IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

SUGARCANE BAGASSE – A USEFUL BIOWASTE

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Abstract - Sugarcane bagasse is a rich source of cellulose, hemicellulose, lignin, and some other extracts. Sugarcane bagasse generated in very high amounts has been a big issue for industries and the environment globally for the past few years. Therefore, an appropriate strategy is important that effectively solubilizes the lignin that exposes cellulose and hemicellulose for enzymatic action. Pretreatment decreases the biomass i.e., the crystallinity of cellulose, structural complexity of cell wall, and lignification process for its effective use in biorefinery. The present research describes the utility of sugarcane bagasse as a sustainable and renewable cellulose substrate for the production of industrially important multifarious value-added excipients i.e. Micro Crystalline Cellulose.
Index Terms - Sugarcane bagasse, Microcrystalline Cellulose, Lignin, Cellulose crystallinity, Structural complexity, Saccharification.

1. INTRODUCTION

1.1 EXCIPIENTS - "Pharmaceutical excipients are defined as the substances other than the active pharmaceutical ingredient, that has been appropriately evaluated for safety and are intentionally included in a drug delivery system but do not show the pharmacological effect" [1]

The excipients allow the drug substance to be applied to the patient in the right form and support the way and place of action without being active themselves. There are a variety of excipients in each class of it which firstly made compatibility with the drug or API to form stable and effective dosage form without being engaged in the pharmacological activity. [1]

Excipients have different roles in various formulations, some of the major roles assigned to the excipients can be[1],

1. In the processing of the drug delivery system during its manufacture.
2. Protect, support, or increase stability, bioavailability, or patient acceptability.
3. In product identification, enhance any attribute of the overall safety.
4. In the effectiveness and delivery of the drug in use.
5. Assist in maintaining the integrity of the drug product during storage.
6. Provide stable retention to the API.

Some of the widely used excipients are listed below[2],
Diluents, Binders, Flavoring agents, Disintegrants, Colorants, Lubricants, Glidants, Preservatives

1.2 MICROCRYSTALLINE CELLULOSE[3]

1. MCC is defined as "purified, partially depolymerized cellulose" produced by treating alpha cellulose, derived from lingo-cellulosic biomass with mineral acids.

2. MCC is used as an excipient, binder, and adsorbent in the pharmaceutical industry, and as a stabilizer, anti-caking agent, fat substitute, additive, and emulsifier in the food industry.
3. As gelling agents, stabilizers, and suspending agents in the beverage industry, and as fat substitutes, thickeners, stabilizers for emulsions, reinforcing agents for cement-based composite materials, and binders in cosmetics, which are derived from hardwood.
4. In the pharmaceutics field, microcrystal cellulose is used as a tablet filler ingredient.
5. Microcrystalline cellulose (MCC) is a pure partially depolymerized cellulose synthesized from α-cellulose precursor (type Iβ). It is obtained as a pulp from fibrous plant material, with mineral acids using hydrochloric acid to reduce the degree of polymerization.
6. The MCC can be synthesized by different processes such as reactive extrusion, enzyme-mediated, steam explosion, and acid hydrolysis.
7. It is manufactured by spray-drying the neutralized aqueous slurry of hydrolyzed cellulose. It is a valuable additive in pharmaceutical manufacturing, food, cosmetics, and other industries.

1.2.1 Extraction of Sugarcane Bagasse[4]

1. For extraction of cellulose from SCB, a 3-step delignification was implemented with acid, alkaline pre-treatment, and oxidation process.
2. The grounded SCB was treated with 5% HNO3, at 80°C for 2 hours with occasional stirring.
3. The reaction was quenched with distilled water and filtered. Then the residue was neutralized by washing with water.
4. After drying, the residue was further treated with 2N NaOH at 80°C for 2 hours with stirring.
5. Lignin was removed as filtrate and the residue was neutralized with distilled water to get a pH of 7
6. The delignified biomass was then bleached with 10% CH_3COOH/NaClO at 80°C for 2 hours with occasional stirring.
7. The resulting solution was diluted with distilled water and filtered. Cream white pulpy cellulose was extracted.
8. The cellulose was subjected to depolymerization in the presence of 10% H_2O_2 with 0.5 ml of H_2SO_4 at 80°C for 5 hours.
9. A white turbid solution was resulted. After filtration, the depolymerized cellulose was dried in an oven overnight at 60°C and ground to produce a white, crystalline powder.

1.2.2 Synthesis of Microcrystalline Cellulose[5]

- The MCC can be synthesized by different processes including extrusion and enzyme-mediated process. Other studies reported that it can also be synthesized by steam explosion and acid hydrolysis process.
- The acid hydrolysis process is preferable due to its shorter duration than others. It also gives the possibility to be applied as a sequential process rather than a batch-type process.
- The limited quantity of consumed acid is also an advantage of the process, while, despite the lower unit cost from fewer chemicals used, this process offered more fine particles of the MCC as the final product.
- Fibrous plant pulp is hydrolyzed by mineral acid under heat and pressure.
- In the presence of water and acid, the hydrolysis process breaks cellulose polymers into smaller chain polymers or microcrystals.
- Other celluloses, to which soluble components of cellulose such as beta and gamma celluloses, hemicelluloses, and lignin are dissolved with acid and water are separated during the washing process by water which is continued by filtration.
- The obtained pure cellulose has then been neutralized and given the slurry final product.
- This dispersion is dried to obtain the insoluble white precipitate, odorless, tasteless powder, which has later been characterized as microcrystalline cellulose. MCC is quite hygroscopic in nature but insoluble in water and swells when comes in contact with water.

1.2.3 Types of cellulose[5] –

1. Micro cellulose
2. Nano cellulose

1.2.4 Sources of cellulose[6] –

The various sources for extracting the cellulose include cotton (90%), flax (50-60%), sugarcane bagasse (40-50%), hemp (57%), sisal (40-50%), jute (85%), bamboo (40-50%)

- Sugarcane is an agricultural crop cultivated in tropical and sub-tropical countries in the world which occurs in larger quantities.
- India is considered the second largest country after Brazil for the cultivation of sugarcane. Sugarcane belongs to the *Gramineae* family and *Saccharum officinarum* is its botanical name.
- The estimated production of sugarcane crops in India is about 306 million tons, which islower than in Brazil but higher than in other countries.
- Sugarcane is transported to mills after harvesting from fields and used for juice extraction in sugar production.
- Nearly 81% of sugar demand is fulfilled globally by sugarcane cultivation.
- After the industrial processing of sugarcane, the major byproduct sugarcane bagasse is produced in large quantities.
- It is produced after cleaning and extraction of juice from sugarcane.

1.2.5 Composition[7] - Sugarcane bagasse, a fibrous residue consisting of nearly 31–44% cellulose, 20–33% hemicellulose, 18–34% lignin, 1.0–9.1% ash, and some other components. Typically, SCB is a highly heterogeneous material consisting of 40-45% of cellulose (mainly α-67 Cellulose) which have more crystalline domains, 30-35% of hemicellulose, a heterogeneous polysaccharide consisting of xylose, arabinose, galactose, and mannose sugars

- The remaining fraction is lignin 18 - 25% with a smaller amount of mineral, wax, and ash content.
- Due to excess production, bagasse is burnt as a means of solid waste disposal which causesenvironmental pollution and waste recycling has become the main issue of scientific research because of environmental concerns.
- SB can be harvested 100% from agricultural fields as compared to other residues as biofuel.
- Cellulose is an available natural polymer with long chains of D-glucose monomers connected through β-1, 4-glycosidic linkages, and also it is the most widely used organic material and acts as a structural backbone in plants.

1.3 PROPERTIES OF MCC[8] –

1.3.1 Moisture Content

- Several studies have confirmed that the moisture content of MCC influences compaction properties, tensile strength, and *viscoelastic* properties.
- Moisture within the pores of MCC may act as an internal lubricant which reduces frictional forces and facilitates slippage and plastic flow within the individual microcrystals.
- The lubricating properties of water may also reduce tablet density variation by providing better transmission of the compression force through the compact and by decreasing the adhesion of the tablet to the die wall.
- Compressibility of microcrystalline cellulose depends on loss on drying, which means that when microcrystalline cellulose having different losses on drying is compressed with the same pressure, it may not result in the same porosity.

1.3.2 Particle Size

- Particle size has a very low effect on the tablet appearance of neat MCC, i.e. neither lubricated nor blended with other excipients or active pharmaceutical ingredients.
- Particle size and moisture content of MCC are often considered the most important parameters for

tableting performance.

- Despite the lower median particle size of Avicel PH-101, this MCC was described as an easy-flowing powder compared to other brands as illustrated by its low compressibility index and high values of shear cell flow functions which exceed 4.
- Avicel is physically more dense and reveals less compressible or compactable properties.

1.3.3 Particle Morphology

- Rod-shaped particles which are fibrous resulted in higher tablet strengths than round-shaped particles.
- Other physicochemical properties of MCC including moisture content, bulk density, and specific surface area did not correlate well with the tensile strength of the obtained tablet.
- Morphology of MCC was found to be affecting the dissolution may be due to porosity.

1.3.4 Crystallinity

- Modifying the hydrolysis conditions, including temperature, time, and acid concentration, also has very little impact on the degree of crystallinity, i.e., the regularity of the arrangement of the cellulose polymer chains.
- This observation shows that the crystallinity cannot be controlled at the hydrolysis stage.
- Crystallinity appears to be more dependent on pulp source rather than on processing conditions, which is consistent with the method of MCC manufacture where the acid preferentially attacks the amorphous regions.
- The MCC powders with a lesser degree of crystallinity may have more water content than their counterparts with a higher degree.

1.3.5 Bulk Density

- Direct compression excipients are spray-dried, so a porous structure was produced as a result.
- This property is shown by a relatively low bulk density. An increase in porosity (lower density) facilitates higher compressibility, i.e., the densification of a powder bed due to the application of stress.
- Low bulk density of MCC will provide higher dilution and hence better counteract the poor tableting properties of APIs.
- It can therefore be generalized that a decrease in bulk density improves tablets. However, it will often hinder flowability.

1.3.6 Degree of Polymerization

- The degree of polymerization can be expressed as the number of glucose units ($C_6H_{10}O_5$) in the cellulose chain.
- It reduces exponentially as a function of hydrolysis, including temperature, acid concentration, and duration of reaction.
- The rate of hydrolysis slows to a certain range which is stated as the level-off degree of polymerization.
- Theoretically, to obtain a certain degree of polymerization that is higher than the LODP value, the hydrolysis process could be terminated at any time.

1.3.7 Effect of Lignin

- Lignin content increases the dissolution rate of some drugs by being hydrophobic, it may alter cellulose - cellulose or cellulose - API interactions and hence the drug release rate.
- Tablet ability which also varied among the MCC samples was attributed to the differences in moisture content and the internal structure of the particles.
- These are generally caused by different processing situations which are specific to each manufacturer. The effect of crystallinity and particle morphology is negligible.

1.4 SUGARCANE BAGASSE EXTRACTION[8]

1) For extraction of cellulose from SCB, a 3-step delignification was implemented with acid, alkaline pretreatment, and oxidation process.
2) The grounded SCB was first treated with 5% HNO_3, at 80°C for 2 hours with occasional stirring.
3) The reaction was quenched with distilled water and filtered. The residue was then made neutral by washing with water.
4) After drying, the residue was further treated with 2N NaOH at 80°C for 2 hours with stirring.
5) Lignin was removed as filtrate and the residue was neutralized with distilled water to get pH 7.
6) The delignified biomass was then bleached with 10% CH_3COOH/NaClO at 80°C for 2 hours with occasional stirring.
7) The resulting solution was diluted with distilled water and filtered. Cream white pulpy cellulose was extracted.
8) The cellulose was incorporated into depolymerization in the presence of 10% H_2O_2 with 0.5 ml of H_2SO_4 at 80°C for 5 hours.
9) A white turbid solution was resulted. After filtration, the depolymerized cellulose was dried in an oven overnight at 60°C and ground to produce a white, crystalline powder.

1.5 REFERENCES

1. Raymond C., Paul J. Sheskey, Scan C. Owen. "Handbook of Pharmaceutical Excipients", Pharmaceutical Press, London, 5th edition, 334-335, 278-282, 2006.
2. Reymond.C.Rowe. Hand Book of Pharmaceutical Excipients", Fourth Edition 354- 357.
3. Chaerunisaa, Anis Yohana, Sriwidodo. "Microcrystalline cellulose as a pharmaceutical excipient." In Pharmaceutical formulation design recent practices. IntechOpen, 2019.
4. Shlieout G, Arnold K, Muller G. Powder and mechanical properties of microcrystalline cellulose with different degrees of polymerization. AAPS PharmSciTech. 2002;3:E11
5. Suzuki T, Nakagami H. Effect of crystallinity of microcrystalline cellulose on the compatibility and dissolution of tablets. European Journal of Pharmaceutics and Biopharmaceutics. 1999;47:225-230
6. Landín M, Martínez-Pacheco R, Gómez-Amoza JL, Souto C, Concheiro A, Rowe RC. Effect of batch variation and source of pulp on the properties of microcrystalline cellulose. International Journal of Pharmaceutics. 1993;91:133-141
7. Chauhan YP, Sapkal RS, Sapkal VS, Zamre GS. Microcrystalline cellulose from cotton rags (waste from garment and hosiery industries). International Journal of Chemical Sciences. 2009;7(2):681-688
8. El-Sakhawy M, Hassan ML. Physical and mechanical properties of microcrystalline cellulose prepared from agricultural residues. Carbohydrate Polymers. 2007;67:1-10
9. Chuayjuljit S, Su-Uthai S, Charuchinda S. Poly film filled with microcrystalline cellulose prepared from cotton fabric waste: Properties and biodegradability study. Waste Management & Research. 2010:109-117
10. Rashid M, Gafur MA, Sharafat MK, Minami H, Miah MAJ, Ahmad H. Biocompatible microcrystalline cellulose particles from cotton wool and magnetization via a simple in situ co-precipitation method. Carbohydrate Polymers. 2017;170:72-79
11. Uesu NY, Pineda EA, Hechenleitner AA. Microcrystalline cellulose from soybean husk: Effects of solvent treatments on its properties as acetylsalicylic acid carrier. International Journal of Pharmaceutics. 2000;206:85-96
12. Suvachittanont S, Ratanapan P. Optimization of microcrystalline cellulose production from corn cob for pharmaceutical industry investment. Journal of Chemistry and Chemical Engineering. 2013;7:1136-1141
13. Gaonkar SM, Kulkarni PR. Improved method for the preparation of microcrystalline cellulose from water hyacinth. Textile Dyer and Printer. 1987;20(26):19-22
14. Gaonkar SM, Kulkarni PR. Microcrystalline cellulose from coconut shells. Acta Polymer. 1989;40:292-293
15. Fahma F, Iwamoto S, Hori N, Iwata T, Takemura A. Isolation, preparation, and characterization of nanofibers from oil palm empty-fruit-bunch (OPEFB). Cellulose. 2010;17(5):977-985

16. Mohamad Haafiz MK, Eichhorn SJ, Hassan A, Jawaid M. Isolation and characterization of microcrystalline cellulose from oil palm biomass residue. Carbohydrate Polymers. 2013;93(2):628-634
17. Owolabia A, Haafiza M, Hossain M, Hussin H, Fazita N. Influence of alkaline hydrogen peroxide pre-hydrolysis on the isolation of microcrystalline cellulose from oil palm fronds. International Journal of Biological Macromolecules. 2017;95:1228-1234.