Development of Photovoltaic-based Chemical Sensor on Gold Grating Surface Toward Organophosphate Pesticide Chlorpyrifos Detection

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In recent years, organophosphate pesticides have been widely used, especially in a field of agricultural activities. Chlorpyrifos is one of organophosphate commonly used to control insects on agricultural products, which can be easily contaminated in environmental during use. Detection of chlorpyrifos pollution has been reported by different methods such as photoelectrochemical measurements, bio-based detection, surface plasmon resonance techniques, and so forth. In this study, photovoltaic technique was used to detect the chlorpyrifos due to the synergic advantages of both optical method and photoelectrochemical sensors. A sensing layer was first constructed using poly(3-hexylthiophene)(P3HT)-functionalized TiO_2 nanopaticles. To enhance and amplify photocurrent response, gold grating substrate was used for the cathode side while a platinum wire was used as the counter electrode for anode (this experimental setup was shown in Figure 1). The underlying mechanism is that P3HT generated exited electron under visible light irradiation, then it was immediately delivered to conduction band of TiO_2 and then to the gold electrode. On the other hand, holes in valance band of TiO_2 migrate to the valance band of P3HT. This can react with phosphate-buffered saline (PBS pH 7.3) then generate hydroxyl radical (•OH). This dissociation reacts with chlorpyrifos, then it formed chlopyrifos•, which could amplify sensing response. Moreover, gold grating layer also significantly improved the signal by means of an increasing of surface area and plasmonic effect. To compare the effect of grating, the properties on grating and non-grating were studied. Figure 2 shows plots of short-circuit current (I_{sc}) values of both substrates (grating and non-grating) with various concentrations of chlorpyrifos (0, 10 50, 100, 500 and 1000 μM). The result clearly showed that the existence of grating provided an increase of photocurrent response. This study implies a possibility of the photovoltaic sensing platform, which can be applied to the organophosphate pesticide sensor device in the future.

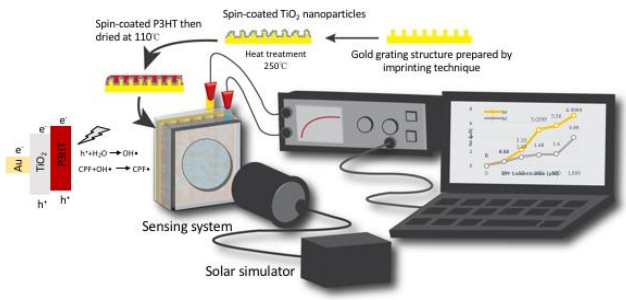

Figure 1. A diagram of photovoltaic sensing platform and the experimental setup.

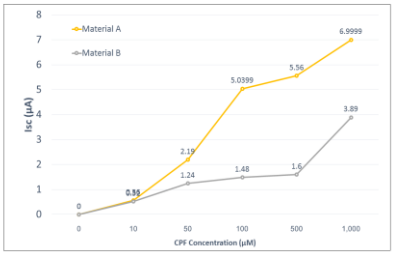

Figure 2. I_{sc} plot of Au grating (Material A) and non-grating (Material B) structure/TiO_2/P3HT with different concentrations of CPF.