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Effect of Acrylic Acid Content on Modified NypaFruticans Regenerated Cellulose Biocomposite Films

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Abstract

Nypafruticans (NF) is one of the agriculture crops, which grows abundantly in Malaysia. It can be used as asubstitute for commercial cellulose in order to utilize biomass waste. Regenerated cellulose (RC) biocomposite films from NF and microcrystalline cellulose (MCC) were prepared by dissolving cellulose in lithium chloride (LiCl) and N, N-dimethylacetamide (DMAc). Acrylic acid (AA) was used as surface modifier of NF. The results indicated that the addition of NF in RC biocomposite films increases the tensile strength and Young's modulus of RC biocomposite film up to 3 wt%. The elongation at break of RC biocomposite films decreased with increases of NF content. The modified NF with AA improved the tensile strength and Young's modulus but reduced the elongation at break of RC biocomposite films. The highest tensile strength and Young's modulus of RC biocomposite films was exhibited by 3% AA content.

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*Keywords:*Acrylic acid; Regenerated cellulose biocomposite films; Tensile properties.

1. Introduction

Cellulose is well known as one of the world's most abundant andrenewable natural resources[1, 2].Cellulose is regarded as one of the most promising raw materials due to its fascinating structure and excellent properties, such as

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environmental friendliness, fast biodegradability and good thermalstability[3, 4]. The usage of cellulose can be classified into three aspects: direct use, degradationinto small molecules and chemical modification based on itssuperstructure[5, 6].

Direct use without any chemical derivation of the cellulose has been receivedconsiderable attention lately. The ability of disrupting the interchain hydrogen bonds of celluloseto make the cellulose dissolve determines the dissolution efficiency of a solvent. Somesolvent systems have already been developed to dissolve cellulose, such as NaOH/urea, NaOH/CS_2,LiOH/urea/H_2O, LiSCN·2H_2O and some other systems like N-methylmorpholine-N-oxide (NMMO), and dimethyl sulfoxide(DMSO)/tetrabutyl ammonium fluoride (TBAF)[7, 8]. But, these systems always have difficulty in solvent separation and cause environmental pollution.

In recent years, ionic liquids, as a new type of environmentally friendly "green solvent", have excellent characteristics, such as high thermal stability and electrochemical stability [9, 10], lower viscosity, non-flammability and immeasurable low vapor pressure have been introduced. In addition, ionic liquids exhibit outstanding dissolving capability for cellulose[11], which would broaden the comprehensive utilization for cellulose[12]. The dissolution and regeneration of cellulose in different ionic liquids have been reported in recent studies[13, 14].

Nypafruticans (NF) also known as Nypa palm are mangrovepalms, and renewable agro-waste. Its can serve as alternativesource of fibres for pulp production. Nypafruticans (family:Arecaceae) has a fairly wide distribution in India, Myanmar,Thailand, Malaysia, Indonesia, Borneo, Philippines, RyukyuIslands, New Guinea, the Solomon Islands and northern Australia[15].Our previous study reported the effect of microcrystalline cellulose (MCC) contents on tensile properties and X-Ray Diffraction (XRD) of regenerated cellulose using ionic liquid[16]and regenerated cellulose/ Nypafruticans fiber biocomposite films using ionic liquid[17].

Normally, the filler-matrix adhesion is affected by surface wettability, surface energy, hydrophilicity, roughness of filler surface, acid-base interaction and chemical functional sites[18].Therefore, chemical modification or uses of adhesion promoteron natural filler can be done to improve the mechanical properties of biocomposite films[19, 20]. Currently, there have many surface treatment systems for natural filler such as alkaline treatment[21, 22], esterification treatment[23], silane treatment[24], anhydride treatment[25, 26]and compatibilizer[26] to improve the properties of biocomposite films.

The objective of this study was to investigate the effect of different NF andacrylic acid (AA) contents on tensile properties and morphology of Regenerated cellulose (RC) biocomposite films.

2. Methodology

2.1. Materials

In this research, MCC with particle size of 50µm, Acetone and Sodium Chlorite ($NaClO_2$) were supplied by Sigma-Aldrich, USA. Lithium Chloride (LiCl) and N, N Dimethylacetamide (DMAc) were obtained from Across, Belgium. Sulfuric acid (H_2SO_4) and Sodium Hydroxide (NaOH) were supplied by HmbG Chemical. Acetic acid was obtained from BASF, Germany. AA were supplied by Fluka, Penang. Nypafruticanswere obtained from Kuala Perlis.

2.2. Pretreatment of NF

At first, NF was cleaned, dried, ground and sieved into smaller particle size. The NF average particle size of 36 µm was measured by Malvern particle size analyzer. The NF fiber was dispersed in 500 mL of a 2% NaOH solution and the suspension was stirred for 2 h at 80ºC. The NF solutions were filtered and washed with water and then the fibers were dried at 80ºC for 24 hours. The dried pretreated fibers were heated at 70ºC in 500 mL of water containing 30% of $NaClO_2$ and 10 drops of glacial acetic acid. The mixture was stirred for 1 hour, filtered and washed with cold water. This procedure was repeated three times using the same condition. The bleached fibers were treated in a concentrated sulfuric acid solution (64%) at 45ºC. The ratio of fibers to acid solution was 1:10 (g/ml). After treatment, the hydrolyzed cellulose samples were washed until pH 7 was reached and dried in oven at 80ºC for 24 hours. Then, the dried pretreated NF were subjected to AA treatment. The different content ofAA werefirst dissolved in ethanol solution at temperature 40ºC using water bath. The NF was slowly added to the AA solution and stirred for 2 hours at speed of 300 rpm. The treated NF was then filtered through Whatman filter paper and dried at 80ºC for 24 hours.