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Effect of Kaolin/Aluminium Hydroxide (ATH) as Hybrid Filler on Mechanical Properties of Ethylene Propylene-diene Monomer (EPDM) Composites

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Effect of Kaolin/Aluminium Hydroxide (ATH) as Hybrid Filler on Mechanical Properties of Ethylene Propylene-diene Monomer (EPDM) Composites

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Abstract
In this work, the effect of incorporation of ATH and Kaolin as a filler on mechanical properties of vulcanizates of ethylene-propylene diene monomer (EPDM) compounds have been studied. The presented compounding formulation was selected based on a typical application of EPDM products in medium to high-voltage cover insulators. The properties of the EPDM rubber loaded with different ratio of ATH/kaolin were evaluated with mechanical properties including tensile strength, modulus, hardness and crosslink density. Results showed that the the tensile modulus, hardness and crosslink density were increased by increasing the ratio of ATH in EPDM composite samples. In addition, elongation at break and tensile strength were decresed by increasing of ATH/kaolin ratio, probably due to lower compatibility of polymer and filler in higher filler contents of ATH. To select appropriate content of hybrid filler of ATH/kaolin, other properties such a electrical and insulation specifications should be considered by application of EPDM composites in practical interesting usage field.

Keywords: EPDM, Mechanical properties, Aluminium hydroxide (ATH), Hybrid filler ratio.

Introduction
EPDM rubber is a polymer with a saturated backbone that is one of the most important synthetic rubbers on market in many applications. It have excellent resistance to ozone, heat, weather and oxidation [1, 2]. Although EPDM has high resistance, but the strength of unfilled EPDM are poor and hence, the incorporation of filler is required [1]. So The main reason for reinforcing rubbers is to improve the mechanical properties as well as reducing the cost of production and to ease the processing [1]. Among all the filler used, carbon black is a typical reinforcing material in rubbers. However, due to pollute environment issues and dark colour of the carbon black, it is not use in recent years. Thus, white fillers are most widely used such as Kaolin and ATH. Yen et al. [3] worked on the influence of the ATH content on mechanical properties of EPDM composites. Their results showed that addition of ATH increase the Modulus. Abitha et al. [4] reported on effect of addition nano-ATH on mechanical properties. In the present study, mixture of ATH and Kaolin in various ratios and its effect on mechanical properties of EPDM compound were investigated.

Experimental

Materials

The EPDM rubber, KEP270 grade (Kumho), dicumyl peroxide (Sigma Aldrich), ATH and iron oxide (Fe_2O_3) were obtained from Sinograce chemical (China) Ltd. The kaolin of laboratory grade was supplied by Merck supplier. The TMQ, ZnO and paraffin wax were industrial grade.

Compounding

The compounding of EPDM samples were done on a laboratory two-roll mill at a temperature of 50-55 ^oC according to the formulation presented in Table 1. Five batches were made by using EPDM rubber as base polymer with variable ratio of kaolin and ATH and other additives (Table 2). All the compounds were cured in hydraulically operated press at 170 ^oC and 10 MPa for 15 min and post cured in air oven for 3 hours and same temperature. All test specimens were put on under ambient temperature for at least 24 h prior to testing.

Table 1. Compounding formulation used for preparation of ATH/Kaolin filled EPDM composites

Sample ingredients	Quantity (Phr)
EPDM	100
Kaolin + ATH	135/105/75/45/15 15/45/75/105/135
TMQ	1.5
DCP	7
Paraffin Wax	5
Fe_2O_3	5
Zinc oxide	5

Rheometer measurement

The rheometer data have been obtained in a moving disc rheometer (MDR). About 5 g of sample from the prepared composite was placed on the rheometer device and cured at 170°C in accordance with ASTM D1646 standard.

Hardness

Hardness interprets the elasticity of the materials. The lower the hardness is the more elasticity of material. Hardness test of cured rubber samples was measured by using shore-A durometer according to ASTM D-2240.

Mechanical properties

Tensile test of samples such as tensile strength, modulus and elongation at break (%) were performed according to ASTM D-412 standards using a tensile testing machine (Santam, Iran) at a crosshead speed of 500mm/min.

Table 2. Designation ratio of EPDM composite samples

Sample code	ATH/Kaolin (%)	Kaolin (phr)	ATH (phr)
A10	10/90	135	15
A30	30/70	105	45
A50	50/50	75	75
A70	70/30	45	105
A90	90/10	15	135

Results and discussion

As can be seen from Figure 1, the ultimate elongation tended to decrease as increase the ratio of ATH in EPDM composite. Decreasing of elongation at break might be related to incompatibility between the polymer and filler in higher filler values. This is in consistent with the previous studies by Wang et al. [5]. In addition, Farzad et al. [6] reported that elongation at break for PP/EPDM blend filled with ATH was decreased.

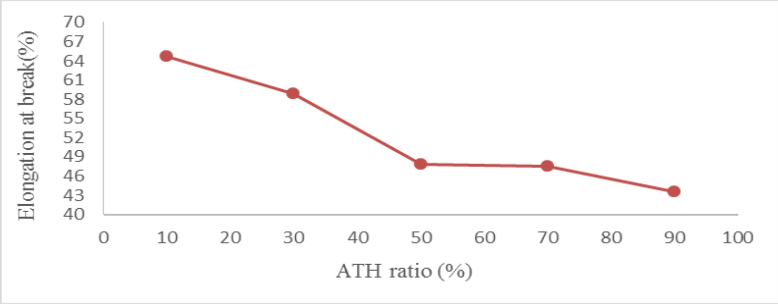

Figure 1. Effect of ATH ratio on elongation at break of EPDM composite samples

The dependence of tensile strength and tensile modulus of ATH/Kaolin filled EPDM are illustrated in Figure 2. Results show that tensile strength of EPDM composites decrease with addition of ATH, that may be due to space between the crosslinks of the polymer chains and hence weak transfer of stress to ATH. Also, it is found increment of tensile modulus with increasing ATH content in EPDM composite samples, due to restrict of mobility of the EPDM matrix by ATH. Similar results were reported by some authors [4-6].

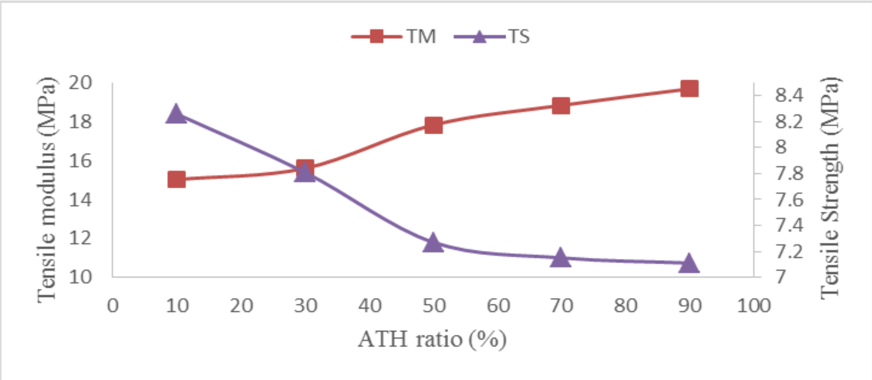

Figure 2. Effect of ATH ratio on tensile modulus and tensile strength of EPDM composite samples

Figure 3 illustrates a increase in hardness of the EPDM vulcanizates with increase in ATH loading before and after post cure. From Figure 3, the increase in hardness of the EPDM composite is probably due to hardness of ATH itself or due to the stiffness developed due to the chemical reaction between ATH and the hydrocarbon chains. Similar finding was reported by Nair et al. [2]. Similar results were also reported when ATH was incorporated into thermoplastic rubber nancomposite by Khattab et al. [7].

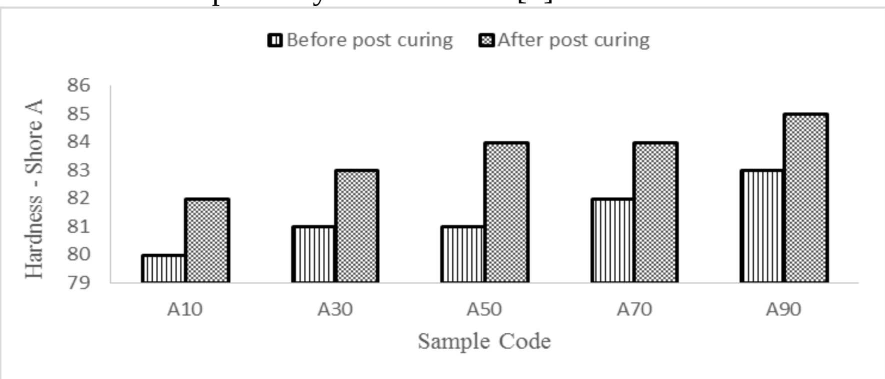

Figure 3. Effect of ATH ratio and post curing on hardness of EPDM composite samples

Table 3 presented the crosslink density of EPDM composites in toluene. The crosslink density were increased by increasing the content of ATH. The reason was that, with increasing the ATH, the mobility of the chains polymer was restricted and more than swelling in solvent that result in the increase of crosslink density.

Table 3. Crosslink density of presented composite samples

Sample code	Crosslink density (mol/m^3)
A10	1010.9
A30	1036.2
A50	1220.8
A70	1232.2
A90	1247.6

Conclusions

EPDM/ATH/Kaolin composites were developed with varying proportions of ATH. The effect of ATH ratio on mechanical properties have been investigated. The results obtained showed that by increasing the ATH ratio in EPDM composite, modulus, hardness and crosslink density was increased. Also, the elongation at break and tensile strength were decresed by increasing the hybrid filler of ATH/Kaolin loading ratio. It might be related to incompatibility between the polymer and filler in higher filler values.

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