

Effect of hydrolysis on the physicochemical properties of microcrystalline cellulose prepared from ripe plantain peels

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Abstract

The study investigates the effect of hydrolysis on the physicochemical properties of microcrystalline cellulose prepared from ripe plantain peels. Sample preparation and analysis was carried out as prescribed by AOAC and physical properties were investigated. The α -cellulose was extracted from ripe plantain peels using inorganic reagents. The α -cellulose extracted was partially hydrolyzed using tetraoxosulphate (VI) acid (H_2SO_4), hydrochloric acid (HCl) and sodium hypochlorite (H_3PO_4) under reflux to obtain its microcrystalline cellulose. The result obtained was in line with Avicel pH 101 (A commercial brand of microcrystalline cellulose) and the acids hydrolysis indicated its high level of crystallinity. The result obtained shows that the bulk densities of H_2SO_4 , HCl and H_3PO_4 was $0.31g/cm^3$, $0.32g/cm^3$ and $0.22g/cm^3$, while the tapped densities $0.40g/cm^3$, $0.40g/cm^3$ and $0.27g/cm^3$ respectively. This proved that HCl is more crystalline while H_3PO_4 is more amorphous (disordered). The study proved agro waste as a good source of microcrystalline cellulose for industrial purposes. Also agro-waste being low-cost alternative, its utilization will contribute to decreasing inflation and also in creating a healthy environment for the society.

KEY WORD: α -Cellulose (Unhydrolyzed Cellulose)

Introduction

Cellulose is an insoluble substance and the principal constituent of plant cell wall and of vegetable fiber. It is a polysaccharide comprising of chains of glucose monomers. It is the most abundant natural occurring biopolymer and are sources of various natural fibers (Hinterstoiser *et al.*, 2000; Bochek, 2003). Cellulose comprises of at least 3000 glucose units and about 33% of vegetable fibers. The level of polymerization in each cellulose chain is as a result of the number of glucose monomers it comprises (Brown *et al.*, 1996; Arun 2015). It appears in different forms for various purposes such as building, paper production, nitrocellulose for explosives, anti caking agents & bulking agents in food industries and so on (Rasheed *et al.*, 2020). Plantain peel as a good source of cellulose has been revealed to account for about 40% of the total fruit weight (Liliana and Gilver, 2017). As an agro waste, the peel of plantain tends to be useful in industries particularly in the agro based industries where it is used as a source of antioxidant and dietary fiber and its also used as a source of nutrient for soil (Eun-Hye *et al.*, 2010; Sakhawy and Hassan, 2007). Regardless of all the existing cellulose, microcrystalline cellulose $(C_6H_{10}O_5)_n$ is a natural occurring substance obtained from refined and partially depolymerized cellulose. It is depolymerized by product generated through the hydrolysis of inorganic acid (Shlieout *et al.*, 2002). Microcrystalline cellulose has length more than $1\mu m$ and diameter $50 - 30\mu m$. Its physical properties include; stable thermal behaviour, building up capacity and biocompatibility (Kian *et al.*, 2020). Its uses and applications are vast in industries such as food, pharmaceutical and cosmetics. It is utilized as adsorbents, binders, recipients, emulsifiers, additives, stabilizers, thickeners, gelling agents, fat substitutes, anti caking agents and suspending agents in industries (Valcher *et al.*, 2020). Moreover, agro waste which are usually cheap and easy to access has drawn the attention of analysts and researchers in an attempt to alleviate climate change and to sustain a healthy environment (Liu *et al.*, 2018). Hence, the quest to determine the effect of hydrolysis on the physicochemical properties of microcrystalline cellulose obtained from ripe plantain peels.

MATERIALS AND METHODS

Ripe plantain peels were obtained from local beans and plantain sellers in Umuoma Uli, Anambra state, Nigeria.

Sample preparation

The peels were cut into smaller portions and spread to dry under the sun for 2 weeks. After drying the peels it was ground and sieved and then the powder was used for the analysis.

Preparation of Microcrystalline Cellulose

A portion (370 g) of the sieved plantain peels (PP) powder was soaked excessively in 2.5 litres of 2% w/v NaOH solution at 80°C for 3hrs in 3 different 1000ml beakers, immersed in a water bath, wash thoroughly and filtered. The resulting de-lignified mass was treated with 2 litres of 3.5% aqueous NaOCl for 30mins at 80°C, filter and further digest the bleached mass with 2 litres of 17.5% w/v aqueous NaOH solution at 80°C for 1hr. The resultant α -cellulose undergoes the final stage of bleaching with 1.5 L (1:1) of 3.5% w/v NaOCl for 1 hr. The resultant mass was repeatedly washed with distilled water until neutral to litmus paper. Excess moisture was squeezed off using a muslin cloth and the small mass obtained was then oven-dried at $65 \pm 1.5^\circ\text{C}$ for 12 hrs. The α -cellulose obtained was then hydrolyzed at 105°C using 2M of hydrochloric acid (HCl) under reflux for 15mins at the solid-liquid ratio of 1:10. The hydrolysis was also repeated using Tetraoxosulphate (vi) acid (H_2SO_4) and Tetraoxophosphate (v) acid (H_3PO_4) respectively. The hydrolyzed cellulose was washed thoroughly with distilled water until neutral to litmus and filtered through a muslin cloth and water squeezed out thoroughly, it was then oven dried at 65 °C for 12 hrs (Gupta *et al.*, 2019) and physicochemical characterization was carried out according to procedures by the British Pharmacopoeia (BP) specifications (2009).

RESULT AND DISCUSSION

The result of the analysis performed on the effect of hydrolysis on the physicochemical properties of microcrystalline cellulose prepared from ripe plantain peel are presented below.

Result of Physicochemical analysis

Parameters	H ₂ SO ₄ Hydrolyzed	HCl Hydrolyzed	H ₃ PO ₄ Hydrolyzed
Bulk density (g/cm ³)	0.31	0.32	0.22
Tapped density (g/cm ³)	0.40	0.40	0.27
Hauseners Ratio	1.28	1.26	1.23
Carr Index	21.75	20.45	18.23
Moisture Content (%)	5.31	4.01	5.47
pH	3.85	5.78	4.89
Solubility	Insoluble	Insoluble	Insoluble
Starch	Present	Present	Present
Swelling capacity	57.14	57.14	111.77
Hydration capacity	3.61	3.70	5.00
Moisture adsorption capacity after 24 hours	0.37	0.24	0.27

%Yield of the Plantain Pee l = 4.119%

The physicochemical properties analyzed revealed that the microcrystalline cellulose obtained by hydrolyzing □ – Cellulose with tetraoxosulphate (iv) acid (H₂SO₄) and hydrochloric acid (HCL) indicated a good flow property and compressibility of the microcrystalline cellulose obtained. Whereas, the microcrystalline cellulose obtained by hydrolyzing □ – cellulose with Tetraoxophosphate (v) acid (H₃PO₄) indicated a Fair Flowability and compressibility (Azubike and Okhamafe, 2012; Nwadiogbu *et al.* 2016). This may be as a result of variation in particle shape, size, and surface area which is directly related to the process of partial hydrolysis of the cellulose in the acids.

CONCLUSION

This study proved plantain peel a potential source of □-cellulose and microcrystalline cellulose. The partial hydrolyzed □-cellulose obtained from ripe plantain peel brought about

microcrystalline cellulose with high grade, refined, purified and improved physical properties used for industrial purposes. This study proved the possibility of utilizing agro waste and thereby decreasing the cost of production in our industries and enhances environmental safety.

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