Nano-Structures & Nano-Objects 25 (2021) 100642

Contents lists available at ScienceDirect

Nano-Structures & Nano-Objects

journal homepage: www.elsevier.com/locate/nanoso

Fabrication of cellulose acetate nanocomposite films with lignocelluosic nanofiber filler for superior effect on thermal, mechanical and optical properties

Amita Sharma [a,b], Tamal Mandal [b,*], Saswata Goswami [a,*]

[a] Center of Innovative and Applied Bioprocessing, Knowledge City Sector-81, Mohali, Punjab 140306, India
[b] Department of Chemical Engineering, National Institute of Technology, Durgapur-Mahatma Gandhi avenue, West Bengal, Pin-713209, India

A R T I C L E I N F O

Article history:
Received 19 May 2020
Received in revised form 6 November 2020
Accepted 27 November 2020

Keywords:
Cellulose acetate
Rice straw
Cellulose nanofibers
Nanocomposite film
Tensile strength
Transparency

A B S T R A C T

Superior effect on thermal, mechanical and optical properties of cellulose acetate nanocomposite (CA) films has been established by its fabrication with rice straw derived cellulose nanofibers (RS CNFs) as nano filler. The ratio of CA/RS CNF were optimized (2, 5, 7.5 and 10 wt % of CNF) through solvent casting method, their effect on the thermal, mechanical and optical properties of the nanocomposite films were observed. Better crystallinity index (92%) and lower lignin content of RS CNF (up to 5 wt % loading) enhanced tensile strength to 65 MPa and Young's modulus up to 2.5 GPa of CA film. The improvement of thermal and optical properties were understood by the enhancement in thermal stability and transparency through TGA and UV–Vis spectrophotometer respectively in higher loading of CNFs. The improvised CA nanocomposite film with RS CNFs keeps better future and promise in packaging and logistic industries as superior to commercial CA films.

1. Introduction

Conventional synthetic polymers such as polyethylene PE, polypropylene PP, polyterepthalate PET, Polyvinylchloride PVC etc. offer many advantages like mechanical performance, versatility, lightness, low cost and easy processing especially in food packaging applications, medicine and electronic industry [1]. However they have been considered as high polluting agents for future generations because of their lower rate of degradation and accumulation in the environment. To avoid this problem, preventive measures such as reuse and recycling other forms of packaging waste, have been taken. The application of natural polymers like cellulose, starch and chitosan have emerged as an alternative to these non-biodegradable polymers because of their renewability with lower energy consumption [2–4].

Cellulose is an abundantly available natural organic polymer and can be converted to its derivatives for high end applications [5]. Cellulose acetate (CA) because of its desirable physical properties such as excellent optical clarity, biodegradability, and high toughness is of particular interest amongst various cellulose derivatives [6]. CA is produced primary through the esterification of renewable and natural occurring cellulose materials such as cotton, wood, rice straw, sugarcane bagasse and recycled paper [7,8]. Due to its water resistance, it emerges as promising material for food packaging applications [9,10]. CA is also widely used as a filler material in cigarettes and as a film base in photography. Furthermore because of its low cost, it can be used in vast range of applications such as membrane technology, drug release, textile, and related materials, separation membranes, UV protector, medical implants, opto-electronic field and so on [11–14]. Nevertheless, high moisture sensitivity and brittle nature of CA limits its wider applications in composite films. Previous studies verified that adding reinforcing nanomaterials such as graphene oxide [15], montmorillonite [16], nanocellulose [17], carbon nanotubes [18], silver, gold [19] and hydroxyapatite nanoparticles [20] improve the properties of nanocomposites. Furthermore, these nanomaterials when embedded in CA matrix, can effectively enhance its properties like antimicrobial, UV shielding, flame retardance, photoactivity and gas permeability [21–24]. Another important property of the nanomaterial is their ability to enhance the mechanical properties without sacrificing the transparency of the film [25].

Among various nanofillers, cellulose nanofibers (CNF) offer superior mechanical properties, transparency and aspect ratio [26,27]. Also when compared to inorganic filler, nanocellulose has low cytotoxicity, higher thermal and mechanical stability [4,28–30]. Besides CNF also has higher degree of crystallinity and large density of covalent bonds per cross sectional area, so they display higher tensile strength when embedded in CA matrix [31]. Main

* Corresponding authors.
E-mail addresses: amitasharma0718@gmail.com (A. Sharma), tamal.mandal@che.nitdgp.ac.in (T. Mandal), saswatagoswami2015@gmail.com (S. Goswami).

https://doi.org/10.1016/j.nanoso.2020.100642
2352-507X/