Deterioration the Properties of Contaminated Natural Rubber with Some Species of Microorganisms.

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Abstract:

The rubber materials are very important in our lives because of its properties and suitability for many applications, and it is a direct target of numerous microorganisms such as bacteria and fungi and there effect on rubber, especially natural rubber poly (cis-1,4-isoprene), as it contains organic material and water, it dealt with the current study. The effect of contaminate (fungi) during bad conditions of transportation and Storage, genus Aspergillus Niger was isolated from contaminated samples for both types (SMR20, SVR20) and study the physical and mechanical properties, which included tensile strength and elongation at break, hardness, abrasion and extraction in addition to the study influenced main constituent of natural rubber growth of fungus using the technique of infrared spectrum. The results showed a negative influence on the physical and mechanical properties for the growth of fungus, in addition to the disappearance of some bands of natural rubber such as (C-H) and (C-N) bands.

Keywords: Deterioration, Natural Rubber, SMR20, SVR20, poly (cis-1,4-isoprene), microorganisms, fungi.

Introduction:

Natural rubber is a biopolymer containing poly (cis-1,4- isoprene). It is an important material for tires, latex gloves, catheters, and so on. Commercial raw natural rubber has a small, but highly important number of nonrubber constituents. The average composition of the natural rubber latex is 25-30% poly-isoprene, 1-1.8% proteins, 1-2% carbohydrates, 0.4-1.1% neutral lipids, 0.5-0.6% polar lipids, 0.4-0.6 inorganic components, 0.4% amino-acids etc.,and other 50-70% water [Nayanashree and Thippeswamy, 2013].

There are many substances that are added to the latex rubber and running as preservatives from injury microorganisms such as fungi and bacteria…etc., but the passage of time and as a result of conditions of transportation, poor storage conditions and moisture, the infection or contamination by many of these microorganisms will occur. The damage will be done in natural rubber appears on the vulcanized rubber products as a result of the change in the structure of his compositional [Shin Sato, 2005].

Many of the previous studies refer to the injury of natural rubber products with microorganisms such as Actinomycetes, Gordonia, Mycobaterium and Nocardia, which lead to a break down chains of rubber and change its properties [Cherian et al, 2009; Trang et al 2013], where organic impurities in the rubber can support microbial growth, and many reports on its biodegradability have been published. It is assumed that degradation of the rubber backbone is initiated by oxidative cleavage of the double bond [Yamamura et al, 2005; Rose and Steinbuchel, 2005; Onyeagoro et al 2012].

The use of microorganisms style treatment to get rid of waste rubber products as mentioned in many previous studies [Cherian et al,2009; Onyeagoro et al,2012] is clear evidence of the power of those microorganisms in attacking the structure of natural rubber and breaking down its chains.

The present study deals with the influence of injured natural rubber vulcanized with microorganisms and the effect of these injuries on the chemical and physical properties of natural rubber products.

Materials and Methods:

Samples were collected for the natural rubber Malaysian and Vietnam origin (SMR20 and SVR20) from Al-Diwaniyha Tires Factory fig. (1) with all required agents as mentioned in table (1).

Table (1): Formulation of natural rubber.

Material	Weight in (gm)	
	type 1	**type 2**
NR, SMR 20	200	-
NR, SVR 20	-	200
Carbon Black, (N220)	100	100
Activators, Stearic acid	4	4
Softening Aids, Oil	6	6
Accelerators, CBS	2	2
Vulcanizing Agents, Sulfur	4	4

Isolation of Fungi:

Isolated fungi which found on the samples after testing samples microscopically and make sure there is fungal growth by taking part of the growth and put the center in a petri dish containing Sabouraud's Dextrose Agar, prepared for this purpose according to the instructions of the manufacturer added to it (0.5%) of anti-bacterial Chloramphenicol [Meletiadis *et al* ., 2002]. Then the samples were incubated degree (25C°) and then monitoring growth for a period of seven days and diagnosed in lab. of microbiology in biology department/ college of science/Al-Qadisiya University.

Experimental Tests:

All tests for the present study were conducted in the Babylon Tires Factory and these tests included:

1. Tensile test, according to ASTM D 412.
2. Hardness test, according to ASTM D 1415 and ASTM 2240.
3. Abrasion test, the abrasion resistance of vulcanized rubber was tested by AKRON Abrasion Tester shown in fig. (2), (according to B.S. 903 PT.A9).
4. Infrared Spectrum (IR), these test methods are applicable to rubbers in the raw state and, when compounded, both in the cured and uncured state, according to ASTM D 3677.
5. Acetone Extract Test, this method is intended to determine the various organic constituents in the rubber as solvent extract according to ASTM D1278 and D 297.

Results:

The results of the laboratory diagnosis of samples of stored rubber which has been obtained from Al-Diwaniyha Tires Factory show, that some of the samples contaminated with fungi and after diagnosis found it belongs to the genus *Aspergillus niger* Van Tieghen. And laboratory testing proved the existence of these fungi is not confined to the surface of the sample, but penetrates inside the sample material, fig. (3).

The results of testing some mechanical properties of natural rubber (SVR20 and SMR20) show, that samples of contaminated rubber gives low value in tensile strength and elongation at break compared with samples of uncontaminated rubber. Also, samples of SVR20 give high value in tensile strength and elongation at break compared with SMR20, fig. (4, 5).

Fig. (6) explain that samples of contaminated rubber gives high value in hardness test compared with samples of uncontaminated rubber. Also, samples of SVR20 gives low value in hardness test compared with SMR20 especially in contaminated samples.

The results of abrasion test showed, that samples of contaminated rubber gives high value in abrasion test compared with samples of uncontaminated rubber. And samples of SVR20 gives low value in abrasion test compared with SMR20 in both contaminated and uncontaminated samples, fig. (7).

Extraction test shows the proportion of additives originally to Natural Rubber in both types shown in fig. (8, 9), where is noted that the percentage of extraction of contaminated samples for both types were higher compared with uncontaminated samples. Add to it can be seen that the percentage of extraction of natural rubber type SMR20 is higher than the percentage extraction of rubber in the SVR20.

FTIR test focus on both types of samples show clearly the effect of the fungus on the natural rubber structure (SMR20 and SVR20) and these results illustrated in fig. (10,11). Where bands in the range of (2900-3010)cm^{-1} of the C-H groups, (1600)cm^{-1} of the C=C groups, (1450-1500)cm^{-1} of the C-N groups and (690-730)cm^{-1} of the C-O groups [Rohana et al, 2011].

Discussion:

During this study isolated the genus *Aspergillus niger* Van Tieghen as microorganism contaminate the natural rubber (SMR20 and SVR20) and showed the higher abilities for natural rubber degradation than the others microorganism, also this results accordant with [Nayanashree and Thippeswamy, 2013]. It was believed that this microorganism grow on the organic material which exist in natural rubber such as proteins, carbohydrates lipids...etc.

The tensile properties for two types of natural rubber (SVR20 and SMR20) in both contaminated and uncontaminated state showed in Figure (5). It seems clear that the tensile strength of uncontaminated samples is better than the other contaminated. It can also note some differences between SVR20 and SMR20, where the first one has the higher value. Same results can be observed in the results of Elongation at break fig. (6).

The contaminated specimens gave results of about 25% less than the values of tensile strength of uncontaminated specimens of SVR 20. Same results but increase to about 30% in case of SMR20. Also the contaminated specimens gave results of about 18% less than the values of elongation at break of uncontaminated specimens of SVR 20, while the percentage increase to 24% in case of SMR20. The change in the structure of natural rubber as a result of contamination causing changes its properties. The structure of natural rubber affected significantly as a result of contaminated with microorganisms (such as fungi) which deliberately to demolish that structure and cracking rubber chains interrelated.

Uncontaminated samples gave same values for hardness for both types of natural rubber, while contaminated gave different values, where it is clear that the samples contaminated rubber type SMR20 gave higher hardness by only (2 %) of those rubbers SVR20. Here we can say that the cause of the contaminate increase hardness samples fig. (7). This may be due cause increased of hardness in the samples of contaminated with fungal growth which is make a mesh network with each other, where the fungal hyphae intertwined with others during growth consisting mass of mycelia, which plays an important role in increasing the hardness.

Figure (8) show the results of abrasion test, where uncontaminated specimens have the lower percentage than the contaminated specimens, where it can note that the samples contaminated rubber type SMR20 gives higher abrasion by about (30 %) of those uncontaminated. Otherwise the samples contaminated rubber type SVR20 gives higher abrasion by about (25 %) of those uncontaminated, and this lead to the conclusion that the growth of microorganisms (fungal growth) reason to weaken the mechanical properties and bonding or crosslinking in the rubber chains attack as a result of those objects for rubber and preliminary analysis of its elements, including that of proteins and other organic materials.

Extraction with acetone are materials installed and additives for the rubber where the expense ratio of these materials for uncontaminated and contaminated samples, which falls within this percentage in the contaminated samples weight growth of microorganisms, including fungi, hence the rate of percentage of the contaminated samples, according to the results of the current study was higher than the percentage of uncontaminated samples, fig. (9).

Finally, infrared spectrum of two types of natural rubber appear strong bands in the range of (2900-3010)cm^{-1},(1450-1500)cm^{-1} were disappeared for contaminated specimens and this lead to conclusion that the effect of fungus growth was not limited on physical properties only, but including the chemical properties, also this results were reported by [Muniandy et al, 2012].

Conclusions

The major conclusion from the results of present study was the ability of micro-organisms (aspergillus) to deteriorated natural rubber (SMR20, SVR20) and this fungal growth effect on physical and chemical properties. Also the present study showed the highly effective of contaminated natural rubber by organisms on the mechanical properties such as tensile strength, elongation, hardness and abrasion, thus the conditions of transport, storage conditions and moisture were considered important limits to saving the products and raw materials of natural rubber.

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Fig. (1): Uncontaminated Specimens.

Figure (2): AKRON ABRASION TESTER.

Fig. (3): Contaminated Specimens.

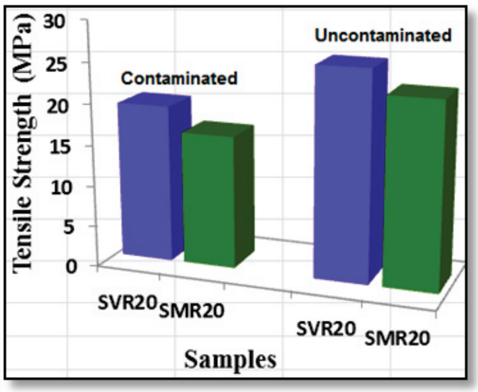

Fig. (4): Tensile Strength Test.

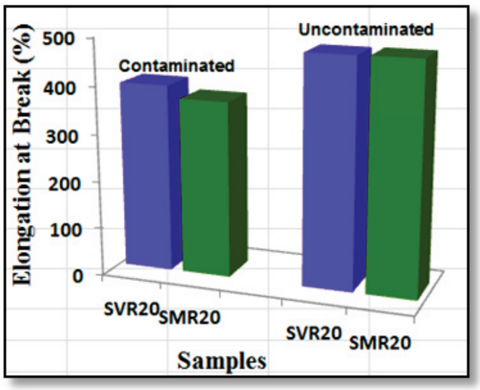

Fig. (5): Elongation at Break Test.

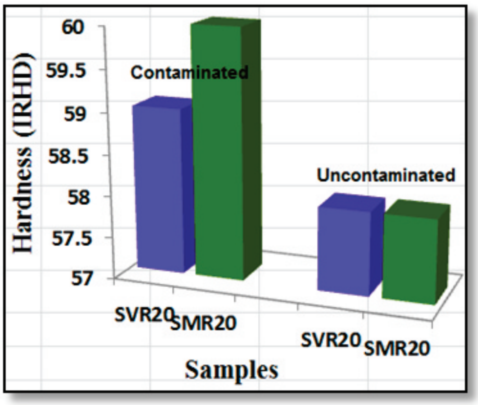

Fig. (6): Hardness Test.

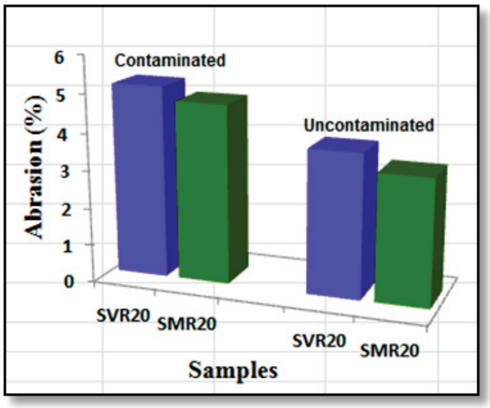

Fig. (7): Abrasion Test.

Fig. (8): Samples after Extraction Process.

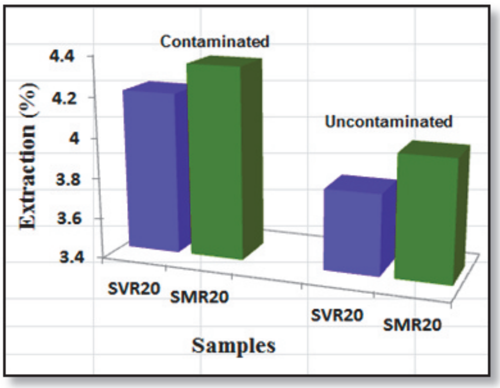

Fig. (9): Acetone Extract.

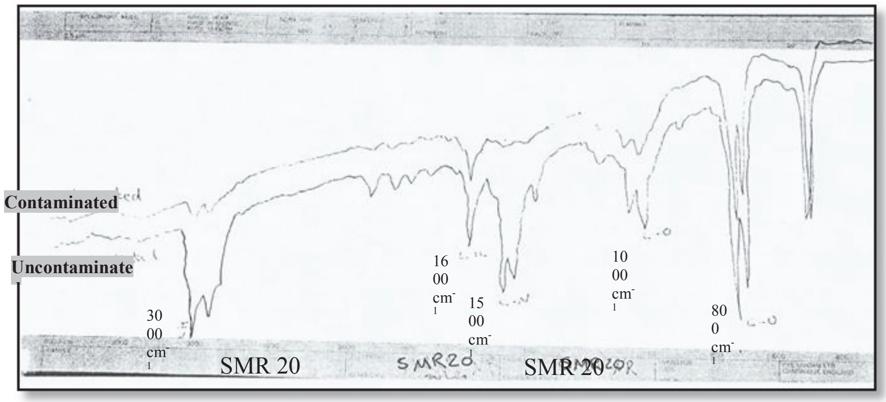

Fig. (10): Infrared spectrum (SMR20).

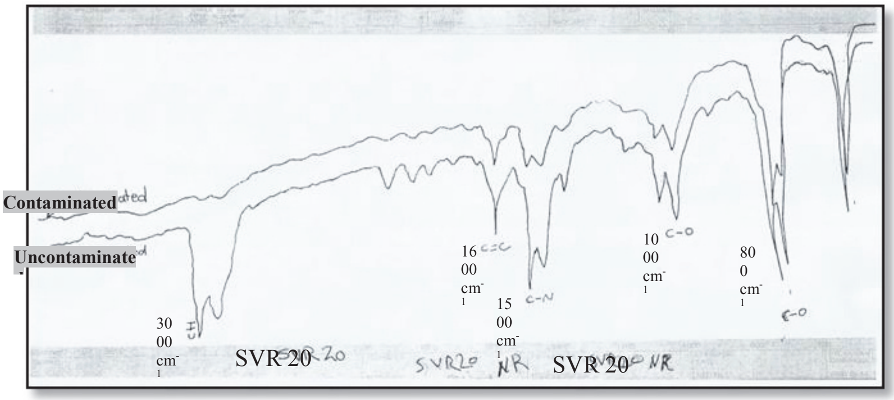

Fig. (11): Infrared spectrum (SVR20).