The silica-loaded styrene-butadiene rubber in the presence of stearamide: The tensile modulus and tensile strength

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Abstract. This study investigated the influences of stearamide on the tensile modulus and strength of silica-loaded styrene-butadiene rubber (SBR). The SBR was filled with precipitated silica reinforcing filler at a settled dose (thirty phr) and the stearamide was compounded into the silica-filled SBR with range doses from two to eight phr. The influences of stearamide incorporation on the tensile moduli i.e. M300 and M100, tensile strength and also breaking elongation of silica-filled SBR were studied. It was revealed that the stearamide caused pronounced affection in tensile properties of the SBR. The stearamide increased tensile strength and modulus up to a six phr of dose. The improvement in tensile moduli and strength was because of the role of stearamide as the extra plasticizing agent for the silica-filled SBR. The oily property of stearamide improved the silica dispersion and crosslinks level, respectively.

1. Introduction
Commonly, two types of reinforcing fillers are applied as rubber additives in attaining rubber vulcanizates with an excellent grade of strength [1, 2]. They are carbon blacks (CBs) and silicas and they are the very famous reinforcing fillers for any type of rubbers [1, 3], and have been widely applied in the rubber product manufacturer. CBs are commonly applied for yielding black-colored rubber vulcanizates/products, whilst silicas are applied in colored products. They also can be applied as hybrid fillers for the aim in gaining their synergistic affection to achieve a better mechanical property overall [3, 4].

In producing of colored rubber vulcanizates/products, normally silicas are applied to strengthen the rubber compounds. However at a relatively bigger silicas doses, the silicas particles are likely to form agglomeration that will damage the tensile properties of the rubber vulcanizates [5]. Commonly, to handle the silica dispersion disadvantage, typical rubber additives are applied during rubber mixing [6]. In this research-work, a nearly new rubber additive i.e. stearamide was chosen to handle the silica dispersion disadvantage. The rubber additive was synthesized from urea and stearic acid and hence, this study informed the influences of stearamide incorporation on tensile modulus and strength of silica-filled SBR.
2. Experimental

2.1. Chemicals

The SBR Taipol 1502 with other rubber additives include sulphur, antioxidant (IPPD), precipitated silica, stearic acid, accelerator (MBTS) and zinc oxide (ZnO) were performed by P.T. Industri Karet Deli, Medan Office, Indonesia. The additive, stearamide, was synthesised in laboratory using urea and palmitic acid. The molecular structure of stearamide is CH$_3$(CH$_2$)$_{15}$C$_8$H$_{17}$ONH$_2$.

2.2. The compounding of silica-loaded SBR

The compounding of silica-loaded SBR applied the semi efficient system on a two-roll mill with XK-160 Model. Table 1 illustrates the system of silica-loaded SBR with/without stearamide.

| Ingredients              | Amount (parts per hundred rubber/phr) |
|--------------------------|---------------------------------------|
| SBR                      | 100                                   |
| ZnO, zinc oxide          | 5                                     |
| S, sulphur               | 2                                     |
| Accelerator, MBTS        | 2                                     |
| CB                       | 30                                    |
| Antioxidant, IPPD        | 2                                     |
| Stearic acid             | 2                                     |
| Stearamide               | 2 to 8                                |

2.3. Tensile Properties

Based on ASTM D412, sheets of silica-loaded SBR compounds were press-vulcanized at 150 °C to their cure times and tested at speed of 500 mm/min applying dumb-bell shaped specimens.

3. Results and Discussion

3.1. Influence of stearamide on M100/M300.

The M300 and M100 (M100 and M300) of the silica-loaded SBR with/without stearamide is exposed in Figs. 1 and 2. The incorporation of two phr of stearamide increased those tensile moduli, but after the dose these properties decreased.

Tensile moduli/modulus of a rubber vulcanizate depends only on the grade of crosslinks [7, 8]. The increase in tensile moduli up to the optimum dose at six phr was connected to a higher crosslinks level, and the decrease in the properties after six phr was connected to a lower crosslinks level.
3.2. Influence of stearamide on tensile strength.

The tensile strength of the silica-loaded SBR plus stearamide is exposed in Fig. 2. The incorporation of two phr of stearamide increased the tensile strength, after the dose caused deterioration in tensile strength. The enhancement in tensile strength was attributed to the action of the stearamide to modify the loaded SBR to gain an advance silica dispersion degree and stronger filler to rubber interactions.
The decline in tensile strength after the six phr was connected to the abundant amount of stearamide which caused a more marked softening affection, resulting in weaker filler to rubber interactions.

![Figure 3](image-url)  
Figure 3. The tensile strength of the silica-filled SBR without/with stearamide.

### 3.3. Influence of stearamide on breaking elongation.

The breaking elongation (EB) of the silica-loaded SBR with/with no stearamide incorporation is shown in Fig. 4. The stearamide increased the EB. Once more, it was connected to the action of stearamide as an extra plasticizer which adjusted the flexibility of loaded SBR vulcanizates. The stearamide served a free volume which let more flexibility for the SBR chains to remove. The bigger the stearamide dose, the greater was the free volume, and the more elastic the SBR chains. Plasticizer could serve free volume inside the rubber vulcanizate [9]. Assumable, free volume was in the layers of abundant stearamide.
4. Conclusion
The stearamide improved the properties of tensile of the precipitated silica-loaded styrene-butadiene rubber. The stearamide enhanced tensile moduli and tensile strength up to a six phr of dose. It was because of the role of stearamide as the extra plasticizing agent for the precipitated silica-loaded styrene-butadiene rubber compounds.

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