RESEARCH REPORT

Recycled gloves as a filler

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Abstract

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Glove rejects can be loaded as filler in the formula (NR 100, ZnO 5, stearic acid 1, MBT 1, S 2.5, BHT 1 and calcium carbonate 40 phr) up to 100 phr to give good properties such as cure time, tensile strength, 300% modulus, elongation at break, tear strength, crack growth and abrasion index. However, scorch time and extrusion quality show a shorter time and rougher surface with higher loading, respectively. A recommended quantity for obtaining good properties in scorch time and extrusion process by garvey die is 40 phr. Powder gloves show a different cure time and scorch time from chlorinated gloves but show no significant changes in physical properties.

Key words : recycled gloves, scrap rubber, devulcanization

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บทคัดย่อ

อรสา ภัทรไพบูลย์ชัย ตุลยพงษ์ ตุลยพิทักษ์ และ อิทธิศักดิ ศรีวัง

การนำถุงมือยางกลับมาใช้ในฐานะเป็นสารตัวเติม

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ถุงมือที่ถูกคัดทิ้งสามารถนำกลับมาใช้เป็นสารตัวเติมได้ถึง 100 ส่วน [ในสูตรที่ประกอบด้วยยางธรรมชาติ 100 ซิงค์ออกไซด์ (Zinc oxide, ZnO) 5 กรดสเตรียริค (Stearic acid) 1 สารตัวเร่งเอ็ม บี ที (MBT) 1 กำมะถัน 2.5 สารป้องกันการเสื่อม บี เฮช ที (BHT) 1] โดยที่ยังคงมีสมบัติที่ดีในส่วนของเวลาในการทำให้ยางสุก (Cure time) ความต้านทานต่อแรงดึง 300% โมดูลัส (Modulus) การยืดตัวของยางจนขาด (Elongation at break) ความต้านทานต่อการฉีกขาด (Tear strength) การขยายตัวของรอยแตก (Crack growth) และความต้านทานต่อการสึกหรอ (Abrasion index) ยกเว้นเวลาในการอบสุกของยางก่อนกำหนด (Scorch time) และกระบวนการดันยางผ่านหัวไดน์ (Extrusion) คือจะใช้เวลาสั้นกว่า และให้ผิวที่หยาบกว่าตามลำดับ เมื่อใส่ปริมาณสารตัวเติมเพิ่มขึ้น การเติม 40 ส่วนเป็นปริมาณที่เหมาะสมในการรักษาสมบัติที่ดีในด้านเวลาในการอบสุกของยางก่อนกำหนดและกระบวนการดันยางผ่านหัวไดน์ชนิด Gravey ถุงมือชนิดมีแป้งมีค่าเวลาในการทำให้ยางสุก และเวลาในการอบสุกของยางก่อนกำหนด แตกต่างกับถุงมือชนิดคลอริเนตแต่สมบัติทางกายภาพของถุงมือทั้งสองชนิดไม่แตกต่างกันอย่างชัดเจน

ภาควิชาเทคโนโลยียางและพอลิเมอร์ คณะวิทยาศาสตร์และเทคโนโลยี มหาวิทยาลัยสงขลานครินทร์ ปัตตานี 94000

Nowadays, people produce tons of scrap rubber every year, for example in the United State alone 170,000 tons of factory scrap are produced annually. In addition, Americans discard 250 million used tires every year. A number of rubber technologists have tried to solve this major waste problem. One of the most common is to burn the scrap rubber as fuel but it generates new air pollution problems. Therefore, the best prospect for recycling scrap rubber is to reuse it in new rubber products. In this way, instead of being a disposal problem, the scrap becomes a raw material. The simplest approach is to use this scrap rubber as filler in new rubber products.

Thailand is one of the biggest glove producters. Each day, there are rejected gloves created about 2-10% in the process depends on the manufacturers individually. Only 7% of the total daily rejects leading to a serious problem for the industry in producing the mountain of black gold. With this result, if one can reuse the rejects by putting them into a virgin compound, the saving costs would be considerable.

The degradation of glove rejects resulting from mechanical treatment is sufficient for them to be used as a recyclate. This process is known as devulcanization that cleaves totally or partially, the poly-di-, and monosulphide crosslinks formed during the initial vulcanization (Warner, 1994). The disposal/utilization of scrap latex rejects can be approached in many ways. The first example is to reclaim or remove the crosslinks (Phadke, *et al*, 1983) in the scrap rubber and then use it as a raw material. The second example is to reuse it as an impact modifier in brittle plastics like polystyrene (Rajalingam and Sharpe, 1993; Pittolo and Burford, 1985) by solution or melt blending techniques. The last one is to reuse it as a filler in polyolefin (Oliphant and Baker, 1993).

Two kinds of glove rejects were studied in this research, one was powder gloves the other was chlorinated gloves. Both gloves were used as a filler in the compounds used as shown in Table 1. The influence of filler loading on the physical properties included cure characteristic (scorch time, t_2 and cure time, t_{90}) and the extrusion quality was compared and presented.

Table 1. Formulations

phr	Ingredients					
	1	**2**	**3**	**4**	**5**	**6**
STR 20	100	100	100	100	100	100
ZnO	5	5	5	5	5	5
Stearic acid	1	1	1	1	1	1
BHT	1	1	1	1	1	1
$CaCO_3$	40	40	40	40	40	40
MBT	1	1	1	1	1	1
Sulphur	2.5	2.5	2.5	2.5	2.5	2.5
Loaded glove	0	20	40	60	80	100

Table 2. Steps of mixing

Step	Ingredients	Mixing time (min.)
1	STR 20	8
2	Zinc oxide	2
3	Stearic acid	2
4	Ground glove rejects	4
5	Calcium carbonate	10
6	BHT	1
7	MBT	1
8	Sulphur	1
9	Make sheet	1
Total		**30**

Materials and Methods

All the chemicals used are shown in Table 1. The basic material used in this work was natural rubber grade STR 20 (Standard Thai Rubber), manufactured by a local manufacturer. The glove rejects were supplied by Safeskin Co-operation (Songkhla, Thailand) Ltd.. Other compound ingredients were of reagent grade and obtained from rubber chemical suppliers.

Both powder and chlorinated gloves used as a filler were prepared by passing the rejects through a two-roll mill six times in a friction ratio 1: 1.2, after which they were made into a sheet form. The steps in preparing compounds are shown in Table 2. All the ingredients were mixed with a two-roll mill at 45 °C for 30 minutes. Then, the compounds were analyzed for scorch time and cure time by Rheometer 2000 at 150 °C. In addition, the compounds were prepared for testing tensile strength, modulus and elongation at break, following ISO 37-1977(E), but tear strength followed ASTM 624-86 (using Universal Testing Machine, Tensometer), crack growth followed ASTM 1052-85 (using Ross Flexing Machine) and abrasion index followed BS: 903: part A (using Akron Abrasion Machine). In addition, the compounds were extruded with 2 inches sample strip through garvey die of cold feed extruder with a speed of 45 rpm at temperature of 110±15 °C and 70±10 °C for die and barrel, respectively, which followed ASTM D2230-93.

Results and Discussion

The scorch time and cure time were found to decrease as powder gloves were loaded. This can be explained by the presence of unreacted accelerator used in the glove rejects (Mathew, *et al*; 2001) leading to decreases in scorch time and cure time with loading filler. Chlorinated gloves showed opposite results in scorch time and cure time when they were loaded over 40 phr because the amount of chlorine from the gloves generated an acid to delay the reaction with loading filler. These results are presented in Figures 1, 2, 3 and 4. Both scorch time and cure time from loaded powder gloves are lower than those from loaded chlorinated gloves. The extruded surface from loaded powder and chlorinated gloves are shown in Figures 5 and 6. It was found that the more loaded the glove rejects, the rougher the surface of the extruded product of both powder and chlorinated gloves, with the extruded edge showing a better result (without obtaining rug edge). In addition, it could be seen that the latter could not be obtained when extruded through a garvey die with powder or chlorinated gloves loaded more than 60 phr

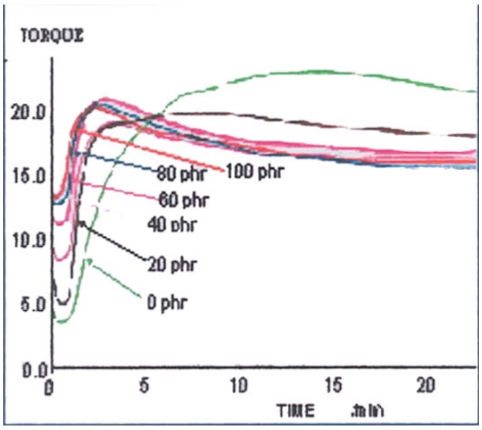

Figure 1. Cure characteristics of powder glove

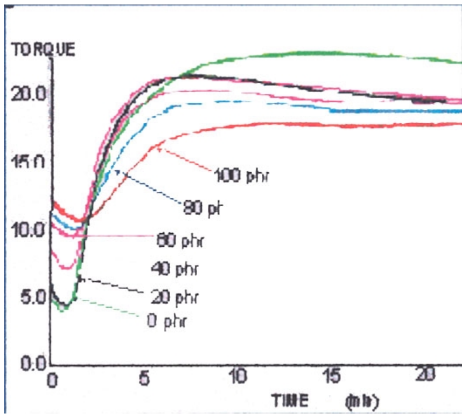

Figure 2. Cure characteristics of chlorinated glove

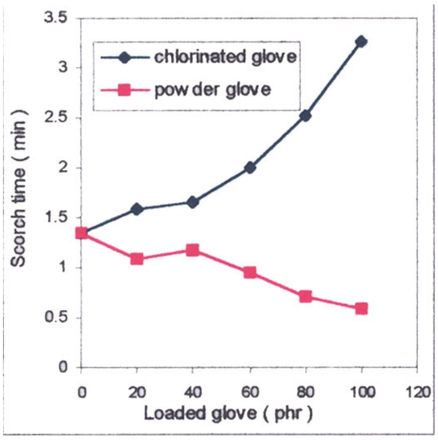

Figure 3. Effect of loaded glove on scorch time

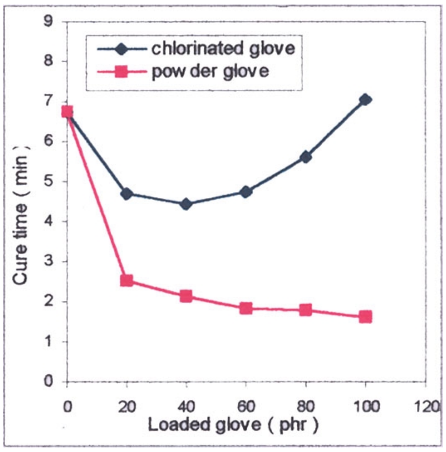

Figure 4. Effect of loaded glove on cure time

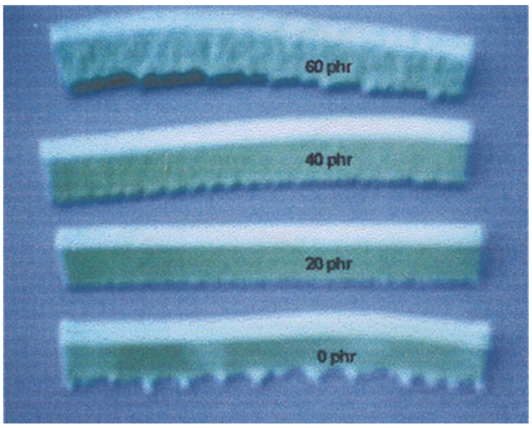

Figure 5. Extruded surface from loaded powder glove

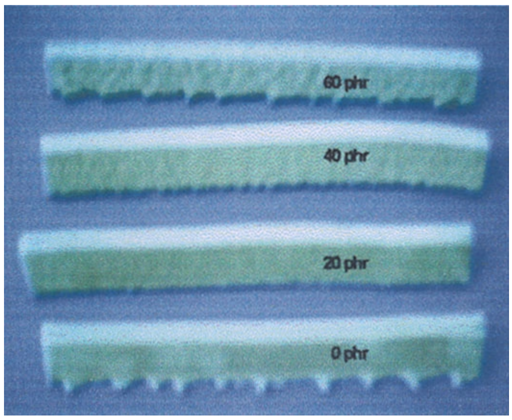

Figure 6. Extruded surface from loaded chlorinated glove

because the compound is scorched during the process. Moreover, the extruded surface starts to get very rough when powder or chlorinated gloves are loaded at over 40 phr. These results can be explained by the higher concentration of unreacted accelerator used in the glove rejects to cause the scorching (Mathew, *et al*; 2001). In the case of physical properties such as tensile strength (Figure 7), 300% modulus (Figure 8), elongation at break (Figure 9), tear strength (Figure 10), % crack growth (Figure 11) and abrasion index (Figure 12), it was observed that the properties tend to decrease insignificantly as powder or chlorinated gloves are loaded for tensile strength (Scott, 1994), 300% modulus, elongation at break and abrasion index but tear strength and %crack growth tend to increase insignificantly. Furthermore, physical properties are not significantly different between powder and chlorinated gloves.

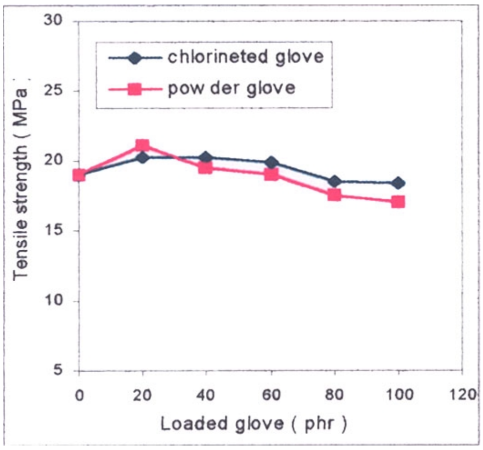

Figure 7. Effect of loaded glove on tensile strength

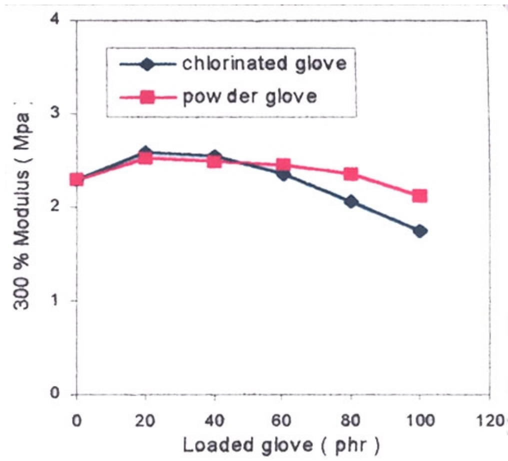

Figure 8. Effect of loaded glove on 300% modulus

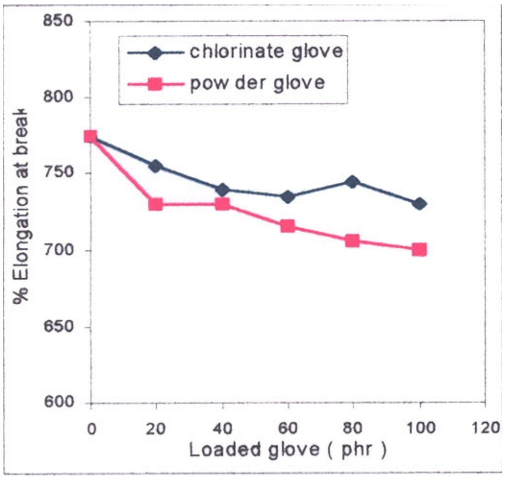

Figure 9. Effect of loaded glove on elongation at break

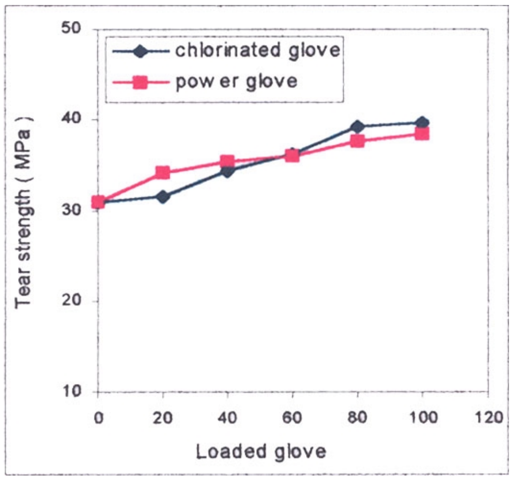

Figure 10. Effect of loaded glove on tear strength

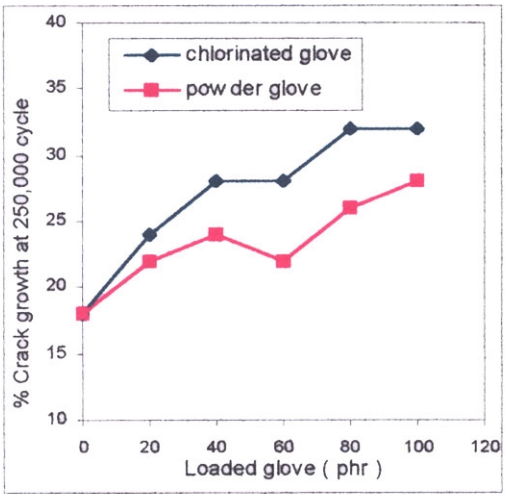

Figure 11. Effect of loaded glove on crack growth

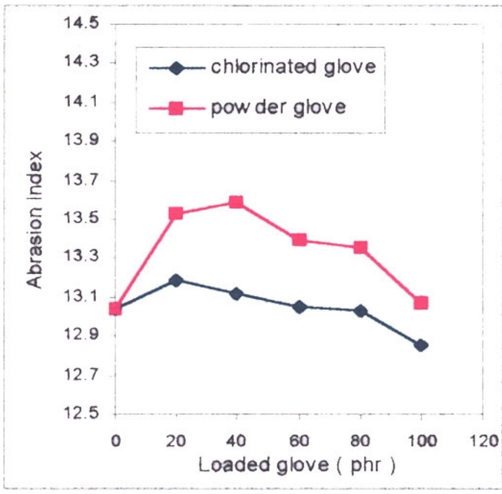

Figure 12. Effect of loaded glove on abrasion index

Conclusion

The utilization of latex glove rejects as a potential filler in natural rubber compounding deserves much attention. It has been observed that as the filler contents increase, the curing characteristics like scorch time and cure time decrease for powder gloves but not for chlorinated gloves. In addition, for the compound with calcium carbonate as a base filler, the physical properties (tensile strength, 300% modulus, elongation at break, tear strength, % crack growth and abrasion index) change insignificantly with loading glove rejects. Furthermore, 40 phr of glove rejects loading is a recommended quantity for obtaining good properties and extrusion quality.

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