The 6th International Symposium on East Asian Resources Recycling Technology
October 23 - 25, 2001, Gyeongju (慶州), Korea
ISBN: 89-952527-0-7 93530

Development of the Environmental Friendly Materials Using the Waste Tires and the Waste Plastics

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In this study, the compound materials of GRT/plastics (HDPE, LLDPE, LDPE, PP and PS) were developed. Their tensile strength, strain at yield and flexural modulus according to the change in GRT content were measured. And, the physical properties of the compound materials that the GRT content was changed in the waste vinyl HDPE and pure HDPE were measured, compared and analyzed. If the GRT is added to PE plastics, the physical properties were superior to those of PP and PS, and in the case of HDPE, the waste vinyl HDPE had superior physical properties by the GRT content to the pure HDPE.
Keywords : Environmental friendly materials, waste tires, waste plastics, mechanical strength

1. Introduction

The waste tires and the waste plastics are not dangerous waste which does direct damage to human bodies and soil and their retrieval is relatively easy, and therefore, their economical value as useful resources, not a waste, can be sufficiently elevated according to the recycling method. In advanced countries, as those waste resources are increased in geometric progression, attempts for the continuous creation of demand are being made through environment-friendly recycling which can induce collection[1].

It is reported that a variety of rubber like the waste tires discharged from cars reaches annually about 26,300 tons in Korea. The number of waste tires discharged in Korea is about 20,730,000 as of 1998, and is expected to be about 25,000,000 in 2000. In Korea, beyond the stage of using the waste tires as an ecocidal energy source, the fundamental application of the waste tires for the construction of a military camp site and as a protective buffer at playgrounds for children, a footboard in golf links, a asphalt blender, a railway structures and a blender in the preparation of bricks and cement was started[2].

Since 1998, the Ground Rubber Tire (GRT) has been produced and the basis for the effective recycling of waste tires which has been made in advanced countries has been formed[3-5]. In the case of the waste plastics, though an annual amount of generation is over 1,000,000 tons, the retrieval rate is only 10% of the amount, and it's because the recycling of the waste plastics is extremely restrictive. For example, most of compound waste plastics is used only as an energy source, owing to a low technological level in sorting and effectively recycling plastics.

In this study, the compound materials were prepared using a physical methods like the adjustment of compound forming ratio of the GRT, various kinds of plastics and waste plastics, the devulcanization of additive and the GRT, etc., and the physical properties - tensile strength, flexural strength - of these compound materials were measured. And, it is intended to induce the physical properties which corresponds with the use of the developed product, develop matrix plastics with high adhesiveness which excluded expensive additive, and utilize it as a fine forming material with high added value.

2. Experimental Procedures

2.1 Preparation of the Sample of GRT/Plastics Compound Materials

As a starting material of the waste tires, the GRT with about -20/+50mesh distribution was used, and as the plastics, Polyethylene (HDPE and LLDPE), adhesive plastics (Polyglue and ADPOLY), Polyprophylene (PP) and Polystylene (PS) were used. The GRT content was increased up to 0～60wt% of the plastics by 15wt%, and it was mixed using an internal mixer at 180℃ at the speed of 400rpm for 5 minutes.

The compound materials mixed went through the cutting process and were injected into a mini-max molder. A flexural sample with tensile dog-bone, 12.5mm long, 74mm wide and 3mm thick was made according to the standard of ASTM D 638-01 (tensile strength and strain at yield). The experimental process of this study is shown in Fig. 1.

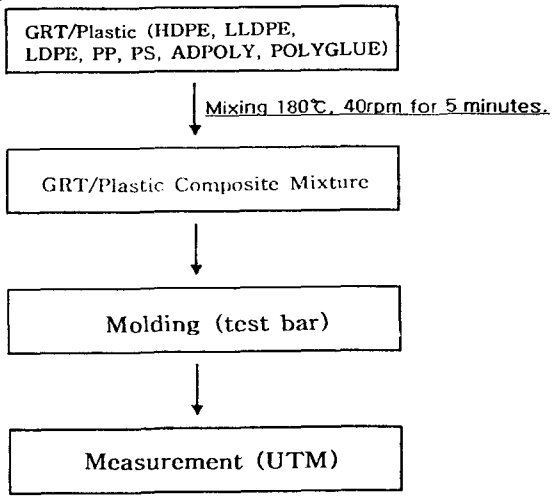

Fig. 1 Experimental Procedure.

2.2 Measurement

Five samples were made in the same experimental conditions and their mechanical properties were measured with UTM (Universal Testing Machine).

3. Results and Discussion

3.1 Physical Properties of GRT/Plastics (HDPE, LLDPE, LDPE, PP and PS) Compound Materials

Fig. 2 shows the result of the changes in the tensile strength of GRT/plastics (HDPE, LLDPE, LDPE, PP and PS) compound materials prepared by changing the GRT content by 15wt%. On the whole, as the GRT content increases, the tensile strength of the GRT/plastics compound materials decreases. In polyethylene (PE), the tensile strength has the order of HDPE>LLDPE>LDPE. If the GRT content is 60wt%, the reduction rate of the tensile strength is 48.6% in HDPE, 55.5% in LDPE, and 42.1% in LLDPE. Therefore, the GRT/HDPE compound materials showed the most excellent tensile strength in PE. It can be found that PP shows superior tensile strength to PE according to the added amount of the GRT, but the reduction rate of tensile strength is greatly reduced. And, it was possible to measure PS at 45 and 60wt% of the GRT content, which is because PS makes cross-linking with a mold.

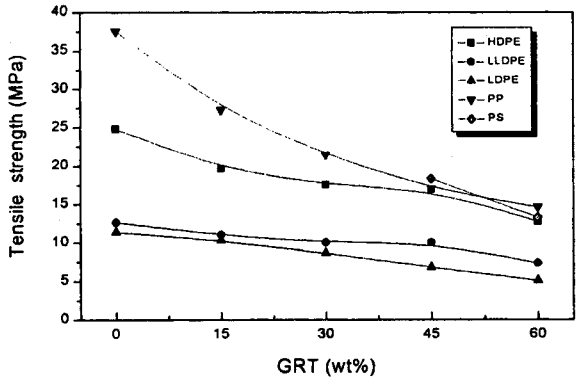

Fig. 2 Tensile strength of GRT/plastic composite.

Fig. 3 shows the result of the changes (%) in the strain at yield of GRT/plastics (HDPE, LLDPE, LDPE, PP and PS) compound materials prepared by changing the GRT content by 15wt%. As the GRT content increases, the strain at yield of LDPE, PP and PS decreases while that of HDPE and LLDPE increases. It's thought to be caused by the fact that if the GRT is mixed with the material which has the structure of high crystallization, the overall strain at yield of the compound material is raised. And, it's estimated that the reason why the strain at yield of HDPE and LLDPE is more increased than that of LDPE is that they have more excellent interfacial adhesion with the GRT than the LDPE.

Fig. 4 shows the result of the changes in the flexural strength of GRT/plastics (HDPE, LLDPE, LDPE, PP and

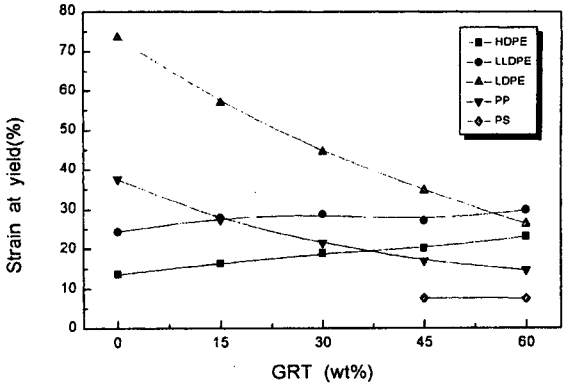

Fig. 3 Strain at yield of GRT/plastic composite.

PS) compound materials prepared by changing the GRT content by 15wt%. It can be viewed that the flexural strength of PS and PP is greater than that of PE. However, the PS has a very large level of reduction, which is thought to be caused by the fact that as the GRT content increases, PS becomes to be brittle. It is shown that PS also has a higher value than PP or PE in the measurement of flexural modulus (Fig. 5), but the level of reduction by the rise in the GRT content is very high.

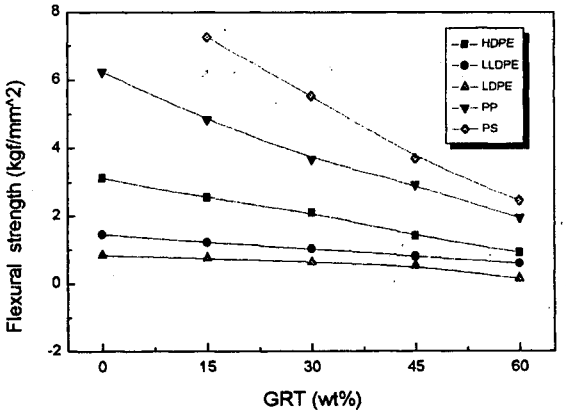

Fig. 4 Flexural strength of GRT/plastic composite.

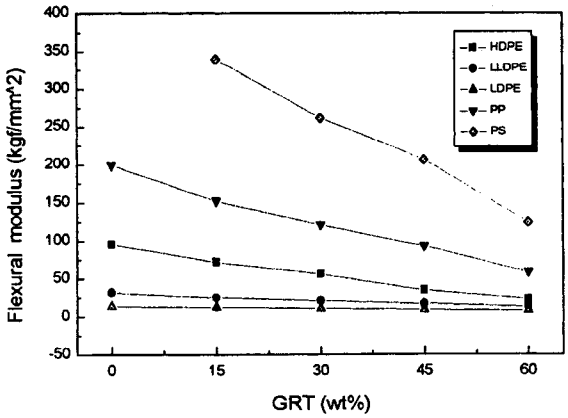

Fig. 5 Flexural modulus of GRT/plastic composite.

3.2 Physical Properties of GRT/Adhesive Plastics (Polyglue and ADPOLY) Compound Materials

Fig. 6 shows the result of the changes in the tensile strength of GRT/adhesive plastics compound materials when the GRT content is raised. If the GRT is added to the adhesive plastics, the reduction in the tensile strength is greater than the case to PE, PP and PS, which is thought to be caused by the fact that the melting point of the adhesive plastics is very low as 125 or 127℃ in the measurement of DSC. On the other hand, judging from the fact that the level of reduction in the tensile strength is not large irrespective of the increase of the GRT content, it seems to be little affected by the GRT.

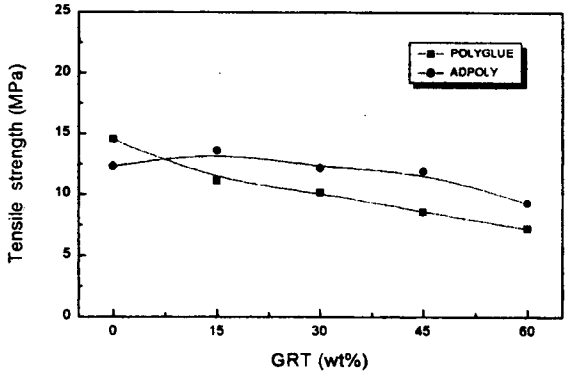

Fig. 6 Tensile strength of GRT/adhesive plastic composite.

As the result of measuring the strain at yield (Fig. 7), the value is notably reduced if the GRT is added over 30wt%, but after that, there's little change up to 60wt%. And, it can be found that though it has a lower value of fluxural modulus than high crystallinity or the PP plastics, the reduction rate of the physical property value is low.

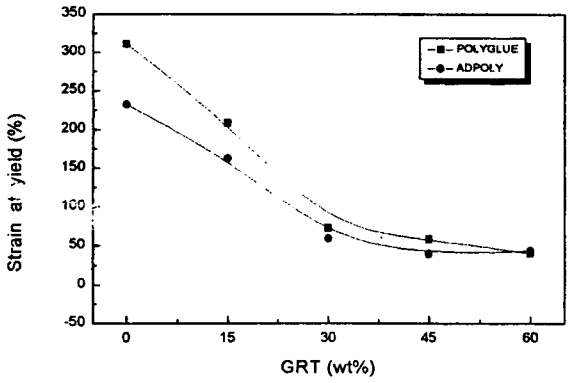

Fig. 7 Strain at yield of GRT/adhesive plastic composite

3.3 Changes in the Physical Properties of Pure HDPE and Waste Vinyl HDPE by GRT Content

This study aimed to effectively utilize and reduce a waste resources by properly using the waste tires and the waste plastics. Therefore, to compare this with the changes in physical properties when the GRT is added to pure plastics, the physical properties of pure HDPE and waste vinyl HDPE by the GRT content were compared and analyzed, using the waste vinyl HDPE of the Korea Resources Recovery Reutilization Corporation.

Fig. 8 shows the result of the changes in the tensile strength when the GRT content is changed in pure HDPE and waste vinyl HDPE. According to the result of measuring the tensile strength of the compound material that the GRT content to the plastics is 0, 30 and 50wt%, waste vinyl HDPE shows more excellent tensile strength than pure HDPE. Particularly, when the GRT is added 30wt%, it showed about 141.76% higher tensile strength.

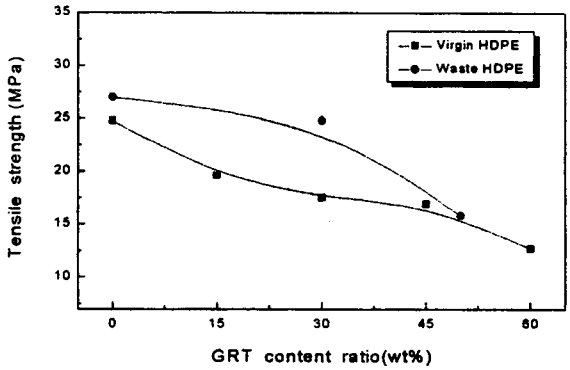

Fig. 8 Tensile strength of GRT/waste HDPE composite.

.When the strain at yield of waste vinyl HDPE is compared to that of pure HDPE at 0~50wt% of the GRT content, it is shown to be reduced. It's thought that the tensile strength is improved and the strain at yield is reduced, because then plastics shows the hardening reaction as the thermoplastic resin is secondly and thirdly processed. And, it could be shown that the flexural strength of waste vinyl HDPE was nearly the same as that of pure HDPE.

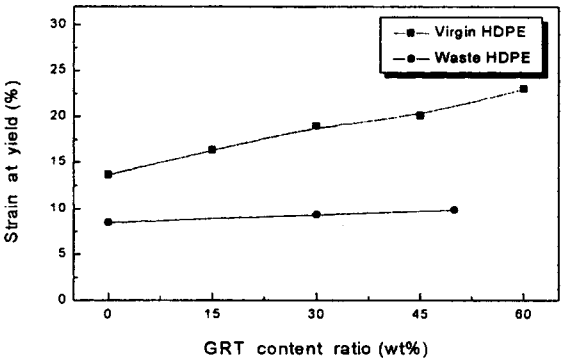

Fig. 9 Strain at yield of GRT/waste HDPE composite.

4. Conclusions

The GRT/plastics compound materials were prepared. HDPE, LLDPE, LDPE, PP, PS and adhesive plastices were used. And, the physical properties of the compound materials that the GRT is added to waste vinyl HDPE and pure HDPE were compared and analyzed.

As the result of measuring the physical properties of GRT/plastics compound materials, the physical properties of the compound materials that the GRT is added to PE showed more excellent values than those to PP or PS. Particularly, the HDPE had the most excellent value of strength among PE plastics.

If the GRT is added to adhesive plastics, there comes greater reduction in the tensile strength than the case to PE, PP and PS plastics, which is thought to be caused by the fact that the melting point of adhesive plastics in the measurement of DSC is very low around 125 or 127℃.

According to the result of measuring the tensile strength of the compound material that the GRT content to the plastics is 0, 30 and 50wt%, the waste vinyl HDPE shows more excellent tensile strength than pure HDPE. Particularly, when the GRT is added 30wt%, it showed about 141.76% higher tensile strength.

Accordingly, it is estimated that the effective and environmental friendly reutilization of the waste resources will be made by preparing the environmental friendly compound materials mixing the waste tires and the plastics at a proper ratio and by developing them not for just primary recycling but as a high-performance compound materials for a water pipes, a septic tanks, a soundproofing and a construction materials.

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