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CONSTANT MAGNETIC FIELDS INFLUENCE ON THE PROPERTIES OF SOME ELASTOMERS AND ELASTOMERIC MATERIALS

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ABSTRACT

External magnetic field application has been accepted as a promising technique for physical type of modification and managing of the polymer materials structure and properties. This is one of the most promising ways to obtain a specific macromolecular chain ordering and desired highly oriented supermacromolecular structure to receive high modules and high strength materials.

The present paper is a report of our attempts to investigate the influence of the constant magnetic homogeneous field on the structure and some stucture-sensitive properties of polar crystallizing and noncrystallizing elastomers.

Keywords: magnetic field, elastomers, vulcanization.

INTRODUCTION

One of the modern methods of physical modification, considered as a promising one in academic and industrial laboratories is the method of magnetic modification. The aim is to obtain a specific highly oriented supermolecular structure, res. high modules and high strength materials by magnetic field application during the polymer stucture formation process.

Based on some data for magnetic field influence on chemical reactions [6-8] and having one of the most important stages in the rubber processing - the process of vulcanization - chemical and radical in its nature, we have tried to investigate the constant magnetic field influence on the vulcanization process.

EXPERIMENTAL

The object of our investigation are polar crystallizing and noncrystallizing elastomers - Chloroprene (Baypren 320, product of Bayer) rubber (CR) and nitrile butadiene rubber (NBR). Macromolecules of these polar elastomers contains strongly polar functional group with high magnetic receptivity (-C≡N- and -C-Cl-) which are very sensitive to magnetic field influence [9]. A magnetic field with induction of 0,20 T has been applied during the sample formation.

Unfilled natural rubber (NR) and nitrile butadiene rubber (NBR) based compositions, containing sulfenamide and dihiocarbamate types of accelerators have been used for investigate the magnetic field influence on the vulcanization process. Vulcanization process was carried out at 30°C for 48 and 96 h, at 140°C for 1h.

The magnetic field influence has been studied by measuring the volume resistivity, mechanical properties - tensile strength and relative elongation at break, kinetic parameters of the equilibrium swelling - (degree and rate) of the obtained vulcanizates.

RESULTS AND DISCUSSION

It has been observed that EMF application leads to increasing in ρ_v of polar crystallizing elastomers (CR)

with ionic type of electroconductivity due to higher level of structure ordering. It is obvious that EMF orientate the macromolecules and influence on the crystallization process and helping for its intenzification. The increased crystal phase makes difficult carrier motion and leads to ρ_v increasing. The magnetic field application leads to slightly decreasing in ρ_v of the polar noncrystallizing elastomers (NBR) with electronic type of electroconductivity due to higher level of structure ordering wich makes easier the current carrier motion in this case in a result of higher level of structure ordering.

The results of X-ray diffraction patterns and DTA analyses shows that the magnetic field train samples is considerably more ordered in comparison the samples, formed without magnetic field applying. In CR based films the degree of X-ray diffraction crystallinity is increased (25 % v. 15 %) due to magnetic field application and structure orientation. The peaks typical of crystal phase are better expressed, the area of the background, typical of amorphous phase is less. It have been seen similar effects and data for more ordered structure in NBR X-ray diffraction pattern.

DTA analyses data also confirm the more ordered structure with increased density due to magnetic field application. These more ordered structure makes difficult the oxygen diffusion and the thermal destruc-

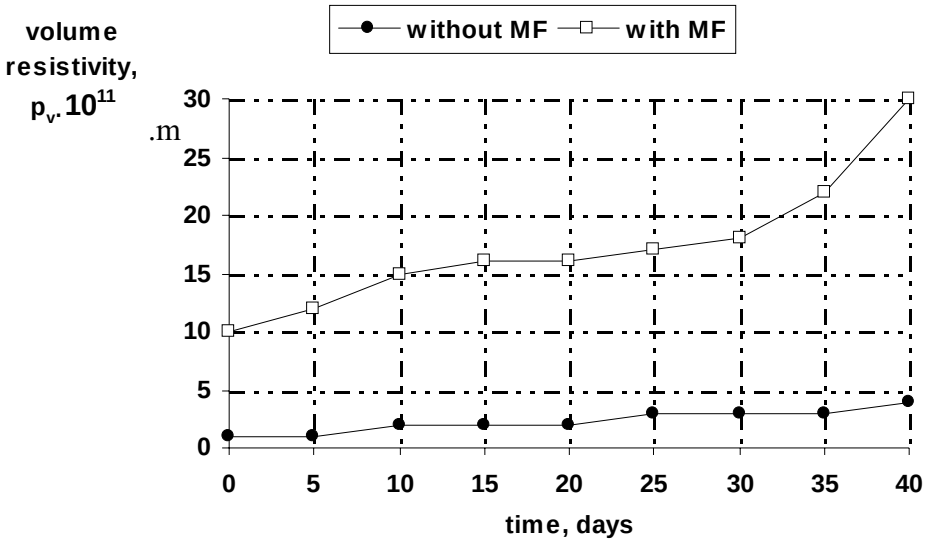

Fig. 1. Kinetics of volume resistivity of CR Baypren-320 based films in presence (H>0) and absence (H=0) of MF.

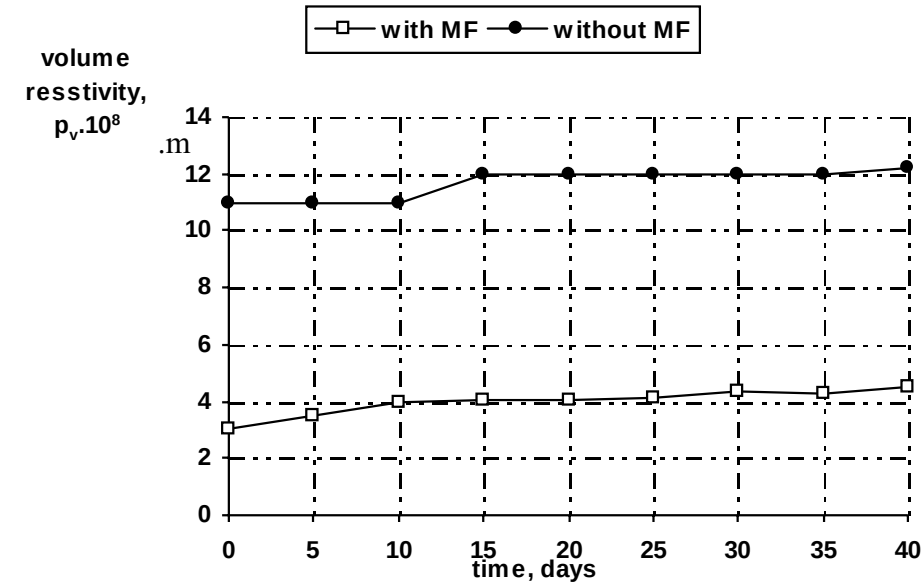

Fig. 2. Kinetics of volume resistivity of NBR based films in presence (H>0) and absence (H=0) of MF.

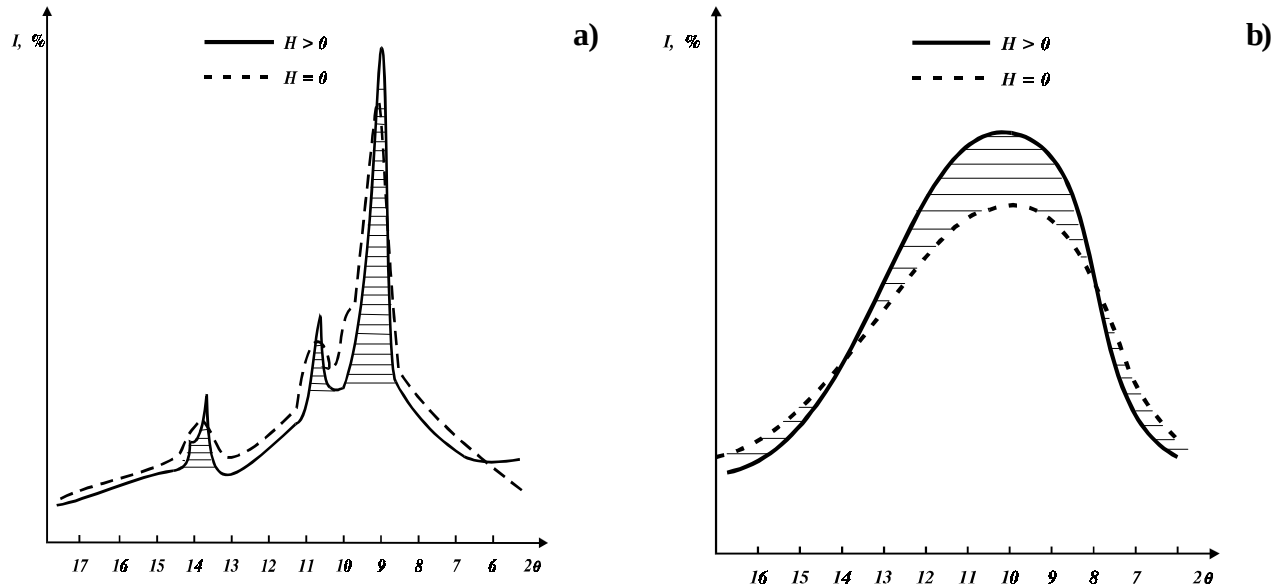

Fig. 3. X-ray diffraction patterns of CR Baypren-320 (a) and NBR (b) based films in the presence (H>0) and absence (H=0) of MF.

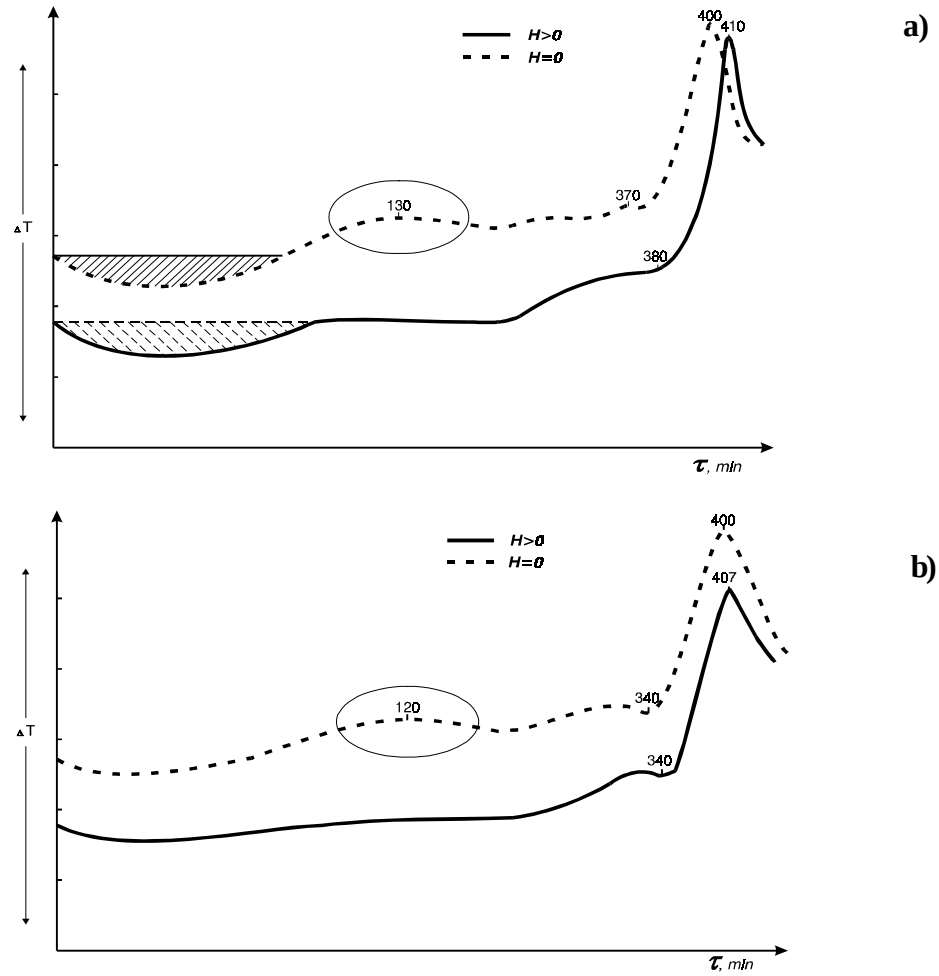

Fig. 4. DTA data of CR (a) and NBR (b) based films in the presence (H>0) and absence (H=0) of EMF.

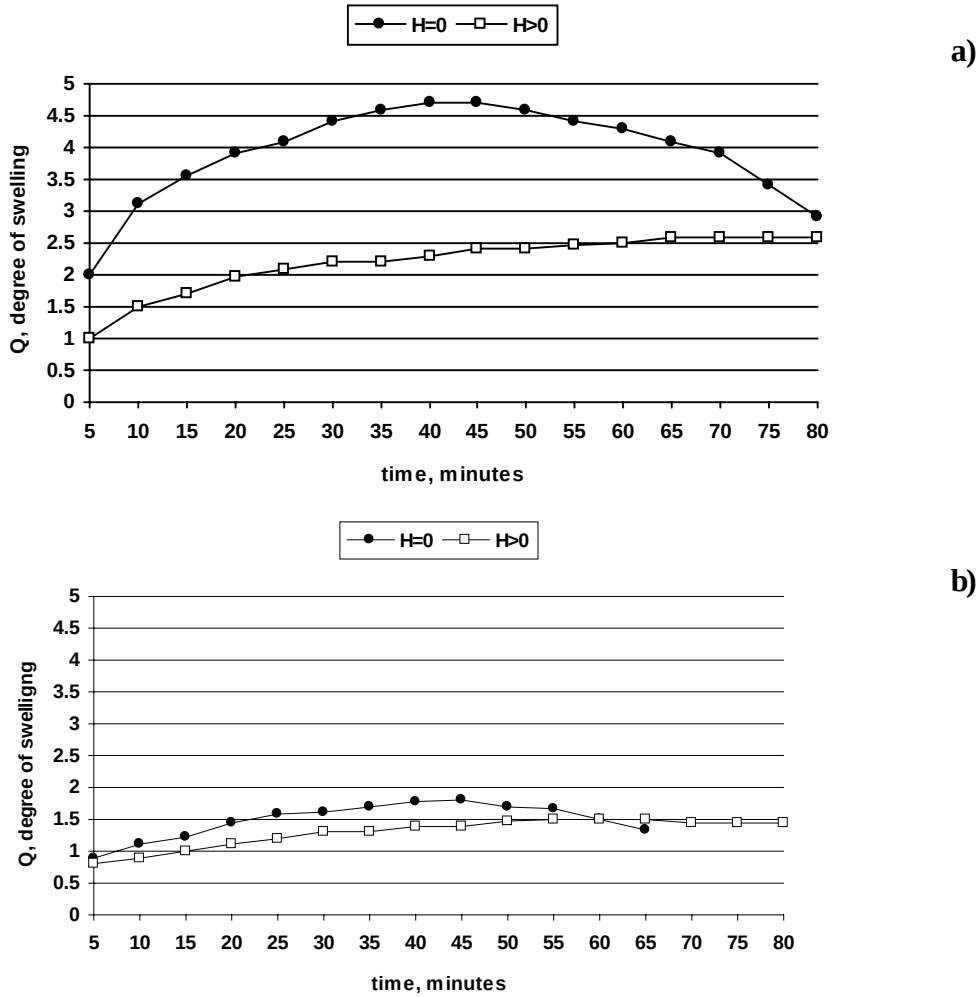

Fig. 5. Swelling kinetic of unfilled NR based vulkanizates, vulcanized at 140°C for 1h (a) at 30°C for 96h (b); H=0 - without MF application, H>0 - with MF application.

tion. In a result the magnetic field modified samples have higher thermal stability (on the average 10°C), decreased mass loss (36 % v. 45 % at 400°C) and increase value of the activation energy of destruction (5,9 J/mol K v. 4,4 J/mol K).

The lack of the ordered structure makes easier the oxygen diffusion at 130°C for the samples obtained without magnetic field influence in comparison the magnetic field modified. Thermal destruction starts (at 370°C v. 380°C) and carry out at lower temperature (400°C v. 410°C).

Mass loses at the maximum of temperature destruction decreases from 45 % to 36 % after magnetic field application. It is observed also increasing about 20 % endothermic effect area, connected with elastomer convertion from crystal to highelastic state. The amount of absorbed heat is directly connected with degree of cristallity and structure ordering. Based on these obtain result we consider that the heat and light aging resistance may be achieved also.

The magnetic field application accelerates the vulcanization process and influence on the kinetic parameters of vulcanization. Figs. 5 and 6 show that magnetic field influences on the vulcanization net characteristics, directly connected to equilibrium degree of swelling. The effect of the magnetic field leads to decreasing of swelling degree and rate. The density of the vulcanization net is higher and contains more crosslinking sulfur bonds per one elastomer molecule for magnetic field modified vulcanizates. This is the reason for the swelling decreasing and the tensile strength and volume resistivity increasing.

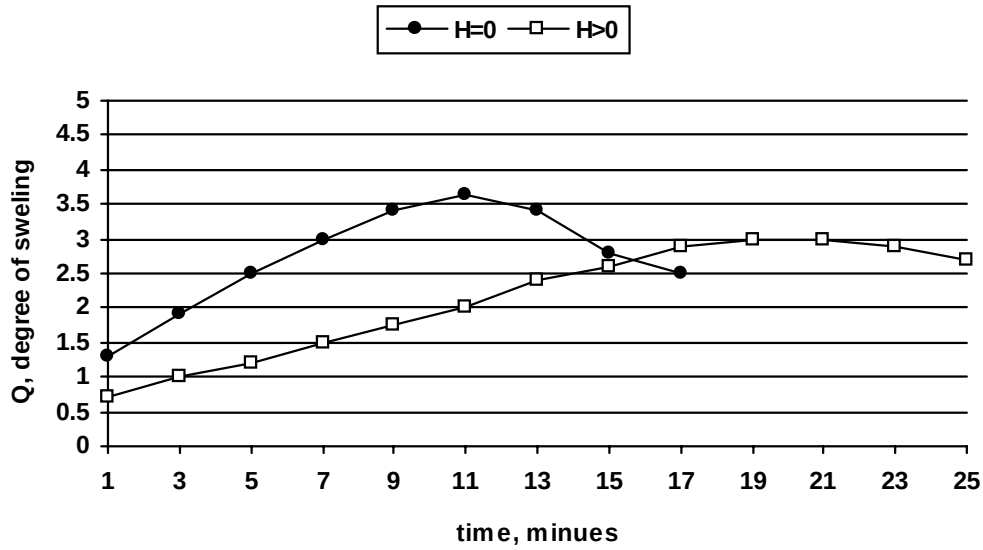

Fig. 6. Swelling kinetic of unfilled NBR based vulkanizates, vulcanized at 30°C for 48h; H=0 - without MF application, H>0 - with MF application.

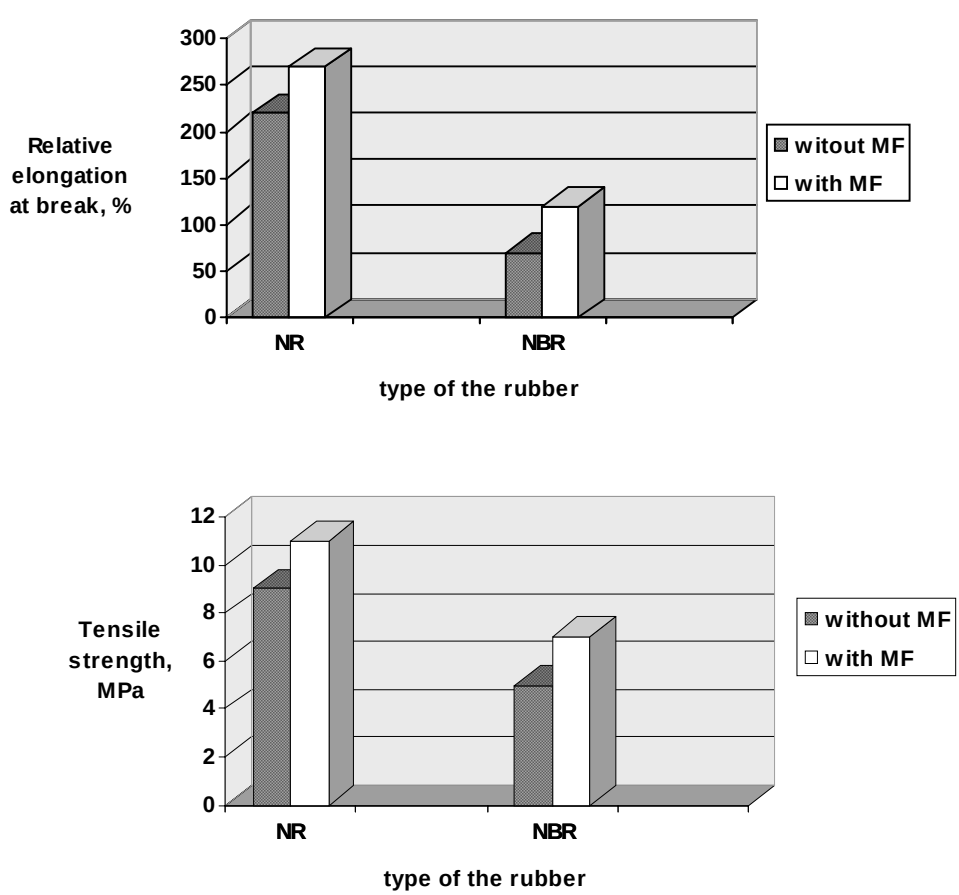

Fig. 7. Physicomechanical characteristics (a-relative elongation at break; b-tensile strength) of NR and NBR based unfiled elastomers obtained with and without magnetic field (MF) application during vulcanization processs.

The magnetic field influences the sensitive singlet - triplet transition in radical couples formed during the vulcanization and responsible for the recombination possibilities, intermediate and final vulcanization products [9,10].

Due to changes in the vulcanization architecture and orientation phenomena in the supermolecular structures the magnetic field application improves the physicomechanical properties of the vulcanizates, which is better expressed in polar noncrystallizing NBR than in nonpolar crystallizing NR elastomers (Fig.7 a,b). The results obtained show that the magnetic field application leads to increasing of tensile strength and relative elongation at break of the vulcanizates.

CONCLUSIONS

EMF application leads to increasing in ρ_v of polar crystallizing elastomers (CR) with ionic type of electroconductivity due to higher level of structure ordering. It is obvious that EMF orientate the macromolecules and influence on the crystallization process and helping for its intenzification. The magnetic field application accelerates the vulcanization process and influence on the kinetic parameters of vulcanization - equlibrium degree of swelling, due to higher density of the vulcanization net. The magnetic field application leads to increasing of volume resistivity, as well as tensile strength and relative elongation at break of the vulcanizates.

REFERENCES

1. F. Hardouvin, M.F. Ackard, J. Gasparoux, J. Polym. Sci., **20**, 6, 1982, 975.
2. E. Perplies, J. Appl. Polym. Sci., **28**, 1983, 3603.
3. Y. Rodin, Y. Molchanov, Mechanics of the Ionposite materials, **5**, 1990, 783, (in Russian).
4. Y. Rodin, Y. Molchanov, Mechanics of the Ionposite materials, **3**, 1991, 490, (in Russian).
5. Y. Rodin, V. Korchov, Mechanics of the Ionposite materials, 2, 1992, 255 (in Russian)
6. K. Zamaraev, Spinovii obmen,Teoriia i fizikohimicheskie prilojeniia, Nauka, Novosibirsk, 1987, (in Russian).
7. H. Fescher, K.H. Hellwege, Magnetic properties of free radicals, Springer Verlag, Berlin,1989.
8. H. Fescher, J. Amer. Chem. Soc., **102**, 1982, 7393-7397.
9. A. Alekseev, A. Kornev, Magnetic elastomers, Moscow, Nauka, 1987, (in Russian).
10. N. Dishovsky, K. Ruskova, N. Shoilev, J. Univ. Chem. Technol. Met. (Sofia), **36**, 2, 2001, 13-20.