

European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

WGs Meeting, Belgrade, 13 - 14 October 2015

organized by VINCA Institute and co-organized by Public Health Institute of Belgrade

hosted by Faculty of Mechanical Engineering, University of Belgrade

Action Start date: 16/05/2012 - Action End date: 30/04/2016

Year 4: 1 July 2015 - 30 April 2016 (*Ongoing Action*)

VOLATILE ORGANIC COMPOUNDS SOURCE OF INFORMATION



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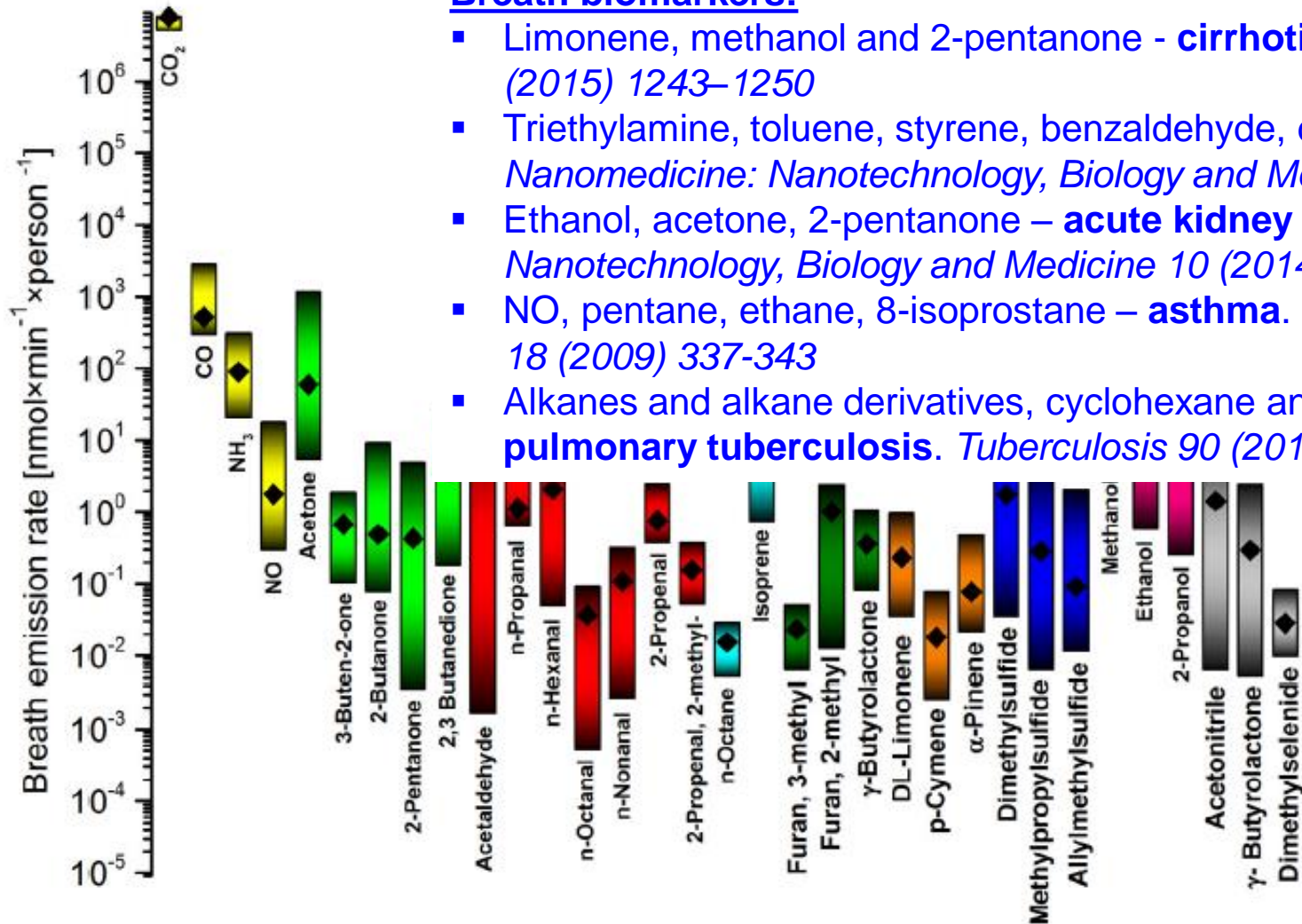
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 **cost**
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY



VOC in medicine



Breath biomarkers:

- Limonene, methanol and 2-pentanone - **cirrhotic liver**. *EBioMedicine* 2 (2015) 1243–1250
- Triethylamine, toluene, styrene, benzaldehyde, decanal – **lung cancer**. *Nanomedicine: Nanotechnology, Biology and Medicine* 9 (2013) 758-766.
- Ethanol, acetone, 2-pentanone – **acute kidney injury**. *Nanomedicine: Nanotechnology, Biology and Medicine* 10 (2014) 1767-1776.
- NO, pentane, ethane, 8-isoprostane – **asthma**. *J Gastrointest Liver Dis.* 18 (2009) 337-343
- Alkanes and alkane derivatives, cyclohexane and benzene derivatives - **pulmonary tuberculosis**. *Tuberculosis* 90 (2010)145-51.

P. Mochalski et al./Trends in Analytical Chemistry 68 (2015) 88–106

VOC in food industry

1. Smart/intelligent packaging



The OnVu™ indicator changes its color.

Indicator for frozen goods (cold chain interruption)

http://www.onvu.com/?page_id=16

Journal of Colloid and Interface Science 363
(2011) 1–24

Freshness/shelf-life

Detection of microbial action

2. Food/beverage processing

- Fermentation process monitoring in beverage industry (2,3-Butanedione; 2,3-Pentanedione; t-2-Nonenal; Dimethyl Sulfide)
- Beer aging and photodegradation

Food Chemistry 141 (2013) 1055–1062

3. Aroma/flavor control

- If raw materials are changed, will it meet the same flavor?
- Alcohols/esters ratio key to beer aroma balance
- Off flavor analytes: 1-octen-3ol – mushroom odor; diacetyl (2,3 butanedione) – butter flavor

Trends in Food Science & Technology 22 (2011) 165 - 174

VOC in air quality control



- One of air pollutants → forms ozone at air-ground interface;
- Increased health risks at work environment;
- Explosive and highly flammable.

Legislation

- EU regulation on ambient air quality and cleaner air for Europe (benzene);
- US Occupational Safety and Health Administration (TWA, PEL, IDLH, STEL).

VOC	TWA, ppm	STEL, ppm	IDLH, ppm
Toluene	100	150	500
Acetone	250	-	2500
Ethyl acetate	400	-	2000
Benzene	0.1	1	500
Formaldehyde	0.016	0.1	20

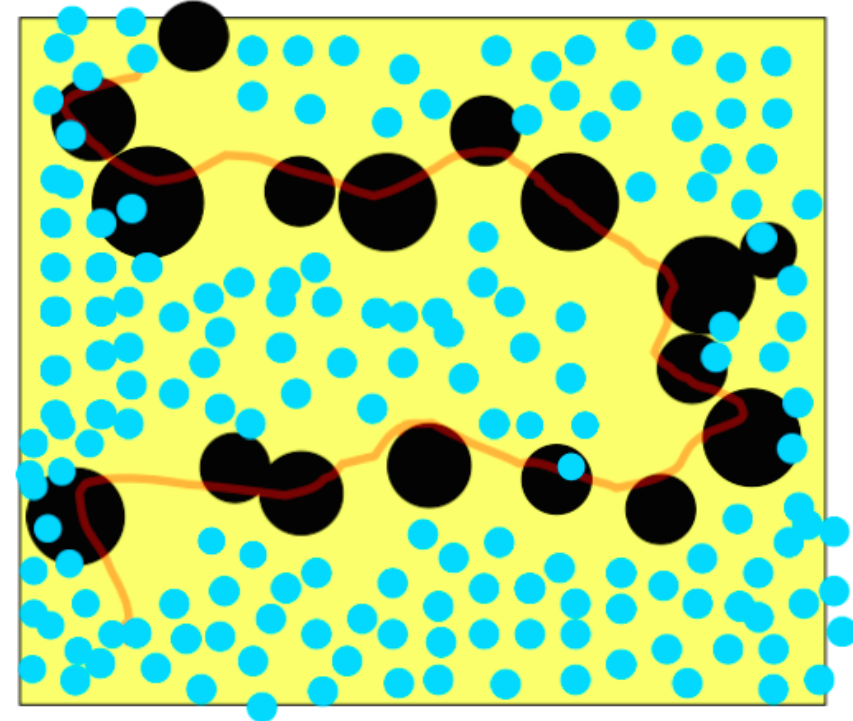
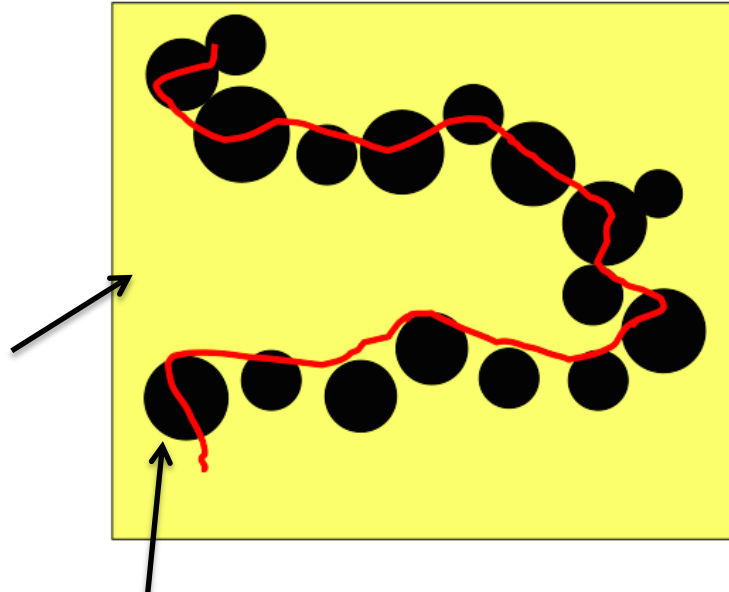
Polymer based VOC sensors. Sensing principle

After exposure to VOC

Before exposure

Polymers:

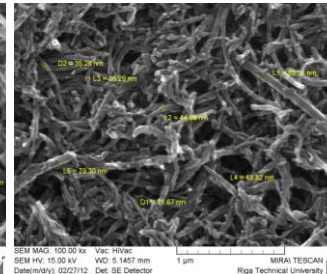
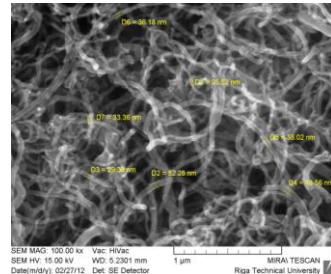
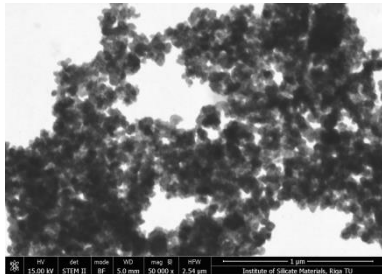
- polyisoprene (Pi)
- Ethylene-vinyl acetate (EVA) copolymer
- Silicon rubber



Conductive filler:

Carbon nanoparticles (CB)

Multi wall carbon nanotubes

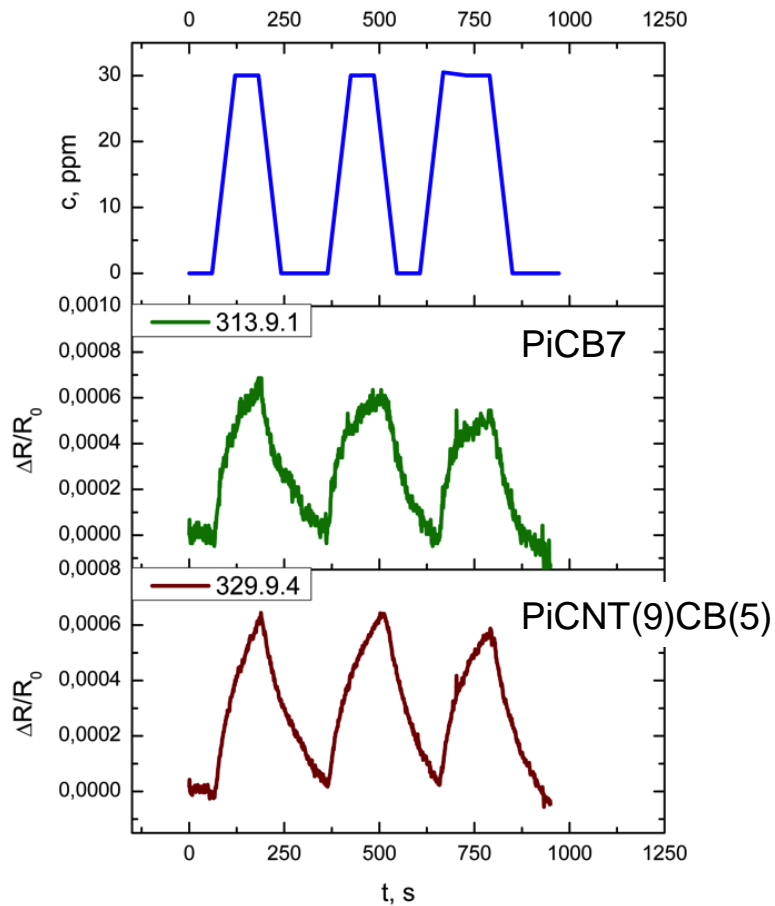


$$\frac{R}{R_0} = \frac{s}{s_0} \exp[\gamma(s - s_0)]$$

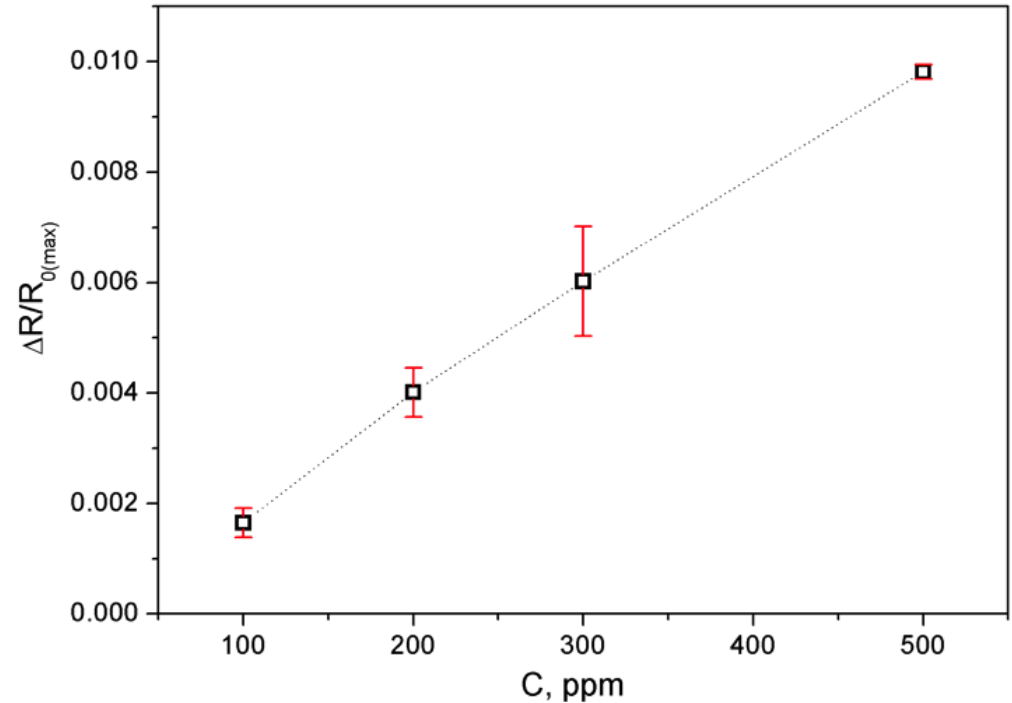
G. Sakale, D. Jakovlevs, I. Aulika, M. Knite
J. Nano Res. 21 (2013)



Polyisoprene based nanocomposites

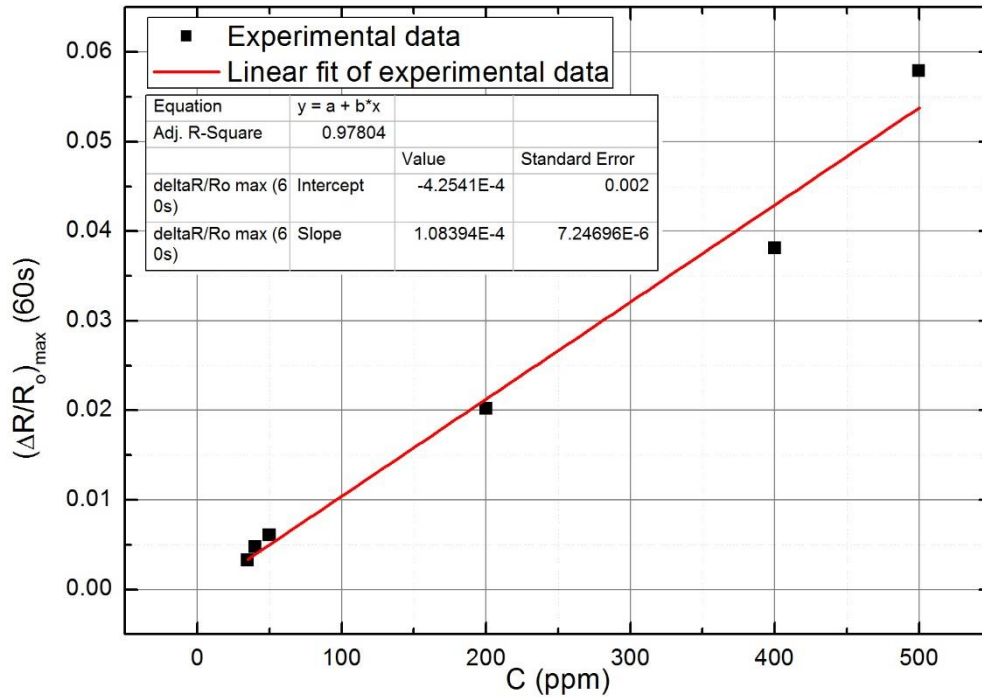


PiNCC response to toluene 30ppm, exposure time 60s. Carrier gas N_2 .

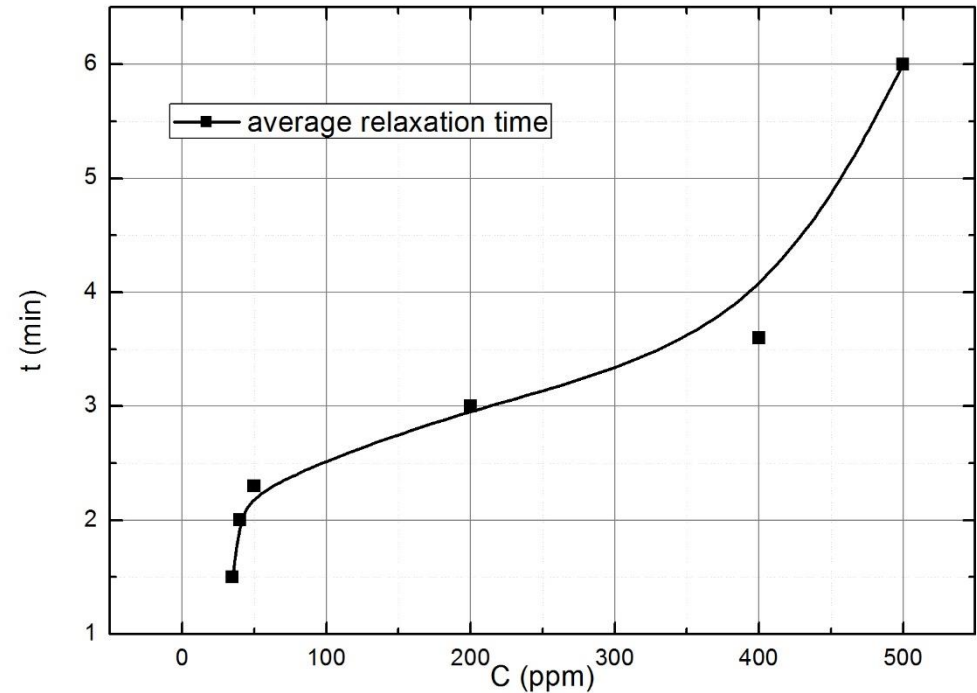


PiCB8 response versus toluene concentration, exposure time 60s.

Ethylene-vinylacetate based nanocomposites

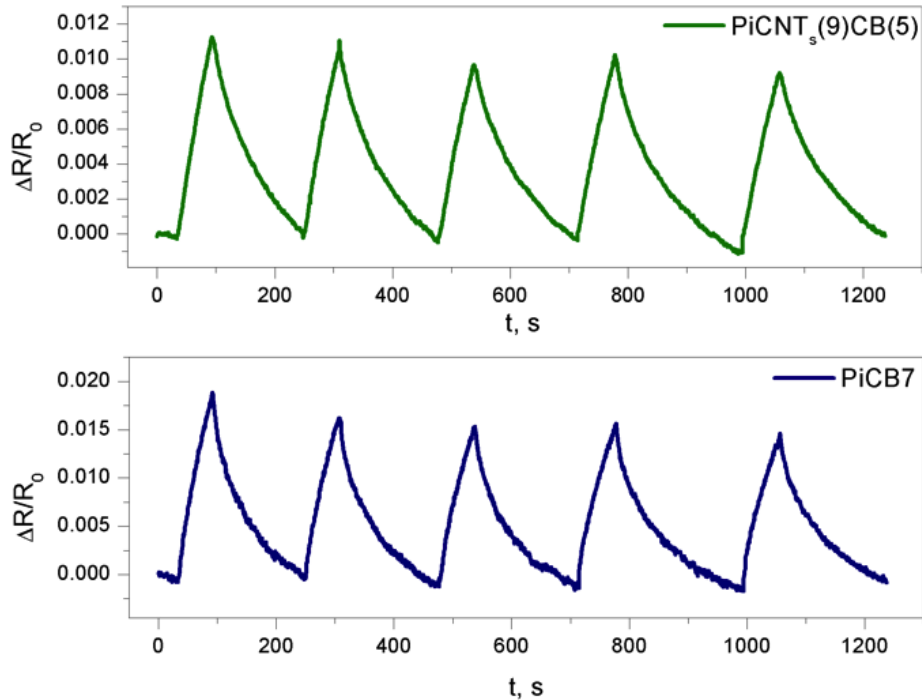


EVACB7,75 maximal relative electrical resistance value at 60 seconds versus toluene vapour concentration.

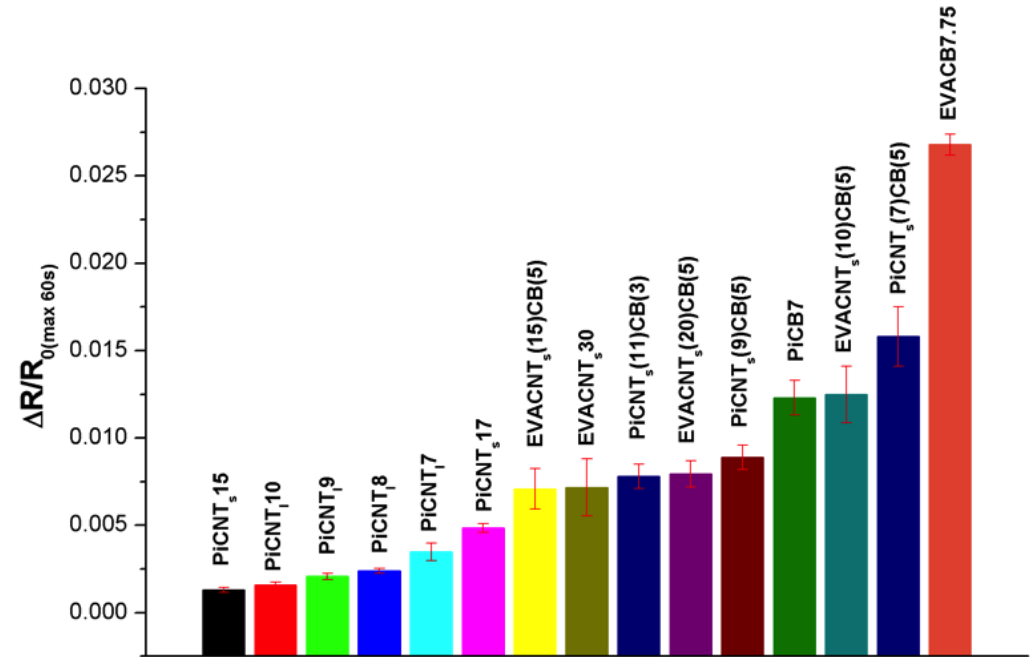


EVACB7,75 recovery time versus toluene vapour concentration (60s).

Comparison of different compositions

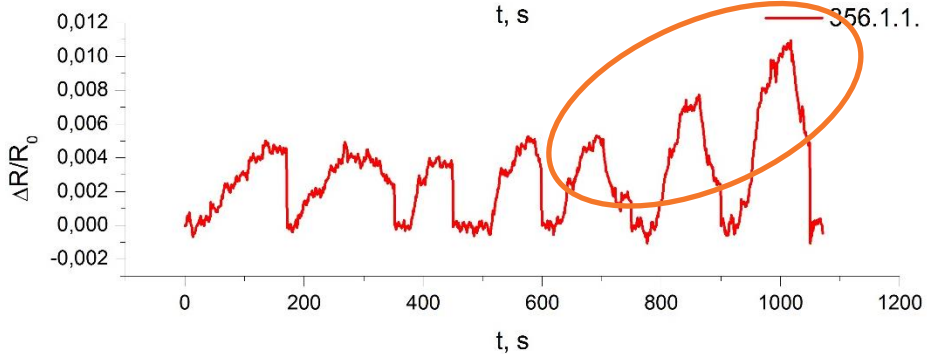
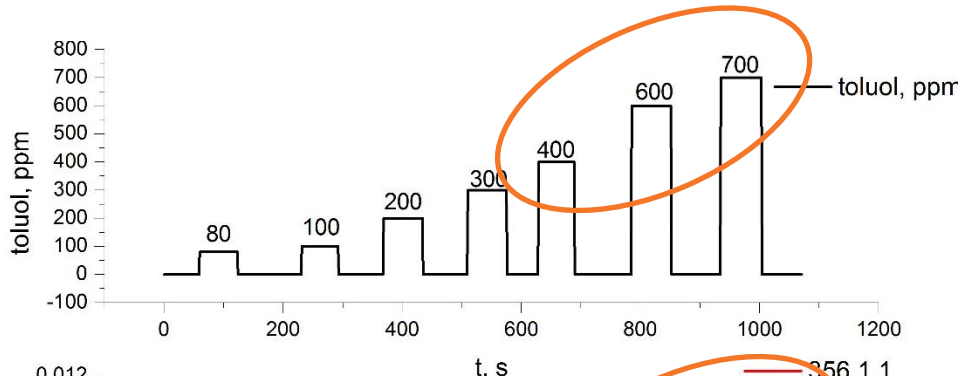
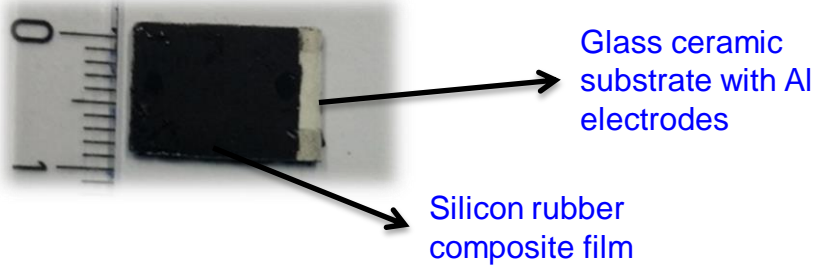


PiNCC relative electrical resistance change vs. time, exposure time 60s toluene 400ppm.

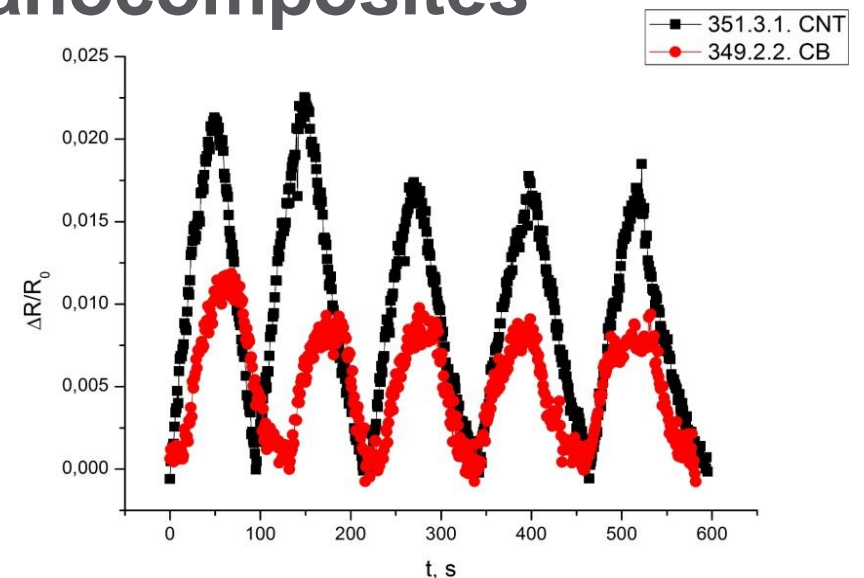


Average max relative electrical resistance change for different composite compositions.

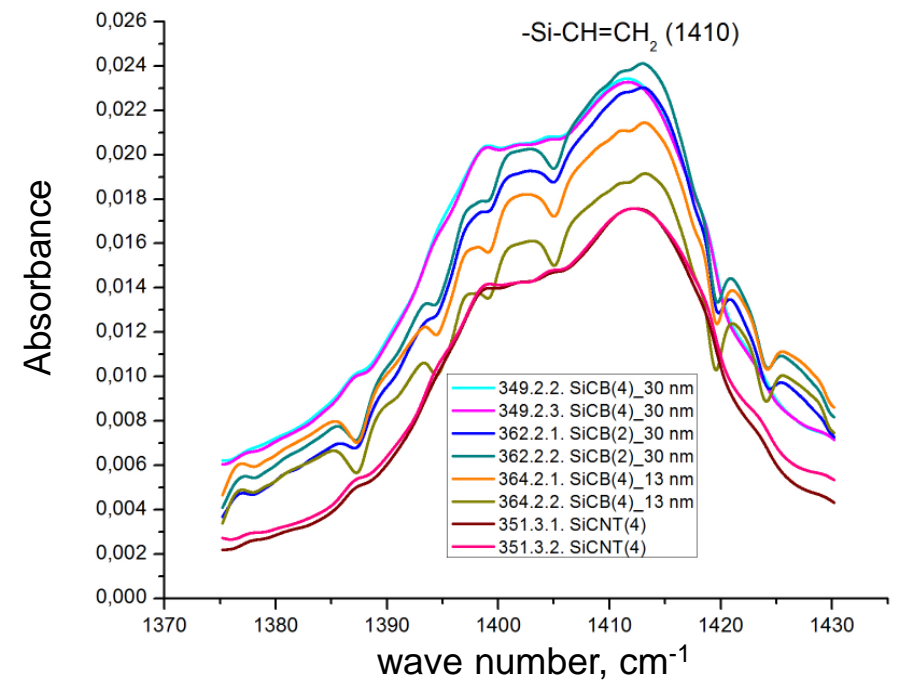
Silicon rubber based nanocomposites



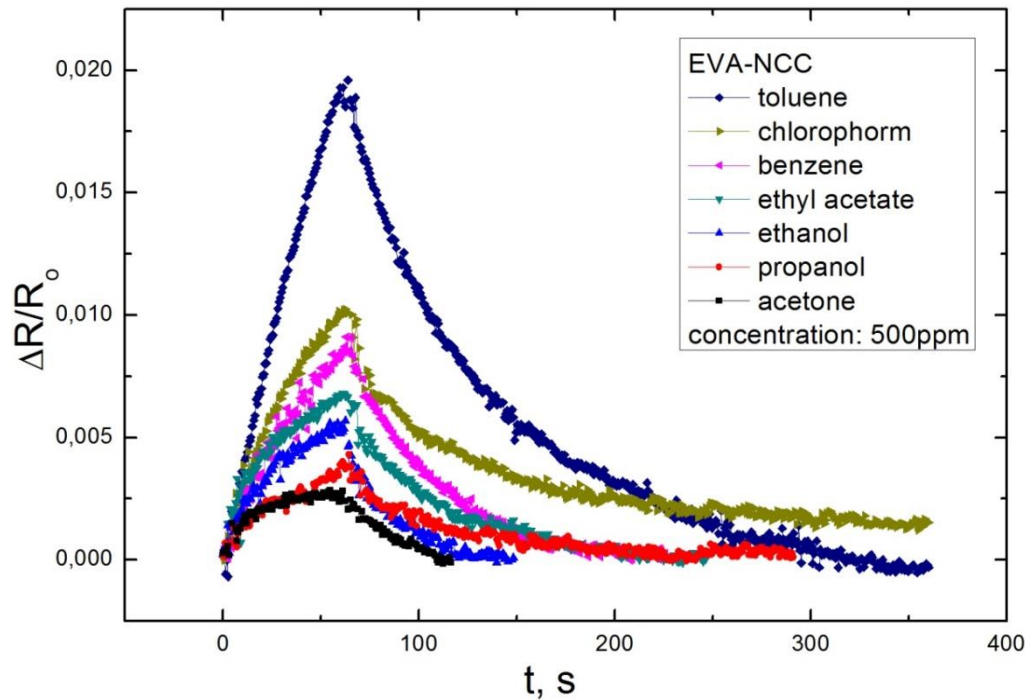
Silicon rubber composite with CB response to different concentrations of toluene.



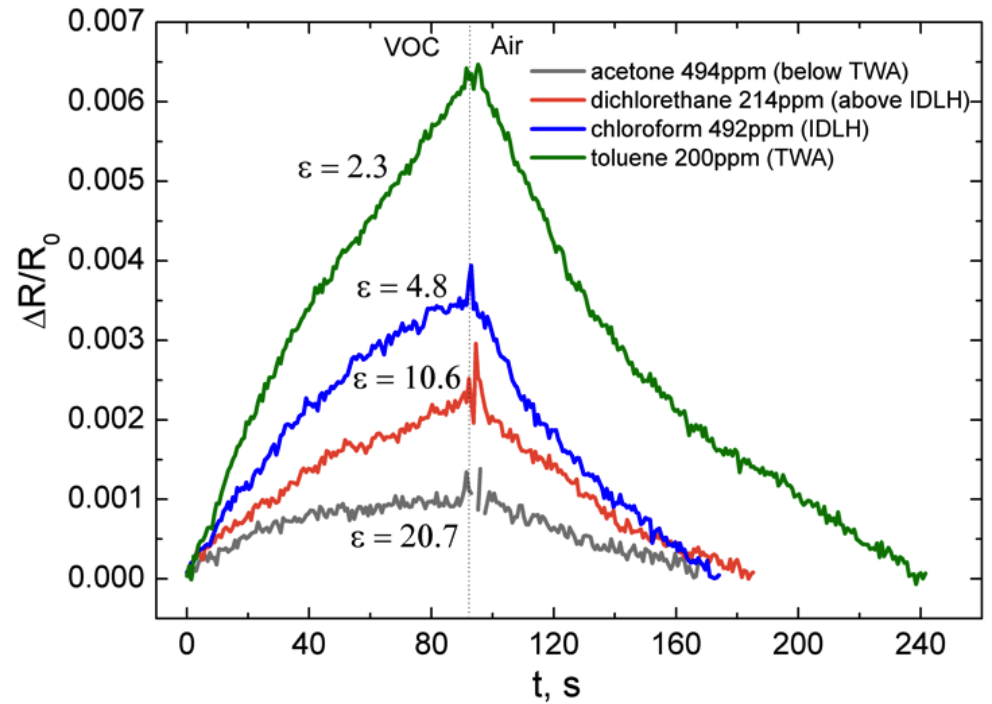
Relative electrical resistance change of silicon rubber composites with CB and SMWCNT in toluene vapours (800 ppm).



Selectivity

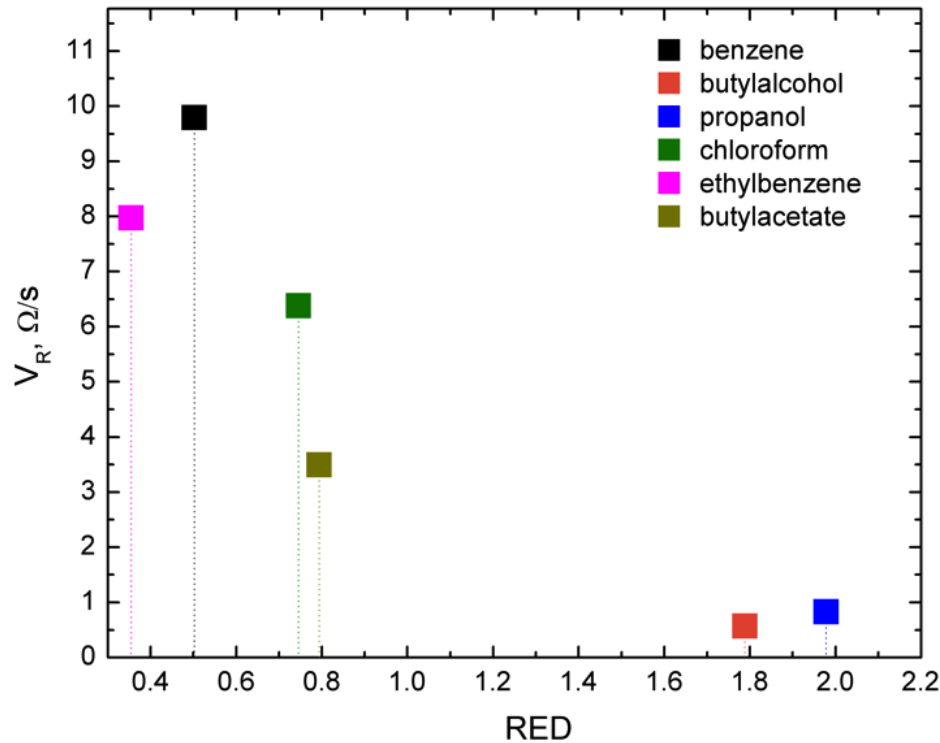


EVACB8 relative electrical resistance change vs. time, exposure time 60s.

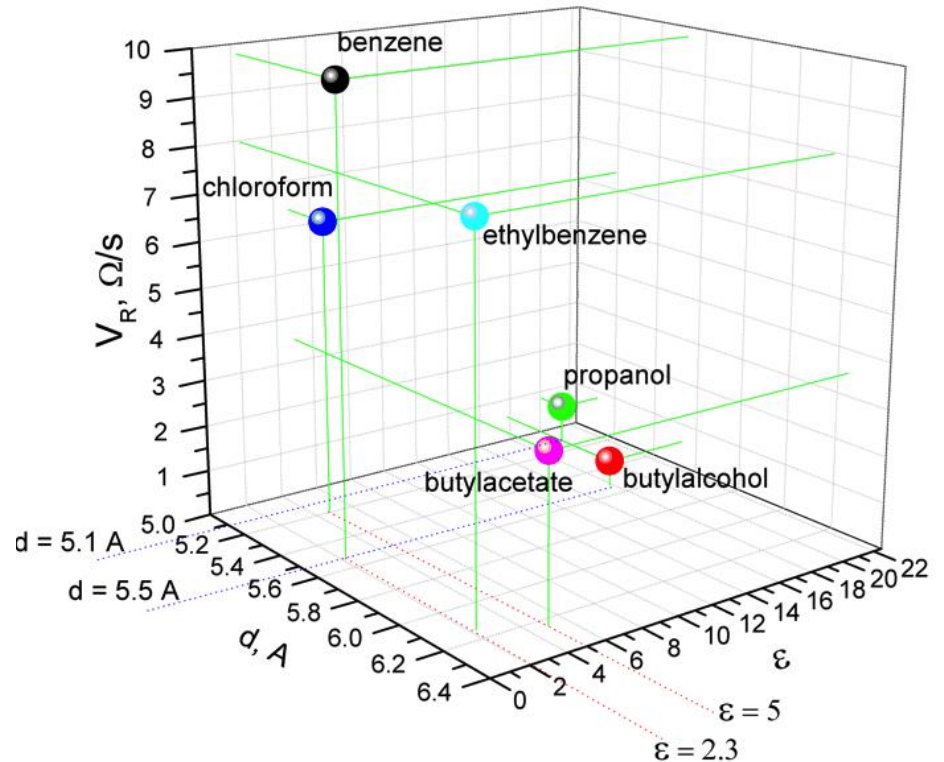


PiCB4.4 24h relative electrical resistance change vs. time.

Selectivity 2



PiCB10 electrical resistance response as function of relative energy difference (Hansen solubility parameters).



PiCB10 electrical resistance response as function VOC molecule diameter and dielectric permittivity value (ϵ).

CONCLUSIONS

- Lets use the information generated by VOC using sensors as preliminary method of detection.
- Polymer based sensors can be successfully applied for detection of VOC in fields like air quality control and food industry (VOC in ppm range).
- EVA-based nanocomposites shows the highest sensitivity, however recovery time at high concentrations are considerably long.
- Pi-based nanocomposites has good sensitivity and due to rubber like structure good recovery time.
- Addition of CB to CNT nanocomposites considerably increases the response to VOC.

Acknowledgments

- This work is supported by ESF Grant Nr. 1DP/1.1.1.2.0/13/APIA/VIAA/030



IEGULDĪJUMS TAVĀ NĀKOTNĒ



- Two National Research Programs in Materials Science

Institute of Polymer Materials at RTU
Velta Tupureina

Materials Physics Laboratory at RTU
Dr.habil.phys. Maris Knite (Professor)
Dr.sc.ing. Igors Klemenoks (Researcher)
Santa Stepiņa (PhD student)
Sandra Guzlēna (PhD student)
Raimonds Orlovs
Valdis Teteris
Jānis Barloti

Thank you!