Chapter 22
Chemiresistive Gas Sensors Based on Conducting Polymers

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ABSTRACT

Chemiresistive gas sensor based on conducting polymer is a type of sensors that presents gas sensors with excellent characters; low-cost fabrication, fast detection, simultaneous determination (array gas sensor), portable devices and so. Theses gas sensors are commonly based on polyaniline (PANI), polypyrrole (PPy), polythiophene (PTh) and their derivatives as a transducer. Common configuration and response mechanism of these sensors are reported in this section. Some factors that induce selectivity to these sensors are discussed. Different materials (conductor or insulant) can be used as a substrate of polymerization. Type of substrate, selective membranes, surface modification of conducting polymer and so can change response behavior of these sensors.

INTRODUCTION

Recently, there is very attention to the application of conducting polymers as chemical sensors, biochemical sensors, gas detection devices and other types of gas sensors. Many researchers studied about conducting polymers as a transducer in sensor devices (Arshak, Moore, Lyons, & Clifford, 2004). Conducting polymers (CPs) have some excellent characters like; easy, fast and uniform polymerization, electrical conductance, stability and so. These polymers as a transducer or absorbent in different sensors interact with gas molecules and are used for detection and determination of poisonous and pollutant gasses, so gas sensor based on conducting polymers is used to control air pollution (Freund & Lewis, 1995). Polypyrrole (PPy), polyaniline (PAANI) and polythiophene (PTh) are common conducting polymers that generally possess an extended p-electron conjugation system along with a polymer backbone (Gardner & Bartlett, 1995). These polymers and their derivatives like N -methyl pyrrole, N-Phenyl pyrrole and so as protective materials are used to protect oxidizable metals due to their high electrical conductivity and stability. They are coated on the different substrates like; metals, semimetals, plastics, textiles and so (Mahmoudian, Alias, Basirum, & Ebadi, 2011; Tüken, Tansuğ, Yazıcı, & Erbil, 2007). There are different methods to

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synthesize of these polymers but, chemical synthesis of conducting polymers provided a condition to coat them on the insulant surfaces like textiles and plastics (Redondo, Sa´nchez, Garcı´a, Raso, Tortajada, & Gonza´lez-Tejera, 2001). These polymers have excellent electrical, chemical, thermal and mechanical properties that these properties depend on different parameters, on the other hand, different parameters can change these properties. Many humidities and PH sensors based on conducting polymers are reported, because these polymers resistance is changed in different PH and humidity condition (Skotheim, 1986). Conducting polymers in the other forms were also prepared successfully like; Composites, copolymers and double layers that have a conductive matrix. Copolymers or composites of conducting polymer have different properties than conducting polymer, so chemical, physical, mechanical properties and stability of these polymers are changeable and controllable (Selapinar, Toppare, Akbulut, Yalcin, & Suzer, 1995; Song, Wang, & Yang, 2011). Currently, the focus is on the development of selective sensors for various organic solvent vapors/gaseous molecules. For this purpose, synthesize of CPs in different composites has been developed quickly, because different composite can induce the CPs to grow in certain manners and hence result in CPs with ordered morphology and porosity which will show superior properties, and using of different composites cause to design some selective gas sensor (Matsuguchi, Sugiyama, & Sakai, 2002; Ratcliffe, 1990, pp. 257–262). Surface modification of gas sensors is a method to obtain selective gas sensor based on CPs with excellent chemical characteristics. For this purpose, the nanocomposite of CPs by semi metals and surface modification of CPs by semi-metals have been developed, because semi-metals can induce the selective interaction of CPs and gas samples (Amaya, Saio, & Hirao, 2007; Li, Wang, Cao, Yuan, & Yang, 2008; Do & Chang, 2001). Their poor selectivity and strong interference with humidity are the major disadvantages of conducting polymer based Chemiresistive gas sensors. An array of conducting polymer-based gas sensor is a suitable method to overcome poor selectivity of chemoresistive gas sensors (Ulrich, Nataliya, & Vladimir, 2008).

CONDUCTING POLYMERS

Conducting polymers against conventional polymers possess some metal characters like; magnetic, electrical and optical properties but, have some conventional polymers character like process ability, mechanical properties and so, also called “Synthetic metals or Organic metals” (Bartlett & Ling-Chung 1989). In the most chemical compounds among normal covalent bonds, valence electrons are tightly held and shared between the atoms that these electrons don’t act as a charge carrier (Bhadra & Khastgir, 2008). However, compared to σ-electron the π-electrons are relatively free in double and triple c-c bonds. The interaction of neighboring π-orbitals results in delocalizing of π-electrons in a conjugated double bond system. Thus, π-electrons in the conjugated system can mobile freely over all molecules in the result of π-electron delocalization (Tzamalis, Zaidi, Homes, & Monkman, 2002; Anderson, Mattes, Reiss, & Kaner, 1991; Aphesteguy & Jacobo, 2004).

- The conducting polymer is a type of polymer with a backbone of π–conjugated electrons.
- Upon oxidation and doping, the polymer develops delocalized electrons and conducts electricity.

Polypyrrole (PPy), polyaniline (PANI), polythiophene (PTh) and their composites, copolymers, and derivatives, as conducting polymers have been used in the gas sensor device as the transducer in new recent years (Miasik, Hopper, & Tofield, 1986).