POTENTIAL OF NANOFIBRILLATED CELLULOSE FROM KENAF BAST USING ULTRASONIC APPROACH

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Introduction

Nanofibrillated cellulose (NFC) is a material which comprises of nanosized cellulose fibrils with high aspect ratio. The usual dimensions are below 100 nm in width and length up to several micrometers (Zimmermann *et al*. 2010). The dimensions depend on the various factors such as raw materials and mechanical processes of NFC (Abdul Khalil *et al*. 2014). In recent years, productions of NFC are greatly being focused due to potential in many areas especially in nanocomposite (Virtanen *et al*. 2014).

Kenaf *(Hibiscus cannabinus)* is one of the non-woody plants that is applied as cellulose sources to produce NFC (Kuramae *et al*. 2014). Other non-woody plants that have been studied are listed as abaca, sisal, flax, hemp and jute (Alila *et al.* 2013). The chemical composition of kenaf bast is around 63.5 % cellulose, 17.6 % hemicellulose and 12.7 % lignin (Janoobi *et al*. 2009). Fig. 1 exhibit the physical look of kenaf bast, unbleached kenaf bast pulp and bleached kenaf bast pulp.

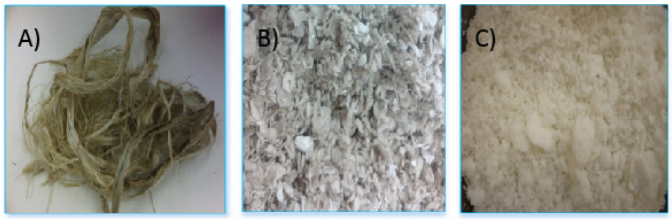

Fig. 1. A-Kenaf bast, B-Unbleached kenaf bast pulp and C- Bleached kenaf bast pulp

Recently, the ultrasonic method has been applied to produce nanocellulose (Mishra *et al*. 2012). The important process called cavitation occurs where ultrasonic energy is transferred to cellulose chains. This refers to the formation, growth and violent collapse of cavities in water (Tischer *et al*. 2010). Consequently, the ultrasonic collision can gradually disintegrate or collapse the micron-sized cellulose into nano-sized fibers (Fig. 2).

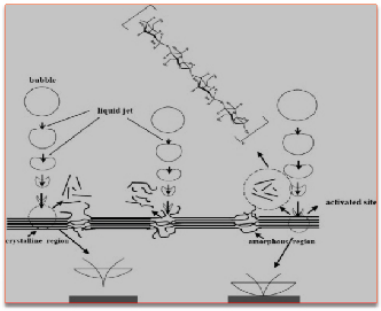

Fig. 2. Schematic diagram of ultrasonication process (Li, Yue & Liu, 2012)

Morphology of the fibers

The FESEM and STEM images on the morphology of the kenaf bast cellulose (KB-Cellulose) before and after ultrasonic treatment can be shown in Fig 3. It can be seen that before ultrasonic treatment the surfaces of cellulose bleached fibers exhibited even and plain. This is caused by the removal of impurities (Fig. 3A). The images show a mixture of micro-sized fibers and nano-sized fibrils with web-like structures, and the diameter of the kenaf bast nanofibrillated cellulose (KB-NFC) was in the range of 9-20 nm (Fig. 3B & 3C). The cavitation process plays an important role to disintegrate the fibers from micron to nano size (Qian et *al*. 2012).

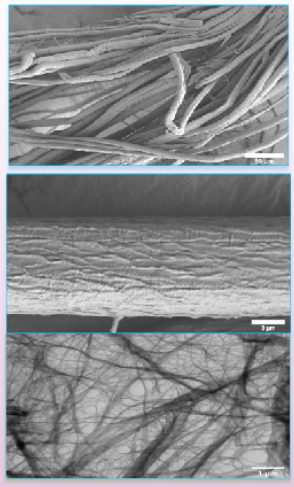

Fig. 3. (A) - (B) FESEM images of KB-Cellulose before ultrasonic treatment and (C) STEM image of KB-Cellulose afterultrasonic treatment at 20 kHz in frequency and 700 W output power for 60 min.

Viscosity Analysis

Table 1 shows the viscosity values of KB-Cellulose and KB-NFC, 12.70 cP and 9.03 cP, respectively. The calculated degree of polymerization (DP) was 1,058.36 (KB-Cellulose) and 833.76 (KB-NFC). The deterioration in viscosity value of NFC is highly due to fibrillation during the ultrasonic treatment. Lignin content also could probably affect the viscosity value. Higher lignin content may decrease the viscosity value as well. The value of DP strongly correlates with the aspect ratio of the fibrils. Lower DP means that more shorter fibrils and constant diameter are obtained (Zimmermann *et al*. 2010).

Sample	Viscosity (cP)	Degree of Polymerization (DP)
KB-Cellulose	12.70	1,058.36
KB-NFC	9.03	833.76

Conclusions

Nanofibrillated cellulose from kenaf bast was successfully produced using ultrasonic treatment at 20 kHz in frequency and 700 W output power. FESEM and STEM images revealed the existence of NFC from kenaf bast in the range of 9-20 nm diameters. Conclusively, higher crystallinity led to higher thermal stability and lower viscosity of NFC. Such property has very good and high potential to be used in various applications such as reinforcing material in the matrix.

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