

# Self-assembled Zn-OPV Composite for Ammonia Sensing

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## Abstract:

We have made an effort to demonstrate a simple and facile methodology i.e. electrodeposition for synthesizing oligo(*p*-phenylenevinylene(OPV) and Zn-OPV nanocomposites films. On combining the benefits of the two materials, it is seen that this structure exhibited more sensitive performance for ammonia sensing. The findings of this study showed that fabricating highly sensitive gas sensors with organic-inorganic semiconductors helped to reduce the operating temperature and, also paved way towards a more selective gas sensor.

**Key words:** ZnO, functionalized-organic, hybrid, ammonia, sensing-application.

## Introduction

In the past few decades, gas sensors based on metal oxide semiconductors have drawn much attention for numerous applications such as environmental monitoring, industrial process control, and for the detection of toxic substrates gases. [1,2] Further, the self-assembly of  $\pi$ -conjugated arrangements have paved way towards many interconnected advances in various fields. [3,4] In this perspective, we accomplished our goal of synthesising self-assembled hybrid nanostructures having both electronically active organic (*i.e.* oligo(*p*-phenylenevinylene) (OPV)) and inorganic (zinc oxide (ZnO)) components. One amongst the various noteworthy properties of ZnO, is its rich and precisely accessible nanostructures.[5] Also, the supramolecular architectures of functionalized OPVs, which are driven by hydrogen bonding as well as  $\pi$ - $\pi$  stacking interactions, are highly regarded.[6]

These sensors with nanocomposites have improved the limitations of metal oxide semiconductors based sensors such as high working temperature, low selectivity, etc., and also minimised the thermal instability of organic gas sensors. Zn-OPV based gas sensor has shown high selectivity for ammonia (NH<sub>3</sub>) and operated at a quite lower temperature.

## Experimental details

The hybrid nanostructures were grown by electrodeposition on working electrodes (ITO

coated glass) from zinc nitrate hexahydrate (Zn(NO<sub>3</sub>)<sub>3</sub>·6H<sub>2</sub>O) and surfactant in a solution of 1:1 (v/v) H<sub>2</sub>O/dimethylsulphoxide (DMSO). Prior to electrodeposition, the working electrodes were cleaned with DI water and purged with high-purity (99.999% pure) nitrogen gas. Platinum (Pt) and silver/silver chloride (Ag/AgCl) were used as counter and reference electrodes, respectively.

The crystal structure and the phase composition were identified by RigakuSmartLab automated multi-purpose X-ray diffractometer with Cu-K $\alpha$  X-radiation ( $\lambda = 1.54 \text{ \AA}$ ). The morphology of the crystals was observed by field-emission scanning electron microscope (FE-SEM) by Sigma Supra™55 of Carl Zeiss. The Autosorb iQ2 was used to determine specific surface area using the Brunauer–Emmett–Teller (BET) method based on the N<sub>2</sub> adsorption–desorption tests. Gas sensing properties of the samples were measured in a dynamic flow-through system.

## Results and discussions

The FESEM images of ZnO, Zn-OPV nanocomposite samples are shown in Fig. 1(a) and 1(b) respectively. In Fig. 1(a), deposition of randomly oriented ZnO cone-like structure can be noticed. Fig. 1(b) shows the FESEM of Zn-OPV nano-composite deposited film. Fig 1 (c) shows the operating temperature optimization of the samples. From Fig 1 (c) it is clear that the Zn-OPV hybrid has a lower operating

temperature than ZnO. The optimised operating temperature is around 120 °C. Fig 2(a) shows the response of all the samples towards ammonia ( $\text{NH}_3$ ) at 120 °C. It is clear from the responses that the Zn-OPV samples are more sensitive towards ammonia gas. Calculating the response as  $R_g/R_a$ , it is found that the response of Zn-OPV is approximately 8.5 at 10 ppm of the analyte gas. However, this value is quite low in case of ZnO and OPV individually. Fig. 2 (b) shows transient response of ZnO, OPV and Zn-OPV.

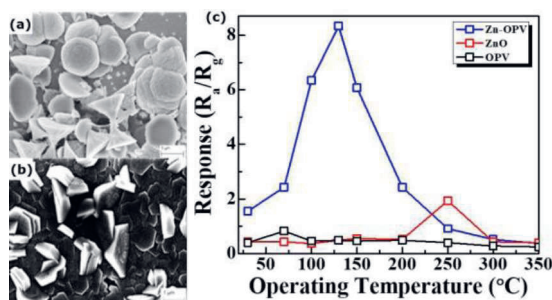


Figure 1: FESEM image of (a) ZnO, (b) Zn-OPV, and (c) variation of sensor response with temperature.

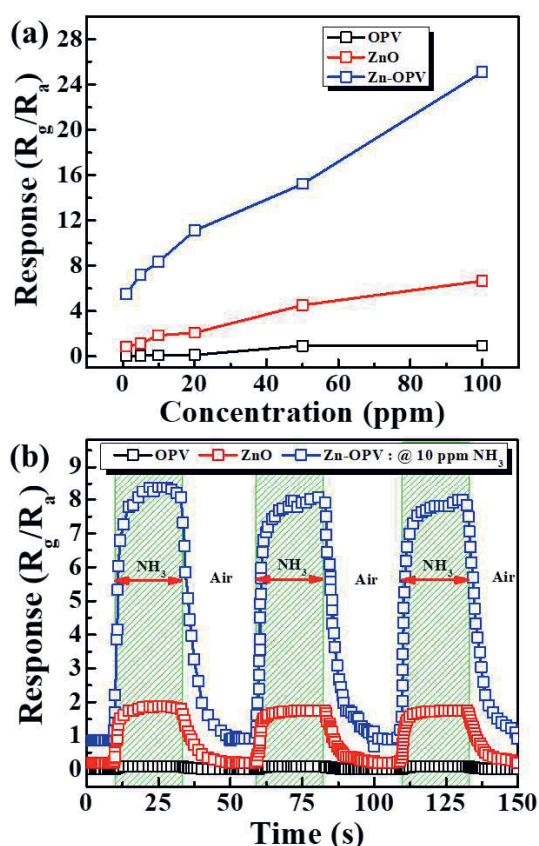


Figure 2: (a) Sensor response towards ammonia gas, and (b) dynamic response at 10 ppm of ammonia.

## Conclusion

In conclusion, we have electrodeposited Zn-OPV nanocomposites films and studied their gas sensing performance. It is seen that the Zn-

OPV composite exhibited more sensitive performance than its individual constituents towards ammonia gas. The findings show that the response of Zn-OPV is approximately 8.5 at 10 ppm of the ammonia. Also, the operating temperature of the composite is lower (120 °C) in comparison to that of ZnO which is ~ 250 °C.

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