Influence Calcium Carbonate Nano-particles CaCO3 on Mechanical Properties for NR Compound

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Abstract--The aim of this work was to study the influence of Calcium Carbonate CaCO3 nanoparticles (N-CC) in preparation NR compound. Four compositions of NR/ CaCO3 nanocomposites with filler loading Calcium Carbonate of [0, 3, 5, 7 and 10] hpr, the compositions were prepared in Laboratories Inc. Tires Babylon. The tests included the tensile, compression, hardness, density and Rheometric properties of NR/ CaCO3 nanocomposites compound using a vulcanization system [ASTM D3182]. Carbon black (N326) was used as a filler (50 hpr). To determine the tensile strength, M300 (tensile stress at 300% elongation) and elongation at break a tensile test device called (Tensilmete) was used According to ASTM D412, operating at strain rates of 500 mm/min.

The compression test (ASTM D395B) shown that the compression is decreased when the percentages of CaCO3 nanoparticles is increased. Finally, by using a device (Hardness), to determine the Hardness IRHD of NR compound.

Index Term---Calcium Carbonate CaCO3 nanoparticles (N-CC), filler loading, NR compound, M300 (tensile stress at 300% elongation).

I. INTRODUCTION
Recently, CaCO3 nanoparticles were commercially available for toughening polymers. Although small and uniform particles are believed to be more effective in toughening than large ones, nano-particles, even if they were surface-modified, often agglomerate and cause a significant decrease in toughness[1-2]. Hence, failure to obtain uniform nanoparticles dispersion in the polymer matrix is a first major challenge for effective toughening. Chan et al.[3] so thought that the interfacial interaction between nanoparticles and polymer matrix is one of the most important factors affecting the crystalline morphology of the nanocomposites[4]. On other hand, Calcium carbonate nanoparticles have been widely used as fillers in polymeric materials with the main purpose of reducing costs[4-6], however recently works showed that the incorporation of calcium carbonate nanoparticles can lead to higher impact resistance associated with higher elastic modulus[7-8-9].

In 2009, Eiras and Pessan [10] studied the influence of calcium carbonate nanoparticles in crystallization process of polypropylene. Four compositions of PP/CaCO3 nanocomposites were prepared in a co-rotational twin screw extruder machine with calcium carbonate content of 3, 5, 7 and 10 wt. (%). The tests included SEM analyzes for calcium carbonate, differential scanning calorimetry (DSC) and wide angle X-ray diffraction (WAXD) for the nanocomposites. The results showed an increase in PP crystallization temperature and crystallinity degree, and a reduction in spherulites size.

In 2006, Wan , yul, Xie, Guo, Mao and Huang [4] studied the effects of the surface-treatment of CaCO3 nanoparticle on the crystalline morphology of polypropylene. The dielectric properties of the nanocomposites were tested using the dielectric analyzer (DEA) at room temperature.

Nowadays, the improvements of mechanical and chemical properties of material with addition of nano-sized filler are widely done. The introduction of nanofiller in the structure of a composite can develop the interaction strength between the polymer matrix and nanometric fillers, which can increase significantly the electrical, thermal, and mechanical properties [11-12]. As an example, the MMT nanofiller are often used as an enhancement of composite tensile properties [13].

II. EXPERIMENTAL WORK

A. Materials:
The Elastomers used in this study, i.e. NR (Nature Rubber RSS) was supplied by the laboratories of the public company of tires Babylon. Carbon black (N330) and other fillers Materials was obtained from same company too. The calcium carbonate Nanoparticles size 50 nm and Specific surface 20m²/g produced in China

The four loading of filler calcium carbonate CaCO3 nanoparticles of [0, 3, 5, 7, 10 ] hpr.

B. Preparation Specimens:
Rubber specimens for various mechanical testings, including the tensile test, hardness test, density test, were prepared by mixing the rubber compounds. The formulation of rubber compounds was shown in Table 1.
result is observed for the yield stress. It was described in the literature that elastic modulus of polymeric composites depends, just, on surface contact area of the filler and not on its surface treatment[14]. On the other hand yield stress depends on both interfacial strength and surface contact area[15,16,17]. As the surface treatment is the same for all samples, the mechanical properties will be analyzed just in terms of surface contact area, which can be related to the dispersion of nanoparticles in the matrix.

Table I

<table>
<thead>
<tr>
<th>Compound Recipes</th>
<th>NR blend (phr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR (RSS)</td>
<td>100</td>
</tr>
<tr>
<td>Zinc oxide</td>
<td>5</td>
</tr>
<tr>
<td>Stearic Acid</td>
<td>2</td>
</tr>
<tr>
<td>Fillers</td>
<td>variable</td>
</tr>
<tr>
<td>P-oil</td>
<td>4</td>
</tr>
<tr>
<td>6PPD (Antioxidant)</td>
<td>3.25</td>
</tr>
<tr>
<td>Sulphur</td>
<td>1.8</td>
</tr>
<tr>
<td>MBS</td>
<td>0.8</td>
</tr>
</tbody>
</table>

1 According to Table 2
2 N-(1,3-dimethylbutyl)-N’-phenyl-p-phenylene diamine
3 2-(4-morpholinothio)benzothiazole

Table II

<table>
<thead>
<tr>
<th>Compound Recipes</th>
<th>NR/N-CC0</th>
<th>NR/N-CC3</th>
<th>NR/N-CC5</th>
<th>NR/N-CC7</th>
<th>NR/N-CC10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon black (N-326)</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Nano calcium carbonate</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>10</td>
</tr>
</tbody>
</table>

Table III

<table>
<thead>
<tr>
<th>Compound</th>
<th>Break Strain %</th>
<th>Break Stress [MPa]</th>
<th>Stress of 300% elongation</th>
<th>E of 300% elongation MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR/N-CC0</td>
<td>408</td>
<td>15.098</td>
<td>5.694</td>
<td>18.98</td>
</tr>
<tr>
<td>NR/N-CC3</td>
<td>465</td>
<td>15.685</td>
<td>5.697</td>
<td>18.99</td>
</tr>
<tr>
<td>NR/N-CC5</td>
<td>471</td>
<td>16.991</td>
<td>7.023</td>
<td>23.41</td>
</tr>
<tr>
<td>NR/N-CC7</td>
<td>517</td>
<td>17.627</td>
<td>8.140</td>
<td>27.13</td>
</tr>
<tr>
<td>NR/N-CC10</td>
<td>501</td>
<td>19.6</td>
<td>9.641</td>
<td>32.13</td>
</tr>
</tbody>
</table>

C. Determination of Mechanical Properties.

1. Tensile properties were measured based on the ASTM D412 procedure by a tensile tester (Tensilemer) using a dumbbell specimen at room temperature and at a crosshead speed of 500 mm/min. All the test specimens of the tensile test were compression molded (35 MPa) 350 bars at 150°C [ASTM D3182] and cure time 45 min. For the tensile experiment, dumbbell samples were cut from a 2 mm thick molded rubber sheet. The gauge length and width of the dumbbell was 334±2 and 6.3±0.1mm respectively. [ASTM D 412 (Test Method A)] was adopted for the tensile testing procedure of the rubber samples.

2. The test specimens (compression test) [ASTM D 396 (Test Method B)] were compression molded 350 bars at 150°C, and cure time 20 min [ASTM D3182].
3. The test specimens [fatigue (crack growth) test ASTM D 813] were compression molded 350 bars at 160°C, and cure time 20 min. [ASTM D 3182].
4. The test specimens (hardness test) were compression molded 350 bars at 150°C, and cure time 15 min. [ASTM D 3182].
5. The cure time for all the tests specimens above, According to specification for Dunlop British Company.

III. RESULT AND DISCUSSION

i. Tensile Test

From Table 1 we can observe a great increase in elastic modulus with the addition of 10 phr. of COCl nanoparticles (N-CC), but the incorporation of larger contents of COCl did not lead to successive increase in this property. A similar
ii. **Compression Test:**
Figure (3) represents the results of compression set by the constant deflection for the standard vulcanized rubber and five other percentages of Calcium Carbonate Nanoparticles (N-CC) which were added to the Nature rubber in (0, 3, 5, 7, 10), shows that the compression set is decreasing proportionally with increasing the percentages of Calcium Carbonate Nanoparticles, the minimum value of compression set (C%) at NR/N-CC 10 phr reaches 17%.

iii. **Hardness Test:**
Figure (4) shows the values of the hardness test to the NR Compound and show increase in the hardness when the percentages of the Calcium Carbonate Nanoparticles (N-CC) are increasing. This means that a hardness property is improved when the carbon black is added, the maximum value of Hardness at NR/N-CC 10 phr reach to 68 [IRHD].

**IV. CONCLUSION**
1- The tests in which the spacing (diverge) of the particles such as tensile test, the nanoparticles of calcium carbonate is not affected significantly.
2- The tests in which the convergence of particles such as compression test, there is a significant impact and improved properties.
3- Tensile strength, M300 of NR Compound show an increasing trend with an increase in Calcium Carbonate Nanoparticles loading. The maximum value of tensile stress at NR/N-CC10, and maximum Youngs Modulus of 300% elongation at NR/N-CC10.
4- Compression set for NR Compound decreased with increasing in percentage of Calcium Carbonate Nanoparticles loading. The minimum value of compression set at NR/N-CC10.
5- The hardness of the NR Compound or generally of elastomers, increases with the filler ratio increases. The maximum value of hardness at NR/N-CC10.

**REFERENCE**


