TEKNIK BARU UNTUK PENGITARAN SEMULA PELBAGAI SISA GETAH

(304.PBAHAN.6035021)

Laporan Akhir Projek Penyelidikan USM Jangka Pendek

Oleh:

Profesor Hanafi Ismail (Ketua Projek)
Pusat Pengajian Kejuruteraan Bahan dan Sumber Mineral
Universiti Sains Malaysia
14300 Nibong Tebal
Pulau Pinang.

BAHAGIAN PENYELIDIKAN & PEMBANGUNAN
CANSELORI
UNIVERSITI SAINS MALAYSIA

Laporan Akhir Projek Penyelidikan Jangka Pendek

1) Nama Penyelidik: PROFESOR HANAFI ISMAIL

Nama Penyelidik-Penyelidik Lain *(Jika berkaitan)* :

2) Pusat Pengajian/Pusat/Unit : Kejuruteraan Bahan dan Sumber Mineral.

3) Tajuk Projek: Teknik Baru Untuk Pengitaran Semula Pelbagai Sisa Getah

4) (a) **Penemuan Projek/Abstrak**

*(Perlu disediakan makluman di antara 100 - 200 perkataan di dalam **Bahasa Malaysia dan Bahasa Inggeris** Ini kemudiannya akan dimuatkan ke dalam Laporan Tahunan Bahagian Penyelidikan & Pembangunan sebagai satu cara untuk menyampaikan dapatan projek tuan/puan kepada pihak Universiti).*

ABSTRAK : Di dalam projek ini, 2 kaedah pengitaran semula sisa buangan getah telah berjaya dilaksanakan. Dalam kaedah pertama, dengan bantuan ricihan mekanik (menggunakan peralatan pemprosesan getah seperti pencampur dalaman dan penggiling berguling dua) kesemua sisa getah telah berjaya dikitar semula menggunakan satu bahan kimia baru yang dipanggil "DeCrossCHEM". Getah yang dikitar semula boleh digunakan kembali untuk menghasilkan pelbagai produk baru. Di dalam kaedah kedua, pelbagai sisa buangan getah telah berjaya diadunkan dengan getah baru dan termoplastik seperti polipropilena bagi menghasilkan suatu bahan baru bagi penghasilan pelbagai produk.

ABSTRACT: In this project, 2 methods of recycling rubber wastes were successfully done. In the first method, with the help of mechanical shearing (using rubber processing equipments such as internal mixer, two roll mill etc), all rubber wastes can be recycled using new chemical called "DeCrossCHEM". The recycled rubber can be re-used to produce various new rubber products. In second method, various rubber wastes were successfully blended with virgin rubber and thermoplastic such as polypropylene to produce new materials for manufacturing various products.

(b) Senaraikan Kata Kunci yang digunakan di dalam abstrak:

Bahasa Malaysia	Bahasa Inggeris
Pengitaran semula	Recycling
Sisa Getah	Rubber Wastes
Adunan	Blend
Polipropilena	Polypropylene
Pemprosesan getah	Rubber Processing
Bahan kimia baru	New Chemical

5) **Output Dan Faedah Projek**

(a) Penerbitan *(termasuk laporan/kertas seminar)*
(Sila nyatakan jenis, tajuk, pengarang, tahun terbitan dan di mana telah diterbit/dibentangkan).

10 Kertas kerja telah pun diterbitkan didalam
pelbagai jurnal antarabangsa. (Lihat Lampiran)

(b) Faedah-Faedah Lain Seperti Perkembangan Produk, Prospek Komersialisasi Dan Pendaftaran Paten.
(Jika ada dan jika perlu, sila gunakan kertas berasingan)

6 Research Award telah dimenangi iaitu:
(a) Silver Medal di International Exhibition (Geneva 2004)
(b) Gold Medal di ITEX 2004
(c) Gold Medal di ITEX 2003
(d) Silver Medal di MOSTE 2003
(e) Bronze Medal di ITEX 2002
(f) Bronze Medal di MOSTE 2002

(c) Latihan Gunatenaga Manusia

i) Pelajar Siswazah 2 orang pelajar Ijazah Sarjana iaitu Suryadimsyah dan Razf Nordin telah berjaya memperoleh MSc melalui kajian ini.

ii) Pelajar Prasiswazah: 4 orang pelajar tahun akhir telah membuat projek penyelidikan berkaitan pendaftaran semula sisa getah.

iii) Lain-Lain :

6. Peralatan Yang Telah Dibeli:

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UNTUK KEGUNAAN JAWATANKUASA PENYELIDIKAN UNIVERSITI

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Projek ini telah mencapai kejayaan yang cemerlang.

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T/TANGAN PENGERUSI
J/K PENYELIDIKAN
PUSAT PENGAJIAN

Prof. Madya Dr. Azizan Aziz
Timbalan Dekan
(Pengajian Siswazah dan Penyelidikan)
P.P. Kejuruteraan Bahan & Sumber Mineral
Kampus Kejuruteraan
Universiti Sains Malaysia

Effect of Palm Oil Fatty Acid Additive (POFA) on Curing Characteristics, Mechanical and Morphological Properties of Silica Filled Natural Rubber/Recycle Rubber Powder Blends

Hanafi Ismail and R. Nordin

School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Seberang Perai Selatan, Penang, Malaysia

Received: 24 April 2003 Accepted: 28 July 2003

ABSTRACT

The effect of palm oil fatty acid additive (POFA) on curing characteristics, mechanical and morphological properties of silica filled natural rubber (NR)/ recycle rubber powder (RRP) blends were studied. Results indicate that the presence of POFA is not only improved the cure rate of NR/RRP blends but also improved it's processability. Compared to control NR/RRP blends, the presence of POFA increased the mechanical properties such as tensile strength, tensile modulus and hardness of silica filled NR/RRP blends. The presence of POFA enhanced crosslink density and improved filler dispersion of silica filled NR/ RRP blends which consequently increases the silica-NR/RRP interaction.

INTRODUCTION

Scrap rubber particularly scrap tyres cause a significant environmental and health problems since it's difficult to degrade at normal conditions and causes several other environment pollution, if a usual disposal method was implied. Therefore, recycling is an appropriate way of handling scrap or waste rubber. Recycling of waste rubber had widely been investigated as an alternative method of disposal while at the same time to develop new type of materials[1-5].

Recently, we have reported the potential of recycle rubber powder, RRP (waste rubber from manufacturing artificial eggs and ball) as a filler in natural rubber compounds[6] and the effect of partial replacement of NR with RRP[7]. The results indicate that cure characteristics and mechanical properties do not show adversely significant effect with RRP incorporation, even at 40% replacement of NR compounds. This implied that RRP can be used as another alternative cheap material (filler) or extender in rubber industry.

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TESTING

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Material Properties

Thermoplastic elastomers based on polypropylene/natural rubber and polypropylene/recycle rubber blends

H. Ismail *, Suryadiansyah

School of Industry Technology, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia

Received 2 July 2001; accepted 3 September 2001

Abstract

Fine rubber powder obtained from the sanding process of polishing rubber balls and artificial eggs (recycled rubber, RR) was used to prepare polypropylene (PP)/RR blends, a thermoplastic elastomer using different RR content. A similar series of blends using natural rubber, SMR L (NR) was also prepared. The results indicated that at a similar rubber content, PP/RR blends have higher, tensile strength and Young's modulus but lower elongation at break and stabilization torque than PP/NR blends. Scanning electron microscopy (SEM) examination of the tensile fracture surface of PP/RR blends indicates that a higher energy is needed to cause catastrophic failure compared to PP/NR blends.

Keywords: Thermoplastic elastomer; Polypropylene; Natural rubber; Recycle rubber; Blend

1. Introduction

Thermoplastic elastomers (TPEs) belong to a class of materials that have the combined physical properties of thermoplastics and elastomers. They exhibit properties typical of rubbery materials but can be processed like thermoplastics. TPEs give better material utilization because scrap and rejects can be recycled [1]. Furthermore, productivity is high because no compounding or vulcanization is required and they are easily processed by internal mixers or extrusion. As the composition of blends vary, materials with a wide range of properties are obtained [2]. Because of its excellence in molding processability and good mechanical properties, polypropylene (PP) has been widely used in the form of molded articles, films or sheets. Toughening of PP can be enhanced while maintaining stiffness, strength and processability by addition of some elastomers. Blending of recycled rubber (RR) into plastics such as rubber powder blended with PP plays an important role in the modern polymer industry not only for the development of new materials but also for practical recycling purposes [3].

The purpose of this study is to compare the mechanical and morphological properties of polypropylene/natural rubber and polypropylene/recycled rubber blends. Mechanical properties such as tensile strength, Young's modulus and elongation at break for various blends ratios of polypropylene with natural rubber and recycled rubber were studied and compared. The torque development during mixing and tensile fracture of the blends was also examined.

2. Experimental

2.1. Materials

Polypropylene homopolymer used in this study was of injection molding grade, from Titan PP Polymers (M) Sdn Bhd, Johor, Malaysia (code 6331) with a MFI value of 14 g/10 min at 230°C. Natural rubber (SMR L) was purchased from Kumpulan Guthrie Sdn Bhd, Seremban,

* Corresponding author. Tel.: +60-4-657-7888x2214; fax: +60-4-657-3678.

E-mail address: ihanafi@usm.my (H. Ismail).

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Material Behaviour

Cure characteristics, tensile properties and swelling behaviour of recycled rubber powder-filled natural rubber compounds

H. Ismail [a,*], R. Nordin [a], A.M. Noor [b]

[a] *School of Industrial Technology, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia*
[b] *School of Chemistry, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia*

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Abstract

The effect of recycled rubber powder (RRP) on cure characteristics, tensile properties and swelling behaviour of natural rubber (NR) compounds was investigated in the concentration range of 0 to 50 phr. Results indicate that the minimum torque and Mooney viscosity of the natural rubber compounds increase with increasing RRP loading whereas the scorch time and cure time exhibit a decreasing trend. Increasing RRP loading also gives natural rubber compounds better resistance towards swelling and reduces the elongation at break but the tensile stress, M100 (stress at 100% elongation) and M300 (stress at 300% elongation), increases slightly. However, the tensile strength increases up to 10 phr of RRP and then decreases. © 2002 Elsevier Science Ltd. All rights reserved.

Keywords: Cure characteristics; Tensile properties; Natural rubber; Recycled rubber powder; Swelling behaviour

1. Introduction

Scrap rubbers are made up of rubber that does not meet processing and product specifications, leftover rubber from manufacturing activities and also old and defective rubber products. The scrap rubbers are waste and usually discharged. The discarded scrap rubber does not degrade rapidly enough and this causes environmental pollution. To reduce this pollution there is a need to recycle scrap rubber [1].

Reclamation of scrap (vulcanized) rubber can be done by mechanical [2,3] and chemical processes [3,4]. Crane and Kay [5] have shown that scrap rubber vulcanizates could be depolymerized to a product known as "depolymerized scrap rubber", which should be useful as a rubber compounding ingredient and as a fuel-oil extender.

The purpose of this study is to investigate the cure characteristics, tensile properties and swelling behaviour of recycled rubber powder (RRP)-filled natural rubber (NR) compounds. A morphological study of the tensile fracture surfaces of the natural rubber compounds was also carried out.

2. Experimental

2.1. Material

Natural rubber (SMR L) was purchased from Kumpulan Guthrie Sdn Bhd, Seremban, Malaysia. The recycled rubber waste (rubber powder) product from the sanding process (polishing) of rubber ball and artificial eggs with particle size of 250–500 μm was obtained from Watas Holding (M) Sdn Bhd, Penang, Malaysia. Table 1 shows the formulation used in this study. Other compounding ingredients such as zinc oxide, stearic acid, sulfur, *N*-cyclohexyl-2-benzothiazole sulfenamide (CBS) and 2,2-

* Corresponding author. Tel.: +60-4-657-7888x2214; fax: +60-4-657-3678.
E-mail address: ihanafi@usm.my (H. Ismail).

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THE EFFECT OF FILLER LOADING ON CURING AND MECHANICAL PROPERTIES OF NATURAL RUBBER/RECYCLED RUBBER POWDER BLENDS

H. Ismail
R. Nordin
School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia, Seberang Perai Selatan, Penang, Malaysia

A. M. Noor
School of Chemistry, Universiti Sains Malaysia, Penang, Malaysia

Curing characteristics and mechanical properties of carbon black– and silica-filled natural rubber (NR)/recycled rubber powder (RRP) blends were studied. Results indicate that the minimum torque and maximum torque increase with increasing filler loading in the compounds, whereas scorch time shows a decreasing trend. Cure time of carbon black–filled NR/RRP blends decreases with increasing filler loading whereas silca-filled NR/RRP blends show an opposite trend. Incorporation of filler loading has improved the tensile modulus, hardness, tear strength, and resistances toward swelling. However, elongation at break and resilience exhibit a different trend. For tensile strength, optimum values were obtained at 15 phr of both fillers. Overall results show that carbon black (N550) is more suitable to be used as a filler in natural rubber/recycle rubber powder blends compared to silica (Vulcasil S).

Keywords: cure characteristics, mechanical properties, recycle rubber powder, silica, carbon black

INTRODUCTION

Accumulations of waste rubber have created major environmental problems, as waste rubber is non-degradable material. This usual method of disposing of waste rubber, such as discarding in a landfill or burning,

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Address correspondence to Prof. H. Ismail, School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Seberang Perai Selatan, Penang 11800, Malaysia. E-mail: hanafi@eng.usm.my

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PROPERTIES OF POLYPROPYLENE/NATURAL RUBBER/RECYCLE RUBBER POWDER BLENDS

Hanafi Ismail* and Suryadiansyah

School of Industrial Technology, Universiti Sains Malaysia,
11800 Minden, Penang, Malaysia

ABSTRACT

Thermoplastic elastomers have been prepared by blending polypropylene (PP), natural rubber (NR), and recycle rubber powder (RRP). The blends were melt-mixed using a Brabender Plasticorder torque rheometer at 190°C and 50 rpm. A fixed 70:30 blend ratio (wt%) of PP and rubber was prepared. The effect of partial replacement of NR with RRP at a fixed rubber content (NR + RRP), 30 wt% on mechanical properties, swelling behavior, torque development, and morphological properties of PP/NR/RRP blends was studied. Results show that the tensile strength, Young's modulus, and swelling resistance increase with

*Corresponding author. Current address: School of Materials and Mineral Resources Engineering, University Sains Malaysia Engineering Campus, 14300 Nibong Tebal, Penang, Malaysia. Fax: +604-5941011; E-mail: hanafi@eng.usm.my

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The Effects of Recycle Rubber Powder (RRP) Content and Various Vulcanization Systems on Curing Characteristics and Mechanical Properties of Natural Rubber/ RRP Blends

Hanafi Ismail[1(*)], Razif Nordin[1], and Ahmad Mohd Noor[2]

(1) School of Materials and Mineral Resources Engineering, University Sains Malaysia, 14300 Nibong Tebal, Seberang Perai Selatan, Penang, Malaysia
(2) School of Chemistry, University Sains Malaysia, 11800 Minden, Penang, Malaysia

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ABSTRACT

The effects of recycle rubber powder (RRP) content and conventional (CV), semi-efficient (semi-EV) and efficient vulcanization (EV) systems on curing characteristics and mechanical properties of natural rubber (NR)/recycle rubber powder (RRP) blends were examined. The minimum torque, maximum torque and torque difference are increased with increasing recycle rubber powder (RRP) content in NR/RRP blends, whereas, the scorch time and cure time show the opposite trend. NR/RRP Blends cured with the CV system showed the highest minimum torque, maximum torque and torque difference but longest cure time, t_{90}. Increasing RRP content in NR/RRP blends increases the tensile modulus and hardness but decreases the tensile strength, tear strength, resilience and elongation-at-break. Although the CV system exhibits the highest tensile modulus and hardness but NR/RRP blends cured with EV system show the highest tensile strength, tear strength, resilience and elongation-at-break followed by semi-EV and CV systems.

Key Words:
recycle rubber; curing; mechanical properties; sulphur vulcanization system; natural rubber.

INTRODUCTION

Development of a process to reclaim scrap tyres and waste rubber is great interest for all countries, since accumulation of waste rubber has significant effect to environment. A normal disposal method of wastes rubber such as incineration or landfilled is not desirable approach as it caused several other environmental problems such as air or / and water pollution. Reclaiming waste rubber by mechanical [1,2] or chemical [3,4] methods is the ultimate approach to solve the problems created by waste rubber.

*)To whom correspondence should be addressed.
E-mail: ihanafi@usm.my

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THE COMPARISON PROPERTIES OF RECYCLE RUBBER POWDER, CARBON BLACK, AND CALCIUM CARBONATE FILLED NATURAL RUBBER COMPOUNDS

Hanafi Ismail,[1,*] R. Nordin,[1] and Ahmad Md. Noor[2]

[1]School of Industrial Technology, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia
[2]School of Chemistry, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia

ABSTRACT

The effects of filler loading on the curing characteristics, swelling behavior, and mechanical properties of natural rubber compounds were studied using a conventional vulcanization system. Recycle rubber powder (RRP), carbon black (CB) (N550), and calcium carbonate ($CaCO_3$) were used as fillers and the loading range was from 0 to 50 phr. Results show that the scorch time, t_2, and cure time, t_{90}, decrease with increase in filler loading. At a similar filler loading, RRP shows shortest t_2 and t_{90} followed by CB and calcium carbonate. The tensile strength, tensile modulus, and

*Corresponding author. Current address: School of Materials and Mineral Resources Engineering, University Sains Malaysia Engineering Campus, 14300 Nibong Tebal, Penang, Malaysia. Fax: +604-5941011; E-mail: hanafi@eng.usm.my

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Effect of Epoxidized Natural Rubber (ENR) and Ethylene-co-acrylic Acid Copolymer on Properties of Silica-Filled Natural Rubber/Recycle Rubber Powder Blends

Hanafi Ismail* and R. Nordin

School of Materials and Mineral Resources Engineering,
Universiti Sains Malaysia, Seberang Perai Selatan,
Penang, Malaysia

ABSTRACT

A study of the effects of two component compatibilizers, epoxidized natural rubber (ENR) and ethylene-co-acrylic acid copolymer (EAA) on curing characteristics, mechanical properties, swelling behavior, and morphology of silica-filled natural rubber (NR)/recycle rubber powder (RRP) blends was carried out. Results indicate that the

*Correspondence: Professor Hanafi Ismail, Department of Polymer Engineering, School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Seberang Perai Selatan, Penang, Malaysia; Fax: 604-5941011; E-mail: hanafi@eng.usm.my.

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POLYMER–PLASTICS TECHNOLOGY AND ENGINEERING
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A Comparative Study of the Effect of Degradation on the Properties of PP/NR and PP/RR Blends

H. Ismail* and Suryadiansyah

School of Materials and Mineral Resources Engineering,
Universiti Sains Malaysia, Penang, Malaysia

ABSTRACT

The effect of various degradations on the tensile and morphological properties of polypropylene (PP)/natural rubber (NR) and PP/recycle rubber (RR) blends at different rubber content were studied. The blends were melt mixed using a Brabender Plasticorder torque rheometer at 190°C and 50 rpm. All blends were exposed at three different conditions, i.e., heated in oven (100°C) for 24 hrs, immersed in distilled water (90°C) for 24 hrs, and immersed in ASTM oil No. 3 for 70 hrs. The results indicated that at a similar rubber content and

*Correspondence: Professor H. Ismail, Department of Polymer Engineering, School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Penang, Malaysia; Fax: 604-5941011; E-mail: hanafi@eng.usm.my.

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TENSILE PROPERTIES AND SWELLING BEHAVIOUR OF POLYPROPYLENE / NATURAL RUBBER AND POLYPROPYLENE / RECYCLED RUBBER BLENDS

Suryadiansyah and H. Ismail
School of Industrial Technology, Universiti Sains Malaysia,
11800 Minden, Penang,
Malaysia.

ABSTRACT

Thermoplastics elastomers (TPE's) based on polypropylene (PP)/natural rubber (NR) and polypropylene/recycled rubber (RR) blends were prepared using a Brabender Plasticorder at 190°C and 50 rpm. Tensile properties and swelling behaviour of both TPE's were determined and compared. Results indicated that at a similar rubber content, PP/RR blends have higher tensile strength and Young's modulus but lower elongation at break than PP/NR blends. Swelling study shows that PP/RR blends have better oil and toluene resistance than PP/NR blends

Keywords: polypropylene/natural rubber, polypropylene/recycled rubber blends

INTRODUCTION

Thermoplastic elastomers (TPEs) are a new class of thermoplastics of which the properties can be easily tailored compared to block copolymers by simply changing the ratio of the rubber in the blend. These materials are phase-separated systems in which one phase is rubbery at room temperature and other is hard and solid (Zhu *et al* 1995; De and Bhowmick 1990). They possess the elasticity of the rubber and the thermoplasticity of the plastic; yet retain unique features of its component such as better tensile properties, solvent resistance, and high deformation temperature compared to elastomers. As the result, many

Universiti Sains Malaysia, 11800 Penang, Malaysia.
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INTERLOCKING RUBBER TILES/BLOCKS FROM RECYCLE RUBBER WASTES USING A NOVEL RECYCLING CHEMICAL CALLED DeCrossCHEM

INVENTOR
Assoc. Prof. Dr. Hanafi Ismail

MAIN PURPOSE OF THE INVENTION

1. **To recycle rubber wastes** such as tyres, scrap gloves, catheters, motorbike tubes, etc into **interlocking rubber tiles/blocks** which can be used as bound rubber tiles/mats or pavers under playground equipments, in gymnasium weight rooms and aerobics halls or with a textured/corrugated surface to prevent slipping for walkways and ramps in airport, factories and office buildings.

2. **Help Malaysian government to solve the environmental problem** of disposal various rubber wastes through the recycling of scraps into valuable products.

3. **To find the simplest and cheapest technology to recycle rubber wastes**.

THE MAJOR ADVANTAGES OF THE INVENTION

1. Using the conventional rubber processing equipments, all rubber wastes can be recycled and converted into interlocking rubber tiles/blocks with the help of **a novel rubber recycling chemical, DeCrossCHEM.**

2. Only 5 gram of DeCrossCHEM is needed to recycle and converted 100 gram of rubber wastes into interlocking rubber tiles/blocks.

3. Advantages of interlocking rubber tiles/blocks are:
   - **. sound deadening**
   - **. interlocking**
   - **. moisture proof**
   - **. easy to install**
   - **. cheap**
   - **. durable**
   - **. adhesives are not required**
   - **. impact absorption**
   - **. non-slip/anti-fatigue**
   - **. multicolour**

Contact:
Assoc. Prof. Dr. Hanafi Ismail
School of Materials & Mioneral Resources Enineering
Engineering Campus
Universiti Sains Malaysia
14300 Nibong Tebal, PENANG
Tel: 04-5937788 ext 6113; Fax: 04-5941011
Email: hanafi@eng.usm.my

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DE CROSS PRO- A NOVEL MECHANO-CHEMICAL PROCESS FOR RECYCLING RUBBER WASTES

Inventor:
ASSOC. PROF. HANAFI ISMAIL

DE CROSS PRO-A NOVEL MECHANO-CHEMICAL PROCESS FOR RECYCLING RUBBER WASTES

Introduction

The annual consumption of natural rubber is more than 15 million tons, and the putput of rubber products is more than 31 million tons worldwide. With the development of rubber industry, a lot of waste rubber is produced in the world every year. The main source of waste rubber is discarded rubber products, such as discarded tires, rubber pipes, rubber bolts, rubber shoes, edge scraps and waste products which are produced in rubber processes. Presently, the amount of discarded tires reaches 10 million every year worldwide.

Objective

To recycle all rubber wastes such as tyres, scrap gloves, tubes, shoe sole, rubber hose, etc. and assist the Malaysian government to solve the environmental problem in disposing various wastes through the recycling of scrap as well as to find an economical method of recycling rubber wastes and to produce a new product using recycled rubber.

Description

1. With the help of mechanical shearing (rubber processing equipment such as internal mixer, roll-mill, etc.), all rubber wastes can be recycled using DeCrossCHEM
2. The recycled rubber called DeCross Compound can be vulvanised into new product either using 100% DeCross Compound (recycled rubber compound) or blend it with new rubber in the presence of curative agents.
3. A moderate strength of new products (about 5-7 MPa) is obtained using 100% recycled compound and a very good strength of new products (about 18-20 MPa) is obtained by blending 50% of recycled rubber and 50% of new rubber.
4. Only five gm. of DeCrossCHEM is needed to recycle 100gm of rubber wastes.
5. The manufacturing cost for DeCrossCHEM is only RM15/kg.

Contact

ASSOC. PROF. HANAFI ISMAIL
SCHOOL OF MATERIAL & MINERAL RESOURCES ENGINEERING
ENGINEERING CAMPUS, UNIVERSITI SAINS MALAYSIA,
14300 NIBONG TEBAL, PENANG, MALAYSIA.
Tel : 604 – 593 7788 ext 6133 Fax : 604 – 594 1011
e-mail : hanafi@eng.usm.my