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# Development of Powder Utilization of Waste Rubber

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Waste tires are a significant problem with the increasing in number of automobiles. Therefore, many researches have been studied on this field. Recycling is the one of the popular method aspect to environmental and economical in the treatment methods of the waste tire, which loads that the reuse of scrap tire rubber has been a challenge in the past. However, it is not easy method to melt down and mold into new products because the tire rubber is a cross-linked polymer. Most difficulty in recycling is the recycled product is not economic. Therefore, the goal of this study is to develop the high valuable products for reused waste tires.

In this paper, we try to make an economic recycled technology using scrapped waste tires. This technology may applied for manufacturing the end products such as a rubber block and a ballast mat for high-speed train.

Key word: Recycling scrap tire rubber, high valuable products recycled technology.

## INTRODUCTION

Many attempts[1-3] to recycle waste tires have been undertaken for environmental reasons. Three methods of the waste tires treatment; combustion buried under ground and recycle has been developed. The most paid attention to method among them is the recycle[4]. However, one of the obstacles of recycling is an economic problem. In recycling the waste tires variety method, which are summarized in Table Ⅰ, have been developed. A further, potentially attractive method is the utilization of powdered rubber. Commercially, one of the most popular applications of the powder utilization[3,5] is in golf range, industrial flooring and pathways. The advantage of powder utilization is that it is easy to apply with simple equipment. Although much work[3, 5, 6, 7, 8] has been done, problems still remain. The difficulties in recycling of the waste tires are the scrap of tire is a closs-linked polymer which inducing hard to melt and to process. This makes some special additives treatment for easy to processing such as binder and devulcanization[9, 10]. Generally, the commercial products used polyurethane binder.

Binder shows very good adhesion but very expensive. Therefore, this recycling processing is not economic. We studied how to make a high value products by using powdered rubber in this research work. We tried to make a good and economic rubber sheet using scrap tires without binder in this study. We believed that this kinds work is rapidly gaining attention as a valuable market for the rubber waste stream.

**Table Ⅰ Recycling methods for used tires**

| Body utilization | | Processing | | | Heat utilization | |
|---|---|---|---|---|---|---|
| Retreating | Products | Stripping | Reclaim | Powder | Pyrolysis | Incineration |
| Retreated tires | Dock fender, Fish house etc. | Flooring | Mat, Belt | Flooring, Pavement, Ballast mat, Rubber block etc. | Gas(Fuel), Oil(Fuel), Carbon black(Reinforcing material) | Cement material and Fuel, Boiler etc. |

## EXPERIMENTAL

Sample Preparation

The recipe for rubber compound is summarized in Table Ⅱ. In Table Ⅱ, the initial characters, LR and KD, are used because the company does not want to open the recipe. After mixing in a stirrer, the mixture was compressed by Hotpress.

**Table Ⅱ The recipe for rubber compound.**

| | |
|---|---|
| Crumb Rubber | 100(phr) |
| LR | 10 g |
| Sulfur | Varied |
| TMTD | Varied |
| DEG | 30ml |
| KD | 10ml |

We used 50 ton hydraulic press equipped with hot platens to produce a rubber sheet with a temperature of 150℃ was maintained for curing. The curing times were 15 minutes for crumb rubber compound. The last step of sample preparation was cutting by cutter. After curing the rubber sample for 1 day. We cut a specimen Dumbbell 3 shape for mechanical test.

Methods of Measurement

Measurement of the tensile properties was carried out using UTM(Instron series IX Automated Materials Testing System 7.25) equipped for tensile strength and elongation and tear strength in accordance with KSM (Korea Standard Method) 6518. The instrument operated at 500mm/min head speed with 10KN load cell.

Swelling Experiment

Take a 0.1 to 0.3 gram sample from each of the cure level tensile piece and place in n-heptane for 48 hours to swell. Quickly remove swollen piece from n-heptane, blot off excess n-heptane and weigh in a stoppered pre-weighed vial. Deswell the sample in a 60℃ vacuum oven for about 3 hours. Weigh the deswollen sample. We calculated the number of crosslinking chains per unit volume to find the crosslinking density by using weight differences from equation (1).

$$\upsilon_e = -[\ln(1-V_R)+V_R+\chi_1 V_R^2]/V_1(V_R^{1/3}-V_R/2) \quad - - - - (1)$$

$\upsilon_e$: Effective number of chains in a real network per unit volume (mole/$m^3$)

$V_1$: Molecular volume of solvent ($m^3$/mole)

$V_R$: Volume fraction of rubber in swollen state

$\chi_1$: Parameter expressing the first neighbor interaction free energy

Samples were aged in a oven for 24 hr, 48 hr, 72 hr and 96 hr at 60℃ to investigate the effect of aging.

## RESULTS AND DISCUSSION

One of the obstacles in rubber recycling is high cost for produce of the recycled rubber products. One of the popular commercial products in recycling of the waste tires is the rubber block. Normally the rubber block has been compounded with polyurethane binder, which induced a high cost.

Therefore, we tried to replace a low cost material of the polyurethane binder. First our effort was used SBR latex instead of the polyurethane binder. The second effort was developing no binder system.

Figure 1 shows the elongation at break of the samples compare before aging and after 24 hours aging with different binder system. More than 200% elongation showed in PU binder system but the elongation decreased with SBR binder. The value of elongation is down to 130% in no binder system. The elongation decreased by aging for SBR binder system and decreased for no binder system. However, we could not find any aging effect in PU binder system.

Tensile strength of the rubber compounds is shown in Figure 2. The result also similar tendency to elongation of the rubber compounds. From these experimental results, the mechanical properties (tensile strength and elongation of break) decreased without binder compare to binder system, but the cost of the recycled rubber block can be down to 50%.

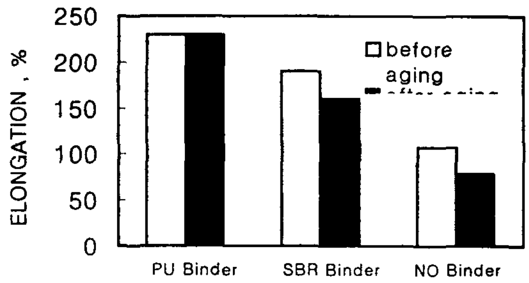


Figure 1 Elongation at break with various binder systems.

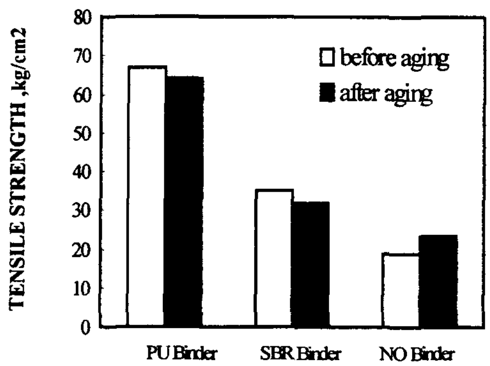


Figure 2 Tensile strength with various binder systems.

The standard required properties of rubber block are shown in Table III. All three samples satisfied from the commercial products. Therefore, no binder system product may be a high valuable recycled product. Now our effort

**Table Ⅲ Requirement of properties for rubber block**

| Mechanical properties | | Quality | |
|---|---|---|---|
| | | High grade | Low grade |
| Tensile properties | Tensile strength ($kgf/cm^2$) | 50 over | 25 over |
| | Elongation at break (%) | 150 over | 120 over |
| Hardness (shore A) | | 55 over | |

moves to how we make a good quality product in no binder system. We considered curing system of the rubber compounds.

Fig. 3 shows the effect sulfur content in rubber compound. According to the mechanical properties which are elongation, tensile strength and tear strength, the optimum content of sulfur was 10phr.

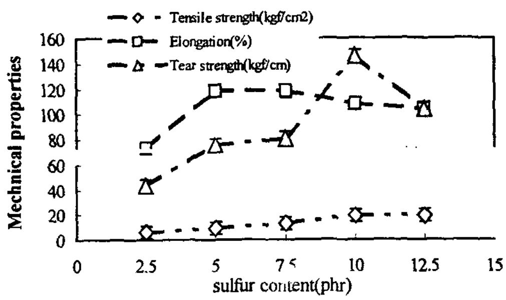


Figure 3 Effect of sulfur content on properties.

We tired to determine the optimum accelerator content in rubber samples containing 10phr of sulfur. Fig. 4 shows the effect of the accelerator (TMTD) on the mechanical properties of no binder system with 10phr of sulfur. The results show that mechanical properties of increased by the addition of TMTD until 2phr and decreased. Therefore, we observed 10phr of sulfur and 2phr of TMTD showed the best result in the view of the mechanical properties for the no binder system.

It was very strange results for us with this condition we investigated the aging effect which is shown in Fig 5. The

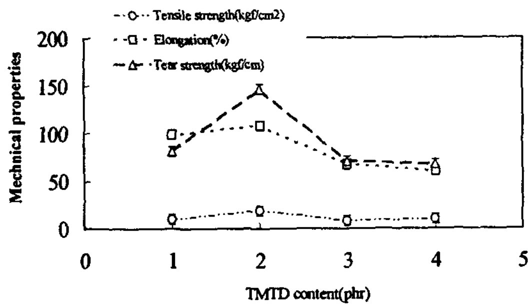


Figure 4 Effect of TMTD content on properties.

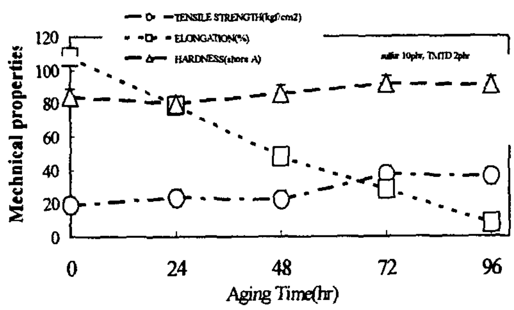


Figure 5 Effect of the curing Time on properties.

elongations at break decreased and hardness increased with increasing aging time as we expected. However, the tensile strength increased with time. Therefore, we tried to find the answer for these phenomena with checking the cross-linking density.

## CONCLUSIONS

From our experiments, we concluded as follows. The crumb rubber without binder which recipe is shown in Table I may be prospective a high valuable recycled product in economic view. However, it is not applied to produce the product required high mechanical properties. We determined the following optimum curing system of the products without binder; Temperature: 150℃, time: 15 minutes, sulfur content: 10phr, accelerate content(TMTD) 2phr. In this study, we developed a recycling technique to produce a high valuable recycled product. We believe that this technique contribute to develop the recycling industry.

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