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FennoBind New Generation of Functional Coating Binder Allows New Coating Properties Design and Higher Cost Efficiency

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Abstract: *The main functional role of a Paper coating binder is to bind the pigment particles, which make up for more than 85% of the dry weight of the formulation. In addition, the binder affects the printability of the paper by helping the absorption and drying of the printing ink. Approximately 50% of the coating costs can be attributed to the binder system, so one of the main driving forces in binder development has been to reduce the cost of the binder system. As starch as coating binder is significantly cheaper than latex it has become very common to use more and more starch in coating formulations. Especially in precoating and also top coating for matte and silk papers of lower quality adding more starch is a feasible option. Too much starch as binder, however, has also disadvantages for binding strength, gloss, fold cracking and mottling and results in lower coating solids, high shear viscosity and difficulties to run lower coat weights. The new patented FennoBind binder technology deviates in a significant and surprising way from well-established knowledge about synthetic binders. We will demonstrate in this paper the main deviations and give some examples how it is possible to utilize these new findings to develop more cost-effective formulations and show how papermakers can pass with this knowledge the current boundaries in order to create additional value.*
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Key words: Coating, Binder, Ink Setting, Mottling

1. Introduction

Papers are often coated with water based pigment formulations to enhance their smoothness, visual appearance and their process ability and color reproduction in various solvent or water based printing processes. Although the binder content in those coatings is below 18% of the total coating composition, up to 50% of the total cost of the coating can be usually attributed to the binder system. Therefore, a lot of effort is spent on binder development to reduce the coating costs. Adding more starch is a feasible option in pre-coating and top coating for matte and silk papers. Too much starch as binder, however, has also disadvantages like lower binding strength, negative effect on gloss, fold cracking and risk of mottling and results in lower coating solids, increased high shear viscosity and difficulties to run lower coat weights.

In this article, we will show how FennoBind, a new synthetic binder technology can deliver higher strength and gloss at lower total binder level and the consequences for rheology, stability and effect on printability of the coated paper or board.

New FennoBind technology

It is known from many studies throughout the last 3 decennials that the primary parameters to describe the functional properties of latex coating binders are *Monomer composition; Particle size and size distribution;* level of *carboxylation; cross linking as well as surfactant and gel content.* It is well researched and understood how secondary parameters follow from these like e.g. Tg (glass transition temperature), effect on coating rheology and stability, porosity, ink absorption and surface polarity as well as gloss and print gloss development. The new FennoBind technology deviates to some of this well-established knowledge in a significant and surprising way (Table1).

By polymerization of styrene and acrylate co-monomers in a new and patented process we are now able to prepare 50% binder dispersions with uniform particle size distribution and very high stability. The individual particles are about 50 % reduced in particle size compared to a typical SB latex which is shown in the attached picture (Graph 1). This smaller particle size of the Fennobind will create 5 times higher specific surface area and a 30 times higher number of particles for the same volume. In addition, the new advanced colloid dispersion system keeps the small individual particles well dispersed, so no flocculation can occur during coating consolidation – which results in a very good distribution of the binder in the coating. Ultimately, due to the much higher specific surface and the absence of most of the surfactant the particles can bind very effectively to the coating pigments giving enhanced surface strength to the coated papers.

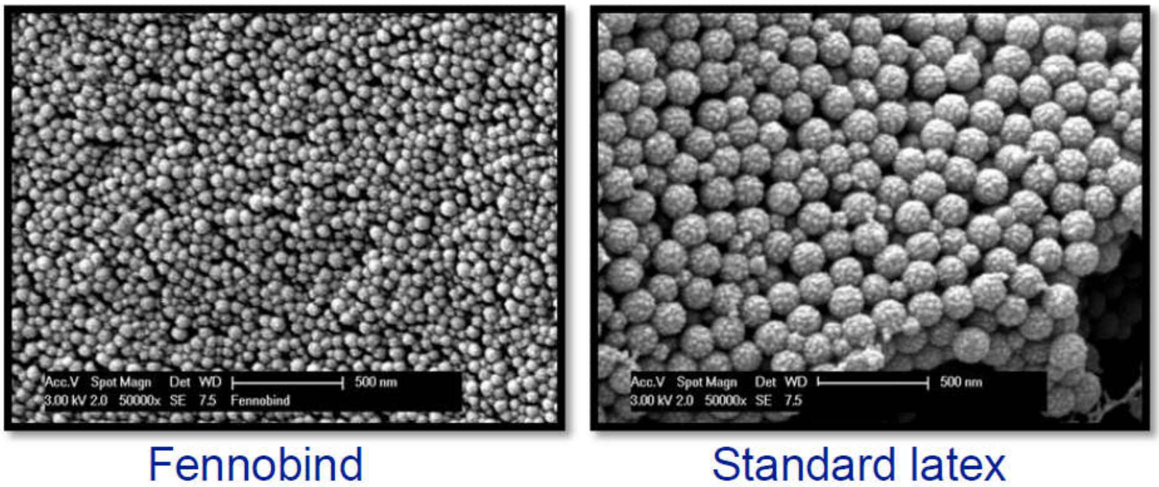


Fig. 1. Cryo SEM pictures of Fennobind against a SB latex

Table 1: Typical properties of synthetic binders

Synthetic binder	Main monomers	Surfactant level	Tg	Particle size nm	Ca2+ stability	Brightness & aging stability	charge, meq/l
SB	Styrene, Butadiene	0.5—1.0%	-20-20	100-180	low	+	-147
SA	Styrene, Butylacrylate	0.5—1.0%	15-30	170-200	low	++	-230
Fennobind	Styrene, Butylacrylate	< 0.3%	20-50	50-80	Excellent	+	-33

Value in paper coating **- Effect on coating rheology and coated paper properties**

When FennoBind is used to successively replace SB- or SA-latex in a formulation the particle size distribution of the coating binder will become bimodal. As with respect to binding power 1 part FennoBind in the formulation can substitute two parts of conventional binder, total binder volume will decrease and pigment volume will increase. Additionally, the lower anionic charge on FennoBind particles will reduce pigment to binder interactions in the coating color. The consequence of this is in many formulations that the viscosity at high shear is reduced (Fig. 2). It is worth noting that the stabilization plays here the dominant role for the flow curve because same replacement rations for products with different Tg give exactly the same flow profile in the high shear curves. As high shear will get lower, coating solids can be increased without compromises on coater runability or increased blade pressure. At the same time, the low shear viscosity is slightly increased which makes some of the thickener obsolete.

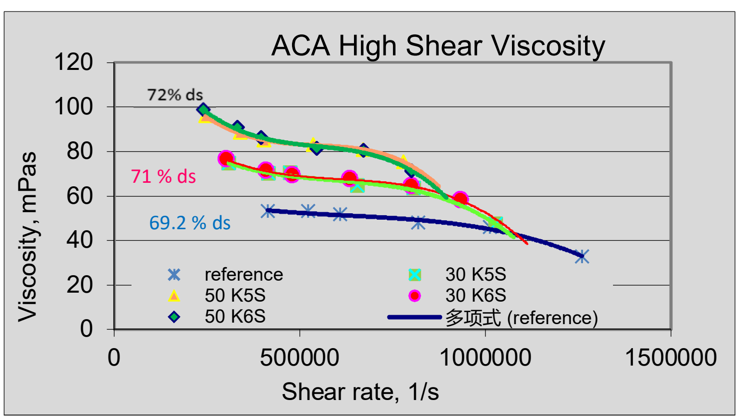
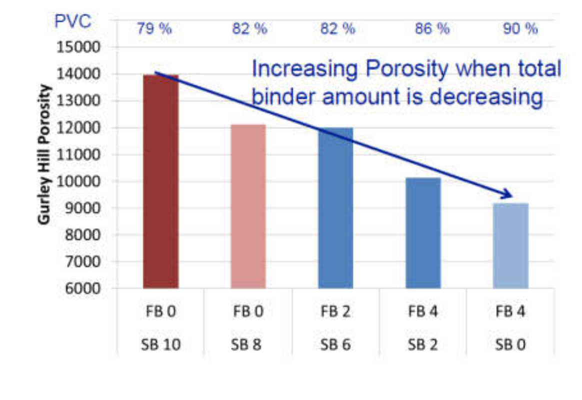


Fig. 2. High shear viscosity with FennoBind K5S (Tg 40°C) and K6S (Tg 20°C).

Usually the water retention in the coating is not very much changed when FennoBind is introduced in the formulation; however, as higher solids can be run water retention is usually improving. The binder can be run on most coating systems with low and high coating solids and binder content due to the very good stability which makes the product less sensitive to changes in temperature, soluble calcium Ions or changes in pH or shear. As the particles are small, high coating solids is preferred in order to avoid losing surface strength due to migration into the base sheet.

As the new technology is used to replace standard latex by 2:1 there will be an increase in the pigment volume concentration (PVC). This means a lower volume of binder and thus a higher volume of pigment is achieved. The porosity of the sheet will be increased accordingly (see Fig. 3). As a consequence of the lower binder volume the gloss after calendar will increase, brightness will enhance due to better coating coverage and opacity at the same gloss will also increase. The ink setting speed will be usually faster due to higher micro porosity of the coating layer.



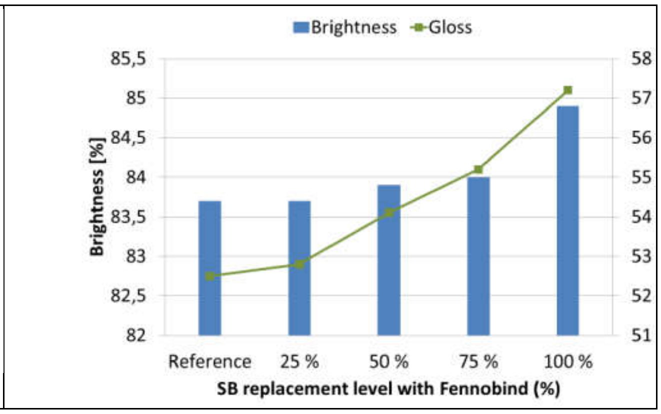


Fig. 3. Coating porosity when SB latex is replaced by Fennobind **Fig. 4.** Paper gloss and brightness for SBB

Depending on the pigment composition and type of the ink used for printing, in some cases of glossy papers the enhanced drying time can lead to increased ink tack during printing. In this case the pigment combination can be changed to reduce ink drying speed by decreasing the number of small pores.

Value ***in printing and converting***

A) Coated Sheet fed Offset papers

Latex replacement levels of 30-70% can be achieved at a ratio of 1:2 which results in a total binder level reduction between 15 and 35%. In contrast to coating formulations using high amounts of starch we see with FennoBind an increase of gloss after calendaring. For some coated boards with high binder demand due to high strength requirements in printing and converting enhanced ink setting is wished for because it reduces mottling and smearing and allows for faster converting of the printed material after multi-color offset printing. Also, silk and matte papers benefit usually from faster ink setting. The combined benefits of FennoBind can be higher gloss and delta gloss, faster ink setting, reduced dusting or linting. In addition, we find excellent dispersion varnishing and good glue ability.

B) Coated Rotogravure papers

In rotogravure papers, up to 100% of binder can be replaced by FennoBind as the high micro porosity of the coating is beneficial for solvent absorption. It also leads to significantly lower solvent residuals after drying. We usually achieve equal or improved print quality and excellent dispersion varnish performance.

C) Digital grades

The different dispersion technology of the FennoBind technology creates good stability in formulations for coated digital grades where conventional latex dispersions fail. As surfactants and anionic groups are absent, cationic ink fixatives or salts do not flocculate the binder dispersion. That makes coating formulations possible which can be ink jet printed by 2-dimensional data matrix codes (QR), text or barcode with good resolution and low rub resistance.

Printing case study from India with 15% lower total binder

Finally, we would like to report our first trial with the technology in India together with a producer of high quality Art paper with a modern high speed offline coater with 4 coating stations. We tried the product in several grades and would like to focus here on the results for glossy Art Paper.

On a 130 gsm final grade we replaced 30% of the incumbent SB latex by 15% FennoBind in top coating. With the same pigment formulation and the same solids in the color preparation we saw Brookfield and high shear viscosity within the normal working range.

Good runability and clean bend- blade and a slightly better drying were observed on the coaters.

After the calendar, the trial papers had 3-4 points higher gloss, same surface strength, brightness and bulk. From the burn - out and laboratory printing tests we could see lower two sidedness and better coating holdout. Ink setting is a bit faster (see Table 2).

Table 2. Coating and paper properties with 15% reduced binder for two production grades

	unit	130 gsm reference	130 gsm trial	170 gsm reference	170 gsm trial
GCC blend	pts	85	85	80	100
Clay	pts	15	15	20	0
SB Latex	pts	10,5	7,35	10,5	7,35
Fennobind K6S	pts	0	1,6	0	1,6
Ca stearate	pts	0,6	0,6	0,6	0,6
insolubilizer	pts	0,2	0,2	0,2	0,2
OBA	pts	0,5	0,5	0,45	0,45
synth. thickener	pts	0,24	0,24	0,19	0,19
solids coat. Prep	%	67	67	66,5	70
Brookfield	CPS	1300	1240	1340	1580
Hercules Viscosity	CPS	23,5	26,1	24,2	32,7
after calendar :					
bulk	cm^3/g	0,80	0,80	0,82	0,81
IGT TS/BS	cm/sec	182/182	182/182	182/182	182/182
gloss TS average	%	60,5	64,4	64,6	61,5
gloss BS average	%	60,5	63,1	62,1	60,4
brightness	%	87,9	87,6	87,1	88,1

We also tested a changed pigment formulation with 100% Carbonate. To compensate for the coverage of the clay we ran the formulation at 3% higher solids. High shear viscosity being a bit higher we still had clean blades and normal blade pressures at normal coater speeds. The paper was easier to dry and was calendared to the same bulk as the refence. Slightly lower gloss was achieved (2-3%) which can further be optimized by changes in the carbonate mix. Surface strength again remained in the normal range and brightness was 1 point higher due to the absence of clay.

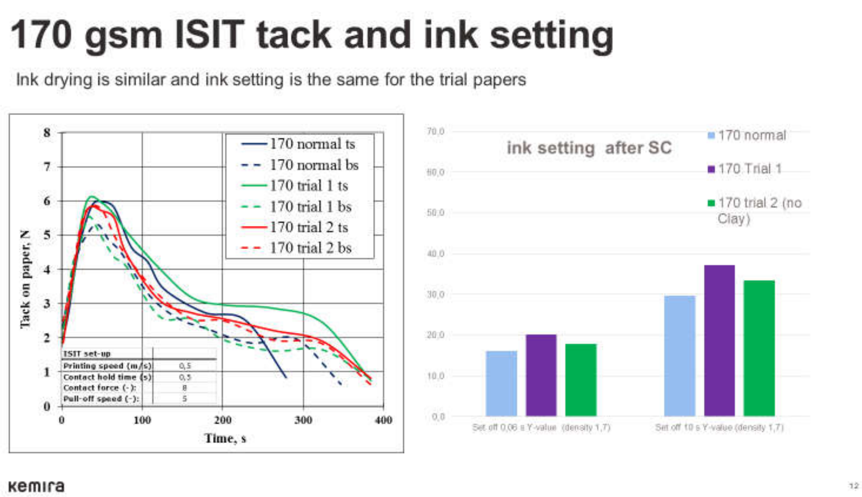


Fig. 5; 6. ISIT and ink setting properties with 15% reduced binder for two 170gsm production grades

Ink to surface interaction and ink setting were determined in the lab. We only show the results for the papers with the different pigment formulations below (Graphs 5;6). Although no clay was used in the formulation ink drying and setting were on very similar levels. Passes to pick in the ISIT test were 10 for all papers.

Burnout tests for the 170 gsm papers show same or better coverage also without Clay.

All offset trial papers were printed in a commercial print shop in India. After inspection of printed paper samples, the judgement was that the trial papers matched the quality of normal production. So, the next step will be further introduction of the concept with a longer-term trial.

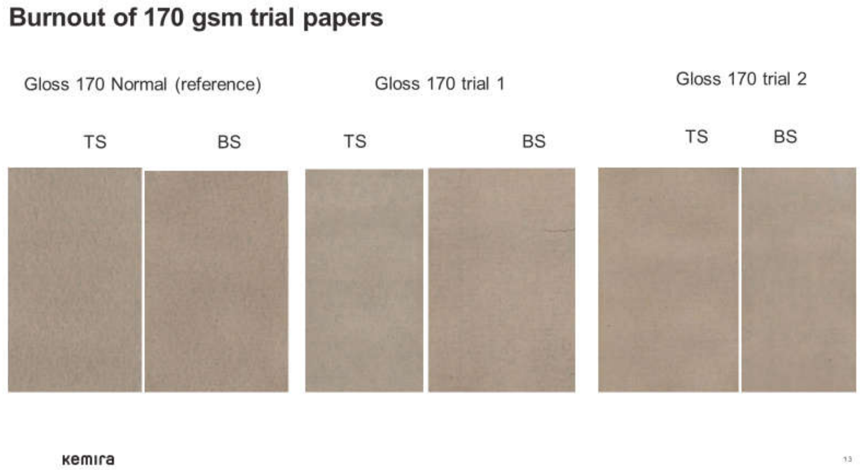


Fig. 7. Burn-out tests for 170gsm production grades

Summary

The new FennoBind binder technology offers to the papermaker higher binding power, improved rheology and run ability as well as better coverage. Gloss of the sheet after the calendar is increased and depending on the pigment formulation ink setting can be adjusted in both directions. As a result of lower overall use of synthetic binder, the Carbon footprint of the resulting product is reduced.