Chemically Derived Graphene for the Detection of NO_2

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Since its discovery, graphene was suggested as very sensitive in binding molecules, enabling even the detection of a single molecule [1]. Chemically derived graphene is an interesting candidate for many types of sensors, and in particular for gas sensors. Sensor-based detection of gases is an important task to improve safety and quality of life. Highly sensitive metal oxide based gas sensors are well established and widely implemented [2]. However, they operate at high temperatures (250 - 600°C), which requires excessive energy and degrades their long term stability. In this respect, graphene-based gas sensors may be an inexpensive alternative. Upon gas adsorption, the conductance changes rapidly and with high sensitivity, even when operated at low temperatures (25 - 85 °C).

In this study, graphene was prepared by reduction of graphene oxide (GO), which was obtained by oxidation of graphite (Hummers method) [3,4]. The resulting reduced graphene oxide (rGO) can be dispersed in water, enabling easy transfer to any substrate. Spin coating was determined to be the most effective transfer method, resulting in consistent layers with reproducible quality. To test the capability of rGO as a gas sensor material, the conductivity of rGO modified electrodes was studied in the presence of various gases at ambient conditions. The change in resistivity of rGO coated electrodes upon adsorption of NO_2 allowed a minimum detection of 0.3 ppm (S/N = 3). As synthesized, this material is also sensitive to the detection of other gases, such as CH_4 and H_2. To introduce selectivity, chemical modifications of rGO were implemented by attaching of functional groups and by doping with metals and metal oxides. Functionalization was performed by wet chemical and electrochemical methods. The reversibility and concentration dependence of the sensor was evaluated by continuous adsorption and desorption of NO_2. Many important parameters affecting the sensor properties were investigated. Of these, humidity had the greatest influence on the electrical conductivity changes and reversibility. Therefore, a constant operation temperature of 85°C was used for all measurements (Fig. 1).

Here, it has been shown that rGO is a suitable material for gas sensors due to its high sensitivity, inexpensive synthesis, ease of transfer to a substrate, and selectivity upon functionalization. With proper arrangement of various modified rGO electrodes onto an array, an artificial nose for gas detection could be realized.

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References

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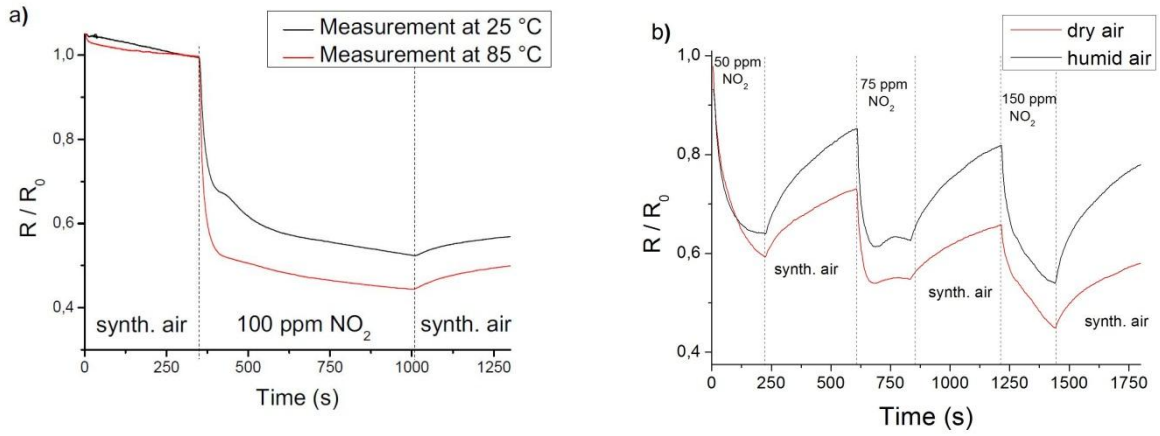
Figures

Figure 1:



Normalized change in electrical resistivity of microelectrodes coated with rGO in the presence of (a) 100 ppm NO_2 at different temperatures and (b) different concentrations of NO_2 with varying humidity.