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Recycled Natural Rubber Latex Gloves Filled CR Rubber: The Effects of Filler Size and loading

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Abstract. The effect of (rNR-G) as a filler with different size and loading on curing characteristics (scorch time, cure time, minimum and maximum torque) and physical properties (swelling test, crosslink density and hardness test) on rNR-G/CR (chloroprene) were investigated. Two sizes of fillers (fine size and coarse size) were utilized with different loadings (0, 5, 10, 15, 20 and 25 phr) for each size. The results indicated, the optimum cure characteristics for the (rNR-G)/CR compounds were at 5 phr for the fine size, meanwhile, for the physical properties, the hardness increased with the increasing of filler loading, and gave higher values in the case of fine size.

1. Introduction

Rubber is one of the most important material in the world. Its versatility has gotten the attentions of researchers worldwide. Nowadays, there are many advancements related to rubber technology and still progressing even now. However, even progress has its own price. Rubbers are basically polymers with high density cross-linked structures, due to those strong bonds, rubbers are difficult to decompose [1]. This causes problems to the world as there are no effective methods of deposing rubber wastes.

Polychloroprene (CR) [poly(2-chloro-1,3-butadiene)] is one of the most important rubber with an annual consumption of nearly 300 000 tons worldwide. CR is utilized as a part of diverse specialized regions, essentially in the elastic business, but on the other hand is paramount as an issue material for glues (both dissolvable based and water based, and has distinctive latex applications, for example, dipped articles (e.g. gloves), formed froth and change of bitumen. Unfortunately, CR as other types of rubber becomes stiff and fragile after long-term utilizing under high-temperature conditions [2, 3].

Nowadays, the natural rubber glove (NRG) is one of the most important in different areas such as health applications. After its use, in general, NRG is convert to waste rubbers after using, which it is not degradable, because polyisoprene chains of NR are crosslinked either by sulphur or peroxide system [4, 5]. As the huge using of NRG in parallel with the diseases diffusion and population growth, the problem of NRG waste started in growing. In addition to NRG waste from hospital and other toxic hazardous waste, more than 11% of NRG products considered as a rejected or defect products during the processing of latex rubber. all of the huge waste rubber quantities might cause serious

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environmental problem and great health risk to public [6]. To solve this problem, many research investigated the reuse of NRG waste in several applications such as mat and large tire [6].
Recently, the rNR-G started in use which blended with virgin synthetic rubber and NR [7, 8]. In this present work, the rNR-G waste was blended with CR to study the effects of different size and loading filler on the cure characteristics and physical properties.

2. Experimental

2.1 Materials
The materials used in the research are listed in Table 1. Along with materials, the functions and also the suppliers name are also listed with the materials. The rNR-G which are obtained from Top Glove Group Corp. Malaysia, requires further processing before it can be used as compounding material.

Table 1. List of materials and chemicals used in this study.

Materials	Function	Supplier
Chloroprene rubber	Elastomer or rubber matrix	RRIM Guthrie Group Sdn. Bhd.
Sulphur	Vulcanizing agent	Anchor Chemical Co. (M) Ltd.
N-cyclohexyl-2-benzothiazole sulfonamide (CBS)	Accelerator	Anchor Chemical Co. (M) Ltd.
Zinc oxide	Activator	Anchor Chemical Co. (M) Ltd.
Stearic acid	Activator	Anchor Chemical Co. (M) Ltd.
Recycled Natural rubber latex glove (rNR-G) filler	Raw materials for fillers	Top Glove Corp. Malaysia

2.2 Formulation and Testing of CR/ rNR-G Compounds
rNR-G waste was cut and masticated by using two-roll mill (X(S)K-160x320) at room temperature for 30 minutes to break the crosslinking of the latex glove, to be able for grinding. After the grinding process, the rNR-G were sieved to obtained filler with particulate size of 300 – 600 µm (fine size), and the rest was considered as coarse size fillers. After preparation the gloves waste in suitable sizes, the compounding was done as shown in Table 2.

Table 2. The formulation of rNR-G filled CR with different size and loading.

Ingredients	Compounds (phr)					
Sample	1	2	3	4	5	6
CR	100	100	100	100	100	100
Sulphur	2	2	2	2	2	2
CBS	1	1	1	1	1	1
ZnO	5	5	5	5	5	5
Stearic acid	2	2	2	2	2	2
rNR-G	0	5	10	15	20	25

2.3 Characterizations and Testing of CR/ rNR-G Compounds
After preparing all the specimens, the cure characteristics were done by using the Rheometer Monsanto Model MDR 2000. By the cure test, the minimum torque (ML), maximum torque (MH), cure time (t90), and scorch time (t2) were studied. In addition, the tensile test was studied according to the ASTM D412 method, which was done by using the universal testing machine Instron 5582. Tensile strength, elongation at break and the modulus at 100% elongation were investigated.

3 Results and Discussions

3.1 Cure Characteristics

Scorch time t2, cure time (t90), minimum torque (ML) and maximum torque (MH) for recycled natural rubber latex gloves filled chloroprene rubber were studied as cure characteristics.

3.1.1 Scorch time (t_2).

Figure 1, shows the graph of scorch time (T2) for CR filled with different loading of rNR-G with different filler size. From the graph, the scorch time showed an increasing trend as the levels of loading of the rNR-G increased. The increased in scorch time can be attributed to the levels filler which hindered the crosslinking process.

However, the T2 of both coarse and fine size filler at 5 phr of filler loading were lower compared to CR without the addition of rNR-G. But after the incorporation of rNR-G at 10 phr and above, the T2 of each respective filler loading were higher than the T2 of CR. This indicated the level of rNR-G at 5 phr did not suffice to hinder the T2 of the CR. On the other hand, rNR-G loading at 10 phr and above were more than sufficient to delay the T2 of CR.

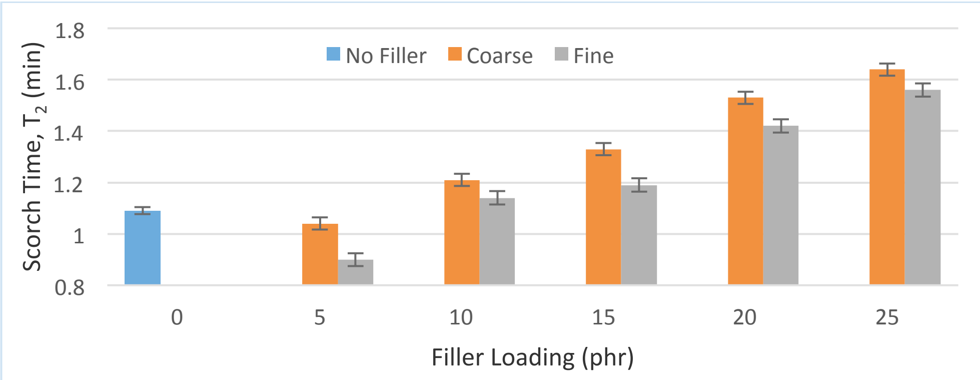

Figure 1. Scorch time (T2) of rNR-G filled CR with different size and loading.

Additionally, the scorch time of the coarse size filler showed slower T2 compared to the fine size filler. The coarse size filler has smaller surface area and are larger in terms of diameter compared to the fine sized filler. Thus, the bigger sized filler gets in the way of the formation of the crosslinking process, which delayed the T2 of the coarse filler, resulting the fine size filler to have lower T2 [9].

3.1.2 Cure time (t_{90})

The graph illustrated in Figure 2, shows the cure time of CR with different levels of filler loading and the incorporation of different size filler. The result revealed that the cure time increased as the filler loading increased. From the result it is obvious that the presence of filler within the matrix inhibits the crosslinking process. Therefore, delaying the cure time as the level of filler within the matrix increased.

Based on Figure 2, the cure time of 5 phr of rNR-G loading were the lowest. Yet, at 10 phr loading and above, the results shown the cure time at the respective filler loading were higher than CR without any filler present. The cure time at 5 phr of rNR-G loading was the fastest due to the decrease of matrix, as the filler loading increased. Even though rNR-G were also incorporated, the results suggested that at 5 phr of filler loading, that level of loading was not ample enough to influence the cure time of CR. Inversely, at 10 phr and above filler loadings, the cure time of the filled CR were higher compared to the unfilled CR. This is because at 10 phr of filler loading, the level of rNR-G was enough to cause an influence (Banerjee, 2012). Thus, further increase of filler loading from 10 phr will increase the cure time even more.

In addition, although the cure time increased as the filler loading increased. The cure time of fine size filler was relatively lower compared to the cure time of the coarse size filler. As described in the previous section, the size of filler played a role in affecting the starting time of the crosslinking process. Similarly, coarse size filler will disrupt the crosslinking process by getting in the way of the formation of the crosslink bonds, thus delaying the cure time. Then again, fine filler will also disrupt the crosslinking process. However, the period of time at which it delays the cure time were much lower when compared to the coarse size filler.

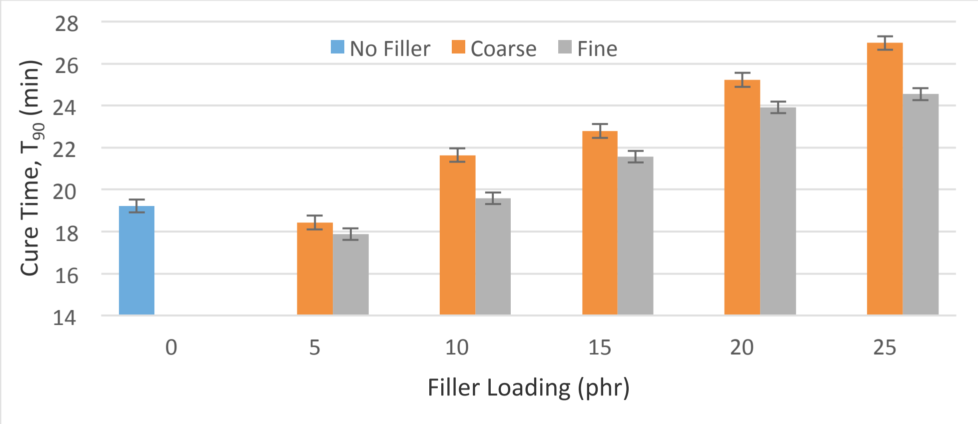

Figure 2. Cure time (T2) of rNR-G filled CR with different size and loading.

3.1.3 Minimum torque (ML)

The graph in Figure 3, illustrates the minimum torque of series 1 based on different levels of rNR-G loadings with different filler size. Based on the obtained results, the graph depicted an increasing trend of minimum torque as the filler loading of rNR-G increases. Based on the results it is apparent that with increase of the loading of rNR-G, the torque of CR also increased. Therefore, as the t increased so did the ML of CR.

However, the ML of both coarse and fine size filler at 5 phr of filler loading were lower compared to CR without the addition of rNR-G. But then again, after the incorporation of rNR-G at 10 phr and above, the ML of each respective filler loading were higher than the T2 of CR with no rNR-G. This indicates the level of rNR-G at 5 phr was not suffice to increase the viscosity of the CR. On the other hand, rNR-G loading at 10 phr and above were more than sufficient to increase the viscosity of CR [10].

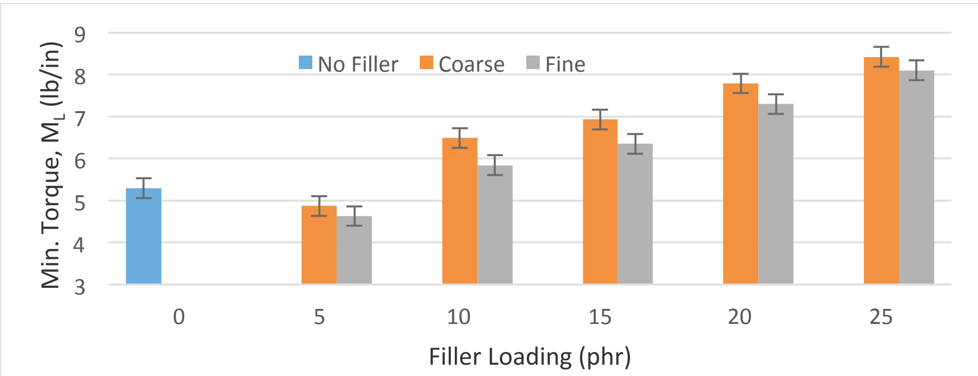

Figure 3. Minimum torque (ML) of rNR-G filled CR with different size and loading.

3.1.4 Maximum torque (MH).

The illustration in Figure 4, shows the graph of maximum torque for CR filled with different loading of rNR-G with different filler size. From the graph, the MH showed an increasing trend as the levels of loading of the rNR-G increased. The increased in MH can be attributed to the levels filler which increased the overall viscosity of the compounds. Higher MH indicates that the difficulty of processing the compound. Therefore, it is clear that the increase in rNR-G levels had increased the viscosity of the CR which made the maximum torque increased.

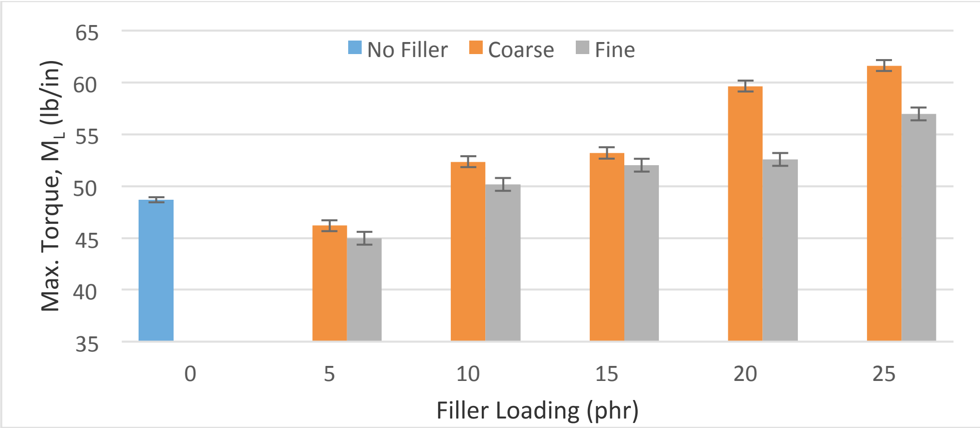

Figure 4. Maximum torque (MH) of rNR-G filled CR with different size and loading.

Based on Figure 4, the MH of 5 phr of rNR-G loading were the lowest for both coarse and fine sized rNR-G filler. Yet, at 10 phr loading and above, the results shown the MH at the respective filler loading were higher than CR without any filler present. The MH at 5 phr of rNR-G loading was the lowest due to the decrease of matrix; CR. Even though rNR-G were also incorporated, the results suggested that at 5 phr of filler loading, that level of loading was not ample enough to influence the viscosity of CR. Inversely, at 10 phr and above filler loadings, the MH of the filled CR were higher compared to the unfilled CR. This is because at 10 phr of filler loading, the level of rNR-G was enough to cause an influence. Thus, further increase of filler loading from 10 phr will increase the MH even more.

4. Conclusion

According to the results obtained, it can be concluded that the addition of recycled natural rubber glove (rNR-G) filler increased the cure characteristics of CR. The increment loading of rNR-G increased the processing time and reduced the ease of processing. By increasing the filler loading, the minimum and maximum torque also increased. As a result, the scorch time and cure time also increased. Moreover, it was determined that the swelling percentage of CR increased with the incorporation of more rNR-G filler. This suggested that the incorporation of rNR-G filler reduced the crosslink density of CR.

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