"Coating & print performance of biobased latex in European graphic papers"

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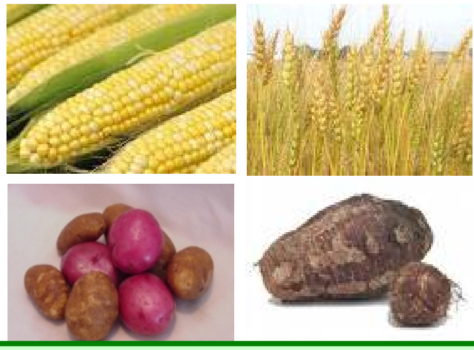
RETHINK PAPER:
Lean and Green

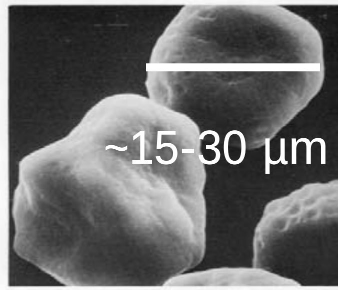
Renewable inputs to biobased latex to coated paper

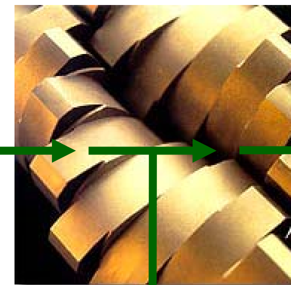
1. Renewable Inputs

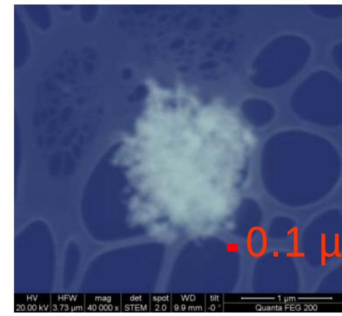


Starch biopolymers (corn, tapioca, potato, wheat, etc.) + additives

2. Produced by Green Manufacturing Process







Proprietary process turns starch (soluble polymer) into a biobased latex nanoparticle (insoluble polymer)

3. Shipped as a dry powder

Dry product provides transportation savings

4. Paper & Board Manufacturing

Improved runnability, water retention, fiber coverage, coating holdout, etc.

5. Coated paper & board products

Superior binder performance & cost savings for the industry

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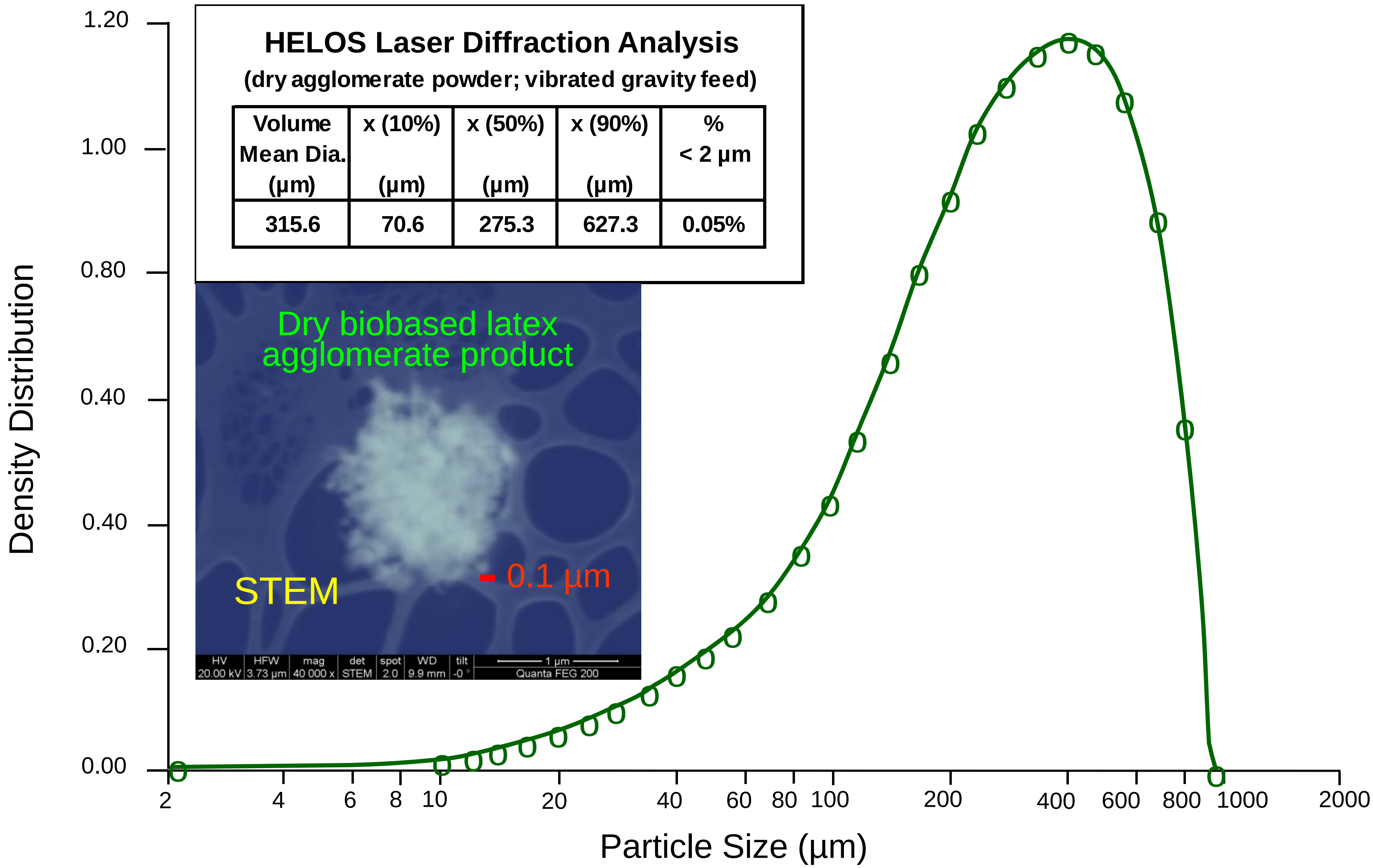
Analysis of dry biolatex powder: agglomerate particles

HELOS Laser Diffraction Analysis

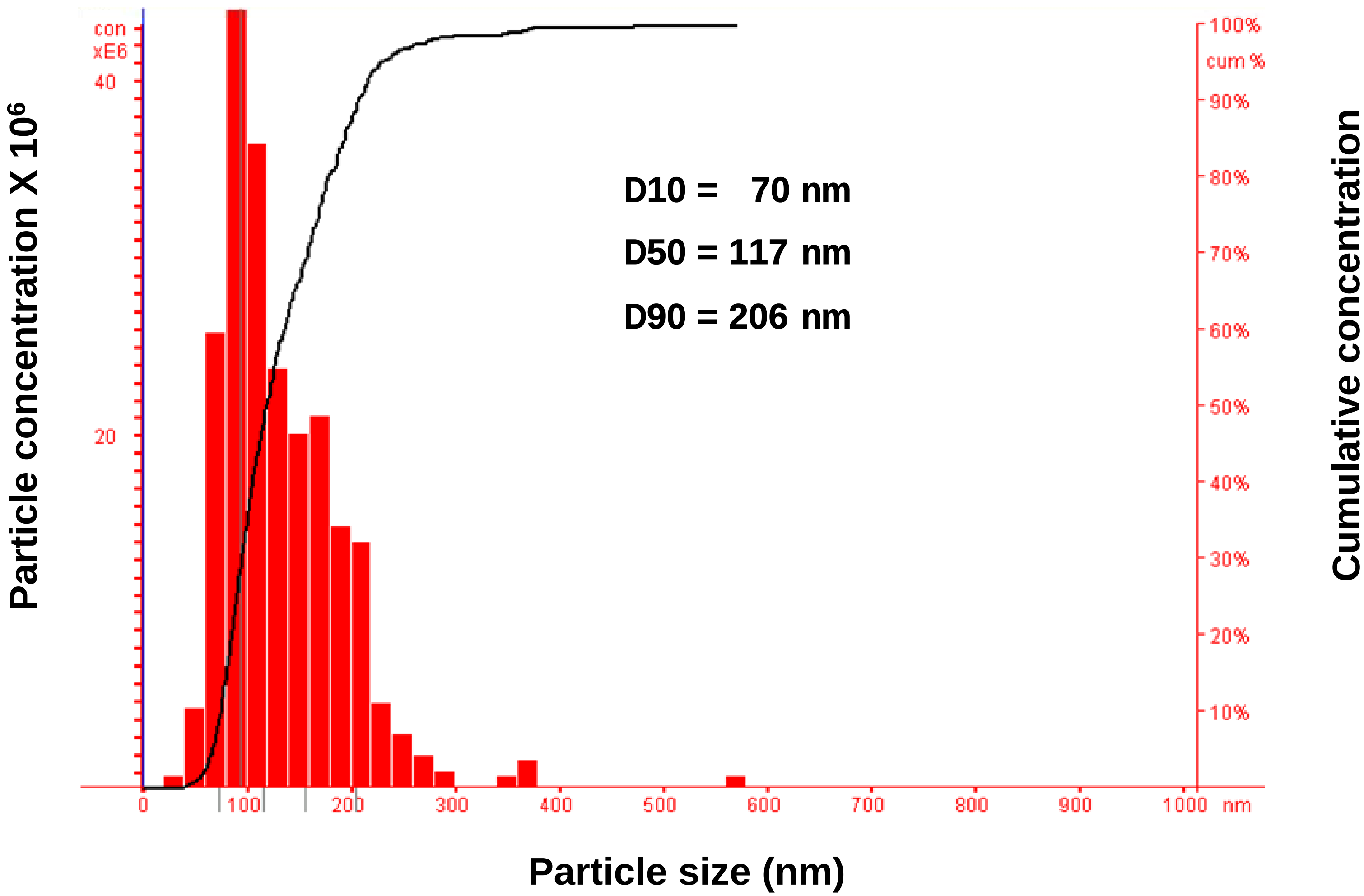
(dry agglomerate powder; vibrated gravity feed)

Volume Mean Dia. (µm)	x (10%) (µm)	x (50%) (µm)	x (90%) (µm)	% < 2 µm
315.6	70.6	275.3	627.3	0.05%



Analysis of biolatex emulsion: biopolymer nanoparticles

Nanoparticle Tracking Analysis (NTA)



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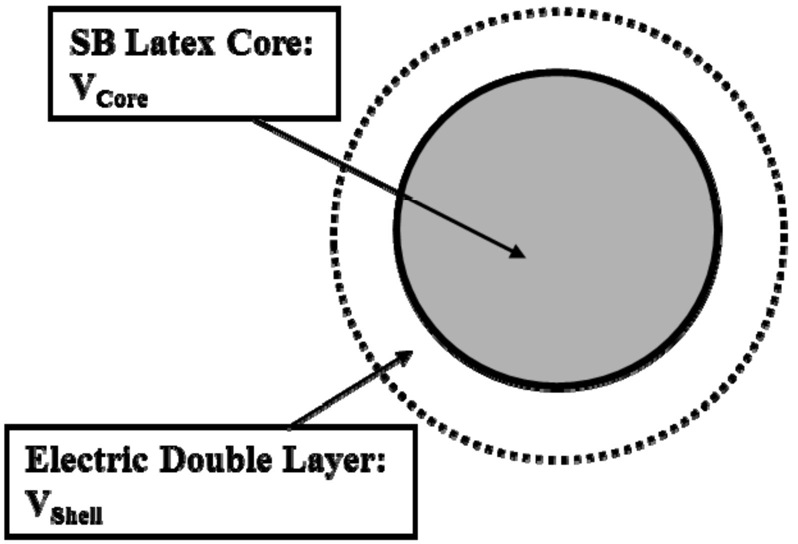
Fundamental lab study on volume swell ratio
(from relative viscosity measurements at extremely low dilution)

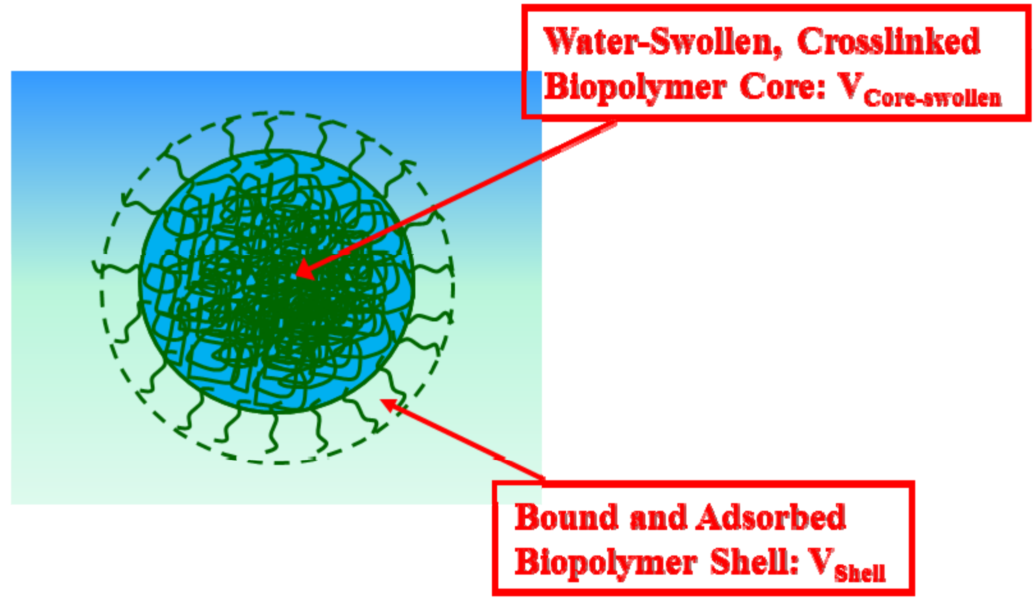
Structure of a Carboxylated SB Latex Particle



Since SB Latex particle cores are not swollen, the swell ratio is one:

$V_{Core\text{-}swollen} / V_{Core\text{-}unswollen} = 1.0$

Structure of a Water-Swollen, Crosslinked Starch Nanoparticle



If V_{Shell} is assumed to be 2 times $V_{Core\text{-}unswollen}$, then the swell ratio will become (at extreme dilution):

$V_{Core\text{-}swollen} / V_{Core\text{-}unswollen} = 4.7$

At 40% solids this swell ratio is:

$V_{Core\text{-}swollen} / V_{Core\text{-}unswollen} = 2.5$

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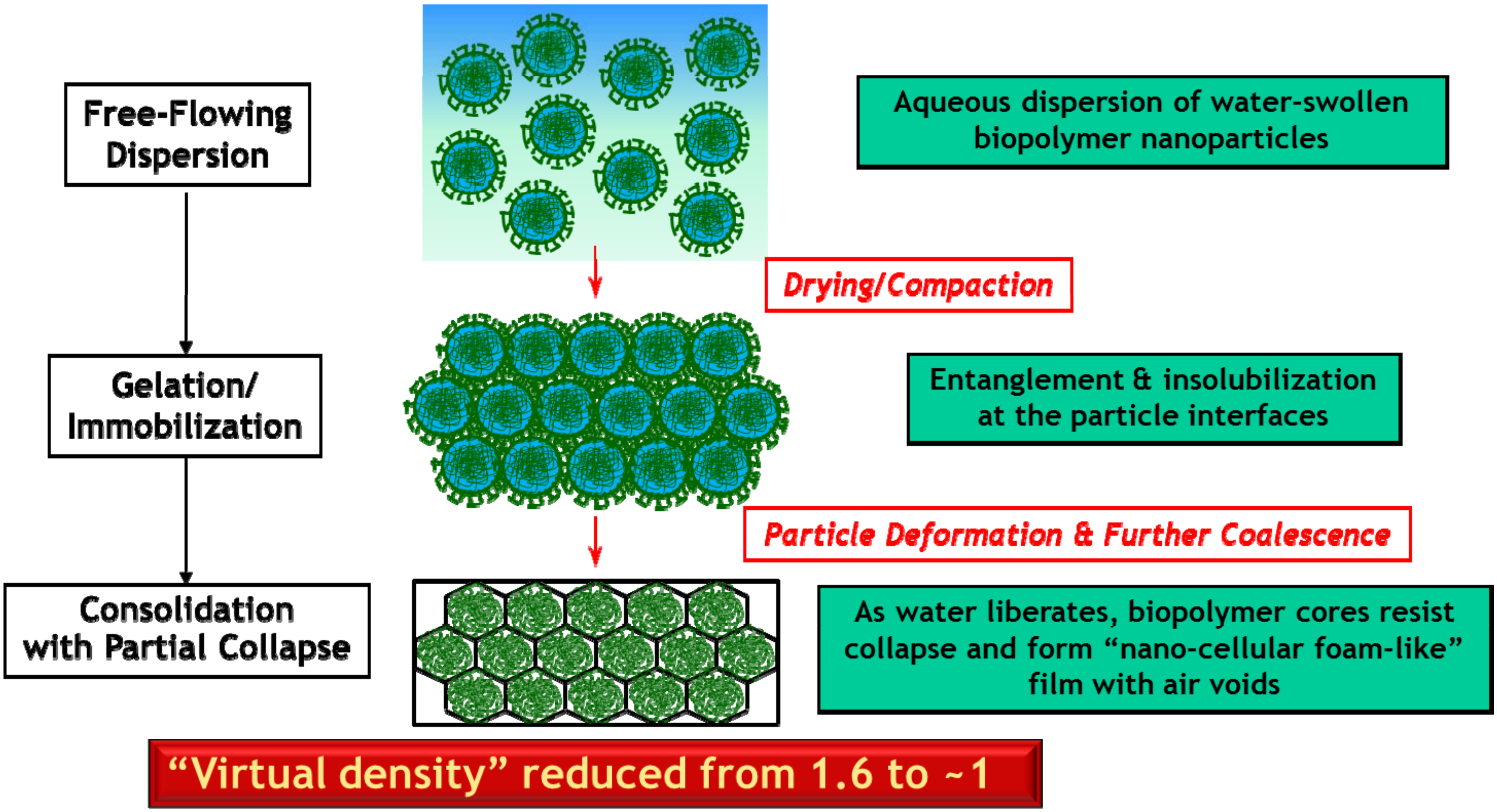
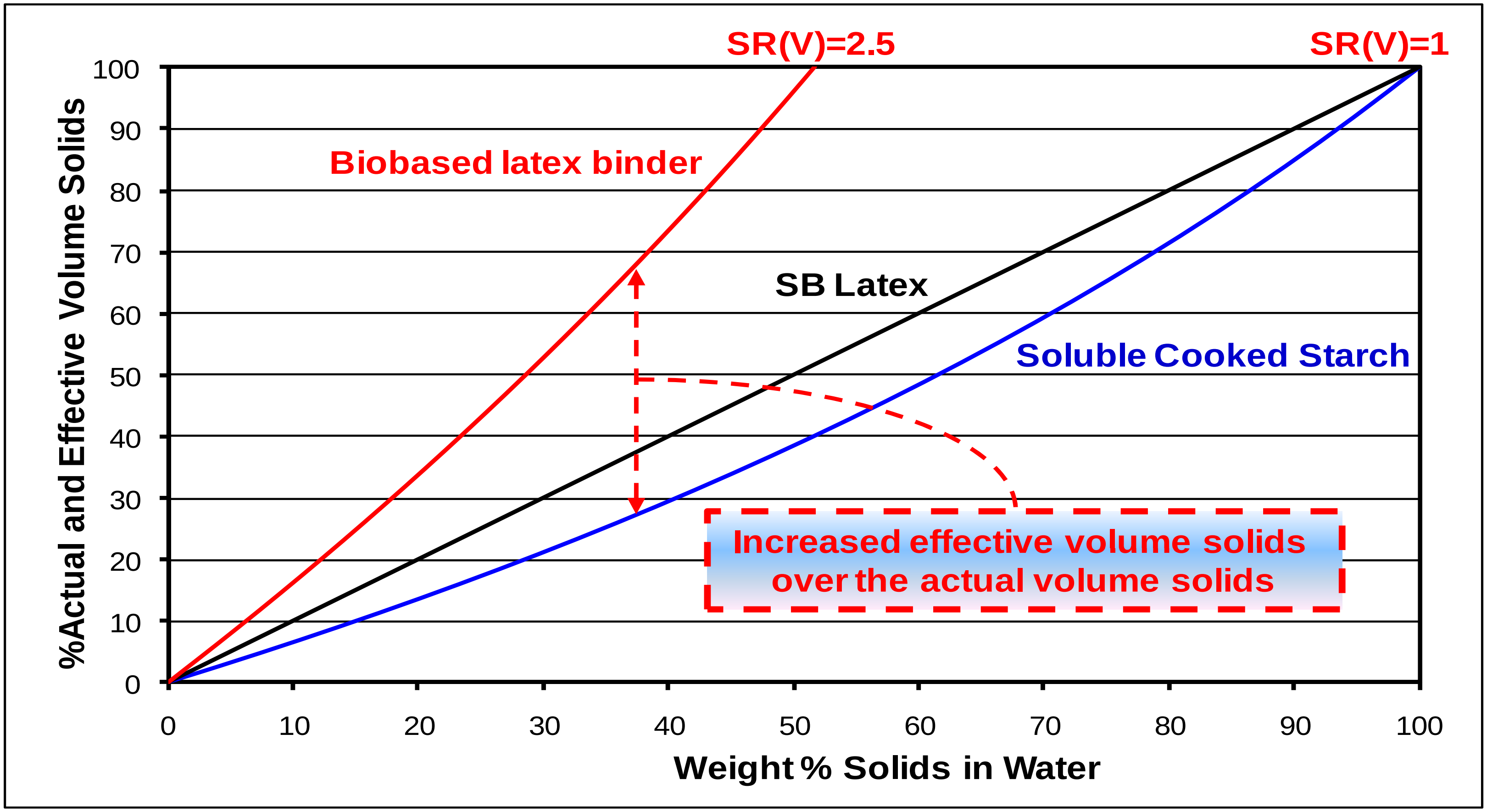
The film formation of water-swollen, crosslinked biopolymer nanoparticles



Higher Effective Volume Solids of biolatex binders leading to excellent coating holdout, fiber coverage, and smoothness

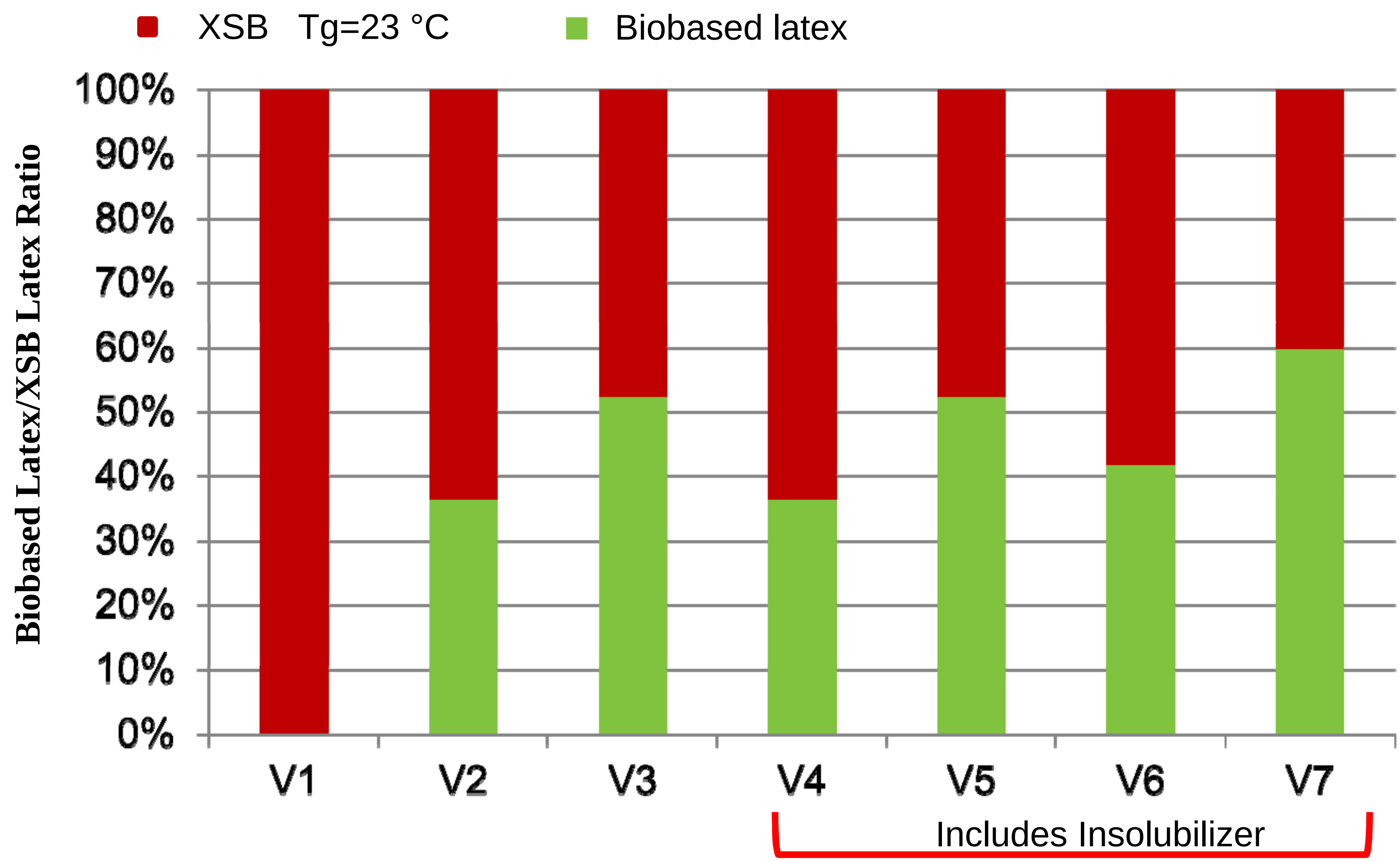


The % effective volume solids of biobased latex nanoparticles, soluble cooked starch, and synthetic SB latex *vs.* % solids

Pilot coater trials – European LWC

- The trials were run in October 2010 at PTS Vestra (Munich, Germany)
  - Base paper was 50 g/m^2
  - Coating at 1200 m/min with rigid blade coater with applicator roll (~14 g/m^2 per side; blade thickness/angle = 0.381 mm/40°)
- All trial rolls were tested and printed with 3 types of surfaces:
  - Uncalendered: referred to as **"Topcoat"**;
  - Matte calendered with 1 nip at 300 m/min., 40 °C and 110 N/mm line load: referred to as **"Matt"**; and
  - Glossy calendered with 11 nips at 300 m/min., 95°C and 200 N/mm line load: referred to as **"Gloss"**.
- Paper printed and tested by Myllykoski MD Papier Albbruck mill
  - 5 color commercial printing on Heidelberg in sheet offset
- XSB binder designed for offset
  - Glass transition temperature, Tg of 23 °C (rel. high glossing)
  - Biobased latex/XSB latex levels evaluated: 36, 45, 52 and 60%

Ratio of petroleum based latex & biobased latex



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Trial targets and planning
Designed to evaluate specific properties of biobased latex

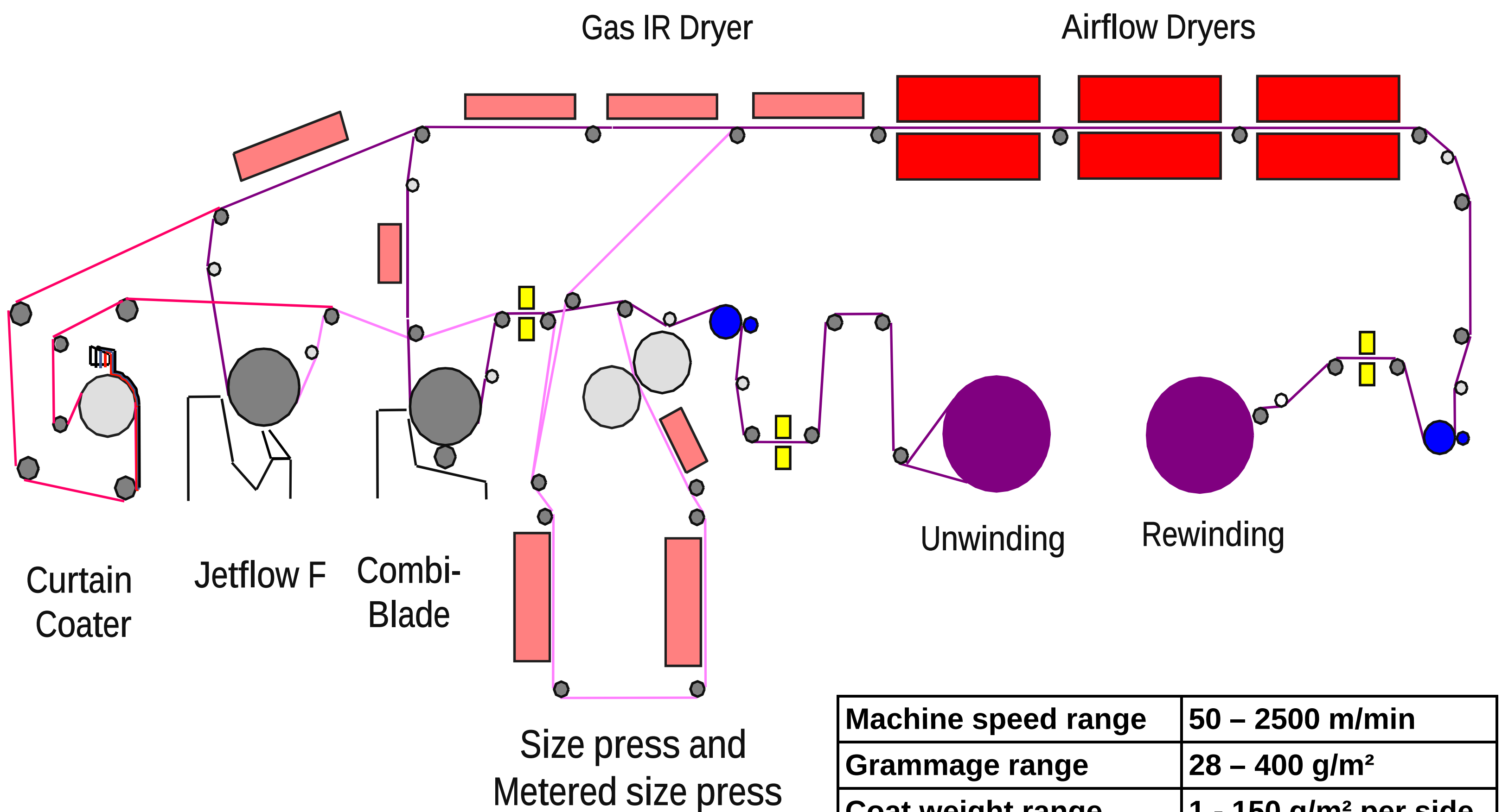
- XSB latex replacement and evaluation of binding power
  - XSB and CMC were replaced on 1:1 basis with biobased latex, PVOH on 1:2 basis, and rheology modifier was removed without additional biobased latex
- Study of coating color runnability with respect to water retention, immobilization solids, viscosity development and dry content
  - Increased water retention and viscosity in the lab suggested removal of CMC and reduction/elimination of rheology modifier
- Effect of the biobased latex on wet pick strength
  - Formulations V4 to V7 test if insolubilizer gives increased wet pick strength compared to insolubilizer-free formulations V1 to V3
- The potential as carrier for OBA studied in formulations V6 & V7
  - Contain reduced or no PVOH which is used in V1 to V5 because of OBA carrier properties

Coating color formulations for pilot coater runs

	Order of Add'n	V1	V2	V3	V4	V5	V6	V7
Pigments								
GCC	1	70	70	70	70	70	70	70
Clay	1	30	30	30	30	30	30	30
Binders								
XSB Binder	4	10.5	7	5.25	7	5.25	7	5.25
Biobased latex	2	0	4	5.75	4	5.75	5	7.75
Additives								
CMC	3	0.5	0	0	0	0	0	0
PVOH	5	1	1	1	1	1	0.5	0
Rheology Modifier	3	0.2	0.2	0.1	0.2	0.1	0	0
Ca-Stearate	6	0.25	0.25	0.25	0.25	0.25	0.25	0.25
OBA	7	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Insolubilizer	8	0	0	0	0.5	0.5	0.5	0.5
Coating Properties								
Solids target		65	68	68	68	68	68	68
Solids at the coater		**66.1**	**68.0**	**67.5**	**67.1**	**66.8**	**67.8**	**67.9**
Brookfield (100 rpm)		1670	1360	1240	1200	1140	820	1760
pH		8.8	8.7	8.8	8.7	8.8	8.8	8.8
% XSB replacement		0	33%	50%	33%	50%	33%	50%
% biobased latex/XSB		0	36.4%	52.3%	36.4%	52.3%	45.5%	60%

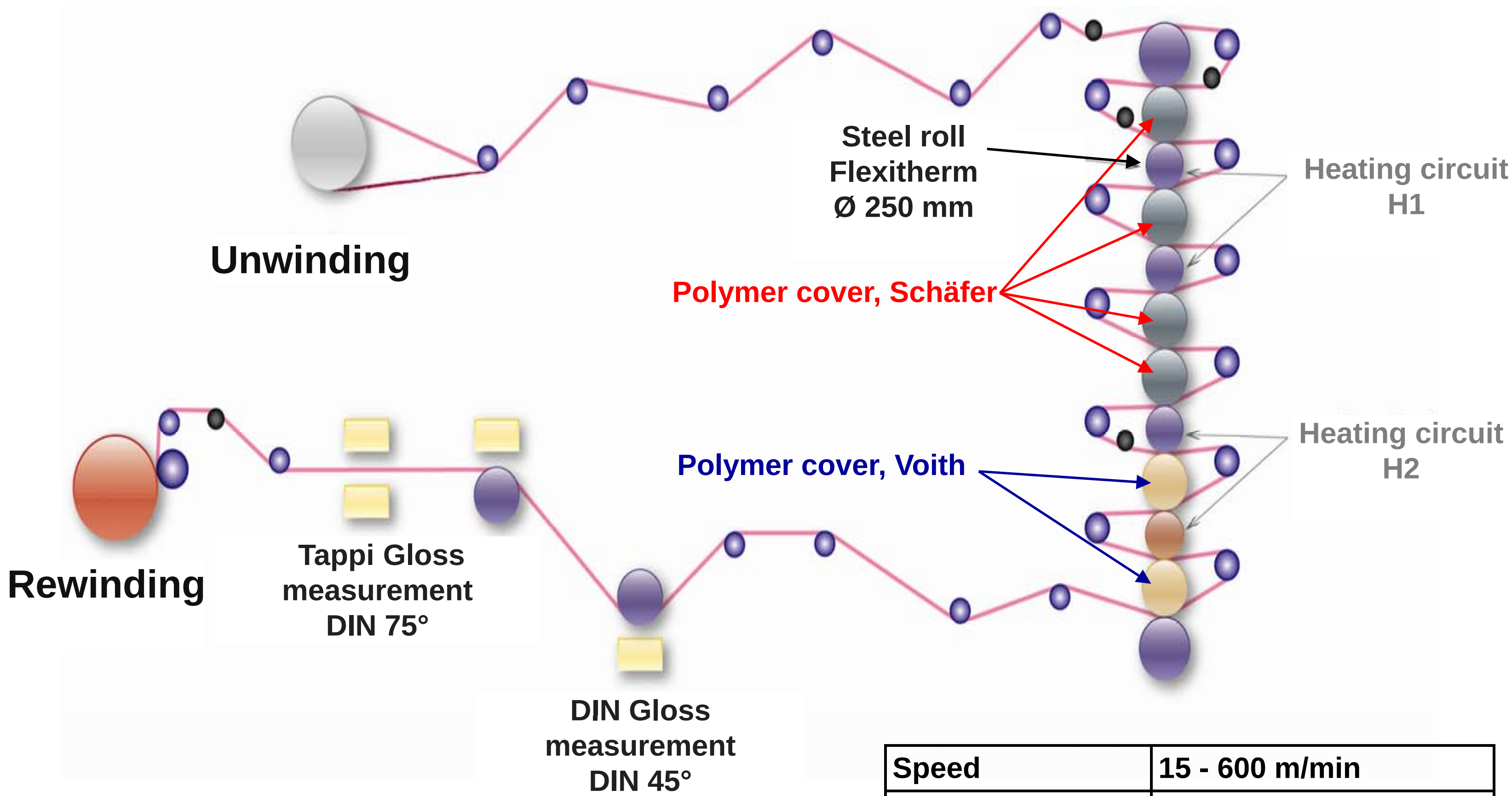
Base paper 50 gsm^2 – 2 side coated – total 80 gsm^2

Pilot Coater Schematic



Machine speed range	**50 – 2500 m/min**
Grammage range	**28 – 400 g/m²**
Coat weight range	**1 - 150 g/m² per side**
Web width	**60 cm**

Supercalender

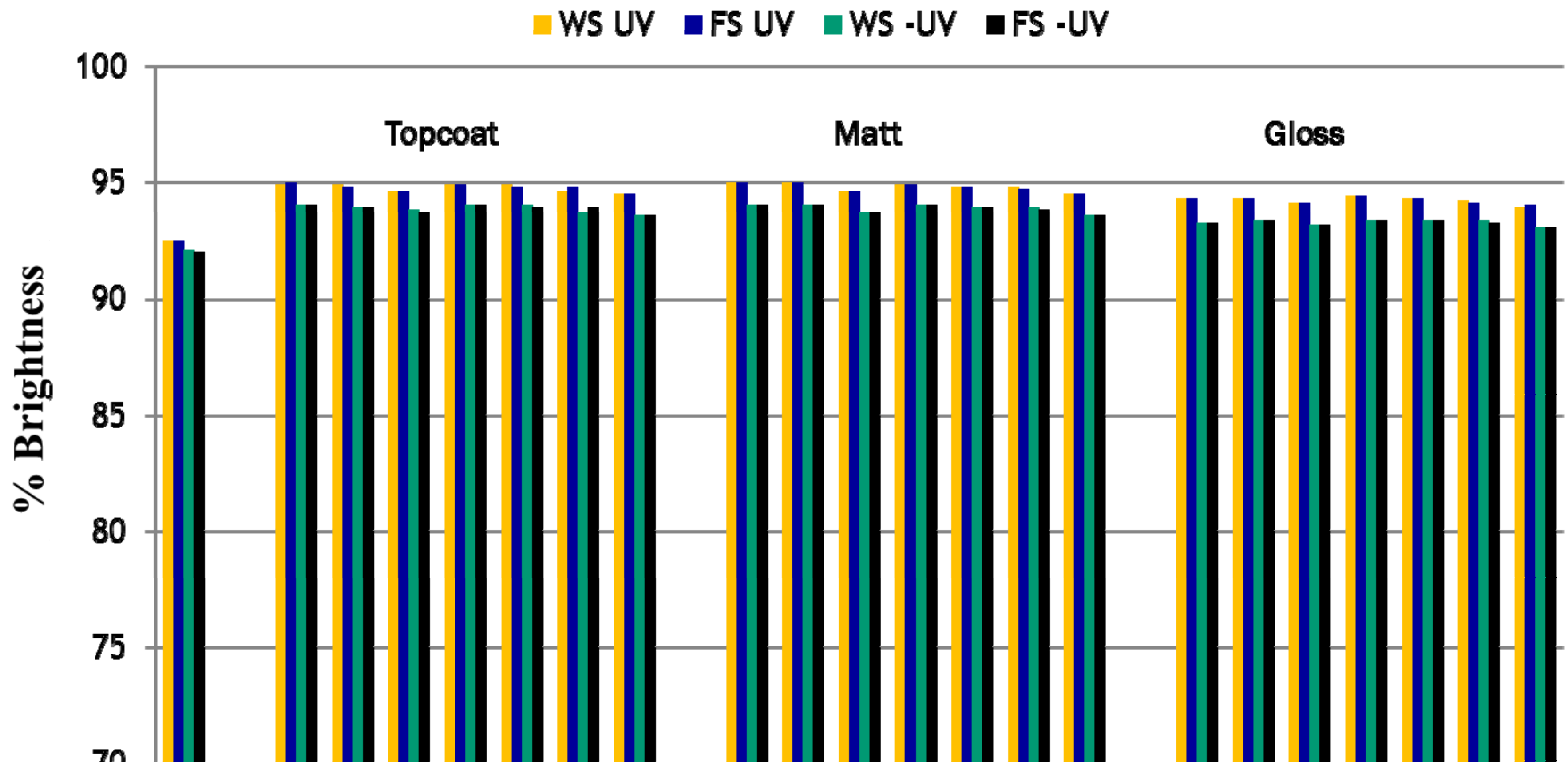


Speed	15 - 600 m/min
Temperature	40 - 95 ° C
Linear load	110 - 320 N/mm²

Coating color make down, runnability & drying

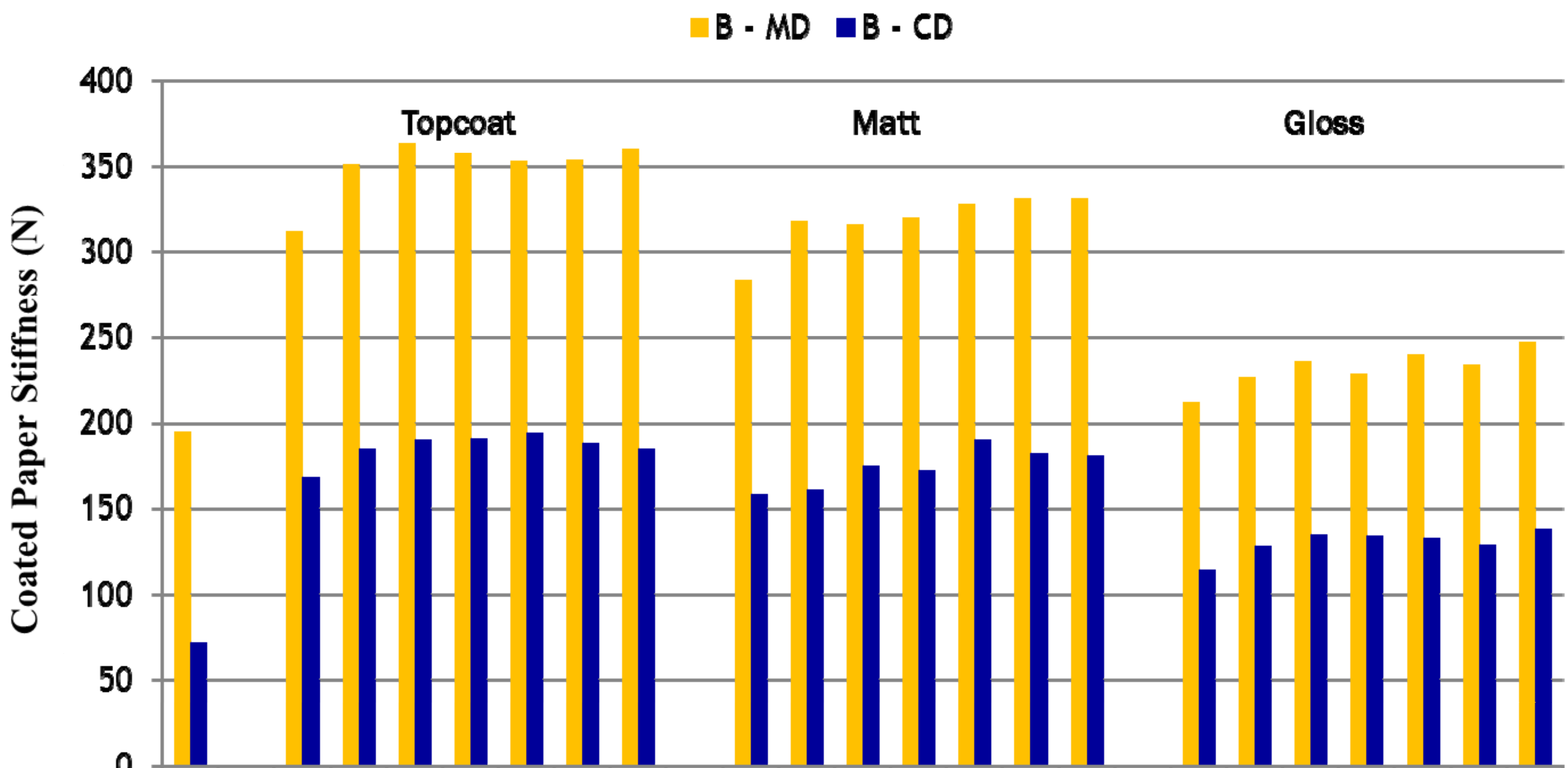
- Target solids from the mill = 65%
  - In all cases the biobased latex allowed for a 1 to 3% increase in total solids relative to V1 and the 65% solids target
  - Successful elimination of CMC, PVOH and rheology modifier
  - Points to superior water retention characteristics of the biobased latex
- Runnability
  - In all cases runnability was as good or better than the control even at the higher solids
- Drying
  - Due to the increase in solids, it was possible to reduce drying and save energy

Results – Brightness



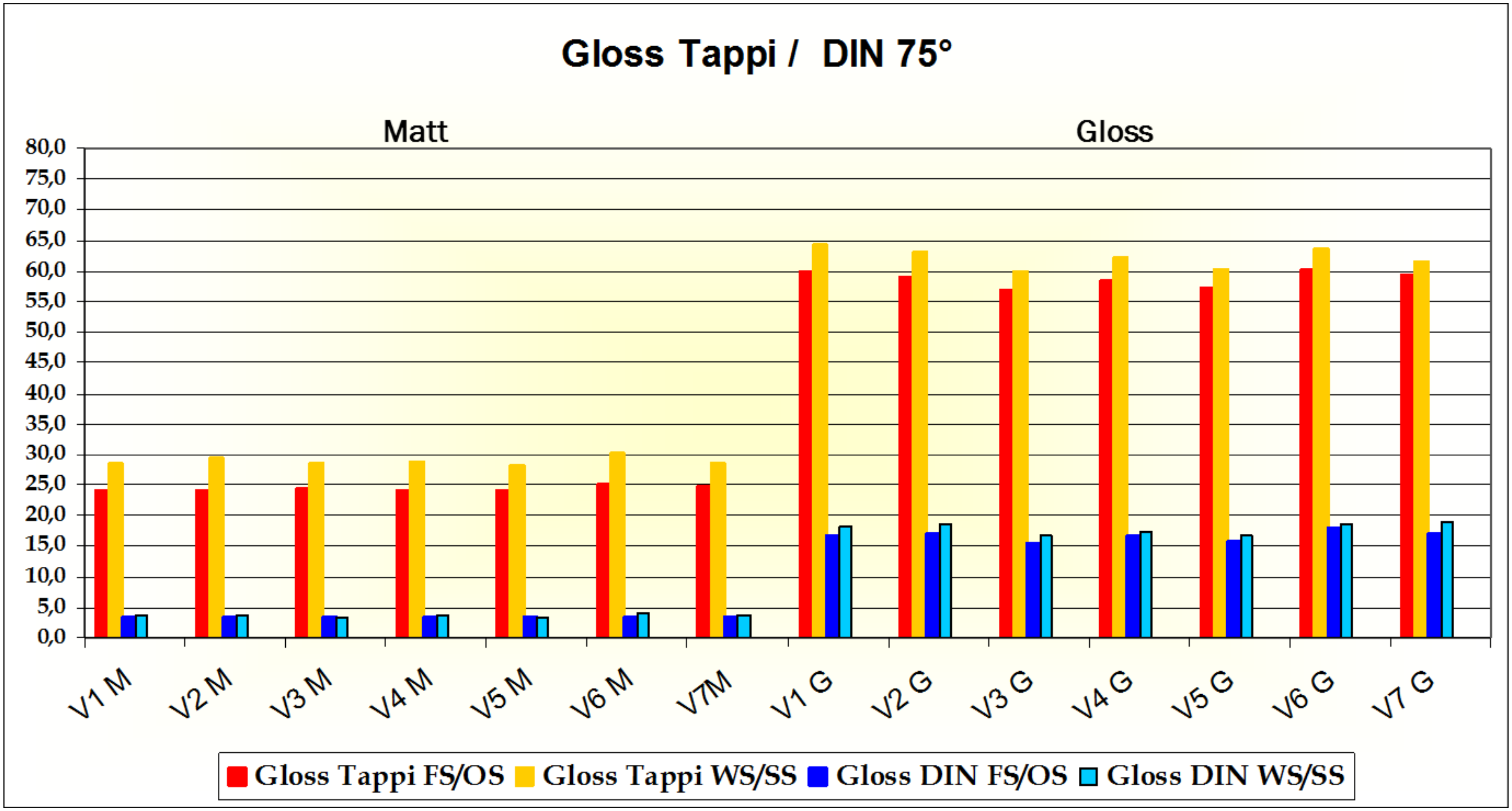
	Base		V1	V2	V3	V4	V5	V6	V7		V1	V2	V3	V4	V5	V6	V7		V1	V2	V3	V4	V5	V6	V7
WS UV	92.5		94.9	94.9	94.6	94.9	94.9	94.6	94.5		95	95	94.6	94.9	94.8	94.8	94.5		94.3	94.3	94.1	94.4	94.3	94.2	93.9
FS UV	92.5		95	94.8	94.6	94.9	94.8	94.8	94.5		95	95	94.6	94.9	94.8	94.7	94.5		94.3	94.3	94.1	94.4	94.3	94.1	94
WS -UV	92.1		94	93.9	93.8	94	94	93.7	93.6		94	94	93.7	94	93.9	93.9	93.6		93.3	93.4	93.2	93.4	93.4	93.4	93.1
FS -UV	92		94	93.9	93.7	94	93.9	93.9	93.6		94	94	93.7	94	93.9	93.8	93.6		93.3	93.4	93.2	93.4	93.4	93.3	93.1

Results – Stiffness

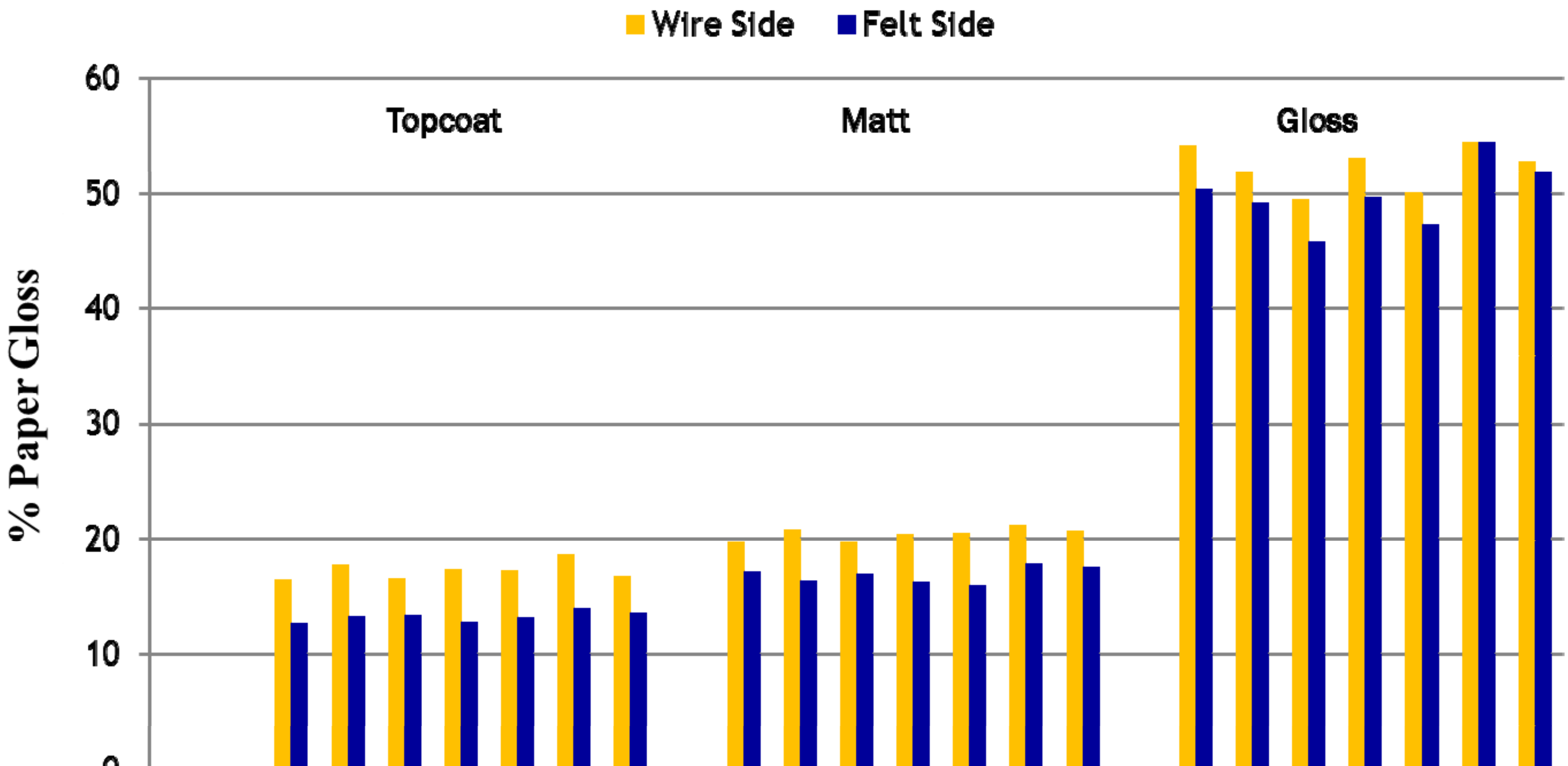


	Base		V1	V2	V3	V4	V5	V6	V7		V1	V2	V3	V4	V5	V6	V7		V1	V2	V3	V4	V5	V6	V7
B - MD	195		312	351	363	358	353	354	360		283	318	316	320	328	331	331		212	227	236	229	240	234	247
B - CD	72		168	185	190	191	194	188	185		158	161	175	172	190	182	181		114	128	135	134	133	129	138

Paper Gloss – measured online



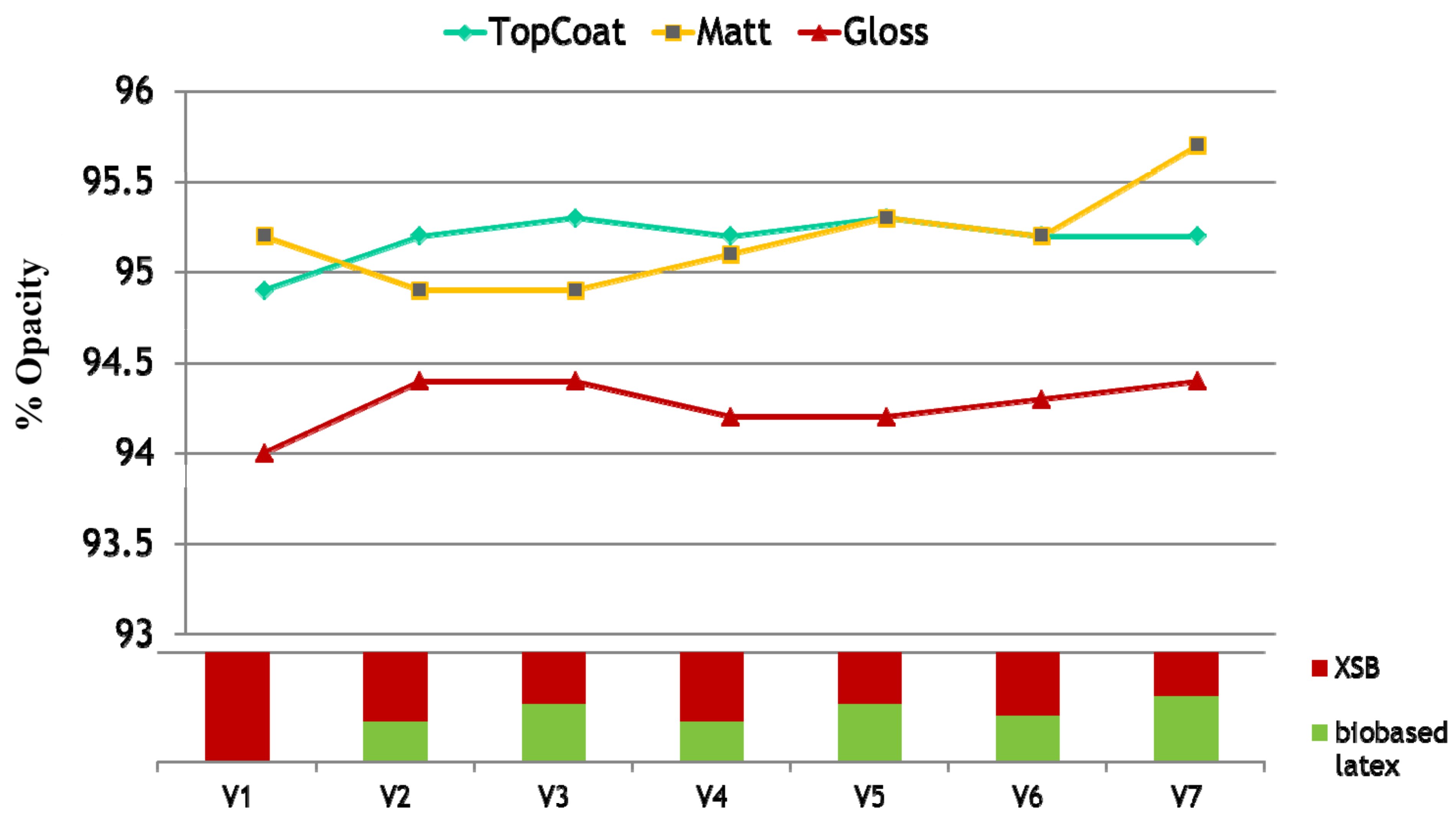
Results – Paper Gloss



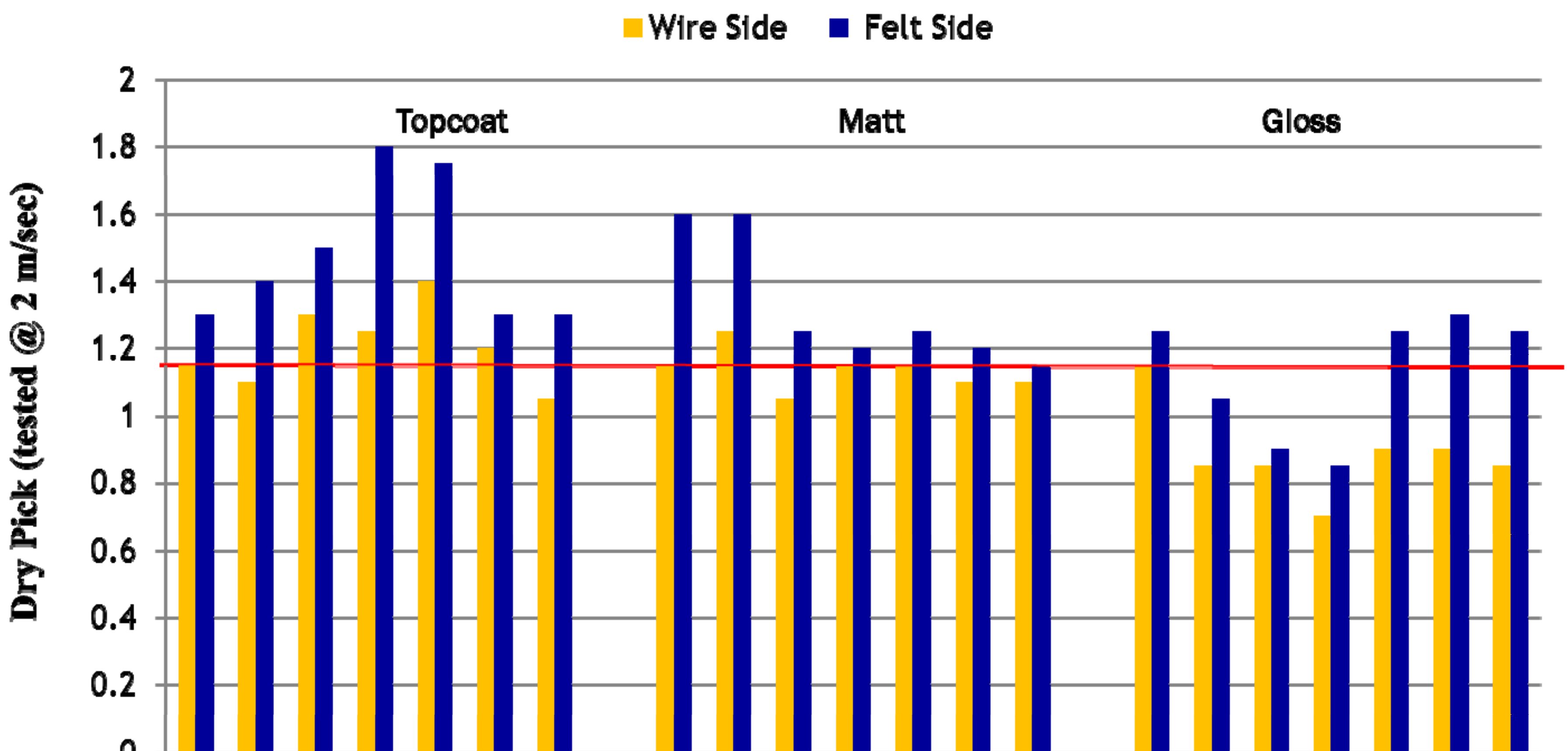
	Base		Topcoat V1	V2	V3	V4	V5	V6	V7		Matt V1	V2	V3	V4	V5	V6	V7		Gloss V1	V2	V3	V4	V5	V6	V7
Wire Side			16.4	17.7	16.5	17.3	17.2	18.6	16.7		19.7	20.7	19.7	20.3	20.4	21.1	20.6		54.1	51.9	49.5	53	50.1	54.4	52.7
Felt Side			12.6	13.2	13.3	12.7	13.1	13.9	13.5		17.1	16.3	16.9	16.2	15.9	17.8	17.5		50.4	49.2	45.8	49.7	47.3	54.4	51.9

Note - XSB used is a relatively hard binder (Tg 23 °C) and good for paper gloss. V6 indicates positive combination with the biobased latex

Results – Opacity

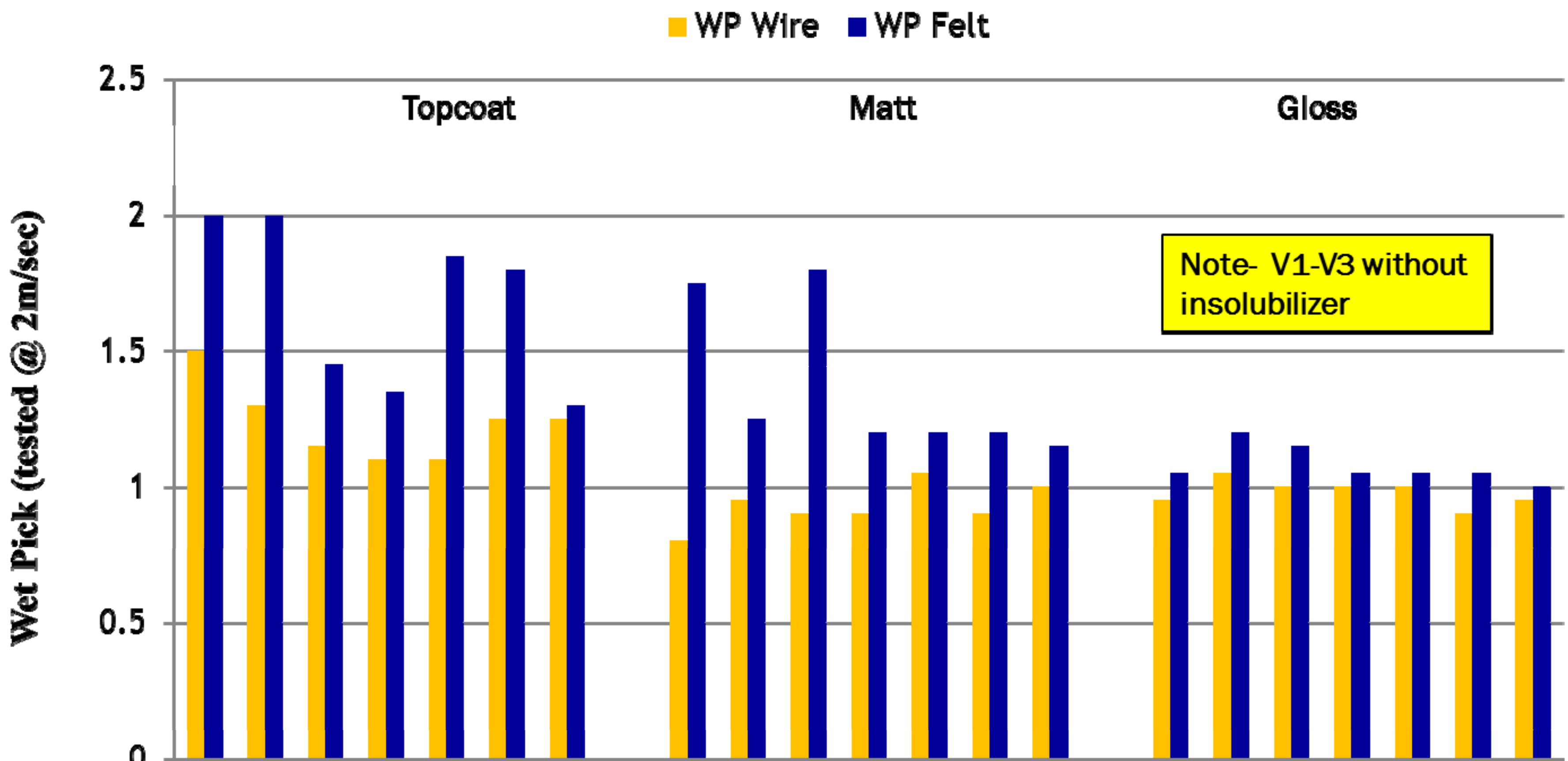


Results – Dry Pick



	V1	V2	V3	V4	V5	V6	V7		V1	V2	V3	V4	V5	V6	V7		V1	V2	V3	V4	V5	V6	V7
Wire Side	1.15	1.1	1.3	1.25	1.4	1.2	1.05		1.15	1.25	1.05	1.15	1.15	1.1	1.1		1.15	0.85	0.85	0.7	0.9	0.9	0.85
Felt Side	1.3	1.4	1.5	1.8	1.75	1.3	1.3		1.6	1.6	1.25	1.2	1.25	1.2	1.15		1.25	1.05	0.9	0.85	1.25	1.3	1.25

Results – Wet Pick



	Topcoat V1	V2	V3	V4	V5	V6	V7	Matt V1	V2	V3	V4	V5	V6	V7	Gloss V1	V2	V3	V4	V5	V6	V7
WP Wire	1.5	1.3	1.15	1.1	1.1	1.25	1.25	0.8	0.95	0.9	0.9	1.05	0.9	1	0.95	1.05	1	1	1	0.9	0.95
WP Felt	2	2	1.45	1.35	1.85	1.8	1.3	1.75	1.25	1.8	1.2	1.2	1.2	1.15	1.05	1.2	1.15	1.05	1.05	1.05	1

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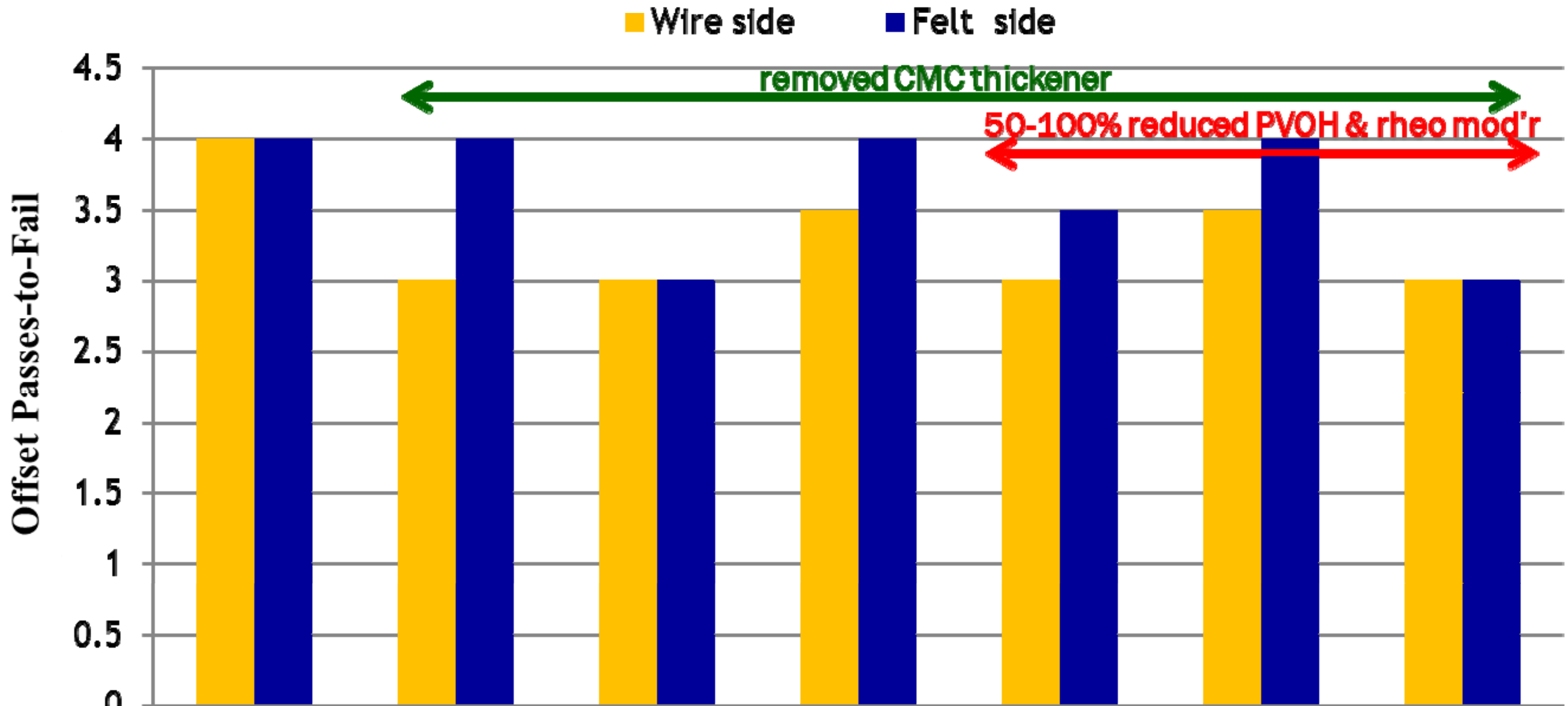
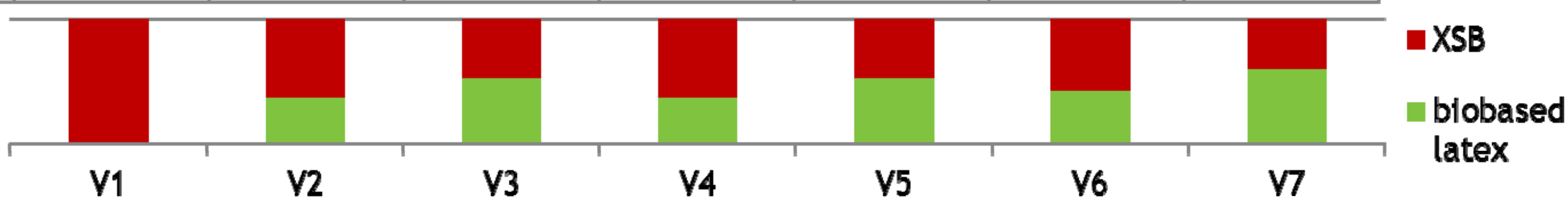
Results – Offset Test



	V1	V2	V3	V4	V5	V6	V7
Wire side	4	3	3	3.5	3	3.5	3
Felt side	4	4	3	4	3.5	4	3



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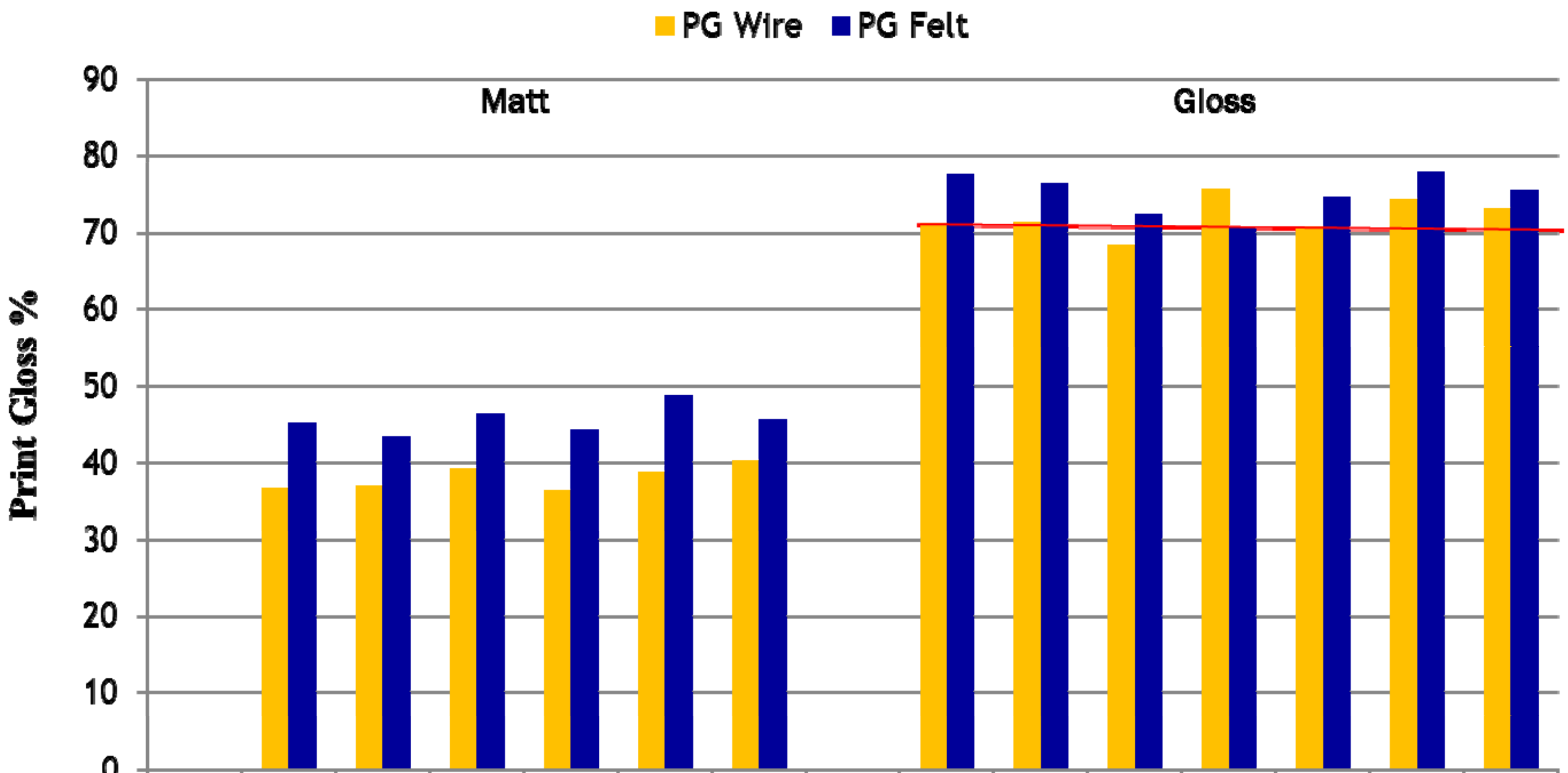
Results – Print Gloss



	Matt							Gloss						
	V1	V2	V3	V4	V5	V6	V7	V1	V2	V3	V4	V5	V6	V7
PG Wire		36.6	36.9	39.2	36.3	38.8	40.2	71.2	71.3	68.4	75.7	70.7	74.3	73.1
PG Felt		45.1	43.3	46.3	44.3	48.7	45.6	77.6	76.5	72.4	70.8	74.6	77.9	75.5

Conclusions

- Biobased latex binders consist of a re-engineered biopolymer
  - Discrete particles are not water soluble but form colloid dispersion
  - Exist in the form of water-swollen crosslinked nanoparticles
  - Excellent runnability, paper and print performance
  - 30 - 50% of XSB latex plus much or all of the cobinder, rheology modifier and OBA carrier can be replaced with biobased latex
  - Benefits in optimizing coating formulation and paper moisture
  - Emphasizes the need to handle biobased binder in a slightly different way to achieve optimal results
  - Effective solids of biobased latex are higher than actual solids
  - Enables coating colors to get closer to their immobilization solids
  - Supplied in dry form – can be used by the mill to further boost solids
- Benefits beyond paper & print performance, improved runnability and carbon footprint were noted, including dryer energy savings

Acknowledgements

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Thank you for your attention!

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