# An Efficient Approach to Preparing Conjugated Polymer/Reduced Graphene Oxide Nanocomposites for High-Performance Gas Sensors

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## 1. Introduction

In this paper, we have reported a facile strategy that improved both the charge transport of CP matrices and interfacial charge interactions between CP and rGO components in CP/rGO composites using a simple photoirradiation of technique. We demonstrated that the nucleation and growth of crystalline P3HT aggregates on the rGO surface can be facilitated via the photoirradiation of P3HT/rGO composite solutions. The photoirradiated P3HT/rGO composite films were applied to OFETs gas sensors that demonstrated outstanding responsivity to polar Volatile organic compounds (VOCs). In addition, these OFET sensors exhibited rapid response/recovery behaviors, which enables their practical use as real-time monitoring portable sensors in health and environmental applications.

## 2. Experimental

### 2.1 Preparation of P3HT/rGO composite solutions

P3HT and rGO were introduced separately into chloroform, heated at 55 ℃ for homogeneous dissolution and dispersion, respectively, and they were eventually cooled to room temperature. Consecutively, the two solutions were mixed in the appropriate ratios to obtain P3HT/rGO composite solutions. Then, they were heated at 55 ℃ for homogeneous dissolution and dispersion, respectively, and eventually cooled to room temperature. Finally, the composite solutions were photoirradiated by exposing them to UV light.

### 2.2 Gas sensor test

Dry nitrogen gas was used as a carrier and dilution gas to evaporate the target solvents and mix them simultaneously. Next, a gas mixture at an appropriate concentration was introduced into the gas chamber. After exposure to an analyte gas for 60 s, pure nitrogen gas was introduced for 60 s to purge the analyte.

## 3. Results and Discussion

The photoirradiated P3HT/rGO composite-based OFETs exhibited improved charge transport characteristics compared to those based on pristine P3HT, hotoirradiated P3HT, and pristine P3HT/rGO (80/20) (Fig. 1a) It is known that UV irradiation causes P3HT polymer chains in the solution to become photoexcited and thus planarized because of the π–orbital overlap between the individual thiophene rings arising from the delocalization of π - electrons along the polymer backbone [1-3]. The maximum mobility was measured in OFETs based on the photoirradiated P3HT/rGO (80/20) composite films; this value represented an improvement by approximately 5.0-fold, 1.9-fold, and 2.7-fold relative to those of the OFETs based on pristine P3HT, photoirradiated bare P3HT, and pristine P3HT/rGO (80/20) composite films, respectively (Fig. 2b). Typical p-channel OFET characteristics were observed in transfer (Fig. 2c) and output curves (Fig. 2d) of the devices.

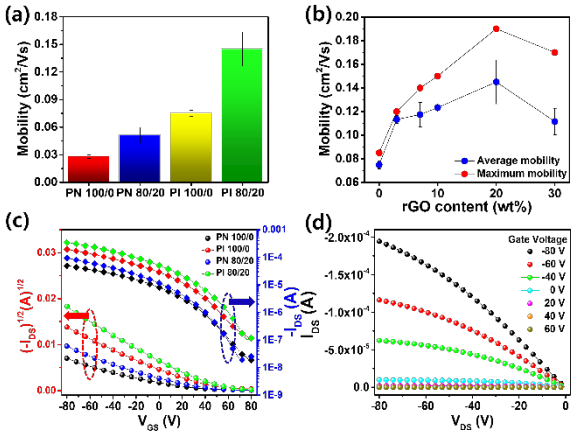


**Figure 1.** (a) Comparison of average charge carrier mobilities. (b) Average and maximum charge carrier mobilities of P3HT/rGO composite films with different rGO contents. (c) Typical transfer curves of the OFETs based on P3HT/rGO composite films. (d) Typical output curve of OFET based on photoirradiated P3HT/rGO (80/20) composite film.

The OFET sensors were utilized to detect acetone, ethanol, and isopropyl alcohol vapors, as shown in Fig. 2. The OFET sensors exhibited good responses to all analytes at concentrations of 10 ppm, as shown in Fig. 2a. High responsivity and rapid response/recovery speed of sensors are essential prerequisites for the detection of analytes [4]. In our study, the recorded drain currents were normalized to systematically estimate the response and recovery times (Fig. 2b). Changes in drain current were recorded by

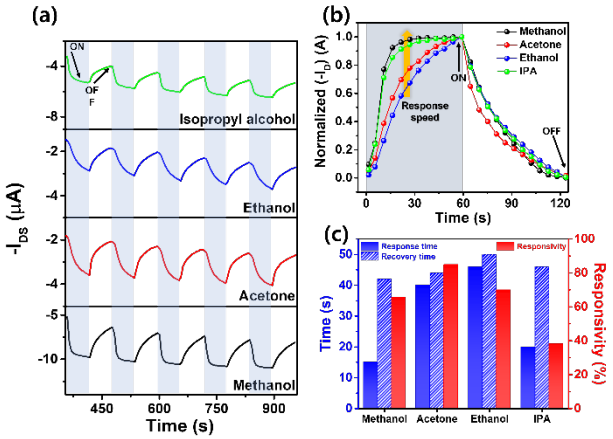


**Figure 2.** (a) Responses and (b) normalized drain currents of the photoirradiated P3HT/rGO (90/10)-based OFET sensors obtained by exposure to 10 ppm of polar VOC vapors. (c) Corresponding response/recovery time and responsivity. The OFET sensor test was performed at a constant voltage ($V_{GS}$ = − 10 V and $V_{DS}$ = − 40 V).

exposing the OFET sensors to 10 ppm of a solvent vapor for 60 s, and subsequently, to pure nitrogen gas for 60 s. The obtained responsivities and response/recovery times are presented in Fig. 2c. The OFET sensors exhibited excellent responsivity to acetone (84.9%), isopropyl alcohol (38.1%), methanol (110.6%), and ethanol (69.9%).

## 4. Conclusions, Significance and/or Future Works

We developed a facile strategy to fabricate P3HT/rGO composite films via the photoirradiation. It was found that rGO and photoirradiation act synergistically to facilitate the molecular ordering of P3HT. In addition, the interfacial interactions between rGO and P3HT in the photoirradiated P3HT/rGO composite films were enhanced compared to those in pristine P3HT/rGO composite films by favorable π–π and electrostatic interactions. In the evaluation of sensing performance, the OFETs based on the photoirradiated P3HT/ rGO composite films exhibited outstanding sensitivity to polar VOCs. The approach presented here can be envisioned as a general strategy to fabricate CP-based nanocomposite films with good charge transport properties and interfacial interactions to develop portable and real-time monitoring OFET sensors for a variety of health and environmental applications.

### References

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