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Cellulose nanocrystals prepared from sugarcane peel: A potential polymer material for acid fuel cells

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Introduction

Sugarcane peels are agricultural waste, available in abundance in Ogun State, Nigeria and are underutilised at present. The peels of sugarcane are residues produced in large mass annually by sugar and alcohol industries(1), hence, the indiscriminate disposal of this residue creates nuisance in the environment. Therefore, this agro-waste deserves to be utilized effectively for the production of cellulose nanocrystals (CNCs) as solid electrolyte membrane for acid fuel cells.

The aim of this study was to isolate cellulose from sugarcane peel by treating with sodium hydroxide and sodium chlorite and to extract CNC using sulphuric acid hydrolysis in order to achieve a polymer material suitable as acid fuel cells, suggesting the great potential of CNC as retaining the conductivity of current anion exchange sheath.

Methodology

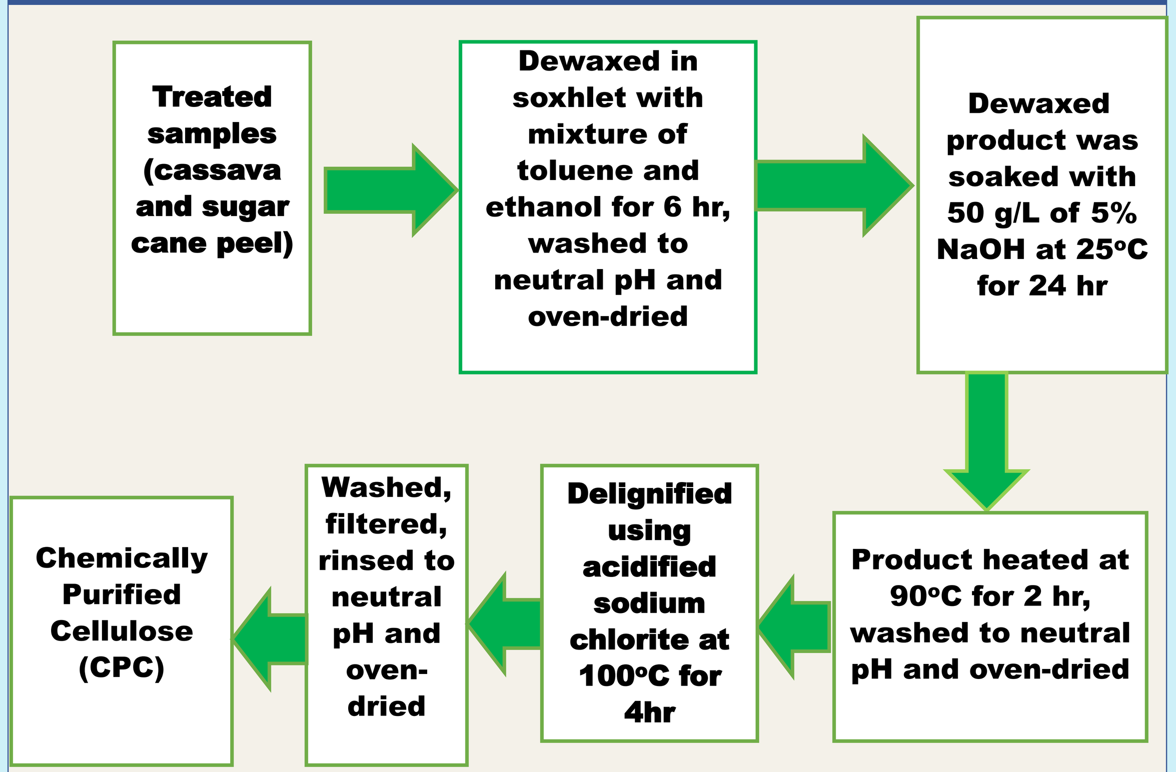

Figure 1a: A Flow Chart of the Isolation of Chemically Purified Cellulose

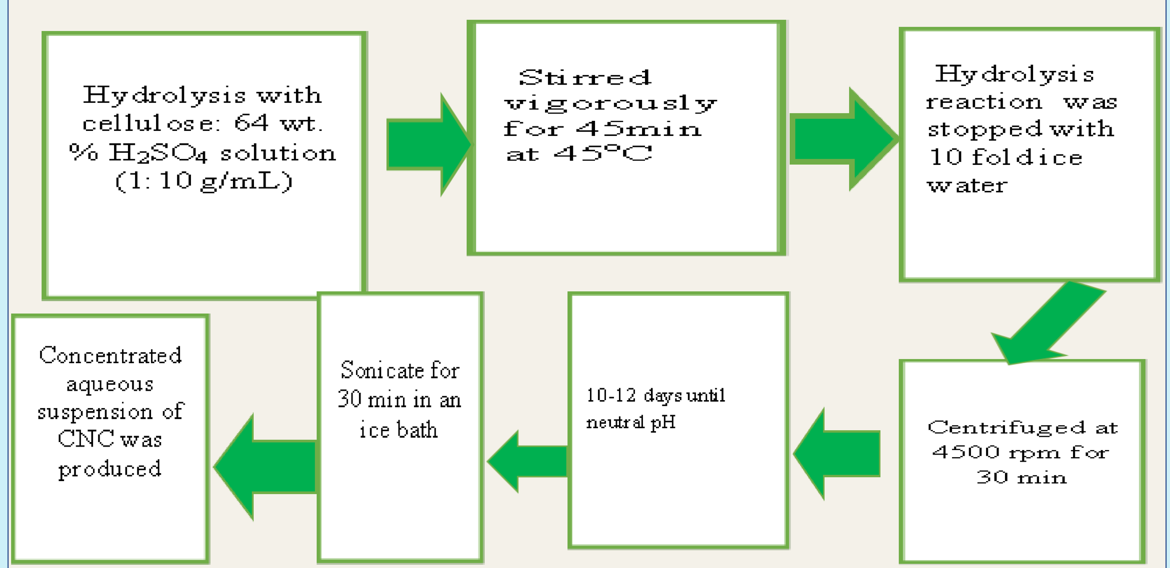

Figure 1b: A Flow Chart of the Extraction of Cellulose Nanocrystals

Note: RSP-Raw Sugarcane Peel
SPCPC-Sugarcane Peel Chemically Purified Cellulose
SPCNC-Sugarcane Peel Cellulose Nanocrystal

Results and Discussion

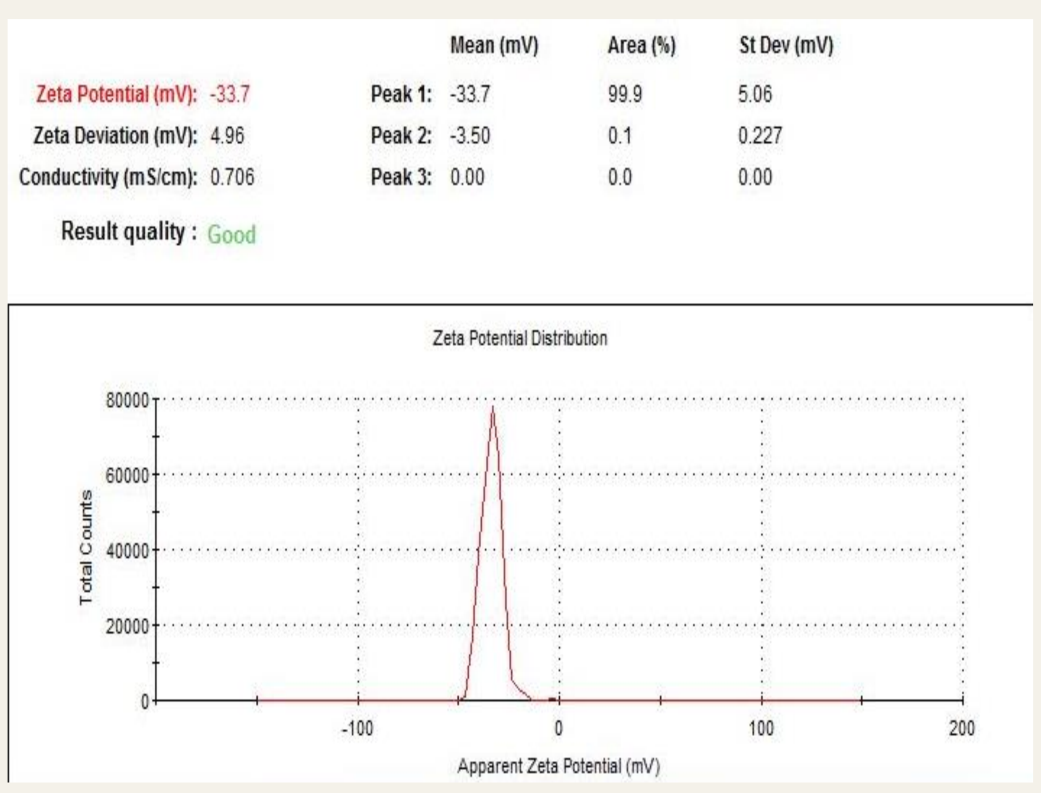

Figure 2:: Zeta Potential Measurement for SPCNC

The zeta potential revealed a conductivity of 0.706 mS/cm, which prompted the formation of a layer of negative electrostatic charge on the surface of the material 2, suggesting the great potential of CNC as retaining the conductivity of current anion exchange sheaths

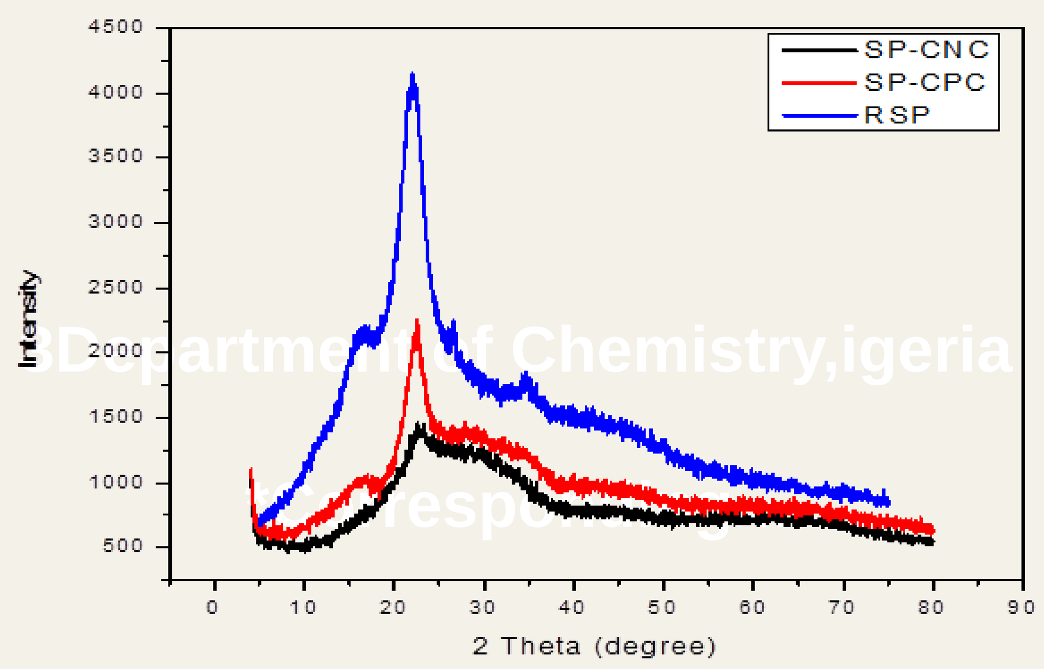

Figure 3 X-Ray Diffraction Patterns of RSP, SPCPC and SPCNC

The XRD diffrratogram showed the characteristic peaks of raw sample (SP) identified at 2θ=16.9° and 34.7°, also a peak was identified at 2θ=16.7° for the SPCPC. The three diffractograms showed characteristic peaks around 2θ = 22.7°. The crystallinity index of RSP, SPCPC and SPCNC was calculated to be 86.5, 95.6 and 99.2% respectively. The crystallite particle size showed a trend from untreated to CNC to be 25.8, 21.1 and 5.6 nm, respectively.

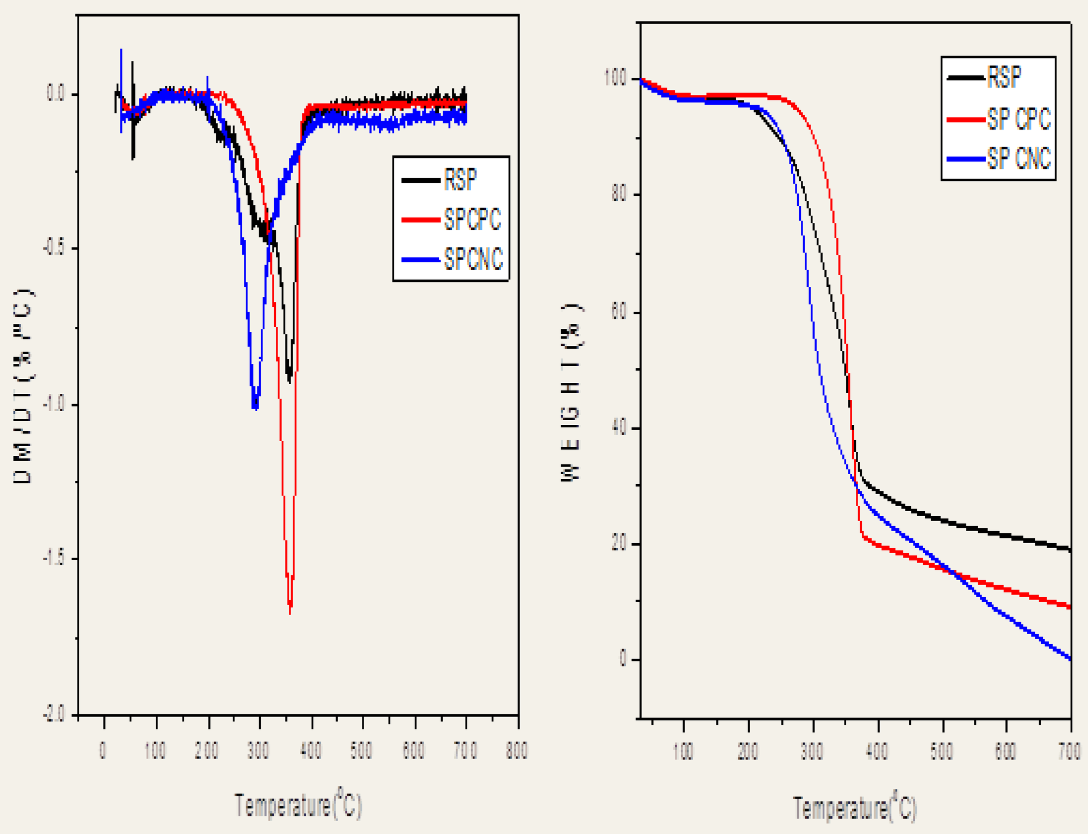

Figure 4: (a) DTG and (b) TG Curves for RSP, SPCPC and SPCNC

Three endothermic peaks were observed in the raw sample spectra and two endothermic peaks were observed in the cellulose and cellulose nanocrystal spectra analysed. The raw showed a temperature of maximum degradation at 356°C, the CPC and CNC samples exhibited a temperature of maximum degradation at 357.88 and 290°C, respectively. The CNC was thermally less stable.

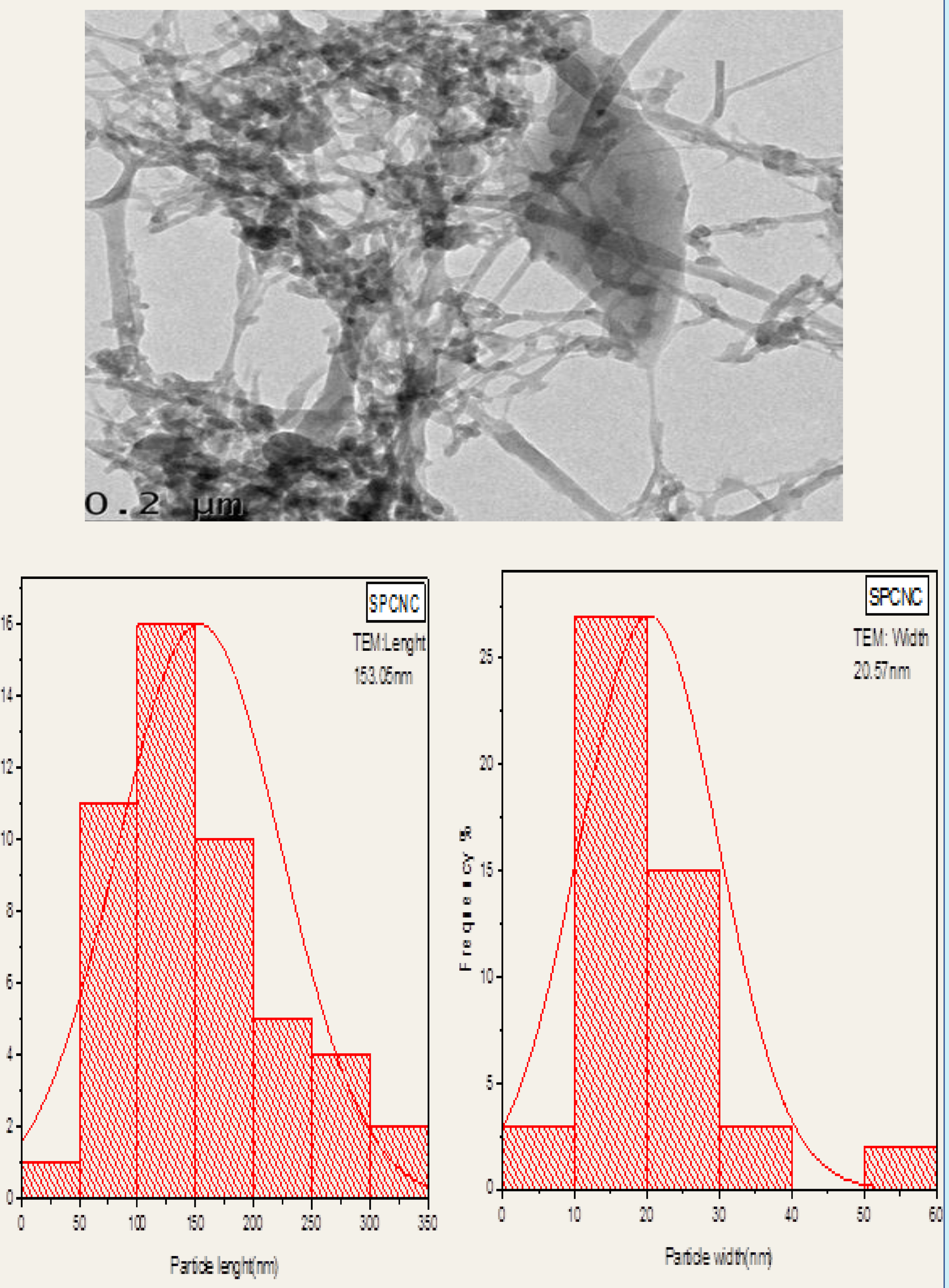

Figure 5: TEM Micrographs of (a) CNC of SPCNC (b) TEM Histogram of Width and Length SPCNC

The TEM image confirms that the SPCNC was needlelike in shape, they are uniform nano dimension bundles of crystals. The particle size has an average value of 20.57±9.47 nm in width and 153.05±70.82 nm in length. Figure 5b displays the histograms corresponding to the measurement.

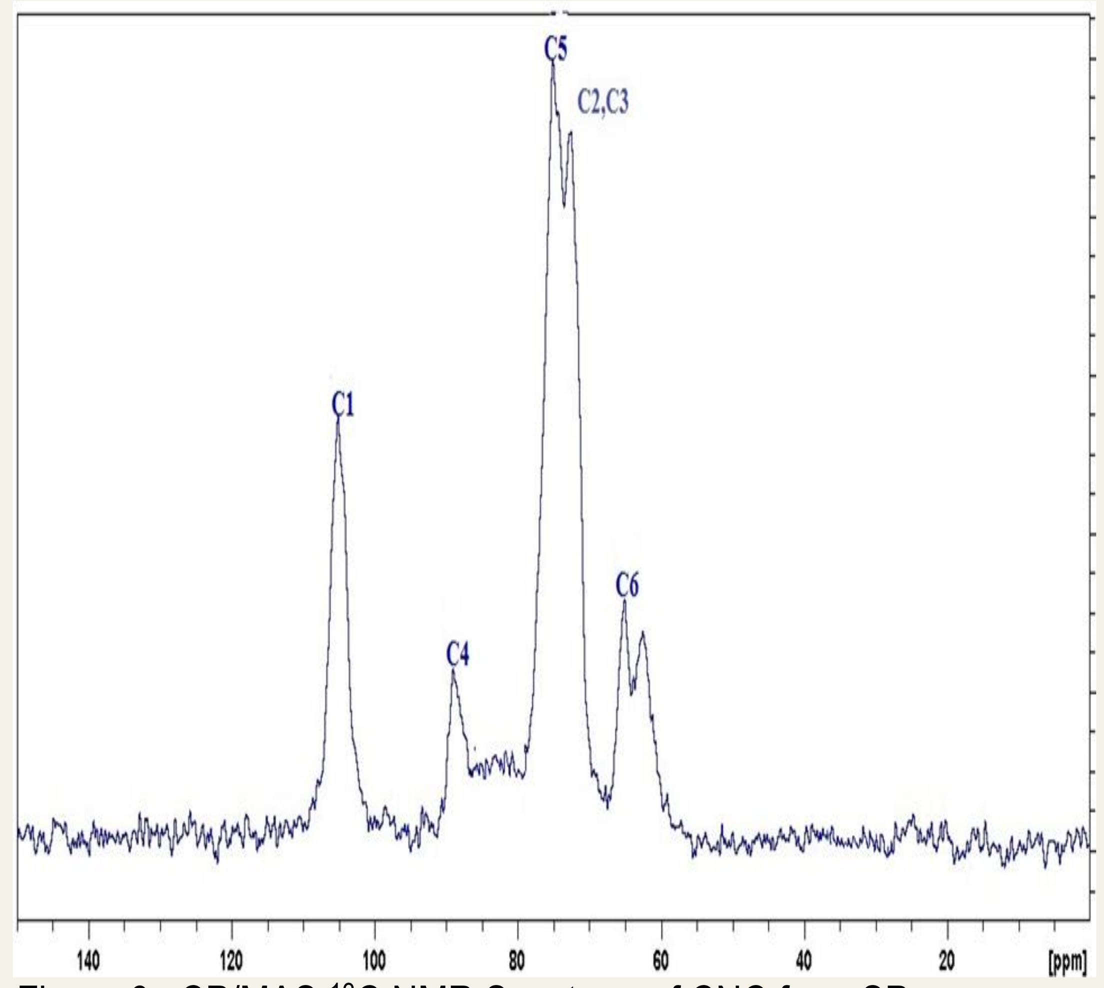

Figure 6: CP/MAS ^{13}C NMR Spectrum of CNC from SP

The CP MAS ^{13}C NMR evaluates the molecular structure and purity of a material. The disappearance of signals at 89 ppm of C4 , 102 ppm of C1,21 ppm and 173 ppm of methyl group of lignin indicates the complete removal of the amorphous region.

Table 1: Physicochemical Properties of RSP, SPCPC and SPCNC of Sugarcane Peel

Sample	Swelling Capacity (mL/g)	Water Holding Capacity(g/g)	Oil Holding Capacity (mL/g)	Loss of Mass on Ignition (%)	Moisture Content (%)	pH
RSP	3.05±0.05	3.5845±0.0005	5.05±0.05	4.975±0.005	11.21±0.01	1.54
SPCPC	2.55±0.05	4.0755±0.0005	5.55±0.05	4.965±0.005	6.125±0.005	6.38
SPCNC	0.5±0.00	5.7005±0.0005	11.05±0.05	4.895±0.005	7.005±0.005	6.02

Conclusion

This study showed the effective synthesis of cellulose nanocrystal from sugarcane peel (a waste material from agricultural process) based on the results of the various techniques and its suitability as a solid electrolyte membrane for acid fuel cells.

Acknowledgements

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References

1. Simkovic, I., Mlynar, J., Alfoldi, J. and M. M.Micko, M. M. (1990). New aspects in cationization of lignocellulose materials. XI. Modification of bagasse with quaternary ammonium groups. *Holzforschung,* **44:** 113–116.
2. Naduparambath, S., Jinitha, T. V., Shaniba, V., Sreejith, M. P., Apama, K. B. and E. Purushothaman. (2018). Isolation and characterisation of celulose nanocrystals from sago seed shells. Carbohydrate Polymers, 180: 13-18.