

PAPER • OPEN ACCESS

## Crosslink density and rheometric behaviour of natural rubber/chloroprene rubber blends

To cite this article: I Surya and M Z Siswarni 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **505** 012113

View the [article online](#) for updates and enhancements.



**IOP | ebooks™**

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the collection - download the first chapter of every title for free.

# Crosslink density and rheometric behaviour of natural rubber/chloroprene rubber blends

I Surya<sup>\*1</sup> and M Z Siswarni<sup>1</sup>

<sup>1</sup>Chemical Engineering Department, Universitas Sumatera Utara, Medan, 20155, Indonesia

\*E-mail: [indradanas@yahoo.com](mailto:indradanas@yahoo.com)

**Abstract:** Crosslinking density and rheometric behaviour of natural rubber (NR)/ chloroprene rubber (CR) blends with blend ratios from 0.0 to 100.0% rubber were investigated utilizing the semi efficient vulcanization. The degrees of crosslinking density were calculated using FloryRehner equations. The rheometric properties were tested by utilizing moving die curemeter (MDR 2000). From the overall results, cure and scorch times of the rubbers blends enhanced with increases the CR content. Whilst, the maximum values of torque difference and crosslinking density were performed by the rubbers blend with the 50/50 blend ratio.

## 1. Introduction

The blending of some prospective raw rubbers is an activity achieving some new rubbery substantial with a wide scope of applications. The activity takes some advantages due to the gorgeous properties of the rubbers blends counterparts whilst desisting from technical and economic riskiness related to manufacturing new rubbery substantial [1, 2]. In the blending of 2 or more raw rubbers of different categories is helpful for material formation with properties missing in raw rubbers units [3, 4, 5]. The rubber blends based on natural rubber (NR) have been extensively investigated due to their excellent performances in a wide range of applications, especially in tire application. NR is decumbent to depreciation by ozone aggression because of its almost fully unsaturated hydrocarbon on its backbone. Generally, enhancement in weak ozone protection of NR is gained by blending the rubber with some low unsaturation rubbers such as chloroprene rubber (CR). The CR is popular as Neoprene is one of the first oil fight synthetic rubbers [6] and one of the most important specialty elastomers. Its ranges of usage in rubber industry are boundless include conveyor and transmission belts, moulded products, seals, jackets of cable and also coated fabrics.

The CR has a similar molecular structure with NR; with one exception that chlorine atoms have replaced some methyl groups [7]. The chlorine atoms reduce reactivity of the unsaturation hydrocarbon on its backbones and hence, its reactivity to sulphur becomes less pronounced.

In this study, NR was blended with CR with some blend ratios. The crosslinking density and rheometric properties of the rubber blends were investigated. The crosslinking density of the rubbers blends was measured by the FloryRehner approach. The rheometric properties were tested by utilizing a curemeter.

## 2. The experimental

### 2.1. Materials for rubbers blends



The raw NR, skyprene B-30 type of CR, sulfur, IPPD antioxidant, stearic acid, ZnO and CBS accelerator were prepared by Rubber Lab, USM, Malaysia

### 2.2. Rubbers Blending

The semi efficient vulcanization was utilized for the blending of rubbers. Recipe for making the rubbers blends is presented in Table 1. The procedures of rubber blending were done according to ASTM D3184-80 and the blend operations were done on a lab scale mill.

**Table 1.** A typical recipe of rubbers blends

Materials	Composition
Rubber blend*	100
ZnO	5
IPPD	2
CBS	1.5
Stearic acid	2
Sulfur	1.5

\*Ratio of the blend for NR/CR (100/0, 75/25, 50/50, 25/75 and 0/100)

### 2.3. Crosslinking density determination

The crosslinking density of the rubbers blends was determined using toluene according to ASTM D471-12a. The (30mm × 5mm × 2mm) sized of the blends were weighed on a balance and swollen them inside toluene for 72 hrs (ambient temperature). The blends were taken out from solution and cleaned remained toluene from the surfaces of blends and their weights were marked. The blends were dried inside an oven (70 °C) for constant weights were reached. The data can be used for calculating the weight of molecular between 2 crosslinking,  $M_c$  based on Flory and Rehner Equations [7-8].

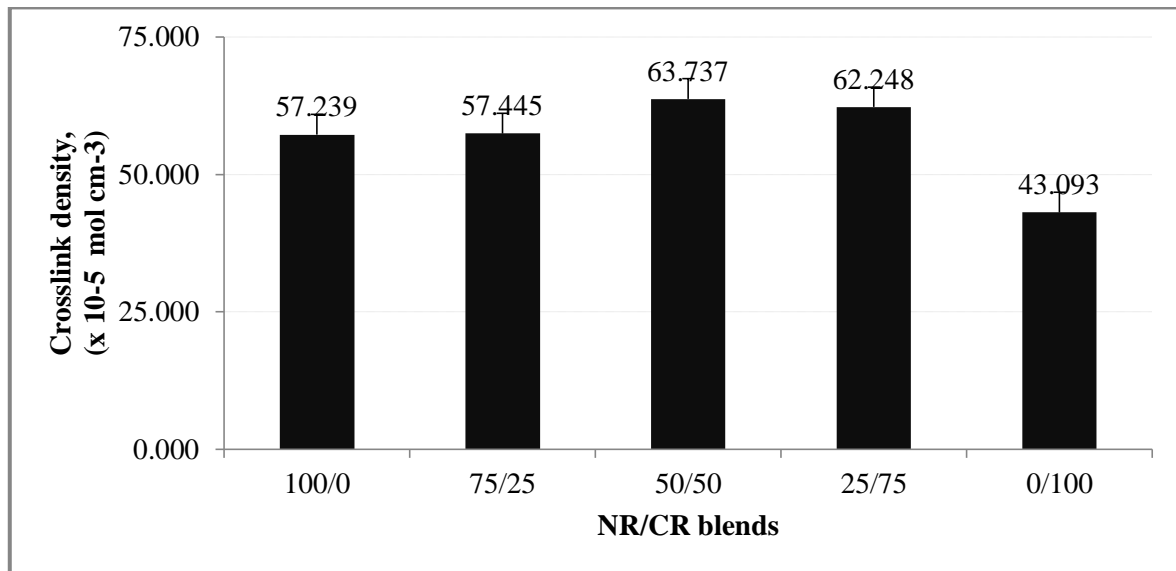
### 2.4. Rheometric behaviour

The cure and scorch times, maximum and minimum torques and also torque difference of rubbers blends were determined utilizing an MDR2000 (Monsanto Moving Die Rheometer) ASTM (D2084-11). The temperature of the testing was 150 °C.

## 3. Results and Discussion

### 3.1. Crosslinking density

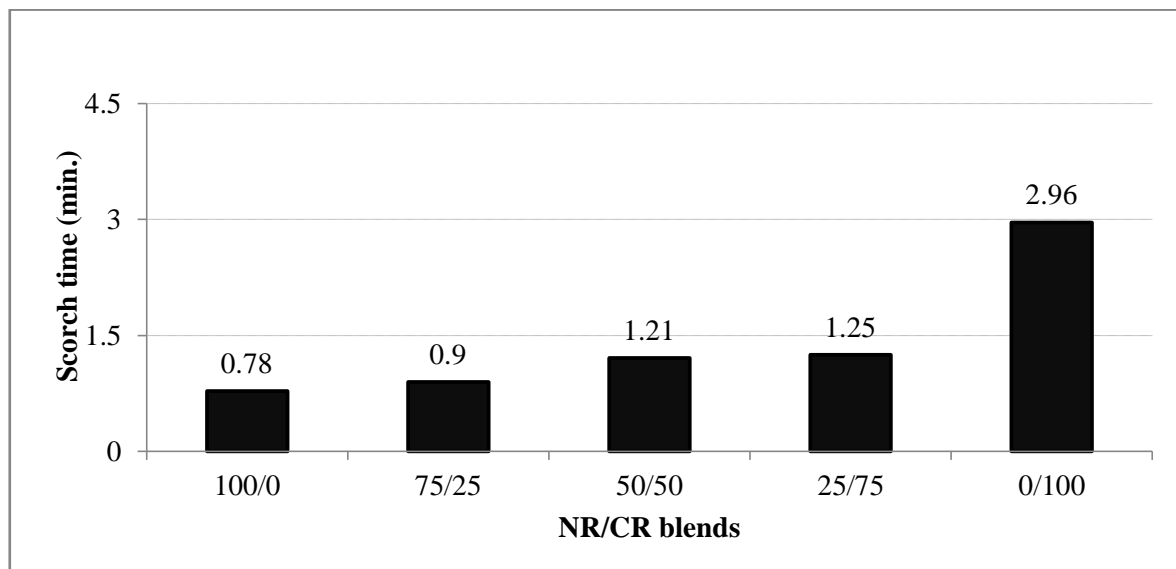
Crosslinking density degree of rubbers blends was calculated using FloryRehner Equations [Eqs. (1-3)]. Figure 1 presents crosslinking density of rubbers blends at room temperature. A 50/50 NR/NR rubber blend has the highest crosslink density. It can be due to the synergetic effect of both raw rubbers, NR and CR.



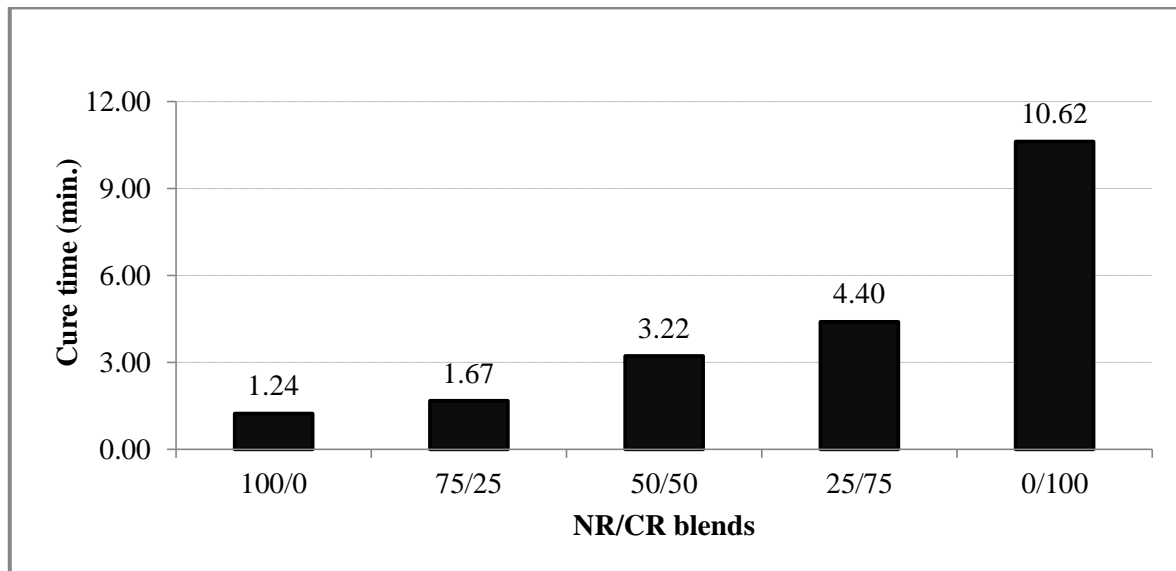
**Figure 1.** Crosslink density of NR/CR blends

### 3.2. Rheometric properties of the rubbers blends

The cure and scorch times of rubbers blends are presented in Figs. 2 and 3. Those times increased with increases the content of CR in the rubber blends. According to Chang and Chouch [9,10], the rates of cure of a rubbers blends depend on the amount of the allylic hydrogen in the repeating units, in which a more amount of allylic hydrogen causing in a lower curing energy of activation and hence, increased the rate of cure. The scorch is the initial stage of curing. Therefore, a shorter cure time and scorch time were due to a more amount of allylic hydrogen inside the rubbers blends.

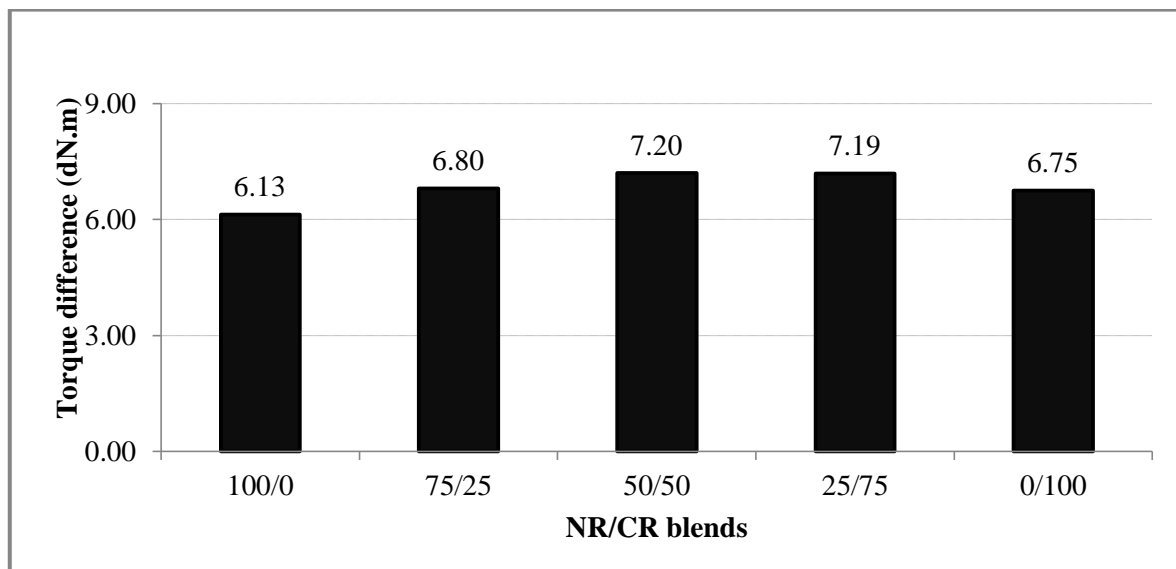


**Figure 2.** Scorch time of NR/CR blend



**Figure 3.** Cure time of NR/CR blend

Fig. 4 presents torque difference ( $M_H - M_L$ ) of the rubbers blends. A 50/50 NR/CR blend got the highest value of torque difference. This result is in line with Fig. 1. The 50/50 NR/CR blend showed the highest value of crosslinking density. It is believed that torque differences reflect the degree of crosslinking density [11, 12]. A greater value means a higher degree of crosslinking density.



**Figure 4.** Torque difference of NR/CR blended compound

#### 4. Conclusions

The cure and scorch times of chloroprene rubber/natural rubber blends increased with increases the amount of chloroprene rubber. The 50/50 chloroprene rubber/natural rubber blend was the optimum blend ratio for chloroprene rubber/ natural rubber blends which caused in maximum values of torque difference and crosslink density.

#### Acknowledgement

Authors thank USU Medan for a Penelitian Hibah Bersaing research grant with a number of contract 4804/UN5.1.R/KEU/2014.

## References

- [1] I. Surya, S F Siregar, H. Ismail, The effects of alkanolamide addition on cure characteristics, swelling behaviour and tensile properties of silica-filled natural rubber (NR)/chloroprene rubber (CR) blends, E3S Web of Conferences, 34 (2018) 01030.
- [2] W. Arayaprane, G. Rempel, Properties of NR/EPDM blends with or without methyl methacrylate-butadiene-styrene (MBS) as a compatibilizer, Intern. J. Mater. Struc. Relia. 5 (2007) 1-12.
- [3] P. Sae-oui, C. Sirisinha, U. Thepsuwan, P. Thapthong, Influence of accelerator type on properties of NR/EPDM blends, Polym. Test. 26 (2007) 1062-1067.
- [4] S. H. El-Sabbagh, Compatibility study of natural rubber and ethylene-propylene-diene rubber blends, J. Appl. Polym. Science. 90 (2003) 1-11.
- [5] Y.W. Chang, Y.S. Shin, H. Chun, C. Nah, Effects of trans-polyoctylene rubber (TOR) on the properties of NR/EPDM blends, J. Appl. Polym. Sci. 73 (1999) 749-756.
- [6] F.W. Barlow: Rubber compounding: principles, materials, and techniques (CRC Press, 1993).
- [7] J.S. Dick, Rubber Technology: compounding and testing for performance (Hamser, 2001).
- [8] P.J. Flory, J. Rehner Jr., Statistical mechanics of crosslinked polymer networks II. Swelling, J. Chem. Phys., 11 (1943) 521.
- [9] H. Ismail, S. Shaari, N. Othman, The effect of chitosan loading on the curing characteristics, mechanical and morphological properties of chitosan-filled natural rubber (NR), epoxidised natural rubber (ENR) and styrene-butadiene rubber (SBR) compounds, Polymer Testing, 30 (2011) 784-790.
- [10] S.H. Chough, D.H. Chang, Kinetics of sulfur vulcanization of NR, BR, SBR, and their blends using a rheometer and DSC, Journal of Applied Polymer Science, 61 (1996) 449-454.
- [11] B. Boonstra, H. Cochrane, E. Dannenberg, Reinforcement of silicone rubber by particulate silica, Rubber Chemistry and Technology, 48 (1975) 558-576.
- [12] H. Cochrane, C. Lin, The influence of fumed silica properties on the processing, curing, and reinforcement properties of silicone rubber, Rubber Chemistry and Technology, 66 (1993) 48-60.