Elastic and Burning Properties of PVA/MMT Nanocomposites

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Introduction

It is a matter of big concern that even though you succeed delaminating the clay homogeneously in a polymer matrix, this do not guarantee improved mechanical properties in the final Nan composite. There is research work on new methods, new process devices and new clays to mix with polymers to produce nanocomposites [1]. There is a common trend to search for new intercalary reagents to open the gap of the layer clays and, in this way, to allow the polymer molecules to occupy the interlayer space. This work considers a method to disperse the clay in the poly vinyl alcohol without intercalary reagent. The main idea is to improve the mechanical properties in the new material, and improved burning properties. When the polymer-clay solution dries, the solid nanocomposite may be evaluated to see the level of dispersion of the clay in the polymer, and its characteristics. In this work, we added MMT to PVA to improve the adhesive and mechanical properties of PVA. The contact angle was measured to know how it modifies the interaction of the adhesive to the substrate. Transmission and Scanning Electron Microscopy's were used to see the distribution of the clay in the polymer matrix.

Objective

Improve the mechanical properties in matrix polymeric and the burning properties, using a method to disperse the clay in the poly vinyl alcohol without intercalary reagent.

Methodology

Polyvinyl alcohol 51-05 from Du Pont, with 196 °C melting point, and Montmorillonite (MMT) from Nanocor with 120 meq cationic exchange capacity (CEC) were mixed together in water at 80°C. Solutions had 9 g of PVA, 90ml of deionized water were prepared in different concentrations of MMT ranging from 2 to 40%. After drying the samples, they were analyzed in a transmission electron microscope Jeol 1200EX. Samples were previously cut in a cryogenic ultra microtome. Elastic Modulus was evaluated according to ASTM D-1708 norm at 1mm/min in an Instron 5500 testing machine.

Results

Elastic Properties

For PVA nanocomposites, elastic modulus in tension is very sensitive to MMT content. In Figure 1 shows how the elastic modulus is increasing with the weight percent of MMT. Initially, the data increase linearly up to 10% MMT. The modulus increases 100% from the original value. Then, it reaches a maximum with 30% of MMT; the modulus y 150% higher than the original modulus of PVA with no MMT. Finally, with 40% of MMT content, the elastic modulus decreases substantially. However, it is still 50% higher than the modulus with no clay.

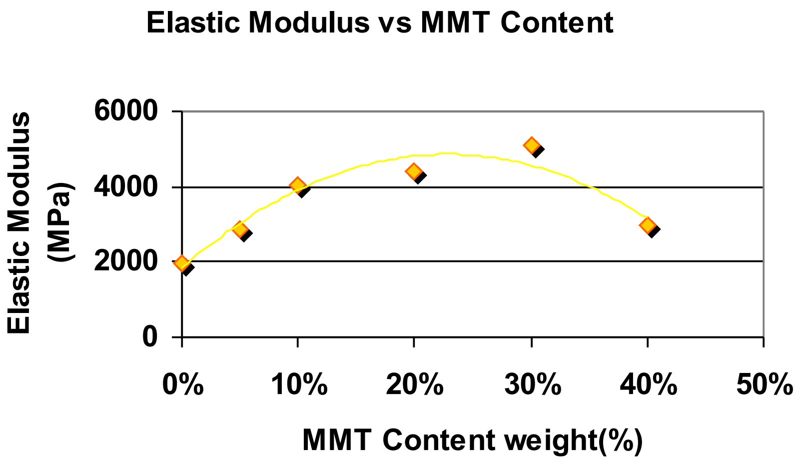
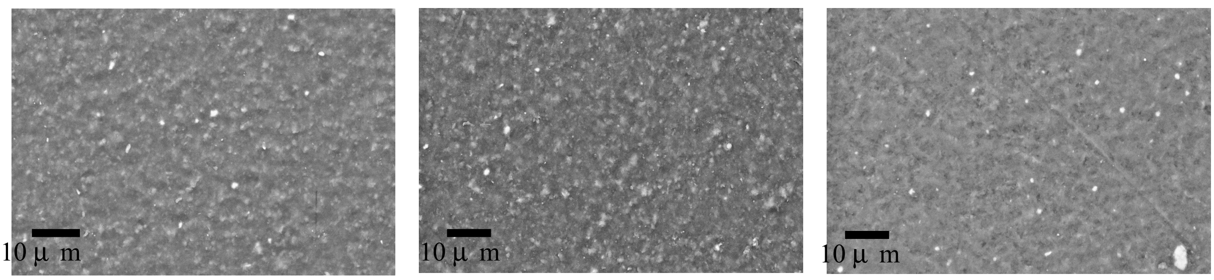


Figure 1 Elastic Modulus of PVA in function of MMT content

Scanning Electron Microscopy

Figure 2 show the effect of the concentration of the clay in the polymer. With 5% of montmorillonite, the micrograph has some bright dots of around 3 microns spread in the polymer matrix, probably because of the presence of MMT tactoids. The enlarged tactoids present in the whole have an aspect ratio ranked between 0.32 and 0.45. There are other diffuse dots, in major number that the bright dots. These diffuse dots have a broad distribution of grey scale. It is more probable that these diffuse dots are the images of clay intercalated in the polymer in different grade of intercalation, and, probably, delamination, (b) with 15% MMT and (c) with 40% MMT are a sequence of how the diffuse dots increase as the MMT content augments. Figure 2 (b) has some bright dots with many of those diffuse dots, and increases until in Figure 2 (c) most of the surface becomes white with some very bright dots. This suggest that the PVA succeeds in intercalate and/or exfoliated the MMT to produce a nanocomposite even at that very high MMT clay content. This will be analyzed with TEM, and explained below.

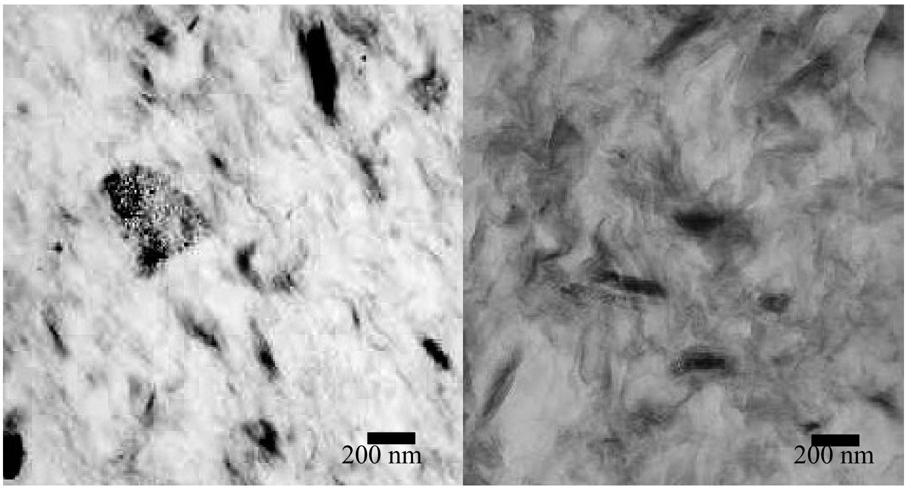


(a) (b) (c)

Figure 2.- PVA with (a) 5% MMT; (b) 15% MMT and (c) 40% MMT

Transmission Electron Microscopy

The images of the transmission electron analysis allow us to see the tiny lines of intercalated clay in the polymer matrix. With 10% of MMT in the nanocomposite, the fine lines related to the delaminated layers of the clay are oriented and extended, although the lines have a smooth curvature. In the micrograph, there are tactoids with an aspect ratio from 0.2 to 0.8, and a length of 860 nm. When the concentration of the clay increases at 30 % the lines of layer of clay are twisted, and distributed randomly in the polymer. It seems the tactoids to be the origin of the delamination, as the layers of clay seem to emerge from these nucleuses of clay. The tactoids did not suffer any intercalation or delamination. The aspect ratio of the tactoids in this concentration of clay is between 0.17 and 0.57. The maximum length of the tactoid was 400 nm. At 40 % of MMT content, the distribution of the clays is completely different from the other two concentrations analyzed above. The layers of clays look intercalated were there are small clay concentrations. In areas with high concentration of clay, the layers look curved and twisted, grouped in some areas like a mountainous region. It is also possible to find tiny tactoids with an aspect ratio from 0.16 to 0.25, with a length of 230 nm. There are also some formations like arrow tips (white arrows drawn) made up of layers of the clay joined in one end, but completely separated in the other end. Surprisingly, the length of the tactoids diminishes as the MMT content increases, and so the aspect ratio. The reason for the tactoids to diminish in size as the MMt content increases may be because of the friction among all the tactoids when they are stirred in solution.



Conclusions

Nanocomposites with high concentration of MMT have improved elastic modulus, even though there is any intercalant. 10% of MMT gives the best burning properties improving 450% the burning time.

With 5 % of MMT the contact angle increases substantially, and then, in most of the range of MMT content, the contact angle for pine wood is roughly constant. CPF is more hydrophobic than pine wood. Intercalation and some tactoids are the structures presents in the microscopy analysis.

References

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