Mechanical Properties of Natural Rubber Compounds with Oil palm boiler ash and Carbon Black as a Filler

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Abstract. This study aims to determine the mechanical properties of natural rubber compounds with variations of OPBA nanoparticle fillers and carbon black. Preparation methods for natural rubber compounds using Open Mill. Indonesian rubber standard -20 (SIR-20) mixed with antioxidants, activators, curing agents, accelerators and OPBA nanoparticle fillers size 56.31 nm and commercial Carbon black type (N330) with variations (0,2,4,6 and 8)% wt. The results showed that tensile strength increased with the increase in the composition of OPBA nanoparticles and carbon black, as well as the elongation of break and hardness. The best composition of OPBA filler 8% wt showed a hardness of 52 Shore A, a tensile strength of 1.7 MPa, an elongation of break 150%. The best composition of carbon black 8% wt filler with a hardness of 55 Shore A, a tensile strength of 2.5 MPa, elongation breakdown of 140%.

1. Introduction

Oil Palm Boiler Ash (OPBA) as a filler is economically beneficial and also environmentally friendly. OPBA is ash which has undergone a grinding process and burning of shells and fruit fibers at a temperature of 500-700°C in the boiler. OPBA contains silica (SiO₂) 31.45% and (CaO) 15.2%. The burning of shells and fruit fibers produces a hard grayish-white crust due to high-temperature combustion with a silica content of 49.2% [1].

Many studies have made a mixture of palm oil waste with natural rubber such as [2,3,4,5]. Based on previous research, OPBA contains a lot of silica (SiO₂). Silica is a pozzolanic material [6]. OPBA contains chemical elements of silica (SiO₂) of 49.50%, Al₂O₃ of 5.45%, Fe₂O₃ of 5.73%, and SiO₂ of 45.55% and Fe₂O₃ of 10.53% [7]. Alumina is an important ceramic oxide material with immense potential for use in an extensive range of engineering products [8]. The rubber compound is the most important derivative of rubber commodities. Almost all rubber compounds use carbon black as a filler. Carbon black fillers function as reinforcement, volume enlargement, and rubber properties. The rubber compound is useful for shoe soles, gloves, and motorized vehicle tires. There have been many studies on making rubber compounds such as [3, 9,10].

Carbon black is a carbon material close to pure from the results of the combustion of hydrocarbons or biomass. Burning temperature, time and materials affect the size of the carbon black. Carbon black as an active filler has a functional group. Carbon black is useful for strengthening bonds between rubber molecules [11]. The structure of carbon black determines the optimal composition of fillers in...
polymer matrix composites [12]. The preparation of rubber and thermoplastic compounds with carbon black fillers has been widely carried out, among others [13,14,15].

This study aims to determine the value of mechanical properties such as tensile strength, elongation at break, and hardness of natural rubber compounds with variations of nano-ash filler materials for palm oil boilers and carbon black. In the composition (0,2,4,6 and 8)wt%.

2. Research Methods
2.1 Material.
Indonesian Standard Rubber -20 natural rubber (SIR-20), nano OPBA research results [16,17], zinc oxide (ZnO), stearic acid, Wax, IPPD,Tetra Methyl Thiura Disulfarat (TMTD),MBTS, Marcapto Benzothiazole Disulfida (MBTS) , sulfur, carbon black (N330)

2.2 Rubber Compound Preparation.
Preparation of rubber compounds using Open mill tools. Materials such as SIR-20 natural rubber, zinc oxide (ZnO), stearic acid, OPBA, black carbon, Wax, IPPD, TMTD, MBTS are mixed. Table 1. shows the variation of OPBA and Carbon black filler compositions. All ingredients are put into a roll mill machine, then ground until the rubber is completely solid. While the rubber grinding process is running, the ingredients are inserted one by one in stages into the rheometer. Natural rubber compounds such as Figure 1a which have been cut to 14 cm in length and 14 cm in width, are inserted into standard slab molds. Then heated for 5 minutes at 170°C. Next the slab is cooled at room temperature. Then the slab is cut with a shapper according to the Dumb-Bell test standard to form the specimen as shown in Figure 1c. The results of vulcanization are cut according to the rules for testing.

| No | Materials | Compound Formula | OPBA | Carbon black | function |
|----|-----------|-----------------|------|--------------|----------|
|    |           |                 | S1   | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | |
| 1  | SIR-20    |                 | 100  | 98 | 96 | 94 | 92 | 98 | 96 | 94 | 92 | Binder |
| 2  | Wax       |                 | 1.5  | 1.5| 1.5| 1.5| 1.5| 1.5| 1.5| 1.5| 1.5| Antilux |
| 3  | Filler    |                 | 0    | 2  | 4  | 6  | 8  | 2  | 4  | 6  | 8  | Filler |
| 4  | ZnO       |                 | 5    | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | Activator |
| 5  | Streat Acid|                 | 2    | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | Activator |
| 6  | Sulfur    |                 | 3    | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | Curing agent |
| 7  | IPPD      |                 | 2    | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | Antioxidant |
| 8  | TMTD      |                 | 2.5  | 2.5| 2.5| 2.5| 2.5| 2.5| 2.5| 2.5| 2.5| Accelerator |
| 9  | MBTS      |                 | 2.5  | 2.5| 2.5| 2.5| 2.5| 2.5| 2.5| 2.5| 2.5| Accelerator |

Testing of mechanical properties such as elongation at break was carried out based on America testing and material standards (ASTM) D 412 Type D with MosantT-10 Tensiometer tensile test equipment. The shape and size of the sample cut according to ASTM D 412 Type D is shown in Figure 1 b.
3. Results And Discussion

3.1 Hardness
Based on the characterization carried out by mechanical testing machines obtained hardness data. Hardness Test was conducted to determine the hardness of rubber, using a Durometer Shore tool. The relationship between hardness and filler composition can be seen in Figure 2.

![Figure 2. Relationship between hardness and filler composition](image)

The hardness of rubber compound with OPBA and Carbon Black Nanoparticle filler material has increased compared to the hardness of rubber compound without filler material. The increase in the hardness of the rubber compound is due to the silica content in OPBA. Similarly, Carbon Black is also able to increase the hardness of the rubber. The more SiO$_2$ in the matrix, the harder the result will be.

The highest hardness was found in the 8% Carbon Black filler of 55 Shore A and also 5% OPBA Nanoparticle filler of 52 Shore A. This shows a better value of hardness than research [17] were in this study used silica powder as a reinforcement of natural rubber matrix of 36.67 Shore A. The hardness value obtained in Figure 2 can be used for the tire compound manufacturing process in a 50 ± 5 (Shore A) motor vehicle, (SNI 06-1542-2006).

3.2 Tensile strength.
The tensile strength of the rubber compound has increased after adding OPBA Nanoparticle fillers. OPBA nanoparticles increase tensile strength due to an increase in covalent and hydrogen bonds with the OH group and oxygen from the carboxyl group which each adds bonds between fillers with natural rubber matrix [4]. The tensile strength of the rubber compound with Carbon Black Filler has increased because Carbon black particle size is smaller than the OPBA particle size. Smaller particle size of Carbon Black makes it easier for Filler to interact with polymers and has an influence on tensile stress and hardness [10]. The relationship between tensile strength and filler composition can be seen in Figure 3.
Figure 3. Relationship between Tensile Strength and Composition Filler

3.3 Elongation at Break
Based on the characterization carried out by mechanical testing machines, the results of the relationship between tensile strength and filler composition can be seen in Figure 4.

Figure 4. Relationship between elongation at break with filler composition

Elongation at break of rubber compound with filler material has increased compared to rubber compound without filler material. This is because the rubber compound produced is not rigid, so it is easy to stretch so it has a large elongation at break value. But on OPBA 6% elongation at break decreases because the compound produced is difficult to stretch. Carbon Black fillers have increased elongation at break compared to rubber compounds without fillers. This is because the rubber compound produced is not stiff. The results of this compound can be used for the process of making shoe soles according to Indonesian national standards (SNI 12-0172-1987) and shoe soles (SNI 12-0172-2005).

4. Conclusion
In general, there is an increase in tensile strength, elongation at break and hardness with increasing OPBA and Carbon black filler compositions compared to without fillers. The best composition of natural rubber compound with OPBA nanoparticle filler 8% wt showed hardness of 52 Shore A, Tensile Strength of 1.7 MPa, elongation at break of 150%. Carbon black filler 8% wt has a hardness of 55 Shore A, Tensile Strength of 2.5 MPa, elongation at break 140%. The hardness obtained can be used for the tire compound making process in motorized vehicles 50 ± 5 (Shore A) (SNI 06-1542-
2006). The elongation at break value obtained can be used in the process of making shoe soles for Indonesian national standards (SNI 12-0172-1987) and shoe soles (SNI 12-0172-2005).

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