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Acetone detection at room temperature by chemical sensors based on PVDF/Al_2O_3 composite

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Detecting and measuring acetone concentrations in the workplace or human body are necessary for our safety and health. When the concentration of acetone in air is higher than 10,000 ppm, people may develop a headache and fatigue. Chemical sensors play a vital role in detecting the presence of hazardous and poisonous gases in the atmosphere. In the present work, a thick film of composite was prepared by using PVDF and Al_2O_3 (PVDAl). Then, the composite's chemical sensing behaviour for acetone vapours were tested by measuring the resistance change of the composite at room temperature. An increase in resistance has been observed with a response time of about ten seconds. The PVDF/Al_2O_3 (PVDAl) composites were characterized by using PXRD, FTIR and SEM. The results show that the thick film of PVDAl omposite can function as a very good gas sensor for acetone vapours.

Keywords: PVDF, polymer composite, Al_2O_3, FTIR, acetone.

Introduction

A chemical sensor is a device that transforms chemical information into an signal and can be used in medicine, home safety, environmental pollution. For preparation of paints, air fresheners, cosmetics and other products VOCs are the fundamental ingredients[1]. Acetone, a colourless and flammable liquid. Monitoring of acetone is very important in the medical field[2,3]. An easy detection of this could improve diagnosis of the disease. Chemical sensing based on semiconducting metal oxides incorporated in the the polymer matrix has been largely proposed for acetone sensing, although some major technical challenges such as high operating temperature still remain unsolved[4–7]. This work presents the development of an chemical sensor based on PVDF/Al_2O_3 composite for acetone detection at room temperature.

Experimental

Preparation of PVDAl composites:

PVDAl composites were prepared by sol gel method[8].

Characterization techniques:

The prepared PVZr composites were characterized by XRD, FTIR and SEM and chemical sensing were performed using digital multimeter.

Results and discussion

The XRD patterns obtained for PVDAl (Fig. 1), reflect their composite nature. However, the peak intensity for β phase of PVDF has decreased as compared to that of Al_2O_3 in the composites as the weight percent of Al_2O_3 increased in PVDF. The average crystallite size is found to be 0.1332 μm.

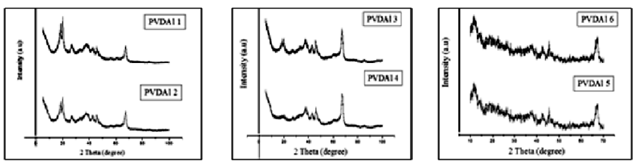

Fig. 1. XRD spectra of PVDAl composites.

The spectrum of PVAl composites show the main characteristic band of PVA at 3710 cm^{-1} is due to O-H stetching. A broad and strong peak at 3222 cm^{-1} is shifted to 3388 cm^{-1} is due to the stretching vibrations of O-H group in the composite. Upon the addition of Al_2O_3 to PVA, the intensity of peaks decreases which in turn decreases the crystallinity of host polymer and favours ionic conduction (FTIR figures now shown here).

The resistance increased until reaching saturation. All the measurements have been done at room temperature. Both the rise time (base line to signal saturation) and the recovery time (saturation back to base line) of about 1000 s have been observed for the response of polymer composite sensors to acetone gas. Two consecutive cycles (Fig. 2) have been performed for the gas sensing for acetone to test the stability of the sensor. It was found that the base line was able to achieve from the recovery at room temperature. The sensor has been tested for a continous two subsequent cycles to test it stability. It was found that the resistance could return to the base line after each cycle[9]. The resistance, responsivenss and sensitivity of the composite-based sensor obtained from the response and recovery curves are summarized in Table 1. The response time of the polymer composite sensor is 10 s. The fast response time may be due to the fast reaction rate between the test gas and adsorbed oxygen. The films exhibited fast response time and recovery time when compared to the reported[10,11].

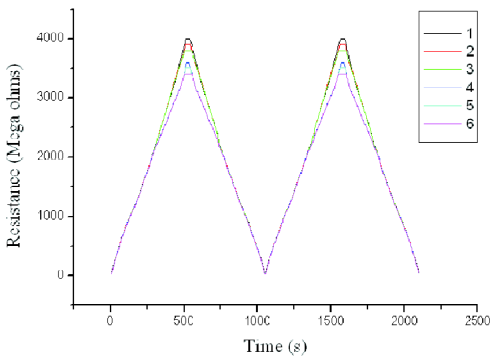

Fig. 2. Response-recovery plots of PVDAl composites to acetone vapour.

Table 1. Sensor response of PVDAl composites to acetone vapour

$PVDF/Al_2O_3$ composites	R_o MΩ (Initial resistance)	R_t MΩ (Maximum steady state resistance)	R_t/R_o (Sensitivity)
PVDAl 1	50	4000	80
PVDAl 2	48	3900	81
PVDAl 3	46	3800	82
PVDAl 4	42	3600	86
PVDAl 5	39	3500	90
PVDAl 6	35	3400	97

Conclusion

The $PVDF/Al_2O_3$ (PVDAl) composites were characterized by using PXRD, FTIR and SEM. An increase in resistance has been observed with a response time of about ten seconds. The results show that the thick film of PVDAl composite can function as a very good gas sensor for acetone vapours at room temperature.

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