

Synthesis and Characterization of Cellulose Acetate and its Derivatives from Sawdust and Corn Husk Lignocellulosic Biomass Waste

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Abstract

The recalcitrant nature of cellulosic biomass waste and its environmental pollution arising from incessant burning and indiscriminate dumping continue to raise global health concerns. This study investigated the synthesis and characterization of cellulose acetate derivatives from two lignocellulosic biomass waste, sawdust and corn husk waste. The work was designed to support biomass valorization of agricultural residues into cellulose esters. Sawdust and corn husk waste biomaterials underwent sequential alkaline treatment using 4 and 17.5 % sodium hydroxide, followed by oxidative bleaching to isolate alpha cellulose. The recovered cellulose was acetylated through a heterogeneous esterification route using glacial acetic acid, acetic anhydride and sulphuric acid catalyst to obtain cellulose acetate, cellulose diacetate and cellulose triacetate grades. The products were characterized by FTIR, thermogravimetric analyses and scanning electron microscopy. Sawdust produced a higher cellulose recovery of 52.3 %, compared with 48.5 % from corn husk waste, indicating its higher cellulose content and better purified pulp yield. However, corn husk waste produced higher acetate derivative yields, with cellulose acetate, cellulose diacetate, and cellulose triacetate yields of 78.0, 79.0 and 83.5 %, respectively, compared with 72.0, 76.0 and 80.0 % for sawdust. FTIR spectra confirmed acetylation through the appearance of ester carbonyl absorption around 1740-1750 cm⁻¹, C-O stretching bands and reduced hydroxyl intensity. TGA showed improved thermal resistance of the acetate derivatives, with major degradation occurring above 250 °C and maximum degradation within the industrially relevant processing range. SEM revealed progressive transformation from fibrous cellulose to denser, film-forming acetate matrices suitable for industrial modification.

Keywords: Biomass valorization, Cellulose acetate, Corn husk waste, Lignocellulosic biomass, Sawdust waste

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Introduction

The growing environmental burden associated with petroleum-based plastics has intensified scientific interest in renewable and biodegradable polymer systems [1-4]. Among the available bio-based polymers, cellulose acetate remains important because it combines the abundance of cellulose with useful film-forming, fibre-forming, and membrane-forming properties [5, 6]. Recent studies on lignin-derived materials, modified cellulose nanofibres and smart waste-recycling systems further show that waste-derived polymers and biomass-based materials are becoming increasingly important in sustainable material development [7-9]. Its applications in packaging, textiles, filtration, membrane systems and bio-based composites make cellulose acetate a practical candidate for circular material development [3, 6, 8]. The central challenge, however, is to produce cellulose acetate from feedstocks that do not compete with food resources or increase pressure on primary forests [2, 8, 10].

Lignocellulosic residues provide an attractive alternative to conventional cellulose sources such as cotton linters and purified wood pulp because they are abundant, renewable and underutilized [11-13]. Sawdust from timber processing and corn husk waste from agricultural production are generated in large quantities in many

developing economies, including Nigeria [10, 14]. Biological colonization, chemical pretreatment and thermal or physicochemical processing of lignocellulosic materials have been widely explored for corn stalk, corn stover and other biomass residues [15-17]. In addition, carbohydrate-chemistry and lignocellulose-nanofibril studies show that cellulose-rich residues can be transformed into useful intermediates and functional materials when pretreatment is properly controlled [17-19].

The suitability of a biomass feedstock for cellulose acetate synthesis depends strongly on its lignocellulosic architecture, cellulose accessibility and effectiveness of pretreatment. Degree of substitution, ester formation and product performance are commonly evaluated using spectroscopic, thermal and morphological techniques, including ATR-FTIR spectroscopy [20, 21]. Studies on corn stover valorization, corn-husk-derived packaging films, rice-straw cellulose acetate, microcrystalline cellulose recovery, ionic-liquid acetylation, Xylan biovalorisation, hardwood pulping, biodegradable packaging films, bio-based textile materials, deep-eutectic-solvent pretreatment, cellulose-rich acoustic boards and Nigerian tropical hardwood pulping collectively show the broad relevance of cellulose recovery and conversion from agricultural and wood-



based residues [22–25]. These differences can influence cellulose extraction yield, acetylation efficiency, degree of substitution, thermal stability and morphology of the final product [24, 25].

Previous studies have reported the extraction and modification of cellulose from several agricultural residues and biomass sources [11, 13, 23–26], but comparative studies involving sawdust and corn husk waste under the same laboratory acetylation conditions remain useful for local feedstock selection [10, 27, 28]. This study therefore synthesized cellulose acetate, cellulose diacetate and cellulose triacetate from sawdust and corn husk waste and compared their yield, functional group transformation, thermal behaviour and surface morphology. The objective was to determine the relative suitability of both residues as low-cost precursors for value-added cellulose ester production, in line with current research priorities on cellulose ester synthesis, biodegradable packaging and circular biomass valorization [2, 3, 24, 29].

Materials and Methods

Materials

The sawdust was collected from Oko-oba sawmill at the bank of Lagos Lagoon, Ebute Metta Oyingbo, Lagos, Nigeria. The sawdust wood specie was identified as *Symphona globulifera* (Okilolo) at the Forestry Research Institute of Nigerian (FRIN). While the corn husk was obtained from the white Oba super maize grain planted at the Mountain Top University (Ogun State, Nigeria) farmland after harvesting the corn. The corn specie is the type mostly cultivated in the south west region of Nigeria. The reagents used included glacial acetic acid, acetic anhydride, sodium hydroxide pellets, hydrogen peroxide, concentrated sulphuric acid and distilled water. All reagents used were of analytical grade.

Sample preparation extraction of cellulose from sawdust and corn husk

The raw sawdust was collected from the sawn wood and was further reduced to smaller particles by sieving through 2.8–5 mm mesh, while corn husk was cut into smaller sizes of 3–4 cm to improve interaction between the biomass and pulping chemicals. The moisture content of each sample was determined by oven drying at 105 °C to constant weight. Then, 1 kg (1000 g) of each sample was subjected to alkaline sulfite chemical pulping in a digester containing NaOH (100 g) and NaHSO₃ (100 g) in 4 L of water, giving a biomass-to-liquor ratio of 1:4. The digester was maintained at 170 °C and 200 kPa for 1 h, 30 min in a batch process, following established pulping and lignocellulosic pretreatment approaches [15, 20, 25]. At the end of each pulping process, the contents were emptied into a bowl, washed with deionized water and air-dried.

Isolation of alpha cellulose

Cellulose isolation was carried out through sequential alkaline delignification and bleaching. The biomass samples were treated with 4 % sodium hydroxide solution at a liquor-to-solid ratio of 20:1 under reflux at

100 °C for 120 min. A secondary treatment with 17.5 % sodium hydroxide at 80 °C was used to further disrupt lignin and hemicellulose associations. The treated pulp was bleached with 4 % hydrogen peroxide at 70 °C for 60 min, washed repeatedly to neutral pH and dried at 60 °C to obtain purified alpha cellulose. Alkaline treatment and oxidative bleaching are widely applied to disrupt lignin-carbohydrate associations and increase cellulose purity before esterification [15, 17, 18, 20, 30].

Synthesis of cellulose acetate

For each acetylation reaction, 2.0 g of bleached cellulose was dispersed in 35 mL of glacial acetic acid in a 250 mL beaker. The system was kept in a water bath at 50 to 55 °C for 30 min with frequent stirring. An acetylating mixture containing 10 mL acetic anhydride and 0.4 mL concentrated sulphuric acid was added while maintaining the temperature below 60 °C. The use of acetic anhydride with acid catalysis is a common route for cellulose esterification because it promotes substitution of cellulose hydroxyl groups by acetyl groups [4, 5, 21, 24, 26]. The reaction mixture was kept at 50 to 55 °C for 1 h with occasional stirring until a clear reaction mixture was obtained. The mixture was poured into distilled water with stirring, and the precipitate was filtered, washed to neutrality and dried.

Synthesis of cellulose diacetate and triacetate

The diacetate product was prepared using the same initial acetylation sequence, followed by controlled hydrolysis with acetic acid and water before precipitation in distilled water. The precipitate was filtered through a Buchner funnel, washed to neutrality and dried. The triacetate product was obtained by maintaining the acetylation conditions toward higher substitution and precipitating the final product in a large volume of water. Controlled acetylation and hydrolysis are important for obtaining cellulose acetate grades with different substitution levels and processing behaviour [5, 21, 24, 26]. The dried mass of each acetate product relative to the initial cellulose mass was used to calculate percentage yield.

Characterization

Fourier transform infrared spectroscopy was used to identify functional group changes associated with delignification and acetylation (Plate 1). Spectra were recorded over 400 to 4000 cm⁻¹ using the potassium bromide pellet method. FTIR is commonly used to monitor ester carbonyl formation, hydroxyl reduction and degree-of-substitution-related changes in cellulose acetate systems [18, 21, 24, 26]. Thermogravimetric analysis was conducted from room temperature to 600 °C at a heating rate of 10 °C/min under nitrogen atmosphere to evaluate thermal stability and degradation patterns. Scanning electron microscopy was used to examine surface morphology and the transition from fibrous cellulose to acetate-based polymer matrices [16, 23, 25, 31]. Samples were dried and sputter coated before imaging.

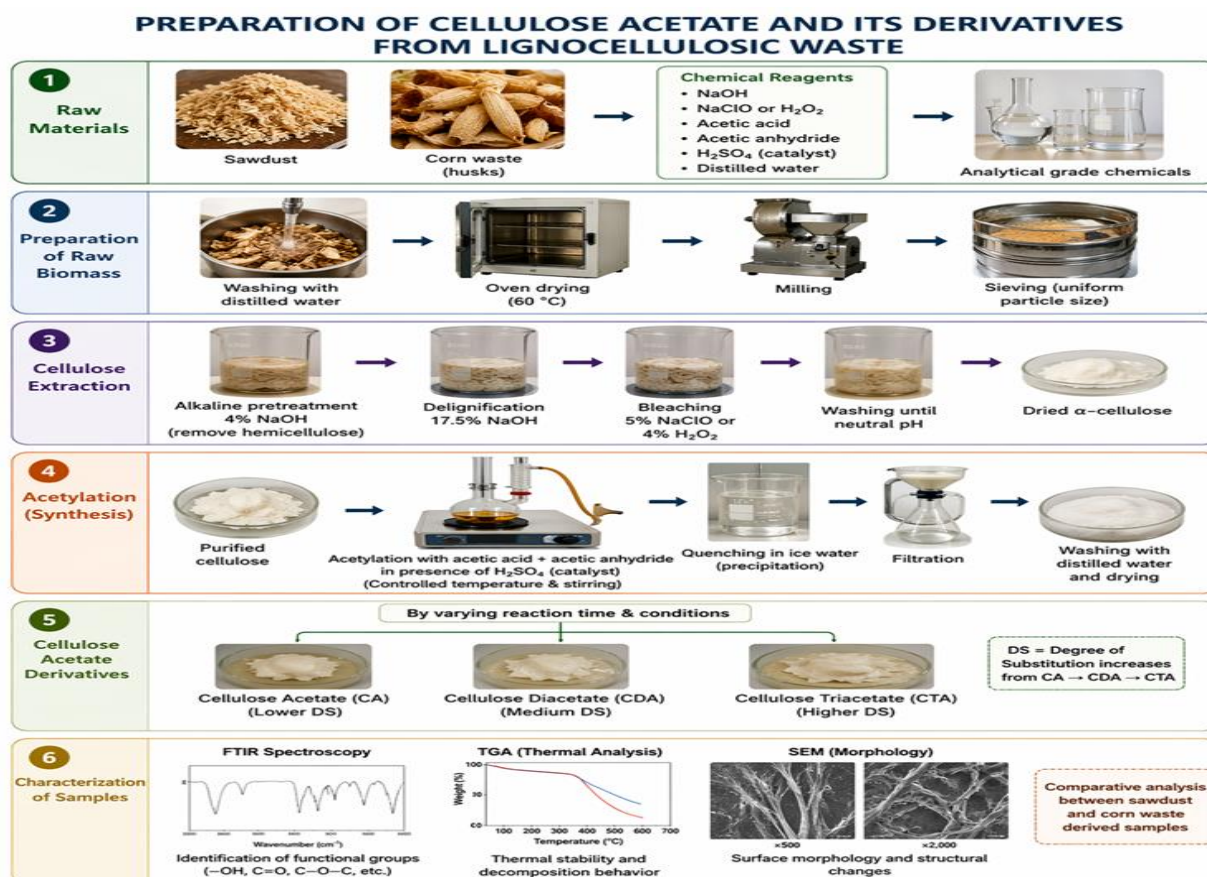


Plate 1: Pictorial flow of the preparation and characterization of cellulose acetate derivatives from lignocellulosic waste

Yield calculation and data treatment

Cellulose extraction yield was expressed as the dry mass of isolated cellulose relative to the dry mass of initial biomass. Acetate derivative yield was calculated as the dry mass of the acetate product relative to the initial cellulose mass. Product grades were assigned as cellulose acetate, cellulose diacetate and cellulose triacetate based on reaction conditions, nominal acetylation level and characteristic spectral changes. The results are presented descriptively because the work focused on synthesis feasibility and comparative material behaviour.

Results and Discussions

Cellulose recovery and acetate derivative yield

The pretreatment and bleaching sequence successfully produced purified alpha cellulose from both lignocellulosic feedstocks. Sawdust gave the higher cellulose recovery of 52.3 %, while corn husk waste gave

48.5 % (Table 1). The higher value for sawdust indicates that the wood-based residue contained a larger recoverable cellulose fraction. However, the result also shows that a high cellulose recovery does not automatically translate into the highest acetylation yield, because chemical accessibility of the cellulose fibres is equally important during esterification.

The delignification behaviour differed between the two residues. Sawdust showed lower ease of delignification, consistent with a more compact wood fibre structure and stronger lignin carbohydrate association. Corn husk waste, although giving slightly lower cellulose recovery, was easier to delignify because of its less compact agricultural residue structure. This structural difference became important during acetylation, where corn husk waste produced higher yields of all three cellulose acetate derivatives.

Table 1: Cellulose extraction yield from sawdust and corn husk waste

Feedstock	Cellulose Yield (%)	Delignification behaviour	Main observation
Sawdust	52.3	Lower ease of delignification because of higher recalcitrance	Higher alpha cellulose recovery and stronger structural integrity
Corn husk waste	48.5	Higher ease of delignification because of lower recalcitrance	Lower cellulose recovery but greater chemical accessibility during acetylation

**Table 2: Percentage yield of cellulose acetate derivatives from sawdust and corn husk waste**

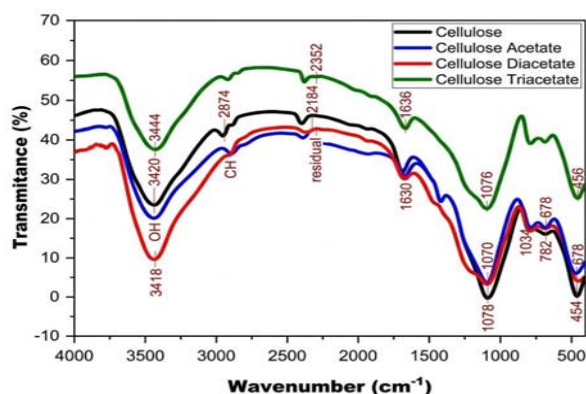
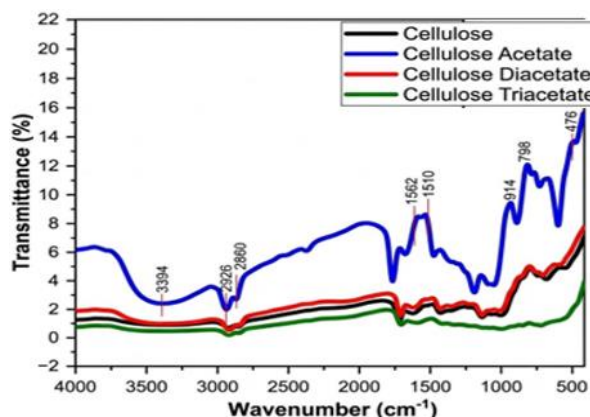
Feedstock	Product	Nominal acetylation level	Yield (%)	Interpretation
Sawdust	Cellulose acetate	1	72.0	Successful initial acetylation
Sawdust	Cellulose diacetate	2	76.0	Improved substitution and processability
Sawdust	Cellulose triacetate	3	80.0	Highest sawdust derivative yield
Corn husk waste	Cellulose acetate	1	78.0	Higher conversion than sawdust acetate
Corn husk waste	Cellulose diacetate	2	79.0	Stable high derivative yield
Corn husk waste	Cellulose triacetate	3	83.5	Highest overall derivative yield

The acetate derivative yields increased with the intended acetylation level for both feedstocks (Table 2). Sawdust produced cellulose acetate, cellulose diacetate and cellulose triacetate yields of 72.0, 76.0 and 80.0 %, respectively. Corn husk waste gave higher corresponding yields of 78.0, 79.0 and 83.5 %. The highest yield was therefore obtained for corn husk derived cellulose triacetate. This trend suggests that the corn husk cellulose was more accessible to the acetic acid/acetic anhydride reaction medium, allowing more efficient substitution and precipitation of acetate derivatives.

FTIR characterization of corn husk cellulose and acetate derivatives

The FTIR spectra of the corn husk series showed the expected functional group changes associated with cellulose isolation and acetylation (Fig. 1). The extracted cellulose spectrum retained the broad hydroxyl stretching region around 3400 cm^{-1} , which is typical of hydrogen bonded hydroxyl groups in cellulose. The C-H stretching region around $2870\text{ to }2920\text{ cm}^{-1}$ and the strong fingerprint absorption around $1000\text{ to }1100\text{ cm}^{-1}$ are associated with the polysaccharide backbone and C-O-C glycosidic vibrations.

After acetylation, the spectra of cellulose acetate, cellulose diacetate and cellulose triacetate showed reduced relative hydroxyl contribution and stronger ester related absorptions. The appearance or strengthening of ester carbonyl absorption in the region of $1740\text{ to }1750\text{ cm}^{-1}$, together with C-O stretching bands in the fingerprint region, confirms incorporation of acetyl groups into the cellulose backbone. The progressive change from cellulose to the acetate derivatives indicates that the corn husk cellulose was chemically modified rather than merely physically treated.

**Figure 1: Comparative FTIR spectra of cellulose, cellulose acetate, cellulose diacetate and cellulose triacetate derived from corn husk waste****Figure 2: Comparative FTIR spectra of cellulose, cellulose acetate, cellulose diacetate, and cellulose triacetate derived from sawdust**

FTIR characterization of sawdust cellulose and acetate derivatives

The sawdust FTIR spectra also confirmed chemical modification, although the spectral profile was more compressed and showed lower transmittance in several regions (Fig. 2). This behaviour may arise from greater sample opacity, higher matrix density and residual aromatic components associated with the wood-based feedstock. The extracted sawdust cellulose retained hydroxyl and glycosidic backbone features, while the acetate derivatives showed clearer methyl, C-O and ester related features after acetylation.

Compared with the corn husk series, the sawdust spectra suggest a more heterogeneous matrix. Persistent bands in the aromatic and fingerprint regions are consistent with the stronger lignin carbohydrate structure of sawdust. Nevertheless, the transition from cellulose to acetate derivatives is supported by the reduced dominance of the hydroxyl region and the increased contribution of ester-associated absorptions. The FTIR result therefore indicates successful acetylation in both feedstocks, but with clearer spectral resolution for corn husk waste and stronger matrix effects for sawdust.

TGA characterization of corn husk cellulose and acetate derivatives

The TGA thermograms of the corn husk series in Fig. 3 showed clear differences between extracted cellulose and its acetate derivatives. The cellulose sample underwent its major mass loss in the cellulose pyrolysis region, corresponding to depolymerization and breakdown of glycosidic linkages. The acetate derivatives showed reduced low-temperature moisture loss, which is

consistent with the replacement of hydrophilic hydroxyl groups by less hydrophilic acetyl groups.

The thermal profile also changed with the intended acetylation level. The cellulose acetate sample showed an earlier main mass loss than the more highly acetylated derivatives, while the diacetate and triacetate curves shifted toward higher temperature regions. The triacetate curve showed the greatest resistance to early thermal degradation among the corn husk derivatives. This supports the interpretation that increased acetyl substitution improved the thermal endurance of the corn husk-based acetate matrix.

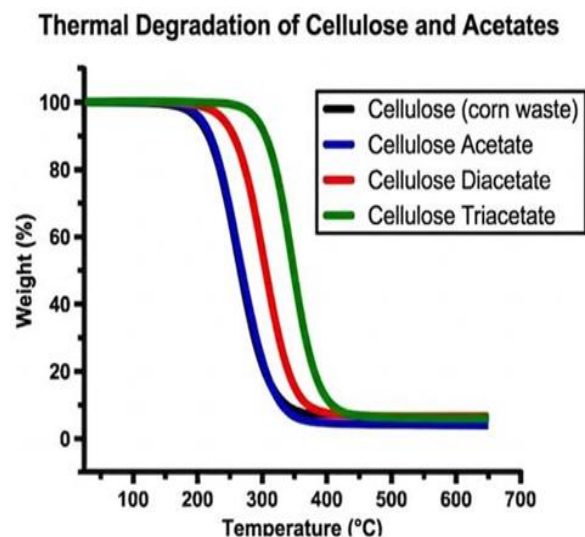


Figure 3: Comparative TGA thermograms of cellulose and acetate derivatives from corn husk waste

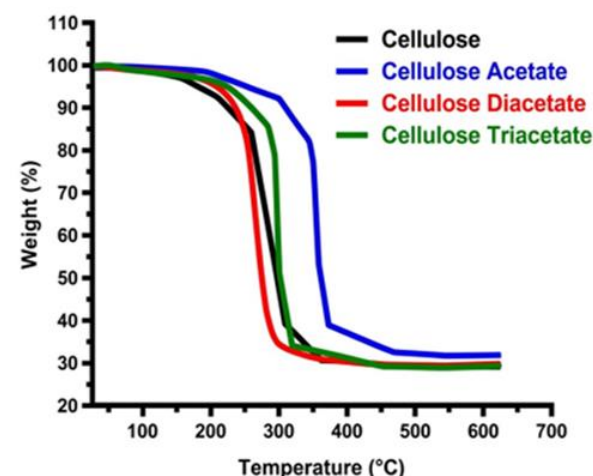


Figure 4: Comparative TGA thermograms of cellulose and acetate derivatives from sawdust

TGA characterization of sawdust cellulose and acetate derivatives

The sawdust thermograms in Fig. 4 showed broader thermal behaviour and higher residual mass than the corn husk series. This is consistent with the more complex and lignified nature of wood-based biomass. The residual char was higher for sawdust derived materials, indicating that the wood matrix retained more carbonaceous or aromatic residue after thermal decomposition.

The sawdust acetate derivatives nevertheless showed improved thermal organization compared with the extracted cellulose. The triacetate derivative displayed a sharper major decomposition event than the lower acetylated products, suggesting improved chemical uniformity after extensive acetylation. The higher char residue of the sawdust series may be advantageous for applications requiring thermal ruggedness, but it also suggests that complete removal of non-cellulosic components is more difficult in the wood-based feedstock.

SEM morphology of corn husk cellulose and acetate derivatives

SEM micrographs of the corn husk series in Plate 2 revealed a progressive transformation from fibrous cellulose to a denser acetate matrix. The extracted cellulose showed ribbon-like and fibrous structures, indicating that pretreatment exposed the cellulose framework while retaining some native fibre architecture. After acetylation, the fibre bundles became disrupted and less defined, showing that esterification weakened the original hydrogen-bonded cellulose network.

The higher acetate derivatives showed greater surface fusion and compactness. Cellulose acetate displayed a fragmented and roughened morphology, while the diacetate and triacetate samples became denser, textured, and film-forming. This morphological collapse is consistent with chemical substitution of hydroxyl groups by acetyl groups, which reduces intermolecular hydrogen bonding and promotes a more plasticized polymeric surface.

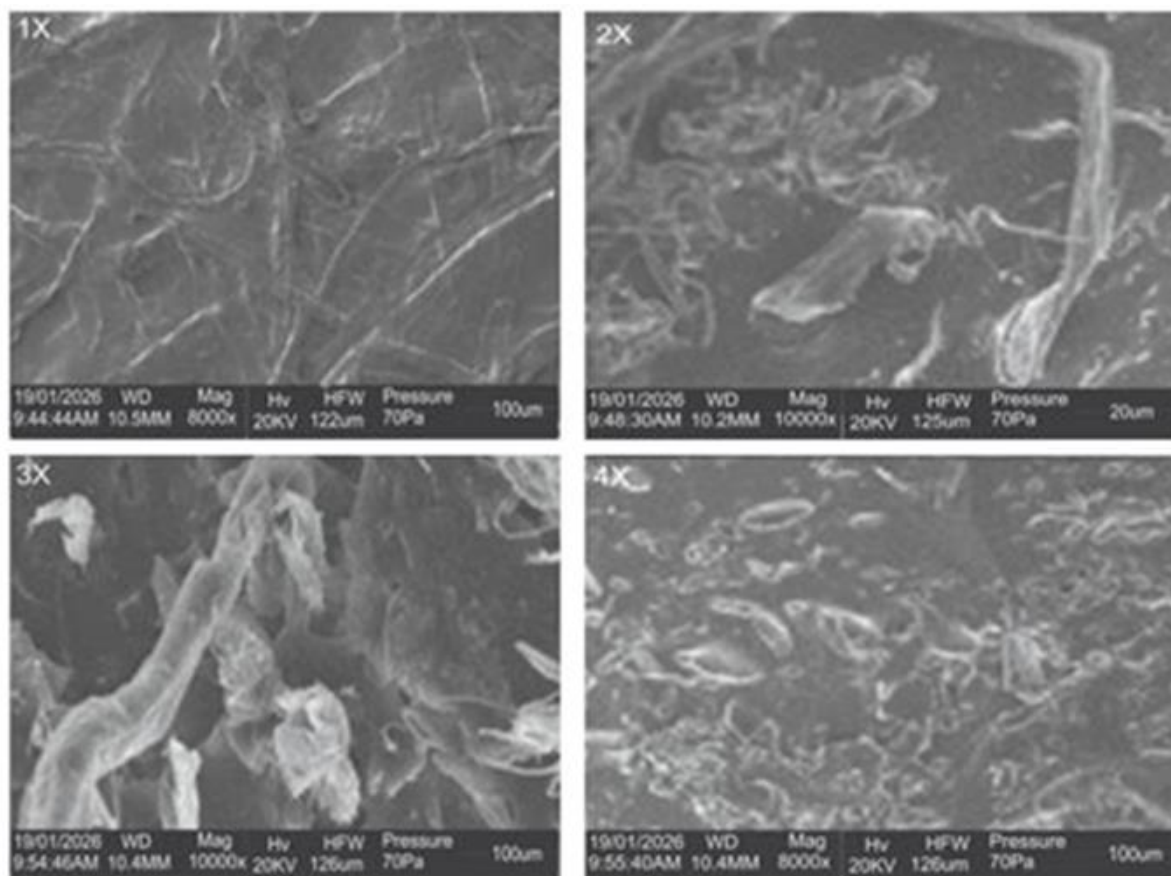


Plate 2: SEM micrographs of corn husk-derived cellulose and acetate derivatives

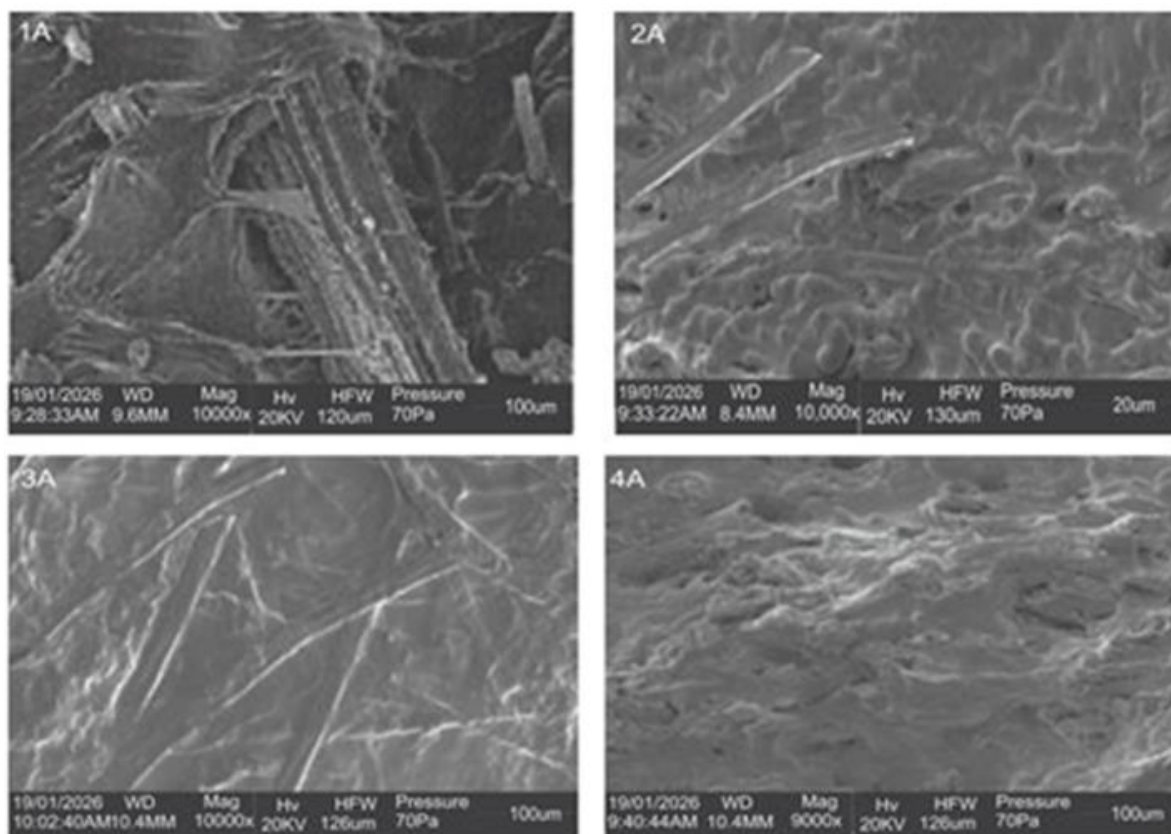


Plate 3: SEM micrographs of sawdust-derived cellulose and acetate derivatives

SEM morphology of sawdust cellulose and acetate derivatives

The SEM micrographs of the sawdust series in Plate 3 showed a different morphological pathway. Extracted sawdust cellulose retained thick fibre bundles, grooves and striated surfaces that reflect the structural memory of wood fibres. These features indicate that the sawdust cellulose was mechanically robust and more ordered than the corn husk cellulose.

Acetylation progressively smoothed and fused the sawdust fibre surface. The acetate and diacetate samples showed partial loss of fibre definition, while the triacetate sample showed a denser and more integrated polymeric surface. Compared with corn husk waste, sawdust maintained a more uniform fibre to film transition. This supports the view that sawdust-derived acetate may provide stronger structural continuity, whereas corn husk-derived acetate may offer faster conversion into dense film forming matrices.

Relationship between feedstock structure and yield

The results show that sawdust and corn husk waste behaved differently during cellulose recovery and acetate synthesis. Sawdust produced the higher cellulose yield, which is expected for a wood-based residue with a relatively high cellulose fraction and stronger fibre structure. However, sawdust did not produce the highest acetate derivative yields. This indicates that the efficiency of cellulose ester synthesis depends not only on how much cellulose can be recovered, but also on how easily the recovered cellulose can swell, react and allow diffusion of acetylating reagents.

Corn husk waste produced lower cellulose recovery but higher yields of cellulose acetate, cellulose diacetate and cellulose triacetate. This is an important observation because it highlights chemical accessibility as a major factor in biomass valorisation. The less compact structure of corn husk waste likely allowed easier penetration of acetic acid and acetic anhydride into the cellulose structure, promoting more effective acetylation. Therefore, corn husk waste may be a better feedstock when rapid conversion and high acetate yield are the main priorities, while sawdust may be more suitable when higher cellulose recovery and stronger structural integrity are desired.

Spectroscopic evidence of acetylation

The FTIR results provide direct evidence that acetylation occurred in both feedstock series. In native cellulose, the broad hydroxyl region around 3400 cm^{-1} is prominent because cellulose contains three hydroxyl groups per anhydroglucose unit. During acetylation, these hydroxyl groups are partially or extensively substituted by acetyl groups. The observed reduction in hydroxyl contribution, together with ester carbonyl absorption around 1740 to 1750 cm^{-1} and C-O stretching bands in the fingerprint region, confirms the formation of cellulose ester structures [21, 24, 26].

The corn husk spectra showed clearer acetylation related changes than the sawdust spectra, suggesting that corn husk cellulose was more accessible and more uniformly

modified. The sawdust spectra showed stronger baseline compression and lower transmittance, which may be linked to sample density, residual lignin or incomplete spectral dilution. For publication quality, the sawdust FTIR spectra should be presented with clear peak labels and, where possible, repeated using better KBr dilution or ATR correction so that the ester carbonyl and hydroxyl reduction can be seen more clearly. Also, because FTIR is mainly confirmatory, the stated acetylation levels should be treated as nominal unless supported by titrimetric acetyl content, NMR or another quantitative DS method.

Thermal behaviour and processing implication

The TGA results demonstrate that acetylation modified the thermal behaviour of the extracted cellulose. The lower low-temperature mass loss of the acetate derivatives indicates reduced moisture sensitivity, which is expected after replacement of hydrophilic hydroxyl groups with acetyl groups [5, 21, 24, 26]. This is beneficial for film and membrane applications because moisture absorption can reduce dimensional stability and affect processing behaviour [23, 29].

The corn husk acetate derivatives showed cleaner degradation profiles and lower residual char than the sawdust derivatives. This suggests more complete conversion to organic cellulose ester material and lower contribution from residual aromatic or inorganic components. In contrast, sawdust derived derivatives retained higher char residue, reflecting the stronger wood matrix and possible residual lignin contribution. This higher char may be a disadvantage where optical clarity and purity are required, but it may be useful where higher thermal ruggedness, carbon rich residue or reinforcing behaviour is desired.

The higher acetylated products generally showed improved resistance to early thermal degradation compared with the lower acetylated materials. This supports the suitability of the synthesized acetate derivatives for controlled thermal processing, solvent casting and potential film forming applications. However, exact processing conditions should be selected below the onset of major degradation, and future work should include DSC and mechanical testing to define the safe processing window more precisely.

Morphological evidence and application relevance

The SEM observations support the chemical and thermal results. The transition from fibrous cellulose to compact acetate matrices is consistent with disruption of cellulose hydrogen bonding during acetylation and with morphological changes reported for cellulose-rich materials and bio-based films [16, 23, 25, 32]. Corn husk cellulose changed rapidly from a fibrous material into a fragmented and dense film-forming matrix. This fast morphological collapse agrees with the higher derivative yields and suggests easier chemical penetration during acetylation.

Sawdust cellulose retained more of its original fibre architecture, showing grooves, striations and thicker bundled structures. During acetylation, these features



gradually became smoother and more fused, but the sawdust derivatives still showed stronger structural continuity than the corn husk derivatives. This suggests that sawdust based cellulose acetate may be useful where dimensional stability and reinforcing character are important, while corn husk-based acetate may be more favourable for applications that require easy film formation and higher conversion efficiency.

Integrated interpretation of FTIR, TGA and SEM results

Taken together, the FTIR, TGA and SEM data confirm successful conversion of sawdust and corn husk cellulose into cellulose acetate derivatives. FTIR established the chemical transformation through ester formation and hydroxyl reduction. TGA showed the effect of acetylation on thermal stability, moisture resistance and char formation. SEM provided visual evidence that the fibre structure was progressively transformed into denser polymeric matrices.

The combined characterization results support a feedstock specific conclusion. Sawdust is advantageous where cellulose recovery, structural uniformity and thermal residue formation are important. Corn husk waste is advantageous where easier delignification, higher acetate yield and faster fibre-to-film transformation are desired. This means that both residues are useful, but their best applications may differ. Sawdust derived acetate may be more suitable for structurally stable films, reinforcing bio-composites or applications requiring higher thermal residue, while corn husk derived acetate may be more suitable for biodegradable films, coatings and membrane precursors where high conversion yield and easier processability are important. In the present study, the acetylation levels are therefore treated as nominal product grades rather than absolute degree of substitution values. This cautious interpretation is appropriate because actual degree of substitution should ideally be confirmed using acetyl content titration, nuclear magnetic resonance or validated FTIR calibration. Nevertheless, the combined FTIR, TGA and SEM evidence supports the successful preparation of cellulose acetate, cellulose diacetate and cellulose triacetate grades from both biomass sources [26, 33].

Comparison with literature and uniqueness of the present study

The findings of this study agree with previous reports that lignocellulosic residues can serve as effective precursors for cellulose acetate production and other sustainable bio-based materials [2, 3, 10, 23, 24, 29]. Earlier studies have shown that agricultural residues and wood-based wastes contain recoverable cellulose fractions that can be chemically modified into cellulose esters after suitable pretreatment and bleaching [11, 13, 15, 20, 26]. In the present work, both sawdust and corn husk waste were successfully converted into cellulose acetate, cellulose diacetate and cellulose triacetate, confirming that these locally available residues are

suitable alternatives to conventional cellulose sources such as cotton linters and purified wood pulp.

Compared with literature reports on wood-based biomass, the higher cellulose recovery from sawdust is expected because woody residues generally contain a more ordered cellulose framework and higher alpha cellulose content [12, 20, 28, 33]. However, the present study also shows that higher cellulose recovery does not necessarily produce higher acetate derivative yield. Although sawdust gave the higher cellulose yield of 52.3 %, corn husk waste produced higher derivative yields across all acetate grades, reaching 83.5 % for cellulose triacetate. This observation is important because it shows that the success of cellulose acetate synthesis depends not only on cellulose content but also on fibre accessibility, swelling behaviour and ease of reagent penetration during acetylation.

This result agrees with studies on corn-based agricultural residues, which report that their less compact structure can make them more responsive to chemical pretreatment and conversion into cellulose-based materials [11, 14, 17, 18, 22, 23, 31]. However, the uniqueness of the present work lies in the direct comparison of sawdust and corn husk waste under the same extraction, bleaching and acetylation conditions. Many studies focus on a single biomass source, but this work demonstrates the contrasting behaviour of two different waste streams: sawdust is better for cellulose recovery and structural uniformity, while corn husk waste is better for acetate derivative yield and faster chemical conversion.

The FTIR results are consistent with established cellulose acetate literature. The reduction in hydroxyl absorption around 3400 cm^{-1} and the appearance of ester-related bands, especially carbonyl absorption around $1740\text{--}1750\text{ cm}^{-1}$, are widely recognized as evidence of acetylation and can also support degree-of-substitution interpretation when properly calibrated [21, 24, 26]. In this study, these spectral changes were observed in both feedstock series, confirming successful substitution of cellulose hydroxyl groups by acetyl groups. The corn husk samples showed clearer acetylation-related changes, suggesting more accessible cellulose chains, while the sawdust samples showed stronger matrix effects, probably due to residual lignin or higher sample density. This comparison adds value because it links spectral behaviour directly to the original biomass structure.

The TGA results also compare favourably with literature on cellulose ester thermal behaviour. Previous studies have reported that acetylation can reduce moisture sensitivity and alter the degradation profile of cellulose by replacing hydrophilic hydroxyl groups with acetyl groups [5, 21, 24, 26]. In the present work, the acetate derivatives showed reduced low-temperature mass loss and useful thermal stability above the normal moisture loss region. Corn husk-derived acetates showed cleaner degradation and lower char residue, while sawdust-derived acetates retained higher char. This difference is unique because it shows two possible application directions: corn husk acetate may be more suitable where

purity, film formation and low residue are important, while sawdust acetate may be useful where higher char formation, thermal ruggedness or reinforcement behaviour is desired.

The SEM observations further support the uniqueness of the work. Literature reports that acetylation and cellulose modification can disrupt cellulose hydrogen bonding, reduce fibre definition and promote the formation of smoother or denser polymeric surfaces [16, 23, 25, 32]. The present study confirms this transformation, but also shows that the two feedstocks follow different morphological pathways. Corn husk cellulose changed rapidly from a fibrous structure into a fragmented, dense and film-forming acetate matrix, while sawdust retained more fibre memory before gradually becoming smoother and more fused. This feedstock-dependent morphological behaviour is a major contribution of the study because it helps explain why the two biomass sources may be suitable for different industrial applications.

Overall, the novelty of this research is not only in synthesizing cellulose acetate derivatives from waste biomass, but in showing how two locally available residues behave differently under the same chemical treatment. The work demonstrates that sawdust and corn husk waste should not be treated as interchangeable cellulose sources. Sawdust offers higher cellulose recovery, stronger structural continuity and higher char forming tendency, while corn husk waste offers easier delignification, higher acetate derivative yield and faster fibre to film conversion. This feedstock specific interpretation gives the study practical relevance for sustainable material design, especially in regions where both timber and agricultural residues are abundant.

The study therefore contributes to the circular bioeconomy by demonstrating a waste to value pathway for two underutilized Nigerian biomass residues. In contrast to studies that only establish whether cellulose acetate can be produced from biomass, this work compares yield, FTIR evidence, thermal behaviour and SEM morphology together to identify the best potential use of each feedstock. This integrated comparison is the main uniqueness of the research and strengthens its relevance for biodegradable films, coatings, membrane precursors, textile fibres and bio-composite applications.

Conclusion

This study demonstrated that sawdust and corn husk waste can be converted into cellulose acetate derivatives through alkaline pretreatment, bleaching, and heterogeneous acetylation. Sawdust produced the higher alpha cellulose yield of 52.3 %, while corn husk waste yielded 48.5 %. In contrast, corn husk waste produced higher acetate derivative yields, reaching 83.5 % for cellulose triacetate compared with 80.0 % for sawdust triacetate.

FTIR confirmed successful acetylation through ester-related absorption and reduction in hydroxyl intensity. TGA confirmed that the acetate derivatives possessed improved thermal behaviour suitable for controlled polymer processing. SEM confirmed the transformation

from fibrous cellulose to denser film-forming acetate structures. The results establish both sawdust and corn husk waste as promising low-cost precursors for sustainable cellulose acetate production. The findings also support further optimization toward biodegradable films, filtration membranes, textile fibres, and other value-added biopolymer applications.

The unique contribution of this work is the comparative demonstration that sawdust and corn husk waste, although both are suitable for cellulose acetate synthesis, offer different advantages. Sawdust is more favourable for cellulose recovery, structural uniformity, and thermal residue formation, while corn husk waste is more favourable for higher acetate derivative yield, easier chemical accessibility, and rapid film-forming morphology. This feedstock-specific understanding provides a practical basis for selecting local biomass residues for targeted cellulose acetate applications.

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