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Cassava starch/clay/natural rubber bionanocomposites

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Abstract – Elastomers are reinforced mainly with carbon black, a non-renewable material. Starch is a natural, renewable commodity with many interesting features: low density, low cost and “green”. Its elaborate structure suggests a number of possible nanostructures that can be used to make new materials with desirable and unprecedented properties. This paper reports the preparation of bionanocomposite films of natural rubber latex with carboxylated cassava starch and clay particles, by casting without using any plasticizer. The films obtained are flexible and translucent, with high modulus and tensile strength but showing high elongation at break. Films exhibited different capacities to absorb oil and water, which can be useful in applications requiring absorbing materials and asymmetric membranes.

Nanocomposites from natural polymers have been actively investigated due to their potential contribution to sustainability.[1] The most common method for the preparation of nanocomposites of starch/natural rubber and clay is dry blending followed by extrusion, but this is made difficult by low compatibility and low adhesion between phases. Rubber nanocomposites with highly dispersed clay were obtained from aqueous dispersions of natural rubber latex and clay, thanks to the electrostatic adhesion and the overall cohesive capacity of water that facilitates the obtention of complex materials by mixing in aqueous media.[2] Mechanical properties of these nanocomposites benefit from the strong adhesion between the layers of clay and anionic groups present in the rubber chains, mediated by cations.[3]

Bionanocomposite films of natural rubber latex with fixed content of 5% of carboxylated cassava starch and 0, 5 and 10% of Na^+-montmorillonite clay were prepared by casting and they were characterized by X-ray diffraction, mechanical measurements (ASTM D882) and morphology (not shown).

Figure 1 shows a photo of films laying on printed paper, evidencing their transparency under contact. X-ray diffractograms in Figure 1 show that clay is fully exfoliated in the films, since there is no peak due to (001) clay plane. Young modulus shows extraordinary 8750% increase and tensile strength is >600% larger than rubber while elongation does not vary significantly. Thus, the addition of starch yields materials mechanically stronger than those prepared with the same amount of clay, but without starch.

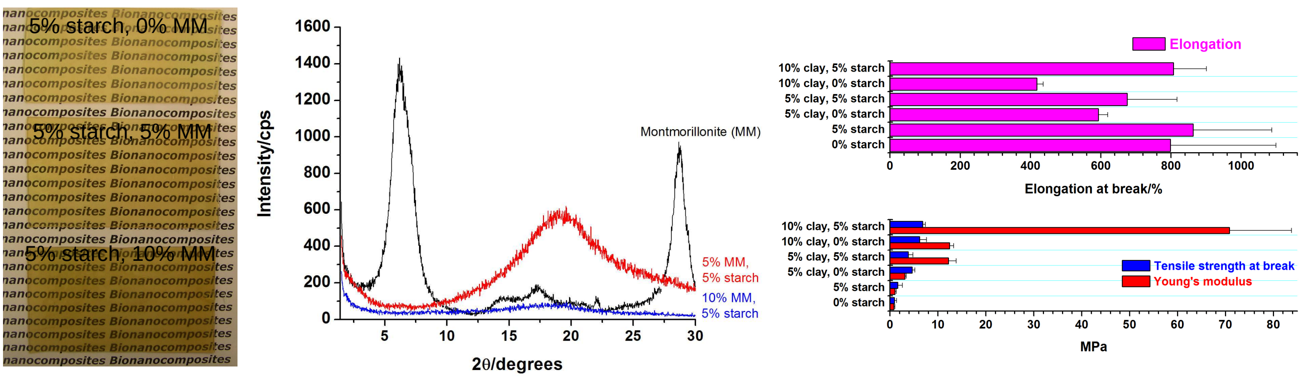

Figure 1: Left, pictures of bionanocomposites films. Middle, XRD diffratograms of Na^+-montmorillonite and bionanocomposites with 5% cassava starch together with 5 and 10% of clay. Right, Young modulus, tensile strength at break and elongation at break for unvulcanized rubber and for the bionanocomposites prepared with starch, clay and combinations of both.

To sum up, starch/clay/natural rubber bionanocomposites obtained through the technique of aqueous dispersion yield transparent highly resistant and flexible films. Thus, starch has a high compatibility with natural rubber and clay platelets, which is based on electrostatic adhesion between the negatively-charged polymer phases probably with a synergistic contribution of hydrogen bonds.

References

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