

Nanocellulose and Their Thermoplastic Nanocomposites

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ABSTRACT

Nanocellulose fibers with the average diameter below 100nm were successfully obtained by a high shear microfluidizer. Their large surface area and nano-scale dimensions can lead to the emerging materials for reinforcements in polymer composites, differentiating from common polymer composites and providing the opportunity for nano-engineered materials that could have not achieved from conventional materials.

However, Enormous amount of hydroxyl groups, covered on the surface of nanocellulose, could often be a drawback as a reinforcement in hydrophobic polymeric matrix.

Silanization have been a well-known technology to modify the surface of the reinforcement with a compatibility.

The silane treatment on the surface of nanocellulose resulted in the increase in mechanical properties of nanocomposite compared with non-treated original nanocellulose. However, excessive treatment resulted in decrease of tensile strength and modulus.

Keywords: Nanocellulose, Silane Treatment, Thermoplastic Nanocomposites, Wet-laid sheet forming processes

1. INTRODUCTION

Over the last decades, there has been an emerging interest in the development of novel composite materials based on biodegradable and renewable materials. Therefore, it is advantageous to utilize different types of cellulosic fibers as reinforcements in such biocomposites, since cellulose is an abundant, renewable, and biodegradable resource. Furthermore, the mechanical properties of cellulose fibers are desirable in the utilization as reinforcements in novel low-density and high strength materials [1].

Wood pulp fibers are presently a major area of research for several end-use applications. Cellulose can be utilised as reinforcements in biodegradable composites and as a source of raw materials for bioenergy and biochemical production. Wood pulp

fibers have been applied as the raw material for the production of fibrillated materials, which were introduced and defined as microfibrillated cellulose (MFC) by Turbak et al. [1] and Herrick et al. [2]. Several modern and high-tech nano-applications have been envisaged for MFC [1]. Although cellulose fibers have constituted the main source for MFC production, the utilisation of other pulp fibres, agricultural crops and by-products have also been explored [3-5]. With the years, various subjective definitions have been given to the fibrillated materials, e.g. nanofibrillated cellulose, nanofibers, nanofibrils, microfibrils and nanocellulose [6-10].

In the context of nanocomposites, cellulose nanofibers are also of interest. Due to the high modulus and strength of 134 GPa and 4 GPa, respectively, CNFs are suitable as reinforcements in polymer nanocomposites [11]. Cellulose exists as a load-bearing component in plant cell walls on land, but is also found in algae and tunicate sea animals or can be produced by bacteria. Cellulose is a linear polysaccharide, poly- β (1,4)-D-glucan. The molecules aggregate and are present as microfibrils [12]. These microfibrils consist of aligned extended molecules, laterally stabilized by hydrogen bonds [13] and contain both ordered and less ordered regions [14].

The cross-sectional dimension of these microfibrils varies due to the origin of the cellulose, but is about 4 nm for wood cellulose. Wood microfibrils form aggregates and are present as 15-18 nm thick microfibril aggregates in wood pulp fibers [12]. In nanocomposites, wood based cellulose nanofibrils is used either in the form of microcrystalline cellulose or microfibrillated cellulose.

In our previous work, the wet-laid process was found a good method to make nanocellulose /Polyamide 6 nanocomposites [14].

In this study, we characterize the surface charge of nanocellulose and the investigate the effects on the mechanical properties.

2. EXPERIMENTAL

2.1 Preparation of nanocellulose

Microcrystalline celluloses (VIVAPUR® 102, JRS, Germany) were used to prepare the slurry by

dispersing the celluloses in distilled water at a solid weight content of 0.5% using an overhead mixer for 30 minutes. The resulting slurry was subject to high pressure homogenization to fibrillize the cellulose fibers.

The homogenization of the slurry was performed by the microfluidizer (MinideBee, Bee International, USA) with parallel flow nozzle setup configurations for the fabrication of nanocellulose. In each nozzle setup, the slurry was totally passed 30 times through the microfluidizer with various nozzles sizes and various operating pressures.

The first ten passes were carried out a operation pressure of 10,000 psi with a nozzle of 10/1000” diameter, and then the second ten passes at a operation pressure of 30,000 psi with a nozzle of 8/1000” diameter and the last ten passes at a operation pressure of 45,000 psi with a nozzle of 5/1000” diameter.

2.2 Preparation of naocellulose / Polyamide 6 fiber composite

Nanocellulose composite were prepared by the inclined wire Fourdriner wet-laid machine.

At the first stage, silane-treatment on the surface of nanocellulose was done at the slurry state after the homogenization by the microfluidizer

Short-cut fiber of polyamide 6 and as-prepared nanocellulose were mixed together in the pulper to prepare the slurry for wet-laid process.

The composite sheet was dried continuously by the cylinder dryer, and then the dried sheets were calendered under the of 800 psi below thermal degradation temperature of nanocellulose.

3. RESULTS AND DISCUSSION

Nanocellulose fibers with the average diameter below 100nm were successfully obtained by a high shear microfluidizer as shown in Figure 1. Their large surface area and nano-scale dimensions can lead to the emerging materials for reinforcements in polymer composites, differentiating from common polymer composites and providing the opportunity for nano-engineered materials that could have not achieved from conventional materials[14].

Mechanical properties of nanocomposite were increased due to the treatment with silane on the surface of nanocellulose compared with non-treated original nanocellulose. However, excessive treatment resulted in decrease of tensile strength and modulus as shown in Figure 2.

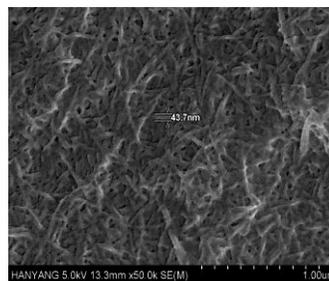


Figure 1. FE-SEM micrographs of nanocellulose

Figure 2 showed the mechanical properties of nanocomposite were increased due to the treatment with silane on the surface of nanocellulose compared with non-treated original nanocellulose. However, excessive treatment resulted in decrease of tensile strength and modulus .

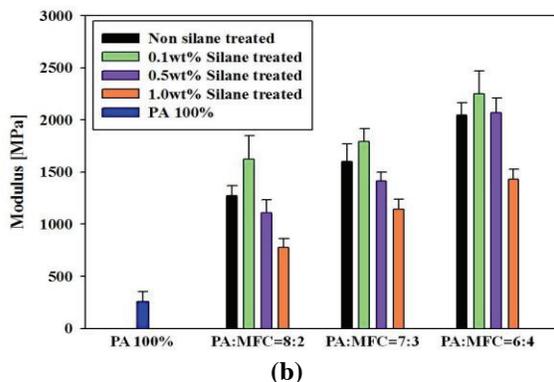
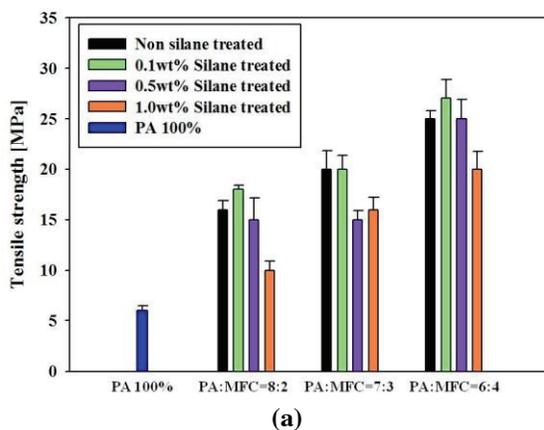


Figure 2. The effects of silane surface treatment on mechanical properties of nanocellulose/Polyamide 6 nanocomposites

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