Development of Graphene based Gas Sensor

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Abstract

Now a day graphene is a promising material for the development of high sensitivity sensing system.current status of the intrinsic mechanical properties of graphene along with properties of bulk graphene based nano-composite is thoroughly examine.

Graphene (G) is a two-dimensional material with exceptional sensing properties. In general gas sensor are produced in field effect transistor configuration on several substrate. The role of substrates on the sensor characteristics has not yet been entirely established.Graphene has gather must interest in research in recent years due to its unique mechanical, electrical, chemical & optical properties that can be developed into various applications with noval functionalities. Graphene-based gas sensor has attracted much attention in recent years due to their variety of structure, unique sensing performance, room temperature working conditions & tremendous application prospectus etc.

***Keywords**– Graphene, graphene oxide (GO), reduced graphene oxide (rGO), nano-composite , sensitivity*

1. Introduction

Nanotechnology is a new area of science that involves working with material and devices that are at the nanoscale level. A nanoscale is billionth of a meter that is about 1/80000 of the diameter of human hair it manipulates the physical properties of a substance and molecular level. For a safe and clean environment, it is necessary to pay more attention for the development of gas sensors which can detect minute concentration of toxic, inflammable and harmful gases. A sensor is a device that detects events that occur in the physical environment (like light, heat, motion, moisture, pressure, and more), and responds with an output, usually an electrical, mechanical or optical signal. Today's modern day society has brought numerous luxury items but with them series of health problems like cancer, diabetes, blood pressure, been introduced to our society. Gas leak detection is the process of identifying potentially hazardous gas leaks by sensors. Our objective is to show the amount of pollutant gases emitted from automobile applications. So we need gas sensors that can continuously and effectively detect the harmfull contain to avoid most of the future problems regarding health. Having knowledge about the characteristics of sensing systems also allows us to extract meaningful conclusions with minimal error.

Various researchers have been already reported metal oxides, like TiO_2, SnO_2, etc as better sensing material, but the biggest disadvantages of metal oxides are long term stability. In industrial sector the study of the mechanical properties of graphene based composites is becoming increasingly popular. The discovery of two diamensional (2D) material like graphene, semiconductor transition metal dischalcogenides and 2D insulator have brought exciting predictions for sensing device due to their mechanical, electrical, thermal and surface properties. For instance, graphene based sensing system is in under the intensive discovery since it all area is capable to interacting with surrounding gas; to create graphene is highly sensitive material for gas detection.

1.1 Problem Statement

The aim of the present study is to develop a graphene base sensor for the detection of harmful gases from automobile. This graphene based lab on chip (LOC) will be more suitable for point of care detection. In the present work, along with graphene, metal nanoparticles plays important role for detection of gas due to their high catalytic activity and high affinity towards graphene. Several proof of principle and analytical concepts do exist which suggest graphene materials being extremely valuable tools for sensor applications. The chemically derived variants, i.e. Reduced Graphene Oxide (rGO) provide additional benefits such as: processing in solutions, higher sensitivity for particular analytes, attraction and discrimination effects, as compared to pristine graphene attraction and discrimination effects, as compared to pristine.

1.2 General Information

History has shown that advancements in materials science and engineering have been important drivers in the development of sensor technologies. For instance, the temperature sensitivity of electrical resistance in a variety of materials was noted in the early 1800s and was applied by Wilhelm von Siemens in 1860 to develop a temperature sensor based on a copper resistor, which was first manmade sensor. Gas leak detection methods became a concern after the effects of harmful gases on human health were discovered. Before the development of electronic household carbon monoxide detectors in the 1980s and 1990s, carbon monoxide presence was detected with a chemically infused paper that turned brown when exposed to the gas. Gases detecting and harmful vapors with early warning feature are playing increasingly important roles in many fields, including environmental protection, industrial manufacture, medical diagnosis, and national defense. Meanwhile, sensing materials are of intense significance in promoting the combination properties of gas sensors, such as sensitivity, selectivity, and stability. Around 19^{th} century people were trying to detect the harmful gases which were directly affects on the health. In recent years more interest in the development of analytical devices for detection and monitoring of specific chemical species which leads to the emergence of petrochemical industry. The main reasons are that, some conventional methods are cumbersome and time consuming and not available for remote places. Nodaway “Graphene” has been a “Rising Star” in the field of sensor, owing to its high conductivity, wide potential window and suitability for various modes of sensing and detection. Apart from high conductivity and high catalytic activity, the main reason behind using noble metal for detection is that, they have high surface to volume ratio and high surface energy to provide a large amount of loading of toxic elemental gases. Furthermore, nanoscale noble metals could provide suitable microenvironment for gases immobilization. In graphene based sensor, noble metal could effectively prevent aggregation of graphene and facilitate electron transfer. Therefore graphene based metal nanoparticles used for sensor application.

1.3 Future Prospective

A more comprehensive and in – depth research can be carried out to obtain a clearer picture in the mechanism of gas sensing on screening metal@rGO composite based sensors can be used to identify the specific pattern of the various compound in gas. Further modification and incorporation of gas sensor electrode in Lab on chip (LOC) devices fabrication can be possible.

2. Methodology

There are several methods by which we can synthesize rGO such as thermal reduction or chemical reduction of GO and electrochemical production of rGO. Chemical reduction of GO and electrochemical production of rGO are the two very good methods for mass production The rGO is electrically conductive and has defect sites making it useful for molecular sensors. In this work we report synthesis of GO using modified Hummer’s method and further reduction to rGO using hydrazine hydrate.

2.1 GO Preparation

The first step is conversion of graphite to the sulfuric acid-graphite intercalation compound (GIC), which can be considered as the first intermediate. The second step is conversion of the GIC into the oxidized form of graphite, which we define as “pristine graphite oxide” (PGO), constituting the second intermediate. The third step is conversion of PGO to GO by the reaction of PGO with water. The first step, H_2SO_4- GIC formation, begins immediately upon exposing graphite to the acidic oxidizing medium. The GIC formation is manifested by the characteristic deep-blue color acquired by graphite flakes. In above described method with flake graphite, the stage-1 GIC forms within 3-5 min. The second step, conversion of the GIC into PGO, is significantly slower; it takes several hours and even days depending on the graphite source. After consumption of the $KMnO_4$, all of the flakes sampled from the reaction mixture appeared to be completely oxidized. No dark blue colored areas were detected.

The oxidation mechanism and chemical structure model of GO were proposed. During oxidation process, phenolic groups formed firstly not only at the edges but also on the basal plane of graphene sheets. With further development of oxidation, part of phenolic groups converted to C–O–C or quinone groups, subsequently quinone was transformed into ketone groups and O–C=O accompanied with the formation of CH_2 groups, which destroyed the aromatic structure of GO.

2.2 RGO preparation

To obtain rGO, above suspension was again sonicated for 2 h. Hydrazine hydrate was added drop wise to the exfoliated graphite oxide suspension at room temperature. The reduction was performed at 100 ^{0}C for 1 h. The weight ratio for hydrazine hydrate and GO was maintained at 9:7 for this sample. Resultant black precipitates were filtered by cellulose filter paper and washed with a 1M HCl solution and distilled water to obtain neutral pH. Finally, the filtrate was dried at room temperature for 24h to obtain rGO

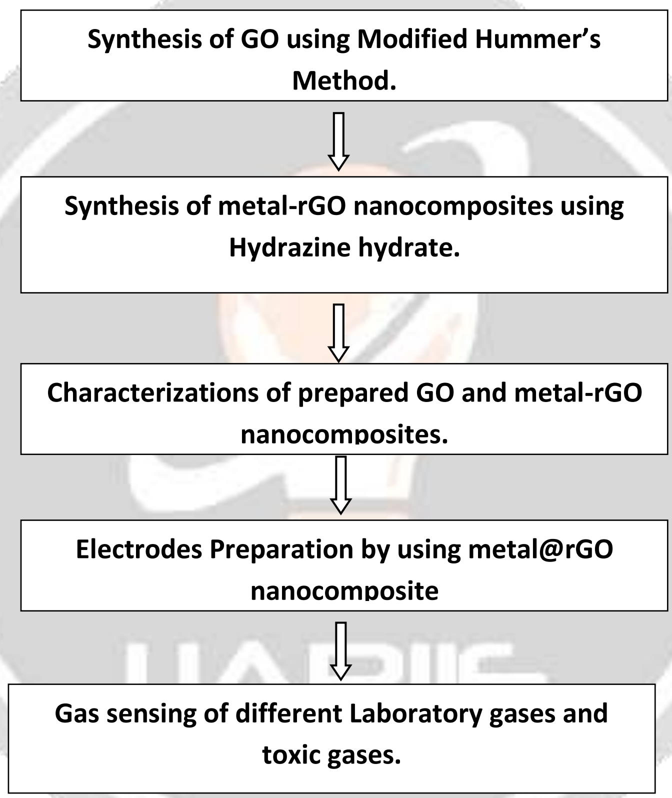

Chart. Flowchart of Synthesis and characterizations of GO and metal-RGO**.**

3. Overview

Carbon, an element in the periodic table with an atomic number of 6, is one of the most abundant elements on Earth. It can exist as amorphous carbon, or as allotropes. Some examples of the allotropes of carbon include diamond and graphite, which has a 3 dimensional (3D) structure, Graphene, which has a 2D structure, carbon nanotubes (CNTs), which have a 1D structure, and fullerenes, which have a 0D structure. Graphene is a two-dimensional material made of carbon atoms, often dubbed "miracle material" for its outstanding characteristics. It is 200 times stronger than steel at one atom thick, as well as the world's most conductive material. It is so dense that the smallest atom of Helium cannot pass through it, but is also lightweight and transparent Graphene, as a new member of carbon family, has emerged as a promising candidate for sensing because of its unique electronic, excellent mechanical, chemical, and thermal properties. Graphite is an abundant and widely available mineral. Due to this, top-down synthesis routes starting from graphite promise easy and scalable access to graphene materials. Graphite consists of many graphene layers held together by weak interplanar forces. One must disturb and break these attractive forces to separate the material and release the individual layers. There are several mechanical and chemical methods to achieve this goal. Chemical methods provide an attractive alternative. The general idea is to insert elements or molecules between the layers of graphite to simply push them apart from each other. One method use oxygen for the intercalation process. In this method, the surface of the graphite layer is oxidized by strong oxidizing agent such as permanganate. The resulting product, graphite oxide, is very hydrophilic which allows the preparation of stable solutions in water. By repetitive dilution, they can be exfoliated to eventually achieve solutions of graphene oxide.

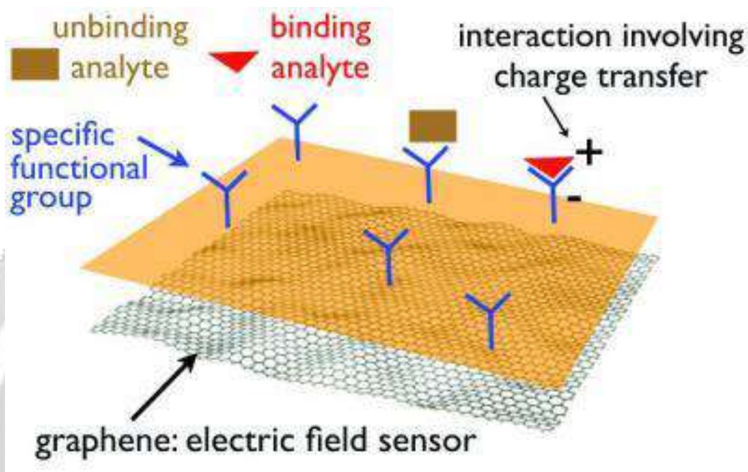

Figure 1. Overview of the different stages on the route to reduced graphene oxide.

4. CONCLUSION

Currently for detection of various toxic gases in petrochemical as well as in automobile industry . Nanomaterial based VOC sensors are the established the importance while developing portable gas sensors. Synthesis of reduced graphene oxide using Modified Hummer's Method by using GO was applied as described by Paulchamy. Reduction of graphene oxide using hydrazine hydrate has been carried out.

5. References

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