Product Data Sheet

Product Name: METHOCEL K3 PREMIUM LV HPMC

The following specifications apply to sealed, unopened containers stored under the recommended conditions for the duration of the shelf life.

MATERIAL DATA, PHS

MATERIAL NUMBER	93970
MATERIAL DESCRIPTION	MCK3 PRM LV DF25KG 12/P
SPECIFICATION NAME	METHOCEL(TM) K3 Premium LV Hydroxypropyl Methylcellulose
SPECIFICATION TYPE	SALES SPECIFICATION
SPECIFICATION EFFECTIVE DATE	August 4, 2022
SPECIFICATION SUPERSEDES DATE	July 24, 2019

GOVERNMENT AND INDUSTRY STANDARDS:

Current E464 - European Parliament and Council Directive

Current EP - European Pharmacopoeia

Current JP - Japanese Pharmacopoeia

Current USP - United States Pharmacopeia

U.S. FDA 21 CFR 172.874

U.S. FDA GRAS Notification GRN 000213

VISUAL PROPERTIES, PHS

OPALESCENCE	PASS
	CURRENT EP OPALESCENCE
COLOR EVALUATION	PASS
	CURRENT EP SOLUTION COLOR

PHYSICAL PROPERTIES, PHS

PH (2%)	5.5 - 8.0
	CURRENT USP/EP/JP

EVALUATIONS, PHS

IDENTIFICATION [AB]	PASS
	CURRENT USP/EP/JP

Document ID 1996209
Profile 6273

Product Data Sheet

EVALUATIONS, PHS

RESIDUAL SOLVENTS [AB]	PASS
	CURRENT USP/EP/JP
SULFATED ASH	<= 1.5 %
	CURRENT USP/EP/JP
MOISTURE (LOSS ON DRYING)	<= 5.0 %
	CURRENT USP/EP/JP
RESIDUE ON IGNITION (%)	<= 1.5 %
	CURRENT USP/JP

VISCOSITY, PHS

APPARENT VISCOSITY	2.4 - 3.6 mPa.s
	CURRENT USP/EP/JP 2% IN WATER, @ 20DEGC
APPARENT VISCOSITY (TARGET)	3.0 mPa.s

MICROBIAL, PHS

E.COLI ABSENT PER G [AB]	PASS
	CURRENT USP NEGATIVE
PSEUDO. AERUG. ABS IN 1G [AB]	PASS
	CURRENT USP NEGATIVE
SALMONELLA ABS PER 10G [AB]	PASS
	CURRENT USP NEGATIVE
STAPH. AUR. ABS IN 1G [AB]	PASS
	CURRENT USP NEGATIVE
YEASTS AND MOLDS PER G [AB]	<= 100 /g
	CURRENT USP TOTAL COUNT
TOTAL PLATE COUNT PER G [AB]	<= 100 /g
	CURRENT USP TOTAL AEROBIC

COMPOSITION, PHS

HYDROXYPROPOXYL CONTENT	7.0 - 12.0 %
	CURRENT USP/EP/JP
METHOXYL CONTENT	19.0 - 24.0 %
	CURRENT USP/EP/JP

METALS, PHS

HEAVY METALS (AS PB) [AB]	<= 20 mg/kg

METALS, PHS

CURRENT USP/EP/JP

Identification Tests A-E specified in the USP and EP monographs are identical to tests 1-5 specified in the JP monograph.

Based on knowledge of the manufacturing process and controlled handling and storage, this product complies with ICH Q3C Residual Solvents Guidance requirements. The solvents listed as Class 1, 2 and by the USP/NF are not used in the manufacturing process.

Tests tagged or noted as "Audit Basis" [AB] are conducted on a frequency that is established for each test.

Audit testing is justified by knowledge of the manufacturing process, process control, use of dedicated equipment and raw material specifications.

For tests conducted on an audit basis, individual batch test results are not provided on the Certificate of Analysis (COA). Instead, a statement of typical properties is given.

Tests tagged or noted as "Microbiological Tests" [MT] are conducted on a audit-based frequency that is established for each test.

Specification limits apply to the material as packaged in the original containers. They do not apply if the material has been repackaged, improperly stored, or if the package has been opened in an uncontrolled environment.

Samples returned for analysis must have been obtained under conditions which prohibit the introduction of microbial contamination. Sterile containers and sampling equipment must be used.

This product meets all requirements of substitution type 2208 in the current USP, EP and JP monographs for Hypromellose.

This product meets the specific purity criteria for the food additive Hydroxypropyl Methyl Cellulose (E 464) listed within the Official Journal of the European Union.

This product is certified Kosher for Passover and Pareve.

This product is certified to contain not more than 0.1% of each of the following components: Propylene glycol, Dipropylene glycol, Tripropylene glycol, Dipropylene glycol monomethyl ether and Tripropylene glycol monomethyl ether.

This is a computer generated document and is therefore not signed.

Pharma & Food Solutions

Chemistry of METHOCEL™

Cellulose Ethers - A Technical Review

Chemistry of
METHOCEL™ Cellulose Ethers

METHOCEL™ cellulose ether products are available in two basic types: methylcellulose and hydroxypropyl methylcellulose.

Both types of METHOCEL™ have the polymeric backbone of cellulose, a natural carbohydrate that contains a basic repeating structure of anhydroglucose units.

Regulated Uses

Chemical Inventory

METHOCEL™ products, methylcellulose and hydroxypropyl methylcellulose, comply with all applicable rules and orders under Toxic Substances Control Act PL94-469. The Chemical Abstracts Services Registry No. (CAS) is 9004-67-5 for methylcellulose and 9904-65-3 for hydroxypropyl methylcellulose.

METHOCEL™ products have also been reported for the following inventories:

- European Inventory of Existing Chemical Substances (EINECS)
- Australia Inventory of Chemical Substances (AICS)
- Ministry of International Trade and Industry Inventory (MITI, the Japanese inventory)
- Canadian Domestics Substances List (DSL)

Many countries are in the midst of creating new chemical inventories.

Pharmaceuticals

Premium grades of METHOCEL™ products meet the specifications of the United States Pharmacopoeia (USP XXIII), European Pharmacopoeia (EP) and Japanese Pharmacopoeia (JP) and are listed as methylcellulose and hypromellose[1]. In addition, methylcellulose (METHOCEL™ A products) is Generally Recognized As Safe (GRAS) by the U.S. Food and Drug Administration.

To support new drug applications in the United States, drug master files (DMFs) for these products are on file at the Bureau of Drugs of the U.S. Food and Drug Administration.

[1] The former official monograph name of hypromellose was “hydroxypropyl methylcellulose” or “HPMC”.

Comparison of METHOCEL™ Grades for Pharmaceutical Applications

METHOCEL™ Premium Products:	K3 LV	K100 LV	K4M	K15M	K100M	E3 LV	E5 LV	E6 LV	E15 LV	E50 LV	E4M	E10M	VLV	A15 LV	A4C	A15C	A4M
Viscosity (mPa.s 2% in water at 20C)	2.4-3.6	80-120	2,663-4,970	13,275-24,780	75,000-140,000	2.4-3.6	4.0-6.0	4.8-7.2	12-18	40-60	2,663-4,970	9,525-17,780	2.3-3.3	12-18	320-480	1,298-2,422	2,663-4,970
Methoxyl substitution	19.0-24.0%	19.0-24.0%	19.0-24.0%	19.0-24.0%	19.0-24.0%	28.0-30.0	28.0-30.0	28.0-v30.0	28.0-30.0	28.0-30.0	28.0-30.0%	N/A	27.0-30.0%	27.5-31.5%	27.5-31.5%	27.5-31.5%	27.5-31.5%
If CR designation, methoxyl substitution	N/A	22.0-24.0%	22.0-24.0%	22.0-24.0%	22.0-24.0%	N/A	N/A	N/A	N/A	N/A	28.0-30.0%	28.0-30.0%	N/A	N/A	N/A	N/A	N/A
Hydroxypropoxyl substitution	7.0-12.0%	7.0-12.0%	7.0-12.0%	7.0-12.0%	7.0-12.0%	7.0-12.0	7.0-12.0	7.0-12.0	7.0-12.0	7.0-12.0	7.0-12.0%	N/A	4.2-7.5%	N/A	N/A	N/A	N/A
If CR designation, hydroxypropoxyl substitution	N/A	7.5-9.5%	7.5-9.5%	8.5-10.5%	9.5-11.5%	N/A	N/A	N/A	N/A	N/A	8.5-10.5%	8.5-10.5%	N/A	N/A	N/A	N/A	N/A
Loss on Drying (weight %)	5.0% Max	5.0% Max	5.0% Max	5.0% Max	5.0% Max	5.0% Max	5.0% Max	5.0% Max	5.0% Max	5.0% Max	5.0% Max	5.0% Max	5.0% Max	5.0% Max	5.0% Max	5.0% Max	5.0% Max
If CR designation, Particle size, % thru 40 mesh	N/A	≥ 99.0%	≥ 99.0%	≥ 99.0%	≥ 99.0%	N/A	N/A	N/A	N/A	N/A	≥ 99.0%	≥ 99.0%	N/A	N/A	N/A	N/A	N/A
If CR designation, Particle size, % thru 100 mesh	N/A	≥ 90.0%	≥ 90.0%	≥ 90.0%	≥ 90.0%	N/A	N/A	N/A	N/A	N/A	≥ 90.0%	≥ 90.0%	N/A	N/A	N/A	N/A	N/A
If CR designation, Particle size, % thru 230 mesh	N/A	50.0-80.0%	50.0-80.0%	50.0-80.0%	50.0-80.0%	N/A	N/A	N/A	N/A	N/A	50.0-80.0%	50.0-80.0%	N/A	N/A	N/A	N/A	N/A

(These are typical properties, not to be construed as specifications)

How to Prepare Aqueous Solutions of METHOCEL™ Cellullose Ethers

METHOCEL™ cellulose ether products are carbohydrate polymers which dissolve in cold water (and in some instances in certain organic solvents) by swelling and subsequent hydration. There is no sharp solubility limit such as occurs in the dissolution of ionizing salts. The concentration of METHOCEL™ in solution is usually limited by the viscosity that a manufacturer is equipped to handle. It also depends on the viscosity and chemical type of METHOCEL™ product used. Solutions of low-viscosity products can be made at 10% to 15% concentration while high-viscosity products have a normal limit at 2% to 3% concentration.

The form of METHOCEL™ cellulose ether product chosen (powder, surface-treated powder or granules) influences the techniques used to make solutions. Surface-treated and granular products can be added directly to aqueous systems. They disperse readily with mild agitation and dissolve (build viscosity) gradually under neutral conditions. The dissolution rate of surface-treated products can be increased by adjusting to an alkaline pH after dispersing the powder in water. Although untreated METHOCEL™ powders are soluble in cold water, they must first be thoroughly dispersed in the water to prevent lumping.

Working with Surface-Treated Dispersible Powders

In many applications, the combination of easy dispersion in cold water and rapid hydration (viscosity build) is desirable. Surface-treated METHOCEL™ powders are chemically treated so that they become temporarily insoluble in cold water. This allows the METHOCEL™ product to be added to a formulation and dispersed at relatively low shear without any significant initial increase in viscosity.

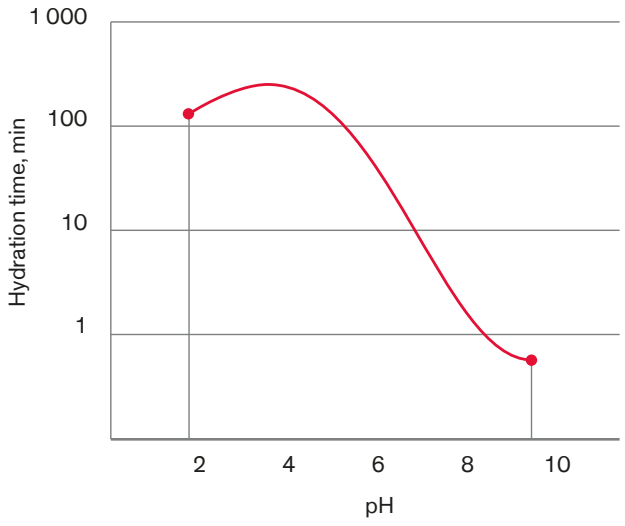
This “time delay” of hydration or viscosity build is a function of the level of surface treatment as well as temperature, pH of the system, and concentration of the METHOCEL™ product. Normally, the concentration of METHOCEL™ in the system does not become a factor until the concentration exceeds 5% by weight (relative to water in the system). At higher concentrations, the time of hydration (referred to as delay time) is reduced. The delay time is generally reduced as temperature is raised. In many cases it is desirable to “trigger” viscosity build immediately following dispersion. Aqueous slurries can be held for 45 minutes and still remain usable in neutral systems. A trigger can be conveniently initiated by adding a small amount of a base, such as ammonium hydroxide, sodium bicarbonate, etc. If METHOCEL™ is dispersed in neutral water (pH approximately 7), there is adequate time for thorough dispersion. Addition of base to raise the pH to approximately 9 causes the hydration to be completed in just a few minutes.

For best results and to achieve maximum hydration, surface-treated powders should be added with good agitation to a neutral pH system. The system should be agitated thoroughly for a few minutes, followed by an adjustment of pH to 8.5 to 9.0 with continued agitation, until full viscosity is reached (usually 10 to 30 minutes). Once the pH has been shifted to the alkaline side (pH 8.5 to 9.0), allowing full and rapid solubilization of the surface-treated product, solutions will be stable over the pH range of 3 to 11.

The addition of a slurry to an alkaline pigment grind or filler dispersion, or the addition of a slurry to a basic pigment-latex formulation, provides rapid solubilization and uniform viscosity development. The addition of dry, alkaline pigments or fillers to a slurry on high-speed or low-speed mixing equipment also results in rapid solubilization and viscosity development.

CAUTION: Attempts to adjust the pH of high-concentration slurries may lead to excessively high viscosity that will prevent pumping or pouring. The pH adjustment should be made only after the slurry is diluted to the concentration at which it will be used.

Hydration Delay Time of Surface-Treated METHOCEL™ Products as a Function of pH



Working With Untreated Powders

Although METHOCEL™ powders are soluble in cold water, they must first be thoroughly dispersed in the water to prevent lumping. In some applications, dispersion can be accomplished at ambient temperatures or in cold water by using an eductor funnel or high-shear mixer. However, if untreated powders are added directly to cold water without sufficient agitation, a lumpy solution may result. Lumping results from incomplete wetting of the individual powder particles. Only part of the powder dissolves, and a gelatinous membrane shields the remaining powder from complete hydration. Several dispersion techniques are commonly used and are described below. Each has advantages in certain applications.

Dispersion in Hot Water

Often called the "hot/cold" technique, this method takes advantage of the insolubility of METHOCEL™ cellulose ethers in hot water. The powder is first dispersed by mixing thoroughly with 1/5 to 1/3 of the total required volume of water that has been heated to above 90°C (194°F). Mixing continues until all particles are thoroughly wetted.

For complete solubilization, the remainder of the water is then added as cold water or ice to lower the temperature of the dispersion. Once the dispersion reaches the temperature at which that particular METHOCEL™ product becomes water soluble, the powder begins to hydrate and viscosity increases.

In some applications, it may be desirable to heat the entire volume of water, disperse the METHOCEL™ powder, and then cool the mixture while agitating until hydration is complete. It is very important, however, to have adequate cooling after wetting with hot water to ensure complete hydration and viscosity development.

Dispersion in Concentrated Salt Solutions

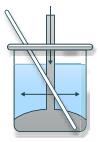
Both untreated and surface-treated METHOCEL™ cellulose ethers can be dispersed in concentrated salt solutions. Dissolution occurs when the brine is diluted with cold water

Dispersion by Dry-Blending

Dry-blending involves mixing METHOCEL™ powder with other dry ingredients before adding the water component. Dry-blending separates the particles of METHOCEL™ cellulose ethers to allow thorough wet-out and complete hydration when water is added. The minimum ratio of other dry, powdered ingredients to METHOCEL™ powder varies from 7:1 to 3:1.

Dispersion Techniques

1. Add the surface-treated METHOCEL™ powder to the water. Begin agitation.



2. Continue agitation and add sufficient ammonium hydroxide, sodium bicarbonate, or other alkaline material (e.g., pigment grind) to the dispersion to obtain a pH of 8.5 to 9.0. This will result in rapid viscosity development. Continue agitation until sufficient hydration has been achieved.

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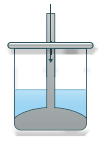
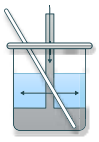
1. Add the METHOCEL™ cellulose ether to the non-solvent. A ratio of 5-8 parts non-solvent to 1 part METHOCEL™ is recommended to obtain a liquid slurry.

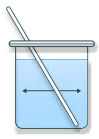


2. Agitate the mixture and METHOCEL™ powder until the particles of METHOCEL™ cellulose ether are evenly dispersed.

3. The dispersion of METHOCEL™ in a nonsolvent medium may be added to cold water, or cold water may be added to the dispersion.



4. Continue mixing until the METHOCEL™ powder is completely hydrated and the solution is smooth. You can now add the remaining ingredients in your formulation.



How to Prepare Solutions of METHOCEL™

Celulose Ethers in Non-Aqueous Solvents and Non-solvent Media

Solvents

The solubility of METHOCEL™ cellulose ethers in non-aqueous media varies according to the nature and quantity of substituent groups on the anhydroglucose chain. When using a water-miscible, organic solvent, such as an alcohol or glycol, use a ratio of at least 5 to 8 parts solvent to 1 part METHOCEL™.

Dispersion in Non-solvent Media

Untreated METHOCEL™ cellulose ethers may also be dispersed in non-solvent media such as vegetable oil, propylene glycol, polyethylene glycol, glycerine, corn syrup, and high-fructose corn syrup. A ratio of 5 to 8 parts nonsolvent to 1 part METHOCEL™ is recommended to obtain a fluid slurry. The dispersion of METHOCEL™ in a non-solvent medium may then be added to cold water, or the cold water may be added to the dispersion.

Properties of METHOCEL™
Celulose Ethers in Powder Form

METHOCEL™ cellulose ether products are white to slightly off-white powders which are essentially odorless and tasteless. The apparent density of the powders ranges from 0.25 to 0.70 g/cm³ (250–700 kg/m³).

Moisture Sorption

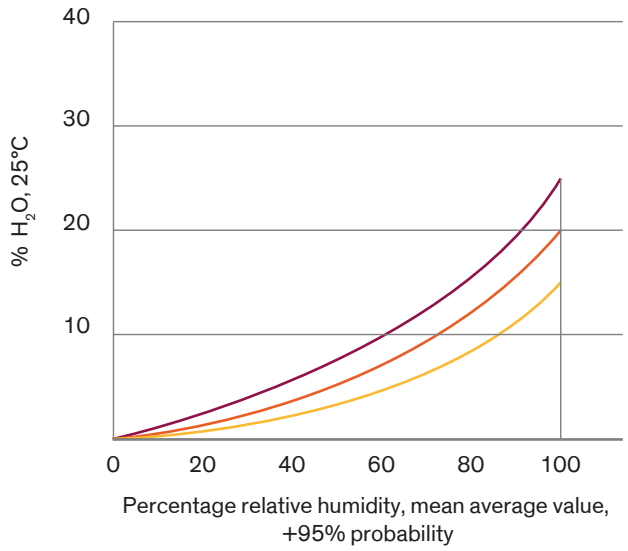
METHOCEL™ products sealed in their original shipping containers absorb little to no atmospheric moisture. Once a container is opened, however, there is pickup of moisture from the air. When "exposed" METHOCEL™ cellulose ether is weighed, a portion of the total weight, therefore, may be water. Such weight must be corrected for moisture content to ensure that the proper weight of METHOCEL™ is used to give the desired viscosity.

Resistance to Microorganisms

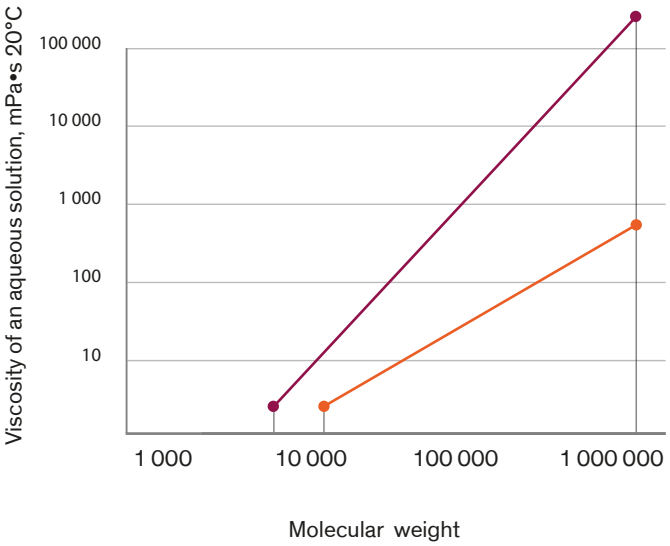
An important property of METHOCEL™ cellulose ether products is their high resistance to attack by microorganisms. METHOCEL™ products with higher degrees of substitution are especially resistant to enzymes. The fact that virtually all METHOCEL™ ethers pass through the intestinal tract essentially unchanged attests to the stability of these products to a wide range of biochemical and enzymatic systems.

As the cellulose is modified by substitution with various radicals, such as alkyl and hydroxyalkyl groups, resistance to microbial attack increases. Several researchers have reported that the degree of substitution (D.S.) of watersoluble cellulose derivatives was a primary factor, with a threshold D.S. value of 1.0 required for protection. Because METHOCEL™ cellulose ether products have excellent uniformity of substitution, with a D.S. much higher than 1.0, they possess excellent resistance to microbial attack.

Equilibrium Moisture Content Versus Percent Relative Humidity (25°C)



Molecular Weight/Viscosity Correlation, 20°C



Properties of Solutions
of METHOCEL™ Cellulose Ethers

Molecular Weight/Viscosity Relationships

The viscosity of an aqueous solution of METHOCEL™ cellulose ether is proportional to the molecular weight or chain length of the specific METHOCEL™ product used. Commercial designations of METHOCEL™ products are based on viscosity values determined in water at 20°C, with a concentration of 2% METHOCEL™. The measurement methods used are described in the current ASTM monographs D1347 and D2363.

The table on page 9 provides further information regarding the correlation of number average molecular weight with the commercial viscosity designation. Intrinsic viscosity is the limiting quotient of the specific viscosity divided by the concentration as infinite dilution is approached (as the concentration approaches zero). The number average molecular weight (Mn) is calculated from the limiting osmotic pressure of the solvent as the concentration of the solute approaches zero. The average molecular weight (Mw) will be 3 to 10 times the Mn.

Effect of Concentration on Viscosity

Most formulations require a predetermined product viscosity of METHOCEL™ cellulose ether. The figure on page 3 shows how the concentration of METHOCEL™ products of varying viscosity affects the aqueous solution viscosity at 20°C. The measurements were made using an Ubbelohde viscometer (ASTM D2363). Data for both low and high molecular weight METHOCEL™ products are shown and represent the average material found within a viscosity specification.

This figure is plotted on an 8th root scale, not a logarithmic scale. The 8^{th} root of the viscosity is a roughly linear function of the concentration. The equation which expresses the illustrated approximate relationship between solution viscosity and polymer concentration is $\_1/8 = (C\cdot\_) + 1$, where _ is the solution viscosity in millipascal-seconds, C is the polymer concentration in solution (expressed in percent), and _ is a constant specific to the molecular weight. The value of _ may be calculated by substitution and may then be used to calculate the approximate viscosity at the desired concentration.

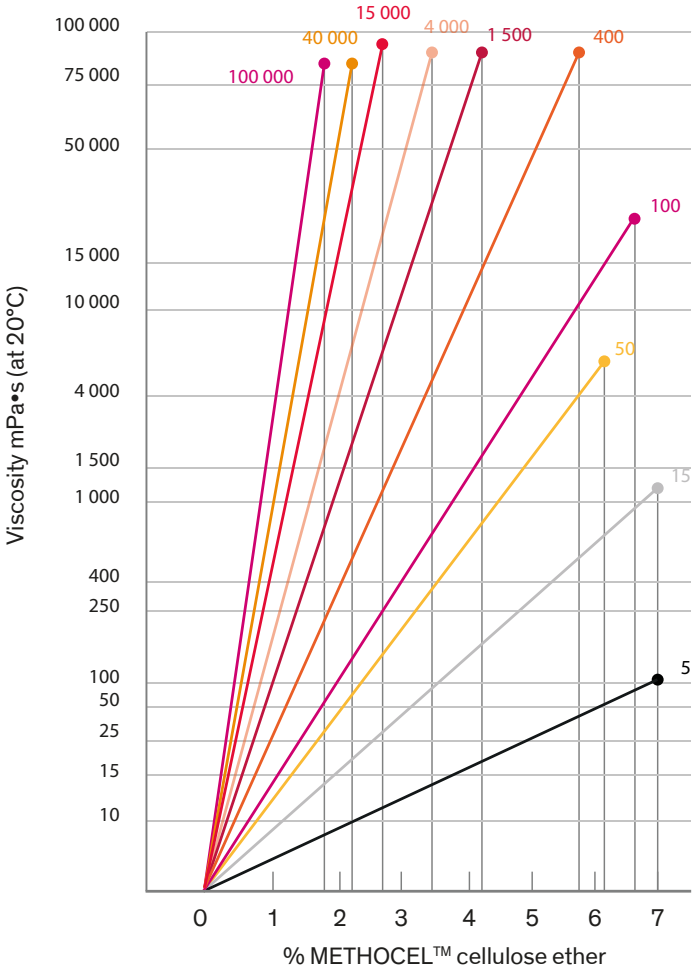
For example, for a 4,000 mPa·s product, $(4{,}000)1/8 = (C\cdot\_) + 1$. Solving for _ yields a value of 0.910. For a 1,500 mPa·s product, $(1{,}500)1/8 = (C\cdot\_) + 1$. Solving for _ yields a value of 0.747. Having calculated _ for a particular METHOCEL™ product, this value can be used to calculate viscosity at other concentrations.

To find the line for any intermediate grade, locate the desired 2% viscosity above 2% on the abscissa and draw a straight line to the point of origin.

Viscosity of Methylcellulose of Various Molecular Weights

Viscosity grade, 2%, 20°C, mPa•s	Intrinsic viscosity (h), dL/g	Number average degree of polymerization	Number average molecular weight (Mn)
5	1.2	53	10 000
10	1.4	70	13 000
40	2.0	110	20 000
100	2.6	140	26 000
400	3.9	220	41 000
1 500	5.7	340	63 000
4 000	7.5	460	86 000
8 000	9.3	580	110 000
15 000	11.0	650	120 000
19 000	12.0	750	140 000
40 000	15.0	950	180 000
75 000	18.4	1 160	220 000

Viscosity / Concentration Relationships



Blending for Intermediate Viscosity

METHOCEL™ products of the same substitution type, but of different viscosity grades, can be blended to obtain an intermediate viscosity grade. The figure to the right is a blending chart that can be used for this purpose. To use the chart, mark the viscosity of one material along the left axis (Scale A) and the viscosity of the other material along the right axis (Scale B). Connect the two points in a straight line that crosses the graph. In the example shown, the viscosities of the starting materials are 400 mPa·s on the left and 15,000 mPa·s on the right. Now find the desired final viscosity on either axis and draw a horizontal line that intersects with the first line. From this intersection point, draw a vertical line down to the bottom scale. The number of that scale shows the percentage of Scale B Material needed in the blend. In this example 4,000 mPa·s is the desired final viscosity. So the required blend is 60% of the 15,000 mPa·s (Scale B) material and 40% of the 400 mPa·s (Scale A) material.

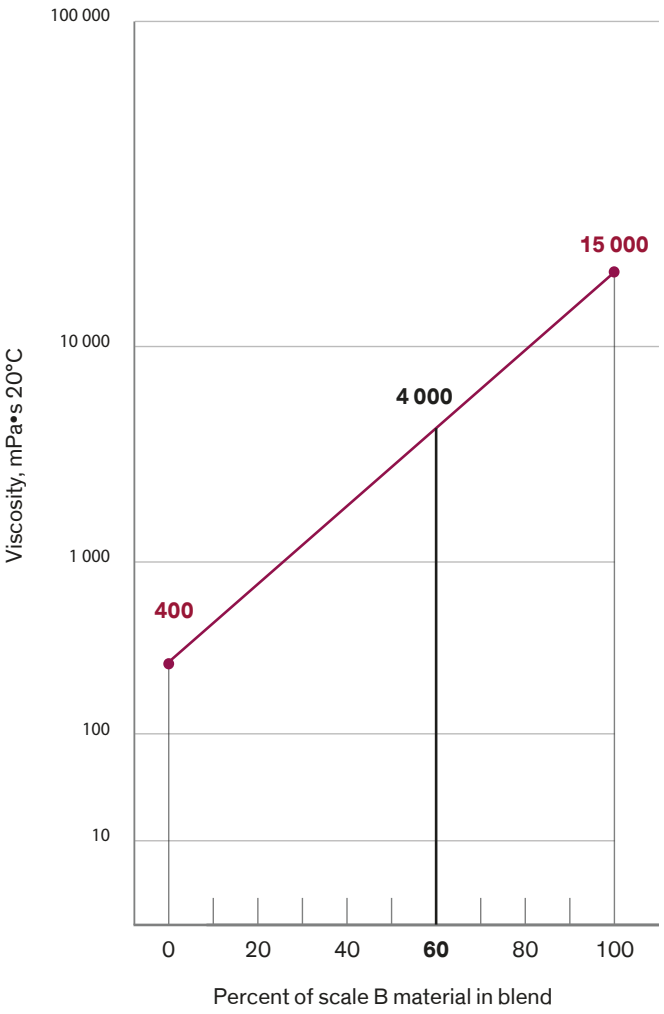
The relationship may be expressed mathematically as: _B 1/8 = x1 _ 1 1/8 + x2 _ 21/8 , where x1 and x2 are the weight fractions of components one and two, respectively.

The example on the chart shows that 60% of 15,000 mPa·s material and 40% of the 400 mPa·s material are needed to make a blend having a viscosity of 4,000 mPa·s.

Effect of pH on Viscosity

Because METHOCEL™ products are nonionic, the viscosities of their solutions are generally stable over a wider pH range than are the viscosities of gums that are ionic in nature. Outside the range of pH 3 to 11, however, there may be a gradual loss of viscosity at higher temperatures or after long periods of standing, especially with high-viscosity solutions. Solutions of METHOCEL™ cellulose ethers in acids or in strong caustic solutions will decrease in viscosity. This factor should be considered when determining the shelf life of products.

Blending Chart



Properties of METHOCEL™
Celulose Ethers in Powder Form

Effect of Additives on Viscosity
In the preparation of formulations, viscosities may occasionally result which are considerably higher than expected. This phenomenon can be caused by the interaction of METHOCEL™ with one or more of the formula ingredients. As a result, it may be possible to use less thickener and still have adequate viscosity.

This effect usually passes through a maximum that is dependent on the concentration of the interacting materials and on the presence of other ingredients such as pigments, latex particles, or preservatives.

Effect of Freezing on Solutions
Solutions of METHOCEL™ cellulose ether products do not undergo separation into phases upon freezing. There is no separation of fluid layers (syneresis) or formation of insoluble precipitates or haze. This lack of phase separation on freezing is particularly important in frozen food items. As solutions of METHOCEL™ cellulose ether products are cooled, solubilization increases, as evidenced by increasing viscosity and improved clarity of solutions. When the solutions freeze, part of the water is held in the latent supercooled state and does not freeze. The heat normally released on freezing (heat of fusion) is decreased by the amount of the super cooling.

Defoamers for Aqueous Solutions
The foaming of solutions of METHOCEL™ cellulose ethers is easily controlled by using foam stabilizers and defoamers.

Defoamer concentrations should be kept to the minimum required because these materials are generally low in water solubility. The choice of a defoamer depends on the type of surfactant, latex, and other ingredients in the system. For defoaming complex systems, consultation with the supplier of defoamers is suggested.

Antifoam agents are extremely efficient surface-active compositions which displace other surface-active substances at the air/water interface. Their use, therefore, might interfere with the performance of METHOCEL™ products in applications where the mechanical properties of solution surface films is critical.

Preservatives for Aqueous Solutions
METHOCEL™ cellulose ethers normally do not require preservatives. They are not, however, antimicrobial agents. If contamination occurs, microorganism growth will not be inhibited.

To preserve solutions of METHOCEL™, addition of 0.05% to 0.15% of DOWICIDE™ A antimicrobial or DOWICIL™ 75 preservative is suggested. More information on these products is available upon request. For regulated uses, the appropriate permitted preservative should be used .

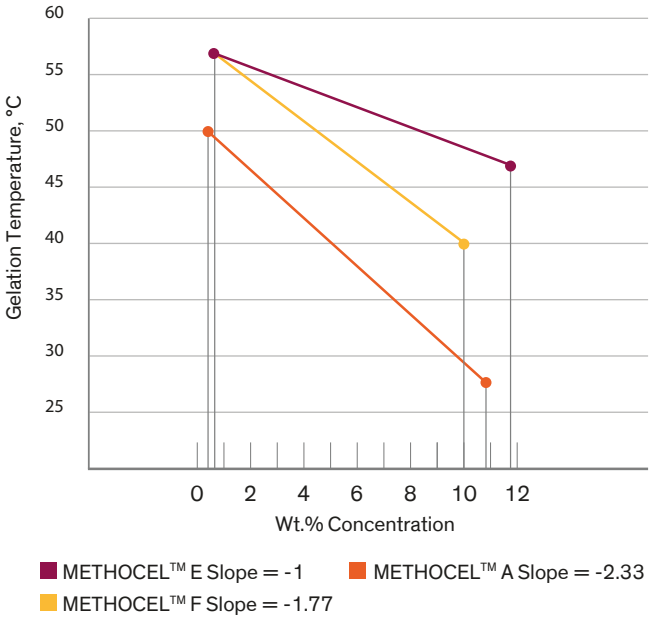
Compatibility of Aqueous Solutions
The methylcellulose molecule is nonionic and is not precipitated as an insoluble salt by multivalent metal ions. However, METHOCEL™ cellulose ethers can be salted out of solution when the concentration of electrolytes or other dissolved materials exceeds certain limits. This is caused by competition of the electrolytes for water and results in reduced hydration of the cellulose ether.

Water-insoluble materials such as pigments, fillers, etc. will not adversely affect METHOCEL™ cellulose ethers. Actually, solutions of METHOCEL™ often serve as excellent dispersing media for such materials. Other water-soluble substances, such as starches, glues, and resins, may or may not be compatible with METHOCEL™. Tests should be run on these materials to determine compatibility. Because METHOCEL™ cellulose ether products are not soluble in concentrated salt solutions, these media can be used as non-solvent dispersing media for non-surface-treated METHOCEL™ products. Subsequent dilution reduces the salt concentration to a level that allows dissolution of the METHOCEL™ product.

Controlling Gel Temperature

The specific temperature at which bulk thermal gelation occurs (the incipient gelation temperature or IGT) and the firmness of the gel are governed by the nature and quantity of the substituent groups attached to the anhydroglucose ring. Thus, gelation and the gel firmness vary with each type of cellulose ether. The molecular weight of the particular METHOCEL™ product selected has little effect on the gel temperature. However, increasing the concentration of the solution lowers the gel temperature.

Gelation Temperature as a Function of Concentration



The Effects of Heating Rate and Agitation on Gelation

Accurate measurement of gelation temperature requires care because it is a function of the rate of heating and the rate of shear. Both a high rate of shear and a fast heating rate result in an apparently high gel temperature.

Agitation also affects the strength of the gel. Continued rapid agitation during gelation may break down the gel structure and alter both the texture and strength of the gel. For maximum development of gel strength, heat the solution well above the gelation temperature under quiescent conditions.

Gel Strength and Texture

The texture and strength of gels produced by heating solutions of METHOCEL™ cellulose ethers varies with the product type, viscosity grade, and concentration of METHOCEL™ used. In general, the strength of the gel increases sharply as molecular weight increases and gradually becomes constant at or above a viscosity of 400 mPa·s. Gel strength also increases with increasing concentration.

Interfacial Gelation

In addition to bulk-phase gelation, METHOCEL™ cellulose ethers also exhibit interfacial or surface gelation phenomena as a result of their surfactant nature. Interfacial gelation plays an important role in many applications where a protective colloid, emulsification, or surfactant function is desirable. Examples include: suspension polymerization of vinyl chloride; aqueous foam stabilization in shampoos, bubble baths; and the stabilization of non-dairy whipped toppings and salad dressings.

To achieve bulk thermal gelation, concentrations of 1.5 wt % are generally necessary. However, even at concentrations as low as 0.001 wt %, many METHOCEL™ products exhibit surface thermal gelation due to the migration of polymer molecules to the air/water interface.

The equilibrium concentration of METHOCEL™ products at any given interface depends upon the nature of the interface, presence of other solvents, temperature, and potential for formation of associative structures with other surfactants. However, the concentration of METHOCEL™ at an interface can be orders of magnitude greater than that presumed to be present in the bulk phase. As a result, surface film formation (surface gelation) occurs.

Surface gelation (filming) occurs very rapidly in many solutions of METHOCEL™ products whether dilute or concentrated. This effect is most evident (and troublesome) when one employs du Nouy tensiometry to determine surface tension.

Generally speaking, increasing the molecular weight, concentration, or temperature of a solution of METHOCEL™ will promote the onset of surface gelation just as in bulk thermal gelation.

Properties of Unplasticized Films of METHOCEL™ Cellulose Ethers

Properties*	METHOCEL™ A15 LV	METHOCEL™ E15 LV
Specific gravity	1.39	1.29
Area factor	24 000 in^2 / lb / mil	25 860 in^2 / lb / mil
Moisture vapor transmission rate, 100°F (38°C), 50% RH	67,5g / 100in^2 / 24h / mil	65g / 100in^2 / 24h / mil
Oxygen transmission rate, 75°F (24°C)	25cm^3 / 100in^2 / 24h / mil	70cm^3 / 100in^2 / 24h / mil
Tensile strength, 75°F (24°C), 50% RH	9 000 lb /in^2 (62MPa)±10%	10 000 lb /in^2 (69MPa)±10%
Elongation, 75°F (24°C), 50% RH	5-15%	5-15%
Stability to ultra violet light, 500h, Fadeometer exposure	Excellent	Excellent
Resistance to oils and most solvent	Excellent	Excellent
Ultraviolet transmission (2 mil film) 400nm 290nm 210nm	 55% 49% 26%	 82% 34% 6%

*Typical properties, not to be construed as sales specifications. Data based on a mil dry film

Effect of Additives on Thermal Gelation

Additives may either increase or decrease thermal-gelation temperature, depending on whether the additive exhibits a coagulant or a solubilizing effect on the METHOCEL™ product. For example, solutes such as ethanol, PEG 400, and propylene glycol all raise the gel points of METHOCEL™ products, which is due to the solubilizing effect the solutes impart. Additives such as glycerin, sorbitol, and salts lower gel points by lowering the solvency of the aqueous system, resulting in a more rapid dehydration of the METHOCEL™ product.

If a manufacturer requires a high thermal gelation temperature and plans to use additives known to reduce the gel temperature, a METHOCEL™ product with a gel point higher than the temperature required should be used. As the concentration of the gel-causing additive increases, the thermal gel temperature decreases. Although the behavior of a particular solute must be determined empirically, the following general guidelines apply.

Properties of Films of METHOCEL™ Cellulose Ethers

High-strength, water-soluble films, supported or unsupported, may be rolled, cast, or extruded from formulations of METHOCEL™ cellulose ether products. These clear, smooth films or coatings are impervious to oils, greases, and most solvents. They are also effective binders, even when loaded with inert materials. The need for a plasticizer may be more pertinent when using low viscosity 5 mPa·s METHOCEL™ cellulose ethers because of lower film elongation properties. This can be more acute if drying temperatures are too high.

Effect of Additives on Film Solubility

The water solubility of films and coatings of METHOCEL™ cellulose ethers can be altered by the use of cross-linking compounds and resins. The degree of insolubility can be controlled by the choice and quantity of a cross-linking reagent. All urea formaldehyde, melamine formaldehyde, and resorcinol formaldehyde resins can be used. Dialdehydes such as glyoxal are also effective. Supplier literature should be consulted for selection of catalysts and curing compounds.

Resistance of Films to Solvents

Films and coatings of METHOCEL™ are unaffected by animal and vegetable oils, greases, and petroleum hydrocarbons.

Analytical Methods

Measuring Viscosity
Certain precautions must be observed for the accurate measurement of the viscosity of solutions of METHOCEL™ cellulose ethers because they exhibit a nonlinear shear stress/shear rate relationship, which results in pseudoplastic viscosity behavior at most shear rates.

Dow employs the ASTM reference method (D1347 and D2363) as its standard procedure. This method involves the use of Ubbelohde viscometers, one type for low viscosities and another for high viscosities. The Ubbelohde viscometer is a precision device which requires only a small test sample.

For measuring low viscosity, the appropriate capillary tube size is chosen to obtain a flow time of 50 to 150 seconds (see table to the right). The viscometer is placed in a 20°C bath, and the length of time required to deliver a given volume through the capillary tube is measured. The time in seconds is then converted to millipascalseconds (mPa·s). Detailed procedures are given in current ASTM standards D1347 and D2363. The most reproducible viscosities are obtained by cooling to 4°C and holding for at least one-half hour before testing at 20°C.

Viscosity may also be determined using a rotational viscometer such as the Brookfield model LVF† viscometer. When the viscosity of a solution is less than 500 mPa·s, the viscosity is less dependent on shear, and the solution may be regarded as near-Newtonian. The apparent viscosity of a solution of higher viscosity will be highly dependent on the rate of shear, decreasing as the rate of shear is increased.

The rotational instrument should be calibrated against standard oils. It's important to note, however, that there is no direct correlation between Ubbelohde and Brookfield measurements for non-Newtonian liquids. For details regarding analysis methods, please contact your local salesperson for METHOCEL™ cellulose ethers.

Handling Considerations
Material Safety Data Sheets/Safety Data Sheets for METHOCEL™ products are available from The Dow Chemical Company to help you further satisfy your own handling, disposal, and safety needs and those that may be required by government regulations. Such information should be requested prior to handling or use. The following comments are general and are not a substitute for the detailed safety information found in the Material Safety Data Sheet/Safety Data Sheet.

Safety Considerations
METHOCEL™ cellulose ether products resemble the naturally occurring plant and seaweed gums in many of their chemical, physical, and functional properties. All of these materials possess a basic carbohydrate structure.

METHOCEL™ products have had extensive evaluation and testing in both acute and long-term feeding studies in a number of species, including humans. Their many years of use in a wide variety of food items attests to the safety of METHOCEL™ Premium products.

Although dust from METHOCEL™ cellulose ether products could conceivably cause temporary mechanical irritation to the skin and eyes under extreme conditions and may be considered a nuisance dust if inhaled, the products are considered to present no significant health hazard in handling. Please review the handling precautions within the Material Safety Data Sheet/Safety Data Sheet for more information.

Capillary Tubes for Measuring Viscosity

Viscosity mPa•s	Size of Heavy Wall Tubing, inside diameter
Low viscosity	
15	1.5 mm
25	1.8 mm
100	2.4 mm
400	3.2 mm
High viscosity	
1 500	5.0 mm
4 000	6.0 mm
8 000	7.5 mm
15 000	10.0 mm
50 000	15.0 mm
75 000	15.0 mm

Flammability
Cellulose ether products are organic polymers that will burn when exposed to heat and a sufficient oxygen supply. Fires can be extinguished by conventional means, avoiding any raising of dust by strong water jets. Dow recommends the use of water spray, carbon dioxide, or powder extinguishers.

Storage
Caution: A fine dust of this material is capable of forming an explosive mixture with air. Powder samples should not be exposed to temperatures above 135° to 145°C. Samples may decompose and lead to a possible dust explosion. As in storage of any dusts or fine powders, good housekeeping is required to prevent dusts in air from reaching possibly explosive levels. When handling in large quantities or in bulk, the general precautions outlined in NFPA 63, "Prevention of Dust Explosions in Industrial Plants," and in NFPA bulletins 68, 69, and 654 are recommended.

With METHOCEL™ cellulose ether products with particle sizes of 74 µm or less (finer than 200 mesh), critical levels are reached at concentrations of 28 g/m3 (0.03 oz/ft3). The minimum ignition energy required to cause a dust explosion is 28mJ. Static from a human body has about 25mJ. This is normally not enough energy to ignite the powder.

As with any organic chemical material, METHOCEL™ cellulose ethers should not be stored next to peroxides or other oxidizing agents.

Accidental Spills and Housekeeping
Solutions of METHOCEL™ cellulose ethers are slippery. To prevent employee falls and injury, floor spills of dry powder should be thoroughly vacuumed or swept up. Any slight residual product on the walls or floor can then be flushed with water into a sewer. If the spill is a viscous solution, it should be further diluted with cold water before disposal. Likewise, accumulation of dust should be avoided to control this hazard.

Disposal
Despite the very slow rate of biodegradation, cellulose ether products should not present any hazard in the waste/soil compartment. Their behavior is similar to wheat flour or sawdust. Although Dow studies using standard procedures showed no 5-day, 10-day, or 20-day BOD values, activated sludge studies with (14C) methylcellulose showed that methylcellulose was 96% degraded or otherwise removed from solution in 20 days. Thus, METHOCEL™ cellulose ethers should present no ecological hazard to aquatic life.

Because METHOCEL™ cellulose ether products and their aqueous solutions present no significant ecological problems, they can be disposed of by industrial incineration or in an approved landfill, providing regulations are observed. Incineration should be done under carefully controlled conditions to avoid the possibility of a dust explosion. Customers are advised to review their local, state, provincial or national regulations governing the disposal of waste materials to determine appropriate means of disposal in their area.

Customer Notice
Dow strongly encourages its customers to review both their manufacturing processes and their applications of Dow products from the standpoint of human health and environmental quality to ensure that Dow products are not used in ways for which they are not intended or tested. Dow personnel are available to answer your questions and to provide reasonable technical support. Dow product literature, including safety data sheets, should be consulted prior to use of Dow products. Current safety data sheets are available from Dow.

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