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A new sustainable green protocol for production of reduced graphene oxide and its gas sensing properties

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ABSTRACT

In this report, we report a green, rapid and scalable synthetic route for the production of reduced graphene oxide (rGO) using an environment-friendly reducing agent (L-glutathione/L-Glu) to test its feasibility for CO & NO_2 gas sensing. The structure, morphology, and thermal stability of as-synthesized rGO are investigated via Raman spectroscopy, Fourier infrared spectroscopy, X-ray diffraction, Field emission scanning electron microscope, and thermal gravimetric analysis. The L-Glu-rGO shows higher sp^2 carbon hybridization (42at.%) than graphene oxide (GO) (29 at.%). The results indicate that L-Glu-rGO exhibits good relative response at 150 °C to both gases (10 ppm of NO_2 and CO). Further, L-Glu-rGO shows a smaller response time (~10.61 s for NO_2 and ~5.05 s for CO) than GO (~16.64 s, ~11.92 s to NO_2 and CO respectively) at 150 °C, indicating the potential application of L-Glu-rGO for gas sensing.

1. Introduction

Exposure to toxic gases puts our everyday life at risk in a commercial and domestic ambiance. This has led to the development of low cost and high performing gas sensors exhibiting a low level of detection for toxic gases to address health issues. Gas sensors perform an important role in various areas viz. agriculture, medical field, electronics, aerospace, etc. Metal oxide gas sensor like Fe_2O_3, SnO_2, In_2O_3, WO_3, ZnO, TiO_2, and MoO_3 [1–9] are the most investigated ones due to their exclusive benefits such as small response time, large range of target gases, long lifetime, high sensitivity, cost efficiency, but suffer from issues such as long-term stability, and high operating temperature [10]. Nanotechnology gives liberty to cultivate the next generation gas sensing layers with improved sensitivity, selectivity, fast recovery, and smaller response time for a small concentration of gas [11]. Surface area is one of the favorable parameters which decides the sensitivity of any material. Graphene is a material contains one atom thick layer of sp^2 hybridized carbon atom, which is reported to give promising results in sensing applications due to its intrinsic electrical properties and having large surface area resulting from its nanostructure.

Graphene has been widely used for gas sensing, in energy storage devices [12,13], as transparent conducting electrode [14], in electrochemical sensors [15], ultrafiltration application on account of its unique properties *viz.* very high mobility-200,000 $cm^2 v^{-1} s^{-1}$, mechanical stiffness -1060 GPa, excellent light transmittance -97.7%, large surface area-2630 $m^2 g^{-1}$, and thermal conductivity -5000 $W m^{-1} k^{-1}$ [16–18].

The graphene derivative, graphene oxide (GO), containing carbon, hydrogen, and oxygen in a varying ratio is hydrophilic and biocompatible in nature and is used in energy storage, as a biosensor, for disease detection, etc. GO is a starting point for the synthesis of high quality, cost-efficient, and large yield graphene. Reduced graphene oxide (rGO) is the best-known material as graphene derivative, having the same configuration and properties like pristine graphene, hence is suitable for electronic devices.

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