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Preparation and Properties Nanozeolite-Filled Modified Oil Palm Trunk Starch Nanocomposites

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Abstract. This research was conducted to utilize natural resources in the form of zeolite and waste oil palm plantation in North Sumatera. Palm waste in the form of oil palm trunk is produced by replanting of oil palm plantations that are in the range of 20-25 years old. Oil palm trunk used is derived from 22-year-old palm trees which is planted in the village Pematang Jaya, the sub district of Langkat province in North Sumatera. Oil palm trunk starch is extracted by the extraction process and then precipitated and modified using disodium tetraborate (DSTB). The zeolite used comes from the Sarulla, the sub district in North Tapanuli province, North Sumatera. Adhesive produced from oil palm trunk starch was filled by nanozeolite to increase adhesion strength. The method used to produce the adhesive is blending. Zeolite was milled with grinding process using ballmill. The result was 232 nm. The result of nanozeolite covers the entire surface of the adhesive so that the adhesives appear by having no cavities/pores.

Keyword: starch, nanocomposites, nanozeolite, borax, adhesive, modified.

1. Introduction

The activities of human life such as; packaging and labeling, development economics, automobiles, dentistry, medicine, consumer goods, and food industry rely entirely on adhesive material [1]. Adhesive is always problematic. Starch and protein which are the main source of adhesive materials are susceptible to moisture and mould [2]. Borax increases the viscosity and functions as stabilizer of adhesive structure [3]. The addition of nanocellulose as filler improves mechanical, electrical, thermal, optical strengths, the polymers, and reduces the production costs [4]. This study aims to see the effect of adding nanozeolite on the eco-friendly nanocomposite adhesive. Starch has an important role in various industries such as paper, glue, textile, candy, glucose, dextrose, fructose syrup and others. In known trade there are two types of starch, namely unmodified ordinary starch and modified starch [5]. Starch consists of amylose and amylopectin which are polymers of glucose, the chains are linear and branched as shown in Figure.1. Each glucose unit potentially has 3 reactive hydroxyl groups which are the basis of all derivatives. Starch retrogradation is a process that occurs when starch becomes gelatin by composite molecules that rejoin in a structured structure [6].



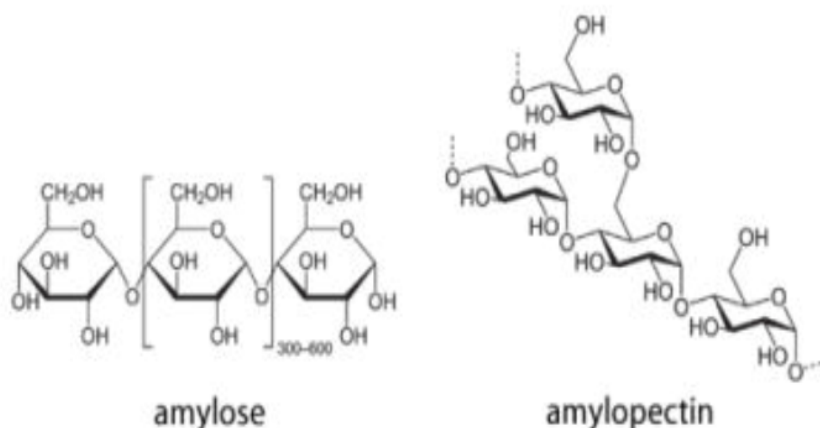


Figure 1. Amylose and Amylopectin Build Formulas

Amylose is composed of straight chain maltose while amylopectin is composed of straight chain maltose which forms branches after 2-4 monosaccharide units.

Oil palm trunk starch consists of fat (0.37%), ash (0.68%), fiber (1.78%) higher than sago starch and tapioca starch but has a lower amylose content (28.76%). Gelatinization temperature of oil palm trunk starch (77°C) was the same as sago but larger than tapioca while white starch (83.02%) and paste clarity (15.4% T) were smaller than sago and tapioca. Two meters oil palm trunk extraction from shoots produced 4.7% starch. The content of α -amylose in oil palm trunk starch is lower than the content of α -amylose in sago starch and tapioca starch while the acid content of oil palm trunk starch is almost the same as the acid content of sago and tapioca [7].

The starch granules are heated and will be reached at a temperature where at that time there is a loss of the polarizing properties of the light in the hilum, the expansion of starch granules which are irreversible which is called gelatinization. Sources of starch are obtained from oil palm trunk that are aged 20-25 years which will be replaced with new plants [8].

Starch is a naturally occurring polymer from glucose. It differs from cellulose in 2 (two) significant aspects. The glucose ring is present in the α -D configuration better than the β -D configuration and starch can be differentiated into 2 (two) types of polymers. One of the polymers namely amylose consists of α -D-anhydroglucopyranose monomer units which combine linearly through 1-4 bonds with few branches or not at all. Other polymers namely amylopectin are linked through 1-4 bonds but also have branches that form on the primary alcohol group at C-6. Careful analysis of various starches shows that there is also a fraction which is thought to be amylopectin which is rarely branched. The amount of amylose and amylopectin in starch depends on the source of the starch. Many starches contain amylose by 20-30% by weight even though certain hybrids can contain more than 80% amylose. Usually the proper industrial starch is waxy corn starch, regular corn starch, type V corn starch which has high amylose, and type VII corn starch which has high amylose with amylose concentrations respectively 0, 28, 55, and 70%. If only the starch are suspended in cold water is essentially not able to act as an adhesive for a very strong bound starch in granular form. This granule consists of a crystalline region where the chain molecules are straight and the molecules that have branch chains are joined together. The crystalline regions are connected together by the same area by more amorphous regions where the molecules are not joined together [9].

Starch will have higher economic value if its properties are modified through physical or chemical treatment or a combination of both. Starch users want starch which has specifications: (1) stable viscosity both at high and low temperatures, (2) good resistance to mechanical treatment, and (3) its

thickening power is resistant to acidic conditions and high temperatures. Desirable important properties of modified starches (which natural starches do not have) are: (1) higher brightness (white starch), (2) low retrograde, (3) lower viscosity, (4) formed gel more clear, (5) the texture of the gel formed is softer, (6) the stretch strength is low, (7) the starch granules are more fragile, (8) the time and the gelatinization temperature is higher, (9) and the time and temperature of starch granules to rupture. Technological developments in the field of starch processing indicate that natural starch can be modified so that it has the desired properties. Modifications here are intended as changes in molecular structure that can be carried out chemically, physically and enzymatically. Natural starch can be made into modified starch with the desired properties or according to needs. In the field of food, modified starch is widely used in the manufacture of cream salts, mayonnaise, thick sauces, jellies, convection products (chocolate candy etc.), substitutes for arabic gum and others. Whereas in the non-food sector, it is used in the paper industry, textiles, building materials, and mixing materials (insecticides and fungicides, detergent soap and bar soap). Today the method that is widely used for starch modification is modification with acids, enzymes, oxidation, and crosslinking [5].

The starch modification process can be carried out with 2 (two) methods namely physical and chemical treatment as shown in the following. Modification of starch was carried out to (1) increase flow capability, (2) increase elastic / thick properties, improve texture, (3) texture thickening, (4) texture stability, (5) viscosity control, (6) expiration period length, (7) increase in shear stability, (8) increase in process tolerance, (9) increase stability of pH, (10) acid stability, (11) increase in insertion stability, (12) retrogradation, (13) gel formation, (14) amylose crystallization, (15) freeze-thaw stability, (16) film formation properties, (17) elasticity, (18) cohesion, (19) adhesion-adhesion / cohesion, (20) water binding, (21) flocculation, and (22) starch for sensory properties. The properties of chemically modified starches depend on 3 (three) things, namely (1) raw materials such as corn, potatoes, wheat, tapioca, rice, and (2) modification types such as ether, esters, crosslinking and (3) degrees from the modification itself. Non-food applications from chemically modified starches are found in the paper industry, textile market, construction sector, oil drilling industry, mining industry, pharmaceutical industry, cosmetics, and agrochemicals[10].

Nanotechnology is a term for a range of technologies, techniques, and processes involving manipulation of matter at the molecular level (groups of atoms), systems that have at least one physical dimension in the 1-100 nanometer range. However, an agreement developed that up to 500 nanometer particles are still categorized as nanometer sizes. As the name implies, nanotechnology or nanoscience is science and technology on a nanometer scale, or a billionth of a meter. Nanotechnology is a technology that results from the utilization of molecular properties or atomic structure when measuring nanometers. So if molecules or structures can be made in nanometer size, extraordinary new properties will be produced. These new properties are used for technological purposes so that this technology is called nanotechnology[11].

2. Methods

This study was conducted in Medan, North Sumatra. The starch was extracted from oil palm trunks. The modifier used is Borax (DSTB). Nanozeolite is produced from natural zeolite using ballmill through glinting process. The palm stems and zeolites are from North Sumatra. Adhesive nanocomposites are produced by blending the materials above. The adhesive characterization includes SEM. Nanozeolite is measured by PSA. The zeolite characterization includes XRD.

3. Results and Discussions

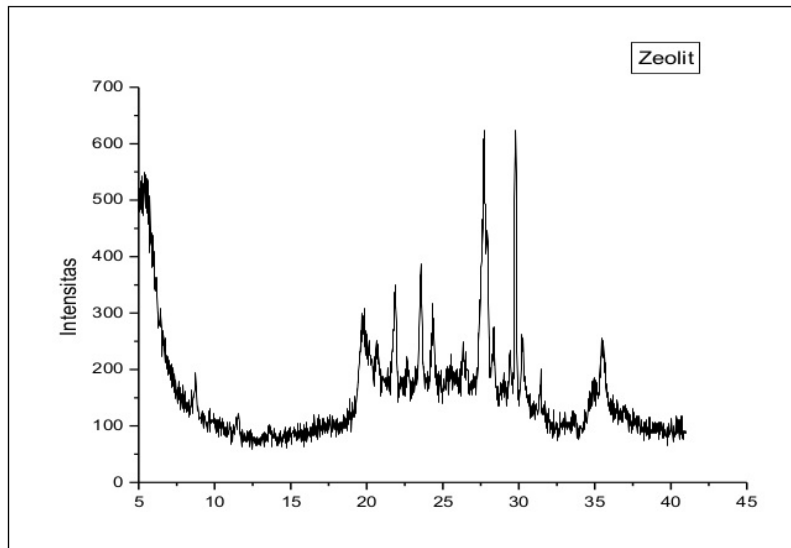


Figure 2. The Natural Zeolite Spectrum Using X-ray Diffraction

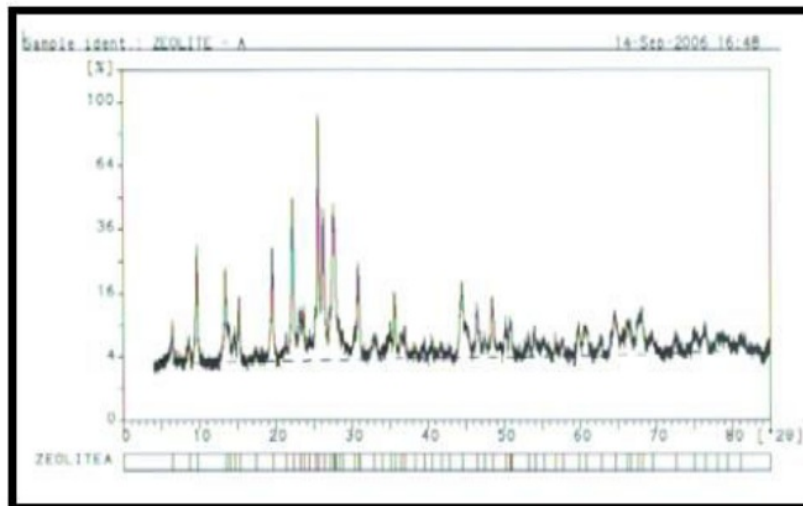


Figure 3. Mordenite Zeolite Spectrum (MOR) Standard Using X-ray Diffraction

TheThe diffractogram results from the natural zeolite in Figure 2 show the greatest intensity at an angle of 2θ around 29.76; 27.92; 23.00. These results are compared with the standard mordenite zeolite diffractogram in Figure 3. Standard mordenite has a high intensity at an angle of 2θ which is 27.00; 25.63; 23.00. From this comparison where the raw material of natural zeolite obtained from North Tapanuli Regency approached the mordenite zeolite ($\text{Na}_8(\text{Si}_4\text{OAl}_8\text{O}_96) \cdot 24\text{H}_2\text{O}$). However, there were peaks (peaks) with a high intensity of internal peaks (counts) appearing on the spectrum XRD

from Sarulla's natural zeolite which is not owned by mordenite such as at an angle of 29.76 which indicates that the crystallinity formed in Sarulla's natural zeolites is not only mordenite but is likely mixed with the clinoptilolite type ((K₂, Na₂, Ca)₃[Al₆Si₃₀O₇₂]·20H₂O) and some impurities compounds. The diffraction angle in Figure 3 is $5 \geq 2\theta \geq 42$ to see the metal composition in the sample of the test material.

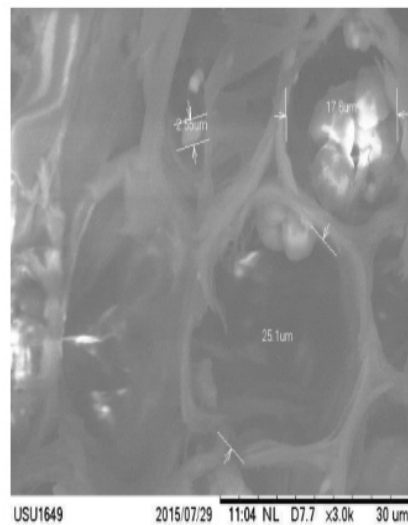


Figure 4. The characterization of SEM adhesive without DSTB and without nanozeolite.

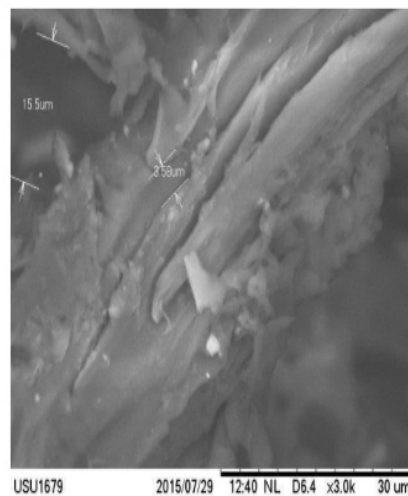


Figure 5. The characterization of SEM adhesive with DSTB and nanozeolite.

The addition of borax as modifier results in borax distributed in binding the granules on the sago starch in palm stem as adhesive matrix which decreases the cavity size. Nanozeolite covers the entire adhesive surface so that the adhesive does not appear to have pores.

4. Conclusions

Characterization of SEM shows that the addition of nanozeolite to the modified adhesive has a morphological diameter of an outer cross section of 15.07 and 9.54 μm respectively figure 4 and 5. Eighty (80) grams of zeolite is converted to 15 grams of nanozeolite using a ballmill for 34 hours. The average zeolite size is 232 nm after PSA characterized.

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