## General Properties of METHOCEL™, Premium Cellulose Ethers

General properties common to METHOCEL™ cellulose ether products are listed below. Individual METHOCEL™ products exhibit these properties to varying degrees and may have additional properties that are desirable for specific applications.

**Water solubility.** METHOCEL™ cellulose ethers dissolve in water with no sharp solubility limit. This feature provides exceptional handling flexibility and control of solubilization rate. Although METHOCEL™ powders are soluble in cold water, they must first be thoroughly dispersed in the water to prevent lumping. The maximum concentration is limited only by solution viscosity.

**Organic solubility.** Certain types of METHOCEL™ cellulose ethers are also soluble in binary organic and organic solvent/water systems, providing a unique combination of organic solubility and water solubility.

**No ionic charge.** METHOCEL™ cellulose ethers are nonionic and will not complex with metallic salts or other ionic species to form insoluble precipitates.

**Thermal gelation.** Aqueous solutions of METHOCEL™ products gel when heated above a particular temperature, providing controllable quick-set properties. Unlike gels formed by protein thickeners, the gels go back into solution upon cooling.

**Surface activity.** METHOCEL™ products act as surfactants in aqueous solutions to provide emulsification, protective colloid action and phase stabilization. Surface tensions range from 42 to 64 mN/m. The surface tension of water is 72 mN/m; a typical surfactant solution has a surface tension of 30 mN/m.

**Metabolic inertness.** Used as food and drug additives, METHOCEL™ products do not add calories to the diet.

**Enzyme resistance.** The enzyme-resistance of METHOCEL™ products provides excellent viscosity stability during long-term storage.

**Low taste and odor.** METHOCEL™ cellulose ethers have excellent (low) flavor and aroma properties, which is important in food pharmaceutical and nutraceutical applications.

**pH stability.** METHOCEL™ cellulose ethers are stable over a pH range of 2.0 to 13.0.

**Thickening.** METHOCEL™ cellulose ethers thicken both aqueous and nonaqueous systems. The viscosity is related to the molecular weight, chemical type and concentration of the specific METHOCEL™ product.

**Film Formation.** METHOCEL™ products form clear, flexible films.

**Binding.** METHOCEL™ cellulose ethers are used as high-performance binders for pharmaceutical products.

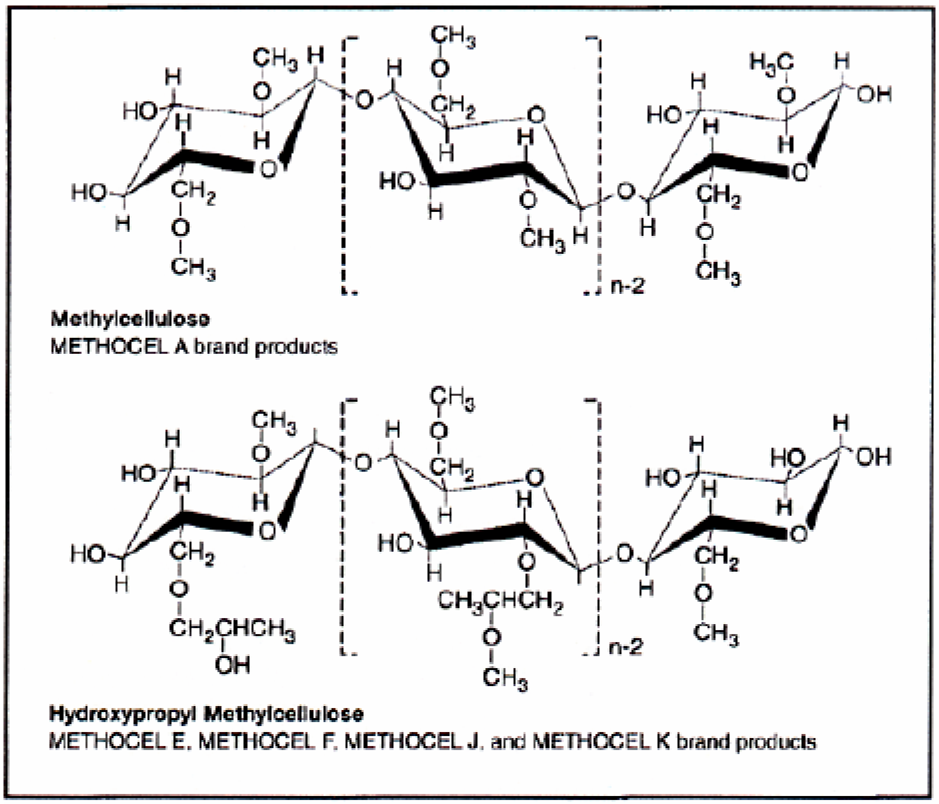
**Suspending.** METHOCEL™ products are used to control settling of solid particles, for example, solids in antacid suspensions.

**Protective colloidal action.** METHOCEL™ products are used to prevent droplets and particles from coalescing or agglomerating.

**Emulsification.** METHOCEL™ cellulose ethers stabilize emulsions by reducing surface and interfacial tensions and by thickening the aqueous phase.

## CHEMISTRY OF METHOCEL™

***Figure 1. Typical Chemical Structure of METHOCEL™ Products***




METHOCEL™ cellulose ether products are available in two basic types: methylcellulose and hypromellose. Both types of METHOCEL™ have the polymeric backbone of cellulose, a natural carbohydrate that contains a basic repeating structure of anhydroglucose units (Figure 1). During the manufacture of METHOCEL™, cellulose fibers are heated with a caustic solution which in turn is treated with methyl chloride, yielding the methyl ether of cellulose. The fibrous reaction product is purified and ground to a fine, uniform powder.

Methylcellulose (METHOCEL™ A) is made using only methyl chloride. For hypromellose products (METHOCEL™ E, F and K), propylene oxide is used in addition to methyl chloride to obtain hydroxypropyl substitution on the anhydroglucose units. This substituent group, -OCH2CH(OH)CH3-, contains a secondary hydroxyl on the number two carbon and may also be considered to form a proplyene glycol ether of cellulose. These products possess varying ratios of hydroxypropyl and methyl substitution, a factor which influences organic solubility and the thermal gelation temperature of aqueous solutions.

## DEGREE OF SUBSTITUTION

The amount of substituent groups on the anhydroglucose units of cellulose can be designated by weight percent or by the average number of substituent groups attached to the ring, a concept known as “degree of substitution” (D.S.). If all three available positions on each unit are substituted, the D.S. is designated as 3, if an average of two on each ring are reacted, the D.S. is designated as 2, etc.

The number of substituent groups on the ring determines the properties of the various products. METHOCEL™ A cellulose ether contains 27.5 to 31.5% methoxyl, or a methoxyl D.S. of 1.64 to 1.92, a range that yields maximum water solubility. A lower degree of substitution gives products having lower water solubility, leading to products that are only soluble in caustic solutions. Higher degrees of substitution produce methylcellulose products that are soluble only in organic solvents.

In the METHOCEL™ E, F and K cellulose ether products, the methoxyl substitution is still the major constituent (Table 1). The molar substitution (MS) reports the number of moles of hydroxypropyl groups per mole of anhydroglucose.

***Table 1. Degree of Substitution for METHOCEL™ Products***

| Product | Methoxyl Degree of Substitution | Methoxyl % | Hydroxypropyl Molar Substitution | Hydroxypropyl % |
|---|---|---|---|---|
| METHOCEL™ A | 1.8 | 30 | - | - |
| METHOCEL™ E | 1.9 | 29 | 0.23 | 8.5 |
| METHOCEL™ F | 1.8 | 28 | 0.13 | 5.0 |
| METHOCEL™ K | 1.4 | 22 | 0.21 | 8.1 |

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