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FTR-001-1 (Supersedes FTR-001)

Synergistic Viscosity of Aquacel™ Cellulose Gum and Guar Gum

Introduction

It is known that cellulose gum (E466), also called sodium carboxymethylcellulose (CMC), and guar gum will exhibit synergistic viscosity.[1] The purpose of this work is to find the most effective CMC grades that when mixed with guar gum give the greatest viscosity effect. This is different from previous studies conducted in our laboratories in which synergy was calculated as a percent of viscosity achieved over expected viscosity. Therefore, in this report actual viscosity data are presented so a comparison can be made among CMC grades.

It has been shown that when CMC and guar gum samples of similar viscosity are used, the synergy is highest when the guar gum is in the highest portion (guar gum:CMC 80:20 to 70:30). A practical learning from the present work is that the new grades of CMC, Aquacel™ GSH and GSA CMC, yield higher viscosity when blended with guar gum. These new grades of CMC also allow wider working ranges of guar gum to CMC ratios for effective use of synergistic behavior. For example, blends of Aquacel™ GSH CMC with Supercol™ U guar gum showed unusually high synergistic viscosity in blends with 20% to 50% CMC. This gives customers more options in using guar gum and CMC blends to replace guar gum. Data in this report show that a blend of 50:50 Aquacel™ GSH CMC and Supercol™ U guar gum may be dosed at 60% to replace 100% guar gum alone to achieve similar viscosity in water. High viscosity synergy and wider working ranges of CMC addition give formulators greater latitude in formulation adjustments to replace guar gum and, in the current economic situation with guar supplies, will lead to greater cost savings opportunities.

It is well known that blends of CMC and guar gum dispersed in water create higher viscosity than would be expected if solution viscosities of individual components were simply additive.[1] Work in this area has been conducted in our laboratories in the past. For example, in previous studies it was noted that viscosities were much higher than expected when CMC and guar gum solutions were mixed. The highest synergies are noted in 80:20 blends of high viscosity CMC and guar gum.

Hydrocolloid synergy is explained as the formation of associated junction zones between lengths of unsubstituted areas along polymer backbones, promoting interpenetrating polymer networks. This theory can be useful in determining which hydrocolloid grades to select for the study. For example, Aqualon™ and Blanose™ CMC 7 and 9 types (carboxymethylcellulose) would be expected to have greater synergistic interactions with guar gum versus a highly substituted cellulosic such as hydroxypropyl methylcellulose.

In the present work, the focus is on total viscosity rather than “% synergy” as in previous reports. The objective of this work is to determine which Ashland Specialty Ingredients (ASI) CMC grades and in what ratios render the maximum viscosity in blends with guar gum. Synergistic viscosity on new grades of Aquacel™ CMC, Aquacel™ GSH and GSA CMC, are reported here. Also included in this study is Aquasorb™ A500 CMC synergistic behavior with guar gum.

Methods

In previous work in our laboratories, viscosity measurements were conducted by first making solutions of hydrocolloids separately. Viscosity was measured after mixing the two solutions in the desired ratio. Further, often the powders were first dispersed in ethanol to eliminate lumping. While this is the best way to ensure accurate data on viscosity will be collected and to reduce variables, it is not the way customers will make solutions.

In the present work, the objective is to evaluate CMC grades for viscosity synergy with guar gum. A lower dose was evaluated compared with previous reports, 0.5% versus 1%. Lower doses are less problematic in mixing and measuring viscosity and also representative of use levels in many applications. Polymer powders were dry blended then added directly to the vortex of rapidly agitated reverse osmosis (RO) filtered water. Solutions were mixed for 1 hour, checking for lumps, and any lumps were dispersed. Viscosity was evaluated 30 minutes after mixing, 2 hours after, and the next day. This was done to observe any viscosity changes over time and in keeping with standard practices in evaluating guar gum viscosity at 2 hours and 24 hours. In this report the viscosity synergy was reported using values obtained the next day, unless otherwise reported.

CMC and guar gum grades used in this work are in Table 1.

Table 1: ASI hydrocolloids used for study

Sample Number	Hydrocolloid	Grade	Ashland plant origin
1	Guar gum	Supercol™ U	Kenedy, TX, USA
2	CMC	Aquacel™ GSH	Hopewell, VA, USA
3	CMC	Aquacel™ GSA	Alizay, France
4	CMC	Aquasorb™ A500	Alizay, France
5	CMC	Aqualon™ 7HF	Hopewell, VA, USA

Viscosity Synergy Analysis

Samples of guar gum, CMC, or blends thereof were weighed using an analytical balance. To make the half percent solutions used in this study, 1.25 g hydrocolloid dry powder was added to 248.75 g RO water to create a solution with total weight of 250 g. Dry powders were not corrected for moisture. Ratios may be found in Table 2.

Table 2: Guar gum and CMC ratios for synergy analysis, as percentage of hydrocolloid blend

Guar gum	CMC
100	0
90	10
80	20
70	30
60	40
50	50
40	60
30	70
20	80
10	90
0	100

Hydrocolloid powders were lightly mixed in sample vials then carefully added to the vortex of the water, mixing in a 400 ml beaker and stirring with an overhead-style mixer with double propeller attachment. After powders were added, they were allowed to stir for approximately 1 hour. Stirring was stopped to check for lumps and any lumps were dispersed with a spatula.

Liquid solutions/dispersions were transferred to 8 oz glass jars. Viscosity was measured after 30 minutes, after 2 hours, and the next day. Viscosity was measured with a Brookfield LVT viscometer with settings of spindle 2 and 10 rpm. Liquid samples were held at ambient temperature. Temperature was monitored at time of viscosity measurement and showed very little fluctuation.

Viscosity Dosage Analysis

Using data from the methods above, synergy curves were constructed as hydrocolloid ratio versus viscosity. To further understand what hydrocolloid blend dose might replace guar gum at a given weight percent, dosage analysis was conducted. Ratios of 50:50 and 60:40 guar gum:CMC were examined for viscosity in a series of doses to compare with viscosity of guar gum at 0.5%, as found in the methods previously described.

Results

Viscosity Synergy and Rheological Analyses—Aquacel™ GSH CMC

All guar gum and CMC blends showed evidence of viscosity synergy. The greatest viscosities were seen with new Aquacel™ CMC grades versus a standard high viscosity CMC, Aqualon™ 7HF CMC. Of the Aquacel™ CMC grades, the highest synergy was found with Aquacel™ GSH CMC and guar gum (see Figure 1). Note that the viscosity found with blends of guar gum and Aquacel™ GSH CMC were similar in blends from 70:30 guar gum:CMC to 40:60 guar gum:CMC. This gives a wide working range of blend ratios while still allowing full advantage of the synergistic viscosity. In this study the amount of CMC in the blend ranged from 30–60% of the guar gum-CMC blend with optimum synergy.

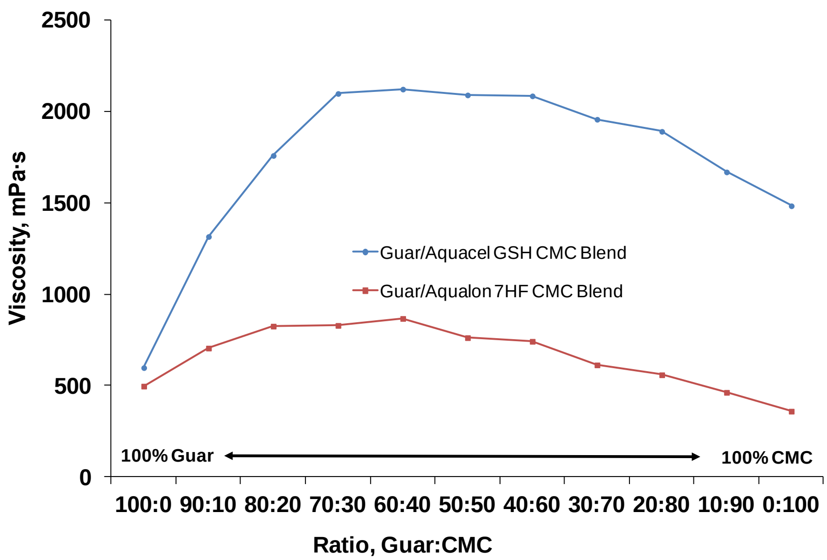

Figure 1. Viscosity of blends of Supercol™ U guar gum + Aquacel™ GSH CMC

In addition to overall synergy, analysis of dosages of the blends was also conducted. Shown in Figure 2 are blends of 50:50 guar gum:CMC, using Aquacel™ GSH CMC at various dose levels. It can easily be observed that 0.3% of this blend is of comparable viscosity versus 0.5% of guar gum alone.

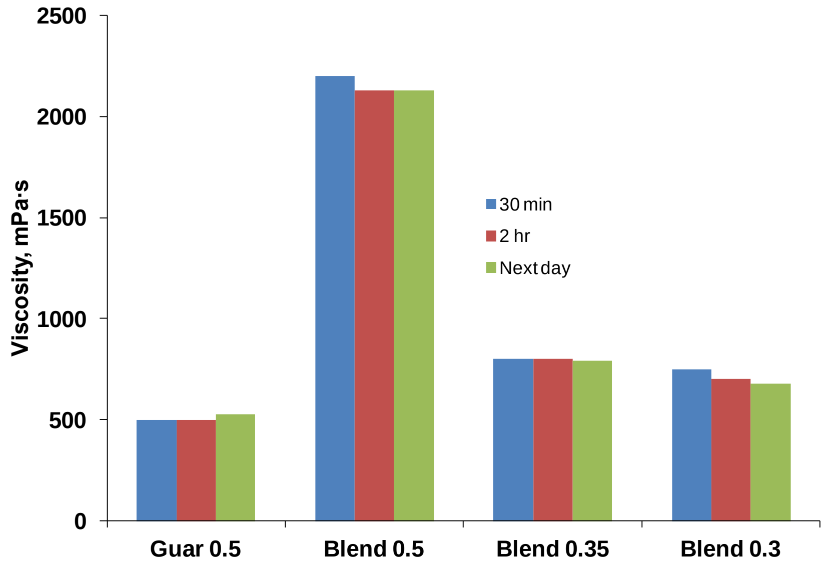

Figure 2. Viscosity of 50:50 blends of Supercol™ U guar gum + Aquacel™ GSH CMC

Flow characteristics of guar gum and CMC solutions differ. Guar gum solutions exhibit greater shear thinning behavior, while CMC solutions have higher viscosity at lower shear rates. As a result of these differences, the influence of the amount of CMC in the blends as well as dose was evaluated using a rheometer to examine shear rate versus viscosity (frequency sweep; see Figure 3). Low dose, 0.3%, of a 60:40 blend of guar gum and Aquacel™ GSH CMC was most similar in shear rate response to the full dose, 0.5%, of guar gum. The 50% CMC blend at 0.3% was also similar. This information suggests that cases blending CMC with guar gum and reducing the dose to benefit from the synergy may have low impact on the performance across shear conditions.

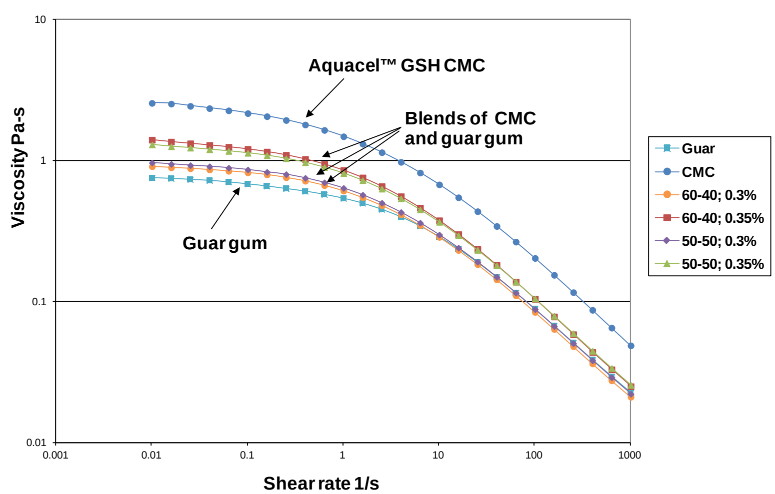

Figure 3. Shear thinning behavior of guar gum, Aquacel™ GSH CMC, and blends thereof

Viscosity Synergy Analysis—Aquacel™ GSA CMC

Aquacel™ GSH CMC exhibited the greatest synergy, as previously demonstrated. This study also included CMC grades from another plant location, Alizay, France. CMC from the France facility is made only from wood based cellulose and would be suitable for customers with stringent genetically modified (GM)-free requirements. Blends of guar gum and Aquacel™ GSA CMC showed excellent viscosity synergy, much greater than standard high viscosity CMC (see Figure 4). Also it was observed that that synergy could be realized over a wide range of ratios of guar gum and this CMC; good synergy was seen from blends with 30–60% Aquacel™ GSA CMC.

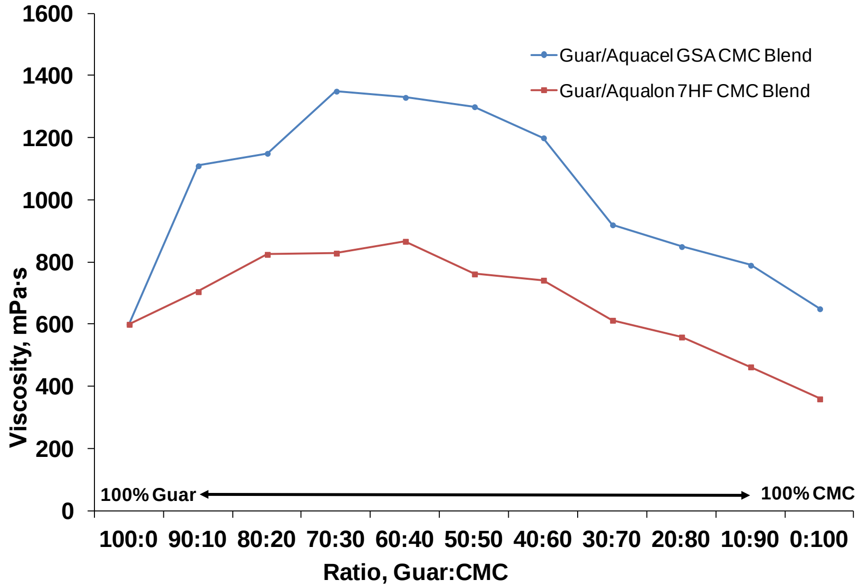

Figure 4. Viscosity of blends of Supercol™ U guar gum + Aquacel™ GSA CMC

Dosage analysis of 60:40 blends of guar and Aquacel™ GSA CMC revealed that use levels of 0.35% gave viscosities over time similar to or slightly greater than guar gum alone at 0.5% by weight (see Figure 5).

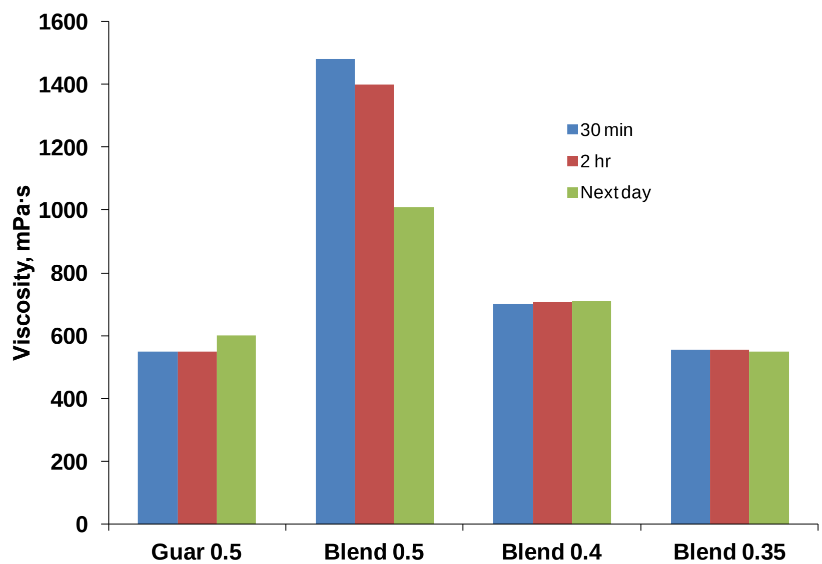

Figure 5. Viscosity of 60:40 blends of Supercol™ U guar gum + Aquacel™ GSA CMC

Viscosity Synergy Analysis—Aquasorb™ A500 CMC

Also evaluated for viscosity synergy was Aquasorb™ A500 CMC, a specialty product for bakery applications. As can be seen in Figure 6, viscosity synergy was observed. The Aquasorb™ A500 CMC samples were also made in Alizay, France.

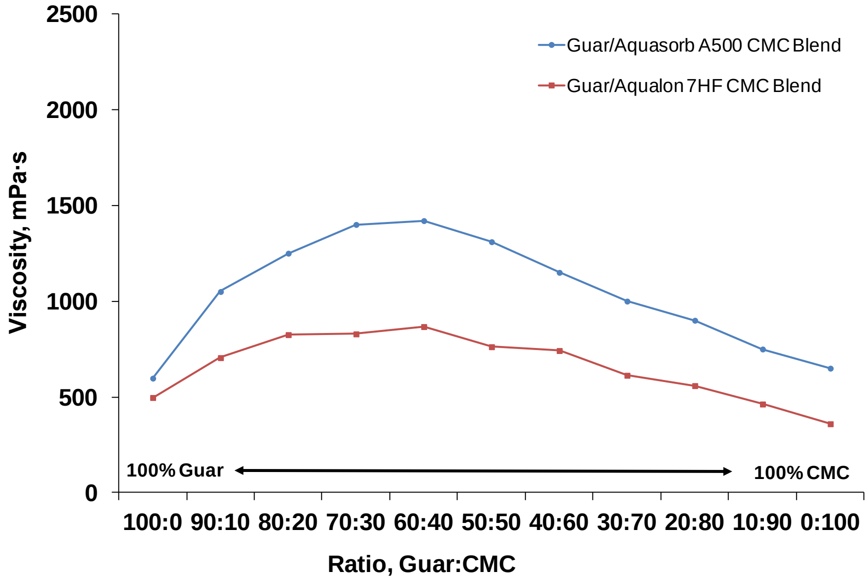

Figure 6. Viscosity of blends of Supercol™ U guar gum + Aquasorb™ A500 CMC

As seen with other CMC grades in this study, lower doses of the blends matched viscosity of guar gum used alone. In Figure 7, it can be seen that studies of 60:40 blends of guar gum and Aquasorb™ A500 CMC revealed that use levels of 0.35% produced viscosities over time that were similar to or slightly greater than guar gum alone at 0.5% by weight.

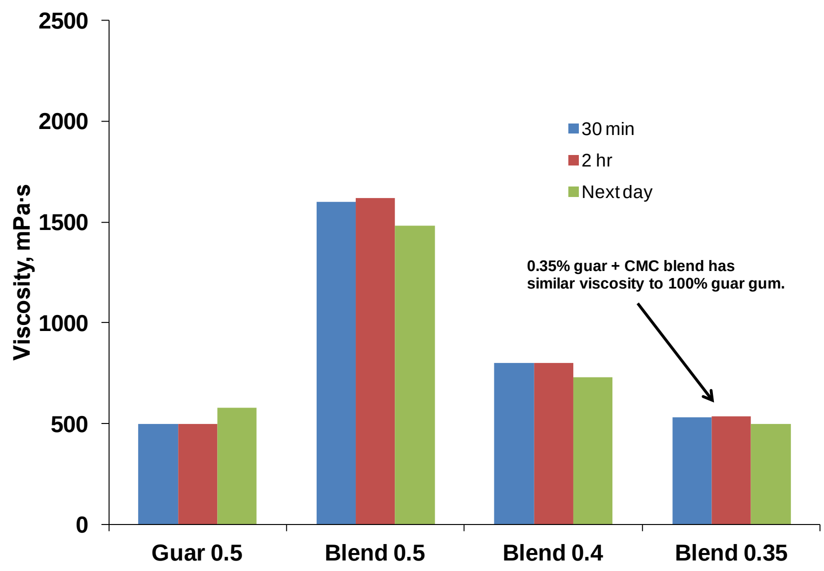

Figure 7. Viscosity of 60:40 blends of guar gum + Aquasorb™ A500 CMC

In bakery applications, the feature of water absorbency is often more important than viscosity. Water absorption was tested as static water uptake of the hydrocolloid powder held in a folded filter paper submerged in water. It can be seen in Figure 8 that the water absorption was greatest in this study for a blend of 60% Aquasorb™ A500 CMC with guar gum.

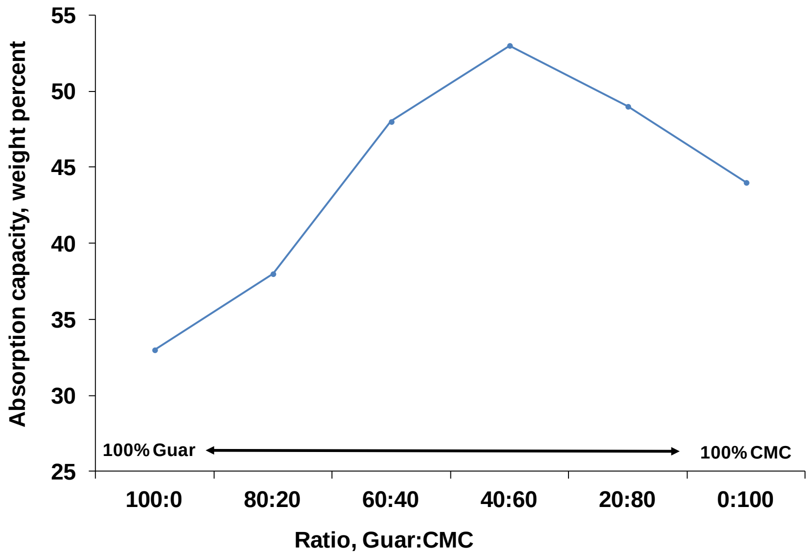

Figure 8. Water absorption of blends of guar gum + Aquasorb™ A500 CMC at 5000 mPa·s

Conclusions

It has been found in previous laboratory studies that CMC and guar gum will exhibit synergistic viscosity. In our previous studies, synergy was calculated as a percent of viscosity achieved over expected viscosity. The purpose of this work was to find the CMC grade or grades that when mixed with guar gum gave the greatest viscosity effect. Therefore in this report actual viscosity data are presented so a comparison can be made among CMC grades.

It has also been shown that when CMC and guar gum samples of similar viscosity are used, the synergy is highest when the guar is in the highest portion (guar gum:CMC 80:20 to 70:30). A practical finding from the present work is that Aquacel™ CMC grades will yield higher viscosity solutions; this in turn allows a wider working range of CMC to guar gum ratios for effective use of this synergistic behavior. Wider working ranges of CMC addition give formulators greater latitude in formulation adjustments to replace guar gum and, in the current economic situation with guar supplies, will lead to greater cost savings opportunities.

References

[1]Hoefler, A. *Hydrocolloids*. St. Paul, MN: Eagan Press.