

The World of Cellulose Gums

By Aida Prenzno, Contributing Editor

If you were to imagine the world without cellulose, you would have to imagine plants without a skeleton to support them, and fruits or veggies without a crunch. Cellulose—a water-insoluble, linear polysaccharide of glucose residues, connected by glycosidic linkages—is a key ingredient in nature, and it is believed to be the most-abundant naturally occurring organic compound. We can't digest cellulose, because we lack the appropriate enzymes to break down its specific beta linkages. Some animals, like cows, have symbiotic bacteria in their intestinal tract that produce the enzymes necessary to digest cellulose, and this allows them to feed on grass.

The field of options

Most commercially used cellulose comes from renewable materials like cotton linter and pulp from softwood trees. Purified celluloses, like powdered cellulose and microcrystalline cellulose, are widely used as sources of insoluble fiber in food products. They can also be used to create special texture effects. Powdered cellulose is a mechanically ground cellulose, and it is mainly used as an anticaking, dispersing and texturizing agent. Microcrystalline cellulose, a more-refined product, is a partially depolymerized cellulose prepared by treating alpha cellulose with mineral acid. Colloidal microcrystalline cellulose is usually processed by adding sodium carboxymethyl cellulose (CMC) to depolymerized cellulose before drying it. These products have found a great niche in lowfat applications where they provide fatty texture and creamy mouthfeel.

Cellulose can be modified through different chemical reactions to create a wide range of products with very specific characteristics, ranging from products that provide mouthfeel and low viscosity to those capable of creating gels when heated.

The clear solution

Three cellulose derivatives are commonly used to create special effects in food products. Probably one of the most-popular gums used in the food industry to create clear solutions is sodium carboxymethyl cellulose (CMC), or cellulose gum, as it is more commonly known. It is an anionic, water-soluble, cellulose ether-obtained by treating cellulose with sodium hydroxide followed by reaction with monochloroacetic acid. This reaction replaces hydroxyl groups with carboxymethyl groups along the cellulose chain.

Four key characteristics of the CMC molecule determine how the product behaves in solution: the degree of substitution (DS); the uniformity of substitution on the molecule; the average chain length (expressed as degree of polymerization, DP); and the degree of neutralization of the carboxyl methyl groups. Increasing the DS and DP translates into higher molecular weight and solutions with higher viscosity. An increase in DS also makes the cellulose gum more hydrophilic and more water-soluble. Uniformly substituted CMCs provide solutions with smooth flow, while non-uniformly substituted

cellulose gums exhibit thixotropic behavior. This is especially important when selecting a CMC for applications like syrups and sauces. Title 21 of the *Code of Federal Regulations (CFR)*, Part 182, Section 1,745 describes this product as GRAS and sets a maximum DS of 0.95.

Particle size also influences CMC hydration. Therefore, for instant applications, a fine-mesh product is usually recommended, while a coarse material is better for applications where little shear is available to disperse the gums and to slow down the hydration to allow for better dispersion.

Temperature also influences the viscosity of CMC solutions; the higher the temperature, the lower the viscosity. Usually, the effect of the temperature is reversible as long as the heating period is not extensive and the pH is not too low. In applications with low pH, it is important to hydrate the gum before adding the acid. It is also recommended to hydrate the CMC before adding high concentrations of salts. There are some grades of CMC that are specially designed to be more acid-stable and salt-tolerant.

Hot gels

Two other popular nonionic cellulose ethers are methylcellulose (MC) and hydroxypropylmethyl cellulose (HPMC). These products are GRAS per 21 *CFR* 182.1,480 and 172.874, respectively. MC is prepared by treating the cellulose with an alkali, followed by a methylation reaction with methyl chloride. To obtain HPMC, propylene chloride is used in addition to the methyl chloride to create the hydroxypropyl substitution.

These gums have the unique ability to create gels upon heating that return to a liquid phase once cooled. This thermal gelation typically can occur at temperatures in the ranges of 40 to 90°C. The gelling temperature depends on the degree of substitution of the molecule, the concentration of the gum in the solution and the presence of other ingredients in the solution. For example, ingredients like salt and sugar reduce the gelling temperature, while propylene glycol increases it.

MC and HPMC are soluble in cold water, but insoluble in hot water. Their viscosity usually decreases when the temperature increases until the gelation point is reached. In general, MC gels are stronger than HPMC gels, and the thermal gelation occurs at lower temperatures for MC. Also, MC requires a lower hydration temperature than HPMC.

These products are commercially available in many different types, ranging from products with very low to high viscosity, and even some special grades that are soluble in organic solvents. MC and HPMC are stable in an extensive range of pH. They are stable in solutions with a low salt concentration, but high amounts of salt in the solution can cause precipitation of the gum due to its reduced hydration. Also, they exhibit surfactant properties in solution, which makes them a great option for stabilizing emulsions and/or creating aerated texture. They can also form strong films. MC and HPMC are compatible with other gums.

Using cellulose gums

The fact that these gums have been so carefully engineered over the years to create more-efficient and functional products makes them a great option for a wide range of applications. Since these products are chemically modified, they can't be used for applications where "all natural" claims are required. However, using these products opens the door to special benefits, such as the ability to create very clear solutions without flavor masking; formulating a product that holds well when hot, but has low viscosity when cold; or forming films that can act as barriers to oil absorption.

Aida Prenzno is the laboratory director at Gum Technology Corporation, Tucson, AZ, a manufacturer of gum and hydrocolloid blends. For over 10 years, she has been actively involved in the development and creation of synergistic gum blends. Prenzno and her R&D team provide customer technical service and oversee a strict quality control program. For more information, email Prenzno at aida@gumtech.com, or log on to www.gumtech.com.