شبكة المعلومات الجامعية

بسم اللّه الرحمن الرحيم

Ain Shams University Information Network

جامعة عين شمس

شبكة المعلومات الجامعية

@ ASUNET

شبكة المعلومات الجامعية

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات

يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار

شبكة المعلومات الجامعية

بعض الوثائق الأصلية تالفة

بالرسالة صفحات لم ترد بالأصل

EFFECT OF COMPRESSION AND EXTENSION ON THE ELECTRICAL, MECHANICAL PROPERTIES AND TSDC OF RUBBER-POLYMER COMPOSITES

A THESIS
SUBMITTED FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN PHYSICS
(SOLID STATE)

BY

MOHAMED HAMDY MOHAMED OTHMAN

TO

PHYSICS DEPARTMENT
FACULTY OF SCIENCE
CAIRO UNIVERSITY

B

2007

APPROVAL SHEET

Title of The Ph.D Thesis

" EFFECT OF COMPRESSION AND EXTENSION ON THE ELECTRICAL, MECHANICAL PROPERTIES AND TSDC OF RUBBER-POLYMER COMPOSITES"

Name of the Candidate

MOHAMED HAMDY MOHAMED OTHMAN

Faculty of Science, Cairo University

Supervised by

PROF.DR. MOHAMED AMIN SOLIMAN M. Amin

Professor of Physics, Faculty of Science, Cairo University .

PROF. DR. GAMAL ABD-EL NASSER G. M. Nasr

Professor of Physics, Faculty of Science, Cairo University .

DR. SOBHY IBRAHIM S. Sayed

Lecturer of Physics, Faculty of Science, Cairo University .

PROF.DR. HOSAM HAMED

Head of Department of physics

Faculty of Science, Cairo University .

CONTENTS

ACKNOWLEDGEMENT

I wish to express my grateful to **Prof. Dr. M. Amin Soliman,** Professor of Physics, Faculty of Science, Cairo University, for his supervision, valuable help and advice which have rendered many difficulties surmountable.

I should like to take this opportunity to thank **Prof. Dr. G. Abd-El Nasser,** Professor of Physics, Faculty of Science, Cairo University, for suggesting the point, valuable supervision, great help, fruitful discussions, and helpful guidance throughout the discussion and work.

Sincere thanks to **Dr. S. Ibrahim,** Physics Department, faculty of Science, Cairo University, for his supervision, help and encouragements.

I would like to take this chance to make great thanks for **Prof. Dr. H. Othman,** Professor of Physics, Faculty of Science, Cairo University, for his great help and encouragements.

Finally, I am deeply indebted to the staff members of Polymer Science Laboratory, Physics Department, Faculty of Science, Cairo University.

ABSTRACT

Polymer composites are one group of the new approaches for the preparation of new materials from existing polymers. One obvious advantage is that it requires a lower cost relative to the production of new polymers. It is also possible to produce a range of materials with properties completely different from those of composite constituents.

The present study. is concerned with acrylonitrile butadiene rubber (NBR), loaded with a 20% barium titanate ($BaTiO_3$) and vulcanized with sulphur. The blend is loaded with different concentrations of carbon black; semi-reinforcing furnace (SRF) N770.

All tested samples are prepared under the same conditions according to the standard methods. The main idea of this study is to observe the effect of compression and extension on the physical properties of these composites.

From studying the effect of SRF black concentration on the dielectric constant, ε', and the ac electrical conductivity, σ_{ac}, at different frequencies for uncompressed NBR/$BaTiO_3$ vulcanizates, it was noticed that, ε' is increased with the increase of SRF black content. It is also interesting to know that, at certain concentration of SRF blacks, ε' and σ_{ac} reach extremely high values as a result of interfacial polarization between carbon black particles and the NBR chains.

The values of the aspect ratio which are chosen to fit the experimental permittivities with the calculated one from Tsangaris equation depend on the volume fraction of SRF carbon black.

A small change in ε` is noticed for samples loaded with SRF>30 phr with frequency at room temperature for uncompressed samples. The strong low frequency dispersion that characterizes the frequency dependence of the dielectric constant of NBR/$BaTiO_3$ loaded with SRF black may be due to the hierarchy of barriers to the carrier diffusion. The observed dispersion can be explained without assuming any particular type of barrier.

From the temperature dependence of the dielectric constant and dielectric loss for uncompressed samples, it was found that for samples loaded with SRF≤40 phr, there is a smooth increase in the dielectric constant, while those with SRF≥50 phr, there is a peak in the dielectric constant and a step in the dielectric loss. The positions of the peak and the step shift to higher temperatures as the measuring frequency increased (except for samples loaded with 100 phr of SRF black).

The volume resistivity of uncompressed samples decreases at its percolation threshold and maintains low values after percolation. The percolation threshold is about 30 phr of SRF black. The resisitivity of NBR composites decreased over 7 orders of magnitude as the concentration of carbon black increased.

In the current density-electric field measurements for uncompressed samples, it was found that in the higher field regions all samples exhibit linear current field characteristics. The conduction mechanism in these composites is found to be of the Poole-Frenkel type.

From the mechanical measurements, it was found that as the filler loading increases, the relative tensile strength increases and the elongation at break decreases.

It was also found from the calculations of knee-point strain that the knee-point strain depends on both the elastic modulus and SRF carbon black content. The knee-point strain decreases with the increase of both elasticity modulus and SRF contents.

The pressure plays important factor that affect the behavior of these composites. When pressure is applied on these composites, a percolation path is easily formed which causes a drastic fall in resistivity even when the volume fraction of filler apparently increases compared with the unpressurized composites.

Two main mechanisms competing with each other could be observed due to the effect of pressure on both ac electrical resisitivity and the dielectric constant. The first one is the breakdown of carbon black network into small aggregates, which results in a significant reduction in the total number of conduction paths and dipoles. The second mechanism is the orientation of carbon black aggregates in the direction of the strain.

The calculated values of relative pressure coefficient of dielectric constant show a constant value with the variation of SRF loading to a certain level and after which a sharp increase is detected.

The percolation concentration, ϕ_c, increases appreciably with the applied pressure indicating the aggregation effects of carbon black particles on the rubber matrix.

A last factor is the orientation effects of SRF particles/or aggregates in the direction of compression in addition to the factors mentioned before is considered to describe the strong low frequency dispersion that characterizes the frequency dependence of the dielectric constant of SRF-loaded $BaTiO_3$/NBR.

The dc conductivity measured along the strain direction shows a decrease in its values with increasing the elongation for all tested samples except samples loaded with 80 and 100 phr of SRF black.

It was noted from the values of the activation energy E_v, that the ionic transport is the responsible mechanism of TSDC at different compressive stresses for both pure NBR and 30 SRF/NBR samples. The values of the activation energy decrease with compressive stress.