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Ultrasonic Study on Alkaline Treatment of Natural Fiber

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Abstract: ***Natural fibers as replacement to man-made fiber in fiber-reinforced composites have urged its importance in many industries and fiber technology due to they have low density, low cost, and biodegradability properties. However, the main disadvantages of natural fibers in composites are the poor compatibility between fiber and matrix and the relative high moisture absorption. This interfacial adhesion between hydrophilic natural fibers and hydrophobic polymer matrices is an important issue in many different biocomposite systems. A strong bond in the interfacial region is essential for achieving high mechanical performances of biocomposites.Therefore, a number of chemical and physical treatment studies on a variety of natural fibers have been devoted to understand and enhance the interfacial adhesion between the natural fibers and the polymer matrix and to further improve the composite properties. The chemical methods have been more frequently used because they are relatively simple, inexpensive and effective. However, generally they have been performed in static treatment conditions. In the present study, sodium hydroxide (NaOH) was independently used as fiber surface treatment media. Ultrasonic technique can be utilized as a dynamic treatment to understand the basic mechanism in chemical treatment of natural fiber. Ultrasonic velocity, and density have been measured in the aqueous solutions of Cellulose with sodium hydroxide (NaOH), with a view to understand the nature of interaction between the cellulose and NaOH at temperature 303K.The acoustical parameters such as adiabatic compressibility (β), intermolecular free length (L_f), acoustic impedance (Z) are calculated.These parameters provide valuable information regarding achieving of high mechanical performances of natural fiber.***

Keywords: Natural fiber, Cellulose, Surface treatment, Ultrasonic wave, Acoustic parameters

1. Introduction

The components of natural fibers include cellulose, hemicellulose, lignin, pectin, waxes and water soluble substances [1, 2]. Cellulose is a semi crystalline polysaccharide made up of D-glucopyranose units linked together by β-(1-4)-glucosidicbonds [3]. The presence of large amount of hydroxyl group in cellulose makes it hydrophilic which results is a very poor interface and poor resistance to moisture absorption[4].Because of the low interfacial properties between the fiber often reduces their potential. Thus chemical modifications are considered to optimize the interface of fibers. Chemical may activate hydroxyl groups or introduce new moieties that can effectively interlock with the matrix. Generally, chemical coupling agents are molecules possessing two functions. Firstly the chemical treatment react with hydroxyl groups of cellulose and the secondly it reacts with the functional group of the matrix. As a part of ongoing work the alkali treatment has been made on the surface of natural fiber. The modification takes places in the surface of natural fiber are studied in terms of acoustical parameter. The important modification done by alkaline treatment is the disruption of hydrogen bonding in the network structure, there by increasing surface roughness. Addition of aqueous sodium hydroxide (NaOH) to natural fiber promotes the ionization of the hydroxyl group to the alkoxide .

Cellulose + NaOH → Cellulose - O - Na + H_2O

Thus, alkaline processing directly influences the cellulosic fibril, the degree of polymerization and the extraction of lignin and hemicellulosic compounds. In alkaline treatment, fibers are immersed in NaOH solution for a given period of time.

2. Material and Methods

All chemicals used in this present work were of analytical reagent (AR) grade of minimum assay of 99.9% obtained, SD chemicals, India. Double distilled water was used to prepare the stock solution. Required amount of water and cellulose was taken to prepare the composition of 0.4 M of binary mixtures and 1N aqueous solution of NaOH was prepared. The different concentrations of aqueous solution of NaOH were dissolved in 0.4 M of aqueous cellulose. For this different concentration, ultrasonic velocities of solutions were measured using a single frequency continuous wave ultrasonic interferometer (Model F81, Mittal Enterprises, New Delhi, India) to an accuracy of ±0.05% at a frequency of 2 MHz at 303K. The temperature of the samples was maintained constant to an accuracy of ±0.1 K using thermostatically controlled digital water bath.The densities of the solutions was measured using a specific gravity bottle with an accuracy of ±0.01 kg/m^3.

3. Physical Parameters

Thermodynamic parameter such as adiabatic compressibility (β), intermolecular free length (L_f), acoustic impedance (Z), has been calculated from the ultrasonic velocity and density of the medium using the Newton–Laplace equation.

Adiabatic compressibility $\beta = 1/\rho.C^2$ (1)

Intermolecular free length, $L_f = k.\beta^{1/2}$ (2)

Acoustic impedance, $Z=\rho.C$ (3)

The constant k is temperature dependent which is given as [93.875+ (0.375T)] $\times 10^{-8}$ [4] and "T" being the absolute temperature

4. Result and Discussion

The values of density and ultrasonic velocity of aqueous Cellulose in the presence of aqueous NaOH at 303K are presented graphically. By using ultrasonic velocity and density, various acoustical parameters like acoustic impedance (Z), Intermolecular free length (L_f), and adiabatic compressibility (β) were calculated using the acoustical relations. The variation in ultrasonic velocity as shown in fig.1 in any solution generally indicates molecular association in it. This is due to the interaction between solution–solvent molecules. Interaction is weaker at minimum velocity.

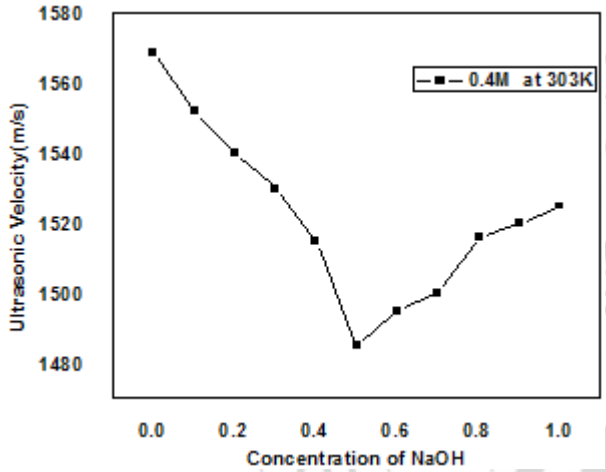

Figure 1

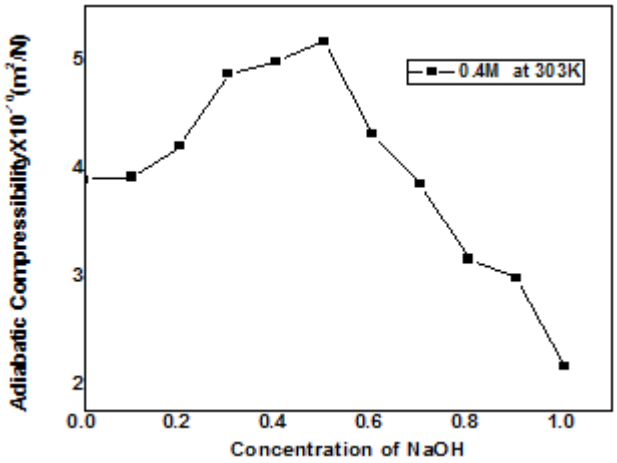

Figure 2

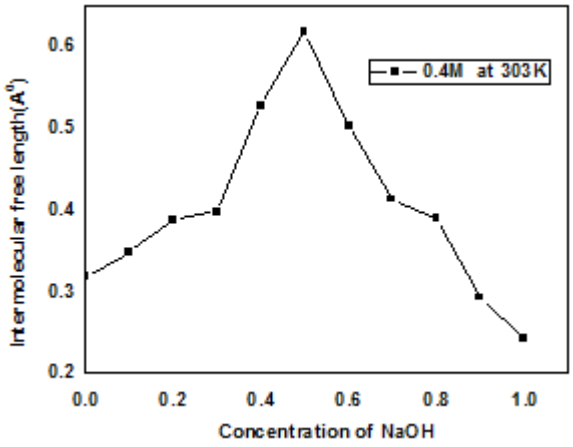

Figure 3

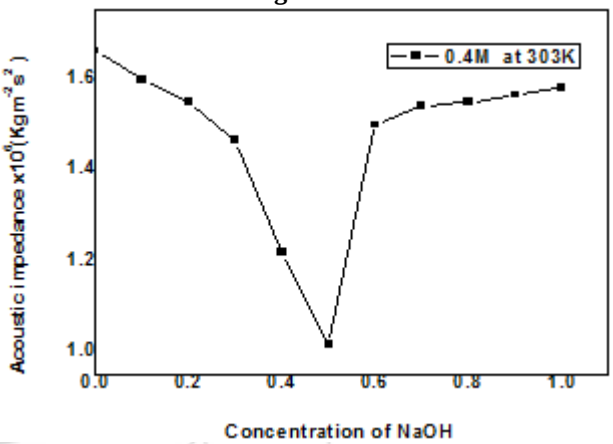

Figure 4

The decrease in adiabatic compressibility fig.2 is attributed to the influence of the electrostatic field of the ions on the surrounding solvent molecules [5]. The decrease in compressibility implies that there is enhanced molecular association in these systems upon increase in solute content, as the new entities (formed due to molecular association) become compact and less compressible. These also suggest that the compressibility of the solution will be lesser than that of solvent. As a result, solute will have mobility and have more probability of contacting solvent molecules. This may enhance the interactions between solute and solvent molecules [6].The decrease in free length fig.3 with increase in solute concentration indicates that there is a significant interaction between the solute and solvent molecules, suggesting a structure promoting behavior on the addition of solute. Due to thermal expansion of liquids an increase in temperature causes the free length to increase. The intermolecular free length is another important factor in determining the existence of interactions among the components of the solution. Acoustic impedance (Z) as shown in fig.4 is the impedance offered to sound wave by the components of the mixture. The increasing trend in these parameters suggests the strengthening of interaction among the component. The interaction may be solute–solute or solute–solvent or solvent–solvent type, it is peculiar to note that these two parameters depend on density.

5. Conclusion

The study of acoustic parameter in mixture of cellulose and aqueous solution of NaOH indicates that here is solute –

solvent interaction.The variation of ultrasonic velocity and other parameters clearly indicates that interaction of ultrasonic wave with aqueous solution of cellulose and alkali This solute –solvent interaction increases the surface roughness resulting in better mechanical interlocking; increases the amount of cellulose exposed on the fiber surface, and increases the number of possible reaction sites by removing lignin.

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