Sol gel graphene/TiO2 nanoparticles for the photocatalytic-assisted sensing and abatement of NO_2

Andrea Giampiccoloa[1], David Maria Tobaldi[2], Salvatore Gianluca Leonardi[3], Billy James Murdoch[1,4], Maria Paula Seabra[2], Martin P. Ansell[1], Giovanni Neri[3], Richard J. Ball[1]

1 — BRE Centre for Innovative Construction Materials, University of Bath, Bath, UK
2 — Department of Materials and Ceramic Engineering, CICECO – Aveiro Institute of Materials, University of Aveiro, Portugal
3 — Department of Engineering, University of Messina, Italy
4 — NEXUS, Newcastle upon Tyne, UK

Outdoor air pollution adversely affects human health and is estimated to be responsible worldwide for severe health problems. Nitrogen oxides (NO_x) are common (indoor and outdoor) anthropogenic air pollutants. NO_x emissions come from the combustion processes in stationary and mobile units, thus they are commonly related to traffic-sources. As such, NO_x are related to several short- and long-term health effects, even to carcinogenity. Simultaneous sensing and abatement are approaches which could both neutralise and monitor these species, providing a safer environment and warning occupants of harmful NOx levels. In this work, graphene/TiO_2 hybrids were synthesised via a sol-gel route. This led to an intimately mixed composite material (Figure 1a). Under UV-vis photo-excitation generated by a low power LED, the graphene/TiO_2 hybrid sensor prepared in this work showed a remarkably enhanced response to 1750 ppb NO_2, about double the response in the dark, and a limit of detection of about 50 ppb of NO_2 (Signal/Noise=3), Figure 1b. Our material, excited by the same wavelength, was also able to photocatalytically neutralise NO_x gases at indoor concentration levels. The significant improvement in sensitivity and photocatalytic at room temperature under the UV–vis excitation was attributed to higher surface area (smaller particle size), and to the increase in the separation of the photogenerated exciton compared to unmodified TiO_2. This makes our material very much suitable for multipurpose environmental applications, offering a safer environment through providing a warning of the presence of NO_x whilst also reducing their levels.

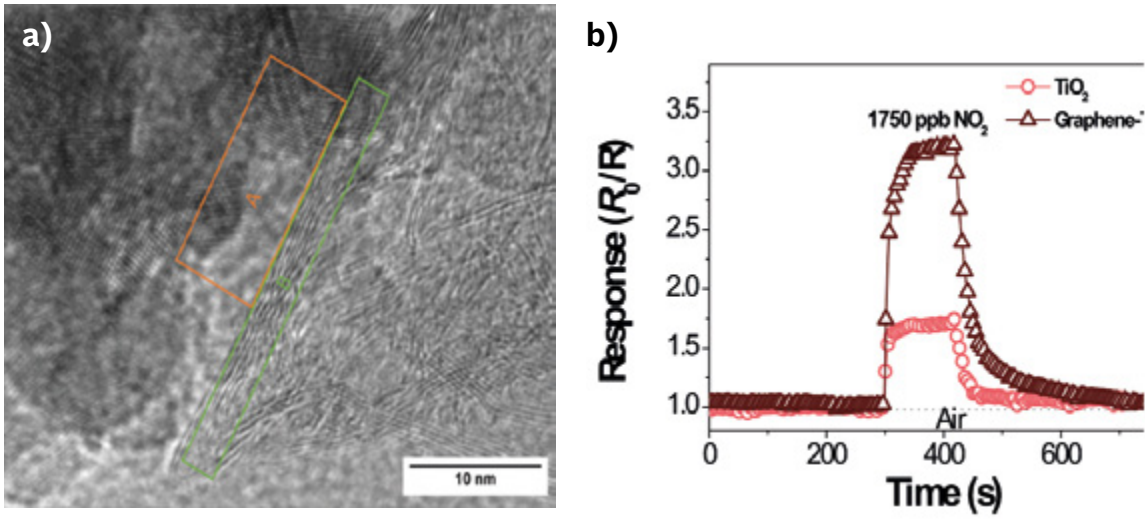

FIGURE 1
a) TEM micrograph showing the interface of atomic planes of TiO2 [A box], and graphene flake [B box].

b) response, under UV excitation, to 1750 ppb of NO2 of the synthesised TiO2 and graphene/TiO2 hybrid.