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ORIGINAL RESEARCH

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Efficient room temperature methanol sensors based on polyaniline/graphene micro/nanocomposites

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Abstract
The chemically prepared pristine and graphene-doped polyaniline (PANI) samples are utilized for the fabrication of room temperature methanol sensors. For the fabrication of PANI/graphene-based sensing devices, four samples of PANI/graphene composites were prepared with four different concentrations of graphene (2, 4, 6 and 8 wt%). The surface morphology of the prepared composites was analyzed under field emission scanning electron microscopy (FE-SEM), which revealed the agglomerated structures of PANI/graphene composites. X-Ray diffraction studies carried out on these samples revealed the semi-crystalline nature of the samples, whereas, Raman studies confirmed the growth of PANI with the presence of all fundamental bands of PANI in the pristine as well as in its doped state. The prepared PANI/graphene composites devices were tested for alcohol detection at two different concentrations (50 and 100 ppm) of methanol. The change in electric current with the change in environment has been recorded as a sensing parameter and is employed to determine other sensor parameters such as percentage response, response time and recovery time. The sensing response of the prepared samples is found to increase with graphene doping concentration as well as methanol ppm level. The PANI/graphene composite with 8 wt% doping of graphene has shown the highest response (~61.5% at 100 ppm) and the lowest response time (55 s). The mechanism of gas sensing has also been discussed in details with the possible theoretical analogy with the adsorption and desorption of gas molecules in accordance with Langmuir kinetic theory.

Keywords Polyaniline–graphene composites · Methanol sensing · X-ray diffraction · Langmuir kinematics · Adsorption–desorption

Introduction

In recent years, conjugated polymers emerged as alternatives to the conventional materials employed for numerous advanced applications including photovoltaic devices [1], secondary batteries [2], electromagnetic shielding [3], chemiresistors/sensors [4–6], fuel cells [7], batteries [8], capacitors [9, 10], solar cells [11], memory device [12], micro-electronic devices [13], etc., due to their low cost, easy preparation, reasonable high conductivity and environmental stability and the most important of all their easy integration with microelectronic. These wide ranges of applicability of conjugated polymers make them important for commercial as well as scientific fields and thus, provoked a great deal of interest in conjugated conducting materials. These polymeric systems have an excellent capability to host for trapping of metals, highly conducting materials and semiconducting nanoparticles and may act as stabilizers as well as surface capping agents [14, 15]. The electrical, optical and mechanical properties of these materials can be easily tailored through chemical reactions by changing the type and concentration of monomer, oxidizing agents, dopants and the reaction temperature, etc., as per the demand of the particular application.

The discharging of various gases/chemical vapors from different industrials units has raised the serious health concerns in modern society when the peoples come in the direct or indirect exposure to these hazardous gases and organic chemical vapors (alcohol). For example, the exposure to

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