BENECEL® Methylcellulose and Hydroxypropylmethylcellulose
Thermal Gelation Temperatures

BENECEL® methylcellulose (MC) products are high-purity, water-soluble, nonionic cellulose ethers designed to perform many functions in processed foods. The functions more commonly fulfilled by Benecel® methylcellulose and its derivatives are:

• Thermal gelation.
• Film formation.
• Thickening.
• Binding.
• Water retention.
• Oil barrier.

These functions may vary depending on the type, viscosity grade, use level, and use condition of the polymer. The choice of Benecel® type will depend on which benefits are needed in a processed food product. Many of these benefits are derived from the thermal gelation properties of methylcellulose and methylcellulose derivatives. For example, methylcellulose stabilizes entrained air during baking, resulting in better finished goods volume. The thermal gelation properties of Benecel® products contribute to added cling and improved appearance of microwavable sauces. This characteristic adds structure to processed foods like onion rings, helping the product to maintain integrity and reducing waste. Finally, in foods that are served hot such as burgers and vegetable-based burger substitutes, Benecel® products help to retain moisture and impart juiciness.

This bulletin reviews the thermal gelation temperatures of various types of Benecel® polymers useful to the processed foods industry.

Introduction and Summary

The incipient gel temperatures (IGTs) for Benecel® products A4M, K4M, and E4M are shown in the following table, along with the chemical composition and viscosity type. The IGT is the temperature at which the solution viscosity reaches a minimum during the heating process and then starts to rise to a gel. The IGT measurement is affected by the rate at which the polymer solution is heated; that is, the faster the heating rate, the higher the IGT. Benecel® A4M develops full gel strength at approximately 70°C, while all of the E, F and K types developed full gel strength at a higher temperature when heated at 0.4°C/min.

(over)
Typical Properties of Benecel®
Methylcellulose Products

<table>
<thead>
<tr>
<th>Benecel® Product</th>
<th>Viscosity at 2%, cps (mPas)</th>
<th>Methoxyl, wt%</th>
<th>Hydroxypropoxyl, wt%</th>
<th>IGT, °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A4M</td>
<td>2,700-5,040</td>
<td>27.1-31.5&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>—</td>
<td>56</td>
</tr>
<tr>
<td>K4M</td>
<td>2,700-5,040</td>
<td>20.0-24.0&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>7.0-12.0&lt;sup&gt;(c)&lt;/sup&gt;</td>
<td>80</td>
</tr>
<tr>
<td>E4M</td>
<td>2,700-5,040</td>
<td>28.0-30.0&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>7.0-12.0&lt;sup&gt;(d)&lt;/sup&gt;</td>
<td>63</td>
</tr>
</tbody>
</table>

<sup>(a)</sup>Targeted wt% 29.<br><sup>(b)</sup>Targeted wt% 22.<br><sup>(c)</sup>Targeted wt% 8.<br><sup>(d)</sup>Targeted wt% 9.

Results

A typical gelation profile is shown in the following figure. As the temperature increases, the viscosity decreases due to polymer dehydration. Once the IGT is reached, the solution begins to gel. This phenomenon is reversible upon cooling. It is important to note that the straight methylcellulose products give a firmer gel than the hydroxypropyl methylcellulose products at a given molecular weight. In addition, higher molecular weights and higher concentrations of Benecel® polymers will give firmer gelling characteristics.

The IGT measurement can be affected by the rate at which the polymer solution is heated. The faster the heating rate, the higher the apparent IGT. When a 1.0% Benecel® A4M solution is heated at two different rates, 0.4°C/min and 2.0°C/min, a difference of approximately 5°C in IGT is observed.
Conclusions
1. IGTs for Benecel® A4M, K4M, and E4M polymers are 56°C, 69°C, 80°C, and 63°C, respectively.
2. Benecel® methylcellulose A4M develops full gel strength at approximately 70°C, while the E, F and K types develop full gel strength at higher temperatures when heated at a rate of 0.4°C/min.

Regulatory Status
Benecel® methylcellulose is in compliance with the requirements of the U. S. Food and Drug Administration for use in foods as specified in the U.S. Code of Federal Regulations, Title 21, Part 182.1480, “Substances Generally Recognized as Safe” (GRAS). Benecel® methylcellulose is also in compliance with the requirements of the U.S. Department of Agriculture for use as an extender and stabilizer at up to 0.15% in meat and vegetable patties and in poultry products as specified in the U.S. Code of Federal Regulations, Title 9, Parts 318.7 and 381.147, respectively.

Benecel® hydroxypropyl methylcellulose is in compliance with the requirements of the U.S. Food and Drug Administration for direct addition to foods as specified in the U.S. Code of Federal Regulations, Title 21, Part 172.874.

Product Safety
Read and understand the Material Safety Data Sheet (MSDS) before using this product.

Experimental
The polymer solutions were prepared at 1% concentration (corrected for moisture) by using the “hot-cold” method in which the polymer was first dispersed in water at 90°C (one third of the total needed), stirred for 10 minutes, and then diluted to final concentration with refrigerated water. The solution was further cooled by placing in an ice box and stirring for 3 more hours. The IGT was measured on a Bohlin(1) rheometer system model VOR. During the IGT measurements, the solutions were heated at a rate of 0.4°C/min, unless otherwise specified.

Aqualon, a business unit of Hercules Incorporated, provides cellulose gum under the trade names Aqualon®, Blanose® and Bondwell® depending on the region in which we serve you.

1(1)Bohlin-Rheologi, Inc., East Brunswick, New Jersey.

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