

ALTERNATIVE CURRENT RESISTIVITY OF RUBBER BLENDS WITH SINGLE WALL CARBON NANOTUBES

P. KOŠTIAL¹, R. HREHUŠ¹, R. JURÍK¹, J. JURČIOVÁ², V. VRETENÁR³

¹ Faculty of Industrial Technologies, Department of Physical Engineering of Materials, Alexander Dubček University of Trenčín; Púchov, Slovak Republic, contact author: kostial@fpt.tnuni.sk

² Faculty of Industrial Technologies, Department of Chemistry and Technology of Polymers, Alexander Dubček University of Trenčín; Púchov, Slovak Republic, jurciov@fpt.tnuni.sk

³ Danubia NanoTech, Ltd.; Bratislava, Slovak Republic, vretenar@danubiananotech.com

ABSTRACT: In this paper we present the study of alternating current resistivity ACR , a dielectric constant and the loss factor $tg\phi$ of rubber blends filled by single wall carbon nanotubes ($SWCNT$). The presence of $SWCNT$ in the blend rises both parts of the complex dielectric constant, as well as the loss factor. On the other hand ACR decreases.

KEY WORDS: electrical properties, rubber

1. INTRODUCTION

Material basis of fillers was being created for a long time by carbon black and later silica with silanes.

We are standing before a new challenge in rubber industry created by the application of carbon nanotubes to a rubber blend.

The process of a carbon black mixing is assumed in the following steps. After the addition of the filler, the agglomerates of the size up to $10-100 \mu m$ are created. The rubber shells are created around the filler particles in the blend, followed by filling up the voids within the filler agglomerates. Under stretching deformation caused by shearing forces, the aggregates of $100 nm$ till $0.5 \mu m$ appear after breakage of agglomerates. Primary particles as a final product of mixing have dimension of approximately $20 nm$. Smaller aggregates and primary particles appear on the expense of larger aggregates and agglomerates [1,2].

There is incomparably worse situation in the field of knowledge about dispersion process of CNT . The problem in the case of CNT application to the rubber blend lies in a destruction of agglomerates before mixing and the following incorporation of CNT in the period of mastication and plasticization in order to obtain good electrical, mechanical and thermal properties of the final blend. Information assembled on these processes are relatively poor.

Authors of the European patent [3] described the realization of cables comprising polyethylene, polypropylene, or mixture thereof, CNT , conductive carbon, copolymer of acrylonitrile and butadiene.

In this paper, we present the results of measurements of ACR , a dielectric constant and the loss factor $tg\phi$ as functions of frequency for sample twins. Two mother samples of a rubber blend were prepared as twins. One with and the second one without $SWCNT$ (marked as standard S).

2. EXPERIMENTAL PROCEDURE

Two mother samples of a rubber blend were prepared as twins. One was with and the second one without $SWCNT$. Rubber blends were mixed in two steps. In the first step, we started with mixing of natural rubber, then we successively added ZnO , carbon black ($N660 Cabot$) and finally we sonicated

SWCNT in oil (or oil only in the case of standard sample). In the second step, sulfur as a vulcanization agent was added to the mixture. The temperature of *Brabender plasti-corder PLV 151* chamber was maintained at 80 °C. Vulcanization temperature was 150 °C.

ACR of blends was measured by *RLC* bridge *Fluke PM6306* controlled by a computer for four samples cut out from the mother sample.

3. EXPERIMENTAL RESULTS AND DISCUSSION

After the sample preparation, *ACR* was measured for every sample. Results are presented in Fig. 1. It is possible to see the decrease of *ACR* for the twin containing *SWCNT* which corresponds to expectancy. Measurement of the dielectric constant reflects the structural properties of the sample. The dependences of ϵ' (real part of dielectric constant) versus frequency for *SWCNT* twin and for the standard one are displayed in Fig. 2. Increase of ϵ' for *SWCNT* twin in comparison to the standard one is between 30-40 % (in steady region of the dependence) for all investigated samples, which presents very good sample preparation reproducibility, in other words a good technology.

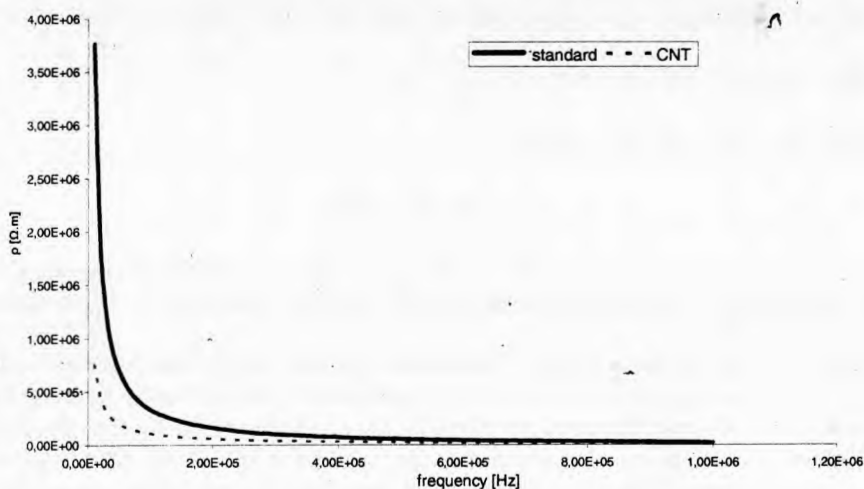


Fig. 1: The dependence of *ACR* versus frequency

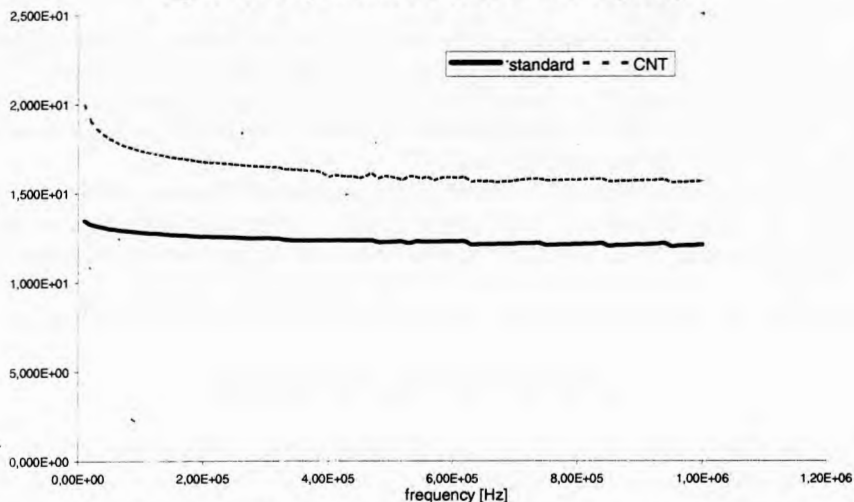


Fig. 2: The dependence of imaginary part of dielectric constant versus frequency

Rising of dielectric losses represented by $tg\phi$ in the *SWCNT* twin is visible and presented in Fig. 3. in order to test the increase of dielectric losses in *SWCNT* twin according to Fig. 3, we heated both twins together in a microwave oven. After few seconds, the sample with *SWCNTs* started burning and the standard sample didn't show any visible changes.

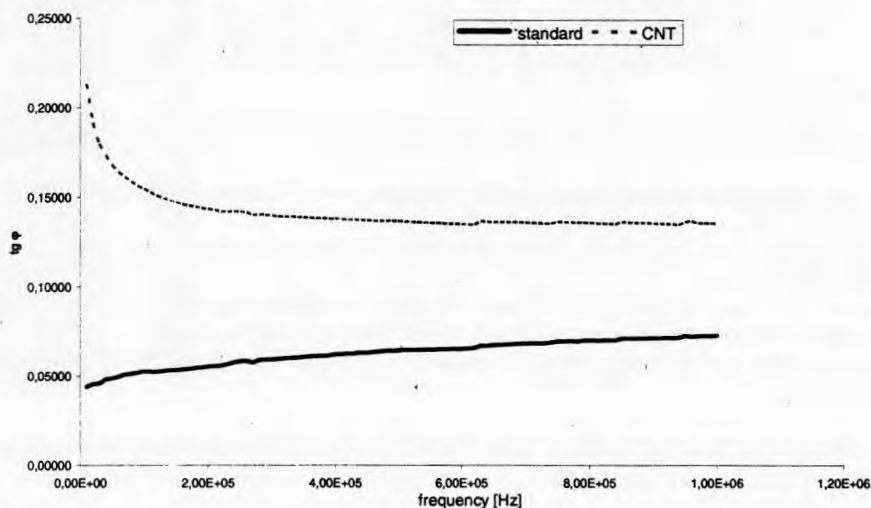


Fig. 3: Frequency dependence of $tg\phi$. Inserted pictures show the photographs and thermogram of twins after electromagnetic irradiation

4. REFERENCES

- [1] DIERKES, W.K.: Economic Mixing of Silica-Rubber Compounds, Print Partners Ipskamp, Netherlands 2005.
- [2] LE, H.H., TIWARI, M., LIISCH, S., RADUSCH, H.-J.: Effect of Molecular Structure on Carbon Black Dispersion in Rubber Compounds, Kautschuk Gummi Kunststoffe 56. No.5, 2003.
- [3] WELL-KUO, L., MARIOS, A.: EP 1052654 A1.