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New Trends and Challenges for Air Quality Control

University of Latvia - Faculty of Geography and Earth Sciences

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CHEMIRESISTIVE VOC SENSOR MATERIALS BASED ON SILICONE RUBBER COMPOSITES

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Function in the Action: Participant in the Riga Workshop

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Materials - matrix

Polydimethylsiloxane

- better weathering and aging resistance
- chemical stability comparing to ordinary organic rubbers

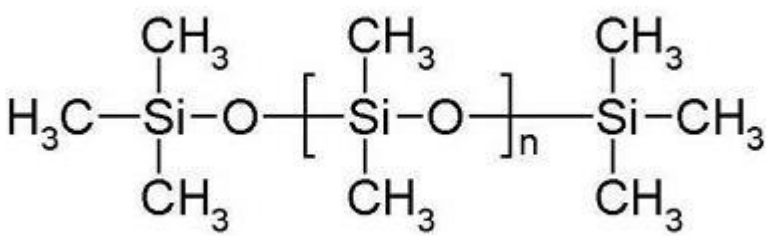


Fig.1. Typical formula of polydimethylsiloxane

Why chose elastomer as matrix for gas sensors?

1. fast response after expose with volatile organic compounds (VOC)
2. faster recovery after contact with VOC
3. repeatebly

Materials - filler

High structured carbon black (HSCB)

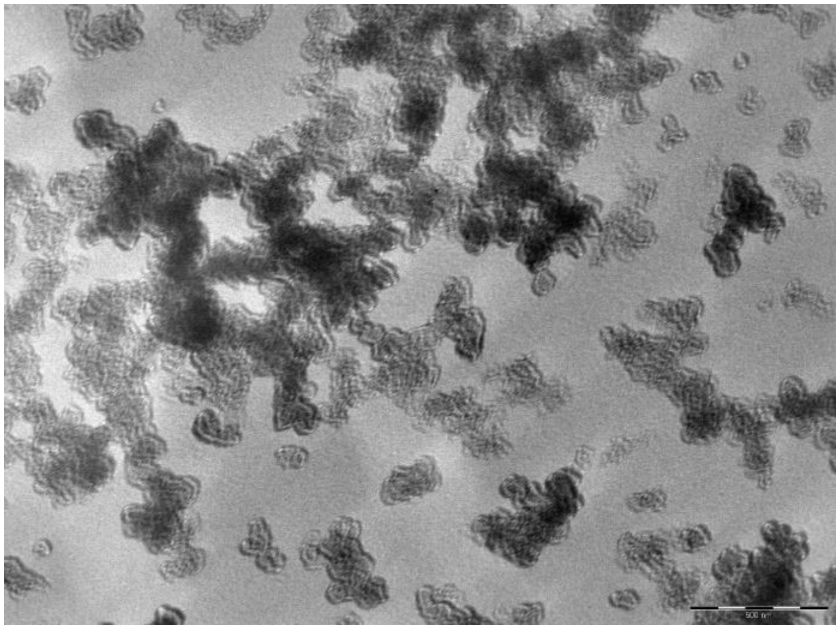


Fig.2. TEM image of carbon black nanoparticles. Image taken with A Philips TEM-301 Keen View II CCD camera. Scale 500nm.

Mean diameter of particles: 30nm,

Specific surface: 950m^2/g,

DBP absorbstion: 380ml/100g,

Charecatrization: forms electroconductive grid within the polymer matrix

Short multiwall carbon nanotubes (MWCNT)

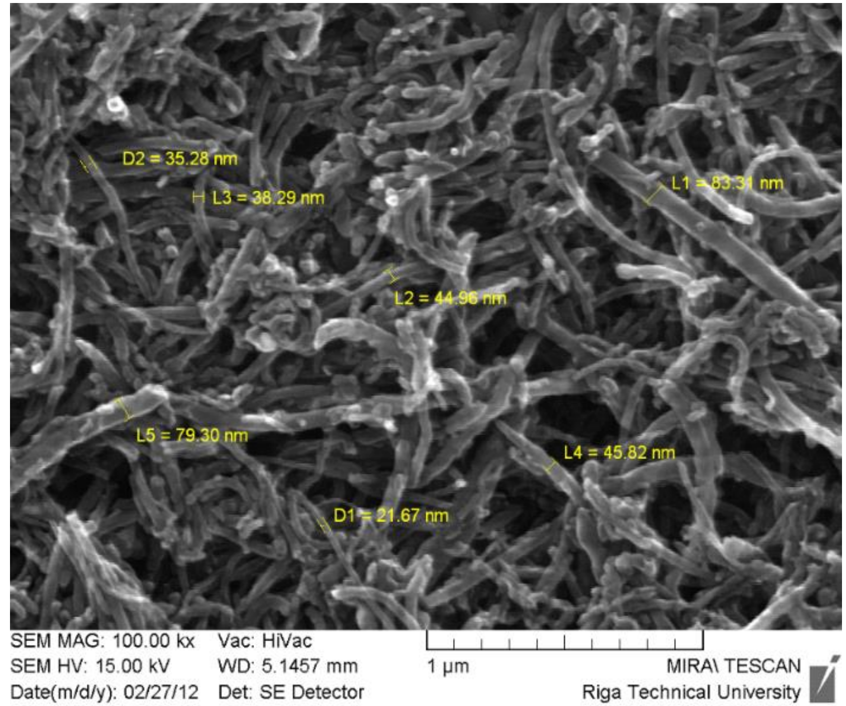


Fig.3. SEM image of multi wall carbon nanotubes. Scale 1µm.

Outer diameter of particles: 5

Inner diameter of particles: 5-15nm,

Lenght: 0,5-2µm, 0-80nm,

Maximal aspect ratio: 40,

Specific surface area: 40m^2/g,

Curing of the composite

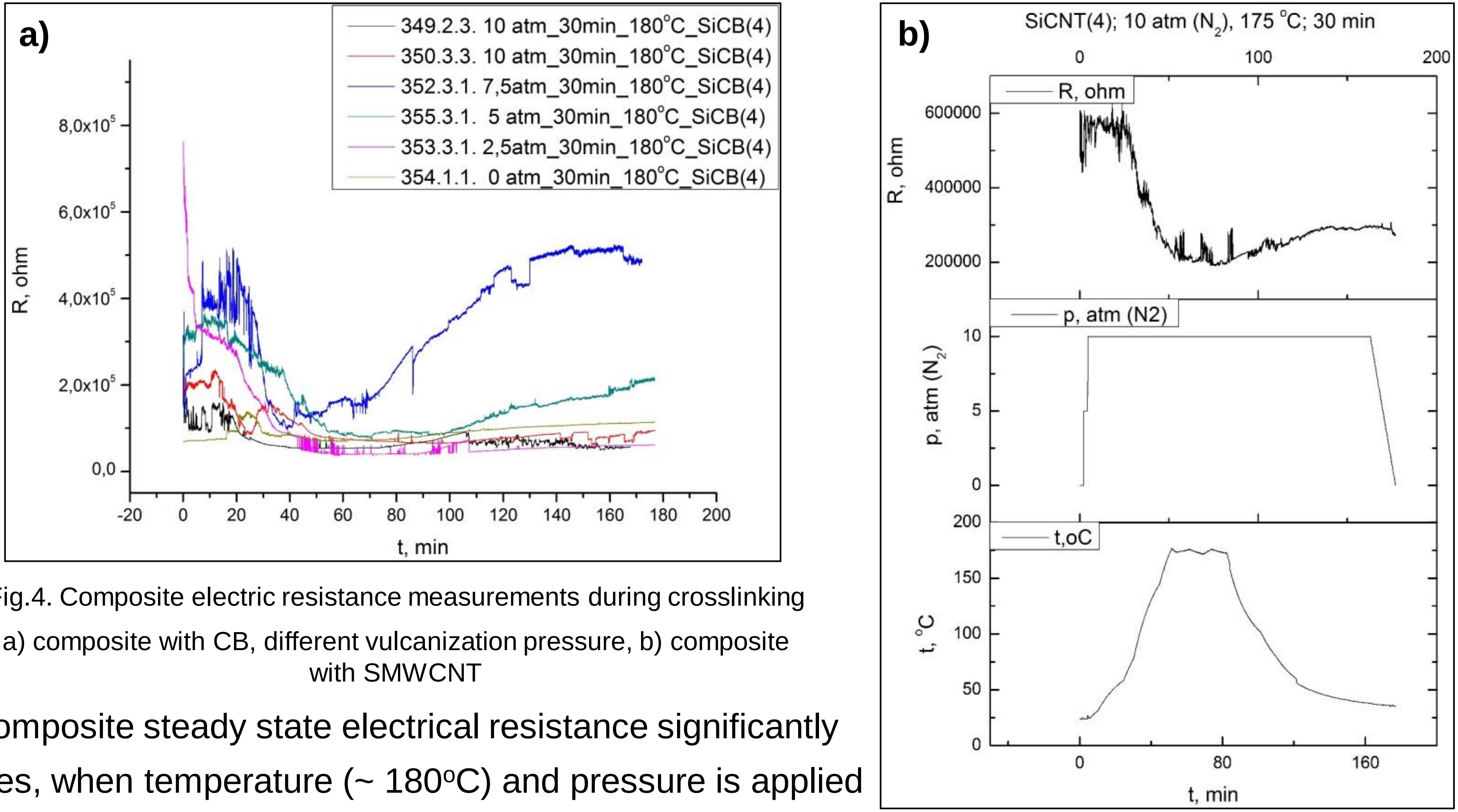
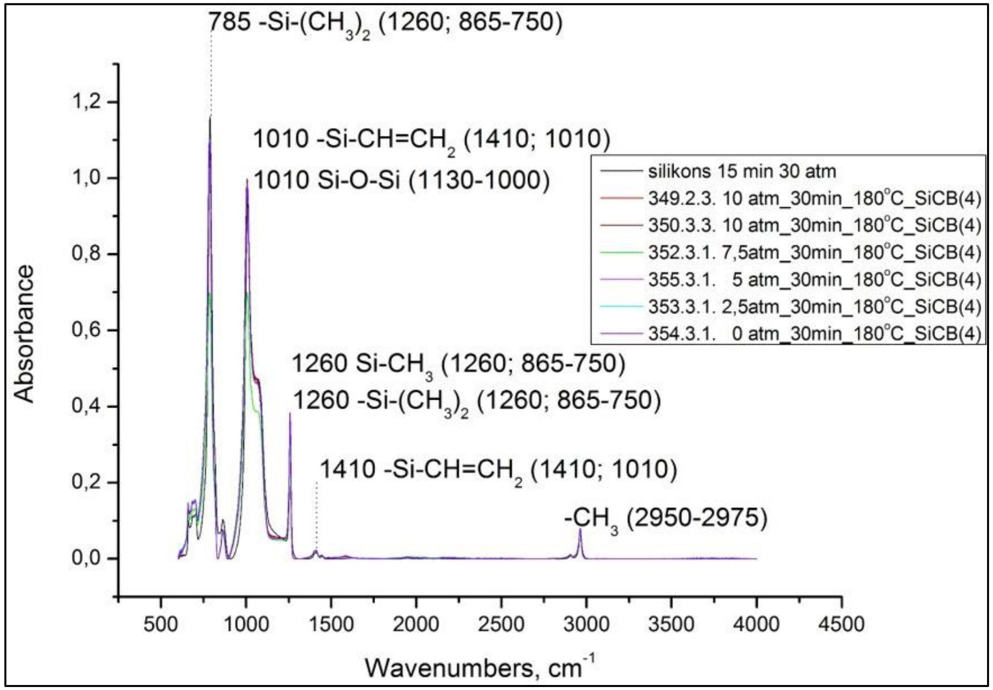


Fig.4. Composite electric resistance measurements during crosslinking

a) composite with CB, different vulcanization pressure, b) composite with SMWCNT

- Composite steady state electrical resistance significantly reduces, when temperature (~ 180°C) and pressure is applied
- Pressure applied during vulcanization changes the sample steady state electric resistance after curing

FTIR data analysis



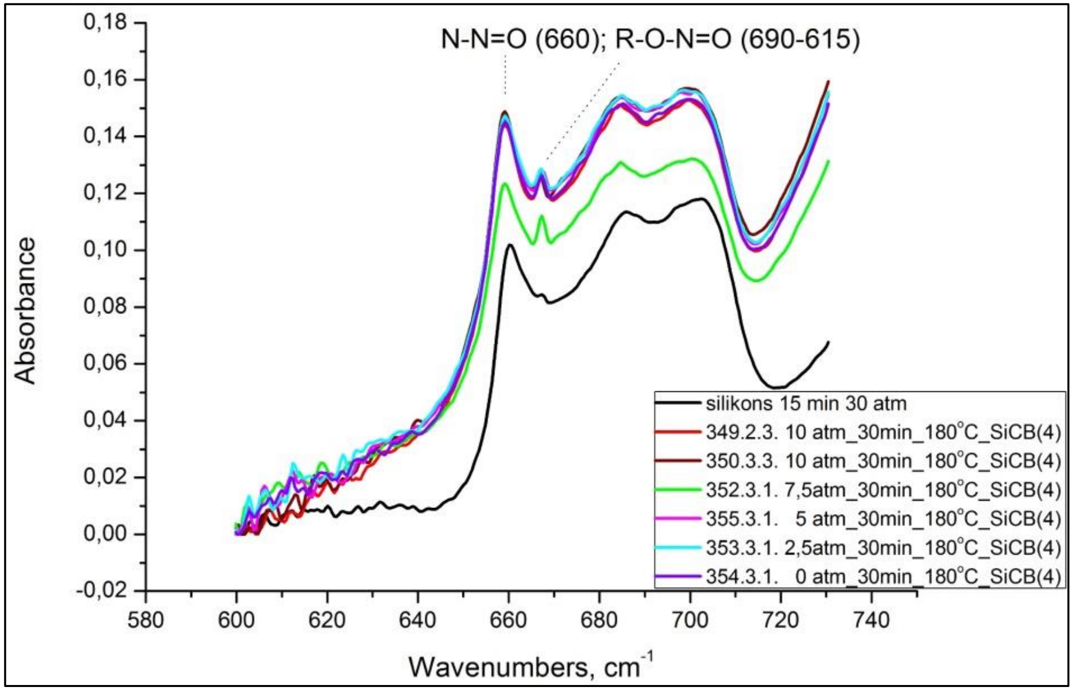


Fig.5. FTIR spectra of composite with different vulcanization pressure

- Applying pressure, absorbance of chemical bonds that approve that crosslinking reactions has been completed, like $CH=CH_2$ (1410 cm^{-1}) stretching, reduces.
- During vulcanization used nitrogen atmosphere affect chemical bond formation.

Sensitivity measurements

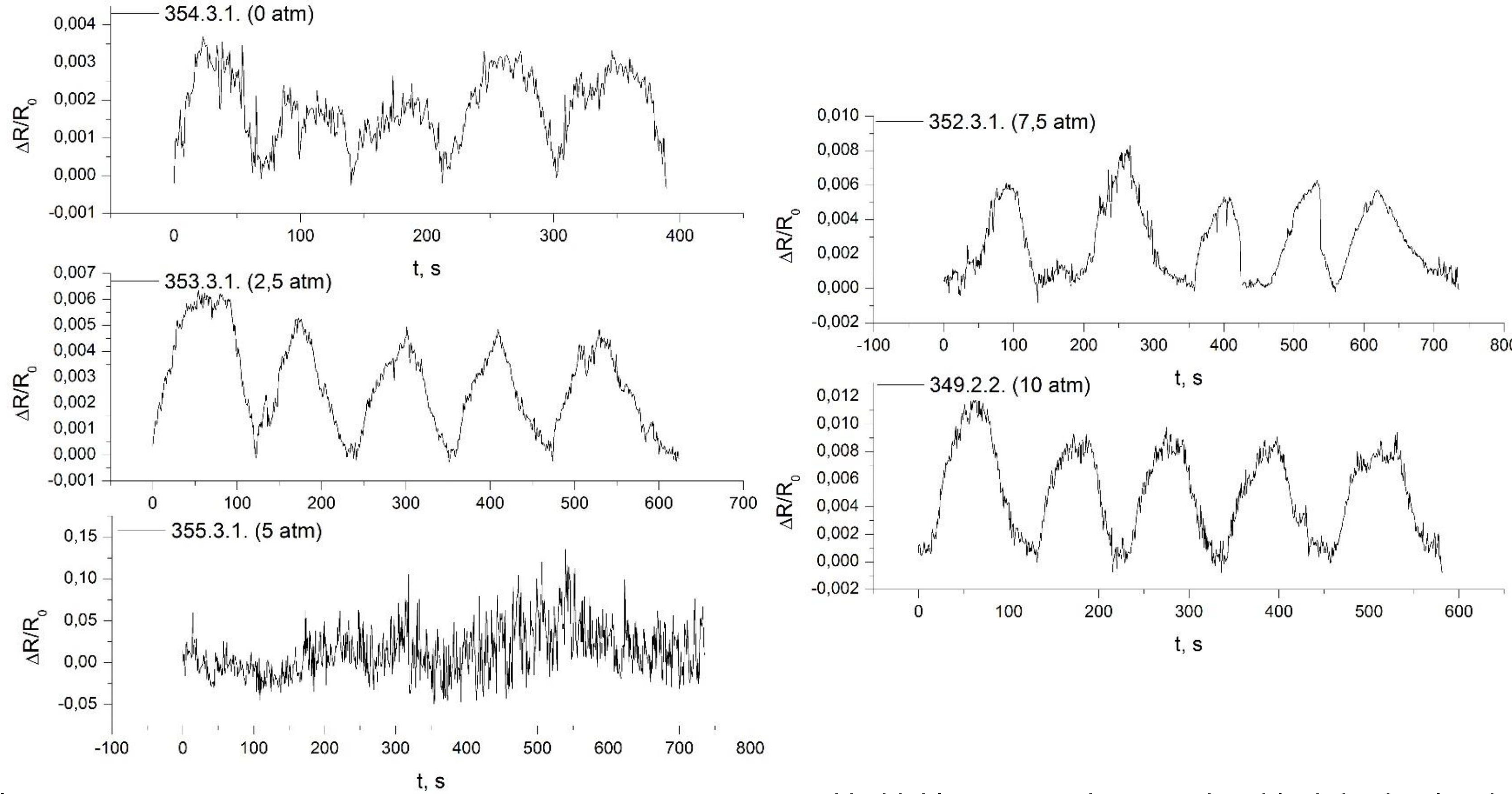


Fig.6. Relative electrical resistance change of silicon rubber composites with highly structured nanocarbon black (CB) vulcanized at different pressures in non-polar toluene vapours (800 ppm).

- If vulcanization pressure is larger then change of relative electric resistance is grater in presence of VOC and sensors sensitivity increases

Sensitivity measurements 2

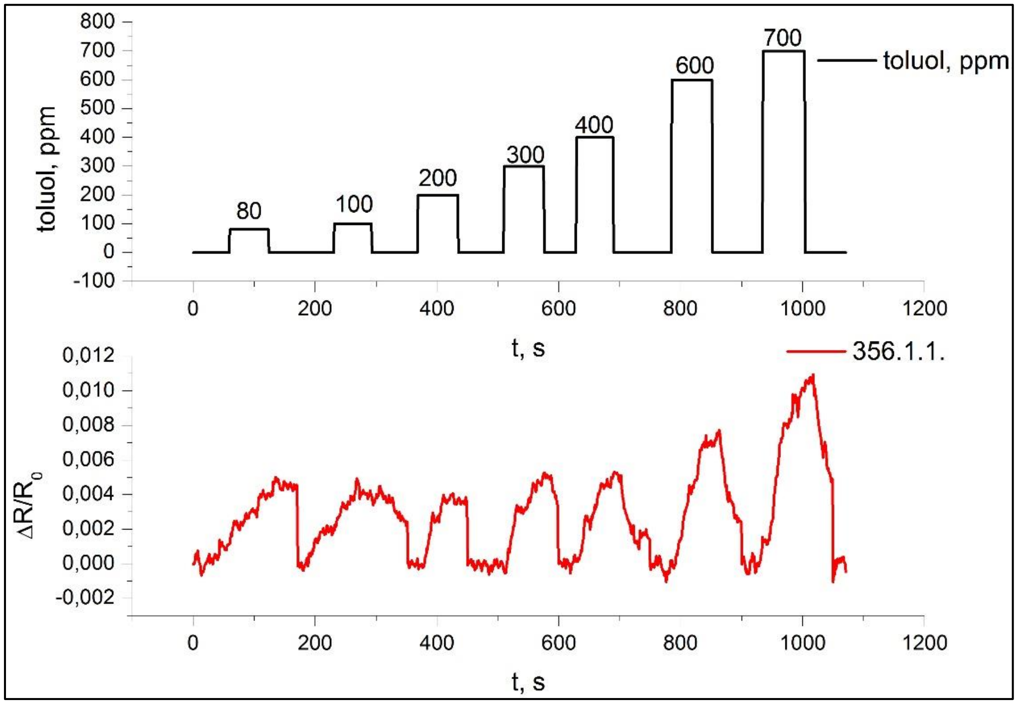


Fig.7. Relative electrical resistance change of silicon rubber composites with CB in non-polar toluene vapours different concentrations.

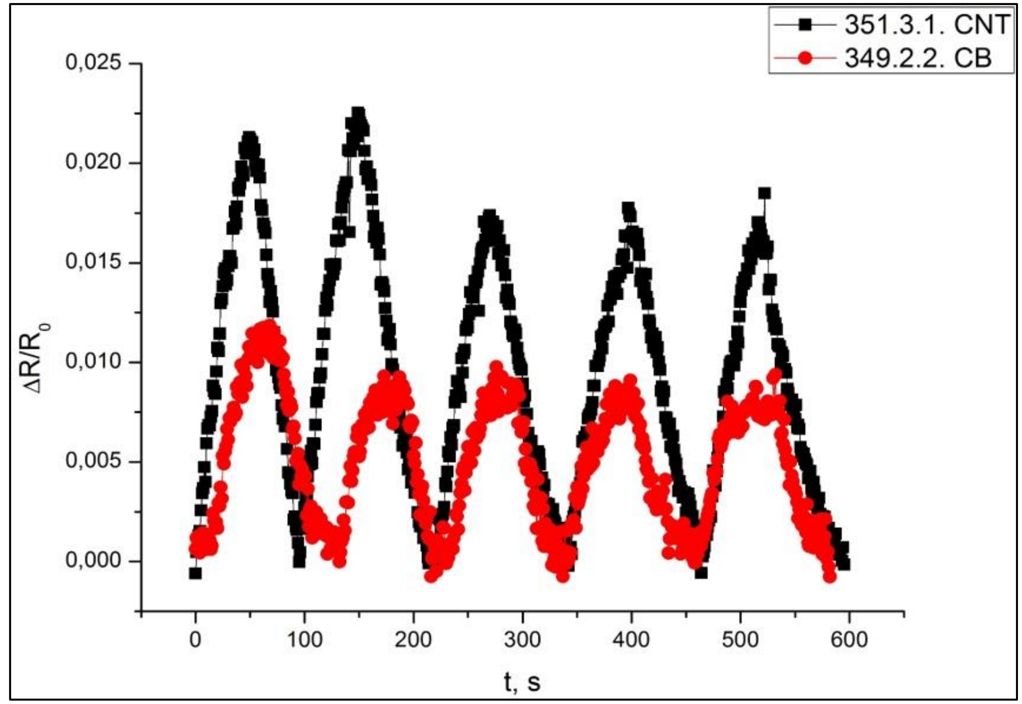


Fig.8. Relative electrical resistance change of silicon rubber composites with CB and SMWCNT in non-polar toluene vapours (800 ppm).

- Composite with CB relative electrical resistance stars to change when it is in contact with 80 ppm toluene (Fig.7.)
- Sample containing CNT relative electrical resistance is twice larger than CB (Fig.8.)

Conclusions

- During vulcanization sample electric resistance measurements has been made. It shows that composite steady state electrical resistance significantly reduces, when temperature (~ 180^{o}C) and pressure is applied.
- Using FTIR measurements various chemical bond changes has been shown, like silicone reaction with nitrogen atmosphere.
- Composite with CNT has larger relative electric resistance comparing with composite with CB. CNT as nanofiller is promising material to improve composites sensitivity.
- Sensitivity measurements after vulcanization at different pressures has been made. It shows that if larger pressure is used during vulcanization, then larger relative electric resistance has been observed.
- Grate advantage for silicone composites is fast recovery of electrical resistance when the composite are not in contact with toluene.

Thank you for attention!