

Nano technology modification of natural fibres for bio-composites

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Introduction

As we know cellulose is one of the most abundant materials in the world, in the past few decades, with the increasing of environmental awareness, exploiting of cellulose is attracting much more concerns. Natural fibres which mainly contain cellulose is also get more attention at the same time. Compare with glass fibre-based composites, natural fibre-based bio-composites display several excellent advantages, e.g. low density; renewable; low cost. Right now, natural fibre bio-composites have been widely used for automotive materials [1, 2], building materials [3, 4]. Many manufacturing methods [5] have also been developed for making composites.

In this present work, we employ nanotechnology to modified natural fibres (hemp fibres). Nanocellulose which was fabricated by a novel way was used as “coupling agent” to treat natural fibres. NTA, FEG-SEM and AFM were used to characterize nanocellulose. Mechanical properties and interfacial properties of modified natural fibres were investigated chiefly. FEG-SEM and XRD were performed to release the mechanism of tensile strength increase of the fibres with nanocellulose modification.

Materials and Methods

Materials

Hemp yarns were obtained from Shanxi Greenland Textile Ltd. Hemp fibres were supplied by a Hemp Farm & Fibre Company

Ltd, UK. Dodecyltrimethylammonium bromide (DTAB), ethylene diamine tetraacetic acid (EDTA), sodium hydroxide, sodium hypochlorite and sodium sulfide were supplied by Sigma-Aldrich. Unsaturated polyester was obtained from CFS.

Methods

NTA, FEG-SEM and AFM were carried out to characterize nanocellulose.

Instron tensile testing, FEG-SEM and XRD were performed to investigate the mechanical properties of nanocellulose modified fibres.

Results and discussion

Fig.1 presents the results of size distribution of nanocellulose with various treatments. According the NTA, the size range of nanocellulose for std1, std2 and std3 is 31-281 nm, 38-278 nm and 29-321 nm respectively, the average size of nanocellulose for std1, std2 and std3 is 100 nm, 112 nm and 103 nm respectively. Fig.3a and 3b shows FEG-SEM and AFM images of nanocellulose. According to FEG-SEM characterization, the size of nanocellulose ranges from 45.45 nm to 168 nm. AFM image of nanocellulose show a slight difference with FEG-SEM, as shown in fig.3b, not only particles can be observed in this image but also rod like of fibril can be found. This may be due to the difference of preparation of samples.

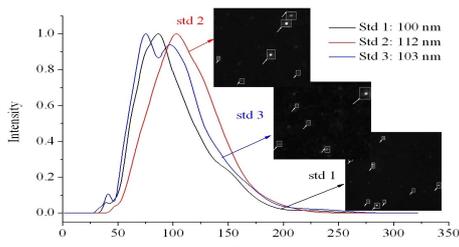


Fig.1 Size distribution and picture from NTA video of nanocellulose (std5, std11 and std21).

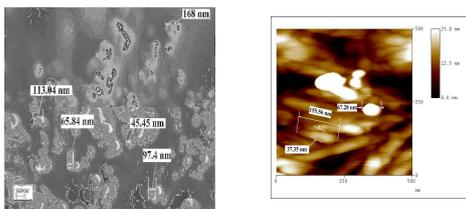


Fig.3 Morphology of nanocellulose (a) by FEG-SEM ($\times 100\ 000$); (b) by AFM (height image)

Mechanical properties of hemp fibres with various treatments were summarized in table 1. It is shown that both of the DTAB and nanocellulose treatment can increase mechanical properties of natural fibres. Especially for nanocellulose treatment, compare with raw fibres, the modulus, tensile stress and tensile strain of nanocellulose modified hemp fibres increase by 36.13%, 72.80% and 67.89% respectively.

Table 1 Mechanical properties of raw hemp fibres, coupling agent modified, DTAB modified and nanocellulose modified hemp fibres

Experiments	Modulus (GPa)	Tensile stress (MPa)	Tensile strain (%)
Unmodified	28.29	696.68	2.29
DTAB modification	29.83	735.29	2.47
Nanocellulose modification	38.51	1203.85	3.84

Conclusions

In this paper we employed nanotechnology to fabricate nanocellulose from natural fibres (hemp fibres) firstly. NTA, FEG-SEM or AFM analysis gives a uniform result that oxidation-sonication can be used to fabricate nano-scale cellulose from natural fibres. After that, nanocellulose fabricated with oxidation-sonication was used as “coupling agent” to modify hemp fibres. Single fibres tensile testing was carried out to measure the tensile performance of raw and modified fibres. For nanocellulose treatment, compare with raw fibres, the modulus, tensile stress and tensile strain of nanocellulose modified hemp fibres increase by 36.13%, 72.80% and 67.89% respectively. Resin adsorption was performed to evaluate the interfacial property of fibres with various treatments. Results show that nanocellulose modification can benefit interfacial properties of fibres.

References

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