Mechanical, thermal and microstructural analysis of laminated composites with red mud and mauve fibers

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Abstract. This work shows the thermal, mechanical and microstructural characteristics of the laminated composites with red mud charge and mauve fibers. It was varied the proportion of red mud in the composites in the following proportions: 10%, 20% and 30%. The proportion of composite fibers inserted into was set at 5 wt%. The manufacturing method used in the laminated composites was the hand lay-up. The polymer used in this study was the isophthalic unsaturated polyester resin, a cobalt-based accelerator and an initiator. The laminates were produced in the form of rectangular plates in a metal mold. The fibers were dispersed randomly within of the matrix along with the red mud. The mechanical tests were based according to ASTM 3039 It was realized flame retardant tests according to ASTM D635-10 and standard UL 94. The microstructural characteristics were based on analysis by scanning electron microscopy (SEM).

Keywords: Laminated Composites, Red Mud, Mauve Fibers.

1. INTRODUCTION

The generation of residue in the mining industry in the Amazon concerns society as a whole in the face of increasing implementation of large mining projects in municipalities close to large urban centers, and environmental implications of the disposal of huge masses of residue generated in the processes production of mining and metallurgy industry.

The aluminum oxide (also known as alumina), in its calcined form (as obtained by the Bayer process), has its use worldwide estimate of 50% for the production of refractory, 20% for production of abrasives and 25% for the production of ceramics. Calcined aluminas are used both in electronic ceramics (constituting integral components of electronic devices such as computers and etc.) as structural. Enamels, porcelain and ceramic electrical insulation contains from 5 to 25% alumina for increasing the strength and impact resistance (Silva Filho et al., 2007). The Fig. 1 illustrate the red mud clod.

In the case of polymer matrix composites, such as red mud presents a reasonably good compatibility with polyester resins, this residue can be used as a potential charge to produce polyester matrix composites cost effective (Mahapatra et al., 2011). It was shown that the addition of red mud in thermosetting unsaturated polyester resin reduces the tensile and flexural strength, causing a significant increase in density (Cunha, 1998). The same thing was observed for unsaturated polyester composite reinforced with fiberglass (FRP), but with significant increase not only the density but also the abrasion resistance (Jena et al., 2011). This same reduction in tensile strength was observed comparing hybrid composite of jute and glass fibers, and epoxy resin matrix, with and without red mud (Dash et al., 2010).

The mauve (Urena lobata, linn) belonging to the family Mallow is an annual plant, herbaceous plant and well adapted to lowland conditions cultivated in the states of Amazonas and Pará, since the 30s.

The fibers extracted from this native plant, are used in the manufacture of paper, clothing and fabrics for upholstery and rugs, especially in the manufacture of sacks for packing products such as sugar, coffee, cashew nuts and cocoa, and has great potential for use in construction civil (Savastano Junior, 2000).

The Mauve has a fiber strength bigger than that produced by jute, but less shiny and silky. Together are planted in intercropping system, and jute in lowland low and mauve in lowland high, both in very fertile lands.
The Mauve fibers come from the temporary cultivation of this species due to its various applications in national and international industries, represent a great investment opportunity, through productive explorations and with specific techniques, besides the fact of opposing the use of synthetic fiber that can cause damage to the environment, depending on its decomposition after disposal. The mauve fibers takes about two years to decay after its disuse, do not harm the environment.

The mauve fiber has gained visibility as a good commercial value plant for practicality and ease of cultivation in places not soggy.

This is a plant which has a high productivity in a short period of time, to be made to the withdrawal of the fiber by a process of soaking it releases the long fiber yellowish appearance and rough surface.

For its plant has a fiber with a degree of quite significant resistance, has gained its place in the commercial sector because it is practical and easy to grow in places that are not soggy.

The mauve produces similar textile fibers traditionally used in the manufacture of paper, clothing, strings and fabrics for upholstery and carpets. It is used mainly in the manufacture of sacks for packing products such as sugar, coffee, cashew nuts and cocoa (Costa et al., 2012).

Grown as an ornamental plant for the beauty of its flowers, the mauve is a plant belonging to the family of Malvaceae, native to Europe and can reach up to about 1 meter in height. Popularly, it receives various names such as mauve-of-pharmacy, mauve-greater or mauve-wild. It is a plant used in herbal medicine and appreciated as vegetables from the eighth century BC. The Fig. 2 illustrates the extraction of mauve background and its plantation.

![Figure 2. Plantation and extraction of mauve fiber](image)

The article shows the mechanical characteristics and the flame retardance of red mud microstructural composites of polymeric fibers mauve.

2. MATERIALS AND METHODS

To carry out the tensile test were produced unsaturated polyester plates composites filled with red mud load mauve and reinforced with fibers 15 mm randomly dispersed. The resin used as the accelerator cobalt and MEK-R primer (Butanox M-50).

The red mud used was provided by the company Hydro-ALUNORTE. This material underwent recirculating drying oven for approximately 8 (eight) hours. After drying, the sludge has undergone manual comminution and screening through a sieve of 28 mesh Tyler series.

The mauve fibers were derived from the Castlereagh region provided by the Castanhal Têxtil company. Which came after the extraction process and were kept in temperature and humidity. Such fibers were used in nature without any surface treatment. The fibers were cut manually with the aid of scissors 15 mm lengths.

The unsaturated polyester composite reinforced load and red mud with mauve fiber was produced in the form of rectangular plates through the manual method of hand lay-up. The mass fraction of mauve fiber was set at 5% in the produced composites. The red mud proportions in the composite were 10%, 20%, 30%. For the latter proportion was the highest achieved before saturation.

The specimens were cut according to the length width dimensions described in ASTM D 3039. The standard tests were performed in a universal testing machine KRATOS, KE 2000 model MP with 5 kN load cell, and test speed 5 mm/min.

The characteristics regarding flammability were verified by testing flame retardance based on ASTM D635-10 standard and UL 94.
3. RESULTS AND DISCUSSION

The mechanical results of composite laminates with red mud loading and mauve fibers are shown in Table 1, with their mass fractions.

Table 1. Composites laminates with red mud and mauve fibers

<table>
<thead>
<tr>
<th>Reinforcement</th>
<th>Mass Fraction Reinforce (FM) [%]</th>
<th>Tensile Strength (σ) (MPa) Average (Standard deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mauve</td>
<td>5</td>
<td>13,30 (± 2,4)</td>
</tr>
<tr>
<td>Red Mud</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Mauve</td>
<td>5</td>
<td>22,46 (± 3,9)</td>
</tr>
<tr>
<td>Red Mud</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Mauve</td>
<td>5</td>
<td>15,51 (± 2,6)</td>
</tr>
<tr>
<td>Red Mauve</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

The results in Table 1 shows that there is an increased tensile strength of the red mud and mauve composite fibers in a proportion of 20% red mud and after that the resistance of the composite tend to decrease. In this case, the red mud residue is operating in the composite as a filler and not as effective reinforcement, which is characteristic of the waste in general. For the waste has lower mechanical strength than the pure matrix and fibers. Besides that because of non-uniform particle size, residues serve as the reinforcing elements coatings in this case the fibers, in this case, the fibers form a layer on the surfaces of the fibers hindering a good anchoring fiber/matrix, thus deprecating its tensile strength properties. The residue can also trigger concentrators points of tension in the structure of composites, with a possible initiator of cracks and consequent fracture of the material.

The results presented in this section is related to the flame retardance test, as based on ASTM D635 standard of UL 94 and are shown in Table 2.

Table 2. The Flame Retardance Test

<table>
<thead>
<tr>
<th>Reinforcement</th>
<th>Massic Fraction Reinforce (FM) [%]</th>
<th>Dripping</th>
<th>Speed [mm/min]</th>
<th>Total burning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mauve</td>
<td>5</td>
<td>Sim</td>
<td>46</td>
<td>Sim</td>
</tr>
<tr>
<td>Red Mud</td>
<td>10</td>
<td>Sim</td>
<td>40</td>
<td>Sim</td>
</tr>
<tr>
<td>Mauve</td>
<td>5</td>
<td>Sim</td>
<td>37</td>
<td>Sim</td>
</tr>
</tbody>
</table>

The ASTM D635 provides examples of the value of the flame propagation speed and calculation of the deviation for some polymers. In accordance with standard polymers have some propagation velocity between 25 and 40 mm/min, with a deviation of up to 10 and can thus reach a value of around 50 mm/min.

The red mud and mauve fiber composites present the flame propagation velocity between 37 and 46 mm/min. These values are above the values given in ASTM D635. However, the flame retardance of the trial were held in closed chapel, but without the gas flow control. This directly influences the spread of results.

Regarding the results of the test standard UL 94 classification that fits was the V-2. The recommendation for the use of polymers on a commercial scale is a rating V-0. However indicates low flammability and capacity for flame extinguished during the test. Another extremely important factor to be emphasized and that the plant fibers (mauve) contribute significantly to this flame propagation speed.

As enshrined literatures, one of the most common mechanisms flame retardance is to release structural water hydrated oxides corresponding to achieve their dehydration temperatures. Thus, it can be supposed that the compounds have a potential for flame retardancy, however, only further tests can be better basis to verify the hypothesis (Cunha, 1998).
The Fig. 3 shows the microstructural analysis of the red mud with mauve fibers composites.

(a) (b)  

**Figure 3.** Fractured surfaces of the composites: (a) Composites of mauve with 10% of red mud; (b) Composites of mauve with 20% of red mud

The Fig. 3 (a) of the mauve composites with 10% of red mud there is the presence of bubbles, voids, craters and other failure mechanism at the fractured surface of the material. It is also noted delamination of composite laminates of the fibrous region with the waste region/matrix, so, a tendency of separation of the layers in the transverse direction of the loading. What may have hampered good adhesion fiber/filler/matrix. Fig. 3 (b) of the mauve composites with 20% red mud is evidenced little or no presence of bubbles, voids, craters and other failure mechanism at the fractured surface of the material. There was not delamination of composite laminates, there was a better distribution and compaction of the composite. What may have improved adherence of the composite constituents and consequently their tensile strength.

4. CONCLUSION

The composites laminates of the red mud with mauve fibers present a tensile strength variation changed as the ratio of red mud to obtain better result for the mauve composites with 20% red mud.

With respect to flammability of the composites produced from the laminate was a flame retarding tendency increases as the proportion of red mud and were ranked to V-2.

In the microstructural analysis of composites mauve with red mud were effective in identifying the characteristics of the fractured surfaces.

REFERENCES


