REINFORCEMENT THE MECHANICAL PROPERTIES OF (NR50/NBR50/CB- 20PPHR) COMPOSITES WITH DIFFERENT RATIOS OF EGG SHELL POWDER

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Abstract

This have a look at prepared the rubber composites making use of natural rubber (NR) and acrylonitrile butadiene rubber (NBR) as fundamental version materials. This composites had been strengthened using eggshell powder (ESP) with a particle length of smaller than (75μm) which includes 97% calcium carbonate, and carbon black (CB-20 phr). two organizations of samples were organized with (0, 10, 30, and 50 phr) loading ratios of ESP and CB-20 phr, while different composites had been organized with out (CB), and mechanical houses along with hardness, tensile strength, elongation at brake, and elastic modulus have been measured the use of [ASTM-D412-88], and Fourier Transform Infrared Spectroscopy (FTIR) became achieved. The results found out that some homes reduced with increasing loading ratios of ESP and CB, along with tensile strength, elongation at brake, and elastic modulus, at the same time as other homes extended with increasing loading ratios, like hardness. Thermal ageing become achieved on all specimens to measure hardness. The end result confirmed that the hardness increases gently because the ESP and CB loading ratios increase.

Keywords: Composite, Eggshell Powder, Calcium Carbonate, Thermal Aging. Mechanical Properties

1. INTRODUCTION

Composites include one or more discrete stages embedded in a non-stop segment to supply multiphase cloth that possesses superior properties that are not obtainable with any of the constituent substances performing alone. These parts continue to be bonded collectively, however, they hold their identities and homes. The continuous phase, which is present in greater amounts in composites, is called a matrix. The discrete section is commonly tougher and more potent than the continuous segment and is known as the "reinforcement" or "reinforcing material. The geometry of the strengthened section is one of the fundamental parameters in figuring out the effectiveness of the reinforcement[1].

Fillers are categorized into reinforcing (energetic) and inert fillers. may be either black or non-black fillers. One of the significant additional materials used within the feature elastic compound that has an effect and an influence on elastic substances is the filler. Fillers are crucial in modifying the bottom polymer's physical characteristics. Additionally, fillers are included into the polymer to either lower the cost or improve the product's quality by adding attractive characteristics to the finished compound[2].

The manufacture of presently used substances is pretty difficult as regards consumption of electricity, uncooked materials, and cost. Consequentially, efforts are made to find suitable opportunity cloth sources, while nearby, effortlessly renewable assets are a superb alternative in the situation of consequent processing with low strength requirements. The difficulty of obtaining renewable fabric assets is crucial from the point of view of the sustainability of material assets [3]. Commonly, In contrast

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to shielding rubber from chemicals, solvents, and flame, carbon black and silica are utilized to enhance the mechanical qualities of rubber. But chance rubber composites largely based on biofillers are the most obvious research project due to their limited reserve and growing need to build rubber composites based wholly on affordable, biodegradable, and ecologically pleasant ingredients[4].

Biofillers for polymeric composites have been the subject of numerous different kinds of studies in recent years. These biofillers, may be derived from either plants or animals (such as jute, oil palm, flax, or rice husk) or waste products from both (such as fish wastes, sea shells, shrimp shells, eggshells [ES], and shells of other animals), might replace the conventional reinforcing fillers[5].

Nearly all food waste carries a few kinds of useful minerals. Therefore, it's mandatory must discover a different method for recovering valuable minerals from these food wastes and overcome the high disposal costs and environmental problems. However, proper disposal is essential for the usage of such organic food wastes with strength, water, and mineral content. Government regulations governing landfills may act as a financial incentive to establish a price for such wastes. Eggshells include a lot of bioactive chemicals with high economic worth among the other meal wastes. A network of protein fibers and a few mineral substances, such as calcium carbonate (CaCO3,) make up eggshells[6].

Over the last two long times, Because of their low densities, inexpensive costs, non-abrasiveness, high filling percentages, capacity to be recycled, biodegraded, and a renewable source, organic fillers have emerged as a formidable rival to inorganic fillers in polymer composites. an organic mineral filler known as eggshell is produced in lots or hundreds of thousands of heaps per year in several countries, including the US and China[7]. A situation developed over the last several years as a novel bio-composite fabric known as polymer/eggshell composites. However, among all the fillers, calcium carbonate (CaCO3)-primarily based fillers are desired and appreciably used because of their higher mechanical energy, thermal houses, and accessibility at a very low cost[8].

In the most recent products, eggshell CaCO3 powder may improve standard limestone-derived CaCO3 by 100%. An ideal reclamation approach is recovering food waste eggshells to produce new materials; the finished goods may be chemicals that might either totally breakdown and

act as nutrients in the soil (for instance, composites made of eggshell particles and a biodegradable polymer matrix) or are entirely recyclable items. Over the last five years, research on eggshell waste has attracted a lot of interest. The research mentioned above on the utilization of a variety of applications for eggshell waste in new materials, including the elimination of dangerous metals from polluted water and soil, the creation of cement, and polymer and metallic composites[9].

This article examines a few mechanical characteristics, including hardness, elastic modulus, elongation at break, and tensile strength. Therefore, using the equation, we can get the tensile strength (TS)[10]:

$$T.S. = F/A \qquad \ldots\ldots\ldots\ldots (1)$$

where A is the cross-sectional area and F is the measured force needed to shatter the object. The slope of the early linear section of the stress-strain relationship was described as the Young's modulus. Stress-strain graphs representing the actual experimental results were provided. The following is a description of the stress and strain: expression[11].

$$\sigma = \text{(Force or load F)/(Cross sectional area A)} \quad \ldots\ldots\ldots\ldots(2)$$

$$\text{Strain } (\varepsilon) = (L-Lo)/Lo \quad \ldots\ldots\ldots\ldots(3)$$

In a tensile test, Young's modulus is calculated as follows:

$$E = \Delta\sigma/\Delta\varepsilon \quad \ldots\ldots\ldots\ldots(4)$$

Consequently, the connection uses mathematics to determine the final elongation;

$$E = [(L-Lo)/Lo]*100\% \quad \ldots\ldots\ldots\ldots(5)$$

where Lo is the starting thickness and L is the finished thickness.

The international rubber hardness tester and the durometer are two hardness measures that have received close to centuries-old endorsement. Despite excellent durometers being shown, the Coast A scale is appropriate for rubber compounds that are often used in engineering. Given that the IRHD scale provides numerical measurements for a variety of engineering compounds with intended applications that have the same number as those of the standard A scale. Although the IRHD and A scales for obviously elastic materials are fundamentally comparable, substantial variations are expected for substances with the stated time-based characteristics[12].

According to the ASTM standard, the rubber's Young's modulus is inversely related to the indenter's penetration. Scott identified this empirical connection in 1948[13].

$$\frac{F}{E} = 1.9\, P^{1.35}\, r^{0.65} \quad \ldots\ldots\ldots\ldots (6)$$

It was shown that a theoretical connection of the following sort could be derived from the conventional theory of flexibility In the case where P is the penetration distance (mm), r is the indenter's radius (mm), F is the indenting force (N), and E is the Young's modulus (Mpa).

$$\frac{F}{E} = 1.78\, P^{1.5}\, r^{0.5} \quad \ldots\ldots\ldots\ldots(7)$$

2. EXPERIMENTAL METHODS

2.1 Materials

MSR 20 NR (50 pphr) was utilized, and it was provided by Perlis, Malaysia. (50 pphr) of NBR (1052, with a 33 percent acrylonitrile content, was obtained from Nantex Industry Co., Ltd. in China. Iran's Doudah contributed the carbon black N375. It is evaluated in line combined with ASTM D136 and D135 standards for DBP and iodine absorption, respectively. N375 (CB-20 pphr) was used. Durham, UK provided the stearic acid (99.4%) and zinc oxide (97%) for the product. Flexsys, a Belgian company, provided 98 percent of 6PPD N-(1, 3-dimethyl butyl)-N-phenylenediamine for this study. oxydiethylenebenzothiazole (MBS).ITT, India provided the most (98.2%) of the 2-sulfonamide. oil processing. Sodium was imported from Al- Meshrak, CO-Iraq. Eggshell powder (ESP) is a 97% calcium carbonate ($CaCO_3$) powder that was developed in the Alkhora Company's facility in Baghdad. It has great mechanical qualities, is lightweight, and is simple to produce.

2.2 Preparation method

Acrylonitrile Butadiene Rubber (NBR) (50 pphr) and vulcanization ingredients, such as sulfur, zinc oxide, citric acid as an activator, 6PPD as an antioxidant, MBS as an accelerator, and oil droplets as plasticizers, were utilized in this design as the basic material fabric; the batch is then supported with the aid of eggshell powder (ESP) at specific loading ratios to attain (NR50/NBR50/ESP).

To prepare the composite, it was added to the fundamental materials with one-of-a-kind loading ratios (0, 10, 30, and 50 pphr) to gain (NR50/NBR50/ESP) within the It was produced to acquire (NR50/NBR50/ESP/CB-20 pphr) inside the institution (B) utilizing identical loads ratio of ESP with carbon black (CB-20 pphr) in another pattern as group (A). Tables (1) and (2) include a summary of it.

Table 1: presented the loading ratio of the components of group (A) composites

No.	Materials	A1	A2	A3	A4
1	NR	50	50	50	50
2	NBR	50	50	50	50
3	Zinc Oxide	4	4	4	4
4	Stearic acid	1	1	1	1
5	MBS	1	1	1	1
6	6PPD	0.5	0.5	0.5	0.5
7	Carbon black	0	0	0	0
8	Process oil	3	3	3	3
9	ESP	0	10	30	50
10	Sulfur	1.5	1.5	1.5	1.5

Table 2: presented the loading ratio of the group (B) composites' constituents

No.	Materials	B1	B2	B3	B4
1	NR	50	50	50	50
2	NBR	50	50	50	50
3	Zinc Oxide	4	4	4	4
4	Stearic acid	1	1	1	1
5	MBS	1	1	1	1
6	6PPD	0.5	0.5	0.5	0,5
7	Carbon black	0	20	20	20
8	Process oil	3	3	3	3
9	ESP	0	10	30	50
10	Sulfur	1.5	1.5	1.5	1.5

2.3 Rubber Batch Preparation

The eggshell wastes amassed domestically were washed very well many times with water, dried in the sun for several days, then divided into tiny pieces. The eggshell and its membranes were separated from the trash eggshell bits using mechanical stirring. The eggshell fragments were dried for an hour at 100°C in a furnace after the membranes were removed. The dried eggshell fragments were then ground into powder in a very centrifugal mill. The eggshell powder became positioned in a field furnace for 2 hours at four hundred°C. heat treatment changed into executed on the ESP to enhance the homes of the eggshell powder. Fig. 1 (a) and (b) display the eggshell powder (ESP) earlier than and after heat treatment, respectively.

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Figure 1-(a): Before Treatment

Figure 1-(b): After Treatment

The composites have been created with the aid of combining the substances in a applying them to the (Comerio Ercole Busto Avsizo, Italy) rubber batch laboratory (2-Rolls). The diameter is one hundred fifty mm in line with the roll, and the period is three hundred mm. Well, mixing turned into done in line with ASTM D15, the temperature turned into regulated at (50–5) °C, and for all types of batches, the materials collection to the architecture and the time needed for each material had been documented.

2.4 FTIR Spectral Characterization

FTIR spectra have been recorded by means of FTIR (Bruker agency, German beginning, kind Vertex -70) Fourier rework Infrared Rays .The wave range variety (four hundred-4000) cm^{-1} .

2.5 Measurement

2.5.1 Tensile strength, elongation at brake and elastic modulus equipment

Checks are done on samples that were organized inside the mill laboratory in line with ASTM D412. Monsanto T10 tensometer check, that's movable at a pace of a hundred mm/min.

2.5.2 Hardness Equipment

In accordance with the Brinall technique, the size of a hard ball's penetration into a rubber specimen is measured using the international Hardness check. The worldwide rubber hardness tiers are converted from the measured penetration. The degree scale is simply chosen such that 100 indicates a material with an infinite elastic modulus and 0 represents a fabric with an elastic modulus equivalent to zero. The usual type of hardness is covered by the scale. The test was conducted in accordance with ASTM D1415 requirements.

2.5.3 Thermal aging

For 96 hours, the samples were cooked at 70°C in an air-circulating oven. after it has been conditioned and cooled to ambient temperature, the test of hardness was carried out for all samples.

2.6 Result and discussion

2.6.1 FTIR analyses

A useful tool for tracking the levels of vibrational electricity in the vicinity of different molecules is FTIR spectroscopy. The most common approach for observing changes in chemical properties is FTIR spectroscopy, which is completely sensitive and harmless. In Figures 2a and 2b, the FTIR spectra of the composites with varied compositions (NR/NBR/ESP) and (NR/NBR/ESP/CB) loadings (zero, 10, 30, and 50 pphr) are shown.

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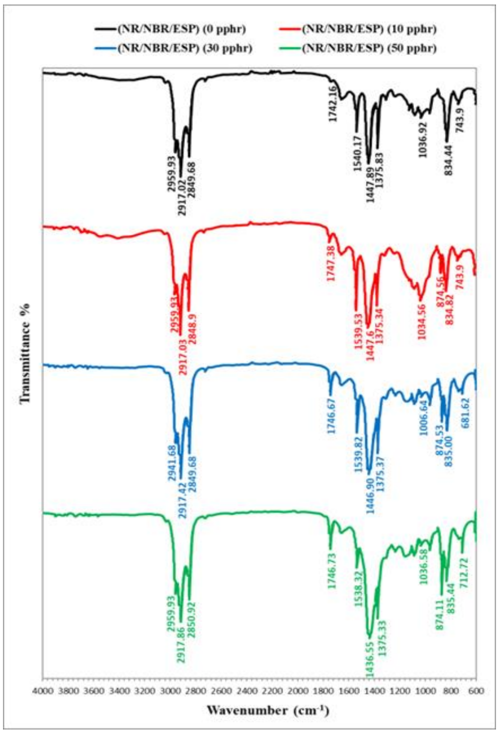
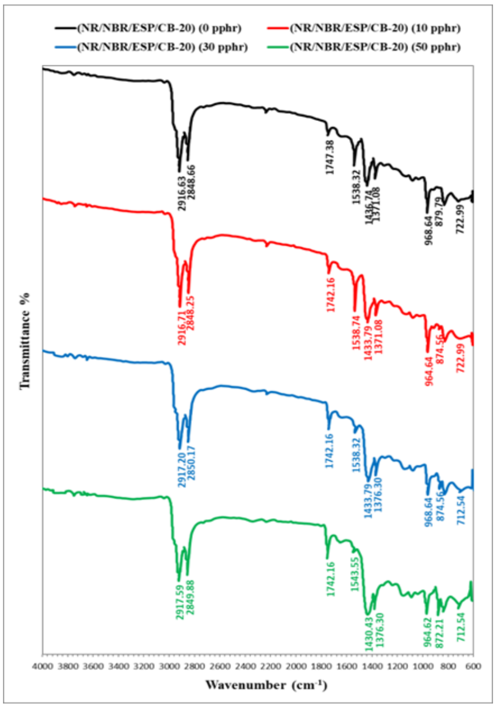
In figures. 2a and b, In NR, There is significant asymmetrical In the methylene group vibrations, (vas CH2) and symmetrical (s CH2) stretching are present. respectively, at spacing of 2959 and 2849 cm-1 and 2916 and 2848 cm-1. The band measures 1742, 1540 cm-1 and 1747, 1538 cm-1 as a result of the CH2 and CH3's stretching vibration. The bands around 960 cm1 are caused by While the bands at 1447, 1375 cm-1 and 1436, 1371 cm-1 are attributed to -CH2 scissoring vibrations and C-H bending vibrations of -CH3, respectively, butadiene's C-H wagging motion vibrations, respectively, which are attributed to the (NR/NBR) composite.By using bands at 834, 743 cm-1 and 879, 722 cm-1 (CO3 out of plane deformation), calcium carbonate's existence was identified.

After varying the loading (0,10,30, and 50), pphr results in the displacement of certain bonds rather than the development of new peaks, as illustrated in Figs. (2,a,b). These findings support the researchers' findings[14][15].





(a) **(b)**

Figure 2: FTIR analyses a-group A(NR/NBR/ESP) and b-group B(NR/NBR/ESP/CB-20)

2.6.2 Mechanical properties

The tensile strength was calculated through equation (1). The variant in Fig. 3 illustrates tensile strength of the composites (NR/NBR/ESP) and (NR/NBR/ESP/CB) with the loading ratio. This image demonstrates that the rubber matrix's tensile strength was reduced as a result of the fast ESP and CB fillers being loaded. and it was a result of the greater filler content, which may also have increased the interfacial area with filler loading throughout the matrix. which increased and decreased the strain inside the non-stop segment to facilitate the transfer of a small phase of pressure to the filler particle in the course of deformation. Without the chemical modification, there may be, in reality, adhesion of the polymer to the filler via vulnerable bonding, i.e., Van

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der Waals or induction interactions; this location is consistent with that of the researcher [16].

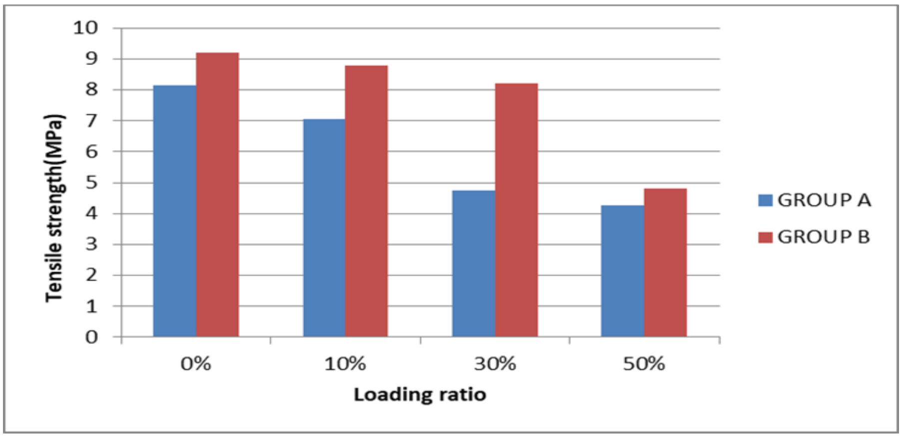

Figure 3: Tensile strength variation for groups Regarding loading ratio ESP, A-(NR/NBR/ESP) and B-(NR/NBR/ESP/CB-20 pphr)

Discern 4 indicates the effects of elongation at ruin decreasing with increasing ESP and CB filler loading ratios. When additional The composite is enhanced with ESP, the ESP and CB particles will arrange themselves among the pliable rubber connections. Regardless of the filler, Lower than-anticipated elongation at break was caused by an increase in filler loading ratios. The encouragement of brittleness and stiffness with filler loading ratios is to blame for this decline, which lowers the elasticity of rubber vulcanizates. Due to the strong physical link between the filler debris and the polymer chain that stiffens the matrix, additional increases in filler loading produce a reduction in molecular mobility [2].

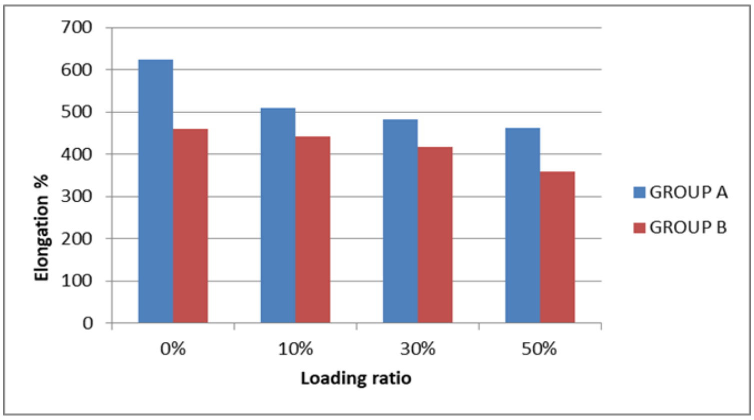

Figure 4: The elongation at break variations for groups Regarding the loading ratio ESP, A and B are (NR/NBR/ESP) and (NR/NBR/ESP/CB-20 pphr), respectively

Determine 5 depicts the lower elastic modulus because of the filler boom's ESP and CB loading ratios. It is widely known that the kind of inclusions, the amount of filler, and primarily the strength of the interfacial contacts between the rubber matrix and the fillers are specifically controlling the mechanical properties of vulcanized rubbers. We examine the mechanical characteristics of the composites to comprehend the role that ESP and CB play at the elastic modulus of the (NR/NBR/ESP) composites. Independent of the filler type, the elastic modulus of the composites generally declines when filler concentration is increased. That is a similar result to the researcher's[17].

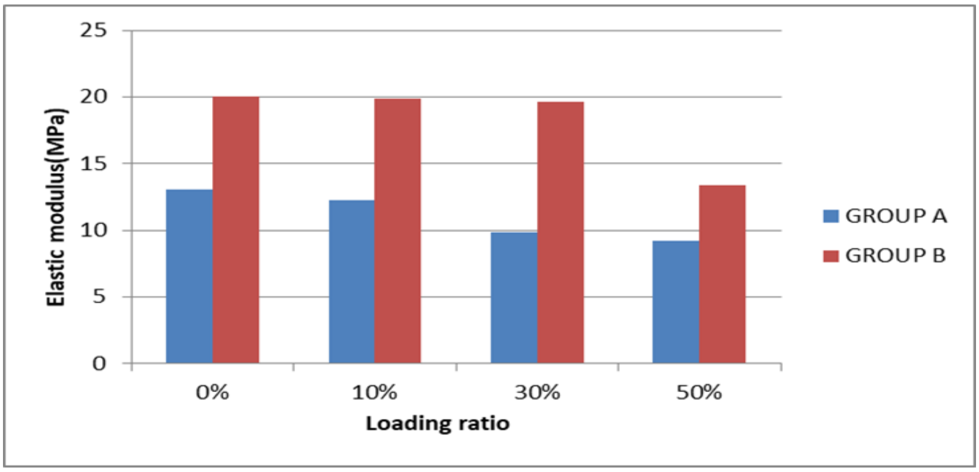

Figure 5: Elastic modulus variations for groups Regarding loading ratio ESP, A-(NR/NBR/ESP) and B-(NR/NBR/ESP/CB-20 pphr)

Parent 6 shows the result of hardness increasing as filler loading rates for ESP and CB rise. The figure shows how different loading ratios of ESP and CB filler affect the hardness of (NR/ NBR/ ESP)as filling materials. It was clear that the use of fillers led to increased filler content and prolonged hardness. This indicated that the hardness assets of the vulcanizate were normally dominated by the filler loading. It changed due to the presence of inflexible calcium carbonate debris (CaCO3) that precipitated increasing brittleness and a trend in the direction of hardness. For the rubber This will be ascribed to the actual pass-linking that occurs between the rubber chains, increasing the toughness, and which increases the flexibility of the rubber vulcanizates. This conduct is consistent with the outcomes found by the researcher[18].

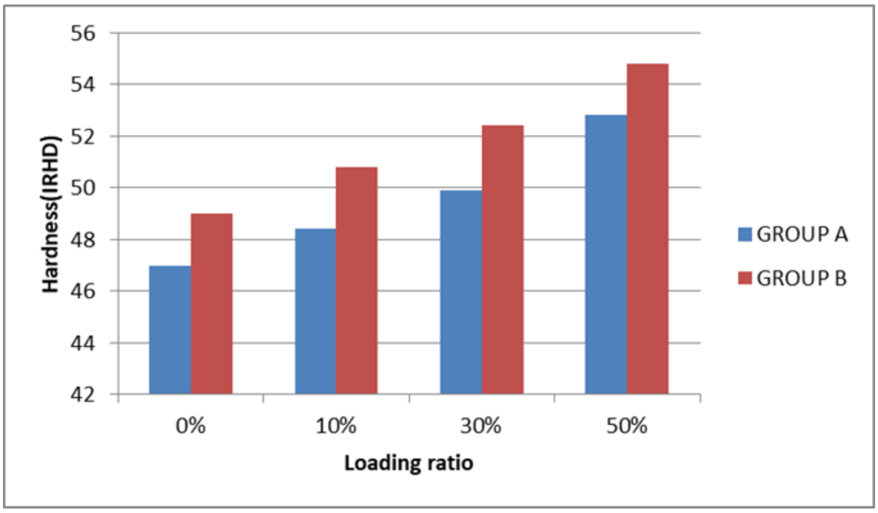

Fig 6: Hardness variations for groups A-(NR/NBR/ESP) and B-(NR/NBR/ESP/CB-20 pphr) with respect to loading ratio ESP

2.6.3 Thermal aging

Determine 7 suggests the result of the thermal aging of hardness increasing because of the ESP and CB loading ratios growth. At some point during aging, sample surfaces were exposed to the influence of a heat load. With aging temperatures and time, higher hardness were attained, which is due to the proportionally higher crosslinking densities. Because there were NBR molecular chains that included unsaturated bonds, they were sensitive to heat and oxygen. This conduct is in line with what the researcher has discovered[19].

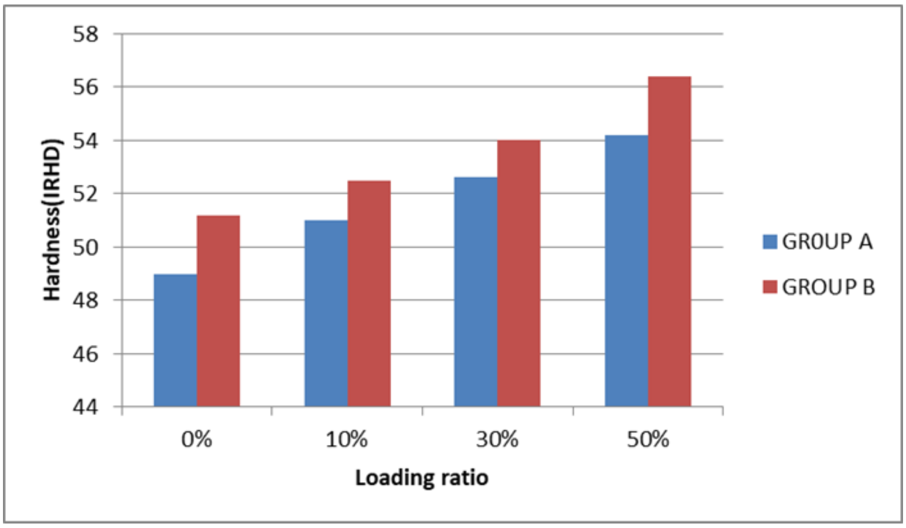

Figure 7: After thermal aging, the hardness change for groups A-(NR/NBR/ESP) and B-(NR/NBR/ESP/CB-20 pphr) with loading ratio ESP

3. CONCLUSIONS

Eggshell powder (ESP) was used in composites as biofillers. Eggshell powder (ESP) and calcium carbonate (CB) reinforcement in composites has been studied for their mechanical qualities. Regarding the mechanical characteristics, it was found that the hardness rose when the loading ratios for (ESP) and (CB) rose. However, when the filler concentration grew, the tensile strength declined, which led to inadequate filler dispersion over the rubber matrix. With more filler in the rubber composites, the elastic modulus and elongation at break were also reduced. According to thermal aging, hardness rises as (ESP) and (CB) loading ratios rise.

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