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The Effect of ZnO as Activator on Mechanical and Chemical Properties of Liquid Rubber Compound

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ABSTRACT

The effect of ZnO as activator on mechanical and chemical properties of liquid rubber compound has been examined. Liquid rubber made by mixing some chemicals such as stearic acid and Zinc Oxide as activator, BHT and liquid smoke as antioxidant, $CaCO_3$ as filler, MBTS and TMTD as accelerator, KOH as stabilizer and Sulphur as vulcanizing agent with concentrated latex at room temperature, then maturated for 72 hours. In this research the use of ZnO as activator was varied as 7, 8, 9, 10 and 11 phr. Before being examined, rubber film made from liquid rubber compound by dyeing process then vulcanization done at 100 ^{o}C with water vapor. The rubber film which produced from liquid rubber compound then was characterized their mechanical and chemical properties such as resistance to heating, resistance to acid, alkaline resistance, solvent resistance and tear resistance. The result showed that ZnO content changed the mechanical and chemical properties of liquid rubber compound and obtained the best conditions on the use of 9 phr ZnO.

KEYWORDS: activator, liquid rubber compound, concentrated latex, additives, rubber film

INTRODUCTION

Liquid rubber compound is a mixture of natural rubber latex with various chemical additives to obtain the final result of vulcanizates with a particular process [1,2]. In the manufacture of rubber goods, liquid rubber is the result before the end of the process to obtain the finished rubber goods. In the process of making liquid rubber or compounding, chemical reaction will occur between polyisoprene of latex rubber with a variety of chemicals that are used to form the three-dimensional cross linking between the molecules of the rubber material polyisoprene with vulcanizator such as sulphur that will improve nature of the original rubber to be more usable for manufacture rubber goods [3-6]. Liquid rubber compound chemicals generally consists of vulcanizator, accelerator, antioxidant ingredients, activator, stabilizer and filler as well as other supplemental materials [1, 2]. Latex rubber finished products generally have certain traits preferred, therefore, liquid rubber composition to be made adapted to the type of product to be produced or the nature of the preferred.

The raw material of liquid rubber compound is concentrated latex with most additive components solid so that the process of mixing or compounding would be more perfect if it is done by mixing various ingredients such additives in the liquid state is by first dispersing the various ingredients into liquid ingredients with the addition of certain dispersants so expect the resulting liquid rubber specification will be eligible to make a variety of rubber goods [7]

The problems that exist in the world rubber industry is the unavailability of liquid rubber or compound in large quantities ready to be used to make a variety of rubber goods as new liquid rubber is usually made prior to manufacture certain goods carried, in addition to compound usually made in the form of a dense mix of rubber material that has been frozen, then solid compound is dissolved if it will be made into a particular item [2].

The purpose of this research is to study the effect of variation in the use of ZnO as activator in the manufacturing process of liquid rubber compound on their changes of the mechanical and chemical properties which includes the resistance to heating or oxidation, resistance to acid, resistance to alkaline, resistance to solvent and tear resistance. Determination the changes of mechanical and chemical properties done by measuring the tensile strength and elongation at break of rubber films before and after a particular treatment [8-10].

EXPERIMENTAL SECTION

The process of making liquid rubber or rubber compound is the process of mixing the concentrated latex materials with different dispersion additives that have been made in advance. such as stearic acid and Zinc Oxide as activator, 3,5-di-tertbutyl-4-hydroxy toluene (BHT) and liquid smoke as antioxidant, $CaCO_3$ as filler, dibenzothiazole disulfide (MBTS) and tetramethyl thiuram disulfide (TMTD) as accelerator, KOH as stabilizer and Sulphur as vulcanizing agent [11]). The addition of chemicals do one at a time, stirring until homogeneous materials recently added next. After all the additive is added, the liquid rubber is then allowed to stand for 72 hours at room temperature for curing. Variation in this study to be carried out is the use of ZnO as activator [12,13]. The variation of the concentration of ZnO to be done is 7, 8, 9, 10, and 11 phr. To determine the quality of liquid rubber compound that produced, the first time made rubber film by means of dyeing, drying and vulcanization by heating in water vapor in order to obtain a rubber film with a thickness of from 0.07 to 0.11 mm in accordance with ASTM D-412 standard [14-18]. Further testing of the mechanical and chemical properties of rubber films include the resistance of heating, the resistance of acid, the resistance of alkaline, the resistance of solvent and tear resistance [19,20]. All of these activities are done in the laboratory of plastics and Rubber Research Facility, Center for Leather, Rubber and Plastics Yogyakarta and in the Laboratory of Chemistry Faculty of Mathematics and Natural Sciences, Bengkulu University, Bengkulu.

RESULTS AND DISCUSSION

The results of this study indicate that increased levels of ZnO are used turned out to significantly affect the physical and chemicals properties of the resulting liquid rubber.

1. Rubber Film

Tests performed with a liquid rubber compound first made rubber film by immersion followed by vulcanization at 100 °C by using a water vapor [16]. As an example of the resulting rubber film is presented in figure 1 below.

Figure 1. Rubber film

2. Resistance to Heating/Aging

From the picture above shows that the tensile strength of rubber films before and after ageing tends to increase if the use of ZnO is greater, reaching the best conditions on the variation of 9 phr ZnO, then turn down to the growing use of ZnO. In this condition the amount of tensile strength after aging of the rubber films obtained is 19,03 N/mm^2, this suggests that the formation process of crosslinking is most prevalent in this variation. In the picture above also shows that on the variation of 9 phr ZnO obtained rubber films most resistant to heating. This situation is caused by the use of ZnO is greater then the polyisoprene of latex will be more active so that the formation of crosslinks between polyisoprene with sulphur will more easily occur, reaching the optimum conditions on 9 phr ZnO. On the use of more ZnO are will cause coagulation of latex so that the formation of crosslinking will also decrease.

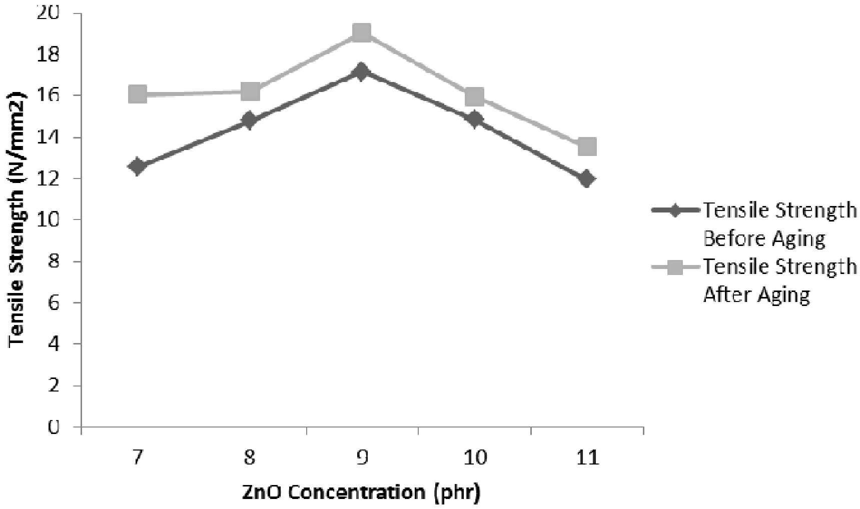

Figure 2. Tensile strength changes before and after ageing at various ZnO content

From the experimental results it is shown that a change in the content of ZnO used give little effect on the elongation at break of rubber films before and after ageing, as seen from the value of elongation at break before and after ageing is not much change in the variation used, but the best conditions of liquid rubber manufacture obtained on the variation of 9 phr ZnO. In this variation the value of elongation at break before and after ageing obtained as high as 812.07% and 766.14%. In this figure also shows that the elongation at break decreased at all levels of variation of ZnO used, it indicates that the rubber is more easily broken when heated.

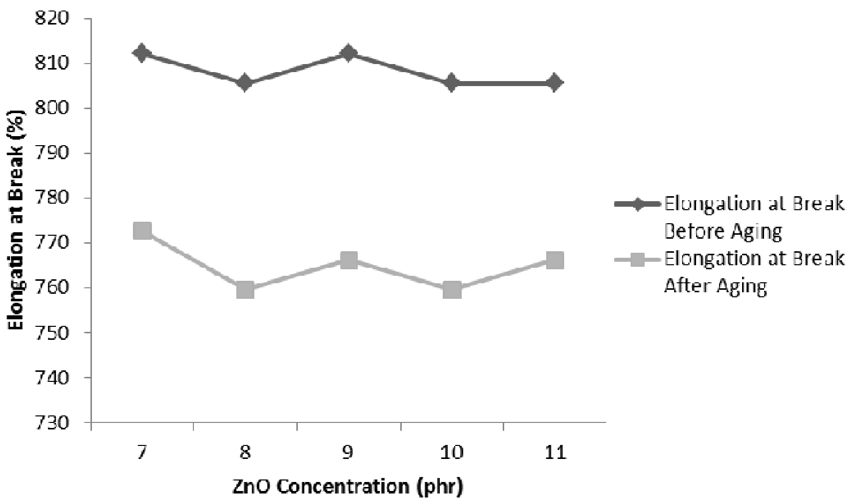

Figure 3. Elongation at break changes before and after ageing at various ZnO content

3. Resistance to Acid

In the picture above shows that the tensile strength of rubber films after immersion in acid tends to rise in the use of ZnO is increased, reaching a peak at the use of 9 phr ZnO and then decreased on the use of ZnO is more and more. This indicates that the rubber film more resistant to the acid on the use of ZnO is more and more. This situation is due to the use of ZnO is more and more the formation of crosslinks between polyisoprene of latex with sulphur will be more and more because polyisoprene more active, so the number of crosslinks formed are also increasingly causing rubber film more resistant to acid. On the use of greater ZnO just turned to coagulation of polyisoprene then resulting the decrease in the number of crosslinks formed and consequently the resistance to acid also decreased. In the best conditions tensile strength data obtained before and after immersion in acid are 17.17 N/mm^2 and 14.90 N/mm^2.

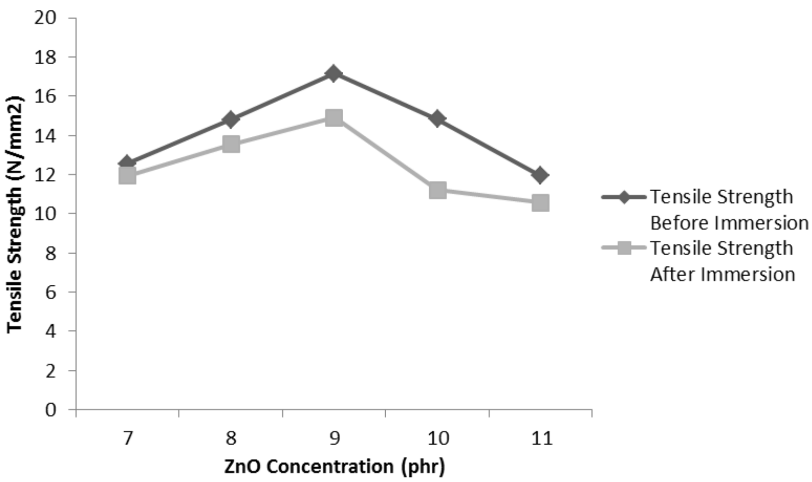

Figure 4. Tensile strength changes before and after immersion in acid at various ZnO content

In the picture above shows that immersion in acid affects the elongation at break of rubber film, it is seen from the change of elongation at break before and after immersion in acid. In this figure also shows that the elongation at break initially fell and then rose and reached a peak at 9 phr ZnO, and then decreases again at higher concentration of ZnO. This is because the amount of crosslinking between sulphur and polyisoprene reach maximum number in use of 9 phr ZnO. At levels below 9 phr the amount of crosslinking that occurs is not maximized yet, while at higher levels has decreased due to the coagulation of liquid rubber during the manufacturing process. At best condition elongation at break of rubber film after immersion in acid is 903.94%.

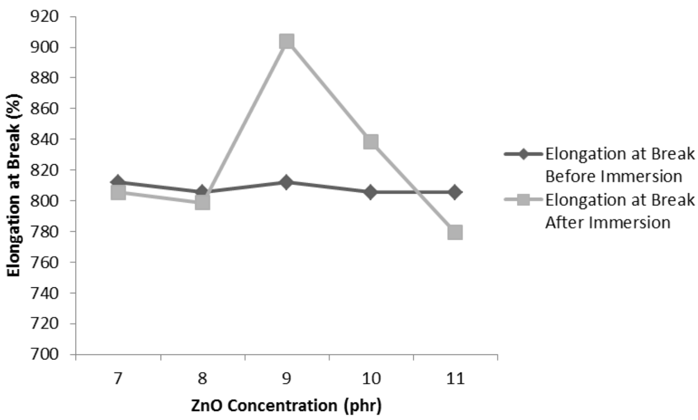

Figure 5. Elongation at break changes before and after immersion in acid at various ZnO content

4. **Resistance to Alkaline**

In the picture above shows that the rubber film made more resistant to bases on the use of ZnO is more and more, achieve the best conditions on the use of ZnO 9 phr, and then decreased at the use of ZnO is more and more. It is seen from the greater value of tensile strength after immersion in alkaline if the use of ZnO is more and more and then decreased after 9 phr ZnO. These condition indicate that the formation of crosslinks between the sulphur and polyisoprene more and more on the growing use of ZnO. Crosslinking formation reach peak at 9 phr ZnO and decrease on the use of ZnO is greater. On the use of ZnO is slightly then polyisoprene still less active so the number of crosslinks formed is still small, but in the use of ZnO larger than 9 phr, it causes coagulation of polyisoprene so the number of crosslinks formed also decrease. In the best condition showed that the tensile strength of rubber films after immersion in alkaline is 18.61 N/mm^2.

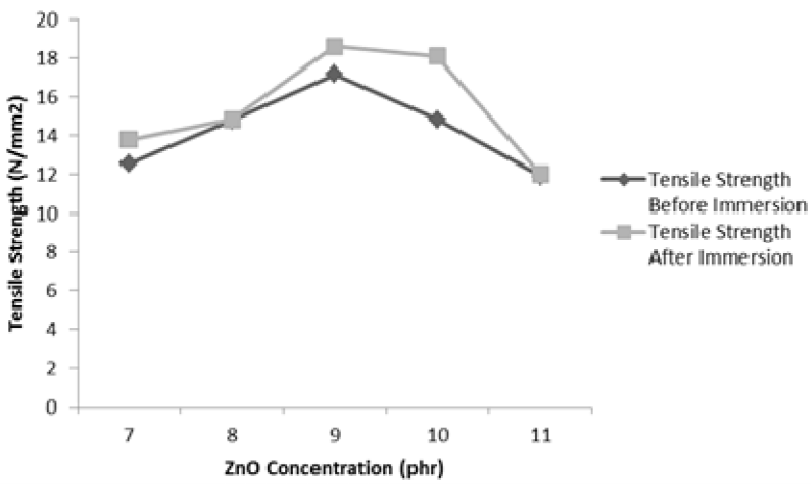

Figure 6. Tensile strength changes before and after immersion in alkaline at various ZnO content

In the picture above shows that the changes in the levels of ZnO affects the persistence of the rubber film to alkaline. It is seen from the increasingly value of elongation at break after immersion in alkaline on the use of ZnO is more and more, reaching a peak on the use of 9 phr ZnO and then decreases on the growing use of ZnO. This shows that the greater number of crosslinks between polyisoprene of latex with sulphur on the use of ZnO is more and more, reaching optimum condition at 9 phr ZnO, and then decreased at the use of ZnO more. In the best condition showed that elongation at break of rubber film after immersion in alkaline is 871.13%.

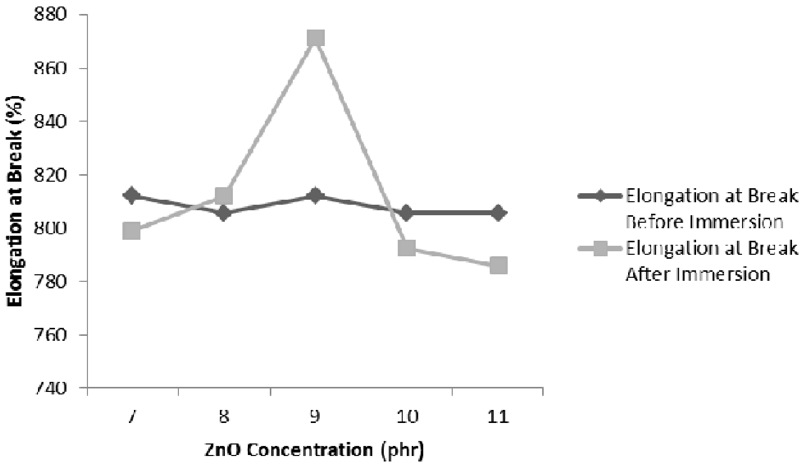

Figure 7. Elongation at break changes before and after immersion in alkaline at various ZnO content

5. Resistance to solvent

In the picture above shows that the number of fractions dissolved in acetone tends to slight on the growing use of ZnO, reaching a minimum at the concentration of 9 phr ZnO, then rise to higher levels of ZnO. This indicates that the rubber film more resistant to solvents on the use of ZnO are getting bigger, but will decrease again on the use of ZnO larger than 9 phr. This condition caused by the amount of crosslinking between polyisoprene of latex with sulphur that more and more if the use of ZnO are more and more, but in the use above 9 phr of ZnO, the amount of crosslinking that occurs has decreased due to the occurrence of coagulation process during the manufacture of liquid rubber compound. In the best condition showed that the soluble fraction in the acetone is 0.0488.

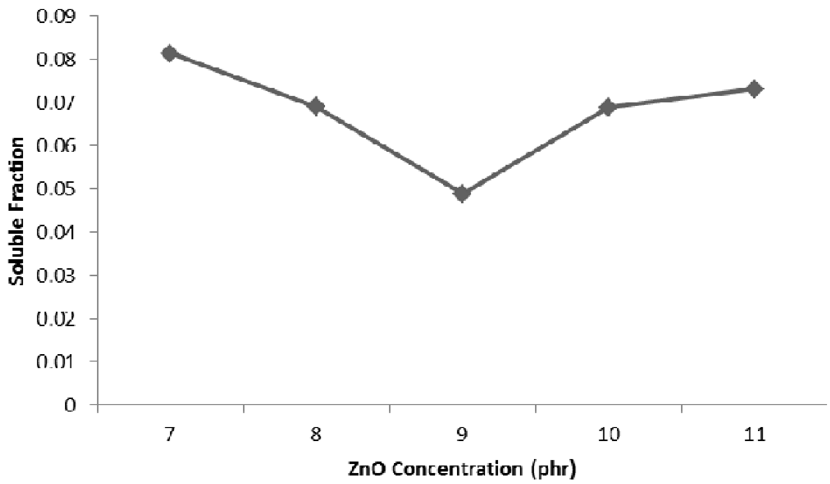

Figure 8. Effect of ZnO concentration on Rubber film solubility in acetone

6. Tear resistance

In the picture above shows that the tear resistance of rubber films the greater the use of ZnO is more and more, reaching a peak on the use of ZnO as many as 9 phr, and then decreased to the growing use of ZnO. This situation is due to the use of ZnO more and more then the polyisoprene of latex will be more active so that the formation of crosslinks between polyisoprene with sulphur will be more and achieve optimum condition at 9 phr ZnO. On the use of ZnO is higher then the formation of crosslinks will actually decrease due to the coagulation of polyisoprene in the manufacture process of liquid rubber compound. At the optimum conditions obtained data that the tear strength of rubber film is 7,10 N/mm^2.

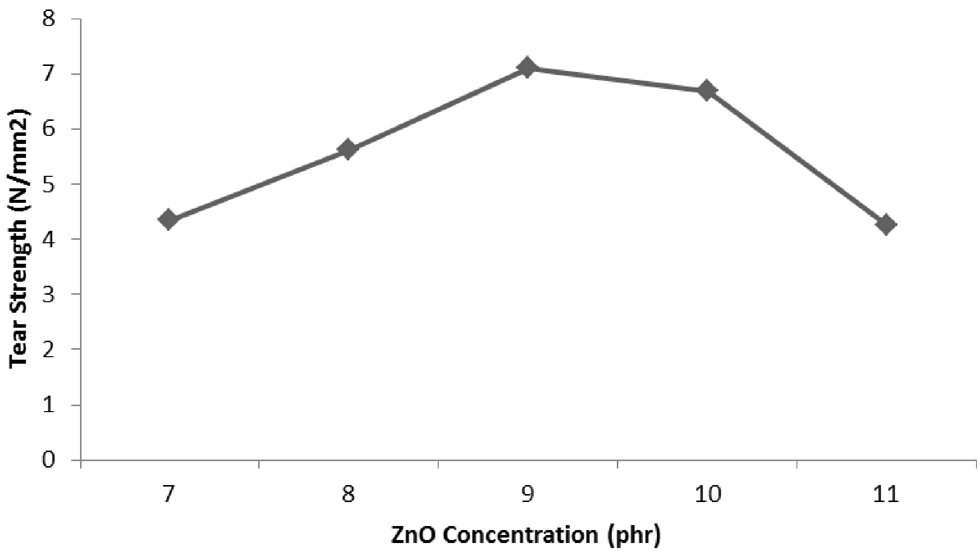

Figure 9. Effect of ZnO content on tear resistance

CONCLUSION

The use of ZnO as activator variation changed the mechanical and chemical properties of liquid rubber compound produced. The best condition was the use of 9 phr ZnO concentration. The mechanical and chemical properties of liquid rubber compound as rubber film produced in this condition are tensile strength before and after heating 17.17 N/mm^2 and 19.03 N/mm^2; elongation at break before and after heating 812, 07% and 766.14%; tensile strength after immersion in acid 14.90 N/mm^2; elongation at break after immersion in acid 903.94%; tensile strength after immersion in alkaline 18.61 N/mm^2; elongation at break after immersion in alkaline 871.13%; dissolved fraction in acetone 0.0488 and tear resistance 7,10 N/mm^2.

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