Sodium CMC Introduction and Application Study in Food Grade Industry

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[ABSTRACT]

Comprehensive study of Sodium Carboxymethyl Cellulose(CMC) structure, formula, properties, characteristics and its application in food industry. Analyze some real application cases as food additive in food production.

Testing method for determining the Food Grade CMC purity, viscosity, Degree of Substitution(D.S.) , pH and Loss on Drying(LOD) and so on. Describe Characteristic Identification Testing(Foam test, Precipitate formation, colour reaction).

Mentioned some international well-known Sodium CMC suppliers. Forecast its prospects and push forward food industry innovation development.

This article aims to provide a comprehensive study of the characteristics, functions, formula, properties and applications of Sodium CMC.

[Key Words]: Sodium Carboxymethyl Cellulose(Na-CMC); Sodium CMC; CMC, food additive; structure; formula, function, Sodium CMC supplier, Cellulose Ether, Cellulose Gum, INS No.: E466, Synonyms, testing method, purity, viscosity, Degree of Substitution(D.S), Cellulose ether etc.

Contents

1.Introduction(background and history)

Sodium Carboxymethyl Cellulose is an anionic, linear, water-soluble cellulose ether that can cause significant changes in the viscosity of most commonly used aqueous solution preparations. It's a type of cellulose derivative.

As early as 1918, the German-E.Jasen invented its synthesis method and obtained a patent in 1921. Since then, commercial production has begun in Europe. At that time, only crude Sodium CMC products were produced and used as colloids and adhesives in industrial application. During the period from 1936 to 1941, the application research of Sodium Carboxymethyl Cellulose became increasingly active, and many innovative utility patents have been obtained.

The American company(Hercules) first produced Sodium Carboxymethyl Cellulose in 1943 and began producing refined grade sodium carboxymethyl cellulose in 1946. The product was recognized as a safe food additive. Japan began industrial production Sodium CMC in 1944. And China began industrial production of Sodium CMC in 1958. Currently, there are more than 100 types of Sodium CMC based on different purity, viscosity, Degree of Substitution(D.S) etc. The main Sodium CMC suppliers around the world are from China, America, Finland, Italy, Turkey, India and Japan.

Sodium CMC is currently widely used in food, pharmaceutical, detergent, ceramic, paper making, textile, oil drilling, mining, construction, toothpaste, tobacco industries due to its excellent thickening, dispersing, suspending, bonding, film-forming, colloid-protecting and moisture-protecting properties.

2.Sodium CMC basic information

2.1 Definition

Synonyms: Sodium Cellulose Glycolate, Na CMC, CMC, Cellulose Gum, Sodium CMC, INS NO.E466

Chemical Names: Sodium Salt of Carboxymethyl Ether of Cellulose

C.A.S. number: 9004-32-4

Chemical Formula: [C6H7O2(OH)x(OCH2COONa)y]n

where n is the degree of polymerization

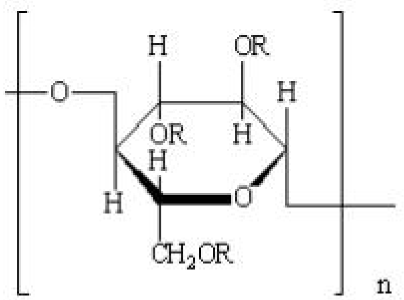
x = 1.50 to 2.80

y = 0.2 to 1.50

x + y = 3.0

(y = degree of substitution)

Structural Formula:



where R = H or CH_2COONa

Formula Weight: Structural unit with a degree of Substitution of 0.2: 178.14;

Structural unit with a degree of Substitution of 1.5: 282.18;

Macromolecules: Greater than about 17,000(n about 100)

Assay: Not less than 99.5% of Sodium Carboxymethyl Cellulose, calculated on the dry basis

Description: White to creamy, almost odourless hygroscopic granules, powder or fine fibers

Function Uses: Thickening agent, stabilizer, suspending agent

2.2 Identification Test(ID test)

Solubility Yield viscous colloidal solution with water, insoluble in ethanol

Foam Test Vigorously shake a 0.1% solution of the sample. No layer of foam appears. This test distinguishes sodium carboxymethyl cellulose from other cellulose ethers and from alginates and natural gums.

Precipitate Formation To 5ml of an 0.5% solution of the sample add 5ml of 5% solution of copper sulfate or of aluminium sulfate. A precipitate appears.(This test permits the distinction of Sodium Carboxymethyl Cellulose from other cellulose ethers, and from gelatine, carob bean gum and tragacanth gum)

Colour Reaction Add 0.5g of powdered carboxymethyl cellulose sodium to 50ml of water, while stirring to produce a uniform dispersion. Continue the stirring until a clear solution is produced. To 1ml of the solution, diluted with an equal volume of water, in a small test tube, add 5 drops of 1 1-naphthol TS. Incline the test tube, and carefully introduce down the side of the tube 2ml of sulfuric acid so that it forms a lower layed. A red-purple colour develops at the interface.

2.3 Main Items

Loss on Drying Not more than 10% after drying(105℃, to constant weight)

pH value: 6.0-8.5(1 in 100 solution)

Sodium Not more than 12.4% on the dry basis

Determine total sodium content by Atomic Absorption Spectroscopy or Flame Photometry

Sodium Chloride Not more than 0.5% on the dry basis

Free Glycolate Not more than 0.4% calculated as sodium glycolate on the dry basis

Degree of Substitution Not less than 0.2 not more than1.5

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3.Main items testing method

3.1 Assay(Purity) testing method

Sodium Chloride Heat 5 g of the sample, weighed to the nearest 0.1 mg, in a platinum or porcelain crucible, first with a small flame so that the sample does not ignite and then, when the charring is complete, heat further in an electric oven for 15 min at about 500℃. After cooling, pulverize the ashes thus obtained and extract several times with warm water. Filter the extracts into a 500-ml volumetric flask, acidify with nitric acid and dilute to the mark.

Determine the NaCl content of 100 ml of this extract by the method of Volhard, using 0.02 N silver nitrate and 0.02 N ammonium thiocyanate. Each ml of 0.02 N silver nitrate is equivalent to 1.169 mg of NaCl. Calculate the sodium chloride content by the formula:

$$\% NaCl = \frac{a \times 0.001169 \times 5}{b} \times 100$$

where

a = ml of 0.02 N silver nitrate used

b = dry weight of 5 g of the sample

Free Glycolate Weigh 0.5g of the sample to the nearest 0.1mg, and transfer to a 100ml beaker. Moisten the sample thoroughly with 5ml of glacial acetic acid, followed by 5ml of water, and stir with a glass rod until the solution is complete(Usually about 15min are required). Slowly add 50ml of acetone while stirring and then approximately 1g sodium sulfate. Contiune the stirring for several min to ensure complete precipitation of the carboxymethyl cellulose. Filter through a soft-texture paper, previously wetted with a small amount of acetone, and collect the filtrate in a 100ml volumetric flask. Use 30ml of acetone to facilitate the transfer of the solids and to wash the filter cake. Make up to volume with acetone and mix.

Prepare a blank solution containing 5ml of water, 5ml of glacial acetic acid and acetone in another 100ml volumetric flask. Pipet 2ml of the sample solution and 2ml of the blank solution into two 25ml volumetric flasks. Remove the acetone by heating the uncovered flasks upright in a boiling water bath for exactly 20 mins. Cool to room temperature and add 5ml of naphthalenediol TS. Mix thoroughly, then add 15ml more of the TS and mix. Cover the mouth of the flask with a small piece of aluminum foil and heat upright in the boiling water bath for 20min. Cool to room temperature and make up to volume with naphthalenediol TS.

Measure the absorbance of sample solution against blank solution at 540nm using 1cm cells. Read the corresponding mg of glycolic acid from the calibration curve obtained as follows:

Introduce 0, 1, 2, 3 and 4 ml aliquots of standard glycolic acid solution(1mg per ml, prepared by weighing accurately 0.100g of glycolic acid, previously dried in a vacuum desiccator for at least 16h, and then dissolving in 100ml of water; do not keep the solution longer than 30 days) into a series of five 100ml volumetric flasks. Add water to each flask to a volume of 5ml, then add 5ml of glacial acetic acid and make up with acetone to mark and mix. Pipet 2 ml of each solution (containing, respectively, 0, 1, 2, 3, and 4 mg of glycolic acid per 100 ml) into a series of five 25-ml volumetric flasks and proceed in the same manner as described for the Test Solution. Plot the mg of glycolic acid in the original 100 ml of solution against absorbance to give a calibration curve.

Calculate the sodium glycolate (free glycolate) content by the formula:

$$\%\ Sodium\ glycolate = \frac{a \times 0.129}{b}$$

where

a = mg of glycolic acid read from the calibration curve

b = g of dry-weight of the sample

3.2 Degree of Substitution(D.S)

Sample preparation

Weigh 5 g of the sample to the nearest 0.1 mg, and transfer it into a 500-ml conical flask. Add 350 ml of methanol or ethanol (80% by volume). Shake the suspension mechanically for 30 minutes. Decant through a tared glass filtering crucible under gentle suction. Avoid suctioning air through the crucible at the end of the crucible Repeat the treatment with the extraction liquid until the test for

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chloride ions with a solution of silver nitrate TS is negative. Normally three treatments are sufficient. Transfer the Sodium Carboxymethyl Cellulose into the same crucible. Displace the extraction liquid that adheres to the substance with acetone. Dry the crucible in an oven at 110o until constant in weight. Weigh it for the first time after 2 hours. Cool the crucible every time in a desiccator and pay attention during weighing to the fact that Sodium Carboxymethyl Cellulose is slightly hygroscopic.

Procedure

Weigh 2 g, to the nearest 0.1 mg, of the bone-dry substance, obtained with the above-mentioned alcohol-extraction procedure and transfer it to a tared porcelain crucible. Initially, char carefully with a small flame and afterwards for 10 min, with a larger flame. Cool and then moisten the residue with 3-5 ml of concentrate sulfuric acid. Heat cautiously until the fuming is finished. After some cooling add about 1 g of ammonium carbonate, distributing the powder over the whole contents of the crucible. Heat again, initially with a small flame until the fuming is finished and heat then at a dull red heat for 10 min. Repeat the treatment with sulfuric acid and ammonium carbonate if the residual sodium sulfate still contains some carbon. Cool the crucible in a desiccator, then weigh. Instead of adding ammonium carbonate and heating further with a flame, the crucible can be placed in an oven at about 600℃ for 1 hour.

Calculate the sodium content of the alcohol-extracted sample by the formula:

$$\%\ Sodium = \frac{a \times 32.38}{b}$$

where

a = weight of residual sodium sulfate

b = weight of the alcohol-extracted dry sample

Calculate the degree of substitution by the formula:

$$Degree\ of\ substitution = \frac{162 \times \%\ sodium}{2300 - (80 \times \%\ sodium)}$$

Method of Assay(Purity)

Calculate the percentage of Sodium Carboxymethyl Cellulose in the sample by subtracting from 100% the sum of the percentages of sodium chloride and sodium glycolate (free glycolate), determined separately by the procedures above.

$$Content\ \% = 100 - (\%\ NaCl + \%\ sodium\ glycolate)$$

3.3 Viscosity testing method

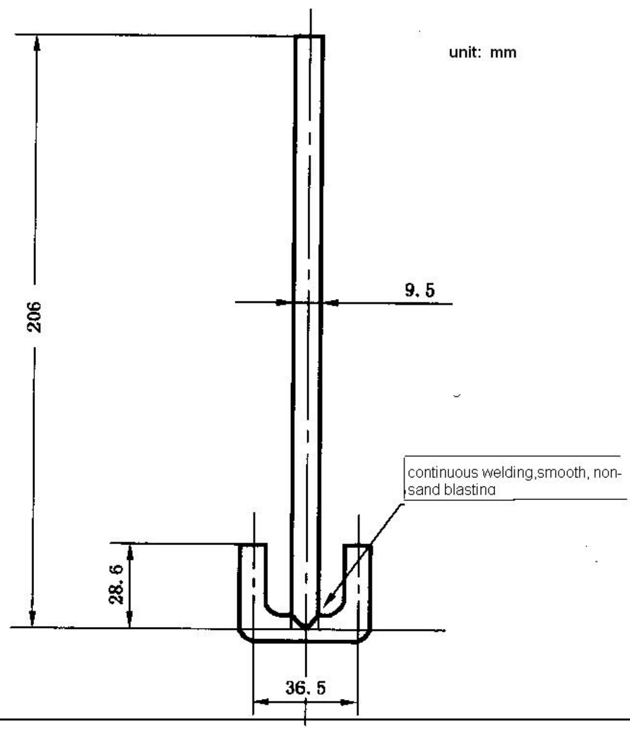
1Test equipment

1) Rotary viscosimeter :Numerical rotary viscosimeter or pointer rotary viscosimeter.

2) Glass cup: diameter is about 90mm,height is about 120mm, The diameter of the top is the same as the diameter at the bottom, and the volume is 500mL.

3) Thermostatic water bath

4) Blender: stainless steel or glass(see the following picture),under the different load connected in a to 900 r/min and 100 r/min variable speed motor rotation.



Steps:

1) Weigh approximately a 5g sample of the1% solution or a 10g sample of the 2% solution ,

accurate to 1mg.

2) Add 495g of the 1% solution or 490g of the 2% solution water into a glass bottle.

3) Put the blender into the glass bottle, mixing blade is about 10mm far from the bottom of the bottle.

4) Begin stirring and add the test sample slowly, adjust the speed to 900 r/min±100r./min, and stir for 2 hours.

5) If the sample was not dissolved completely, continue stirring for an additional 0.5 hour.

6) Move off the blender and put the glass bottle into thermostatic waterbath(25℃±0.2℃) for 1 hour.

7) Take out of the thermostatic waterbath and stir by hand for 10 seconds.

8) Use the Viscometer LVT to test the viscosity, firstly put the rotor of the viscometer into the sample solution, and then start the viscometer , allow it to rotate for 1 minute, when the display value is stable, read the viscosity.

Testing result calculating:

1) Numerical viscometer

2) Direct reading, that is, the viscosity of the sample value.

3) Analog viscometer

Viscosity η, the value in milliseconds (mPa · s), according to formula (A.1) calculation:

$\eta = S \times k$ .... (A.1)

S --- Rotary viscometer pointer indicates the reading number in milliseconds (mPa · s);

k - the coefficient of rotor and speed selected for determination.

The test results should indicate the concentration of the test solution and the rotor number and speed of the rotor used.

The results of the test are based on the arithmetic mean of the parallel determination, and the absolute difference of the two independent determinations results under the repeatability condition. The value should not exceed 5% to 10% of the arithmetic mean.

3.4 pH value testing method

Use the PH paper to test the PH value with a 10g/L sample water solution.

4.CMC functions introduction

4.1 Thicker and emulsifier

Food grade sodium carboxymethyl cellulose can play an emulsifying and stabilizing role in beverages containing fat and protein. Generally, fat beverages contain varying levels of fat and protein, which tend to separate and float during storage, forming unsightly separation and affecting the appearance of the product. In addition, protein tends to coagulate and separate, especially for products with low pH values, the protein will inevitably coagulate, and sodium carboxymethyl cellulose can effectively solve these problems. It dissolves in water as a transparent and stable colloid, which can stabilize protein and reduce the surface tension between fat and water, so that the fat is fully emulsified. Therefore, sodium carboxymethyl cellulose is commonly used as a thickener in the food industry.

4.2 Water retention

Sodium carboxymethyl cellulose exhibits a hydrating effect. It can improve the texture of meat products, bread, steamed buns and other foodsby preventing water from volatilizing, thereby increasing product yield and improving taste.

4.3 Film forming property

Sodium carboxymethyl cellulose can form a film on the surface of food, which can play a certain protective role on fruits and vegetables. Due to the existence of the film, a low-oxygen, high-carbon dioxide gas environment is formed between the film and the fruits and vegetables, thereby reducing the gas exchange rate and the material exchange rate, which is used to extend the shelf life of fruits and vegetables.

5. Typical applications in food industry

5.1 Sodium CMC in dairy products

5.1.1 Application in acidic beverages

Acidic milk drinks have a unique sweet and sour flavor and enjoy a broad market.However, during production, casein tends to aggregate and become unstable under acidic conditions. Therefore, polysaccharides are generally added to protect casein, stabilize the system and ensure a good taste. As a polysaccharide, sodium carboxymethyl cellulose stabilizes acidic milk beverages through the following mechanism: During acidification, when the pH reaches 5.2, CMC-Na begins to adsorb on the surface of casein micelles, and its effect is similar to that of k-casein under neutral conditions. The electrostatic repulsion and steric hindrance of the adsorption layer maintain the stable existence of casein micelles, and CMC-Na has a thickening effect, which can reduce the sedimentation rate of protein particles. The results show that at lower pH values, sodium carboxymethyl cellulose requires a certain concentration; below this concentration, the system becomes unstable. In the range of pH 3.6 to 4.6, the lower pH system requires more sodium carboxymethyl cellulose for stability. Compared with the acidification type, fermented acidic milk beverages have higher requirements for stabilizers.

Acidic milk drinks containing fruit particles are made by adding a certain amount of fruit particles to milk drinks, and stabilizers are also needed to stabilize the system. Tests indicate that CMC-Na is the main stabilizer for acidic milk drinks. When CMC-Na accounts for 0.4% and pectin 0.14% in the compound stabilizer, the system stability is significantly improved.

Some scholars have also studied the application of sodium carboxymethyl cellulose in lycopene active beverages to stabilize the system. The research shows that when the addition of CMC-Na exceeds 0.4%, the product maintains good stability, but the viscosity is greatly increased at this time, so it can be used in combination with other colloids.

After the CMC-Na cold-melting process is optimized, the viscosity of traditionally acidified milk beverages is always higher than that of hot-melting products during the shelf life, resulting in

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improved stability. This also provides a theoretical foundation for the enhanced application of sodium carboxymethyl cellulose in the production of acidic milk beverages.

5.1.2 Application in stirred yogurt

Denaturation and precipitation of milk protein under acidic conditions has always been a key issue affecting the development of yogurt. Due to its multifunctionality, wide availability, and low cost, CMC-Na is frequently used as a stabilizer. Studies show that CMC-Na is greatly affected by temperature and pH value. When only a small amount is added, it fails to stabilize the state of yogurt. When its content reaches 0.4%, the state of yogurt improves and the system becomes more stable. In addition, CMC-Na has a minor thickening effect on yogurt at 0.05%-0.1%, but it provides significant thickening effect at higher content range (0.4%-0.5%).

5.2 Sodium CMC used in steamed bread and bread making

5.2.1 Application in bread making

Since sodium carboxymethyl cellulose contains hydrophilic groups that combine with water to form hydrophilic colloids and absorb water to swell when kneading dough. After expansion, CMC-Na can increase the water-holding capacity of gluten, which is beneficial to the proofing of bread and the retention of carbon dioxide during baking, thereby increasing the volume of bread. However, the amount of sodium carboxymethyl cellulose should not exceed 6%. Due to its strong water retention, a suitable amount of addition can reduce the hardness of bread. Studies have shown that adding an appropriate amount (2%-6%) of sodium carboxymethyl cellulose can significantly improve the quality of baked bread, with the most effective results observed at 6%, followed by 4%. It enhances bread volume, texture, flavor, and shelf life. This provides the possibility of adding sodium carboxymethyl cellulose to bread to improve the quality of bread.

5.2.2 Application in steamed bread

The addition of sodium carboxymethylcellulose has minimal effect on the pH value of oatmeal steamed bread dough. The research shows that sodium carboxymethylcellulose can effectively improve the texture of oatmeal steamed bread, effectively reduce the hardness, stickiness and chewiness of steamed bread, and when the addition of sodium carboxymethylcellulose is

0.06%-0.08%, the texture indexes perform best. At present, the application of sodium carboxymethyl cellulose in steamed bread is still limited, which also provides the possibility for its application in new fields and can increase its application range.

5.3 Sodium CMC in ice cream

Ice cream is a three-phase polydisperse system characterized by a plastic foam emulsion structure. It consists of gas phase, liquid phase and solid phase. In the gas phase, bubbles containing ice crystals are evenly dispersed throughout liquid phase of ice cream; in the liquid phase, solid ultrafine protein particles and insoluble salts are evenly distributed in the mixed liquid. Therefore, ice cream can be considered as a gel containing fat droplets, milk solids, air bubbles and ice crystals. As an important thickener in the production of cold drinks, CMC has a significantly influence on the quality of ice cream. Using CMC in ice cream production can increase the viscosity of the mixed liquid, prevent the fat in the liquid from floating up, and improve the uniformity of the entire system of the mixed liquid. Additionally, it can reduce the generation of large ice crystals in ice cream, enhance the anti-melting performance and delicate and smooth taste of ice cream, gives it a whiter appearance, make the product texture smooth, and increase the volume of ice cream. At the same time, using CMC in ice cream can also reduce the use of solid raw materials, thereby reducing the production cost of ice cream.

5.4 Sodium CMC in wine

Clarity is an important indicator of wine appearance quality. Turbid wine generally has a poor taste. Therefore, during production, it is usually necessary to artificially accelerate the precipitation and flocculation reaction during the wine aging process. CMC can be used as a tartar stabilizer for wine.

Tartar precipitants in wine are mainly potassium hydrogen tartrate and calcium tartrate. These two salts have different stable states in wine due to the different physical properties of potassium ions and calcium ions. The solubility of calcium tartrate is largely unaffected by temperature which is the main reason why the cold treatment method used in production is not effective.

The mechanism of action of CMC is that it may participate in maintaining the balance of wine, making the salt balance of tartrate in wine stable. It can also form complexes with already-precipitated potassium hydrogen tartrate, allowing it to remain stable in the wine for extended periods. However, for calcium tartrate, once formed, it will precipitate quickly, and the unformed calcium salt will maintain a long-term balance and stability.

Sodium CMC can stabilize potassium hydrogen tartrate. In addition to the above reasons, it is also because CMC itself is a polyelectrolyte, which is both an electrolyte and a colloid. Its stability to tartar may also involve a ratio problem of the reaction amount. Experimental results have shown that the tartar precipitation in the simulated wine did not continue to decrease with the increase in the amount of CMC added, but rebounded. When the temperature is lowered, the colloidal properties of CMC play a role in preventing the formation of tartar crystals and ensuring its stability.

5.5 Sodium CMC in other applications

Jam and juice are fluid foods that typically require stabilization using hydrophilic colloids , such as modified cellulose. Sodium CMC as an effective thickener in systems with high soluble solids concentrations (45%-60%) and, like most chemically modified celluloses, can form clear solutions, which is exactly what is needed for this type of product. Sodium CMC is pseudoplastic, offers a refreshing taste, and provides good suspension stability. A CMC mass fraction of 0.4%-0.5% can completely prevent the clarification of juice. Sodium CMC can prevent noodles from breaking and becoming crispy, and make the product resistant to boiling and soaking, with good toughness. In other food applications,. It also inhibits the formation of sugar crystals in candies, icings and syrups. Additionally, CMC acts a a foam stabilizer in beerAnd improves the spreadability of products like jam, cream, and peanut butter. In low-calorie carbonated beverages, CMC helps retain carbon dioxide.

6. Market analysis and outlook

In recent years, both the price and demand of CMC have been growing steadily. The total output of CMC in the world is about 10 million tons. Major markets include China, Africa, Europe, Japan, and the United States, which together account for around 80% of the global market. CMC is widely used in a variety of food products such as soybean milk, ice cream, popsicles, jelly, beverages, canned food, soy sauce, vegetable oil, and fruit juices. CMC has excellent emulsifying properties for animal oil, vegetable oil, protein and aqueous solution, and can form a homogeneous emulsion with stable performance. As a result, its range of applications continues to expand.

Besides, Sodium CMC can be used as a flocculant, chelating agent, emulsifier, thickener, water-retaining agent, sizing agent and film-forming material. It is also widely used in Lithium Battery, pesticides, leather, plastics, printing, ceramics, daily chemicals and other fields. It has a very broad market prospect and great development potential. Especially, with the development of new energy vehicles in China, Which has significantly boost the demand for CMC in lithium battery production. China has Now emerged as the world's largest producer and consumer of sodium carboxymethyl cellulose.

There are more than 100 types of Sodium CMC based different viscosity, purity and D.S(Degree of Substitution) etc. **SINOCMC** has been a professional supplier of Sodium CMC in China since 2003, both granular and powder Sodium CMC can be provided. The Sodium Carboxymethyl Cellulose(CMC) we currently supply has received positive feedback from customers in the international market, with performance comparable to that of internationally renowned suppliers such as Nouryon, Ashland, CPKelco, Lamberti, AkzoNobel. In conclusion, sodium carboxymethyl cellulose is a product with great market prospects. It has a wide range of uses due to its superior performance. SINOCMC is proud to be a leading brand of this product in the international market. We are committed to providing domestic customers with the most cost-effective and superior sodium carboxymethyl cellulose to meet diverse applications needs.

For inquires, please feel free to contact SINOCMC.

Your Trust, Our Responsibility !

Think Cellulose, Think SINOCMC !

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