e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:10/October-2023 Impact Factor- 7.868 www.irjmets.com

MECHANICAL PROPERTIES OF STARCH REINFORCED COMPOSITES

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DOI : https://www.doi.org/10.56726/IRJMETS45357

ABSTRACT

Starch is a promising biopolymer for producing biocomposite materials because it is renewable, completely biodegradable, and easily available at a low cost (Alissandratos & Halling, 2012). The development of biocomposites based on starch has been expanding continuously due to the fact that thermoplastic starch (TPS) can be obtained after the disruption and plasticization of native starch (Hulleman, Janssen, & Feil, 1998). Various types of plasticizers such as glycerol, water, and sorbitol have been used to prepare TPS (Curvelo, De Carvalho, & Agnelli, 2001). Compared to the common thermoplastic polymers, TPS has two main disadvantages including poor mechanical properties and a high water sensibility (Teixeira et al., 2009). The use of reinforcing agents in the starch matrix is an effective means to overcome these drawbacks and several types of biodegradable reinforcements such as cellulosic fibers, whiskers, and nanofibers have been utilized to develop new and inexpensive starch biocomposites (Curvelo et al., 2001, Hietala et al., 2013, Petersson et al., 2007).

I. INTRODUCTION

In this study the effects of chemical modification of cellulose nanofibers (CNFs) on the biodegradability and mechanical properties of reinforced thermoplastic starch (TPS) nanocomposites was evaluated. The CNFs were modified using acetic anhydride and the nanocomposites were fabricated by solution casting from corn starch with glycerol/water as the plasticizer and 10 wt% of either CNFs or acetylated CNFs (ACNFs). The morphology, water absorption (WA), water vapor permeability rate (WVP), tensile, dynamic mechanical analysis (DMA), and fungal degradation properties of the obtained nanocomposites were investigated. The results demonstrated that the addition of CNFs and ACNFs significantly enhanced the mechanical properties of the nanocomposites and reduced the WVP and WA of the TPS. The effects were more pronounced for the CNFs than the ACNFs. The DMA showed that the storage modulus was improved, especially for the CNFs/TPS nanocomposite. Compared with the neat TPS, the addition of nanofibers improved the degradation rate of the nanocomposite and particularly ACNFs reduced degradation rate of the nanocomposite toward fungal degradation.

II. METHODOLOGY

Recently, the cellulose nanofibers (CNFs) derived from renewable biomass have attracted much interest as an alternative to micro-sized reinforcements in composite materials (Jonoobi, Mathew, Abdi, Makinejad, & Oksman, 2012). The CNFs, which are generally isolated from lignocellulosic plants, have specific characteristics such as high modulus and high surface area. These CNFs show great potential for use as reinforcement in polymer matrices (Petersson et al., 2007). However, the processes and polymers that are suitable for producing composite are restricted because of the hydrophilicity of the CNFs as well as the formation of irreversible aggregates when dried (Siró & Plackett, 2010). In addition, the uniform dispersion of the CNFs in polymers is difficult due to their high surface energy, and the presence of hydroxyl groups on the CNF surface. To overcome this problem, different chemical modifications have been used in earlier studies (Goussé et al., 2004, Jonoobi et al., 2010). Among the many chemical modifications, acetylation is one of the most promising processes because it can improve the dispersibility of nanofibers in a polymer matrix (Ashori, Babaee, Jonoobi, & Hamzeh, 2014) and the dimensional stability of the final composition (Khalil, Ismail, Rozman, & Ahmad, 2001). During the acetylation, the chemical will react with the OH groups on the cellulose; thereby modifying the hydrophilic surface of the cellulose to become hydrophobic.

Generally, biocomposites are totally biodegradable and are found to fully disintegrate in ideal conditions (Matthews et al., 2006). Biodegradation is governed by different factors including polymer characteristics, type of organism, and the nature of pretreatment (Gigli, Lotti, Gazzano, Finelli, & Munari, 2012). Various microorganisms such as bacteria and fungi are responsible for the degradation of both natural and synthetic

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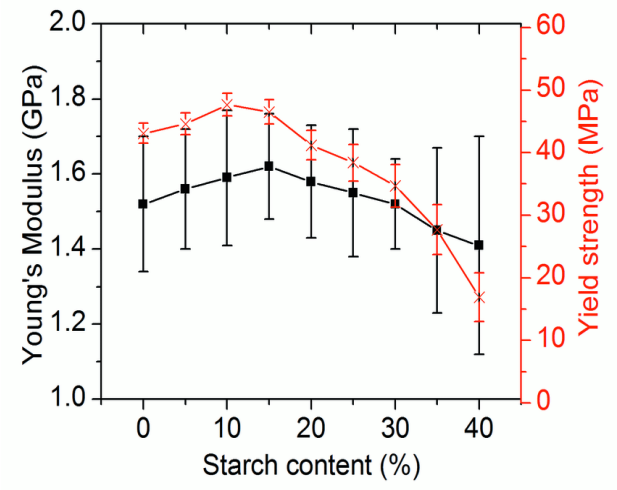
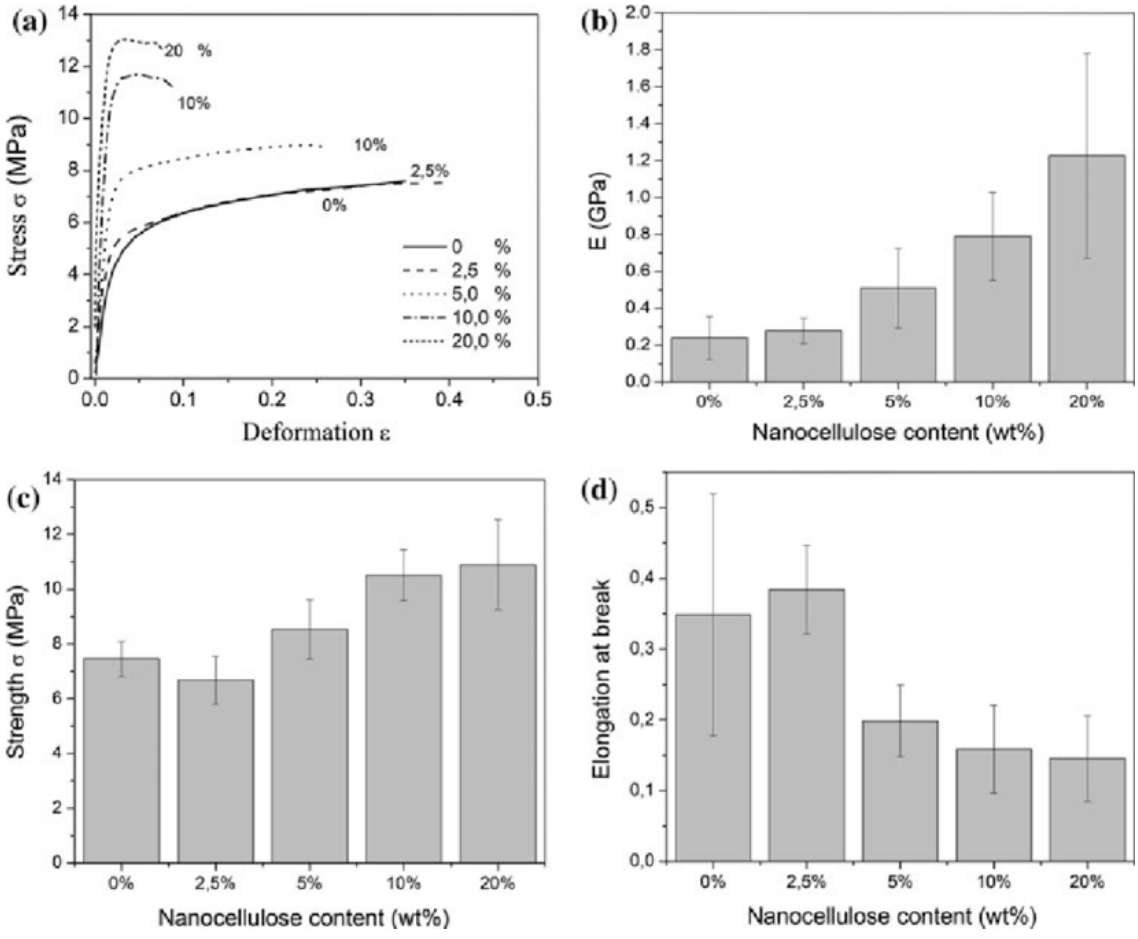
plastics (Gu, 2003). Compared to the conventional polymers, TPS is fully biodegradable in a wide variety of environmental conditions (Shah, Hasan, Hameed, & Ahmed, 2008). Numerous researchers have studied the biodegradation condition of starch biopolymers. Nevertheless, there are few reports regarding the environmental biodegradability of the CNFs/starch nanocomposites.

The main objective of this study was to investigate the effect of the addition of CNFs and acetylated CNFs (ACNFs) on the biodegradation and physicomechanical properties of the starch nanocomposites. Microscopic analysis was used to study the fungal biodegradation of the nanocomposite under various conditions. Furthermore, the influence of acetylation of CNFs on its dispersibility into the starch polymer matrix has been investigated.

III. MODELLING AND ANALYSIS





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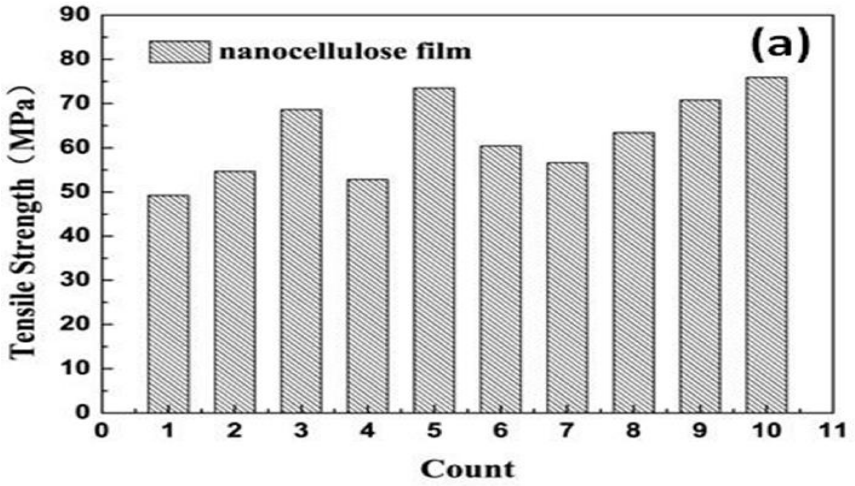

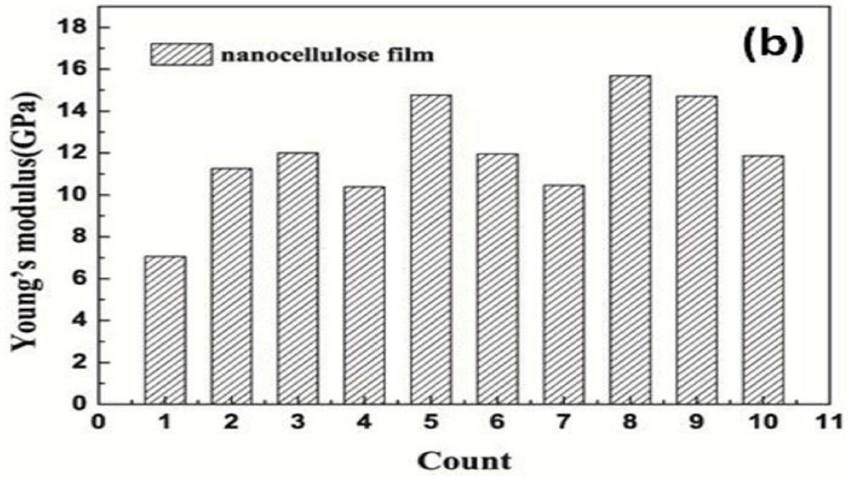

IV. MATERIALS

Unprocessed corn starch composed of 35% amylose and 65% amylopectin was supplied by the Alborz Starch Co., Iran. The CNFs used in this study were provided by the Institute of Tropical Forestry and Forest Products (INTROP), Malaysia, and were isolated from the kenaf bast fibers (Hibiscus cannabinus). The details of the CNFs isolation process are reported elsewhere (Jonoobi, Niska, Harun, & Misra, 2009). In short, the fibers were converted to pulp fibers using NaOH-AQ (anthraquinone) followed by

Acetylation and degree of substitution for CNFs

The acetylation involves the replacement of hydroxyl groups of the nanofibers with acetyl groups in the reagent. The acetylation of the CNFs with acetic anhydride was carried out at 100 °C for 4 h. A long reaction time along with pyridine as a catalyst was used to promote the sufficient diffusion of acetic anhydride into the amorphous regions of the CNFs. Therefore, the bulk substitution was facilitated. The degree of the substitution (DS) of acetylated nanofibers determined by titration was 0.2,

V. CONCLUSION

This study showed that both acetylated and non-acetylated CNFs can be used to fabricate the thermoplastic starch nanocomposite. The composites were prepared successfully by using the solution casting method. The effects of acetylated and non-acetylated nanofibers on water absorption, tensile, dynamic mechanical properties.

VI. REFERENCES

[1] Sanjay MR, Madhu P, Jawaid M, et al. Characterization and properties of natural fiber polymer composites: a Comprehensive review. J Clean Prod 2018; 172: 566–581.

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[2] Lei Y, Wu Q, Yao F, et al. Preparation and properties of recycled HDPE/natural fiber composites. Composites Part A: Applied Science and Manufacturing 2007; 38: 1664–1674.

[3] Rangappa SM, Siengchin S, Parameswaranpillai J, et al. Lignocellulosic fiber reinforced composites: progress, performance, properties, applications, and future perspectives. Polym Compos 2022; 43: 645–691.

[4] Ahmad F, Choi HS, Park MK. A review: natural fiber composites selection in view of mechanical, light weight, and economic properties. Macromol Mater Eng 2015; 300: 10–24.

[5] Ramamoorthy SK, Skrifvars M, Persson A. A review of natural fibers used in biocomposites: plant, animal and regenerated cellulose fibers. Polym Rev 2015; 55: 107–162.