lateral direction and further reduce the detection limit (10 ng) and time (1-minute). Finally, I designed a device with multiple microchannels that allows for the simultaneous detection of multiple antigens from one sample or the detection of one antigen in multiple samples. The dramatic improvement of detection limit (10,000-fold from mg to 10 ng) and detection time (1440-fold from 24 hours to 1 minute) by the miniaturized biochips and their multiplex capability will significantly reduce the cost and increase the efficiency of the immunoassays, and will have tremendous translational potential for disease diagnosis and the detection of contaminants in food and environment.