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Nano Crystalline Cellulose Production and Its Application in Novel Food Packaging

Farid Amidi Fazli[1+], Mohammad R. Ehsani[1], Babak Ghanbarzadeh[2], Gholam H. Asadi[1]

[1] Department of Food Science and Technology Science and Research branch, Islamic Azad University, Tehran, Iran

[2] Department of Food Science and Technology of Tabriz University, Tabriz, Iran

Abstract. After years working in huge scale it seems now to be time to work in nano scale. In contrast with literal meaning of nano, researchers have been achieved mega adventures in this area and every day more nano materials are being introduced to market. After long time application of fossil based plastics nowadays accumulation of their waste seems a big problem to environment on the other hand mankind has more attention to his safety and his living environment. Replacing common plastic packaging materials with degradable ones that degrade faster and convert to non dangerous components like water and carbon dioxide have more attractions; these new materials are based on renewable and inexpensive sources like starch and cellulose. But the functional properties of them do not suitable for packaging. At this point nano technology has an important role. Utilizing of nano materials in polymer structure will improve mechanical and physical properties of them; nano crystalline cellulose (NCC) has this ability. This work has employed chemical method to produce NCC and has characterized obtained material by X-Ray Diffraction technique. Results showed that applied method is a suitable one as well as applicable one to NCC production.

Keywords: Cellulose, Nanocomposite, Biofilm, Packaging

1. Introduction

In recent years synthetic polymers have been commonly used; plastics have been used more and more for many kinds of applications in food industry due to their inexpensive production as well as profit properties of plastics. Nowadays selling food materials out of plastic covers is rare and sometimes impossible. The main problem of synthetic polymers is their non degradable properties. To overcome this problem a suitable way is using biodegradable polymers which are degraded easily by natural microorganisms flora existing in environment. These polymers should ensure functional properties which are needed for food packaging materials. Starch is a cheap and renewable source of biofilm production but needs mechanical and barrier properties improvement. The improvement of starch biofilm could be achieved by fillers like nanocellulose.

Nevertheless, the used packaging materials, such as shopping bags, are still easily visible in the environment in many countries. So biodegradable materials offer a possible alternative to the traditional non-biodegradable polymers, especially in short life-time application and when their recycling is difficult and/or not economical [1]. The term ''biodegradable'' materials is used to describe those materials which can be degraded by the enzymatic action of living organisms, such as bacteria, yeasts, fungi and the ultimate end-products of the degradation process, these being CO_2,H_2O, and biomass under aerobic conditions and hydrocarbons, methane and biomass under anaerobic conditions [2].

Among the biomaterials present today in the market, those derived from renewable resources such as starch- based products are the most widespread and economic biomaterials. Starch is a semi crystalline

+ Corresponding author. Tel.: + 984115247510; fax: +984723343556
E-mail address: amidi_f@yahoo.com

polymer stored in granules as a reserve in most plants. It is composed of repeating α-1, 4 D- glucopyranosyl units: amylose and amylopectin. The amylose is almost linear, in which the repeating units are linked by a (1–4) linkages; the amylopectin has a (1–4)-linked backbone and ca. 5% of a (1–6)-linked branches. The relative amounts of amylose and amylopectin depend upon the plant source. Corn starch granules typically contain approximately 70% amylopectin and 30% amylose [3]. The ratio of the two components characterizes materials with very different properties. In the food packaging sector, starch-based material has received great attention owing to its bio- degradability, wide availability and the low cost (less than 1 euro per kg). Several studies are concentrated on the development of starch-based materials, for the above-mentioned reasons [4]. Unfortunately, the starch presents some drawbacks, such as the strong hydrophilic behavior (poor moisture barrier) and poorer mechanical properties than the conventional non-biodegradable plastic films used in the food packaging industries.

The recent interest in using stiff nanometric particles as reinforcement materials in polymeric matrixes, composites or nanocomposites, has been increasing. Two good examples of these types of particles are carbon nanotubes and cellulose nanocrystals. Cellulose nanocrystals, also reported in the literature as whiskers, nanofibers, cellulose crystallites or crystals, are the crystalline domains of cellulosic fibers, isolated by means of acid hydrolysis, and are called in this way due to their physical characteristics of stiffness, thickness, and length. [5]

Samir et al. report that cellulose whiskers are regions growing under controlled conditions, which allows individual high-purity crystals to form. Their highly ordered structure may not only impart high resistance, but also make significant changes to some important properties of materials, such as electrical, optical, magnetic, ferromagnetic, and dielectric nature, as well as concerning conductivity [6].

The cellulose polymer constituting the whiskers is formed by units of glucose containing three free hydroxyl groups bonded with carbons 2, 3, and 6, which are responsible for the intermolecular interactions, which successive structures are formed from, giving rise to the cell wall of the fiber: micelles, chain grouping into bundles; microfibrils, micelle aggregates; and fibrils, microfbril aggregates that can be also called macrofibrils. Therefore, the microfibrils composing the fibers, resulting from the cellulose molecule arrangement, are constituted by crystalline, highly ordered; and amorphous, disordered regions [7].

2. Materials and methods

There are different techniques to produce nano crystalline cellulose; these methods have been reviewed by Duran et al. [8]. In this work chemical method ha been employed. After cutting cotton linter to small piece about 2 cm to eliminate impurities cotton linter treated with soda then acid treatment took place by H_2SO_4 (65% w/w) for 3 hours then neutralization step took place by 10% (w/w) sodium hydroxide solution. The final pH of suspension was adjusted about 6.5. Suspension drained by deionized water for 1 hour. The washing water was being replaced every 15 minutes. Finally Nano crystalline Cellulose was obtained by ultrasonic treatment at 40 KHz for 15 minutes.

X-Ray Diffraction (XRD) was applied to determine production of nano crystalline cellulose. Scanning took place at 2θ= 2-40 by 0.05˚ step and step time was 1 second. Experiment was done at 25˚ degrees of siliceous.

3. Results and discussion

Regarding diagram obtained through X-Ray Diffraction analysis (fig 1) it was confirmed that nano crystalline cellulose has been obtained during mentioned process above. As there was three peaks in 14.7, 16.5 and 23.2˚. It seems that nanotechnology has the potential to change and improve food packaging industry through designing new applications of cellulose with different properties. It is known that cellulose is the most abundant, natural, renewable and biodegradable polymer that occurs as a nanostructure in plants, giving resistance. The most important aspects of this material are its bioavailability [9].

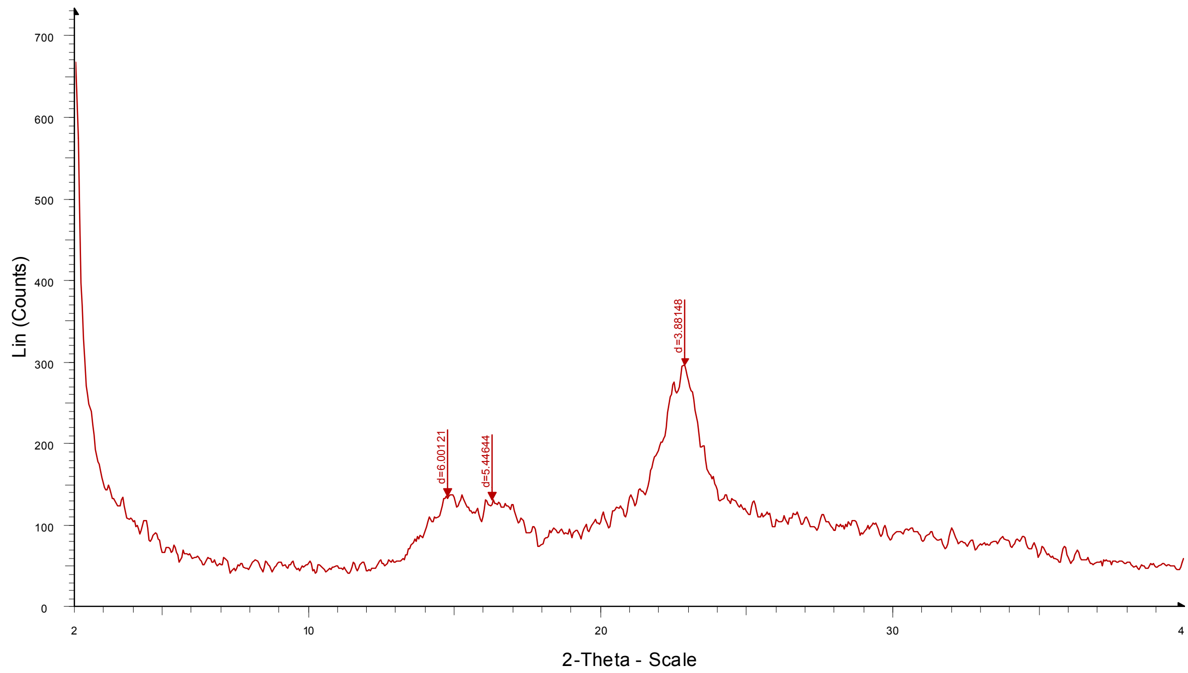

Fig. 1: X-Ray diagram for obtained nano crystalline cellulose

Engineering fiber and design of lignocelluloses or rod-like cellulose nanoparticles and micro fibrils to get high value-added products with special performance can reach new markets through nanotechnology [10, 11]. According with Lima and Borsali charged rod-shaped cellulose whiskers are a good model for understanding the rod-particles behavior with polyelectrolytic properties. Mechanical behavior was pointed out as an important feature of the cellulose whiskers as fllers for reinforcements in different polymer matrices; this reinforcing effect is mainly because of the percolation effect [12].

A recent review showed that nanocrystalline cellulose exhibited intriguing scientific and engineering discoveries and advancements. However, the authors pointed out that, the field is still in its infancy and open to opportunities for new advancements and discoveries [13]. Other authors showed that cellulose nanocrystals are attractive material to incorporate into composites because they can introduce additional strength gains with highly versatile chemical functionality [14].

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