Oxidation of Flax Fiber with Sodium Periodate Solution

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Abstract: The poor crease recovery performance of linen fabrics has resulted in attempts to improve this characteristic by modifying the structure of the flax fibres from which the linen is woven. In this paper, flax fibers were oxidized with sodium periodate solution leading to a variety of polymers having functional groups such as aldehyde group for subsequent modification. Several factors (oxidant concentration, pH values, oxidization temperature and time) on the weight loss, mechanical properties and content of the formed aldehyde groups were analyzed. Structure and morphology of oxidized flax fibers were also investigated. Results show that the characteristic absorption band due to aldehyde group strengthened the oxidized fibers. The crystallinity decreased and endothermic decomposition temperature dropped gradually with the increase of oxidant concentration, oxidation time and temperature, as well as their mechanical properties. Moreover, when the fiber was oxidized with high level oxidization degree, the conformation of flax completely transferred to a random coil. So as a textile material, the oxidization degree of flax should be reasonably controlled.

Keywords: Flax, sodium periodate, structure, properties.

1. Introduction

In spite of tremendous development in the production of chemical synthetic fibers, the constant renewal of fiber materials in nature is still their attractive feature. They are mainly cotton and flax fibers. In recent years the interest in the preparation of textile and other materials from natural fibers exhibiting satisfactory consumer properties has remained high.

Graft polymerization can induce chemical changes in cellulose and the introduction of polymer chains can confer different structural characteristics to the raw material [1]. In this way new cellulose-based products can be obtained with mechanical properties better than the conventional cellulose. Oxidation, as a modification method, can lead to a variety of polymers having functional groups, such as aldehyde and carboxyl groups, in addition to the primary and secondary hydroxyl [2]. Thus many cellulose derivatives can be prepared by oxidation [3].

Flax fiber, as a renewable natural polymer, is widely used in many fields. In our studies, flaxfibers were treated with sodium periodate solution to activate polymer for further reactions. The morphology, structure and mechanical properties of flax during the oxidation were studied.

2. Experimental

2.1 Materials

Flax yarn; sodium periodate, glycerin, sodium hydroxide, hydrochloric acid, were of analytical grade.

2.2 Oxidation of flax fiber

Flax fiber samples were immersed in sodium periodate solution of different concentration at different temperatures at a ratio of 3:100 (w/v). After extensive washed with deionized water and air-dried [4].

2.3 Percentage of weight loss

The weight of flax fiber samples before and after sodium periodate oxidization were measured on a BS224S automatic photoelectric balance scale. Thus weight loss percentage during oxidation was calculated.

2.4 FT-IR analysis

FT-IR spectra of flax samples were performed on Nicolet 5700 FT-IR spectrophotometer (USA) using the traditional transmission technique for KBr-pellets. KBr pellets of samples were prepared by mixing 1.5–2.0mg of flax fiber powder with 200mg KBr

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(spectroscopic grade) in a vibratory ball mixer for 20s. The round pellets were prepared in a standard device under a pressure of 30Mpa. IR-spectra were recorded at 4cm^{-1} resolution and 64 scans were taken for each sample. The measurements were performed at 20℃ and a relative humidity of 65%.

2.5 SEM observation

Surface morphologies of flax samples were observed on a Model S-570 scanning electron microscope. The samples were gold sputtered to give them electronic conductivity under a vacuum prior to the observation.

2.6 XRD analysis

XRD patterns of flax samples were obtained with a model D/MAX3C X-ray detector diffraction system at voltage of 40kV, current of 30mA and scan rate of 2°/min. The crystallinity of the flax fibre was calculated by the method of peaks separation and Gaussian peak fit with the software of peakfit v 4.12 [5].

2.7 Determination of aldehyde group

The aldehyde content in periodate-oxidized fiber was determined by Schiff base reaction with hydroxylamine hydrochloride [6]. Hydrochloric acid released from hydroxylamine hydrochloride was titrated by the consumption of 0.03M NaOH [7]. The aldehyde group content (AGC) is calculated according to the following equation:

$$AGC\ (mmol/g) = 30V/W. \quad (1)$$

Where, V is the volume of sodium hydroxide methanol Standard solution used in titrimetry (l), W is the mass of oxidized flax fiber sample (g).

2.8 DSC analysis

Thermal properties of flax fiber samples were obtained with a Model YRIS Diamond TG-DTA detector ranged from room temperature to 600℃ at heating rate of 10℃ /min in nitrogen flow of 20 ml/min.

2.9 Determination of breaking load and elongation

The breaking strength and breaking elongation of flax yarn samples were determined at an effective gauge length of 250mm and extension rate of 250mm/min performed on a YG020 electron single strand meter. The results were averaged for 20 samples.

3. Results and discussion

3.1 Weight analysis of flax fiber

The weight change of flax fibers during oxidation was investigated. We found weight loss occurred when flax fibers were treated with sodium periodate solution, which contributed to the cleavage at the C-2 and C-3 vicinal hydroxyl groups along the polymer chain[8]. And the percentage of weight loss was effected by the oxidant concentration, oxidation temperature, time, and solution pH value. The results are shown in Figure 1. As an oxidant to flax, the concentration of sodium periodate solution plays an important effect on the weight change and the oxidation extent. With the oxidant concentration raising, oxidation temperature and oxidation time increasing, the weight loss rate of flax samples gradually increased. When raising the oxidant concentration and oxidation temperature, or prolonging the oxidation time, can increase the contact probability of IO_4^- and hydroxyl groups on glucose, meanwhile the degree of other side reactions increase.