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Hydrophobic Paper from the Wax of *Colocasia esculenta* (Taro) Leaf and Chitin from Crab Shell

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Abstract

Safety is very important to everyone, especially when it comes to packaging of food and non-food items. This research aims to make hydrophobic paper containing wax of taro leaves and chitin from crab shells. The physical properties (color, odor, texture, tensile strength, thickness, density, solubility, liquid dropping) and chemical properties (ash content, pH, moisture content) of the formulated hydrophobic paper were compared to the properties of commercial photographic paper. Fourier Transformed Infrared (FTIR) was also used to determine functional groups present in the paper. The prepared hydrophobic paper is dirty white in color, has a pleasant odor, rough texture, can withstand mass of 92 g, about 1.45 mm thickness, and has a density of 0.071g/mL Liquids (like soy sauce, vinegar and water) cannot pass through except cooking oil. It is insoluble in water, hexane and dilute NaOH but slightly soluble in HCl. Physical properties of the hydrophobic paper was found better than photographic paper except for its dirty white color due to the pigment of leaves that was present in wax from taro leaves and its rough texture. The chemical properties showed that the hydrophobic paper has a longer life than that of commercial photographic paper because it has a lower moisture content and has a pH of 8.2 which means that it is basic, and basic papers has longer shelf life than acidic papers. FTIR result showed that the hydrophobic paper has an alkane group.

Chitin; Hydrophobic paper; Taro Leaf; Wax, Crab shell

1. Introduction

Safety is very important to everyone, especially when it comes to packaging of food and non-food items. Paper has its biodegradability and eco-friendly characteristics. It could be processed further to improve its quality hence, this research is formulated.

Hydrophobic papers in some cases has its anti-microbial activity due to its repellant property. In this study, the wax from the taro plant (*Colocasia esculenta*) which is usually used for hydrophobic coatings will be mixed with the chitin. Chitin is used for thickening of paper and according to some studies it has its anti-microbial activity. The two will be mixed in making a hydrophobic paper in order to obtain a new product.

Hydrophobic paper is very important because nowadays, most of the people used plastic bags as their food containers and packaging. Researches revealed that using plastics especially for food is dangerous because of the chemicals present in it. Hydrophobic papers can be a substitute for plastics because they are made from renewable sources, can be recycled and are biodegradable.

2. Related Literature and Studies

Colocasia esculenta, commonly known as taro, is a tropical plant grown primarily for its edible corms. Probably native to southeastern Asia, whence it spread to pacific islands, it became a staple crop, cultivated for its large, starchy, spherical underground tubers, which are consumed as cooked vegetables, made into puddings and breads. The large leaves are commonly stewed.

Figure 1. Taro Leaf

Chitin (poly-beta-1,4-*N*-acetylglucosamine) is the most abundant renewable biopolymer on earth that can be obtained from marine sources. It is biocompatible, biodegradable and bio-absorbable, with antibacterial and wound healing abilities and low immunogenicity. There have been many reports on its biomedical applications. They have been employed in paper making wet-end, paper surface coating, papermaking wastewater treatment, and other sections of the papermaking industry due to their structure and chemical properties. Raw chitin can be obtained from crab shells. Crabs (species Scylla olivacea) can grow up to 150 mm in shell width and 1.5 kilograms. Known for their big claws, mud crabs belong to a group of crabs that have the last pair of legs flattened for swimming. They have smooth carapace (outer shell).

Nasri, N.S. et.al (2013) states that the hydrophobic surfaces in biological form can easily be found on plant leaf. Their findings on their study of Hydrophobicity Characterization of Bio-Wax Derived from Taro Leaf for Surface Coating Applications clearly confirmed the presence of 1-octacosanol as a major components in taro wax, which is responsible for hydrophobicity properties of taro wax. Kalitan, A. and Talukdar, N (2018) in their study on Colocasia esculenta (L.) Leaf Bio-wax as a Hydrophobic Coating Surface Substance for Paper for Preparing Hydrophobic Paper Bags stated that since the leaves of the plant Colocasia esculent

(L.) is abundantly available and its bio-wax possesses high hydrophobic property, the bio-wax could be used as a surface coating substance for papers which might be used for making biodegradable hydrophobic paper bags. These bags will not only reduce the use of plastic bags up to a great extent but also will help in reducing pollution in the environment.

3. Objectives of the Study

This study aimed to produce hydrophobic paper from the wax of *Colocasia esculenta* (taro leaf) and chitin from crab shells. Specifically, this study tried to determine the following:

2.1. Physical properties of hydrophobic paper in terms of color, odor, texture, tensile strength, thickness, density, solubility, and liquid dropping;

2.2. Chemical properties of hydrophobic paper in terms of ash content, pH and moisture content;

2.3. Compare the physical and chemical properties of hydrophobic paper to the commercial photographic paper and

2.4 Determine the functional group present in the hydrophobic paper by using FTIR.

4. Methodology

4.1 Preparation of Samples

The first method of this study was the preparation of samples where the taro plant that was collected from Laoang, Northern Samar were washed thoroughly by distilled water to remove some contaminants that were present on leaves. The crab shells that were taken from Palapag, Northern Samar were also washed to remove foreign materials. The simple paper making process by using a recycled papers as the raw material was done in this study.

4.2 Isolation of Wax from Taro Leaves

The process by Kalita & Talukdar (2018) was followed in the isolation of wax from taro leaf. The clean, fresh leaves of *Colocasia esculenta* was cut into fragments. The researcher prepared 20 mL of chloroform in a beaker and the leaf fragments were immersed completely in the chloroform by using glass rod for 3 minutes. And, after 3 minutes, the chloroform was transferred into another beaker. A white cloudy layer of wax was seen floating on the chloroform. The solvent was allowed to evaporate by letting it stand for 10 minutes.

4.3 Synthesis of Chitin

The chitin was prepared using a combination of several procedures. Five gram of crab shell was treated with 4% NaOH at room temperature for 24 hours. The alkali was drained from the shells and washed with distilled water repeatedly till pH dropped to neutral. This process caused deproteinization of shells. The deproteinized shells were treated with 4% HCl at room temperature for 12hours for demineralization to yield chitin. The acid was drained off from chitin, washed with distilled water and finally dried at room temperature. The process was repeated with 2% NaOH and 1% HCl. The chitin obtained was dried at room temperature.

4.4 Preparation of Hydrophobic Paper

The scrap paper was cut into small pieces and it was blended to obtain the paper pulps. After blending, the chitin was mixed in a pulp of a paper and molded it into a frame, a piece of tissue paper was placed on the both sides of the paper molded in frame to reduce the wetness and pressed it by ironing. The paper was allowed to stand overnight. The dried paper was poured with wax with chloroform isolated from the leaves of taro plant and allowed it to dry under the sunlight. The last step was repeated several times until the hydrophobicity of the paper was observed.

4,5 Determination of Physical Properties of the Hydrophobic Paper.

The color, odor and texture of the hydrophobic paper were assessed by three evaluators using sensory evaluation. Tensile strength was determined by putting some weighed materials in paper samples. Thickness was measured using the Vernier Caliper. The density was evaluated by dividing mass by the volume of the sample. The solubility of hydrophobic paper in four solvents (water, hexane, HCl and NaOH) was also determined. The researcher put the hydrophobic paper in each of this solvent to test if it is soluble in the solvents mentioned. Liquid dropping was also determined by simply dropping liquids (like cooking oil, water, vinegar and soy sauce) to the surface of the hydrophobic paper to check the liquids penetrability to the paper sample.

4.6 Determination of Chemical Properties of the Hydrophobic Paper

Ash content was determined by charring the sample and the initial and final weight of the sample was recorded in the process. This specifies method for determination of the residue of the paper (ash content) on ignition of paper. The pH meter was used to determine pH of the paper samples. The sample paper was cut into pieces and transferred in a 250 mL beaker. The beaker containing 20 mL of water was macerated until the sample was uniformly wet. The researcher added 50 mL more of the distilled water and stirred well, and allowed the sample to stand for 2 hours and measured the pH by using the portable pH meter. Moisture content was determined by using the oven dry method where the hydrophobic paper was weighed and was exposed to a 105℃ oven. The hydrophobic paper was weighed again after cooling. The gravimetric difference was calculated as "percent moisture".

4.7 Comparison of Physical and Chemical Properties of Hydrophobic Paper and the Commercial Photographic Paper

The physical properties and chemical properties of hydrophobic paper were compared to the photographic paper.

4.8 Determination of Functional Group of the Hydrophobic paper

The hydrophobic paper was submitted to the University of Santo Tomas, Manila to determine the functional group present in the sample by using Fourier Transformed Infrared (FTIR).

5. Results

The chemical and physical properties of hydrophobic paper and photographic paper were shown in the table below. All properties are evaluated using three trials.

Table 1. Properties of Hydrophobic Paper and Commercial Photographic paper

Properties	Hydrophobic Paper	Photographic Paper
Color	Dirty White	White
Odor	Pleasant	Pleasant
Texture	Rough	Smooth
Tensile Strength	Can carry until 92 g	Can carry until 358 g
Density	0.709 g/mL	1.81 g/mL
Thickness	1.45 mm	0.30 mm
Solubility	• Insoluble to water, hexane and NaOH • Slightly soluble to HCl	• Insoluble to water and hexane • Slightly soluble to HCl and NaOH
Liquid dropping	All solvents did not passed through the Hydrophobic paper except for cooking oil	All solvents did passed through the Photographic paper
Ash content	80 %	60 %
pH	8.2	6.3
Moisture Content	6.67 %	12.5 %

The data listed in the table above showed that the hydrophobic paper has different properties as compared to the commercial photographic paper. In terms of color, the hydrophobic paper has a dirty white color unlike photographic paper that has a white color because of the usual bleaching done to improve its appearance. In terms of texture, the hydrophobic paper that is manually pressed during its formulation has a rough surface unlike photographic paper that has a smooth surface. The hydrophobic paper can carry less weight, is less dense but thicker than photographic paper. It is slightly soluble to hydrochloric acid while the photographic paper was slightly soluble to hydrochloric acid and sodium hydroxide**.** Of the four solvents tested, cooking oil was the only liquid that passed through the paper due the interactions of molecules of wax from the surface of hydrophobic paper and the cooking oil. On the other hand, all liquids can pass through the photographic paper.

The percent ash present in the hydrophobic paper was 80% while 60% in the photographic paper. Prepared paper is basic while photographic paper is acidic. Most commercial papers are acidic because they are produced using bleaching agents, sizing materials, and coatings that impart to the paper a degree of acidity. Also acid paper as cited in most studies tends to deteriorate very rapidly as compared to alkaline paper. The moisture content of the hydrophobic paper is lesser than the photographic paper that indicates that the hydrophobic paper has longer shelf life than the photographic paper because moisture can also affect the shelf life of a paper.

Fourier Transformed Infrared Results

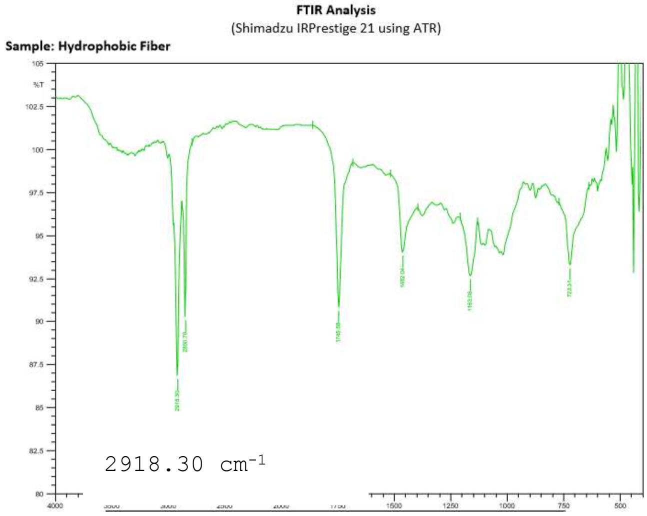

Figure 2. FTIR Spectra of Hydrophobic Paper

The results showed that the hydrophobic paper has a saturated hydrocarbons because it has a wavelength of 2918.30 cm^{-1} and alkane has a wavelength from 3300-2700 cm^{-1}. This means that alkane is present in the hydrophobic paper because hydrophobic surfaces contain hydrocarbons.

6. Conclusions

Based on the findings of this study, the researcher concludes that the prepared hydrophobic paper is better than photographic paper in terms of solubility, liquid dropping, pH and moisture content. These results proves that the combination of wax from taro leaves and chitin from crab shells can produce an acid free hydrophobic paper with low moisture content that can withstand penetration of most solvents. This process can make a good hydrophobic paper that will last longer than ordinary paper.

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