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ELABORATION OF MINIATURE POLYISOPRENE-NANOSTRUCTURED CARBON COMPOSITE FOR VOLATILE ANALYTE DETECTION

G.Sakale[1], M.Knite[1], V.Teteris[1], I.Klemenoks[1], V. Tupureina[2]

[1]Institute of technical physics, Riga Technical University
[2]Department of Polymer Materials, Riga Technical University
Azenes str.14, Riga LV1048,Latvia

Previously made experimental results indicate that PNCC composite material electric resistance increases remarkably, when the composite is exposed to organic solvents vapour (OSV). PNCC composition was: matrix material – polyisoprene; filler – 10 mass parts of carbon black nanoparticles (PRINTEX XE2 specific surface 950 m^2/g, mean diameter of primary particles 25 nm, DBP absorption 380 ml/100g)). PNCC electric resistance increase can be described as follows: when the composite is exposed to OSV, molecules of vapour adsorbs on the surface of PNCC and diffuse into the composite matrix, distance between aggregates made by carbon black nanoparticlles increases, tunnelling currents between carbon aggregates decreases and composites electric resistance increases. The composite is tested to 10 different OSV, results are reported elsewhere [1]. These results were obtained using bulk-nanostructured composite material with dimensions: 50 x 5 x 1(0,4; 0,3; 0,2) mm. Elaborating miniature PNCC composite material we obtain several benefits: (i) increased composite material response to volatile analyte, (ii) reduced electric resistance relaxation time (iii) PNCC can sense lower OSV concentrations limits and (iv) much easily completing of the samples into electronic detection device.

From electric resistance measurements with miniature PNCC sample (see Fig.1) we observed exponential electric resistance response increase versus time (instead of linear increase us for bulk PNCC samples) and saturation of relative electric resistance change at the final of measurements.

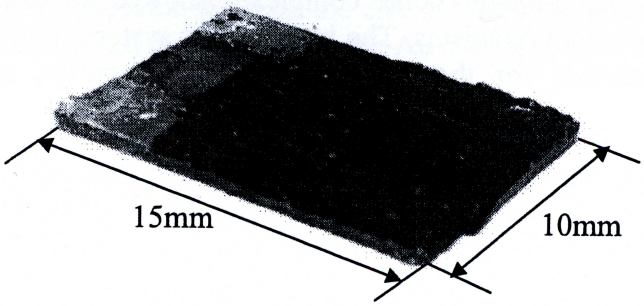

Fig.1. Miniature PNCC sample dimensions (thickens of the film is approximately 75μm).

References

1. M. Knite, K. Ozols, G. Sakale, V. Teteris. Sensors and Actuators B, **126**, 209–213, (2007).

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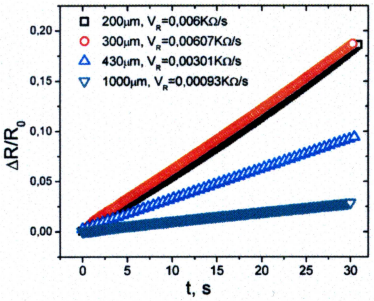
e-mail of presenting author: gitasakale@inbox.lv

INTRODUCTION



Previously made polyisoprene-nanostructured carbon composite (PNCC) samples testing for organic solvent vapour (OSV) sensing showed that PNCC electric resistance increases remarkably and linearly when samples are exposed to organic solvent vapours (see Figure 1). PNCC organic solvent vapour sensing effect is reversible, when a sample is removed from vapour in the air, it's electric resistance returns to initial resistance of the sample.

PNCC electric resistance increase is described as follows: when the composite is exposed to OSV, molecules of vapour adsorbs on the surface of PNCC and diffuse into the composite matrix, distance between aggregates made by carbon black nanoparticles increases, tunnelling currents between carbon aggregates decreases and composites electric resistance increases.

Fig.1. PNCC electric resistance change ($\Delta R/R_0$) for samples with length 50mm, width 5mm and thickness from 1mm to 0,2mm. Toluene vapour concentration 108,69ppm. V_R denotes electric resistance change velocity.

PRODUCTION OF MINIATURE PNCC SENSING ELEMENT

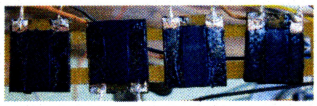
1. Magnetic stirring for 24 hours of chloroform/ polyisoprene - carbon black solution

2. Immersion of textolite with copper electrods into chloroform/polyisoprene - carbon black solution. Immersion were repeated 6 times for each sample with interval 15 minutes.

3. Vulcanization process of obtained samples under 30atm pressure, at 150°C for 15minutes.

4. Evaluation of PNCC organic solvent vapour sensor effect.

RESULTS AND CONCLUSIONS



Miniature PNCC vapour sensing elements with dimensions 10x15x0,09mm.

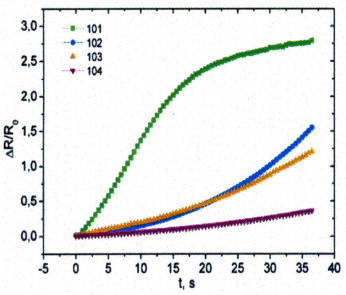


Fig.2. Four parallel PNCC sample electric resistance change ($\Delta R/R_0$) versus time(t), when samples are exposed to toluene vapour with concentration 108,69ppm.

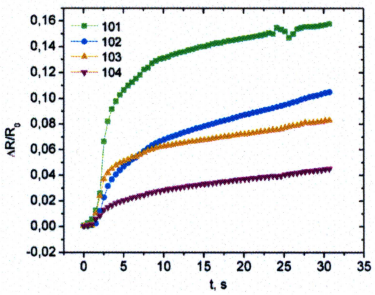


Fig.3. Four parallel PNCC sample electric resistance change ($\Delta R/R_0$) versus time (t), when samples are exposed to acetone vapour with concentration 108,69ppm.

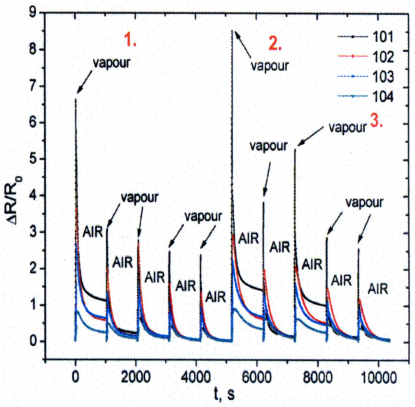


Fig.4. Four parallel PNCC sample electric resistance change ($\Delta R/R_0$) versus time(t), when samples are repeatedly exposed to toluene vapour with concentration 108,69ppm for 30s and after that hold in air till electric resistance of the samples remain unchanged. Red numbers 1., 2. and 3. indicate fill up of exsiccator with toluene vapour.

1. Reducing dimensions of PNCC, we have obtained OSV sensing element with **extreme sensitivity**. But at the same time samples produced in the same conditions exhibit rather different electric resistance change in vapour. There is indefinite whether different PNCC samples response to vapour is due to polyisoprene adhesion difficulties to copper electrodes or due to unhomogeneous distribution of carbon black nanoparticles in the comosites matrix material. We are going to solve this uncertainty in future experimental work.
2. From obtained results we can conclude that PNCC response to toluene vapour are reproducible if we except from Fig. 4 points 1., 2. and 3., which denote filling up of exsiccator with toluene vapour.
3. We have twice reduced electric resistance relaxation time of PNCC, typical electric resistance relaxation time of miniature PNCC samples after exposure to toluene vapour are ~1000 seconds for all tested samples.

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