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DETERMINATION OF THE PHYSIOCHEMICAL PROPERTIES OF BACTERIAL CELLULOSE PRODUCED BY LOCAL ISOLATES OF *ACETOBACTER XYLINUM*

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Abstract

The recent study aimed to isolates *Acetobacter xylinum* from local home vinegar samples processed of apple, dates and grape. From the total fifty; Twenty-one isolates observed on the surface of HS-agar medium, only four isolates showed transparent zone around the colony on GYC agar plates. The isolates (B1, B2, B3 and B4) were examined for bacterial cellulose production in HS broth medium. The dry weight of crude cellulose produced by each isolates was measured and ranged from 0.36 - 0.42 gm. The pH value of bacterial cellulose were (6.2 - 6.9), approximately equal and nearly to the neutral values with comparison with plant cellulose. The thickness of bacterial cellulose membrane is a key parameter in preparing film, **t**he initial thickness of the wet BC membrane was measured as 32 micrometers and after drying the computed thickness of BC membrane decreased to 0.4 micrometers. The average tensile strength value and the average elongation at break value of the dried BC films were 34.5 MPa and 5.2% respectively. The micrograph of BC shows three dimensional porous network structure formed by ribbon fibrils, randomness of fiber distribution without any specific orientation. The SEM micrograph obtained for the purified Bacterial Cellulose (BC) shown a very similar structure with the commercial Plant Cellulose (PC). Furthermore, the fibrils were densely packed ; the aggregated BC showed flat and were smoother surface compared to the PC. X-ray diffraction analysis is used to study the physical properties of both BC and PC samples such as morphology, the degree of crystallinity, crystal size and to categorize cellulose as type I_{α} or I_{β}. 2θ range 5° to 40° is usually adequate to cover the most important area of the XRD pattern. The pattern for BC revealed four main peaks were at 2θ = 14.53, 16.78, 22.79 and 34.67, corresponding to the crystallographic peak plane of (110), (110) (200) and (004), respectively. The X-ray diffractograms of purified BC sample showed their amorphous nature. The distinguishing broad peaks at 3452.58 cm^{-1} for BC and 3356.14 cm^{-1} for PC indicates OH is stretching intra molecular H-bond for cellulose1 . Sharp peaks appeared CH stretching at 2924.09 cm^{-1} in BC and 2900.94 cm^{-1} in The pattern for BC revealed four main peaks were at 2θ = 14.53, 16.78, 22.79 and 34.67, corresponding to the crystallographic peak plane of (110), (110) (200) and (004), respectively. The X-ray diffracts grams of purified BC sample showed their amorphous nature. The FTIR spectrum shown the distinguishing broad peaks at 3452.58 cm^{-1} for BC and 3356.14 cm^{-1} for PC indicate OH is stretching intermolecular H-bond for cellulose 1. Sharp peaks appeared CH stretching at 2924.09 cm^{-1} in BC and 2900.94 cm^{-1} in PC. Overall, these data suggested that the BC and PC samples were the typical profile of the cellulose I crystalline structure and is typical of cellulose isolated from other fiber sources. The present results proved that BC and PC have a similar chemical bond and functional groups.

Key word: *Acetobacter xylinum*, Bacterial cellulose, X-Ray Diffraction (XRD).

Introduction

Microbial cellulose is an exopolysaccharide produced by various species of bacteria. Production of cellulose from *Acetobacter xylinum* was first reported in 1886 by A.J. Brown , who identified a jelly like translucent mass formed over the surface of liquid fermentation medium; mother of vinegar (Czaja *et al.,* 2006). *A. xylinum* can be produce cellulose in the several methods including static culture (Kralisch *et al.,* 2010) agitating culture (Tse *et al.,* 2010), and designing bioreactors; rotating disk bioreactor, airlift bioreactor, bioreactor with silicone membranes and bioreactor with spin filters (Song *et al*., 2009; Ul-Islam *et al.,* 2015). The choice of cultivation methods is dependent on further biocellulose commercial destination; generally utilized two main techniques of

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bacterial cellulose production are static and agitating cultures. Every technique has its own unique properties (Lee *et al*., 2014; Gromovykh *et al*., 2017). One of the most advanced kinds' non- photosynthetic bacterium can utilize glucose, glycerol or other organic substrates and turn them into pure cellulose (Brown *et al.,* 1976; Yamada *et al.,* 1997). The amount of BC synthesized from *Acetobacter* spp. Varies from 1 to 4% (w/v) depending on fermentation culture media and the carbon compounds (Lin *et al.,* 2013).

Cellulose is the most plentiful biological polymer found on earth and is a major component of plant cell wall (Auta *et al*., 2017) it was extensively used in the industries for the production of different products. This leads to the exhaustion in forest resources causing in several ecological problems. To overcome, these issue the use of other alternative sources (Yenn *et al*., 2017). Thus, microbial cellulose can be used as an alternative for plant cellulose products. It can be produced by some fungi, tunicates and certain algae (Brown, 2004); also various species of Gram-positive and negative bacteria are able to produce cellulose very efficiently (Dahman *et al*., 2010 and Chawla *et al*., 2009 Baldan *et al*., 2001 and Sun *et al*., 2007). Even thought, bacterial cellulose and plant cellulose are chemically the same, in the form of β-1, 4-glucans, both of them have the same molecular formula as $(C_6H10O_5)n$ with non–water soluble and non-branched structure, but varies from macromolecular structure and physical features (Gea, *et al*., 2011; Biyik and Coban, 2017). It is distinguished over plant-derived cellulose in being environmentally safe chemically pure comprises of micro-fibrils that are free of lignin, pectin and hemicellulose and other non-cellulosic compound the elimination of which was found to cause ecological hazards (Kamarudin *et al*., 2013). On the other hand BC possesses special and superior physicochemical properties such as a higher degree of crystallinity and polymerization, a high water absorption capacity (Tang *et al*., 2010) good shape retention, large surface area, metabolic inertness, better tensile strength, good flexibility and extremely insolubility in most of the solvent. Moreover, BC has a good biodegradability, biocompatibility, and elasticity, non-toxic with no allergenic side effects materials and easy to be modified chemical ability (Pecoraro *et al*., 2008; Wei *et al*., 2011 and Lin *et al*., 2013). Owing to its superior properties, BC founds multifarious application in many fields like the food industry (Shi *et al*., 2014), optically transparent composites, film coatings as drug delivery systems, textile and paper industry (Klemm *et al*., 2005 and Singh *et al*., 2016); biomaterials in cosmetics and medicine (Amin *et al*., 2012). In the manufacture of audio products such as loud speaker diaphragms (Hassan *et al*., 2014), in this study the physicochemical features of bacterial cellulose produced by *Acetobacter xylinum* were investigated; the physiochemical examination was used to determine and compared; the characteristic, chemical and physical properties of BC, this includes scanning electron microscopy (SEM), mechanical behavior, pH, X-ray Diffraction (XRD), Fourier transform infrared (FTIR) analysis, thickness, swelling behavior. Moreover, the properties of bacterial cellulose also had been compared with the plant-based cellulose powder.

Materials and methods

Sample preparation and Isolation of cellulose producing-bacteria

Vinegar of fermented fruit (apple, date and grape) samples collected from August 2016 to March 2017, twenty-six (26) samples was collected from various markets in Baaqubaa and Erbil cities. One ml of each vinegar sample was taken and added to the Erlenmeyer flask containing 30ml of standard HS-medium broth, and incubated at 30°C for 7-10 days , then a loop full of cell growth pellicle was streaked on the HS agar plates, incubated at 30°C for 72h. All cultures were purified, and then streaked on the (GYCA) medium to verify acid production; colonies which produced clear zone on $CaCO_3$ medium after incubation at 30^0C for 3 days; this could be a tool for the preliminary identification (Kadere *et al*., 2008; Klawpiyapamornkun, *et al.,* 2015).

Production of Bacterial cellulose:

The static cultivation method used in this study for the production of BC process, 10 ml of the bacterial inoculum was added to 90 ml of HS medium in a 500 ml flask (10^6 CFU/ml) and incubated at 30ºC for 10 days statically. The bacterial cellulose with highest cellulose production was selected.

Determination of physiochemical properties of the bacterial cellulose

The cellulose membrane which produced in the medium was harvested by filtration throughout the filter paper Watt man No. 1 at the end of the incubation period and washed with tap water, then immersed into 0.5 N NaOH solution overnight, to remove microbial cells and the remaining culture media. Thereafter, repeatedly washed with distilled water for about 4 to 5 times until the pH became neutral; Afterwards, the wet cellulose membranes were autoclaved and stored in aseptic conditions.

Measurement of pH

One gram of BC powder was mixed with 50 ml of distilled water at pH 6.8 and the suspension was allowed

to stand with accidental stirring for 30 min using a hot plate and magnetic stirrer, the pH of the solution was measured using the electronic digital pH meter (Inolab WTW Series 720), (Halib *et al.,* 2012).

Measurement of BC membrane thickness

Bacterial cellulose pellicles thickness was measured by using a digital micrometer (Mitutoyo, model: 293-185, Japan), at 15 different positions on each pellicles and then values were averaged as described by (Padrao *et al.,* 2016).

Mechanical behavior

The mechanical properties of dried BC films were examined for tensile strength and elongation at break point using a universal testing machine (Model A 13000, Gotech, Taiwan) according to the ASTM D 882-02 guidelines (ASTM, 2002). The BC films were cut into rectangular strips 50 mm length, 5 mm width and 0.5 mm thickness. The tensile strength and break strain were recorded and the average values determined.

Swelling behavior

One gram of dried BC and PC sample were thoroughly mixed with 50 g of different solutions (phosphate saline buffer, acetic acid, acetone, distilled water and dimethyl sulfide). The suspension was allowed to stand at room temperature for 2 hours, and then the suspensions were centrifuged at 3500 rpm for 30 min, after centrifugation, the supernatant was removed and the moist sample precipitate was weighed. (Goh *et al.,* 2012). The results were expressed as a gram of (water/ sample) by using the following Equation:

Degree of swelling= (LRV) = wet weight – dry weight / dry weight × 100

Scanning electron microscope (SEM) of bacterial cellulose fibers

SEM was performed in the Scientific Research Center - Soran University-Iraq. Scanning electron microscopy was used to examine the BC and SC samples composition and structure. At the same time, SEM gives information about the external morphology of the sample. Thin layers of samples were coated with gold using a vacuum sputter-coater to enhance the conductivity of the sample and getting better images. An image of all samples was then taken at 5 and 25 kv using a Hitachi S 4700 SEM (Alyamani and Lemine, 2012).

XRD analysis

XRD is the main technique for the investigation of crystal structure, degree of crystallinity and size of cellulose crystals samples were determined using an X-ray differactometer (PAN analytical) BC cellulose samples were pulverized to fine powder to fit into sample holder with operating at 45 KV and filament emission of 40 mA respectively, using a copper Kα radiation generation at a temperature of 25°C. The diffraction data were collected at a scan angle range 2, of 5-50 degree (Mohammad kazemi *et al.,* 2015). The crystallinity index, CI% of cellulose was calculated as a function of the maximum intensity of the lattice diffraction from the (020) plane, at an angle of 2θ = 22.5o and Iam the intensity of the baseline measured at 2θ =18o, as described by Segal et al. method (Segal *et al.,* 1959) using the peak intensity equation [Eq. (1)].

$$CI\ (\%) = (I200 - Iam)/I200. \quad (1)$$

Moreover, the average crystallite (CrS) size was calculated from the X-ray line broadening of the (002) lattice diffraction according to Scherrer's equation [Eq. (2)]. Where K is the correction factor (K= 0.94); λ is the radiation wavelength (λ = 0.15416 nm); β is the full width at half maximum height and θ is the Bragg's angle corresponding to the (002) plane.

$$CrS \quad \frac{K\lambda}{\beta \cos\theta} \quad (2)$$

Fourier transforms infrared (FTIR) analysis

FTIR was performed in Education College in Salahaden University as follows: A little quantity of the BC, SC samples were mixed thoroughly with (2%) potassium bromide, crushed with a mortar and pestle and compressed into small discs separately. Then FTIR spectrum was measured at wave number ranging from 400–4000 cm^{-1} (Shaharuddin and Muhamad, 2015).

Results and Discussion

Isolation and Identification of *Acetobacter xylinus*

Twenty-six vinegar samples from (apple, dates and grape) were collected; from the total samples twenty-one isolates appeared dense and smooth colonies with creamy colour were observed on the surface of HS-agar medium. Suspected colonies were purified by culturing onto GYC media to confirm acetic acid production. Only four isolates showed transparent zone around the colony on GYC agar plates, these colonies were belonged to acetic acid bacteria as mentioned by Lisdiyant *et al.,* (2001) as well as the characters of these isolates were closely associated to acetic acid bacteria as revealed by Yamada *et al.,* (1999).

Screening of local *Acetobacter xylinum* for cellulose production

The ability of the isolates (B1, B2, B3 and B4) was examined for bacterial cellulose production in the HS broth

medium. The dry weight of crude cellulose produced by each isolates was measured, the results appeared in table 1 indicated that all of the isolates produced cellulose, the formation of white pellicle at the near the surface of the static culture medium. The dry weight of cellulose ranged from 0.4-0.38 gm. The differences in cellulose production amount were due to variation to pyrophosphorylase activity, which has an important role in cellulose biosynthesis, and due to the effect of environmental circumstances (Bielecki *et al.,* 2005).

Physiochemical properties of the bacterial cellulose:

pH Value

The pH value of BC and PC samples were 6.2 and 6.9 respectively. The pH of the supernatant liquid from the samples and distilled water mixture was measured for both BC and PC were approximately equal and nearly to the neutral values. These results are consistent with the British Pharmacopoeia. For more information, the British Pharmacopoeia suggests that the pure cellulose ought to have a pH of supernatant liquid around pH 6.2 – 6.9 (United States Pharmacopaea 2004 and British Pharmacopoeia 2004). The prepared both bacterial and plant cellulose powder's pH during this study was within this description.

Thickness measurement

The thickness of bacterial cellulose membrane is a key parameter in preparing film, the initial thickness of the wet BC membrane was measured as 31-32 micrometers and after drying the computed thickness of BC membrane decreased to 0.4 micrometers as shown in table 1 and Fig. 1. The difference between BC membrane thickness measures can be due to several factors, such as incubation time, culture temperature and medium conditions. Tang *et al.,* (2010) has mentioned that during cultivation, the yield of BC and cell mass increased with time and accumulation of more fibrils.

Mechanical performance

The mechanical properties, which consist of the tensile strength and elongation at break of the BC films with an average thickness of (0.4) µm were shown in table 1, the average tensile strength value and the average elongation at break value of the dried BC films were 34.5 MPa and 5.2% respectively. Results indicated that the BC films produced by *Acetobacter xylinum* had high strength; this due to the powerful H-bonds among cellulose molecules and high crystallinity led to the highest strength and tensile strength of BC films. These results agree with the findings of other studies, but overall the values regarding the parameters of the mechanical properties differ according to the methodology followed. Moreover, mechanical properties of BC films depended on the numerous factor, such as incubation time, failure stress under uniaxial (Keshk, 2006), the drying method applied (Rani *et al.,* 2011), the concentration of NaOH used for BC treatment (Shezad *et al.,* 2010) as well as the pressure applied to the membrane before drying (Tang *et al.,* 2010).

A B

Fig. 1: A the wet thickness and B dried thickness of bacterial cellulose films.

Table 1: The Physiochemical Properties of Local Bacterial Cellulose.

Characters	Bacterial Isolates			
	B1	B2	B3	B4
Wet weight (gm)Dry weight	34.20.40	34.50.42	33.90.36	340.39
pH value 6.5	6.5	6.2	6.9	
Wet thickness(µm)Dry thickness(µm)	320.4	310.4	320.4	320.4
Tensile strength(MPa)% of elongation	34.55.2	34.45.1	34.55.2	34.45.2

Swelling and Absorption Characteristics

The water absorption capacity values of BC in comparison with plant cellulose in various type of solvent at room temperature illustrated in Fig. 2. Recent evidence suggests that the inter-crystalline and intra-crystalline in cellulose was possible to highly swelling in specific solvents (Mantanis *et al.,* 1995). In general, BC was higher retention level in all solvents compared to PC, BC returned to the reflection of higher level of swelling characteristic of bacterial cellulose, this is because BC has three-dimensional nanofibrils network structure that can absorb higher amount of water. Several researchers reported that water retention value of BC up to 100 times of its dry weight (Czaja *et al.,* 2006; Lina *et al.,* 2011; White and Brown, 1989).

According to (Robertson 1964), the swelling power of the cellulosic fibers within the solvent was affected by the degree of molarity volume of the solvent that provided to the H- bonding ability and the cohesive energy density of the solvent. (Robertson 1964 and Cheng *et al.,* 2010).

The result additionally represented that bacterial cellulose shows the best swelling value ranging between (18 and 210%) in all the six solvents than that of PC (10 and 90%). The result during this study mentioned that; dimethyl sulfoxide resulted within the best cellulose swelling value for both the BC and PC, compared to the water. However, acetone showed the lowest cellulose swelling value. The obtained results match those observed in earlier studies (Mantanis *et al.,* 1995 and Yenn *et al.,* 2017).

The LRV in commercial and bacterial cellulose-based products is most important mainly when it was used as a binder, adhesive, thickener, encapsulating agent, fat-sparing agent, gelling agent, film former, and texturizer and with several other applications in the food and non- food products (Shi *et al.,* 2014 and Kaur *et al.,* 2011).

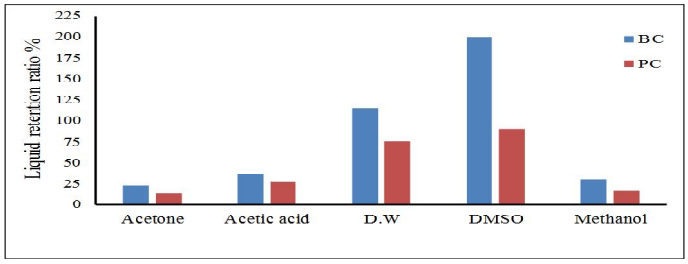


Fig. 2: Swelling of bacterial cellulose and the commercial PC in five different solvent.

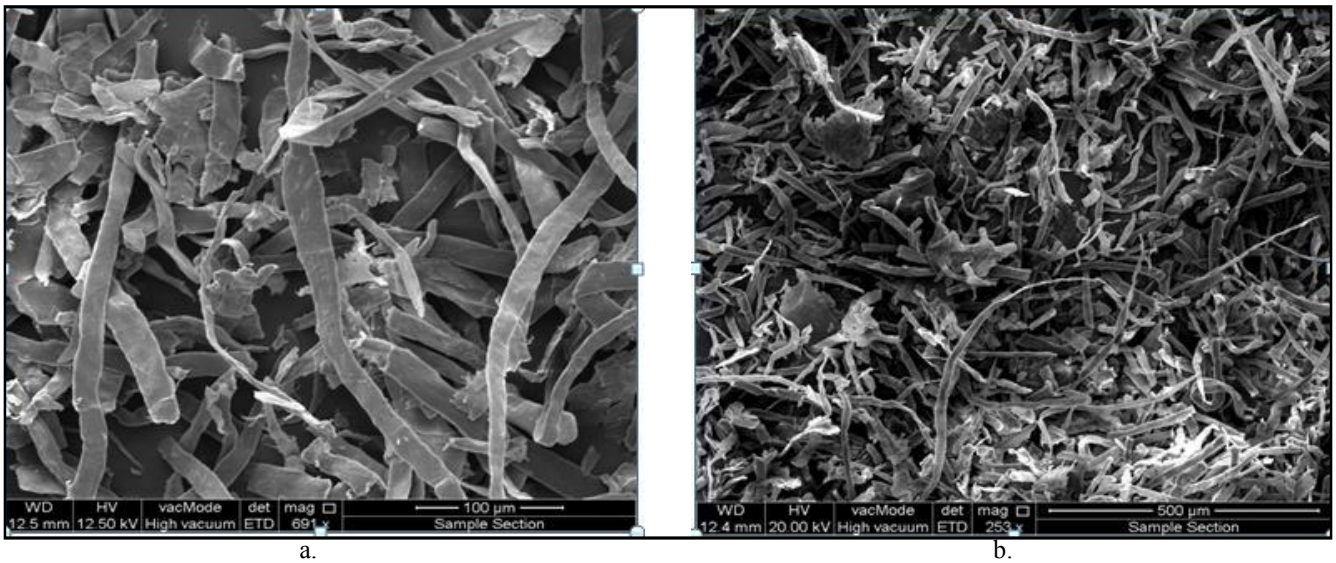
Scanning Electron Microscopic (SEM)

The morphology of the surface structure of the dried BC compared with PC was studied by SEM analysis at different magnifications that are presented in Fig. 3. The micrograph of BC shows three dimensional porous network structure formed by ribbon fibrils, randomness of fiber distribution without any specific orientation as mentioned in Nakagaito *et al.,* (2005). The SEM micrograph obtained for the purified BC shown a very similar structure with the commercial PC. Furthermore, the fibrils are densely packed which conferred a morphological characteristic similar to the plant based cellulose powder. Moreover, the aggregated BC showed flat and smoother surface compared to the PC. Observation of BC under 500xmag (Fig. 3) showed that the particles were fibrous with an irregular size and shape. Besides, the fibril thickness was much thinner than the typical plant cellulose fibrils. This result in agreement with the previous other studies, as Khattak *et al.,* (2015) and Halib *et al.,* (2012) additionally, The bacterial cellulose shows cellulose pilleclic having small gaps between the fibers and the fibers are intertwined closely, while the plant based cellulose has much larger fiber which are closely entwined.

X-Ray Diffraction (XRD)

X-ray diffraction analysis was used to study the physical properties of both BC and PC samples such as morphology, the degree of crystallinity, crystal size and to categorize cellulose as type I_α or I_β. 2θ range 5° to 40° is usually adequate to cover the most important area of the XRD pattern. (Treacy and Higgins 2007). The X-ray diffraction of both samples must arise at the same peak position of the standard sample in order to identify the structure. The widths of the peaks are related to the size of crystalline (Von Ballmoos and Higgins, 1990). In this research XRD patterns is used to determine the phase, crystallinity and crystal size of the BC and PC samples were determined by equation 1 and 2, respectively.

The X-ray diffraction of the BC and PC were shown in figure 4 and 5 respectively. The pattern for BC revealed four main peaks were at 2θ = 14.53, 16.78, 22.79 and 34.67, corresponding to the crystallographic peak plane of (110), (110) (200) and (004), respectively. The X-ray diffractograms of purified BC sample showed their amorphous nature. Overall, these data suggested that the BC and PC samples were the typical profile of



a. b.

Fig. 3: SEM micrographs of a) bacterial cellulose (BC) and b) the commercial (PC) samples.

the cellulose I crystalline structure and was typical to cellulose isolated from other fiber sources. These results agree with the findings of (Hult *et al.,* 2003; Sugiyama, Vuong *et al.,* 1991; Kumar *et al.,* 2014; de Olyveira *et al*., 2017). In this study both Iα and Iβ, crystal cellulose were estimated, which is used to compare the BC and PC. According to obtained data from the X-ray diffractograms profiles the crystallinity, crystallite size, band position (2) and d-spacing of celluloses were calculated and listed in table 2, results from both the diffractograms display that the BC has a higher degree of crystallinity compared to the commercial PC due to the free from lignin and hemicellulose which is often present in PC. (Kumar *et al.,* 2014). The high crystallinity value of BC causes increase tensile strength of cellulose. Thus, it is more suitable for use as biomaterials in industries that require cellulose. 9-2014 findings obtained in the present study gave a higher crystal size (9.4) as compared to the bacterial cellulose fiber which was produced in HS medium. Crystallite size of BC fibres and PC was calculated 8.3 nm and 9.4 nm, respectively. According to (Akerholm *et al.,* 2004; Park *et al.,* 2010) infrared analysis and X-ray diffraction revealed that the two common crystalline forms of cellulose appointed; known as cellulose I and II. Native cellulose I, which is synthesized by the majority of real plants and also by acetic acid bacteria in static culture. (Panicker *et al.,* 2017) reveled that cellulose I comprises two sub allomorphs called cellulose Iα and Iβ, these forms are allocated to triclinic and monoclinic unit cells, respectively. By using the discriminant analysis described by Wada and Okano (2001), it is achievable to categorize native cellulose as Iα - rich or Iβ - rich, where $Z > 0$ indicates Iá-rich type and $Z < 0$ indicates Iβ- predominant form. As can be seen in Table(x), the negative Z value, for commercial PC indicate that the cellulose sample belong to the Iβ dominant type; in contrast, positive Z value ($Z > 0$), for BC, suggesting that cellulose sample was rich in cellulose I α crystal structures.

Table 2: X-Ray Diffraction Patterns Analysis of the BC and PC

Sample	Crysta-llinity	110		110		Z-value	Crystal size(nm)
		2θ	d(nm)	2θ	d(nm)		
BC	94.3	14.259	6.208	16.738	5.328	21.429	8.3
PC	82.4	16.0200	0.5126	22.231	0.4048	-46.30	9.4

Fourier Transform Infrared Spectroscopy (FTIR)

The location and intensity of infrared absorption bands of materials are very specific for materials. Similar a fingerprint of a person, the infrared spectrum by fourier transforms infrared is extensively characteristic for material (Gunzler and Gremlich, 2002). FTIR analysis mainly used to identify the bacterial cellulose by comparing with the reference plant based cellulose from sigma- Aldrich (high purity grade reagents).

The FTIR spectrum of BC produced from acetic acid bacteria and commercial PC were shown in Fig. 6. The distinguishing broad peaks starts at 3452.58 cm^{-1} for BC and 3356.14 cm^{-1} for PC indicates OH is stretching intramolecular H-bond for cellulose1. Sharp peaks appearing the CH stretching showed at 2924.09 cm^{-1} in BC and 2900.94 cm^{-1} in PC. Peaks centered at 1645.28 cm^{-1} in BC, at 1647.21 cm^{-1} in PC could be appeared the presence of C=O (Surma-Œlusarska *et al.,* 2008). The absorption spectra band at 1454.33 cm^{-1} in BC, at 1431.18 cm^{-1} in PC are assigned to the CH_2 bending (Pavia *et al.,* 2008; Spiridon *et al.,* 2011). The peaks observed at

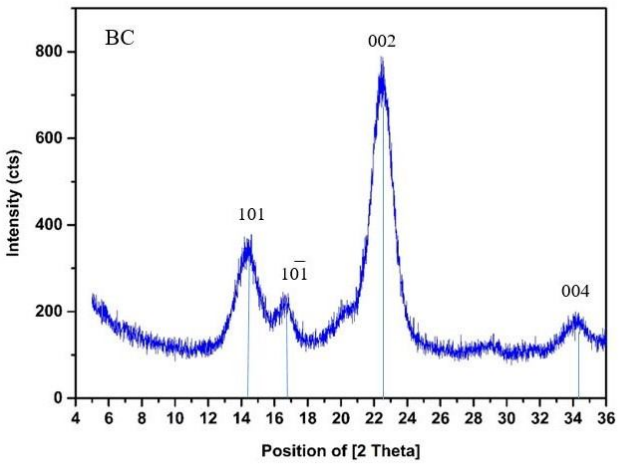


Fig. 4: XRD patterns of bacterial cellulose sample.

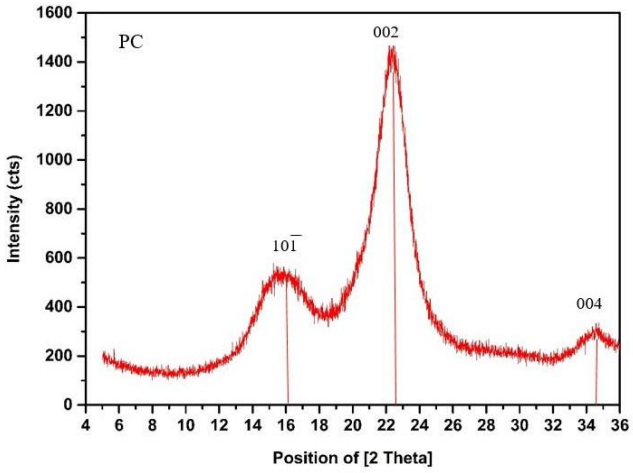


Fig. 5: XRD patterns of commercial plant cellulose sample.

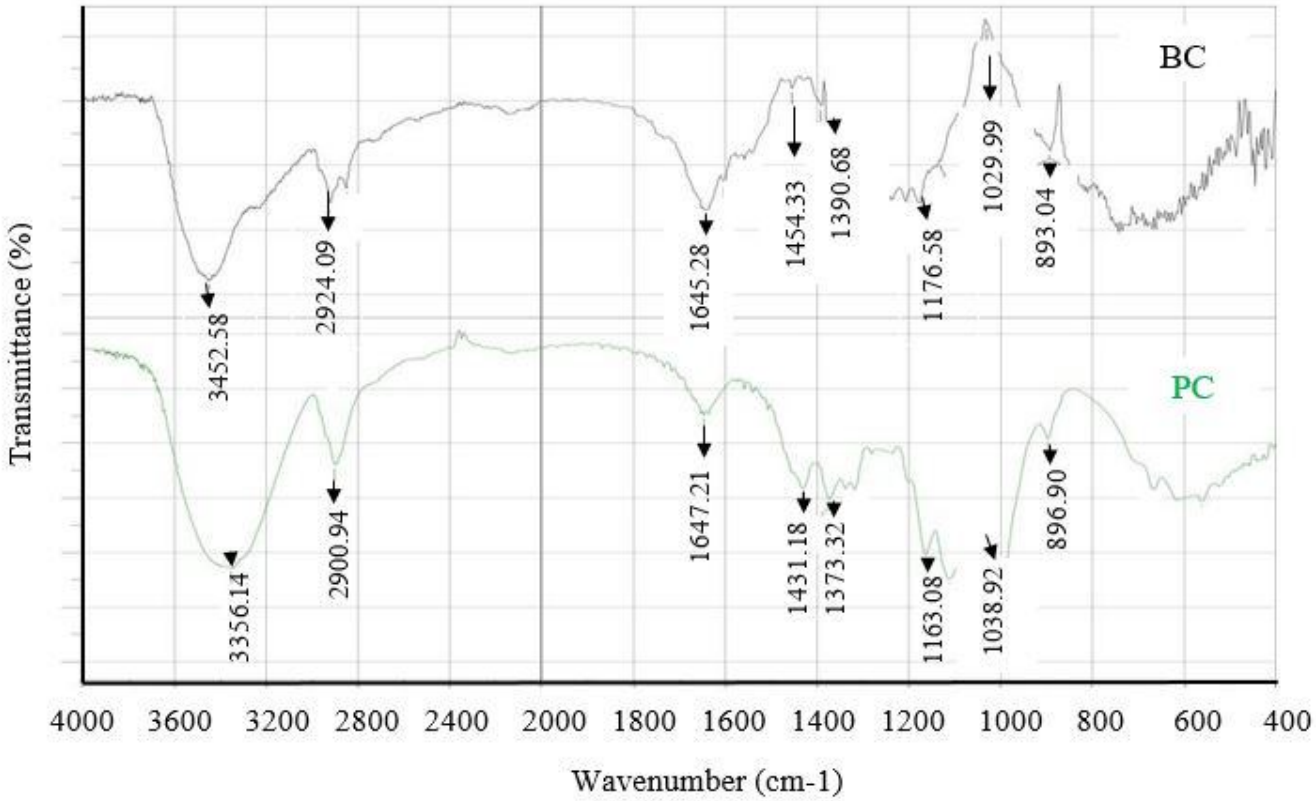


Fig. 6: FTIR Spectrum of Bacterial Cellulose and Plant Cellulose.

1390.68 cm^{-1} in BC and 1373.32 cm^{-1} in PC governed by symmetric deformation and bending vibration of C-H (Kumar *et al.,* 2014 and Ul-Islam *et al.,* 2011). However, it is clear that the absorption band at 1176.58 cm^{-1} in BC and 1163.08 cm^{-1} in PC indicates C-O-C stretching. Peaks at 1029.99 cm^{-1} in BC and at1038.92 cm^{-1} in PC indicate C-O stretching. According to Nelson and O'Connor (1964), another characteristic band at 893.04 cm^{-1} in BC and 896.90 cm^{-1} in PC was ascribed to anomeric carbons for β, 1-4 glucosidic bond/linkages in cellulose.

Previous studies have reported that pure cellulose spectrum had distinguished peaks of 3350 cm^{-1} that shoulders about 3400 cm^{-1} to 3500 cm^{-1} and it indicates O-H stretching, 2800 cm^{-1}, 1 to 2900 cm^{-1} indicates C-H stretching, 1160 cm^{-1} indicates C-O-C stretching and 1035 cm-1 to 1060 cm^{-1} indicates C-O stretching. Other fingerprint regions for cellulose are peaks about 1300 cm^{-1} indicating C-H bending and about 1400 cm^{-1} indicating CH_2 bending (Ramírez-Flores *et al.,* 2009; Marchessault and Sundararajan, 1993). This result especially proved that BC and PC have a similar chemical bonding and functional groups. Therefore, the

chemical nature and spectra bands of BC were confirmed by the FTIR spectra of PC. The difference between diffraction curves of BC and PC was restricted to the intensity of some peaks. The curve of peaks might be different, relying on the source of cellulose. FTIR spectra from figure depicted that BC without contaminants like hemicellulose or lignin as it is in plant based cellulose. The purity of cellulose can be used in special application in varied specific fields.

Conclusion

The study was designed to determine the characteristics of bacterial cellulose produced by fermentation employing the *Acetobacter xylinum.* The information collected had confirmed that pure bacterial cellulose demonstration superior and promising properties compared to plant cellulose products. In summarize, this data on preliminary study of bacterial cellulose (surface morphology, thickness, FTIR and XRD analysis, mechanical and swelling properties) can be employed as an alternative to replacing the plant cellulose product for various applications in the industries such as food, packaging material, cooking surgery cosmetic and biomedical industries. As the potential of this material is great, the development of the commercial applications of about BC depends on the discovery and use of all its distinctive characteristics.

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