PRODUCTION OF CARBOXYMETHYL CELLULOSE FROM SUGARCANE BAGASSE AND WATER HYACINTH

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Abstract

Mines in Zimbabwe are facing a challenge in acquiring carboxymethyl cellulose because at the moment it is not being produced in the country therefore, mines like ZIMPLATS which focus on platinum mining are facing high costs of importing carboxymethyl cellulose from producing countries like China (US $3500/metric tonne) according to Alibaba. Various raw materials including plant biomass and algae have been used to produce cellulose. In this work, sugarcane bagasse and water hyacinth were used as a raw materials for cellulose extraction. Cellulose was extracted from the biomass through the elimination of lignin and hemicellulose. The preparation of CMC involves two main reactions or steps which are mercization and etherification by a slurry process. In the slurry method, cellulose is suspended in a mixture of NaOH-water-alcohol systems at 20 – 30 ºC with an excess of alcohol (ethanol or isopropanol), to ensure a good mixing efficiency. In the mercerization process, the liquid phase (water-alcohol mixture) which acts as a solvent, dissolves the NaOH and distributes it evenly to the cellulose hydroxyl groups forming alkali cellulose. Furthermore, the alkali cellulose produced is reactive towards monochloroacetate acid (MCA), which is added in the second step either as free acid, MCA or its salt, sodium monochloroacetate acid (NaMCA) to form carboxymethyl cellulose ethers. The results indicated that the optimum concentration of sodium hydroxide for alkalization to occur is 30% .The carboxymethylation process of cellulose was confirmed using potentiometric back titration and Fourier Transform Infrared Spectroscopy.The percentage yield was 85,2%.

Introduction

In recent years, there has been a rise in the level of research and interest on the development of beneficial biodegradable materials for use in agriculture and chemical industries. Carboxymethyl cellulose being one of the materials that has drawn much attention, is a linear, long-chain, water-soluble, anionic polysaccharide. Purified carboxymethyl cellulose (CMC) is a white- to cream-colored, tasteless, odorless, powder. Carboxymethyl cellulose (CMC) is extensively used as a flotation depressant in mineral processing. It has many other applications in various industries such as food, lubricants and adhesives.Mines in Zimbabwe are facing a challenge in acquiring carboxymethyl cellulose because at the moment it is not being produced in the country and the aim of this feasibility study was to produce carboxymethyl cellulose using water-hyacinth and sugarcane bagasse as raw materials.

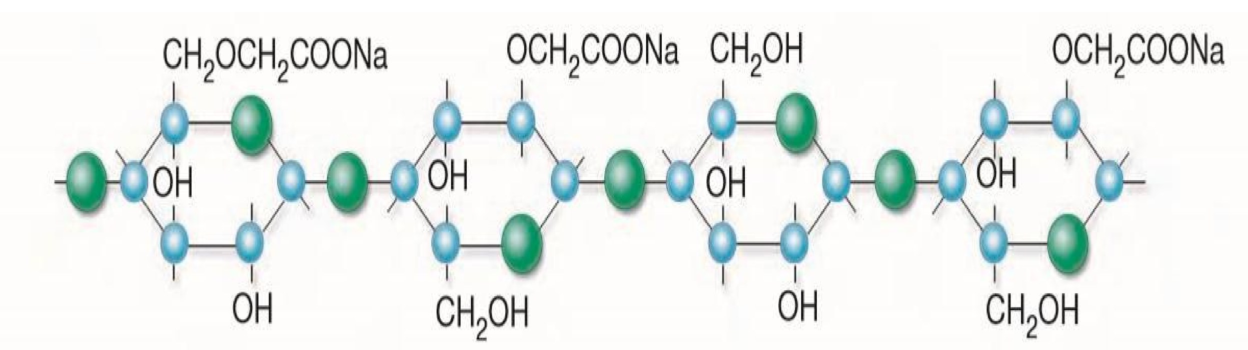

Figure 1. The Structure of Carboxymethyl Cellulose (SidleyChem, 2018)

Process Description

Pretreatment of the raw materials comes first which involves washing the samples and drying using hot air then crushing to increase the surface are to volume ratio of the biomass before hydrolysing it. Hydrolysis is done in order to dissolve unwanted components in the raw materials for example lignin leaving the solid particles of hydrolyzed cellulose. The hydrolyzed slurry is filtered and dried then alkalization and carboxymethylation are carried out respectively to produce CMC. During alkalization cellulose from the raw materials was reacted with sodium hydroxide. The whole process of alkalizing is done in a medium of isobutyl and isopropyl alcohol. Carboxymethylation was then carried out afterwards by reacting the slurry from alkalization with monochloroacetic acid and sodium hydroxide at different concentrations so as to note the optimum concetration at which the most CMC was yielded. The product was washed and neutralized using acetic acid after which, it was dried and stored.

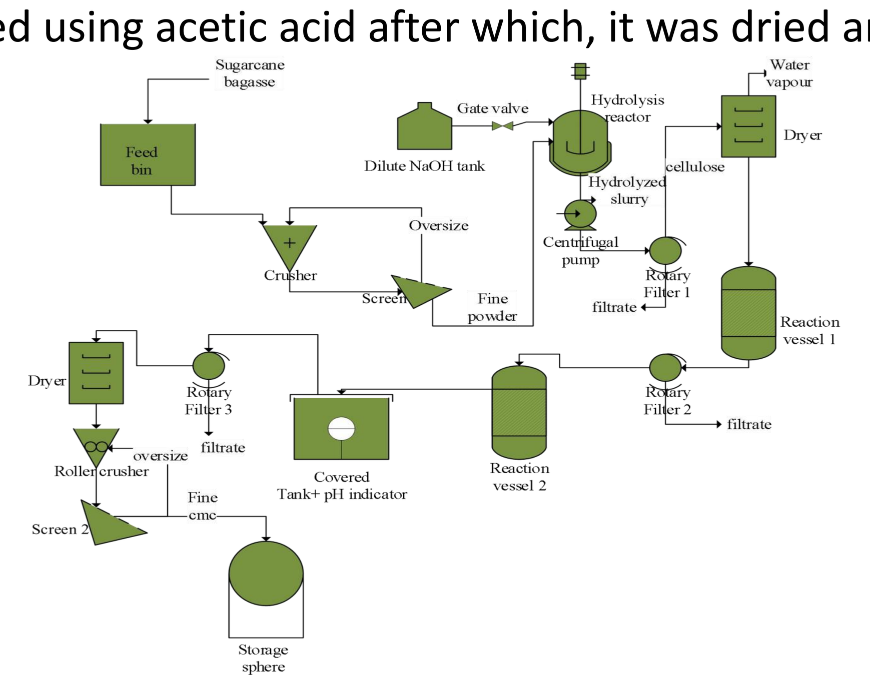

Figure 2. Process Flow Diagam for the production of CMC.

Experimental Results

Table 1. Percentage Yield of CMC.

Type of NaOH-CMC powder(%)	Mass of Sugarcane bagasse (g)	Mass of cellulose (g)	Mass of CMC(g)	Yield (%) of cellulose	Yield (%) of CMC
20	8.33	4.53	6.3	20.04	75.0
30	8.33	4.6	7.1	20.04	85.2
35	8.34	4.45	6.87	20.16	82.3

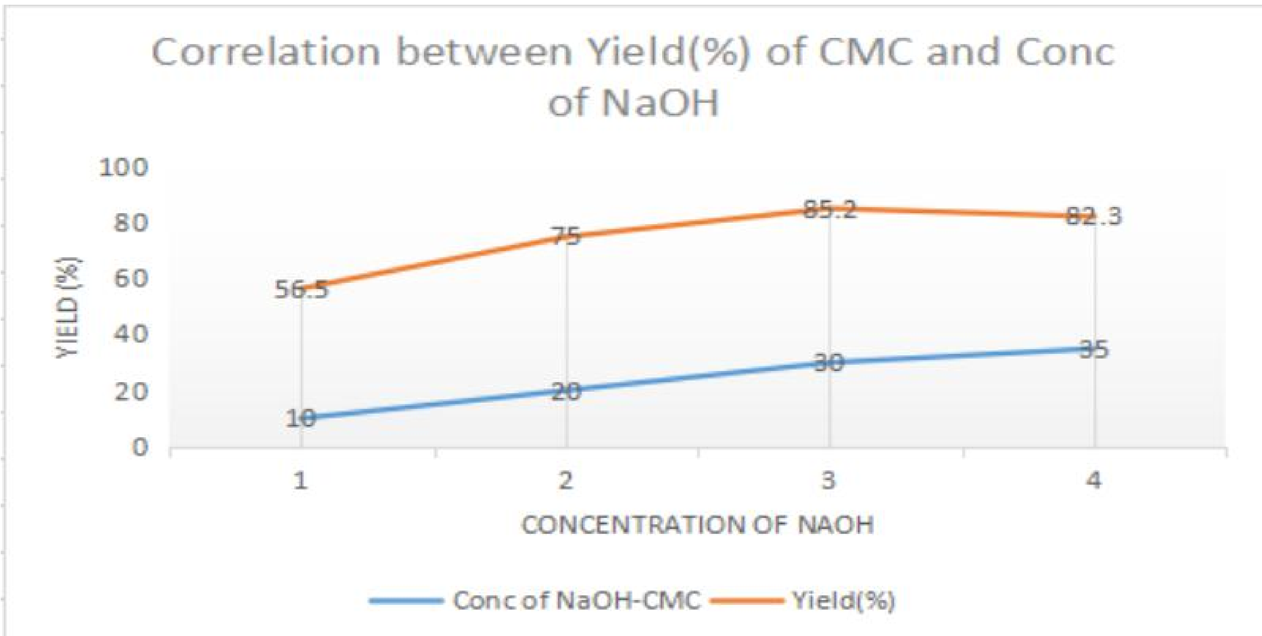

Figure 3. Correlation between the CMC percentage yield and sodium hydroxide concentration.

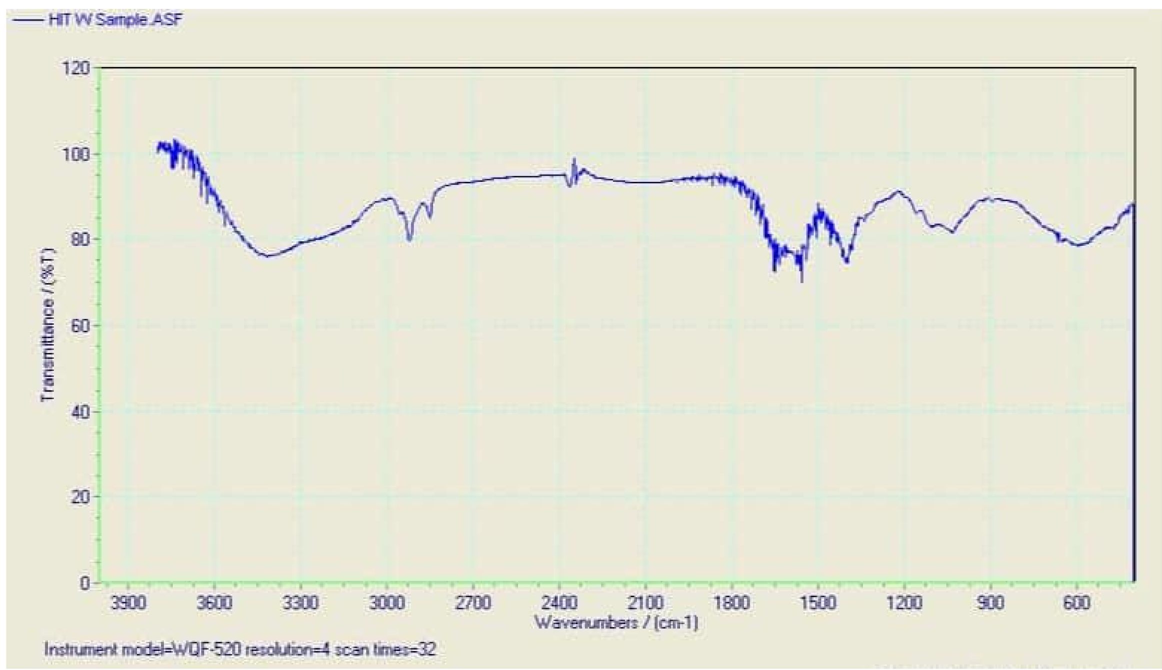

Figure 4. FTIR Results for Water Hyacinth CMC.

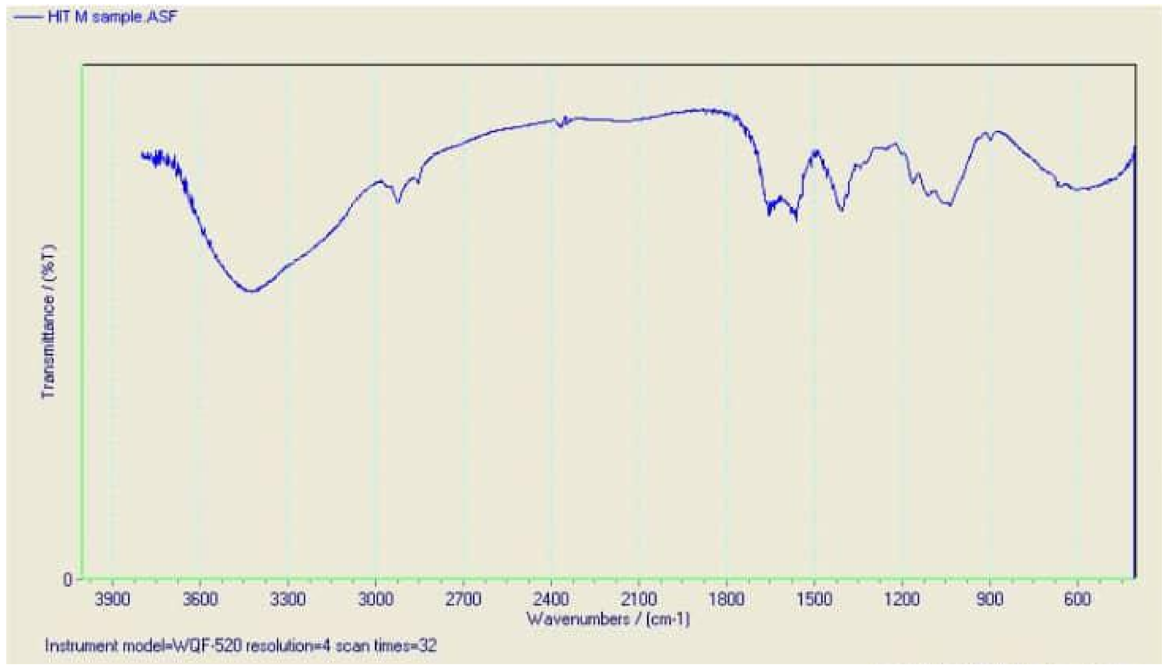

Figure 5. FTIR Results for Sugarcane Bagasse CMC.

Discussion

The graphs obtained from FTIR analysis of sugarcane bagasse and water-hyacinth CMC are amorphous and both having peaks which coincide in the same wavelengths. The broad band located within the range of 3600-3300 cm-1 appeared in all spectra indicates free -OH groups stretching vibration as well as inter- and intra-molecular hydrogen bonds in CMC. The vibration peaks in the wavelengths of 1800-1200 cm-1 are attributed to the C-H and C-O bending vibration in yhe polysaccharide aromatic rings. Sugarcane bagasse produced higher yields of cellulose and CMC which were 20.04% and 85.2% respectively at the optimum concentration of sodium hydroxide (30%). On the other hand the yields of cellulose and CMC from water-hyacinth were 15.7% and 75.25% respectively at 30% sodium hydroxide concentration making sugarcane bagasse the better raw material.

Conclusion and Recommendation

- The results obtained from FTIR characterization of CMC from sugarcane bagasse and water-hyacinth are similar to those from the theoretical FTIR results which are the reference. Thus, it can be concluded that the production of CMC from sugarcane bagasse and water-hyacinth was successful.
- In order to minimize the hazard risk of fires ,and high temperatures and also thermal denaturing of cellulose or CMC, the mills are cooled by cold water.

References

Saputra, A., Qadhayna, L. and Pitaloka, A. (2014). Synthesis and Characterization of Carboxymethyl Cellulose (CMC) from Water Hyacinth Using Ethanol-Isobutyl Alcohol Mixture as the Solvents. *International Journal of Chemical Engineering and Applications*, 5(1), pp.36-40.

Yadav, M., Rhee, K., Jung, I. and Park, S. (2013). Eco-friendly synthesis, characterization and properties of a sodium carboxymethyl cellulose/graphene oxide nanocomposite film. Cellulose, 20(2), pp.687-698.

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