Synthesis and Characterization of Polymeric Drug Binder from Tobacco Waste

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In Indian agriculture, tobacco has a prominent place. So, it is but natural that tobacco waste or dust is generated at various stages of post-harvest processing of tobacco and also while manufacturing various products. As rational production and processing of tobacco plant must include the entire biomass, both the main product leaves as well as stalks that remain after harvest. Residues (stalks and small leaves) and significant amounts of leaf scrap and waste generated during processing of tobacco, can serve as a very important secondary raw material from after final processing, a great number of products could be obtained in industry considering that these stalks contain a certain amount of cellulose. The waste obtained after nicotine extraction was utilized for cellulose extraction. The extracted cellulose was converted to value-added product such as cellulose acetate. Prepared cellulose acetate is characterized by Fourier transform infrared spectroscopy (FTIR).

Key words: cellulose, cellulose acetate, degree of substitution, extraction, FTIR.

INTRODUCTION

Tobacco is an important crop cultivated in India and plays a vital role in economy. Exploitation of the crop for extraction of phytochemicals is a viable alternative. Presence of substantial amounts of useful phytochemicals like proteins, nicotine, solanesol, cellulose and organic acids have enhanced the scope for alternative uses of tobacco (Rao N. et al, 2007; Bartholomew T, 1986).

As rational production and processing of tobacco plant must include the entire biomass, both the main product leaves as well as stalks that remain after harvest. Residues (stalks and small leaves) and significant amounts of leaf scrap and waste generated during processing of tobacco, can serve as a very important secondary raw material from after final processing, a great number of products could be obtained in industry considering that these stalks contain a certain amount of nicotine (Bandosz TJ, 2015).

On the other hand, stalk is an important secondary raw material due to its high cellulose content. Thus; stalks contain 35 % to 36 % of cellulose, while the midrib has 10 % to 15 % of cellulose (Jovanovic S. et al, 2002).

In older leaves, cellulose is present in a crystalline form, while in younger leaves an amorphous form of cellulose prevails. Leaves contain average 10 % to 12 % of cellulose (Baker et al., 2004; Santos RM et al., 2013). Cellulose is natural polymer while natural polymers have advantage of high bio-capability and less immunogenicity. So, a special attention has been shown to natural polymer, other natural polymers are chitosan, starch pectin, alginate and many more (Roy H. et al, 2016).

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Polymers are substances whose molecules have high molar masses and compressed of a large number of repeating units. Polymers can form particles of solid dosage form and also can change the flow property of liquid dosage form. Polymers are the backbone of pharmaceutical drug delivery systems. Polymers have been used as an important tool to control the drug release rate from the formulation (Raiizada A. et al, 2010).

They are also mostly used as stabilizer, taste-making agent, and proactive agent. Modern advances in drug delivery are now predicated upon the rational design of polymers tailored specific cargo and engineered to exert distinct biological functions. Polymers are both naturally occurring and synthetic. Among naturally occurring polymers are proteins, starches, latex and cellulose. Synthetic polymers are produced on a large scale and have many properties.

The polymers for the drug delivery system are classified on the following characteristics:

- Based on origin- The polymers can be natural or synthetic, or a combination of both
- Based on chemical nature- It can be protein based, polyester, cellulose derivatives, etc.
- Based on backbone Stability- The polymers can be degradable or non-biodegradable.
- Based on solubility- The polymer can hydrophilic or hydrophobic in nature (Chandel P. et al, 2013; Cordovez B, 2011).

Polymers act as an inert carrier to which a particular drug can be conjugated. There are numerous advantages of polymer acting as an inert carrier, for example, the polymer enhances the pharmacodynamics and pharmacokinetic properties of biopharmaceuticals though several sources, such as, increases the plasma ½ life, decreases the immunogenicity, boost stability of biopharmaceuticals, improves solubility of low molecular weight drugs, and has potential for targeted drug delivery (Rafiei P, 2017; Liu et al, 2016). So cellulose derivatives are widely used in bio adhesives. In several types of formulation such as buccal, nasal, oral, vaginal, transdermal formulation or with combination of other polymer (Deshponde Mc et al, 2009; Grabovac V et al, 2005; Liu et al, 2016).

Based on these considerations, the present work investigates the extraction of cellulose from agriculture wastes and extracted cellulose is chemically modified to cellulose acetate. Prepared derivative of cellulose was characterized by degree of substitution and fourier transform infrared spectroscopy (FTIR).

**MATERIAL AND METHOD**

**Materials**

Tobacco was obtained from Mahi tobacco, Anand, sodium hydroxide and solvent are used of laboratory grade alcohol were purchased from Atul chemical, Anand.

**Methods**

**Extraction of cellulose**

Tobacco waste after extraction of nicotine was used as a source of cellulose. Weigh 35 g sample of the tobacco waste (after extraction of nicotine) was stirred with 700 ml nitric acid 1.0 molar (M) at room temperature for 24 h, filter the raw material and wash residue. The wet material was subsequently dried in an oven at 100 °C for 24 h to purify extracted cellulose from silica and lignin it was extracted with 1.0 M sodium hydroxide for 24 h at room temperatures. It was then filtered using suction filtration. The solid was washed several times using distilled water. The solid was treated with an alkali solution of sodium hydroxide (6.0 M) for 6 h. The solid was then filtered to be used for cellulose extraction. The filtrate was neutralized with acid at a room temperature using sulphuric acid (5.0 M) under continuous stirring until constant potential of hydrogen (pH) in the range of 5–6 was reached. The resulting suspension hydrolysed material was then separated by vacuum filtration and washed roughly with distilled water to get cellulose.

**Preparation of cellulose acetate**

10.0 g of cellulose was added to a solution of 0.5 g of sulfuric acid in 50 ml glacial acetic acid. Uniform wetting of the cellulose is ensured by stirring with a glass rod, the closed bottle is then allowed to stand for 1 h at room temperature. After this pre-treatment, a mixture of 50 ml 95 % acetic anhydride and 20 ml glacial acetic acid is added and the bottle is closed and placed in a water bath at 50 °C. The cellulose dissolves after 15 min, the reaction being completed after another 15 min. This is called “primary solution”.

50 ml (80% acetic acid) was added to primary solution and stirred in order to destroy the excess acetic acid. The solution is held at 60 °C for another 15 min, and then poured into beaker; 50 ml of water are carefully stirred. After the addition of 200 ml water, cellulose acetate precipitates as a white, crumbly powder.

**Determination of acetyl contain and degree substitution via titration**

Shake 5 g of the sample, in a 250 ml Erlenmeyer flask with 150 ml of water. Stopper the flask and allow it to stand for 3 h, filter off the cellulose acetate and wash it with water. Titrate the combined filtrate and washings with 0.01 N sodium hydroxide solutions, using phenolphthalein indicator solution. Run a blank determination on water with same volume as used while extracting the sample.

\[
\text{% Acetic acid} = \frac{(A - B) \times N \times 0.06 \times 100}{W}
\]

Where, 
A = Sodium hydroxide solution used to titrate the sample, ml
Degree of substitution calculates on the basis of % acetic acid contain according on below equation.

\[
\% \text{ Degree of substitution} = \frac{3.86 \times \% \text{ Acetic acid}}{102.4 \times \% \text{ Acetic acid}}
\]

**FTIR Spectroscopy**

Fourier transform infrared spectroscopy (FTIR) is a technique which is used to obtain an infrared spectrum of absorption, emission, photoconductivity or Raman scattering of a solid, liquid or gas. An FTIR spectrometer simultaneously collects high spectral resolution data over a wide spectral range. This confers a significant advantage over a dispersive spectrometer which measures intensity over a narrow range of wavelengths at a time. In infrared spectroscopy, IR radiation is passed through a sample. Some of the infrared radiation is absorbed by the sample and some of it is passed through (transmitted). The resulting spectrum represents the molecular absorption and transmission, creating a molecular fingerprint of the sample. Like a fingerprint no two unique molecular structures produce the same infrared spectrum. This makes infrared spectroscopy useful over several types of analysis. The resulting products were characterized by FTIR spectroscopy using Perkin Elmer spectrum GX instrument, by the KBr pallet method.

**RESULT AND DISCUSSION**

**Extraction of cellulose**

Tobacco waste after extraction of nicotine was used as a source of cellulose which was extracted by solvent extraction method by using several reagents such as nitric acid, sodium hydroxide and many more. The extracted cellulose evaluated by its physical properties such as appearance, melting point and density. The extracted martial was white powder with melting point 265 °C and insoluble in water with density of 1.43 g/cm³ which confirmed that extracted martial was cellulose.

**Table 1:** Effect of concentration of nitric acid

<table>
<thead>
<tr>
<th>Serial number</th>
<th>Concentration of nitric acid (M)</th>
<th>Time (h)</th>
<th>Result (Cellulose obtains in g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5</td>
<td>24</td>
<td>1.25</td>
</tr>
<tr>
<td>2</td>
<td>1.0</td>
<td>24</td>
<td>3.87</td>
</tr>
<tr>
<td>3</td>
<td>1.5</td>
<td>24</td>
<td>2.15</td>
</tr>
<tr>
<td>4</td>
<td>2.0</td>
<td>24</td>
<td>1.85</td>
</tr>
</tbody>
</table>

Table 1 state that concentration of nitric acid varied from 0.5 M to 2.0 M and time as constant. Maximum yield was obtained at 1.0 M because nitric acid removes most of lignin and solubilized hemicellulose, while acid hydrolysis breaks the amorphous cellulose. As the concentration increases from 1.0 M there is loss in cellulose yield as this method is based on insolubility in water and resistance to diluted acid of cellulose respectively so the cellulose starts to degrade at higher concentration. In fact, when the solvent is saturated on the desired compound, the cellular phenomenon of diffusion stops and there has stabilization rate of extracted compound or decreased.

**Table 2:** Effect of time

<table>
<thead>
<tr>
<th>Serial number</th>
<th>Concentration of nitric acid (M)</th>
<th>Time (h)</th>
<th>Result (cellulose obtain in g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0</td>
<td>12</td>
<td>1.65</td>
</tr>
<tr>
<td>2</td>
<td>1.0</td>
<td>24</td>
<td>2.35</td>
</tr>
<tr>
<td>3</td>
<td>1.0</td>
<td>36</td>
<td>3.87</td>
</tr>
<tr>
<td>4</td>
<td>1.0</td>
<td>48</td>
<td>3.87</td>
</tr>
</tbody>
</table>

Table 2 states that extraction time (12 h, 24 h, 36 h, and 48 h) did not uniformly influence the recovery of cellulose. It also shows that 36 h is optimum reaction time. Because as the time increases, contact between solute and solvent also increases which lead to accelerate the extraction
yield. On the other hand, increased extraction time is uneconomical because there are no further changes observed in the extraction yield of cellulose. So, extraction for 36 h using nitric acid will result in satisfying cellulose extraction.

**Degree of substitution calculates on the basis of % acetic acid**

**Table 3:** Degree of substitution

<table>
<thead>
<tr>
<th>Serial number</th>
<th>Quality of cellulose acetate</th>
<th>D.S</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.87</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0.86</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>0.87</td>
</tr>
</tbody>
</table>

Table 3 indicates the degree of substitution calculates on the basis of % acetic acid contain according by using equation mention in above methods. Percentage acetic content which is 0.87 is indicating substitution of hydroxyl group by acetate group. Which was calculated on the basis of % acetic acid which was 18.8 % obtain from determination acetyl contain and degree substitution via titration.

The IR spectrum of cellulose acetate was shown in figure 2. Peak 1753 cm\(^{-1}\) indicate of starching of carbonyl group (C=O) of the acetyl group (-COCH\(_3\)) in cellulose acetate which also conform that cellulose acetate is successfully prepared.

**CONCLUSION**

The extraction of cellulose from tobacco waste was carried out successfully. Extracted cellulose was used to prepared their value-added derivative (cellulose acetate), which was successfully prepared and it is confirmed by FTIR. The best result for degree of substitution 0.87 obtained by carrying reaction at room temperature for 3 h, titrated with sodium hydroxide. This cellulose acetate can be used as diluent, fillers and test making agents in compounded medicines. Cellulose acetate modified with desirable functional groups, who visualize their use not only for controlled drug delivery systems, but also used for artificial organs lining, immunology testing, agents in drug targeting and substrates for cell growth. The most potential opportunities for these polymers in controlled drug delivery lie in the field of responsive delivery systems.

**REFERENCE**


APPENDIX

ABBREVIATIONS

FTIR - Fourier transform infrared spectroscopy
% - Percentage
g - Gram
ml - Millilitre
M - Molar
h - Hour
°C - Celsius
pH - Potential of hydrogen
min - Minute
N - Normal
IR - Infrared radiation
g/cm³ - Gram/centimetre cube
DS - Degree of substitution
Cm⁻¹ - Centimetre inverse
C = O - Carbonyl group
-COCH₃ - Acetyl group

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