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The Use of Klucel™ *Pharm* Hydroxypropylcellulose to Increase the Utility of Hydroxypropyl Methylcellulose in Aqueous Film Coating

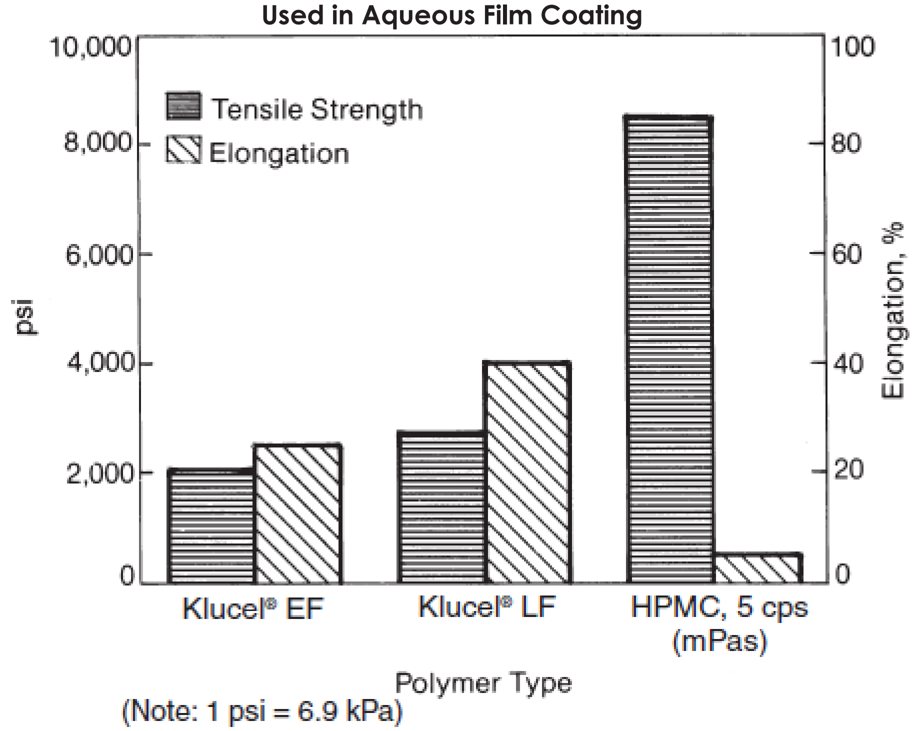
Introduction

Klucel EF and LF hydroxypropylcellulose (HPC) can be used quite successfully in aqueous film coating to greatly enhance the utility of hydroxypropyl methylcellulose (HPMC), *USP*. Klucel EF and LF impart these benefits:

- They eliminate bridging of tablet monograms.
- They provide excellent film adherence to problem tablet substrates such as vitamins.
- They greatly reduce the incidence of film cracking on the edge of tablets.

It is the film properties of Klucel that provide the benefits. Figure 1 shows a comparison of the tensile strength and percent elongation of unplasticized films of Klucel EF, LF, and HPMC, 5 cps (m·Pas).

Figure 1
Film Properties of Various Water-Soluble Polymers Used in Aqueous Film Coating



The HPMC has a very high tensile strength and a very low percent elongation. A great deal of force can be applied before an HPMC film breaks, but the film lengthens only a small amount before the break occurs. To circumvent this problem, plasticizers are added to improve flexibility. However, this approach achieves only limited success, especially with difficult-to-coat tablet cores such as vitamins and monogrammed tablets.

Klucel™ EF and LF hydroxypropylcellulose have a lower tensile strength and a much higher percent elongation than HPMC. Not as much force is required to break a film of Klucel, but the film itself will stretch a great distance before it breaks. This is the basis for the superior flexibility of films of Klucel and HPMC.

Klucel LF shows a slightly higher tensile strength and percent elongation than Klucel EF because of its higher molecular weight (~95,000 vs ~80,000).

Klucel EF and LF are powerful additions to the traditional HPMC film coating formulation, affording greatly enhanced film flexibility and substrate adherence.

Suggested Coating Formulation

An aqueous film coating formulation that has been successfully prepared and used many times in the Ashland Pharmaceutical Laboratory is shown in Table I.

Table I
Film Coating Solution Formula

Material	Solids, %	Batch Solids, g	Total % in Batch	Total Batch Weight, g
Klucel EF, *NF*	100	80.0	4.0	80.0
HPMC 2910, *USP*, 6 cps	100	80.0	4.0	80.0
Opaspray L-7000[a]	60	80.0	4.0	133.3
Polyethylene glycol 400, NF	100	13.9	0.7	13.9
Purified water				1,692.8
Total		253.9	12.7	2,000.0
Polishing Coat				
Purified water				500

[a]Opaspray is a registered trademark of

Klucel EF and HPMC 2910, 6 cps (m·Pas), are the film-forming polymers and are employed in a 1:1 ratio. In this instance, they are present at 8% of the total formulation. This level of use may be adjusted to suit preferences in final solution viscosity. In the sample formulation presented here, the final solution viscosity will be about 200 cps (m·Pas).

Polyethylene glycol 400 is employed as the plasticizer. It is used at a rate of approximately 9% of the polymer solids.

The liquid color dispersion employed in this instance contained a white pigment at the 60% solids level. This percentage will vary with the pigment manufacturer and the color selected. The choice of pigment can also affect the final solution viscosity.

In this formulation, water is used to add some gloss to the tablets. It is well known that aqueous-film-coated tablets have a matte finish at the conclusion of the color-coating step. Gloss can be imparted to the tablets in several ways. The water-polish technique is an effective, cost-efficient approach that takes advantage of the natural glossing property of Klucel. This property can be realized by vigorously buffing a tablet coated with the formula provided. From a production standpoint, the careful application of a very fine spray of water to the moving tablet bed will enhance tablet appearance considerably.

More water can be added to a formula if a lower viscosity coating solution is desired. This has the effect of reducing the total solids content of the coating solution. Generally, a solution viscosity of not more than 200 cps (m·Pas) produces the smoothest finish on the tablets. The lower-solids-content formulas increase the total spraying time of the batch. Table II summarizes the effect of coating solution solids content on solution viscosity.

The Effect of Klucel™ EF and LF HPC on Coating Solution Viscosity and Spraying Time
A coating formula was prepared in which Klucel LF was substituted for Klucel EF. The LF grade is the more economical, but it builds a higher solution viscosity at equal use levels. One consequence of using Klucel LF in a coating formula is that more dilution is needed to reduce the viscosity to a suitable level. This translates into longer spraying times. Figure 2 graphically illustrates the relationship between solids concentration, solution viscosity, and spraying time, based on the data from Table II.

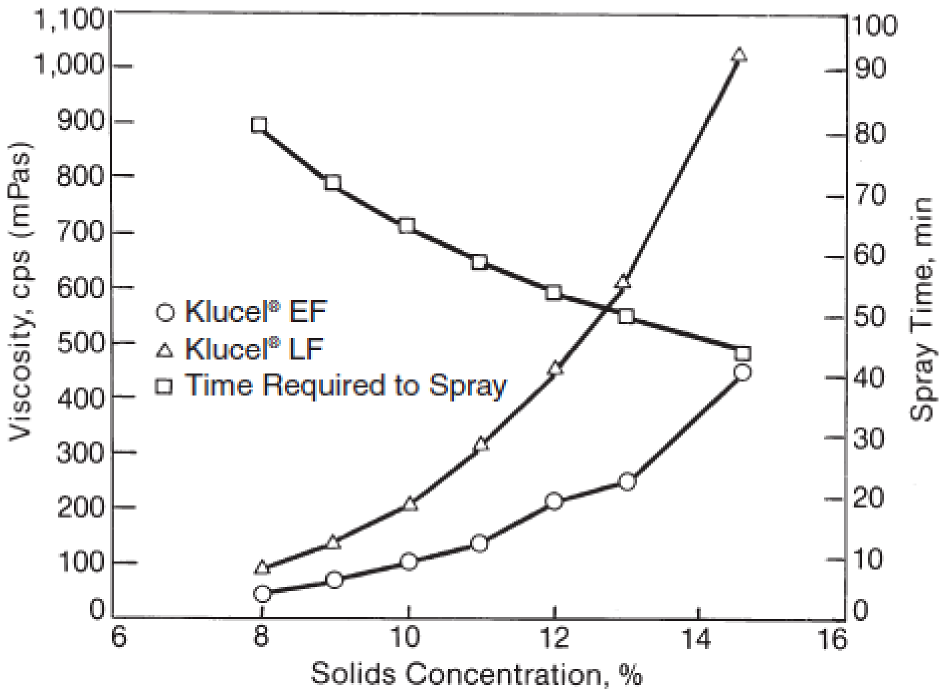
Table II
The Effect of Coating Solution Solids Content on Solution Viscosity and Spraying Time for Two Formulations: Klucel EF/HPMC and LF/HPMC

Solids Content, %	Viscosity, cps (m·Pas) Klucel EF and HPMC	Viscosity, cps (m·Pas) Klucel LF and HPMC
14.6	450	1,025
13	250	613
12	213	450
11	138	313
10	105	208
9	73	138
8	48	88

Spraying Times at 45 g/min

Solids Content, %	Solids, g	Solution, g	Time, min
14.6	292	2,000	44
13	292	2,246	50
12	292	2,433	54
11	292	2,655	59
10	292	2,920	65
9	292	3,244	72
8	292	3,650	81

Figure 2
The Effect of Klucel™ HPC Molecular Weight on Solution Viscosity and Spraying Time



Film Coating Solution Preparation Method

Step I. The two polymers are dry-blended and will be dissolved simultaneously. It is unnecessary to make two separate polymer solutions.

Step 2. About half the water used in the formula is heated to a minimum of 90°C. Neither polymer is soluble in water at this temperature.

Step 3. The polymers are added immediately to the water with agitation. Surprisingly little agitation is required to accomplish proper dispersion of the polymer particles. Low agitation rates are critical at this stage of the process, in order to minimize the incorporation of air into the batch. At this point, the solution temperature will be about 80°C.

Step 4. A little less than half of the remaining water is added to the batch. If this water is at room temperature, the coating solution temperature will be below 38°C at the end of the solution preparation process.

Step 5. Add the polyethylene glycol to the polymer solution and mix for 20 min.

Step 6. Add the color to the polymer solution and mix for 5 min.

Step 7. Adjust the batch to the final weight with the remaining water. The solution is ready to spray when its temperature is below 38°C.

Because the polymers are not soluble in hot water, they will disperse rather than agglomerate. This method has three advantages:

- The polymers will hydrate more rapidly and uniformly.
- Lower shear is needed to achieve polymer solution.
- Less air will be incorporated into the mix.

In general, with the hot water method, propeller stirrers provide an adequate degree of shear. High-shear dispersator-type equipment is not recommended because of its potential to break down polymer chain length. There should be minimal entrained air in the coating solution if the hot water method is employed. As long as the surface of the solution is relatively free of foam, the entrained air levels should not exceed 3 to 4% of the total volume of the solution.

Thus far, studies in our laboratory have shown that little benefit is derived from the use of silicon-based defoamers to reduce foam levels in coating solutions. Controlling agitation during the hot water preparation method is usually sufficient to minimize the incorporation of air into the coating solution.

This manufacturing method is a guideline for preparing coating solutions. Since manufacturing equipment and methods vary from one company to the next, modification of this process may be necessary. However, the basic principles underlying the development of the method have been described.

Monitoring the viscosity of the finished coating solution is recommended if there is a question about the adequacy of hydration of the polymers. There will be no more than a 10% viscosity change over a three-hour period when the polymers are completely dissolved. Polymer hydration time is greatly dependent on individual manufacturing equipment and methods.

Spraying Parameters

A. 24-in. (61-cm) Side-Vented Coating Pan

Typical parameters for spraying in a 24-in. (61-cm) side-vented coating pan (Accela-Cota, Thomas Engineering, Hoffman Estates, Illinois) are listed in Table III.

Table III
Spraying Parameters for 24-inc. (61-cm) Side-Vented Coating Pan

Spray Gun		**Column**	
Binks model	61	Inlet air damper setting	Open
Air cap	66SD	Speed, rpm	12
Fluid nozzle	63 ASS	Baffles	4 antislide bars, 4 shoehorn
Nozzle pressure, psi (bar)	50 (3.4)		
Cylinder pressure, psi (bar)	50 (3.4)	Batch size, kg	10
		Inlet air temperature, °C	Typically 60
Pump		Pan temperature, °C	Typically 50
Peristaltic		Outlet temperature, °C	Typically 37
Delivery rates, g/min		Coating efficiency, %	90
Coating solution	47		
Water	33		

A single spray gun system is used and provides satisfactory results. Any suitable peristaltic pump can be used to deliver the coating solution. The delivery rates are expressed in grams for maximum accuracy. The pan settings listed are typical. The shoehorn baffles are set up in an alternating pattern on opposite sides.

The temperature measurements were made with an electronic thermometer that responds quickly to any changes. The inlet air temperature is measured just below the inlet air damper. The pan temperature is measured at the spray gun. The outlet air temperature is measured at the exhaust duct at the rear of the machine.

B. 7-in. (18-cm) Column Coater
Typical parameters for spraying in a 7-in. (18-cm) air suspension column coater (Glatt GPCG 5/9, Glatt Air Techniques, Ramsey, New Jersey) are listed in Table IV.

Table IV
Spraying Parameters for 7-in. (18-cm) Column Coater

Spray Gun	
Port size, mm	1.2
Spacer ring, mm	3.0
Atomization air pressure, bar	1
Pump	
Peristaltic	
Delivery rates, g/min	
Coating solution	24
Water	16

Pan	
Inlet air damper setting	Open
Outlet air damper setting, %	45
Batch size, kg	3
Inlet air temperature, °C	54
Product air temperature, °C	44
Outlet temperature, °C	33
Coating efficiency, %	85-90

The standard spray nozzle is used and provides satisfactory results. Once again, delivery rates are expressed in grams for maximum accuracy. As is normal for this size of coating unit, the inlet air damper is set wide open and tablet fluidization is controlled with the outlet air damper. The batch size is 3 kg, a small charge for this column. A 5 to 6-kg charge can be accommodated and probably will increase coating efficiency. The air temperatures were measured with probes provided by the manufacturer.

Conclusion

Klucel™ HPC is a highly versatile polymer with excellent film properties that greatly enhance the utility of HPMC coating formulas. The coating formula provided is robust and easily handled in a wide variety of coating equipment, and on a wide variety of tablet cores.

Product Safety

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