

Investigation of the Morphological Properties of Medical-Used Natural Rubber Composites Reinforced with Nano Iron Oxide Nanoparticles

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Abstract: Polymer matrix nanocomposites are one of the most important polymeric materials that exhibit very good mechanical and thermal properties. These materials have applications in medical goods. In this paper nanocomposites based on natural rubber and solid epoxy polymeric resin reinforced with nano-sized iron oxide (Fe₂O₃) nanoparticles are prepared via mechanical blending method. Indeed the melt mixing process by two roll mills are used in this investigation to prepare a well-dispersed nanocomposite samples. In these compounds, dispersion and distribution of nano iron oxide in the natural rubber / solid epoxy resin matrix are investigated. We investigate the morphology of natural rubber / solid epoxy resin/nano iron oxide nanocomposites by scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The results of morphological observations of present investigation showed that the presence of nano iron oxide has almost been distributed in the natural rubber matrix.

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1. Introduction

Polymers are used as a common material in many health applications i.e. manufacturing medical equipment etc.. Specially, polymers are used as the composite matrix in composite materials. Composite materials are one of the main branches of science that nearly started at about half century ago. In these materials, combination of two or more ingredients forms composite [1-6].

Polymers have a wide range of benefits over the conventional traditional materials such as metals that are used in fabrication of goods and devices. They show better corrosion resistance and life time over the traditional metals and therefore these materials might be easily used in water-based medias such as human bodies.

In the composite materials, combination of the properties of each ingredient caused the good performance. Moreover, for enhancing composite properties, reinforcing fillers can be added to composites. Among the reinforcing fillers, nano materials have been attended in recent years [7-9]. Nano materials are special effects on the composite materials due to their nano size. Nano size of these reinforcing fillers cause more surface area. Effective surface area of filler leads to good interactions with matrix. Therefore nanomaterials are used as the reinforcement in many researches by the previous investigators [10, 11].

Synthetically natural rubber could manufacture synthetically by thermal decomposition of natural latex. Natural rubber is one of the most used as a matrix in polymeric nanocomposites. Combination of natural rubber with other polymer like resin materials could be used in nanocomposites. For reinforcing these categories of composites, nano materials could be used.

Ternary nanocomposites have been regarded in the literatures [12-15]. In the ternary nanocomposites, the interaction between ingredients could play main role in the nanocomposites properties. Nanoparticles could influence on the properties of both two ingredients of matrix. Solid epoxy resin is one of the main resins which could be used in the nanocomposites as polymeric matrix. In some works, the influence of nano particles like nano clay in the epoxy resin matrix have been investigated [16-19]. In these papers dispersion of nano particles on the epoxy resin have been studied by electronic microcopies and x-ray diffractions.

Moreover, thermal properties of these nanocomposites based on epoxy resins have been investigated. Combination of epoxy resin and natural rubber has been attended in the literatures [20-24]. This combination of rubber and resin has not been widely attended in the researches. Moreover incorporation of nano particles in the natural

rubber/epoxy resin matrix has not been examined in the literatures.

Understanding of morphological properties of natural rubber/epoxy resin/nano iron oxide nanocomposites could forecast the other properties of nanocomposites. So in this paper influence of nano iron oxide on the morphological properties of natural rubber/epoxy resin have been systematically investigated via experimental approach.

Morphological properties are the base properties of composites that have main role on the other properties of compounds. Therefore, in this work, morphological properties like dispersion and distribution of nano iron oxide have been examined in the polymeric matrix.

2. Experiments

Materials

The main part of matrix is natural rubber (NR) which supplied from Indian national rubber with ISNR-5 code. This kind of natural rubber has 0.75 % mass ash content and plasticity retention index 60 min.

The solid epoxy resin (ER) was D.E.R 671 low molecular weight solid epoxy resin which was prepared from Dow chemical company. The epoxide percentage of this resin is between 7.8-9.1% and its softening point is 75-85°C.

Curing system was used Sulfur, Zinc Oxide. The curing system was kindly prepared by local company.

Nano iron oxide was supplied from nanophase Technologies Corporation with mean particle size of 30 nm and specific surface area 38 m²/g. morphology of nano iron oxide is nearly spherical and density and purity is 5.2 g/cm³ and 99% respectively.

Sample preparation

In the experimental section, first natural rubber (NR) was masticated by two roll mills. Then, solid epoxy resin (ER) was added to paste of natural rubber. After that, nano iron oxide was added to NR/ER paste and mixing stage was continued. Then curing system was added to paste and after finishing of incorporation of ingredients, the compound was mixed for about 15 minutes.

After that, the paste was put in the mold for curing. The cure temperature is 150°C. After curing the compound, post curing reaction was carried out. The formulation of compounds is shown in table 1 based on one hundred parts of natural rubber and resin phenolic.

Table 1: Formulations of NR/ER compound.

NR	ER	Fe ₂ O ₃	Sulfur	ZnO
65	35	0	2.5	5

Table 2: Formulations of NR/ER/3Fe₂O₃ compound.

NR	ER	Fe ₂ O ₃	Sulfur	ZnO
65	35	3	2.5	5

Morphological Test

Characterization of compounds was carried out by scanning electron microscopy (SEM) and transmission electron microscopy (TEM). SEM instrument by Leo Co. Germany was used.

Moreover, for morphological properties and investigation on dispersion and distribution of nano iron oxide, transmission electron microscopy (TEM) was also used. TEM images were taken by The Philips CM200 (field emission gun) transmission electron microscope (TEM) operating at up to 200 kV, a very versatile microscope.

For preparing of samples for TEM analysis, microtoming of samples was carried out by ultra microtomereichert OmU3 Austria. .

3. Results and discussion

In figure 1, SEM image of base sample natural rubber/epoxy resin have been shown. For capturing of SEM images, the samples have been dipped in the liquid nitrogen pot. After reaching the sample under glass transition temperature, the samples have been brought out from pot and have been immediately broken. SEM images have been captured from these surfaces.

As it could be seen in figure 1, continuous surface of base compound could be seen. It may be said that the continuous phase of two ingredients have been occurred. This picture shows that the proper interactions happened between natural rubber and solid epoxy resin.

In the figure 2, SEM image from fracture surface of NR/ER/3Fe which has 3 phr nano iron oxide has shown. As it could be seen in this image, nano iron oxide properly distribute in the natural rubber/epoxy resin matrix.



Fig.1. SEM image from surface of base sample NR/ER sample.

Moreover, agglomerations of nano particles have occasionally occurred. It shows that nano iron oxides could appropriately interact with polymeric matrix. This good dispersion and distribution of nano particles in the natural rubber/epoxy resin will prospect the good properties of nanocomposites. More dispersion of nanoparticles caused more access to surface area of them and resulting good properties.

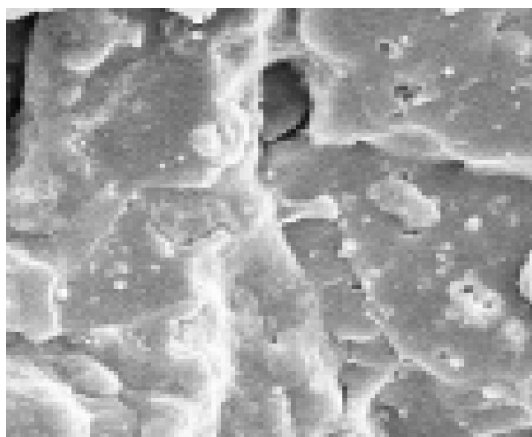


Fig. 2. SEM image from surface of NR/ER/3Fe

Moreover, dispersion and distribution of nano particles in the polymeric matrix could be assay by transmission electron microscopy or TEM images. For this purpose, the TEM image of NR/ER/3Fe samples has been brought in figure 3. This image shows that nano particles of iron oxide could distribute in the polymeric matrix without many agglomerations. Moreover, the average size of dark particles of the image is about 120nm. This size of nano particles shows that 3 or 4 particles of nano iron oxide form an agglomeration and it could be a good dispersion of nano particles thought the matrix.

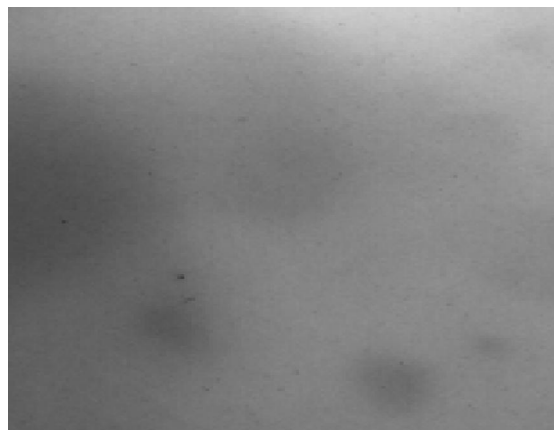


Fig.3. TEM image of NR/ER/3Fe.

4.Conclusions

Dispersion of nanoparticles in polymeric matrix is investigated in this work. By two rolls mill methods, compounding of natural rubber / solid epoxy resin with nano iron oxide particles have conveniently prepared. The morphological results showed that the natural rubber and epoxy resin could properly interact together and formed a good matrix for nano iron oxide particles. The results showed the continuous phase of natural rubber and epoxy resin. Moreover, nano iron oxide could suitably distribute through the natural rubber/epoxy resin matrix. The results of microscopic images showed that less formation of agglomerations of nano iron oxide particles in the polymeric matrix.

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