



HAL
open science

Chemical sensor based on carbon nanotube combined to a pre-concentrator nanoporous layer for the detection of benzene

Eva Grinerval, Frank James, Dominique Porterat, Farhad Abedini, Marie-Pierre Som, Thu-Hoa Tran-Thi, Martine Mayne-L'Hermite

► To cite this version:

Eva Grinerval, Frank James, Dominique Porterat, Farhad Abedini, Marie-Pierre Som, et al.. Chemical sensor based on carbon nanotube combined to a pre-concentrator nanoporous layer for the detection of benzene. *Carbon* 2019, Jul 2019, Lexington, United States. cea-02328549

HAL Id: cea-02328549

<https://cea.hal.science/cea-02328549>

Submitted on 23 Oct 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Chemical sensor based on carbon nanotube combined to a pre-concentrator nanoporous layer for the detection of benzene

Eva Grinerval¹, Frank James¹, Dominique Porterat¹, Farhad Abedini², Marie-Pierre Som²,
Thu-hoa Tran-Thi¹, Martine Mayne-L'Hermite¹

¹NIMBE, CEA, CNRS, Université Paris-Saclay 91191 Gif-sur-Yvette, France,

²ETHERA, 628 rue Charles de Gaulle, 38920 Crolles, France

Corresponding authors e-mail addresses: martine.mayne@cea.fr

Over the years, great effort has been made to use carbon nanotubes (CNT) as gas sensing materials with high specific surface area for detection of gases [1, 2]. Our objective is to design and optimize a chemical sensor based on CNT whose sensitivity arises via coupling with a pre-concentration nanoporous silica layer. The detection mechanism is based on the resistance change of CNT upon gas exposure which is due to the p-type semiconducting behavior of the CNTs [3]. Our choice of nanoporous silica as pre-concentrator for the sensor is based on previous work that has shown the ability of various thick nanoporous silica matrices to trap benzene and toluene over the ppb to ppm range [4]. Here we will show that it is possible to use a thin layer of functionalized silica as pre-concentrator to trap and concentrate benzene and toluene at the vicinity of CNT.

The MWCNTs were covered with a nanoporous SiO₂ layer whose function is to concentrate the pollutant in order to enhance the sensor performances. We will describe the preparation of the sensor and highlight the beneficial effects of both the pre-concentration layer and the operating temperature. Thus, the mechanism involved with the functionalized silica layer will be discussed. MWCNT/SiO₂-based sensors operated at 125°C are able to detect 10 ppb of benzene in air. These results underline the potential of this MWCNTs/SiO₂ hybrid material for the detection of indoor and outdoor air pollutants. Recent developments have also demonstrated that this technology can be integrated into a prototype device.

References

- [1] D.R. Kauffman, A. Star, Carbon Nanotube Gas and Vapor Sensors, *Angewandte Chemie International Edition* 47 (2008) 6550-6570
- [2] I. V. Zaporotskovaa, N. P. Borozninaa, Y. N. Parkhomenkob, L. V. Kozhitovb, Carbon nanotubes: Sensor properties. A review, *Modern Electronic Materials* 2 (2016) 95–105
- [3] A. Gohier, J. Chancolon, P.Chenevier, D. Porterat, M. Mayne-L'Hermite, C. Reynaud, Optimized network of multi-walled carbon nanotubes for chemical sensing, *Nanotechnology* 22 (2011)
- [4] L. Calvo-Muñoz, T-T. Truong, T-H. Tran-Thi, Chemical sensors of monocyclic aromatic hydrocarbons based on sol-gel materials: kinetics of trapping of the pollutants and sensitivity of the sensor, *Sensors and Actuators B: Chemical* 87 (2002) 173-183