DOI : 10.31357/fapsmst.2009.00758

Development of Fluid Resistance Compound Based on NR and NBR Blends for Mats and Floorings

By

R.D.C. Dias

This thesis was submitted in partial fulfillment of the requirements for the Master of Science in Polymer Science and Technology to the faculty of Graduate Studies the University of Sri Jayewardenepura, Sri Lanka.

Date of Submission: - 03/11/2009

Dr Laleen Karunanayake
BSc (SIP), PhD (North London)
Senior Lecturer
Department of Chemistry
University of Sri Jayewardenepura

The work described in this thesis was carried out by the undersigned at Microcells Ltd., under the supervision of Dr. Sudantha Liyanage and Mr. Hema Narangoda, and a report on this has not been submitted to any university for another Degree. Also, I certify that this thesis does not include, without acknowledgment, any material previously submitted for a Degree in any University and to best of my knowledge and belief it does not contain any material previously published, written or orally communicated by another person expect were due reference is made in the text.

R.D.C. Dias

Date: .....26./..10../2009

We certify that the above statement made by the candidate is true and that this thesis is suitable for submission to the university for the purpose of evaluation.

Mr. Hema Narangoda,

Director/ CEO,

Sinwa Rubber Industries Ltd.,

Dehiwala,

Sri Lanka

Date: ..26/10/2009.........

Dr. Sudantha Liyanage,

Senior Lecture,

Department of Chemistry,

University of Sri Jayewardenapura,

Nugegoda,

Sri Lanka

Date: .26./10/2009......

ACKNOWLEDGEMENT

First, I would like to offer my heartfelt gratitude to my supervisors Mr.Hema Narangoda, Secretary Plastic & Rubber Institute, Technical Advisor, Microcells Ltd, and Dr.Sudantha Liyanage, Senior Lecture, Department of chemistry, University of Sri Jayewardenepura, for their support and guidance for my project work. My sincere gratitude also goes to the Dr.Laleen Karunanayeka, Course coordinator, M.Sc Polymer Science & Technology, University of Sri Jayewardenepura, for support and assistance given to me through out academic period and in my project activities.

I would like to express my sincere gratitude to Mr.Anil Wikramarathne, Managing Director, Microcells Ltd, for giving me the sponsorship to follow the M.Sc course of studies and providing me the support services in the laboratory to do my project work. Further my gratitude goes to Mr.Indika Wijerathne, R & D Department, Microcells Ltd, for all the assistance given to me in carrying out related laboratory activities at Microcells Ltd, of my project.

I take this opportunity to express my profound gratitude to the staff of Microcells Ltd, and staff of University of Sri Jayewardenepura.

A special note of thanks to my present employer, Mr. P.H.G. Dharmasiri, Managing Director, DTH Superdag (Pvt) Ltd, for the support given to me to continue this project work.

Finally, heartfelt thanks goes to my all family members and my friends who have been supporting me throughout the course of study.

ABSTRACT

There are altogether around 40,000 rubber products available in the world that are being used for various end use applications. Out of these, rubber mats and flooring find many uses in the industry and domestic purposes mainly due to their excellent anti- fatigue property. Natural rubber is used as the basic elastomer in producing general purpose anti-fatigue mats and flooring. However, the industry calls for additional requirements other than the anti-fatigue property, mainly to fulfill the fitness for use in different environmental conditions.

The manufacturing and service enterprises use various types of fluids either directly in the product or as indirect material. As such, the production or service environment would be subjected to fluid contamination. In such a situation the anti-fatigue mats that are being used should have the resistance to such fluids. Therefore, it is of utmost importance that the mat manufacturer provides suitable technological solutions that would enable the industry to use mats in varying environmental conditions.

This project envisage in developing suitable compound designs based on NBR (Nitrile rubber) and its blends with NR (Natural rubber), so that mats and flooring produced by such compound would be suitable for major cross section of applications in industrial and service environments where fluids based on petroleum, animal and vegetable origin are being used.

The trials were carried out using a typical low cost natural rubber (NR) based compound as the reference. The developmental experiments of altogether 5 compound designs of; NR, NBR and blends of NR: NBR of ratios 25:75, 50:50, 75:25 have be carried as per standard practices employed in Research and Development. The results so obtained in each compound design was evaluated for processability parameters, Stress/Strain properties, ageing characteristics and finally on swelling in different fluids. Based on these finding the project was concluded with suitable recommendation of compound designs to suit mats for applications in fluid based industry and service sector.

List of Figure

List of Table

CONTENT

Chapter 03

3. Results & Discussion

1. Introduction

Today many are concerned of fatigueness or tiredness that causes ill health to workers who are engaged in certain skilled operations in an industrial environment. This is considered to be a health hazard which ultimately lead to lower level of productivity in human resource and also may affect in their quality of work. In certain work areas in the industry, workers continue to work long hours while standing. If, they do not have a cushion surface to stand, the strain on the body may contribute to many health complications.

When standing on hard surfaces, there can be strain on certain body parts specially resulting in mental and physical fatigue. The fatigue condition creates pain in spine and the leg muscles[1]. This situation would invariably result in poor worker motivation and absenteeism in many industrial organizations. It is very important that a solution be soon available to overcome this hazardous condition. If timely solution is not forth coming, there would be drop in productivity and at times may result in worker unrest and industrial disputes.

Natural rubber is a highly resilient material could be conveniently converted into a product that would serve as the anti-fatigue Mat or Flooring. Natural and synthetic elastomers and their blends have been investigated in producing oil resistant, and are discussed in terms of technological compound design and processability parameters. The project report highlights and discusses the experimental work and recommends their suitability of assign rubber mats and flooring in important application.

The anti-fatigue mats find its uses in areas such as, workshops, garages, hospitals, laboratories, sales counters etc. These mats are also tends to uses in domestic areas such as Door mats, Kitchen mats, etc.

There are special applications for anti-fatigue mats where mats cause in contact with different types of oils or fluids. Under such conditions the mats are required to base on polymers or their blends that offers oil resistance in addition to anti-fatigue consideration. The study is also aimed at designing suitable compounds that would satisfy these requirements.

1.1. Health Consideration

Fatigue is caused in people due to various reasons. Specially so when standing for a long time on hard surfaces. Some medical complications would result in leading to muscle fatigue[11] etc. There are various causes for fatigue, and it is important to reduce it while it is in control, because it can cause serious health hazards, if overlooked or ignored.

Anti-fatigue mats are designed to reduce the stress and fatigue caused by the various reasons. These fatigue reducing mats can be made with rubbers. They reduce the foot tiredness of the person suffering from fatigue problems. These mats work in a very scientific manner by using shock-absorbing technology and its cushion reduced foot fatigue. The body part that undergo strain and that contributes to fatigueness is depicted in the given sketch[11].

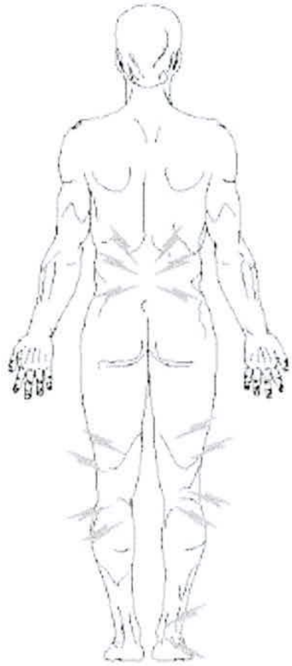

Figure 1.1. Resulting of fatigued muscles

Low back pain caused by excessive stress on the spine and back muscles

Blood stagnates causing varicose veins to develop

Fatigued muscles resulting from long term standing on a hard surface

Arch and heel pain due to excessive flattening of the foot

1.2. Oil Resistant Rubbers

1.2.1. Neoprene

Except for polybutadiene and polyisoprene, neoprene is perhaps the most rubber like of all, particularly with regard to dynamic response. Neoprenes are a large family of rubbers that have a property profile approaching that of natural rubber, and with better resistance to oils, ozone, oxidation, and flame[12]. They age better and do not soften on heat exposure, although high-temperature tensile strength may be lower than that of NR.

These materials, like NR, can be used to make soft, high-strength compounds. A significant difference is that, in addition to neoprene being more costly than NR by the pound; its density is about 25% greater than that of natural rubber. Neoprenes do not have the low-temperature flexibility of natural rubber, which detracts from their use in low-temperature shock or impact applications.

General-purpose neoprenes are used in hose, belting, wire and cable, footwear, coated fabrics, tires, mountings, bearing pads, pump impellers, adhesives, seals for windows and curtain-wall panels, and flashing and roofing. Neoprene latex is used for adhesives, dip-coated goods, and cellular cushioning jackets.

1.2.2. Chlorinated polyethylene

This family of elastomers is produced by the random chlorination of high-density polyethylene. Because of the high degree of chemical saturation of the polymer chain, the most desirable properties are obtained by cross linking with the use of peroxides or by radiation. Sulfur donor cure systems are available that produce vulcanizates with only minor performance losses compared to that of peroxide cures. However, the free radical cross linking by means of peroxides is most commonly used and permits easy and safe processing, with outstanding shelf stability and optimum cured properties.

Chlorinated polyethylene elastomers, sold by the Dow Chemical Co. under the trade name Tyrin, are used in automotive hose applications, premium hydraulic hose, chemical hose, tubing, belting, sheet packing, foams, wire and cable, and in a variety of molded products. Properties include excellent ozone and weather resistance, heat resistance to 300^0F (to 350^0F in many types of oil), dynamic flexing resistance and good abrasion resistance[12].

1.2.3. Chlorosulfonated polyethylene

This material, can be compounded to have an excellent combination of properties including virtually total resistance to ozone and excellent resistance to abrasion, weather, heat, flame, oxidizing chemicals, and crack growth. In addition, it has low moisture absorption, good dielectric properties, and can be made in a wide range of colors because it does not require carbon black for reinforcement. Resistance to oil is similar to that of neoprene[12]. Low-temperature flexibility is fair at -40^0F.

This is a special-purpose rubber, not particularly recommended for dynamic applications. It is used generally where its outstanding environmental resistance is needed. Typical applications include coated fabrics, maintenance coatings, tank liners, protective boots for spark plugs and electrical connectors, cable jacketing, and sheeting for pond liners and roofing.

1.2.4. Nitrile

The nitriles are copolymers of butadiene and acrylonitrile, used primarily for applications requiring resistance to petroleum oils and gasoline. Resistance to aromatic hydrocarbons is better than that of neoprene but not as good as that of polysulfide. NBR has excellent resistance to mineral and vegetable oils[12], but relatively poor resistance to the swelling action of oxygenated solvents such as acetone, methyl ethyl ketone, and other ketones. It has good resistance to acids and bases except those having strong oxidizing effects. Resistance to heat aging is good, often a key advantage over NR.

With higher acrylonitrile content, the solvent resistance of an NBR compound is increased but low-temperature flexibility is decreased. Low-temperature resistance is inferior to that of natural rubber, and although NBR can be compounded to give improved performance in this area, the gain is usually at the expense of oil and solvent resistance.

As with SBR, this material does not crystallize on stretching, and reinforcing materials are required to obtain high strength. With compounding, nitrile rubbers can provide a good balance of low creep, good resilience, low permanent set, and good abrasion resistance.

Tear resistance is inferior to that of natural rubber, and electrical insulation is lower. NBR is used instead of natural rubber where increased resistance to petroleum oils, gasoline, or aromatic hydrocarbons is required. Uses of NBR include carburetor and fuel-pump diaphragms and aircraft hoses and gaskets. In many of these applications, the nitriles compete with polysulfides and neoprenes.

1.2.5. Epichlorohydrin

Epichlorohydrin rubber is available as a homopolymer (CO) and a copolymer (ECO) of epichlorohydrin. Reinforced, these rubbers have moderate tensile strength and elongation properties, plus an unusual combination of other characteristics. One of these is low heat buildup, which makes them suitable for applications involving cyclic shock or vibration.

The homopolymer has outstanding resistance to ozone, good resistance to swelling by oils[12], intermediate heat resistance, extremely low permeability to gases, and excellent weathering properties. This rubber also has low resilience characteristics and low-temperature flexibility only to 5^0F, characteristics that may be unsuitable for some applications.

The copolymer is more resilient and has low-temperature flexibility to -40^0F, but it is more permeable to gases. Oil resistance of both compounds is about the same. Typical applications include bladders, diaphragms, vibration-control equipment, mounts, vibration dampers, seals, gaskets, fuel hose, rollers, and belting.

1.2.6. Ethylene/acrylic

The material has very good resistance to hot oils[12], hydrocarbon-based or glycol-based proprietary lubricants, transmission and power-steering fluids. It is not recommended for use with esters, ketones, highly aromatic fluids or high-pressure steam.

The polymer is recommended for applications requiring a durable, set-resistant rubber with good low-temperature properties and resistance to the combined deteriorating influences of heat, oil, and weather. It is used in various automotive components such as mounts, gaskets, seals, boots, and ignition-wire jackets. Electrical applications include oil-well platform cable jackets, plenum cable, transit-wire jackets, and marine cable.

1.2.7. Perfluoroelastomer

Chemical resistance of perfluoroelastomer parts is similar to that of PTFE, and mechanical properties are similar to those of the fluorocarbon rubbers and essentially unaffected by all fluids, including aliphatic and aromatic hydrocarbons, esters, ethers, ketones, oils, lubricants, and most acids. However, some fully halogenated fluids and strong oxidizing acids may cause swelling[12]. The parts are suitable for continuous service to 290^0C and intermittent service to 316^0C. Resistance to ozone, weather, and flame is exceptional. Radiation resistance is good and high-vacuum performance excellent.

Perfluoroelastomer parts are used primarily in demanding fluid-sealing applications in the chemical-processing, oil-production, aerospace, and aircraft industries.

1.2.8. Acrylate

These are specialty rubbers based on polymers of methyl, ethyl, or other alkyl acrylates. They are highly resistant to oxygen and ozone, and their heat resistance is superior to that of all other commercial rubbers except the silicones and the fluorine-