

Effects of Alkali Treatment and Weight Fraction on Electrical Properties of Palm Sugar Fibre-Epoxy Composite

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Abstract

Effect of alkali strength on the fiber surface treatment and fiber weight fraction variations on the electrical properties of the composite palm sugar fiber-epoxy become the focus in this study. The results showed that the stronger the base or alkaline pH, then the value of the resistivity of the composites increased is greater while the value of the dielectric constant decreases. The increases in weight fraction of palm sugar fibers in the composite resulted in a decrease in resistivity values and otherwise add to the value of the dielectric constant.

Keywords: sugar palm fiber, alkali treatment, electric properties

Introduction

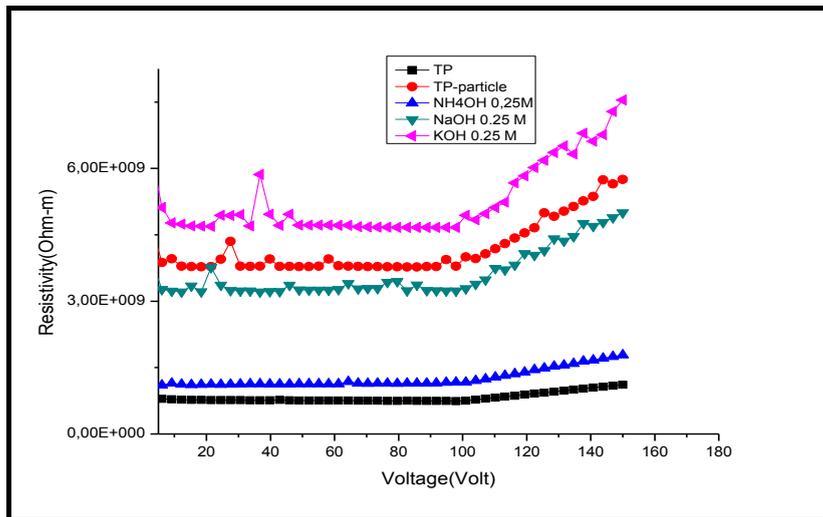
Physically and chemically, surface treatment leads to reduce lignin and hemicellulose on the fiber surface, which turns out to have an impact on the electrical properties of the fibers. Associated with electrical properties, Paul, A. [6], John, M.J. [3] and George, G. [2], has studied the effect of surface treatment on the electrical properties of natural fibre-polymer or rubber composites. The result shows that chemical treatment increases the resistivity and decreases the value of the dielectric constant and the addition of fiber weight fraction in the composite increases the value of the dielectric constant and otherwise reduces the value resistivity. Further research on the treatment with some other alkali associated with its base strength needs to be done. In this study, three different kinds of alkaline of different grade of base strength are used; NH_4OH /ammonium hydroxide, NaOH /sodium hydroxide and KOH /potassium hydroxide, NaOH (pKb 1) and KOH (pKb 0,5) are grouped into strong base of which KOH is more strongly alkaline while NH_4OH (pKb 4,75) is relatively weak base, to compare the results both qualitatively and quantitatively in their effects on the electrical properties(resistivity and dielectric constant) of natural fibers composites.

Experiment Set-up

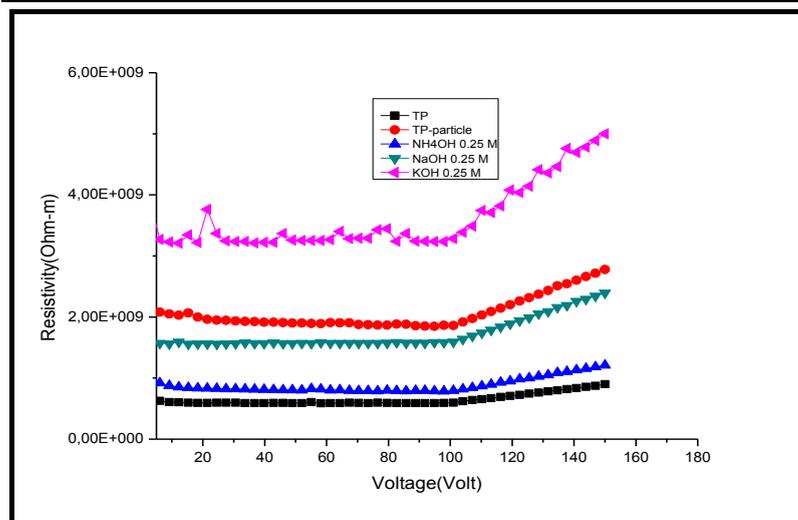
Palm sugar fibers obtained from the Gianyar district, Bali. Palm sugar fibers are cleaned and dried, divided into five sections, two sections without treatment and function as a control, one part of which is kept as longer fibers and one part is made into a fine powder and sieved with a 100-mesh sieve, and the next three sections are treated with alkali, i.e., each of which is given treatment of 0.25 M NH_4OH (pH 8,8), 0.25 M NaOH (pH 9,2), and 0.25 M KOH (pH 9,3) respectively. The ratio of the fiber and the solution (weight / volume) is 1: 20. For the treatment, the fiber is soaked for 1 hour at room temperature in an alkaline solution, respectively, after that it was removed and rinsed with distilled water to clean and rinse water is neutral (pH 7), and then it is dried in the room for 4 days. All the fibers are then cut to the length of composite molds available. The process of making composites by molding injection method is a method of making a composite with a closed mold where the palm sugar fiber is placed in a glass mold which would produce composite size, 250 mm x 200 mm x 3 mm, then the epoxy matrix was inserted into the mold through injection process with a boost air pressure coming from the compressor. The mixture of epoxy resin and hardener was by weight ratio of 1: 1. Having the mold fully filled with epoxy matrix then the injection was stopped. The mold was settling for 24 hours, after the epoxy matrix was dry then the mold is removed. Weight fraction of the fiber used was 30%, 40% and 50%, long fiber with fiber orientation used is parallel to the direction of the axis of the composite. Post curing process can be done by inserting the composite into the oven with a temperature of 60 ° C for 2 hours.

Resistivity test is performed to measure the value of resistance of the composite, square box-sized samples of 25 mm x 25 mm x 3 mm, the specimen was measured by means of an High Resistance Meter electrometer, 6517B. The tests were carried out at a voltage of 0-150 volts and room temperature and it was conducted in Center of Basic Science Laboratory, University of Malang, Malang. Dielectric test is performed to measure the capacity of the composite, with same specimen was measured by Tinsley 6401 LCR Databridge. The tests were conducted at a frequency of 1 kHz and room temperature and it was performed in High Voltage Engineering Laboratory, Faculty of Engineering, Gadjah Mada University ,Yogyakarta.

Result and Discussion



(a)



(b)

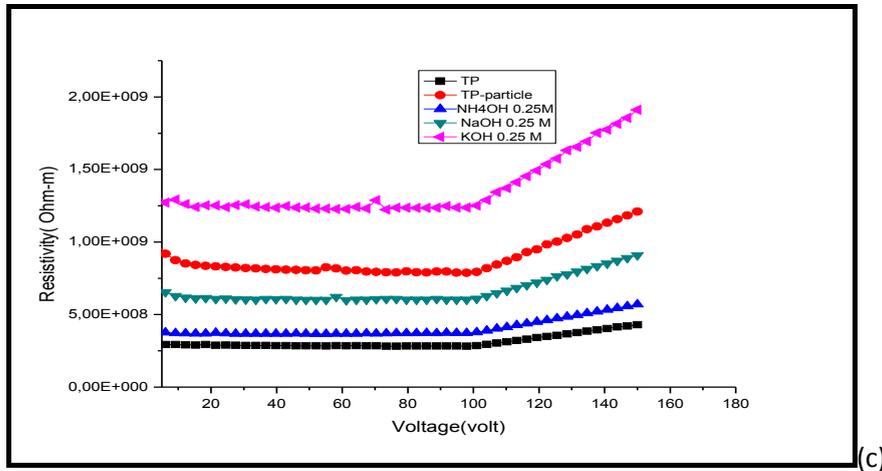


Figure 1 a)b)c) Effect of Alkali Treatment and Weight Fraction on Resistivity

Effect of Alkali Treatment on Resistivity. Variations of resistivity as the alkali treatment function are presented in Fig. 1, which shows that resistivity of composites increased that were subjected to alkaline treatment. Composite resistivity values at 30% weight fraction ranging the smallest to the largest (in Ohm-m) is a composite with fiber without treatment(TP) $7,54771 \cdot 10^8$, NH₄OH treatment $1,13306 \cdot 10^9$, NaOH treatment $3,26653 \cdot 10^9$, powder or particle without treatment(TP-particle) $3,80287 \cdot 10^9$, and KOH treatment $4,71572 \cdot 10^9$. As described earlier, alkali treatment can reduce the moisture content of fiber, lowering the hydrophilic nature of the fibers, reduces content of water polar molecules, or reduces the amount of OH⁻ on cellulose which causes an increase in the value of resistivity. The greater the power of base or alkaline pH of the solution then the more OH⁻ group is missing. It was these polar groups that act as conductor of electric current in natural fibers. With the less polar groups in the fibers also consequently diminishes composite specimens ability to deliver performance of electric. For control specimens with particles, the price resistivity is higher compared to the control specimens with fibers, because the whole unity thing is more conductive compared to particle shape, in addition to the lack of fine powder size and uneven distribution causes the presence of voids that increase resistivity.[1] Electrical conductivity properties of solid materials is the ease conductor moving or flowing electrons in the material, electrons flow easily because of the weak interaction force on the atomic nucleus and the presence of the band gap (the energy gap between the valence band to the conduction band) narrow or overlapping The insulation materials similar with the semiconductor, which the difference is in large energy band gap , i.e the distance between the conduction band and valence band, if more than 1 eV including insulating material. In non-conductor materials, have no electrons in the conduction band, and the charge carriers of the current is two, namely electrons and holes, which

holes are positively charged in the valence band, 'hole' created by electrons move to the conduction band. Contribution to the electrical flow of electrons is greater than the hole. The conductivity of semiconductor or insulation material is proportional to the concentration of the charge and mobility of electrons and holes, the higher the concentration and mobility of the charge, the greater the electrical current is delivered. Then, the electrical transport characteristics of the material is directly influenced by the mechanism of disruption to the movement of charge carriers in the material. Disorder usually occurs as a result of various types of scattering mechanisms that is the scattering lattice (lattice atoms) and the scattering of impurities. Increasing the field strength after breakdown voltages lead to lattice atoms oscillate so that an increase in the probability of a collision which then lead to decreased mobility of the electrons. The more collisions, or scattering non-coherent, the more electrons lose energy, in qualitatively, the energy loss is resistance. [4] Value of electricity currents remains the same due to the frictional forces arising from the collision of free electrons with both scattering mechanisms that inhibit the acceleration of free electrons so that the electron velocity becomes constant, thus the current flowing fixed in the non-ohmic region. In the non-ohmic region, because of the constant current, when the voltage increases, for the material with greater resistivity, it also has greater resistivity improvement. (See figure 1). The boundary between ohmic regions and non-ohmic is characterized by breakdown voltage, in this case the average breakdown voltage of composite is 110-120 volts.

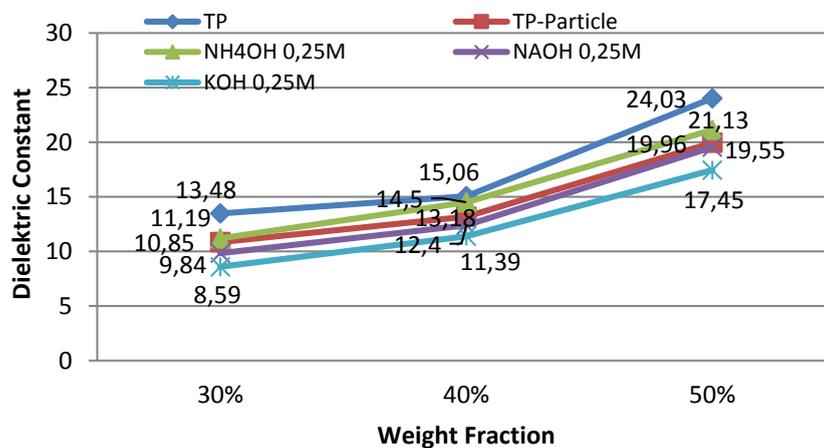


Figure 2 Effect of Alkali and Weight Fraction on Dielectric Constants

Effect of Alkali Treatment on the Dielectric Constant. Dielectric properties of a composite depend on the polarizing ability of its constituent components, namely the matrix and reinforcement, where there are four mechanisms of polarization, interface, dipole, atomic, and electronic.[2] Composite materials are heterogeneous so interface polarizations therefore have considerable influence over the high dielectric properties at low frequencies.

Interface polarization occurs when charge carriers, especially in the lignocellulose fiber-based composites, dipole is trapped at the interface zone of heterogeneous systems. This trapped dipole can be oriented to a certain extent in an external field (electromagnetic) and thus contribute to the polarization of the material. The presence of polar groups in natural fibers (OH⁻ groups in cellulose) and the matrix also contribute to the polarization. Atomic polarization and electronic presence immediately because it does not affect the value of the dielectric constant with frequency applied. Thus, the dielectric constant of lignocelluloses fiber composites depends on the polarizability of the molecule, namely the interfacial polarization and orientational.[5] From the test results it can be observed that the dielectric constant decreases due to alkali treatment which increases the strength of the base or the low pH of the solution caused the decrease in the dielectric constant due to the polarization orientation of the fibers which are chemically treated. Fibers undergo a reduction of moisture and water absorption capacity due to the reduction of the interaction between the OH⁻ groups of palm sugar fiber with water molecules.[3] Figure 2 shows that the control specimens with powder, the price of dielectric constants is lower than the control specimens with fibers. It was caused by the intact fibers have polar groups cluster more and more dense distance compared with particle shape, but it is less refined powder size and distribution causing uneven presence of voids that prevent polarization mechanism. Composite containing fibers treated with KOH have the lowest dielectric constant among other composites. Processing with NH₄OH only resulted in changes in the chemical composition of the smaller on the fiber surface treatment compared with NaOH and KOH, as the value of the dielectric constant of the composite without treatment and treated with NH₄OH showed minimal differences. In the case of processing with NaOH and KOH reacts with OH groups in cellulose natural fibers and produces a change in the chemical structure that reduces the hydrophilic nature and polarity of the fibers and subsequently leads to a reduction in dielectric constant.

Effect of Weight Fraction on Resistivity. At the weight fraction of a larger or more number of fibers in the composite led to increased distribution and density of fibers in the composite. This causes the value of resistivity decreases or conductivity increases after the addition of lignocelluloses fibers. The presence of lignocelluloses fibers increases the moisture content or increasing the amount of polar groups (OH⁻ group) that present in cellulose, is reactive and can conduct electricity. [6] At low fiber fraction, there was less dense fiber distribution so that less facilitating the flow of electric current. At higher fiber loading, fiber population is more tightly to facilitate the flow of electric current. In order to get better conductivity, fiber fillers should be spread evenly, regularly and meeting so that the distance between the fibers is very close to each other, in other words, the conductivity depends on the deployment of fiber in the composite; so in order to get a better conductivity, fiber must be quite a lot, spread evenly and regularly.[7]

Effect of Weight Fraction on Dielectric Constant. Palm sugar fibers are polar and matrix epoxy is non-polar, the incorporation of both in the composite leads to an increase in the number of polar groups in the composite, and this

resulted in increased orientational polarization then improved dielectric constant. In addition, the composite of palm sugar fibers-epoxy matrix is heterogeneous and consequently polarization interface also contribute effectively to the improvement of the dielectric constant. As a result of these effects (interface and orientational polarization), the dielectric constant increases with fiber content on the measurement at low frequencies. At this frequency, the complete orientation polarization made possible and produce high dielectric constants.

Conclusions

Based on the above results, the electrical properties of the composite palm sugar fiber-epoxy matrix such as resistivity and dielectric constant depends on the alkali treatment and fiber weight fraction. Treatment with alkaline solutions of different base strengths indicates the stronger the base or greater alkaline reaction then the value of the resistivity of the composites increased while the value of the dielectric constant decreases, it is associated with a reduction in polar groups that can conduct electric current and can lead to polarization effects. Then, an increase in weight fraction of palm sugar fibers in the composite result in a decrease in the value of the resistivity or increase the conductivity and increase of the dielectric constant value, it is associated with an increase in the density of fiber and increased polarization orientation and interface polar groups are present in the lignocellulosic fibers.

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