Advances in Environmental Biology, 8(8) 2014, Pages: 2727-2731

AENSI Journals

Advances in Environmental Biology

Journal home page: http://www.aensiweb.com/AEB/

Effect of Dipping Tank Coagulum (Dtc) On Cure Characteristics and Physical Properties of Dtc/Natural Rubber Blends

Dayang Habibah A.I.H, Nur Fadhilah Idris , Devaraj Veerasamy and Nor Hidayaty Kamarulzaman

Technology & Engineering Divison, Malaysian Rubber Board, 47000 Sungai Buloh, Selangor D.E.

ARTICLE INFO

Article history:
Received 28 February 2014
Received in revised form 25 May 2014
Accepted 6 June 2014
Available online 20 June 2014

Keywords:
Dipping tank coagulum Schedule waste Blends Natural rubber

ABSTRACT

Dipping tank coagulum (DTC) is the final remains of a pre-vulcanized latex concentrate in a semi-solid form which had settle down as sediments at the bottom of the dipping tank at the end of a 'former' dipping process in a glove manufacturing line. Preliminary study was carried out for the possibility of recovering DTC into a raw material for manufacturing value added raw material. In this study, the effects of cure characteristics and physical properties such as tensile strength, abrasion resistance are investigated using untreated DTC from 3 factories blended with virgin rubber. The inclusion of DTC at 50 phr loading leads to a decrease in the tensile strength and abrasion resistance values and a significant decrease with further increase of DTC loadings. Significant deterioration in physical properties is observed for DTC containing high amount of sulphur, zinc and ash content. This result showed that the composition of the components of DTC, especially the level of additives which still remain intact in the raw DTC could significantly affect the properties of products manufactured.

To Cite This Article: Dayang Habibah A.I.H, Nur Fadhilah Idris , Devaraj Veerasamy and Nor Hidayaty Kamarulzaman., Effect of Dipping Tank Coagulum (Dtc) On Cure Characteristics and Physical Properties of Dtc/Natural Rubber Blends. ***Adv. Environ. Biol., 8(8),*** *2727-2731, 2014*

INTRODUCTION

Many parts of the world have been impacted with perennial problem of mitigating on the ever increasing volumes of rubber waste, which is of grave environmental concern of every country. Discarded rubber products, especially used tyres get accumulated and constitute a major problem if no remedial action is initiated. Currently with the growing environmental awareness, activities of recycling which gives an option of generating income, besides preserving environment are being taken up by some industries with technical support obtained from universities and research organizations.

Recycling of rubber enables the production of cheaper raw material with good inherent properties and provides road map towards manufacturing value added rubber products eventually. Apart from dry rubber products, latex products manufacturing industry also has expanded over the years to meet the world demand for examination gloves, condoms, latex thread, etc. [1]. There are many approaches towards utilizing rubber waste as well as discarded rubber products. One of the approaches is to reclaim or remove the cross-links in the waste rubber and then use it as new rubber; although this approach has many limitations, but it still being pursued by certain quarters. The other approach being blending of virgin rubber with recycled rubber products; this is a common practice for rubber product manufacturing industry. In certain cases, treatment of the waste latex before blending is essential to improve compatibility and adhesions between rubber phases. Another method is blending with thermoplastic material as an impact modifier [8]. Studies by [6] relate to the usage of powdered waste latex (PWL) as filler in the epoxidised natural rubber (ENR) formulations. It was found that the addition of PWL as 'filler' assisted the compound in reducing the stickiness of ENR. Higher amount of PWL filler enhanced the compounding process by reducing mixing time, curing time, scorch time and induction time.

Malaysia currently ranks top in the world in the production of latex dipped goods. Incidentally latex product manufacturing factories too, generate high volumes of formulated latex waste, which is known as dipping tank coagulum (DTC). DTC is the final remains of a pre-vulcanized latex concentrate in a semi-solid form which had settle down as sediments at the bottom of the dipping tank at the end of a 'former' dipping process in a glove manufacturing line. This DTC is turned into latex lump and sent for disposal by incineration. DTC and latex lump are waste pre-vulcanized latex material, with curatives (ZnO, sulphur, accelerators and antioxidant), considered as scheduled waste under the Environmental Quality [5]. This tends amount to wastefully destroying

Corresponding Author: Dayang Habibah A.I.H, Technology & Engineering Divison, Malaysian Rubber Board, 47000 Sungai Buloh, Selangor D.E.
E-mail: dayang@lgm.gov.my

good quality of hydrocarbon chained-material with some loose crosslinking. Preliminary study was carried out for the possibility of recovering DTC into a raw material for manufacturing value added raw material. In this study, the effects of cure characteristics and physical properties such as tensile strength, elongation at break and abrasion resistance are investigated using untreated DTC from 3 factories blended with virgin rubber (Natural rubber (NR), SMR 10).

Methodology:

DTC samples were obtained from 3 different glove factories and are designated as DTC-A, DTC-B and DTC-C. Prior to mixing, the samples were masticated using a two roll mill with the nip gap adjusted to app.1 mm, for about 50 minutes. This was done to turn the DTC samples into sheets so as to blend with virgin rubber (SMR 10) and subsequently fillers and processing oil were added using a Haake Banbury mixer (Haake Rheomix 600 OS). The formulations were completed with the addition of curatives (sulphur and accelerator) using a two-roll mill. A control mix was subsequently prepared without incorporating DTC, but instead, using only virgin rubber to make comparative investigations.

Determination of Cure Characteristics and Physical properties:

The cure characteristics of the rubber compounds were studied using a Monsanto Moving Die Rheometer according to ISO 6502 at 150°C. The respective cure times were measured by t90, scorch times ts2, maximum torque (MH), minimum torque (ML), etc., were determined from the rheograph. The compounds were then compression-moulded at 150°C using the respective cure times, t90.

Dumb-bell samples with the length of 95 mm were cut from a 2-mm-thick moulded sheet. The tensile testing procedure was carried out according to ISO 37. A Shimadzu auto machine AG-X plus universal tensile tester operating at 500 mm/min was used to determine the tensile properties in terms of ultimate tensile strength and elongation at break.

The abrasion resistance (ISO 4649) was measured by moving the test piece across the surface of an abrasive sheet mounted to a revolving drum, and the results were normally expressed as abrasion resistance index compared to a reference or standard compound. Three test runs were performed for each compound.

RESULTS AND DISCUSSION

Processability:

Table 1 shows chemical analyses of DTC samples obtain from 3 different factories, denoted as A, B and C. The components' compositions listed, have direct effect on the processability and characteristics on any products made from these samples. It is observed that DTC-C exhibits higher percentages of ash, zinc and sulphur, whereas the polymer content is slightly lower compared to samples from other two factories. The higher percentage of ash in DTC-C probably explains the difficulty encountered during the processing of this sample, compared to DTC-A and DTC-B. In addition, the sample was quite brittle and powdery after passing through a nip gap of the two-roll mill.

Table 1: Chemical characterization of DTC samples used in this study

Parameter tested	DTC-A	DTC-B	DTC-C
Polymer content (%)	80.3	85.8	71.6
Ash (%)	0.4	2.0	10.2
Calcium carbonate (%)	16.1	9.8	13.6
Zinc (%)	0.2	0.64	1.74
Solvent extraction (%)	1.9	2.4	4.6
ZDBC (%)	0.2	0.4	0.1
ZDEC (%)	0.04	0.5	0.3
Total sulphur	1.4	1.2	2.4

ZDEC - Zinc Diethyldithiocarbamate ; ZDBC - Zinc Dibutyl Dithiocarbamate

Cure characteristics:

The cure characteristics profiles of blendings of NR and DTC-A, DTC-B and DTC-C at various ratios are as displayed in Figures 1(a), (b) and (c), respectively. It can be seen from Figures, 1(a-c), that the minimum and maximum torques increased with increasing level of recycled material (DTC) [4]. Theoretically, the increase in the maximum torque reflects of an increase in crosslink density and resulting in an additional stiffness of the rubber blend. Similar trend is also observed in NR containing DTC-C whereas, this effect is not very obvious for NR containing DTC-B and DTC-A, respectively. It is also observed that NR containing DTC-C at all ratios tested showed the highest value for the maximum torque. (De. D *et. al*, 2007) highlighted that there is the presence of crosslinked gel in the recycled rubber which remained without dispersing as a continuous matrix with virgin rubber, when these two (virgin rubber and DTC) were blended. As such this phenomenon explains

the increase in the stiffness with intermittent presence of crosslinked gel from the recycled rubber, attributing to the maximum torque. Another possible reason could be, with the presence of a high amount of ash in DTC-C sample, it subsequently prevented the formation of vulcanized sheet from 100 phr of DTC-C, due to the highly-crosslinked rubber becoming quite stiff and brittle.

A significant decrease in scorch and cure times were also observed with increasing amount of DTC-A, DTC-B and DTC-C loading. A similar trend was also reported by other researchers [5,6,3] with different types of recycled rubbers. This could be due to the unreacted curatives still present in the raw DTC samples. The results are clearly in good agreement with higher amount of sulphur and zinc content in the raw composition analyses of the DTC. This also contributes to the higher crosslinking density in the blends with increase amount of DTC loadings.

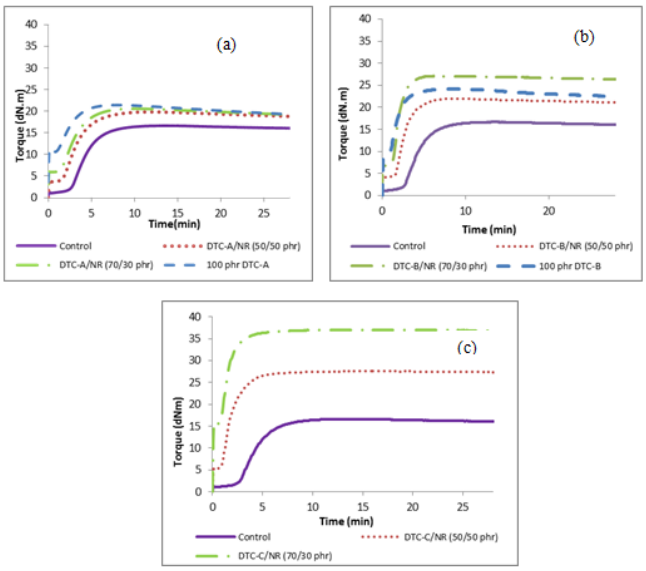

Fig. 1: Rheometer graph of NR containing (a) DTC-A, (b) DTC-B and (c) DTC-C at various ratio.

Physical properties:

In this study, tensile properties and abrasion resistance were used to evaluate the physical properties of the DTC/NR blends. Generally, materials tend to become weak and brittle with increasing concentrations of DTC. Figures 2 and 3 show variations in tensile strength and elongation at break of NR/DTC vulcanizates with different blend ratios using samples of DTC obtained from different sources. The inclusion of DTC at 50 phr loading leads to a decrease in the tensile strength values and a significant decrease with further increase of DTC loadings. It is found that the maximum values of tensile strength decrease, for different samples in the order of DTC-C < DTC-B < DTC-A. A similar trend can also be seen for elongation at break. The decrease in the elongation at break is probably attributed to a reduction on the flexibility of the materials; the higher the crosslink density the greater was the restriction of the rubber mobility [7]. Overall, the physical properties of a blend of virgin and recycled rubber are also affected by many factors [9] such as:

- Presence of crosslink gel in the wastes
- Bonding between recycled material and matrix
- Sulphur distribution between the matrix and recycled
- Crosslink density and distribution

The abrasion resistance of NR containing DTC-A, DTC-B and DTC-C at various ratios are as shown in Figure 4. It is also can be seen that the abrasion resistances of blended vulcanizates (NR/DTC) gradually decrease as the DTC content is increased. The declining of abrasion resistance is more pronounced in NR which was blended with DTC-C sample. As mentioned earlier, the high content of zinc and sulphur present in DTC-C could have attributed to the increase in crosslink density of the blended vulcanizate, which subsequently brought about the deterioration in its physical properties. Therefore, such behaviour confirms the need to ascertain the ideal blending ratios for inducing optimum degree of crosslinking to incorporate relatively good physical properties to the products which would be manufactured using these materials..

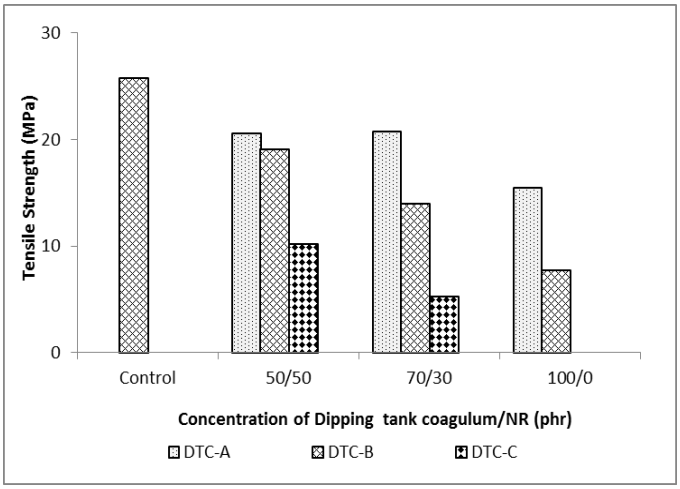

Fig. 2: Effect of DTC loading on tensile strength of DTC/NR blends.

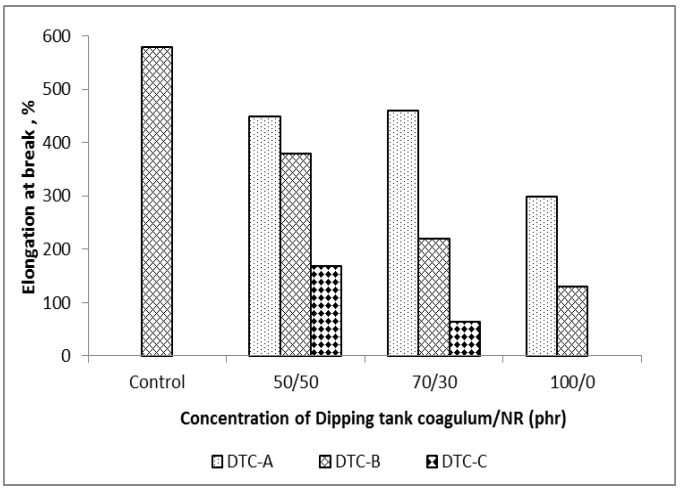

Fig. 3: Effect of DTC loading on Elongation at break of DTC/NR blends.

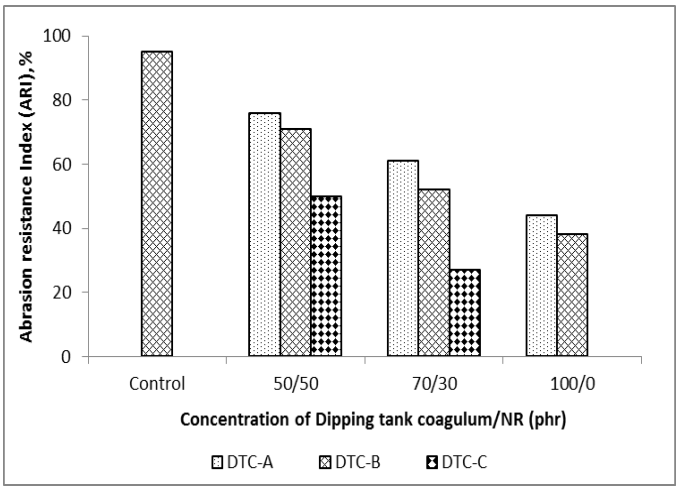

Fig. 4: Effect of DTC loading on abrasion resistance of DTC/NR blends.

Conclusion:

The investigation has shown that dipping tank coagulum types of, DTC-A and DTC B can replace raw natural rubber up to about 50 phr without significantly affecting the physical properties of the NR/DTC blended vulcanizates, whereas the deterioriation in physical properties is observed for similar blends using DTC-C at all

levels. Therefore, it can be concluded that the composition of the components of DTC, especially the level of additives which still remain intact in the raw DTC could significantly affect the properties of products manufactured.

ACKNOWLEDGEMENT

The authors would like to thank Mr. Mohd Akram Abdullah@Shuib and Mr. Che Muhd Firdaus b. Che Mat from Advanced Rubber Technology Unit (ARTU) and Mr Shuhaily Shamsuddin, Mr. Mohd Muzaqqir Mohd Zain and Mr Muhammad Abdul Majid from Processing and Pollution Research Unit (PPRU) for their assistance during the experimental work. Assistance from other staff in ARTU, PPRU, Physical and Characterization Unit are also acknowledged.

REFERENCES

[1] Abraham, E., B.M. Cherian, P.A. Elbi, L.A. Pothen and S. Thomas, 2011. Recent Advances in the Recycling of Rubber Waste in *Recent Developments in Polymer Recycling*, Editors: Fainleib A. and Grigoryeva O. 47-100.
[2] De, D., D. De. and G.M. Singharoy, 2007. Reclaiming of Ground Rubber Tire by a Novel Reclaiming Agent. I. Virgin Natural Rubber/Reclaimed GRT Vulcanizates, Polymer Engineering & Science, 47(7): 1091-1100.
[3] Edirisinghe, D.G., M.I.A. De Silva and J.K. Premachandra, 2011. A Novel Reclaiming Agent for Ground Rubber Tyre (GRT). Part II: Property Evaluation of Virgin Natural Rubber (NR)/Novel Reclaimed GRT Revulcanisates, Progress in Rubber, Plastics and Recycling Technology, 27(3): 161-176.
[4] Environmental Quality (Schedule Wastes) Regulation, 2005.
[5] George, R.S. and R. Joseph, 1994. The Utilisation of Latex Reclaim rubber in Natural Rubber, Die Angewante Makromolekulare Chemie, 215, Nr. 3711: 25-33.
[6] Mathew, G., R.P. Singh, N.R. Nair and S. Thomas, 2001. Recycling of Natural Rubber Latex Waste and its Interaction in Epoxidised Natural Rubber, Polymer, 42: 2137-2165.
[7] Rajan, V.V., W.K. Dierkes, R. Joseph and J.W.M. Noordermeer, 2006. Recycling of NR Based Cured Latex Material Reclaimed with 2,2'-dibenzamidodiphenyldisulphide in a Truck Tire Tread Compound, J. Appl. Polym. Sci., 102: 4194-4206.
[8] Rajeev, R.S. and S.K. De, 2004. Thermoplastic Elastomers Based on Waste Rubber and Plastics, Rubber Chemistry and Technology, 77: 569-578.
[9] Sitisaiyidah Saiwari, 2013. Post-Consumer Tyres back into new tyres: Devulcanization and Re-Utilization of passenger car tyres, PhD Thesis, University of Twente, The Netherlands.