SEKISUI

SELVOL™ POLYVINYL ALCOHOL

Selvol™ Polyvinyl Alcohol as a Protein Replacement in Paperboard Coating Formulations

Polyvinyl Alcohol Technical Bulletin

Soy protein is widely used in paperboard coating formulations as a cobinder with latex to provide on-machine runnability, and to impart non blocking and printing attributes to the coated board. For these purposes, soy protein has been, and still is, a good performer.

This bulletin introduces the concept of using polyvinyl alcohol (PVOH) as a replacement for protein in paperboard formulations. The advantages of this concept will be discussed, and the results from extensive laboratory studies and a successful commercial mill application will be presented.

PVOH Advantages Over Protein

- Polyvinyl alcohol is the strongest binder in the paper industry and much stronger than protein. This means that less PVOH can be used for equivalent strength.
- Less binder means higher brightness and gloss, better hiding power for unbleached fibers, faster ink vehicle penetration for speed of set, and cost savings.
- Polyvinyl alcohol dissolves in plain water - no ammonium hydroxide is required. The PVOH/water slurry is simply heated to ~200°F for 30 minutes, and a clear and colorless solution results.
- Polyvinyl alcohol has a 5-day BOD of less than 1%. It resists microbial attack, so there are no putrefying odors in the mill.
- Polyvinyl alcohol is a synthetic polymer that is manufactured to the highest quality standards. Most importantly, its viscosity is controlled to within very tight specifications. This insures that coating formulations exhibit the same viscosity, and the same performance, day in and day out.

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Recommended Grades

Recommended grades of choice for protein replacement are Selvol 107, Selvol 103 and Selvol 203S polyvinyl alcohols (see Figure 1). Selvol 107 polyvinyl alcohol, a fully hydrolyzed (98%) grade, is the strongest of the three by virtue of its high molecular weight. Selvol 103 polyvinyl alcohol, also a fully hydrolyzed grade, has an ultra low solution viscosity that was developed for optimum balance of strength and runnability in coating formulations. Selvol 203S polyvinyl alcohol is a partially hydrolyzed grade (88%) that is also ultra low in solution viscosity. It is offered as a "non-cook" alternative to Selvol 103 polyvinyl alcohol when used as described in U.S. Patent 5,057,570.

Figure 1: Physical Properties

Grade	Hydrolysis %	Viscosity cps[1]	Ash_3 % Max	Volatiles % max	pH_2
Selvol 107	98.0 - 98.8	5.4 - 6.5	1.0	5	5.0 -7.0
Selvol 103	98.0 - 98.8	3.5 - 4.5	1.0	5	5.0 - 7.0
Selvol 203S	87.0 - 89.0	3.5 - 4.5	1.0	5	4.5 - 6.5

[1] 4% aqueous solution @ 20°C
[2] As % Na_2O corrected values
[3] 4% aqueous solution

Test Results

Dry Pick Strength

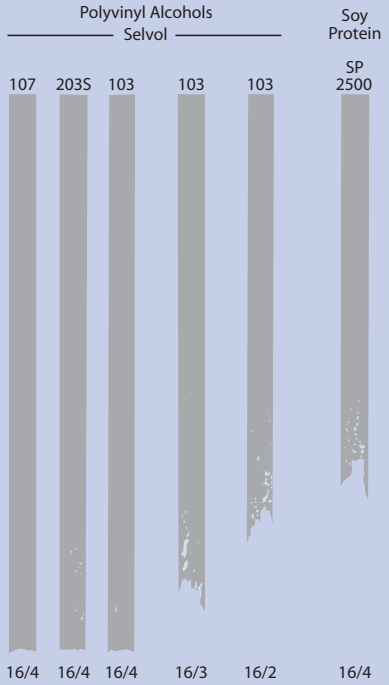
Because of the importance of strength to the protein replacement application, Figures 2 and 3 are provided as supportive evidence to what is widely accepted in the paper industry that PVOH is the strongest binder. Shown in the figures are IGT test strips comparing Selvol 107, Selvol 103 and Selvol 203S polyvinyl alcohol grades with SP 2500 soy protein, when used as cobinders with latex on coated SBS paperboard.

In Figure 2, the binder consisted of 13 parts latex and 7 parts cobinder. Note that at this level, all three polyvinyl alcohol grades were much stronger than the protein, as evidenced by the lack of pick. Reductions in Selvol 103 polyvinyl alcohol to 6, 5 and 4 parts indicate that even the 4 parts Selvol 103 polyvinyl alcohol was stronger that the 7 parts protein control.

In Figure 3, the binder consisted of 16 parts latex with 4 parts cobinder, and the same conclusions were seen in this test as before. Here, the 16/2 latex/Selvol 103 polyvinyl alcohol formulation was stronger that the 16/4 latex protein control formulation.

Figure 2: IGT Dry Pick Test Strips

Figure 3: IGT Dry Pick Test Strips



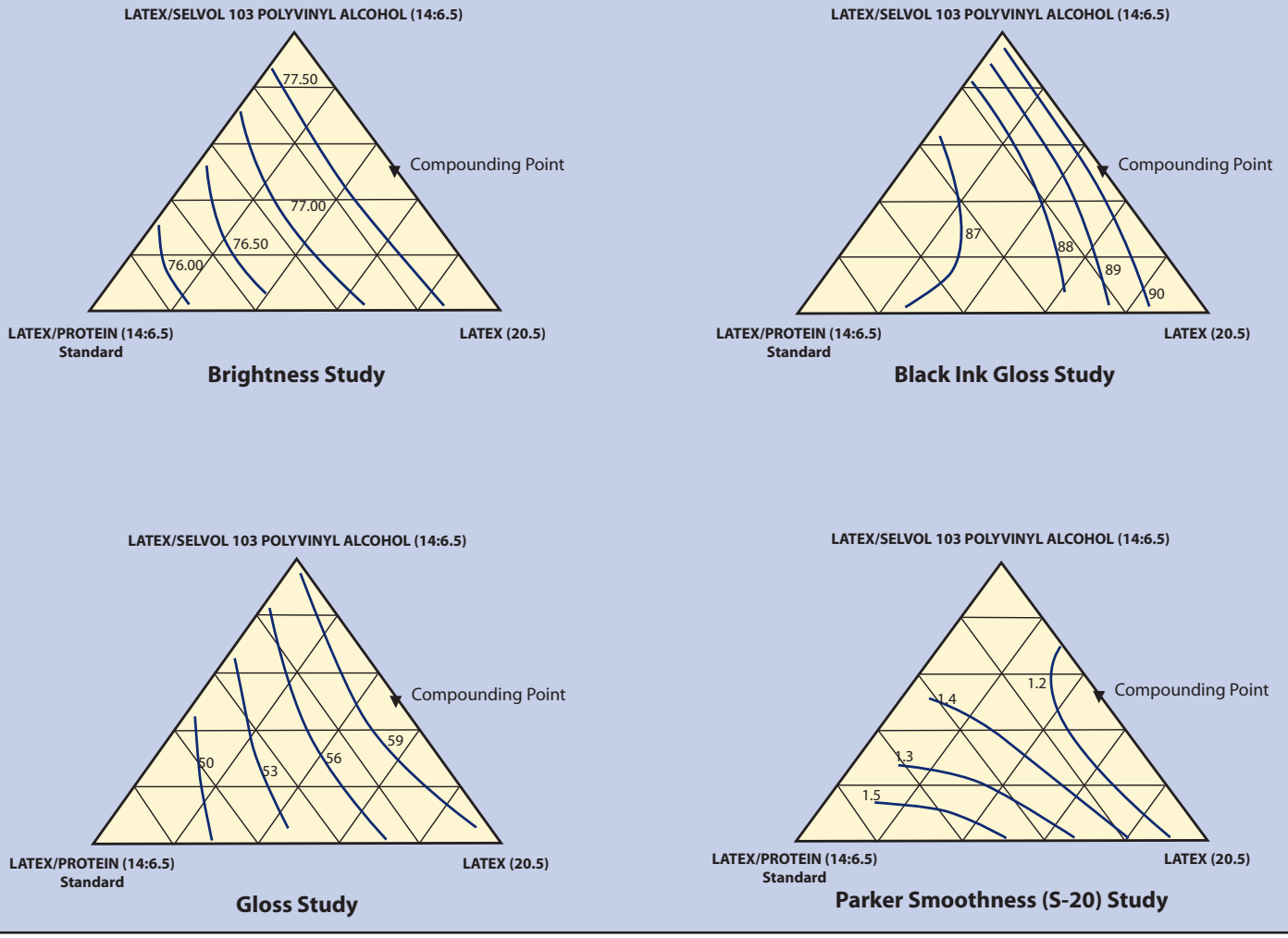
Optimizing Cobinder Level

A more comprehensive laboratory study was conducted using a Simplex experimental design method aimed at optimizing the cobinder level for maximum performance. In this study, Selvol 103 polyvinyl alcohol was incorporated into a latex formulation at half the protein (Pro-Cote 400) control level. The latex portion was increased in the Selvol 103 polyvinyl alcohol formulation in order to maintain an equivalent total binder level to that in the protein control formulation. The pigment system consisted of 85 parts No. 1 clay and 15 parts titanium dioxide.

The results of this study are shown by the four graphs in Figure 4. The "half protein" Selvol 103 polyvinyl alcohol level is indicated on these four graphs by the "Compounding Point" located on the right leg of the triangle. In a comparison formulation, the latex/protein (14/6.5 parts) control formulation, the latex/Selvol 103 polyvinyl alcohol (17/3.25 parts) formulation was found to be:

- Higher in brightness by 2+ units
- Higher in gloss by 12+ units
- Higher in gloss ink holdout by 5+ units
- Smoother by 0.4 Parker (S-20) units

Figure 4: Formulation Study



Commercial Mill Success

A recycled paperboard mill which historically used a protein cobinder in its air-knife formulation became interested in the PVOH approach because of concerns over ammonia odors coming from the protein, and because of the tendency for the protein-containing coating colors to degrade with time, thus causing a "washed out" appearance in the coated board.

Based on preliminary laboratory work, a formula containing 3 parts Selvol 103 polyvinyl alcohol (half the original protein level) and 17.5 parts latex, a vinyl acetate-ethylene latex was chosen for a machine trial.

In the trial, this formulation made up well, and ran well on the air-knife coater. Coated board results from the trial (See Figure 5) showed improvements in brightness of 2-3 units, in 75° gloss of 6-8 units, in gloss ink holdout of 7-9 units, in smoothness (Parker Print) of 0.5 M, and in the dry surface strength of 25%. All of the results were similar to those predicted in the laboratory study. Board from the trial was successfully printed in a commercial five-color offset press and converted.

The trial coating was subsequently run in a second series of mill trials aimed at qualifying the paperboard manufacturer's customers on the PVOH-containing coating. During these trials, the PVOH-containing coatings exhibited excellent coater runnability and continued to provide performance advantages over the standard protein-containing coatings. In printing comparisons of the PVOH-containing coatings versus the standard protein coating, commercial printers noticed a reduced frequency of hickeys, or pickouts. This is directly attributable to the stronger surface strength that PVOH provides.

This paperboard mill has successfully replaced protein with Selvol 103 polyvinyl alcohol in all of its coatings. In replacing protein with PVOH, the mill not only met its original objectives of eliminating ammonia odors and protein spoilage within the mill, but it was also able to upgrade the quality and performance of its coated sheet. In addition, since the protein was replaced with half the amount of PVOH, significant cost savings were realized.

Figure 5: Machine Trial Results

Runnability	Excellent
Brightness	+ 2-3 units
Gloss	+6-8 units
Gloss Ink Holdout	+ 7-9 units
Smoothness	+ 0.5 m
IGT Dry Pick Strength	+ 25%
Printing, 5 Color Offset	Superior/Reduced

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