Mechanical Properties of Natural Rubber-Organo Layer Silicate Nanocomposite

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Abstract. Natural rubber with carbon black filler use as raw material for tire, produceing low barrier and heavy weight tire. These properties were the important parameter for tire material. This research was intended to study the effect of Organo Layer Silicate (OLS) d-spacing in natural rubber OLS nanocomposite to produce lighter and better barrier properties. Research focused on mechanical properties of natural rubber OLS nanocomposite. Natural rubber OLS nanocomposite was prepared using open mill at 65°C, 24 and 33.6 rpm for 5 min. Natural rubber OLS nano composite was formulated with the parameter of 6% OLS with 3.15 and 2.42 nm d-spacing. Mechanical properties of natural rubber OLS nanocomposite was characterized using universal testing machine (UTM), in order to analyze the effect of different OLS d-spacing on mechanical properties. The mechanical properties of natural rubber OLS nanocomposite with OLS d-spacing 3.15 nm was higher than that of OLS d-spacing 2.42 nm. These two mechanical properties also higher than that of natural rubber without OLS.

Keywords: Natural rubber; clay; nanocomposite; mechanical properties

Introduction

The addition of general fillers to elastomer matrix affect the viscoelastic character by an increase in viscosity, limitation of chain mobility, and improvement in mechanical properties. The extent to which this change occure strongly depend on: particle size, rubber filler interaction, filler-filler interaction, filler shape and structure, filler concentration, and filler dispersion in the matrix.

Organo Layer Silicate (OLS) is a synthetic montmorillonite that has layer-like shape with organic surfactant in the interlayer structure where the arrangement of interlayer structure depends on packing density, chain length, temperature [1,2] and head group of organic surfactan(3). The nature structure and excellent properties of OLS with surfactant in the interlayer structure have significant impacts in improving polymer nanocomposite such as mechanical properties, heat resistance, permeability and flammability [4]. By intercalating the interlayer structure using organic surfactant until a certain gallery height (d-spacing) will lead to ease the exfoliation of layer in nanocomposite matrix [1,5].

A good dispersion of silicate layers and a high rubber/clay interphase quality are usually associated with increased tensile strength [6-10]. The deterioration (that usually noticed) or leveling off in the mechanical performance with increasing organoclay loading can be explain by the formation of big agglomerates, which favor the initiation of catastrophic failure [11,12].

The concept of "nano reinforcement" with layered silicates, credited to researchers at Toyota Central Research Laboratory (Japan), became very popular recently. Rubber-clay nanocomposite development compared with thermoplastic or thermoset clay nanocomposite was late due to complicate analysis of the parameters affecting the rubber layered silicate nanocomposite formation. Recently, increasing attention has been paid on rubber/clay nanocomposite. Several rubber clay nanocomposite has been prepared throught solution intercalation [13,14], melt intercalation(15,16), and rubber-latex compounding [17,18].

In this study natural rubber was blended with two type of organo clay, Cloisite 20A and cloisite 15A which having different basal spacing (d-spacing). AFM was used to analyze the morphology of blending result, and the mechanical properties were analyzed using Universal Testing Machine (UTM).

Experimental

Materials

Two type of organoclay: 1) Cloisite 15A, d-spacing 3,15 nm with type of surfactant quaternary ammonium salt, 2) Cloisite 20A, d-spacing 2,42 surfactant quaternary ammonium salt. These two type of organo clays were from Southern Clay Inc. USA, natural rubber SIR 20 was provided by PTPN 8 West Java Indonesia, ZnO, stearic acid, cyclohexylbenzothiazole-2-sulfenamid (CBS), and sulfur were supplied by anonymous local company.

Preparation and characterization

The formulation of natural rubber/clay nano composite is given in Table 1. Preparation of natural rubber-clay nanocomposite was done in two steps. The first step natural rubber was blended with organo clay and other ingredients, except sulfur and accelerator using brabender/internal mixer (Haake Rheometric PolyDrive) at temperature of 170^{o}C and screw speed of 50 rpm for 15 min.

The second step product of the first step was blended_with sulfur and accelarator in the open mill at temperature of 65^{o}C, rotor speed 24 rpm and 33.6 rpm for 5 min. This followed by moulding using hot press equipment, and put into oven for vulcanization.

Tensile test were done based on standard ISO 37 at room temperature 23^{o}C and humidity 61%. The tensile test specimen was prepared from molding product. Universal testing machine Shimadzu AGS-G were used for tensile test.

Table 1. Nomenclature of natural rubber/clay nanocomposite.

Ingredient	Content (phr)		
	NR	NR20A	NR15A
Natural rubber	100	100	100
Organo clay Cloisite 20A		6	
Organo clay Cloisite 15A			6
ZnO	5	5	5
Stearic acid	3	3	3
Processing aid	5	5	5
Antioxidant	1	1	1
Sulfur	2,5	2,5	2,5
Accelerator(CBS)	1,5	1,5	1,5

Results and Discussion

Table 2. Mechanical properties of natural rubber/clay nanocomposite.

Sample	Tensile Strength (Mpa)	Strain at Break (%)
NR	28,6	1383
NR20A	28,9	1407
NR15A	31,57	1260

Result of tensile test in Table 2 showed that addition of 6 phr of organoclay into natural rubber could improve the tensile strength of natural rubber. The reinforcing effect of organo clay with lower d-spacing(cloisite 20A), was lower compare with higher d-spacing organoclay (cloisite 15A), it was seen on the tensile strength of NR20A compare with the tensile strength of NR15A.

The tensile test result for 3 specimens of NR15A sample which using organoclay that has higher d-spacing produce smooth graphics with the value of tensile strength and strain almost the same, see Fig. 1.

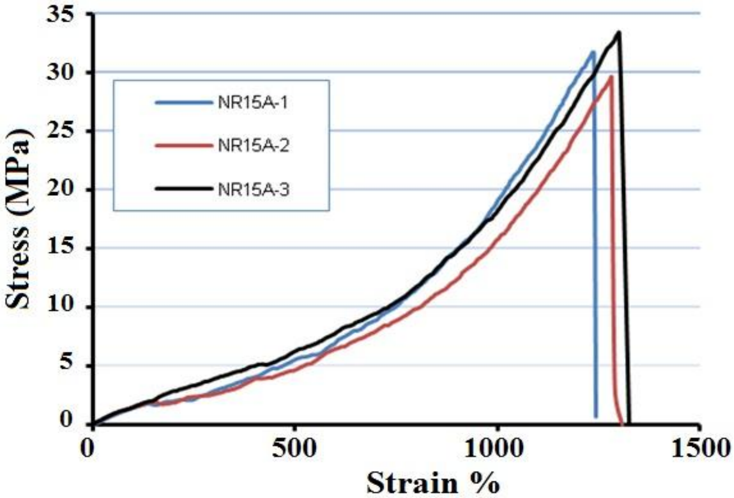

Figure 1. Stress-Strain Curve of NR15A.

This result may be due to organoclay can be well dispersed in the matrix of natural rubber, and it also provides better reinforcement effect. Fig. 2 the stress-strain graphs of tensile test results for 3 specimens of NR20 sample, which can be seen in the graph, the lines are not smooth and the tensile strength and strain value of the test results are not uniform for all three specimens.

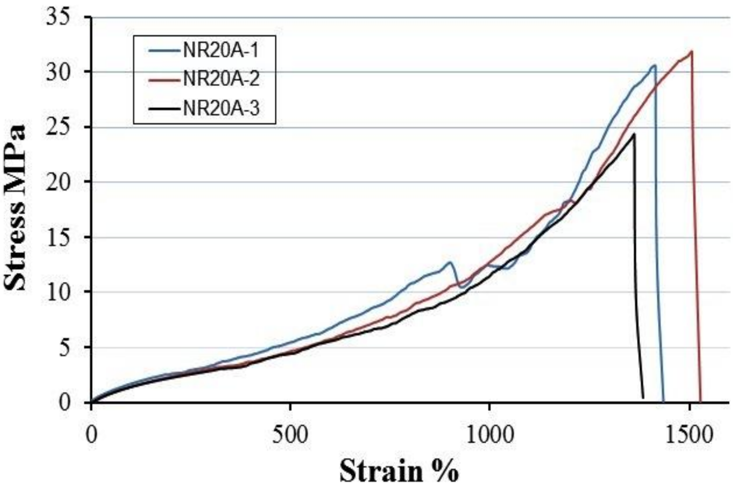

Figure 2. Stress-Strain Curve of NR20A.

The uneven graph and lack of uniformity value of the tensile test results was probably caused by bad dispersion of organoclay in the natural rubber matrix and also due to agglomeration of the clay. This analysis was consistent with the image results from the test using Atomic Force Microscopy(AFM) as shown in Fig. 3.

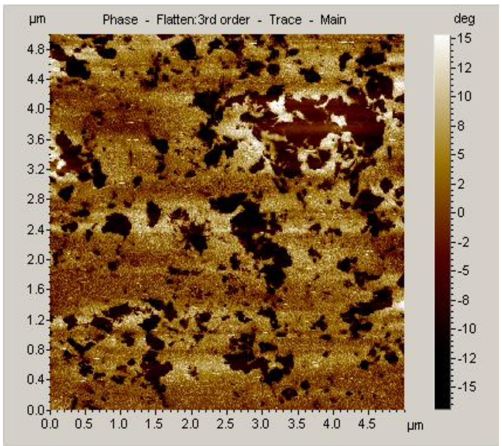

Figure 3. AFM image of NR20A.

Conclusion

The addition of organoclay as a filler for natural rubber can improve tensile strength of the natural rubber. The tensile strength improvement was higher for organoclay with higher d-spacing. Organoclay with higher d-spacing provided better dispersion and give better reinforcment. Organoclay with low d-spacing tend to cause agglomeration and provide low reinforcement.

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