Fabrication of QCM sensor based on graphene oxide/TiO_2 nanocomposite for the detection of gases at room temperature

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Among gas sensing researchers, there is a growing interest to improve the functionality and handiness of sensor devices while applying innovative methods and simple materials. So far, metal oxides have provided a platform for gas detection at small concentrations. Amongst them, TiO_2 has been explored for advanced gas sensors based upon different parameters to detect different gas species. Moreover, graphene and its chemically modified forms attract keen interest in science and technology due to its sheet surface, which provides a good candidate for attached particles and also may become an ideal sensing platform because of potential hydrogen bonding and π- π stacking interactions. The aim of this study is to construct a room temperature gas sensor based on quartz crystal microbalance (QCM) containing graphene oxide (GO) / TiO_2 composite sensor layers.

The oxidised graphite was obtained according to the modified Hummers method. TiO_2 particles were deposited in aqueous GO solution using liquid phase deposition (LPD) technique. The composite was deposited on the gold-coated QCM resonator (5 mm ø, 9 MHz) by spin coating method. Initial experiments were carried out using ethanol vapour which was obtained by injecting known volumes. N_2 gas was passed through the chamber until the frequency difference became stable. All experiments were carried out at room temperature.

The sensing performance of functionalized QCM resonators was examined by changing EtOH concentration from 8333 ppm – 218 ppm. All responses obtained were similar in shape, and the response of QCM resonator decreased proportionally to the concentrations. The adsorbed amount of EtOH over the composite functionalized QCM varied from 0.172 μg to 0.08 μg. This preliminary results denoted that GO/TiO_2 composite has a significant response to EtOH over GO and TiO_2 individually. When 4167ppm EtOH gas was exposed to the functionalized QCM sensor with GO, TiO_2 and GO/TiO_2 composite of different GO ratios, most favourable sensitivity was obtained for 30% GO (w/w) in the precursor solution. Further, sensitivity range of functionalized QCM resonator (GO w/w=30%) for EtOH vapour was expanded from 218 ppm to 21 ppm. Upon exposure to acetone, toluene, acetonitrile, chloroform and ammonia gases, highest response was obtained by ammonia whereas lowest was shown by toluene gas. SEM, TEM and XRD characteristic data of the composite revealed the formation of anatase TiO_2 on GO sheets through bridging and wrapping of the particles. According to XPS and EDX, during LPD of TiO_2 on GO, concurrently somewhat of fluorine and boron have also bonded to the composite. This may be the reason for obtaining the most favorable composite as 30% GO (w/w) in the precursor solution even though 50% GO (w/w) showed the highest surface area according to BET isotherm.