12th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2008, Istanbul, Turkey, 26-30 August, 2008

DILATOMETRY TESTS OF RUBBER BLENDS WITH CARBON NANOTUBES

Ivan Ružiak, Ivan Kopal
Institute of Materials and Technological Research, Faculty of Industrial Technologies
Ivana Krasku 491/30, 02001 Puchov
Slovak Republic

Soňa Rusnáková, Robert Jurik
Department of Physical Engineering of Materials, Faculty of Industrial Technologies
Ivana Krasku 491/30, 02001 Puchov
Slovak Republic

ABSTRACT
Dilatometry is standard method for determination of material behaviour under thermal program. Carbon nanotubes(CNT) were prepared by chemical vapour deposition. Prepared were two mixtures of rubber with carbon nanotubes. First were carbon nanotubes mixed in rubber with carbon black and second used were carbon nanotubes mixed in liquid rubber with very low contribution of carbon black. We have compared the dilatometry curves of rubber blend without CNT and with for all mixing processes. We have also computed linear coefficient of thermal expansion of all 4 samples as function of temperature. Measurements were done on dilatometer 402 PC from Netzsch Instruments.
Keywords: linear coefficient of thermal expansion, rubber, carbon nanotubes

1. INTRODUCTION
In the article [1] authors have dealed with calculation of thermal expansion coefficient of 9 pure cubic metals. They have used Debye-Gruneisen approximation for calculation of CTE using density functional theory.
In the article [2] authors have dealed with evolution of CTE of thermosetting polymer during cure reaction. CTE was determined from modelling of ionic conductivity by modified WLF equation and calculation of CTE from dielectric spectroscopy measurements.
In the article [3] authors have tested thin films at low temperature by dilatometry measurements and have calculated coefficient CTE. Authors have proposed 2 novel methods for determination of CTE of thin films at cryogennic temperature.

2. THEORETICAL BACKGROUND
According to german norm DIN 51005, dilatometry is a technique in which a dimension of a substance under negligible load is measured as a function of temperature while the substance is subjected to a controlled temperature program.
When the sample is subjected to thermal program, her length is changing. Let the sample initial length at temperature T_0 be l_0. Let the sample final temperature be T. Then her length l at this temperature can be calculated using equation (1)

$$l = l_0(1 + \alpha(T - T_0)) \tag{1}$$

where: α - linear coefficient of thermal expansion

Linear coefficient of thermal expansion α can be calculated from equation (2)

$$\alpha = \frac{1}{l_0}\left(\frac{dL}{dT}\right) \qquad (2)$$

where: dL - infinitely small change of length

dT - infinitely small change of temperature

l_0 - initial length of sample

Directly from equation (2), one can see, that materials with increasing length in dilatometry test have positive coefficient α, and with decreasing length have negative coefficient α.

2.1. Measuring apparatus

The measurements were done on dilatometer 402 PC from NETZSCH instruments. Measuring apparatus is shown on figure 1.

Figure 1. Measuring apparatus

2.2. Measuring procedure

1. Rectangular sample of rubber is located in sample carrier and subjected to negligible load by pushrod.
2. When the relative length of sample is set to zero, parameters of measurement program are set. This parameters are initial length, pushrod material, Start temperature, End temperature and heating rate.
3. After the measurement is started, sample is subjected to temperature program and temperature is measured by sample thermocouple. Change in length is measured by LVDT technique.
4. At the end of measurement the measured signals of temperature and extension can be transferred to evaluate program, in which linear coefficient of thermal expansion can be calculated. The measured data can also be exported as text documents in ASCII format.

2.3 Samples

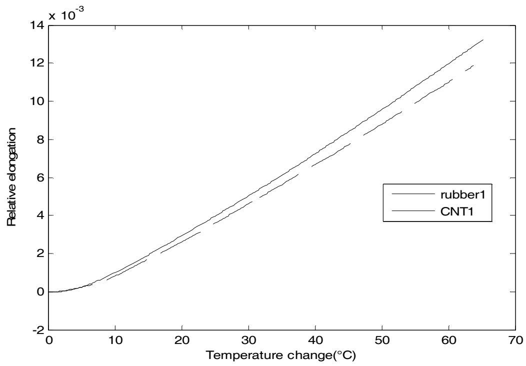
Rubbers dimensions are shown in table 1.

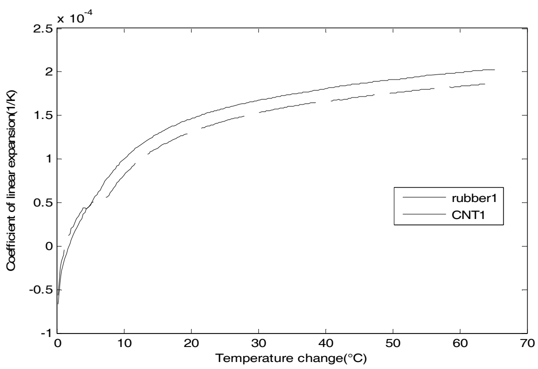
Table 1: Samples dimensions

Name	Diameter [mm]	Thickness [mm]
Rubb1	10.25	2.29
CNT1	10.25	1.83
Rubb2	10.25	1.82
CNT2	10.25	1.75

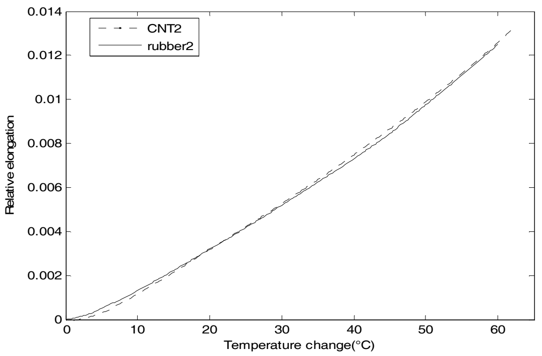
3. RESULTS AND DISCUSSION

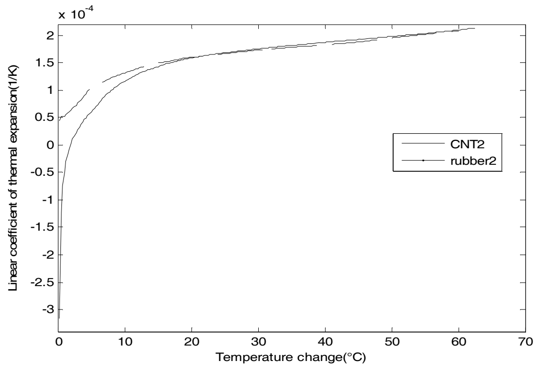
In the figure 1 – left are shown expansion curves of rubber1 and CNT1. In the figure 2 –right, is shown temperature dependence of linear coefficient of thermal expansion of rubber1 and CNT1. Rubber 1 is the standard sample to rubber with carbon nanotubes CNT1. Rubber1 contains carbon black.





In the figure 3 – left are shown expansion curves of rubber2 and CNT2. In the figure 4 –right, is shown temperature dependence of linear coefficient of thermal expansion of rubber2 and CNT2. Rubber 2 is the standard sample to rubber with carbon nanotubes CNT2. Rubber2 contains very low part of carbon black and is liquid.





4. CONCLUSIONS

From figures 1 and 2 it is clearly to seen, that carbon nanotubes mixed in rubber with not negligible amount of carbon black increase linear coefficient of thermal expansion of rubber. Increase in coefficient is cca 8 percent.

From figures 3 and 4 it is clearly to seen, that carbon nanotubes mixed in liquid rubber with negligible amount of carbon black don't change linear coefficient of thermal expansion of rubber.

From presented figures it is also to seen, that end temperature of samples with carbon nanotubes CNT1 and CNT2, subjected to same temperature program as rubber1 and rubber2, is higher as in these rubbers. Probably reason is not negligible higher thermal conductivity of CNT1 and CNT2 as that of rubber1 and rubber2.

5. REFERENCES

[1] JIN, H. M. et al.: Journal of Alloys and Compounds, 343, 2002, 1-2.
[2] LEROY, E. et al.: Polymers, 46, 2005, 23.
[3] WANG, Z. D. et al.: Polymer testing, 24, 2005, 7.