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Review Article

IR SPECTRUMS AND CHARACTERISTICS OF Na-CMC FOUND IN SEVERAL TYPES OF PLANTS: A REVIEW

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ABSTRACT

Natrium carboxymethyl cellulose (Na-CMC) is a cellulose derivative that is produced commercially in greater amounts than other cellulose derivatives. Natrium carboxymethyl cellulose (Na-CMC) is a linear cellulose polymer and is an anion compound that is biodegradable, odourless, colourless, non-toxic, tasteless, flexible and transparent. Natrium carboxymethyl cellulose (Na-CMC) is usually found in the form of granules or powders which are soluble in water but cannot dissolve in organic solutions. Natrium carboxymethyl cellulose (Na-CMC) has a pH range of 6.5-8 and is stable in a pH range of 2-10. Na-CMC is found in several types of plants, such as water hyacinth, durian, elephant grass, rice, peanuts, pineapple, corn, oranges, baobab and sugar cane. Na-CMC is obtained from these plants. Na-CMC is widely used in the pharmaceutical, cosmetic, food, paper, textile, lithography and tobacco industries. Na-CMC sourced from natural materials is characterized by Fourier Transform Infrared Spectroscopy (FTIR). The functional groups of cellulose and carboxymethyl cellulose were investigated using infrared spectroscopy spectra. The pellets were made with CMC with potassium bromide (KBr). The absorbance level was measured for the wave number 3800-400 cm^{-1}. The results of the extraction of cellulose and carboxymethyl cellulose were characterized using the Fourier Transform IR (FTIR) instrument. To obtain the spectrum, the pellets made from the sample were grounded with KBr. Transmission was measured in the wave number range 4000-4400cm^{-1}. Infrared spectroscopy is one of the most versatile techniques used in chemistry and certainly one of the most important analytical methods available. It is a versatile experimental technique and it is relatively easy to obtain a reliable spectrum from a sample in almost any situation. In general, the infrared spectrum is used to determine the functional group of an organic compound and to find out the structural information of an organic compound.

Key words: Natrium carboxymethyl cellulose, Plants, FTIR**.**

INTRODUCTION

Natrium carboxymethyl cellulose (Na-CMC) is one of the cellulose derivatives that is produced commercially in greater amounts than other cellulose derivatives. Natrium carboxymethyl cellulose (Na-CMC) is a linear cellulose polymer and is an anion compound that is biodegradable, odorless, colorless, non-toxic, tasteless, flexible and transparent [1]. Natrium carboxymethyl cellulose (Na-CMC) is usually found in the form of granules or powders which are soluble in water but cannot dissolve in organic solutions. Natrium carboxymethyl cellulose (Na-CMC) has a stable pH range of 6.5-8 over a pH range of 2–10 [2]. Na-CMC has been used widely in the pharmaceutical field as an excipient [3]. *Carboxymethyl Cellulose* (CMC) is a natural polymer derivative that is most widely used in various pharmaceutical industries, such as food, pharmaceuticals, detergents, textiles and cosmetic and drilling products (oil and gas) [4].

CMC is also widely used in the field of oral or topical formulations in pharmaceuticals as thickeners, stabilizers, gelling agents, tablet binders and emulsifiers, as well as disintegrants. [3 5 6 7 4]. Carboxymethyl cellulose (CMC) is widely used as chewing gum [8]. CMC is also a constituent of many non-food products such as personal lubricants, toothpaste [9], anti-caking agent [10], paint, ceramics, cosmetic industry [11], pharmaceuticals and mineral processing [12], as coatings or edible films, cement, adhesives, pesticides, and paper [13,14].

The raw material for CMC mostly comes from wood cellulose because of the high cellulose content in wood. To reduce the use of wood as raw material for making CMC [15 16], CMC raw material can also be derived from cellulose found in plants [17]. Due to its availability as a raw material (used in diet pills, toothpaste, food additives) [18], more attention is being paid to its properties as an anionic polymer [19], and solubility in water [20].

Na-CMC is also known as Akucell®, Aquasorb®, Blanose®, Cellulose gum®, Na-CMCSodium®, E466®, Finnfix®, Nymcel®, SCMC®, Natrium carboxymethyl cellulose®, Sodium cellulose glycolate®, Sodium CMC®, Tylose CB® [21].

The structure of CMC (*Carboxyl Methyl Cellulose*) is a polymer chain consisting of molecular units' cellulose. Each *anhydroglucose* unit has three hydroxyl groups and several Hydrogen atoms from the hydroxyl group is substituted by *carboxymethyl* [5].

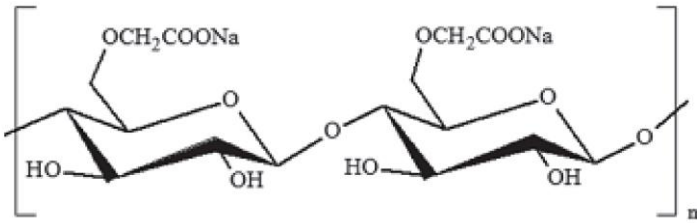

Figure 1. Chemical structure of Na CMC [22].

The carboxymethyl cellulose functional groups were investigated using infrared spectroscopy spectrum (Shimadzu IR Tracer -100). The pellets were made with CMC with potassium bromide (KBr). The absorbance level was measured for the wave number 3800-400 cm-[1]. [23] To obtain the spectrum, the pellets made from the sample were grounded with KBr. Transmission was measured in the wave number range 4000-4400cm-[1] [24]. Infrared spectroscopy is one of the most versatile techniques used in chemistry and certainly one of the most important analytical methods available. It is a versatile experimental technique, and it is relatively easy to obtain a reliable spectrum from a sample in almost any situation [25].

DATA COLLECTION

In compiling this review article, the technique used was literature studies by finding scientific sources or pharmaceutical literature in the form of national and international journals. Also, in the making of this article the search for data was done using online media with the keywords as follows: "utilization of Na CMC from various plant sources" and "Natrium carboxymethyl cellulose". The main references used in this article were searched online by using NCBI, PubMed, Google scholar and Google.

METHODS

Obtaining Na-CMC from various plant sources

The Na-CMC obtained from durian was started from the cut durian rind, then dried in the sun. The dried durian rind was ground and sieved with a 60mesh sieve. Durian rind flour was then dried again by using the oven for 1 hour at 60 ° C [26]. The obtained durian rind powder was then isolated by cellulose. Durian peel powder soaked in 10% sodium hydroxide solution with a ratio of durian rind powder with solvent 1:10 (w / v), 1:15 (w / v), and 1:20 (w / v), then stirred evenly until all durian peel powder soaked perfectly. The powder was soaked for 24 hours. After that it was filtered using a filter cloth. The residue obtained was then immersed in a 5% hypochlorite (chlorine) solution for 1.5 hours. Then the mixture was filtered, and the resulting residue was washed with distilled water that has been boiled until the hypochlorite odor disappears. The residue was then put in a petri dish then dried in an oven at 60 ° C until constant weight [26].

Synthesis of CMC was carried out with 5 grams of durian rind extract (cellulose) then added 100 ml of distilled water in a 250 ml flat bottom flask. Then 10 ml of 30% sodium hydroxide solution was added dropwise. The alkalization process was carried out for 1 hour at 25 ° C on a hotplate equipped with a shaker. After the alkalization was complete, it was followed by carboxymethylation. In this study, the various variations in the amount of sodium chloroacetate (w / w) added to the mixture above were 5, 6, 7, 8, and 9 grams. The mixture was then heated at 60 ° C to 70 ° C for 2 hours, the Carboxymethylation process was carried out with an oil bath. After that the mixture was filtered off and a residue was obtained in the form of CMC [27].

The Na-CMC obtained from elephant grass was started with the elephant grass stalks being washed, chopped, and blended, then dried at room temperature for 3 days. A total of 300 g of elephant grass powder was extracted with hexane-ethanol (2: 1 v / v) in reflux for 6 hours. The waste was then dried at room temperature [28].

As much as 300 g of dry dregs was mixed with 4 liters of 3.5% nitric acid containing 40 mg of sodium nitrite input in a glass beaker container then heated in a water bath at 90 ° C for 2 hours. The rest was washed with water and filtered with filter paper. The waste was added to 3 liters of a mixture of 2% sodium hydroxide solution and 2% sodium sulfite, then heated at 50 ° C for 1 hour. Then it was washed, filtered and bleached in 2 liters with a mixture of 3.5% sodium hypochlorite solution and water (1: 1), it was then boiled for 10 minutes, the mixture was washed and filtered to obtain cellulose [28].

The cellulose obtained from the elephant grass stalk was added with 2 liters of 17.5% sodium hydroxide heated at 80 ° C for 30 minutes and filtered. The result was then washed thoroughly with water, the waste was added with a mixture of 3.5% sodium hypochlorite and water (1: 1) heated at 100 ° C for 5 minutes, and then washed with water until the filtrate was clear, filtered and squeezed, then dried at temperature of 60 ° C in the oven for 1 hour. Then alpha cellulose was obtained [28].

A total of 25 g of alpha-cellulose were obtained, soaked in 750 mL of 30% w / v sodium hydroxide for 1 hour. Then it was filtered. The obtained sodium cellulose was reacted with 750 mL of a mixture of 250 g sodium chloroacetate and isopropanol at 60 ° C for 4 hours in a water bath. The Na-CMC obtained by this process was filtered, neutralized with 0.1 N HCl, and washed with 96% ethanol. After being filtered, it was dried at 60 ° C and then crushed. The obtained Na-CMC was stored at room temperature in a desiccator [29], [21], [30].

The Na-CMC obtained from pineapples was started by samples of pineapple leaves being dried in the sun before usage. Pineapple leaves that have dried were ground and sieved with a 60-mesh sieve. Pineapple leaf powder was dried again in the oven for 1 hour at 60 ° C [31].

25 grams of pineapple leaf powder was put into 1000 ml Erlenmeyer. Then 500 ml of 20% NaOH was added. Then it was cooked in a water bath at 100 ° C for 3 hours. After it has finished heating, it was washed by filtering clean water. Then 5 ml of 10% glacial acetic acid and 10 grams of NaCl were added, followed by filtering and washing with clean water. The slurry obtained was then cooked at 60 ° C for 3 hours with 125 ml 10% NaOCl and 500 ml aquadest. Then washed and filtered to remove the remaining NaOCl. The results of the filtering were then added with 250 ml of 3% Na metabisulfite and 250 ml of aquadest and then cooked at 60 ° C for 3 hours. After that it is filtered and washed with clean water. The wet cellulose obtained was then oven-baked at 70 ° C for 24 hours. After the cellulose was dried,

it was put in a blender and sieved with a 60-mesh sieve. The cellulose obtained was analyzed [31].

Weighed 5 grams of pineapple leaf cellulose was then put it in 250 ml Erlenmeyer, then added 100 ml of isopropanol slowly. After that, the 20 ml NaOH solution was added gradually while being homogenized. The concentration of NaOH solution in this study varied (15%, 30% and 45%). Alkalization was carried out for 4 hours with a temperature of 25 ° C on a hot plate. After the alkalization was complete, it was followed by carboxymethylation with the addition of sodium monocloroacetate reagent with variations of 4, 5, 6, 7, 8 grams. Carboxymethylation was carried out in an oven at 55 ° C for 180 minutes. After the carboxymethylation process was complete. The samples were then immersed in 100 ml of methanol for 24 hours. Then the mixture was neutralized by adding 90% acetic acid to a pH of 7 of 100 ml. The mixture was then filtered again. The residue obtained was then dried in an oven at 70 ° C for 24 hours. The dried residue obtained was then blended and sieved with a 60-mesh sieve. The CMC obtained was analyzed [31].

The Na-CMC obtained from peanuts was started with peanut shells being washed using tap water then dried under the sun. Dried peanut shells were mashed and sieved to obtain a powder measuring 500 millimicrons. The powdered peanut shells were dried in an oven at 50 ° C for 2 hours. Peanut shell powder was weighed as much as 50 grams analytically then added with 1 L of 10% mol NaOH solution. The mixture was heated for 5 hours at 35 ° C using a hot plate. Cellulose and hemicellulose solids were then separated from the lignin solution by filtration using a filter cloth. The cellulose and hemicellulose solids were washed using distilled water 2 times. The cellulose and hemicellulose solids were weighed as much as 25 grams, and then added with 100 ml of distilled water, 5 ml of 10% (v / v) acetic acid and 2 grams of sodium chloride in a beaker. The mixture was heated at 75 ° C for 1 hour while stirring at a speed of 500 rpm. Cellulose solids were filtered using filter paper then washed using distilled water and ethanol, then filtered again. The cellulose solid was dried at 50 ° C for 16 hours [32].

Cellulose was weighed as much as 6 grams. Cellulose was put into a three-neck flask then added 150 ml of isopropyl alcohol and 20 ml of 10% NaOH; 15%; 20%; 25%; 30% (w / v) The mixture was heated at 30 ° C for 90 minutes and then stirred at a speed of 500 rpm. It was then added 4 g of sodium chloroacetate; 6 gr; 8 gr; 10 gr. The mixture was heated to 70 ° C for 4 hours and stirred at a speed of 500 rpm [32].

The Na-CMC obtained from baobab fruit was started with crushed fruit capsules, pulp and seeds removed. The rind was cut into small pieces and washed with tab water and dried at room temperature for 48 hours. Samples were ground in the Kinematic M20 universal plant to pass through a 60-80 mesh standard sieve. Samples were then stored in closed polyethylene storage bags and randomized by shaking the bottles thoroughly before each aliquot was removed for analysis [25].

Isolation of cellulose was carried out according to the method described by [33], washed and room temperature dried baobab fruit peels were initially treated 4 times with 2% (w / v) NaOH for 2 hours and washed with distilled water until neutral pH. Second, BFS treated with alkaline was then given 4 times of 2% (w / v) NaClO 2 treatment for 2 hours and washed to neutral pH and dried. White cellulose was oven dried at 80 ° C.

The synthesis of carboxymethyl cellulose followed the procedure described by [12]. About 15.0 g of cellulose powder, 50 ml of various concentrations of NaOH (20, 25, 30, 35 and 40% w / v) and 450 ml of isopropyl alcohol were mixed in a beaker for 30 minutes. The carboxymethylation reaction was started by adding 18.0 g of monochloracetic acid (MCA) and stirring continuously for 30 minutes. The mixture was covered with aluminum foil and heated to a reaction temperature of 55 ° C in an oven for 3.5 hours. The mixture was separated into two phases. The liquid phase was removed, and the solid phase was suspended in 100 ml methanol (70% v / v), neutralized with glacial acetic acid and filtered using a Buchner funnel. The final product was washed 5 times with suspension in 300 ml of ethanol (70% v / v) for 10 minutes to remove unwanted by-products, and finally washed with 300 ml of absolute methanol. The residue from the filtration was dried at 55 ° C in an oven for overnight and then CMC was obtained.

Na-CMC obtained from sugarcane was started by the bagasse being milled first and seeded, then the fibers were cooked at a temperature of 370 ° C before bleaching with sodium hypochlorite and chlorine gas and washed with 5% KCL. After this process, bagasse fibers were obtained with a whitish degree of 70-80 (Euro standard). Additional bleaching of the sample was carried out in two steps: with 3% sodium chlorite and then 1% (1:10) at Ph = 3.8-4 [34]. Hemicellulose elimination from the pulp was then carried out with 10 g / 100 ml KOH (1:20) at 80 ° C for 2 hours (after 12 hours remaining at room temperature). After each step for residual elimination, the pulp was washed with distilled water. Alpha-cellulose content was measured by following Equation 1 according to the TAPPI T 203 cm-99 standard.

The synthesis of carboxymethyl cellulose followed the procedure described by [35]. Nine grams of powdered cellulose from bagasse, 30 ml NaOH (20 g / 100 ml, 30 g / 100 ml, 40 g / 100 ml, 50 g / 100 ml) and 270 ml of solvent (isopropanol, because of the good etherification ability of cellulose based on research [36], it was stirred in a beaker and let stand for 30 minutes at room temperature. Then 10.8 g sodium mono chloroacetate was added and stirred mechanically for 90 minutes in a beaker and covered with aluminum foil and kept at 55 ° C for 180 minutes. During this time, the reaction was continued, and the slurry was divided into two phases. The wasted and upper sedimentary phases were suspended in 70% methanol (100 ml) and neutralized using glacial acetic acid and then filtered and washed five times with 70% (300 ml) ethanol to remove unwanted salts. After that it was washed again with absolute methanol and filtered. The CMC obtained was dried at 55 ° C in an oven.

Na-CMC obtained from oranges was started with citrus mesocarp being produced from sweet oranges purchased at the Fagba station market in the state of Lagos, Nigeria, after the endocarp and epicarp were removed by peeling, it was dried in the sun and finally put in the oven at 60 ° C for approximately 6 hours. After that, it was put into the laboratory grinding mill. The earthed sample was sieved with a standard 20 mesh sieve. Dried, milled and sieved agricultural waste was boiled in 8% NaOH with a ratio of cellulose to solvent 1:20 (w / v) for 3.5 hours at 100 ° C, the obtained black slurry was filtered and washed using distilled water and bleached with 3, 85% NaOCl for 3 hours at 30 ° C. The bleached cellulose was washed again using distilled water until the smell of hypochlorite was no longer detected, then dried at 60 ° C in an oven. [24].

The synthesis of Natrium carboxymethyl cellulose was carried out in accordance with the study of Adinugraha et al [37]. Two grams of cellulose powder were alkalized at 25 ° C for 1 hour in a water bath with continuous shaking with 20 ml of 15% NaOH concentration in 100 ml of isopropanol as solvent. After the alkalization process was complete, 3 g of monochloroacetic acid was added and the temperature was raised to 55 ° C and the

reaction continues for 3 hours. The slurry was neutralized with 90% acetic acid then filtered. The solid obtained as CMC was washed with 70% ethanol for four times to remove unwanted by-products. The cellulose derivative (CMC) obtained was dried at 60 ° C in an oven.

Na-CMC obtained from water hyacinth was started with the water hyacinth obtained being cut to separate the stems from the roots and leaves. This study resulted in the plant part containing the highest cellulose, namely the stem. Stems were dried to remove moisture. The dried water hyacinth has gone through several stages to be made into powder. Water hyacinth powder was obtained by cutting it into small pieces and putting it into Willey's factory. Then it was sieved to get a powder with the desired 60 mesh size. The next step involved a Soxhlet tool and a mixture of toluene and ethanol solvents with a volume ratio of 2: 1 to heat the water hyacinth powder which has been wrapped in filter paper for dewaxing. The lignin removal process was carried out by mixing a 1% weight solution of $NaClO_2$ with water hyacinth powder from the dewaxing process. Then, the mixture was placed in a water bath at 80 ° C for 3 hours. The next step of cellulose isolation was removal of the hemicellulose content. This step was performed using 17.5% NaOH solution for 3 hours at room temperature. After that, the treated water hyacinth cellulose was washed and neutralized using water distillate and CH_3 COOH. The drying process was carried out in an oven at 60 ° C for 2-3 hours to obtain the final result of cellulose isolation [16].

Synthesis of Carboxymethyl Cellulose (CMC) began with an alkalization process. The alkalization process was carried out by mixing 5 grams of cellulose obtained with various compositions of the reaction media. Isobutyl and isopropyl alcohol were used to produce the desired mixture of reaction media. Then the solution was put into flash 3 necks with a stirrer for 10 minutes and 20 ml of 5% NaOH was added. The entire alkalization process was carried out for 1 hour at room temperature. The next step was the carboxymethylation process which was carried out by adding 6 grams of NaMCA and stirring for 3.5 hours at 55 ° C. The variations in this study were 10%, 20%, 30%, 35% NaOH concentration and the composition of the reaction media consisting of isobutyl-isopropyl alcohol at 50 ml: 50 ml and 80 ml: 20 ml. Solid CMC was obtained by neutralizing and purifying it with CH_3 COOH and 96% ethanol, then rinsing thoroughly to remove unwanted by-products. Finally, the cellulose derivative was dried for 1-2 hours at 60 ° C in an oven [16].

The Na-CMC obtained from rice was started with rice straw being initially washed with water, dried, cut and stored at room temperature. Rice straw was dried for 36 hours in an oven at 60 ° C, and then stored in a closed container that contained silica gel in it. This is so that the rice straw is not damp. The dried rice straw was then blended and then sieved using a 20mesh sieve [38]. The cellulose extraction method used 100 ml of 12% NaOH for every 5 g of rice straw powder for 120 minutes at 120ºC. Then 5 ml of 10% glacial acetic acid and 10 grams of NaCl were added followed by filtering and washing with clean water [38].

Synthesis of CMC was carried out by weighing 5 grams of cellulose of rice straw then putting it into 250 ml Erlenmeyer, adding 100 ml of isopropanol slowly. After that, the 20 ml NaOH solution was added gradually while shaking it. The concentration of NaOH solution in the study was 15%. Alkalization was carried out for 1 hour with a temperature of 60ºC on a water bath equipped with a shaker. After the alkalization was complete, it was continued with carboxymethylation using variations of NaMCA (2, 4, 6, 8) grams and carried out with a water bath shaker at 55ºC for 180 minutes. After the carboxymethylation process was complete, neutralization was carried out by adding 90% acetic acid to pH 7, then washing with 70% alcohol 4 times, each as much as 100 ml. The CMC obtained was then dried in a 70ºC cabinet dryer for 24 hours. The obtained dry CMC was then blended and sieved with an 80-mesh sieve [38].

Na-CMC obtained from rice was started with 5.00 g of rice husk was weighed in 250 mL Erlenmeyer flask and 100 mL of 80% glacial acetic acid, added 10 mL of 70% nitric acid. The flask was covered with aluminum foil and heated in an oven at 120ºC for 20 minutes. The sample mixture was allowed to cool and added with 60 mL distilled water; the mixture was filtered and washed with distilled water and 95% ethanol. The residue was dried in an oven at 60 ° C for 19 hours [23].

The synthesis of carboxymethyl cellulose (CMC) involves two stages: alkalization and carboxymethylation (etherification). Approximately 5.00 g of extracted cellulose was added to 100 mL of distilled water in a 250 mL Erlenmeyer flask. Then 10 mL of 5, 10, 15, 20 and 25% sodium hydroxide solutions were added dropwise. The alkalization process was carried out for 1 hour at 25ºC on the shaker that was installed. Then 2, 3, 4, 5, 6 and 7g of monochloroacetic acid were added to the mixture and heated in a microwave at various power outputs 2, 4, 6, 8 10 corresponding to 140, 280, 420, 560 and 700 watts respectively for 1, 2, 3, 4, 5 minutes, and the resulting contents are filtered off. The residual neutralization was obtained by soaking in 100 mL of methanol for 24 hours, and then the mixture was neutralized using glacial acetic acid. The mixture was filtered, and the residue dried in an oven at 60ºC [23].

Table 1. Na-CMC sources obtained from plants

Plant	Component	Result	Reference
Durian	Rind	Optimum conditions of synthesis reaction carboxymethyl cellulose occurred when the addition ratio of sodium chloroacetic 8: 5 grams obtained yield of carboxymethyl cellulose by 66.712%	39
Elephant grass	Stems	Out of the 300 grams total acquisition alpha cellulose, the cleansed and dried elephant grass stalks were 92.5436 grams or the Na-CMC gain of 25 grams of alpha cellulose was 16.9200 grams or 67.68%. So that from 300 grams, 20.87% of Na-CMC was obtained.	40
Rice	Straw	Extraction of rice straw powder used alkaline compounds, 12% NaOH solution at 120 ° C for 3 hours. The results of the rice straw powder extraction showed that the yield of rice straw cellulose extract was 20.37%. The low yield of cellulose extracted from rice straw can be caused by poor washing and filtering processes.	38
Pineapple	Leaves	The concentration of NaOH also greatly affects the yield, the higher the NaOH concentration, the yield percentage produced also increases. The highest yield was obtained at a concentration of 45% NaOH with variations in sodium monocloroacetate: cellulose (8 grams: 5 grams) with a yield of 96.8% with a reaction time of 4 hours	31
Peanut	Shell	After the pretreatment process, it can be seen that there were differences in the levels of cellulose in the peanuts shell. Before the pretreatment process the cellulose content in the peanut shell was 27% and after the pretreatment process the cellulose content became 64.42%.	32

		This occurred due to the destruction of the lignin binding compound by the NaOH solution. Changes in the color and structure of the softer peanut shell can be seen from the results of visual observation,	
Orange	Mesocarp	CMC generated in this work look good and in powder form. The result WAS 46.5%. The yield was determined by the amount of material lost in the preparation process. The degradation become more pronounced and large amounts of the lower molecular weight material were released due to more drastic reaction conditions such as higher temperatures and the concentration of reagents used.	24
Baobab	Rind	The baobab fruit capsules studied contained 17.88% pulp, 43.78% seeds, 3.95% fiber and 34.39% shell, which is in accordance with literature [41]. The main components found were holocellulose 59.0%, acid insoluble lignin (Klason) 37.44%, α-cellulose 34.73%, hemicellulose 24.27%, ash 2.43% and extractive 5.61%. It should be noted, however, that the average nutshell and stone fruit tended to contain more lignin, and less cellulose content than wood [42]. Cellulose fibers of the baobab fruit shell extraction results showed an average yield of 37.67%, the average molecular weight of cellulose BFS dissolved in a solution of NaOH / Urea approximately 51 024 g / mo	41 42
Sugarcane	Bagasse	Alpha cellulose content of about 81 % ± 2%, which indicates sufficient sample purification of all impurities.	43
Rice	Rice husks	The percentage of cellulose extract obtained from rice husks is 81.67%. Carboxymethyl cellulose obtained from rice husks showed a better substitution rate than CMC from other different cellulose sources.	23

FOURIER TRANSFORMATION INFRARED SPECTROSCOPE (FTIR)

There are some who have used the Fourier transform infrared spectroscopy method for the utilization of Na-CMC from various plant sources in pharmaceutical preparations. The infrared spectrum of Na-CMC produced by the synthesis of water hyacinth cellulose showed several absorption points at 1599.97 cm^{-1} and at 1420.10 cm^{-1}. The peak of the spectrum at a wavelength of 1599.97 cm^{-1} indicated the presence of a carbonyl group, and at 1420.10 cm^{-1} indicates methyl [44].

FTIR spectrum of carboxymethyl cellulose from durian rind, FTIR spectra of carboxymethyl cellulose from durian rind, and the appearance of the wave number 3417 cm^{-1} is the OH group which is characteristic of cellulose [27]. According to [45], CMC was identified as having a carboxyl group at a wavelength of 1604 cm^{-1} and a -CHbond$_2$ at a wavelength of 1419 cm^{-1}. The infrared spectrum on Natrium carboxymethyl cellulose made from elephant grass stalks on the OH functional group bond does not exist, in the C = O functional group bond there is a wave number 1677.71 cm^{-1}, in the COC functional group bond there is a wave number of 1285.60 cm^{-1} and from NaCMC Merck® [40]. The resulting infrared spectrum from NaCMC was less clean than that of Merck's NaCMC. Infrared spectrum on Natrium carboxymethyl cellulose made from peanut shells can be identified at wavelengths 1600.02 cm^{-1} and 1418.71 cm^{-1}. [46] said the carboxyl groups were identified at wavelengths ranging from 1600-1640 cm^{-1} and 1400-1450 cm^{-1}.

Infrared spectrum on Natrium carboxymethyl cellulose made from pineapple leaf fibers, with the peak absorption wave number 1581.63 cm^{-1} indicated the presence of a carbonyl group (CO). The absorption peak with a wave number of 1408.04 cm^{-1} indicated a bond (-CH2) which affected the formation of CMC, the analysis results showed that it is in accordance with the carboxymethyl cellulose structure [31].

Infrared spectra of Natrium carboxymethyl cellulose prepared from orange mesocarp. Infrared spectroscopy of CMC was shown at peaks at wave numbers 1417.73 cm^{-1} and 1597.11 cm^{-1} for orange mesocarp indicating the presence of carboxymethyl substituents [24]. Infrared spectrum on Natrium carboxymethyl cellulose made from the rind of the fruit of the baobab. Infrared spectroscopy of the CMC was shown on the carboxyl group salt having wave numbers of about 1600 cm^{-1} and 1400 -1450 cm^{-1} [47].

The infrared spectrum on Natrium carboxymethyl cellulose made from bagasse, cellulose and carboxymethyl has the same functional group with the same absorption band in FTIR as the hydroxyl group (-OH stretch) at 3200-3600 cm^{-1} [43]. Infrared spectrum on Natrium carboxymethyl cellulose made from rice husk. Infrared carboxymethyl cellulose is similar to cellulose, broad absorption band at 3337 cm^{-1} results in the frequency of OH group stretching and the formation of intramolecular and intermolecular hydrogen bonds. The peak at 2948 cm^{-1} was due to the CH stretching vibration [44].

Table 2. Utilization of Na-CMC with the Fourier Transform Infrared Spectrum Method

Sample	Infrared Spectrum Results	Reference
Water Hyacinth	The infrared spectrum of Na-CMC produced by the synthesis of water hyacinth cellulose showed several absorption points at 1599.97 cm^{-1} and at 1420.10 cm^{-1}. The peak of the spectrum at a wavelength of 1599.97 cm^{-1} indicated the presence of a carbonyl group, and at 1420.10 cm^{-1} indicated methyl. This indicated the presence of carboxymethyl in the structure of the Na-CMC sample. The carboxyl group as a salt structure had a wave range ranging from 16001640 cm^{-1} to 1400-1450 cm^{-1}. Based on FTIR analysis, the unique absorption peaks of the sample, which were at wave numbers 3460.32 cm^{-1} and 3364.36 cm^{-1} (OH group) and located at 10.62.30 cm^{-1} and 1065.68 cm^{-1} (CO group), indicated the presence of the bond in the structure of the two samples of the Na-CMC infrared spectrum obtained from the synthesis of dilute cellulose and from the Na-CMC standard gave similar spectral results, and also showed similar functional groups.	45
Durian Rind	According to the [49], the OH functional group WAS very strong at wave number 3427 cm^{-1}. According to [50], at a wavelength of 3700-3100 cm^{-1} was an OH group which indicated the formation of hydrogen bond groups between hydrogen atoms in another hydroxyl group of glucose monomers on the cellulose polymer chain. According to [49], the hydrocarbon group (CH) was at a wave number of about 2950 cm^{-1}. The wave number 1413 indicated the CH2 group. And at a wavelength of 1600 indicated the presence of a carboxyl group. According to [46], CMC was identified as having a carboxyl group at a wavelength of 1604 cm^{-1} and a ± CH2 bond at a wavelength of 1419 cm^{-1}. Based on this identification, it was evident that the resulting CMC has	49 50 46

	similar functional groups to commercial CMC and has a wave number indicating the constituent groups in CMC, namely the carboxyl group and ± CH2.	
Elephant grass	Infrared spectrum on sodium carboxymethyl cellulose which was made from elephant grass stalks in the OH functional group bond was not present, in the C = O functional group bond there was a wave number 1677.71 cm^{-1}, in the COC functional group bond there was a wave number of 1285.60 cm^{-1} and from NaCMC Merck® as a comparison it was found that the OH functional group bond did not exist, in the C = O functional group bond there was a wave number of 1679.09 cm^{-1} and in the group bond The COC function contained a wave number 1283.78 cm^{-1}. The resulting infrared spectrum from NaCMC was less clean than that of Merck's NaCMC.	40
Peanut shell	FTIR spectrum was conducted to prove the presence of carboxyl groups (COOH) in Na-CMC. In the figure it can be seen that the carboxyl groups can be identified at the wavelengths of 1600.02 cm^{-1} and 1418.71 cm^{-1}. [47] said the carboxyl groups were identified at wavelengths ranging from 1600 to 1640 cm^{-1} and 1400 to 1450 cm^{-1}. The greatest absorption occurred at 1600.02cm^{-1} indicating the presence of a carboxyl group (-COOH.). Then the absorption band at 1418.71 cm^{-1} showed a scissoring vibration of the CH2 group. However, the absorption band intensity at these wavelengths was relatively weak. And other sizable absorption can be seen in the absorption band at the wavelengths of 3971.6 cm^{-1} and 1325.15 cm^{-1}. This showed the presence of –OH and CO groups respectively on Na-CMC as impurities.	47
Pineapple leaf fibers	Based on the results of functional group analysis using the FTIR CMC tool, it was characterized by the presence of an absorption peak at a wave number of 3263.56 cm^{-1} - 3275.13 cm^{-1} indicating the presence of a `hydroxyl group (–OH). The peak of absorption with a wave number of 1581.63 cm^{-1} indicated the presence of a carbonyl group (CO). The peak of absorption with a wave number of 1408.04 cm^{-1} shows the presence of a bond (-CH2) which affected the formation of CMC. The absorption wavelength of 1049.28 cm^{-1} - 1099.43 cm^{-1} indicated the presence of ether formed, namely the group (-O-), the analysis results showed conformity to the carboxymethyl cellulose structure.	31
Orange mesocarp	Peaks at wave numbers 1417.73 $cm^{-1}$and 1597.11 cm^{-1} for orange mesocarp indicated the presence of carboxymethyl substituent. According to literature reports, the carboxy groups and their salts have wave numbers of about 1600-1640 cm^{-1} and 1400-1450 cm^{-1} [37] This spectrum compared with the commercial CMC reported by Adinugraha et al [37] is similar except for peaks at 2125.63 and 2360.95 cm^{-1}. This peak is thought to be contamination from dirt or the combined band of water. The similarity of CMC in this work with that reported in the literature from other agricultural wastes and commercial CMC suggests that CMC can be synthesized from orange mesocarp [51], [10].	37 51 10
Baobab rind	The IR spectrum of BFS cellulose provides very characteristic peaks for a number of special groups. The band at 669.30 cm^{-1} is the OH out-of-plane bending band [13]. The absorption band was observed at 896.89 cm^{-1} according to the β-glycosidic relationship. [52]. The protruding band at 1058.92 cm^{-1} represents ring vibrations and C - OH bending. The band at 1163.08 cm^{-1} is caused by stretching C - O and C - O - C. There was a bending vibration band at C - H at 1377.17 cm^{-1}. The band at 1318 cm^{-1} represented OH in the bending plane or CH bent. A peak at 1423 cm^{-1} indicated CH 2 bending. The characteristic peak at 1625 cm^{-1} is –O– the tensile vibrational band adjacent to group H. The peak at 2902.87 cm^{-1} occurs due to C - H stretching [53]. The broad absorption band at 3417.86 cm^{-1} is due to stretching of the -OH group, which was directly related to the inter-molecular and intra-molecular hydrogen bonds [54]. Additional peaks at the wavelengths of 2339.65 cm^{-1} and 2139.06 cm^{-1} may be due to contamination [55] due to CO_2 treatment, processing or from breathing. The absorption peaks of around 3400, 2900, 1430, 1370, 890 cm^{-1} were attributed to the characteristics of native cellulose I as seen across the cellulose spectrum [56].	13 52 53 54 55 56
Bagasse	Fourier Transform Infrared Spectroscopy (FTIR) showed chemical changes in polymer structure. Cellulose and carboxymethyl have the same functional groups with the same absorption bands on FTIR as hydroxyl groups (-OH stretching) at 3200-3600 cm^{-1}, hydrocarbon groups (scissoring -CH2) at 1450 cm^{-1}, carbonyl groups (C = O stretching) at 1600 cm^{-1} and ether (-O-) groups at 1000-1200 cm^{-1}, also CH stretching vibrations at 3000 cm^{-1} [57]. Esterification of cellulose with NaCMA caused the OH group in cellulose to be replaced with CH COONa, which caused a change in the absorption spectrum of the relate 2 d band. This caused the OH group to peak and strength was weaker or creates new peaks. The absorption bonds, in the absorption bands 1059, 1426 and 1607 were relevant to -O-, CH 2- and -COO. [58] reported that broadband at 1600-1640 cm^{-1} and 1400-1450 cm^{-1} was due to carboxyl and salt groups, which confirmed the substitution of carboxymethyl groups in the structure of cellulose. This peak was not present in the FTIR spectrum of cellulose from bagasse obtained in previous studies.	57 58
Rice husk	The broad absorption band at 3432.39 cm^{-1} was a feature of the OH stretching vibrations and reveals the formation of intramolecular and intermolecular hydrogen bonds and hydrogen bonds [59]. The peak at 2924.13 cm^{-1} was due to the CH stretching vibration. The absorption band at 1631.81 cm^{-1} was water absorbed. The band at 1383.95 cm^{-1} was characteristic for the bending symmetrical CH 2. The hemicellulose and lignin peaks in 1508 and 1459 disappeared completely after extraction. The band at 1104.55 cm^{-1} appeared due to stretching COC [60]. Therefore, the product obtained confirmed that cellulose was successfully extracted from rice husk. Infrared carboxymethyl cellulose is similar to cellulose, the broad absorption band at 3337 cm^{-1} results in the frequency of OH group stretching and the formation of intramolecular and intermolecular hydrogen bonds. The peak at 2948 cm^{-1} was due to the CH stretching vibration [44]. The new band at 1593 cm^{-1} was assigned to the COO- group while the bands at 1459 cm^{-1} and 1086 were attributed to CH 2 scissoring the CO-C stretch [61]. This confirmed that the cellulose has been modified to become Carboxymethyl cellulose.	59 60 44 61

CONCLUSION

Overall, analysis methods have been used for the utilization of Na-CMC from various plant sources. One of them is Fourier Transform Infrared Spectroscopy (FTIR) that works to identify compounds, detect functional groups and analyze the analyzed mixtures and samples. Infrared spectroscopy is one of the most versatile techniques used in chemistry, and certainly is one of the most important analytical methods available. It is a versatile experimental technique, and it is relatively easy to obtain a reliable spectrum from a sample in almost any situation.

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