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## The Effect of Viscosity and Polymer Additives on Fluorescent Dyes in Latex Coatings

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***THE EFFECT OF VISCOSITY AND POLYMER  
ADDITIVES ON FLUORESCENT DYES  
IN LATEX COATINGS***

Faculty Advisor: Dr. Brian Scheller

Industry Advisor: Michael Herbert  
Simpson Paper Company

An Engineering Problem submitted  
in partial fulfillment of  
the course requirements for  
The Bachelor of Science Degree

By

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## **ABSTRACT**

Fluorescent Whitening Agents (FWAs) are commonly used in many areas of the pulp and paper industry. FWAs are also known as Optical Brightening Agents (OBAs) and generically as fluorescent dyes. Nearly one-third of all FWAs manufactured are used in the pulp and paper industry. FWAs work by converting ultraviolet light into blue-white light in the visible region. When FWAs are used in coatings with latex binders, the fluorescent dyes have a tendency to migrate toward the basesheet during drying. This is due mainly to the lack of a suitable carrier for the dye. Previous research has shown that the addition of highly polar polymers, such as polyvinyl alcohol, will help keep the dyes evenly distributed throughout the coating structure. If the dyes accumulate near the bottom of the structure, they will not be activated by the ultraviolet radiation, and are therefore significantly less effective. The purpose of this research project is to determine what effect coating viscosity and polymer additives have on FWAs in latex coatings. After the completion of research and data analysis, it was determined that an increase in coating viscosity effectively caused an increase in fluorescence and the apparent whiteness of the coated papers containing FWAs. It was also concluded that the fully hydrolyzed polyvinyl alcohol was the most effective FWA optimizing agent.

## **KEYWORDS:**

fluorescence, brightness, whiteness, Fluorescent Whitening Agents

## INTRODUCTION

Fluorescent Whitening Agents are fluorescent dyes which are used in the paper industry to increase the apparent whiteness of pulp and paper products. FWAs are widely used internally and in surface treatments in paper, as well as in the coatings of premium coated grades. Fluorescent dyes absorb ultraviolet (UV) light and convert it into blue-white light in the visible region. UV light must be present in the light source in order for fluorescent dyes to be activated. When used in paper products, the paper appears to be more blue-white, which is more appealing to the human eye. Ordinary white paper appears gray when compared with papers containing fluorescent dyes. <sup>1</sup>

When fluorescent dyes are used in coatings with synthetic binders, the dyes tend to migrate toward the basesheet. The main cause of dye migration is the lack of a sufficient carrier for the dye. Dye migration can be overcome with the addition of suitable carriers/cobinders to the coating. The addition of a highly polar polymer will give the dye a substrate on which to attach, therefore keeping the dye evenly distributed throughout the coating structure. An increase in viscosity may also prevent the dye from migrating toward the basesheet by increasing the water retention value of the coating. No previous research was available on the effect of viscosity on dye migration.

The purpose of this research project is to determine what effect the viscosity and polymer additives have on the efficiency of fluorescent dyes in coatings containing latex binders. A chemically modified fluorescent dye will be included in the experimentation to be used as a control. By determining how viscosity and polymer additives effect fluorescent dye migration, producers for fine coated grades may benefit by more economical use of these expensive dyes.

## **THEORETICAL AND BACKGROUND DISCUSSION**

### **Introduction**

The general trend for many U.S. producers of coated papers is to make a whiter and brighter product. This is due to the increasing emphasis of "value added" specialty products and the influence of "high -white" paper products from Europe. There are four methods for improving coated paper whiteness: (1) pulp bleaching, (2) use of high white pigments, and (3) the use of shading dyes and/or fluorescent dyes. Maximum whiteness can only be attained by exploiting all four methods. <sup>4</sup> FWAs can be used internally in the sheet, as a surface treatment at the size press, or in the coating. In most European countries, over 50% of fluorescent dye consumption is in coatings. <sup>2</sup> FWAs increase the apparent paper whiteness by counteracting the blue absorption of yellow impurities in the paper and/or coating.

When FWAs are used in coatings containing latex binders, the dyes have a tendency to migrate toward the basesheet during drying. Some possible reasons for this migration include: (1) increased absorptivity of the basesheet due to lower degree of sizing or a low freeness value of the paper, (2) insufficient fixation of the dye in the coating matrix, or (3) extreme drying conditions. Insufficient fixation of the dye in the coating is the major problem in synthetic binder coatings. <sup>2</sup> The selection of a proper binder/cobinder combination can greatly enhance the dyes performance in the coating. <sup>4</sup> The efficiency of a FWA in a coating is widely dependent on the presence and amount of carrier for the dye. A suitable carrier is generally a long stretched molecule with hydroxyl groups, or similar hydrophilic groups. A latex binder alone will promote insufficient brightening and early saturation of the dye. Because FWAs are water soluble, it is suspected that the dye moves with the water phase of the coating toward the basesheet. Addition of carriers such as polyvinyl alcohol, carboxymethyl cellulose, polyvinylpyrrolidone, or polyglycol may greatly increase the brightening effect and

increase the dyes saturation limit. Polyvinyl alcohol is commonly used in Europe, and is well known as an excellent carrier for fluorescent dyes. <sup>2</sup>

### Fluorescent Whitening Agents

FWAs are similar in structure to anionic direct dyes. FWAs can be grouped into three chemical types: disulpho, tetrasulpho, and hexasulpho depending on the number of sulphonic acid groups. All three groups are chemical derivatives of the basic FWA chemistry: cyanuric chloride-di-amino stilbene. Increasing the number of sulphonic acid groups on the molecule will generally increase the dyes water and acid solubility. Increasing the number of sulphonic acid groups will also decrease the dyes affinity to cellulose. Therefore there is an inverse relationship between the dyes water solubility and its affinity to cellulose. FWAs have a strong affinity to cellulose, starch, or other polymers with a similar structure. The negatively charged dye molecule can rapidly attach to cellulose or starch molecules. A suitable FWA carrier consists of a continuous system of double bonds in a planer stretched molecule with a small number of solubilizing groups. Examples of such carriers are PVA, CMC and Polyglycol. The chemical structure of a fluorescent dye can be manipulated to adapt the dye to various applications. <sup>4</sup>

FWAs absorb light at a minimum of 350-360 nm and convert it into visible light with a maximum of 440 nm. The degree of whiteness is improved by a shift in shade from yellow to blue and by an increase in brightness. <sup>2</sup> Commercial dyes are present in the low energy trans form. Only the trans form of the fluorescent dye is active as the brightener. If highly dilute solutions of the dye are exposed to light, partial conversion of the dye to the cis form occurs very rapidly. Fluorescent dyes are only fully active when they are fixed in a suitable medium. This is because the dye is only fully active when held in a plane. Because of the inherent brilliance of the light emitted by the dye, relatively small amounts are necessary to give a significantly whiter appearance. <sup>4</sup>

FWAs are sensitive to pH, electrolytes, starches and highly cationic retention aids. This experimentation will involve the use of hexasulfonated fluorescent dyes because of their good water solubility and affinity to cellulose. Both properties are very important if the dye is to be used in a coating formulation. For hexasulphonated fluorescent dyes, it is very important that the pH of the coating remain above 5.0. If the coating pH is below 5.0, the dye may precipitate. Because the dye is highly anionic in nature, any chemical with a strong cationic charge should be avoided or else complexes may form. FWAs also have a limited light fastness due to the molecules inherent tendency for cis/trans isomerism, as opposed to photodegradation of the molecule itself. <sup>2</sup>

## EXPERIMENTAL PROCEDURE

Experimentation for this project was divided into four sections. Each section contained a different chemical variable in addition to the standard coating formulation. An additional trial, consisting only of the standard formulation components, was included as a brightness control. The standard formulation consisted of 85 parts No. 1 Clay, 15 parts precipitated CaCO<sub>3</sub>, 16 parts S-Br latex, insolubilizer, dispersant, lubricant and an acrylic viscosity modifier. Table 2 is a detailed list of the ingredients in the formulation. The variable chemicals added to the standard formulation are listed in table 1 by trial number.

<b>Trial No.</b>	<b>Variable</b>	<b>Viscosity</b>	<b>STANDARD FORMULATION</b>	
1	none	3000 cP	<i>Ingredient</i>	<i>Parts</i>
2	CMC	1000 cP	No. 1 Clay	85
3	CMC	2000 cP	Ppt. CaCO <sub>3</sub>	15
4	CMC	3000 cP	S-Br Latex	16
5	A-103	1000 cP	Dispersant	0.1
6	A-103	2000 cP	Lubricant	0.5
7	A-103	3000 cP	Insolubilizer	0.8
8	A-203	1000 cP	Viscosity Modifier	variable
9	A-203	2000 cP		
10	A-203	3000 cP		
11	BCR	1000 cP		
12	BCR	2000 cP		
13	BCR	3000 cP		

*Table 2*

*Table 1*

The trials containing CMC or PVA used a hexasulfonated stillbene based fluorescent dye (Leucophor L) as the FWA. The chemically modified dye used in the trials 11 through 13 was Leucophor BCR. BCR has a structure that is modified to have an affinity to latex. The CMC used was Aqualon 7LT. CMC was applied in the coating at 1 part per 100 (pph).. The fully and partially hydroloyzed PVA used were Airvol 103 (A-103) and Airvol 203 (A-203), respectively. PVA was applied in the coating at 1 pph. The dye addition level for the BCR and L was 1 pph. A detailed description of the individual formulations can be found in appendix I.



Each group was then further divided into three viscosity levels. The levels were 1000, 2000 and 3000 cP Brookfield viscosity (100 rpm). The viscosity was altered using Alcolgom L-23, and acrylic based viscosity modifier. The coatings were prepared to 60% solids with a pH of 8.5. The pH was controlled using a 1% sodium hydroxide (NaOH) solution. Figure 1 is a flowchart of the experimental design.

Immediately following the coating preparation, solids level and pH were measured. The pH was matched to 8.5 +/- 0.1. The coatings were applied using the Dow Laboratory Bench Coater at Western Michigan University. The coater drum temperature was set to 220 °C with a drum speed of 30 fpm. The unwind and rewind tensions were set to 40 p.s.i. The properties of the basesheet coated in this project are found in table 3. The coatings were applied during the same day under the same coater conditions. Approximately 30 feet of coated paper was saved from each trail run for further testing.

**Base Stock Properties**

Basis Weight, (lb./25 x 38 - 500)	59.5
TAPPI Brightness	79.3 %
Fluorescent Component	0.1 %
IIST, 80% Reflectance	702.8 s
Parker Print Surf Roughness	3.5 microns
Gardner Gloss	12.5 %

*Table 3*

The coated paper samples were conditioned for a minimum of 24 hours at TAPPI standard conditions. The samples were trimmed to 8.5 by 11 inch samples and supercalendered for two nips at 700 PLI. Following supercalendering, the samples were tested for coat weight, brightness, color, fluorescence, whiteness, opacity, gloss and roughness. All paper testing was conducted at the Lee Bardeen Research and Development Center in Vicksburg, Michigan. A spreadsheet containing experimental data and graphs are located in the results section of this report.

# Senior Project - Experimental Design

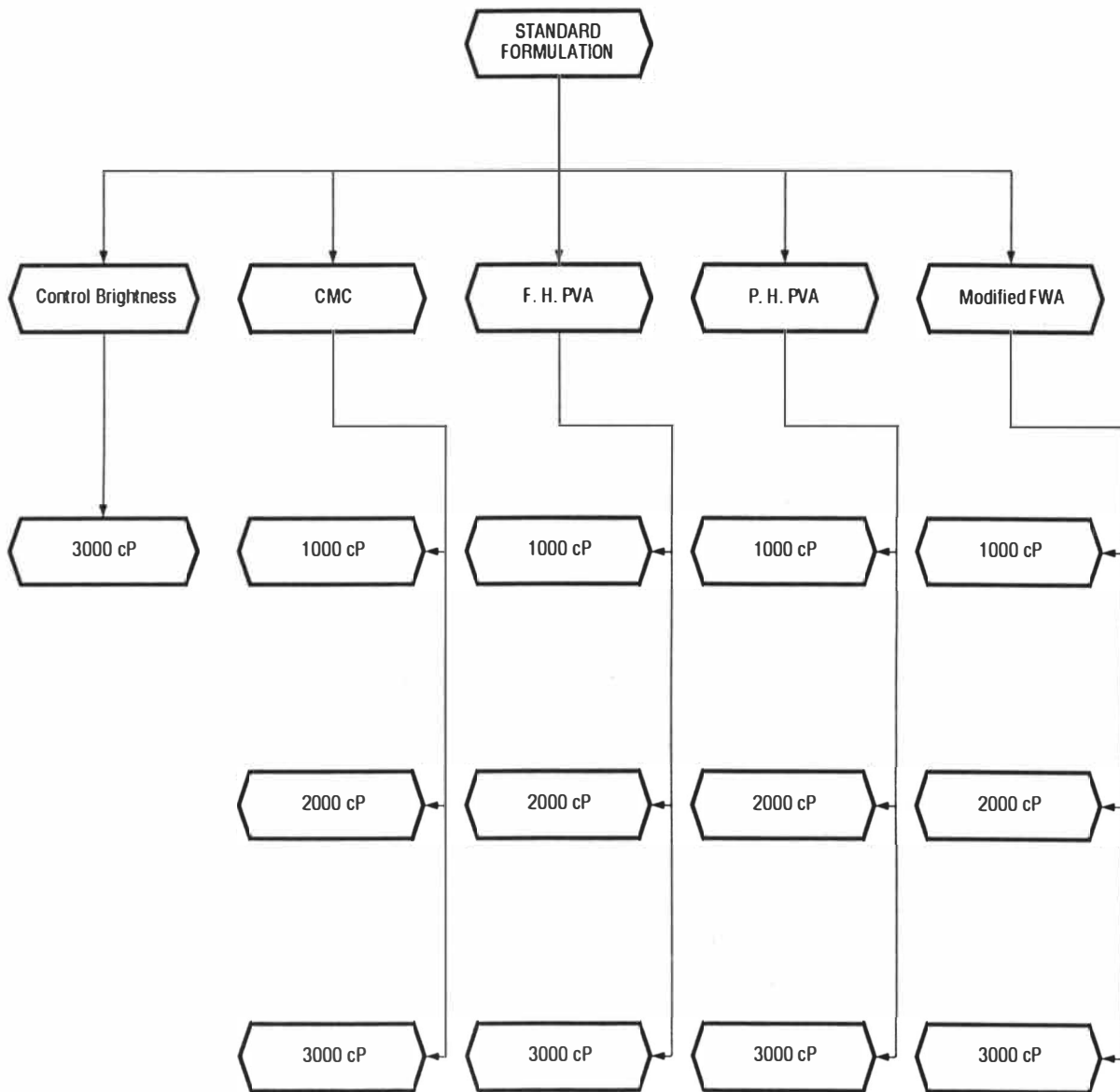


fig. 1

## PRESENTATION AND DISCUSSION OF RESULTS

Discussion of the resulting data is divided into three sections. The first section will investigate the coated paper properties that were held constant. The second section will discuss the problem encountered in the BCR formulation. The final section will focus on the effect of viscosity on coated paper brightness, color, and whiteness.

### Constant Properties

Table 4 is a listing of the average values and standard deviations for the coating and coated paper properties that were held constant.

<b>Property</b>	<b>Average Value</b>	<b>Avg. Std. Deviation</b>
Solids Level	59.6%	1.4%
Coat Weight	7.5 lb.	1.1 lb.
Opacity	92.4%	0.5%
Gloss	37.3%	1.5%
Parker Roughness	1.60 microns	0.1 micron
Sheffield Roughness	127.1 S.U.	2.4 S.U.

*Table 4*

The percent average standard for each property was less than 10%, with the exception of the coat weight which had a deviation of 15%.

### BCR Formulation Problem

The problem with the BCR formulation was not apparent until the testing of color and brightness. Brightness and fluorescence values for the BCR samples were a full two points below that of the PVA samples. When the samples were exposed to a pure UV light source, the color of the coating was dark yellow. Coated papers containing FWAs will fluoresce blue when exposed to pure UV light. The two possible reasons for this phenomena are dye over-saturation, or some sort of chemical incompatibility with the FWA. Modified FWAs can replace regular hexasulphonated FWAs on a 1:1 basis, so the reason for distinct change in color is still unknown.

### The Effect of Coating Viscosity on FWA Efficiency

The trials containing the PVAs and CMC experienced increases in fluorescence and whiteness, and a decrease in the b-color value with increasing viscosity. The CMC and partially hydrolyzed PVA samples experienced a 1 to 1.5 point increase in whiteness, while the fully hydrolyzed PVA gained nearly 2 points as viscosity increased from 1000 cP to 3000 cP. Similar increases were evident in the fluorescence values. B-color values for PVA and CMC trials generally decreased by 0.2 to 0.4 points.

The fully hydrolyzed PVA samples experienced the most significant increase and largest final values in both fluorescence and whiteness. This was expected because as stated in previous research, fully hydrolyzed PVA was the most efficient FWA carrier.

It is suspected that an increase in water retention, induced by increased viscosity, was the reason for the increased FWA efficiency. The presence of both carrier molecules and increased water retention in the coating allowed for better retention of the water soluble FWAs in the coating structure. The result of higher FWA levels in the coating structure is a greater degree of brightening and more efficient use of the FWA.

# FWA Optimization in Latex Coatings

## PAPR 473 - Senior Thesis II

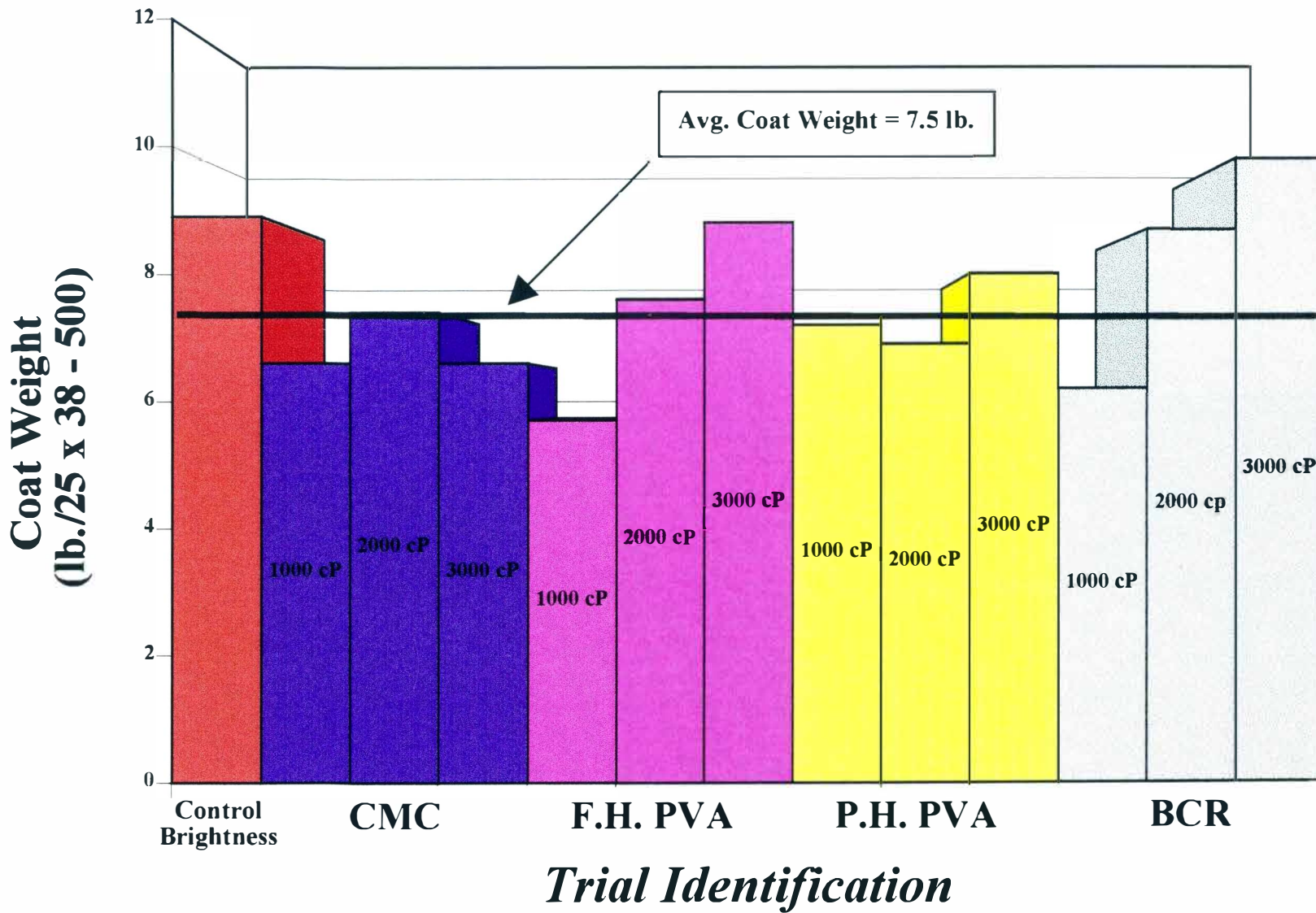
	1	2	3	4	5	6	7
	<i>Control</i>	<i>CMC</i>	<i>CMC</i>	<i>CMC</i>	<i>A-103</i>	<i>A-103</i>	<i>A-103</i>
	<i>Brightness</i>	<i>1000 cP</i>	<i>2000 cP</i>	<i>3000 cP</i>	<i>1000 cP</i>	<i>2000 cP</i>	<i>3000 cP</i>
Coating Solids Level - (%)	59	58	57	57	61	60	59
Coat Weight - (lb. / 25 x 38 - 500)	8.9	6.6	7.4	6.6	5.7	7.6	8.8
Macbeth Color - with UV component							
L	91.97	92.16	92.21	92.24	91.83	91.94	92.32
a	0.13	0.73	0.77	0.81	1.02	1.04	1.05
b	2.55	0.50	0.42	0.32	0.35	0.12	-0.08
Macbeth Color - without UV component							
L	91.96	91.95	92.00	92.00	91.66	91.70	92.01
a	0.13	-0.02	-0.08	-0.18	0.17	0.11	-0.06
b	2.53	2.74	2.76	3.02	2.62	2.68	2.96
Brightness with UV - (%)	81.65	84.56	84.75	84.88	84.15	84.63	85.54
Brightness w/o UV - (%)	81.66	81.43	81.48	81.13	81.70	81.07	81.26
Fluorescence	-0.10	3.13	3.27	3.75	3.08	3.67	4.28
Hunter Whiteness - (L - 3b)	84.32	90.28	90.95	91.28	90.78	91.58	92.56
FWA Concentration - 10 Level Step Wedge	6	6	6	6	6	6	6
Opacity - (%)	92.1	91.8	92.6	92.1	92.8	93.1	91.9
Gloss - (%)	34.1	34.5	38.8	35.7	36.3	35.9	37.9
Sheffield Roughness	125	127	131	128	122	125	129
Parker Print-Surf Roughness - (microns)	1.75	1.72	1.8	1.77	1.65	1.57	1.5

# FWA Optimization in Latex Coatings

## PAPR 473 - Senior Thesis II

	<b>8</b> <i>A-203</i> <i>1000 cP</i>	<b>9</b> <i>A-203</i> <i>2000 cP</i>	<b>10</b> <i>A-203</i> <i>3000 cP</i>	<b>11</b> <i>BCR</i> <i>1000 cP</i>	<b>12</b> <i>BCR</i> <i>2000 cp</i>	<b>13</b> <i>BCR</i> <i>3000 cP</i>
Coating Solids Level - (%)	62	60	60	62	60	60
Coat Weight - (lb. / 25 x 38 - 500)	7.2	6.9	8.0	6.2	8.7	9.8
Macbeth Color - with UV component						
L	91.73	91.74	91.93	91.66	92.09	92.20
a	0.95	1.01	1.08	0.52	-0.21	-0.28
b	0.49	0.40	0.10	1.25	1.83	3.33
Macbeth Color - without UV component						
L	91.54	91.41	91.69	91.47	91.74	91.87
a	0.16	0.19	0.11	0.10	-0.35	-0.38
b	2.64	2.68	2.73	2.73	3.32	3.33
Brightness with UV - (%)	83.79	83.91	84.61	82.87	83.10	83.26
Brightness w/o UV - (%)	80.85	80.56	80.99	80.68	80.54	80.65
Fluorescence	2.94	3.35	3.62	2.19	2.56	2.61
Hunter Whiteness - (L - 3b)	90.26	90.54	91.63	87.91	86.60	82.20
FWA Concentration - 10 Level Step Wedge	6	6	6	5Y	5Y	5Y
Opacity - (%)	93	93.2	91.7	92.4	92.7	92.1
Gloss - (%)	37.6	37.0	40.0	37.6	39.5	39.9
Sheffield Roughness	130	128	126	127	130	124
Parker Print-Surf Roughness - (microns)	1.47	1.51	1.43	1.53	1.59	1.55

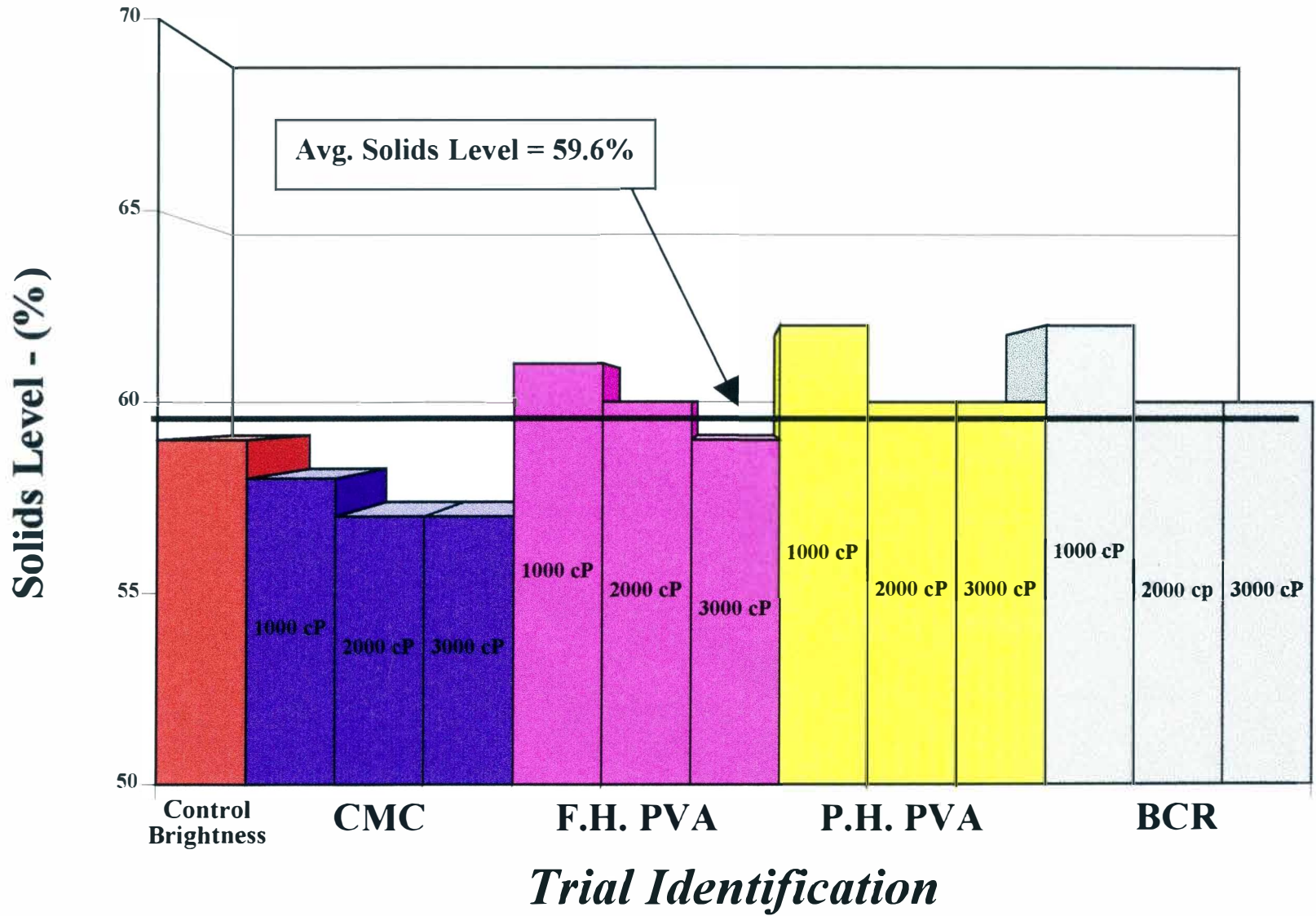
# Coat Weight of Trial Samples





# Trial Coatings Solids Level

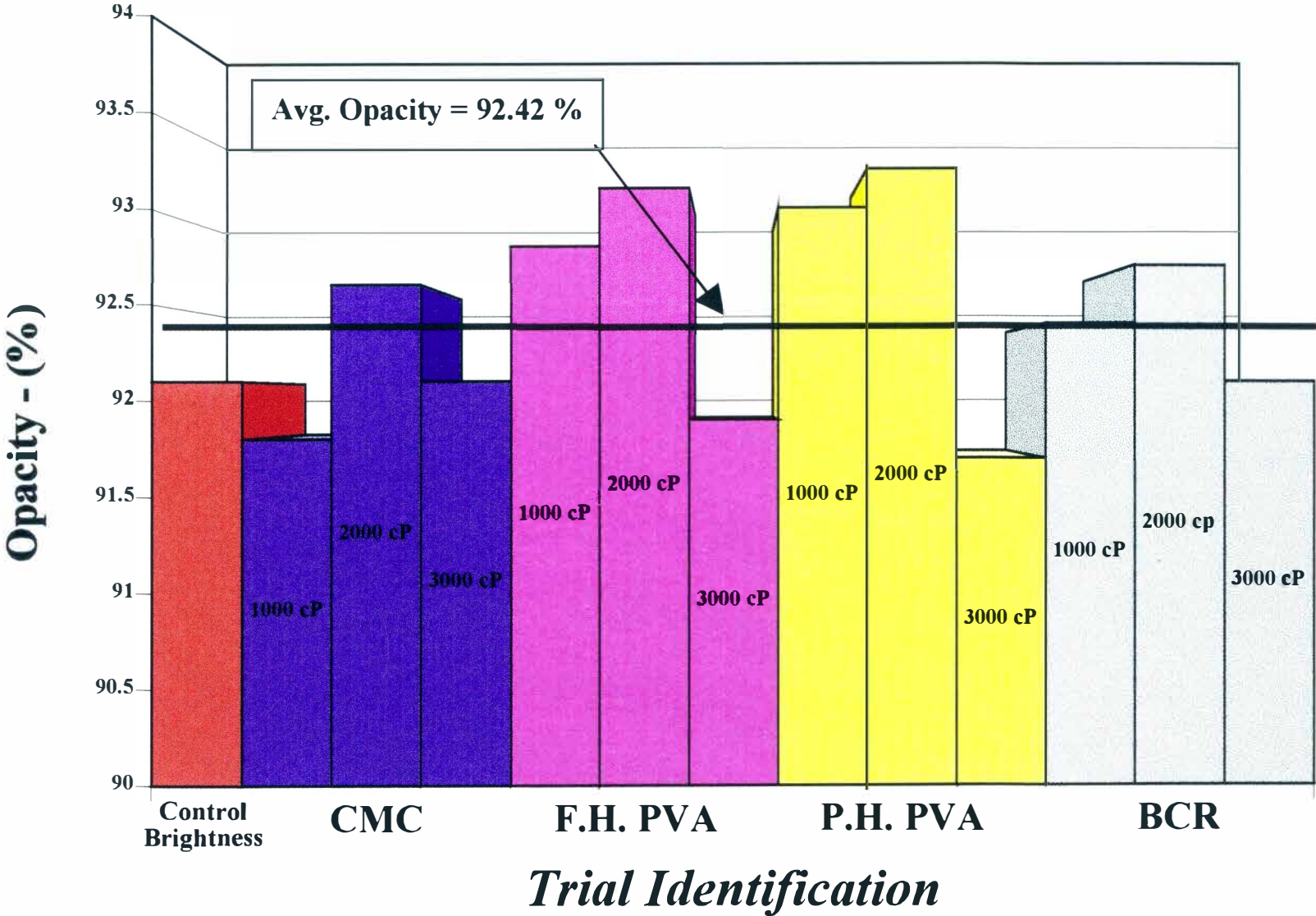
15





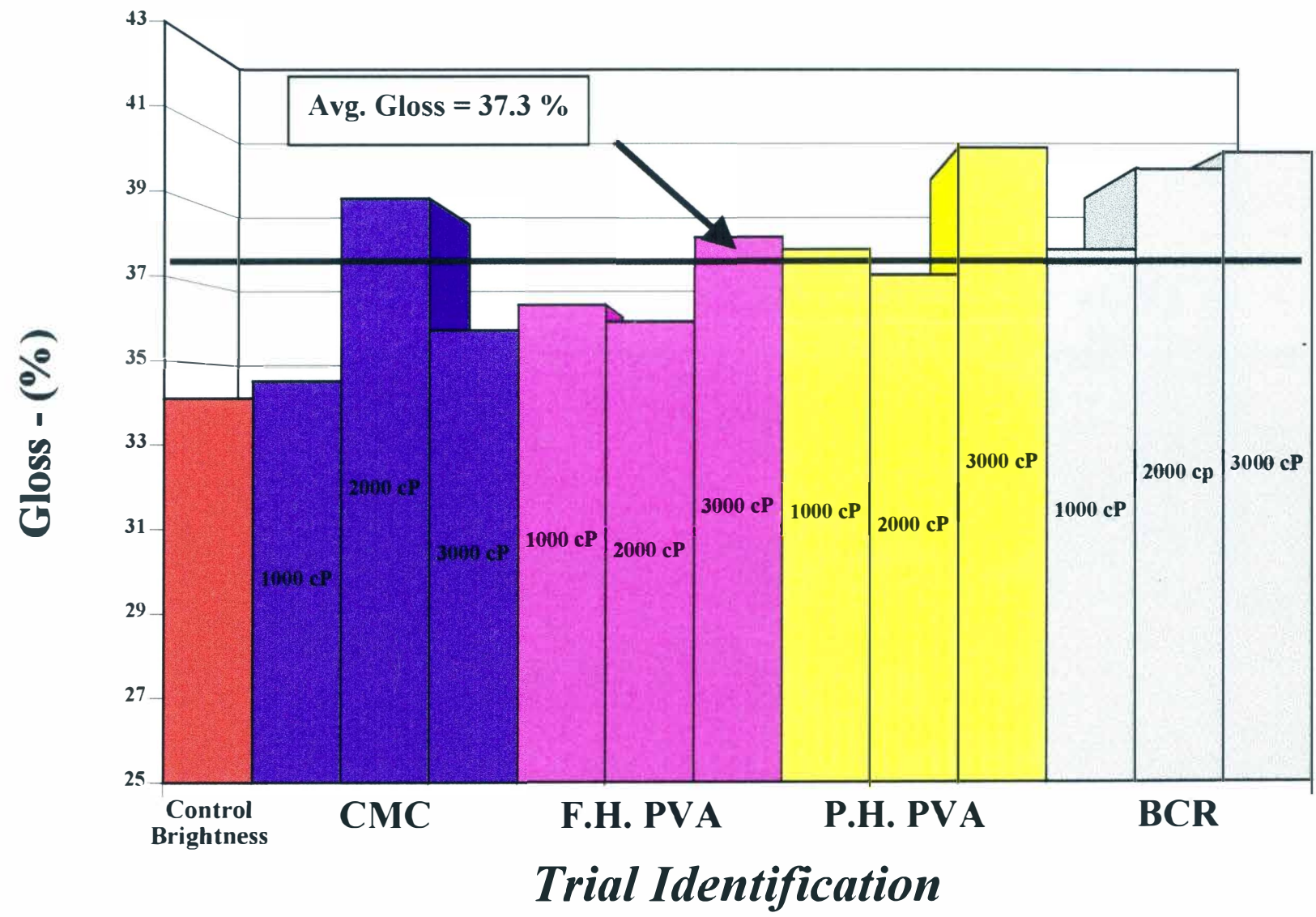
# Opacity of Trial Samples

91

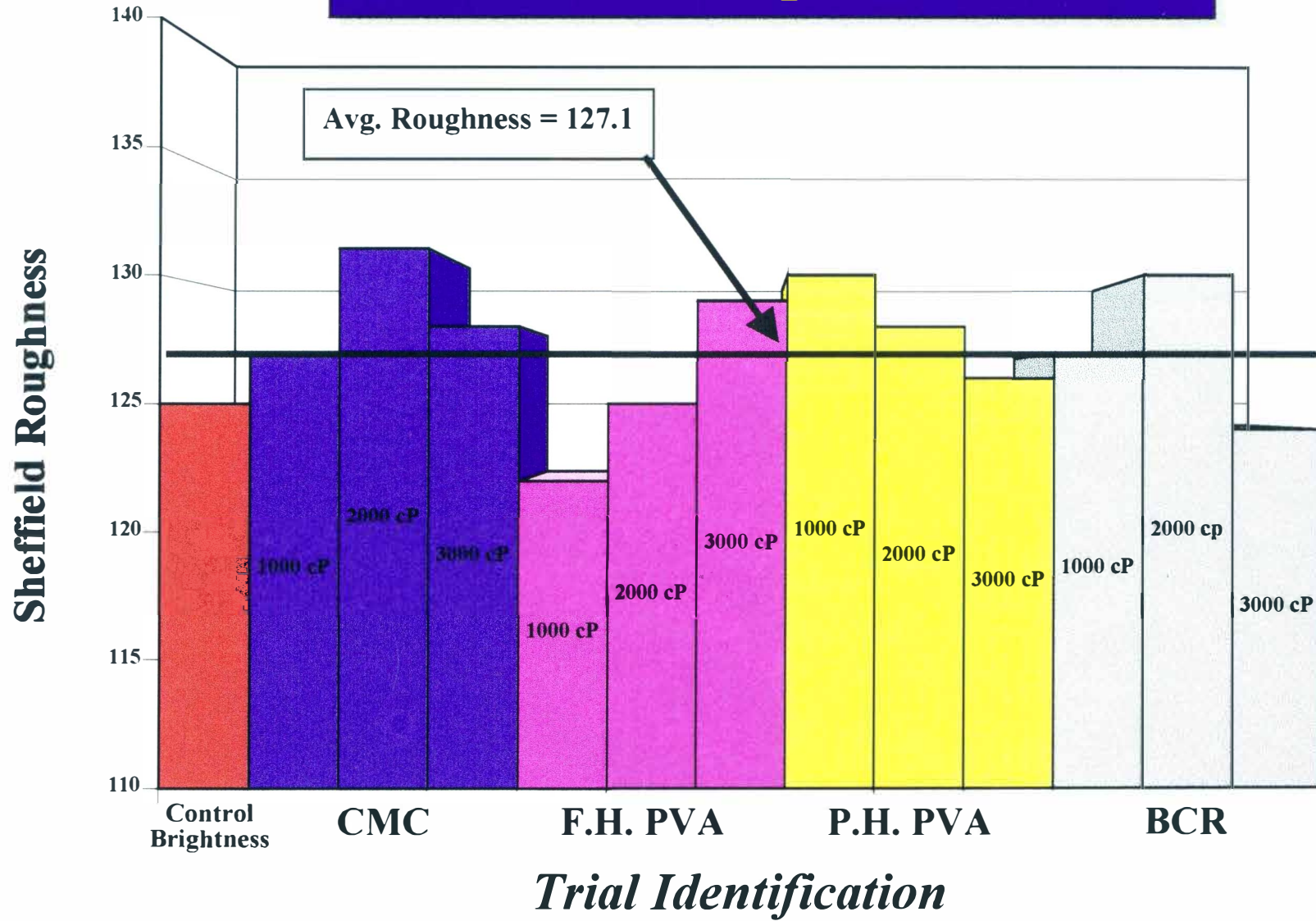


# Gloss of Trial Samples

17

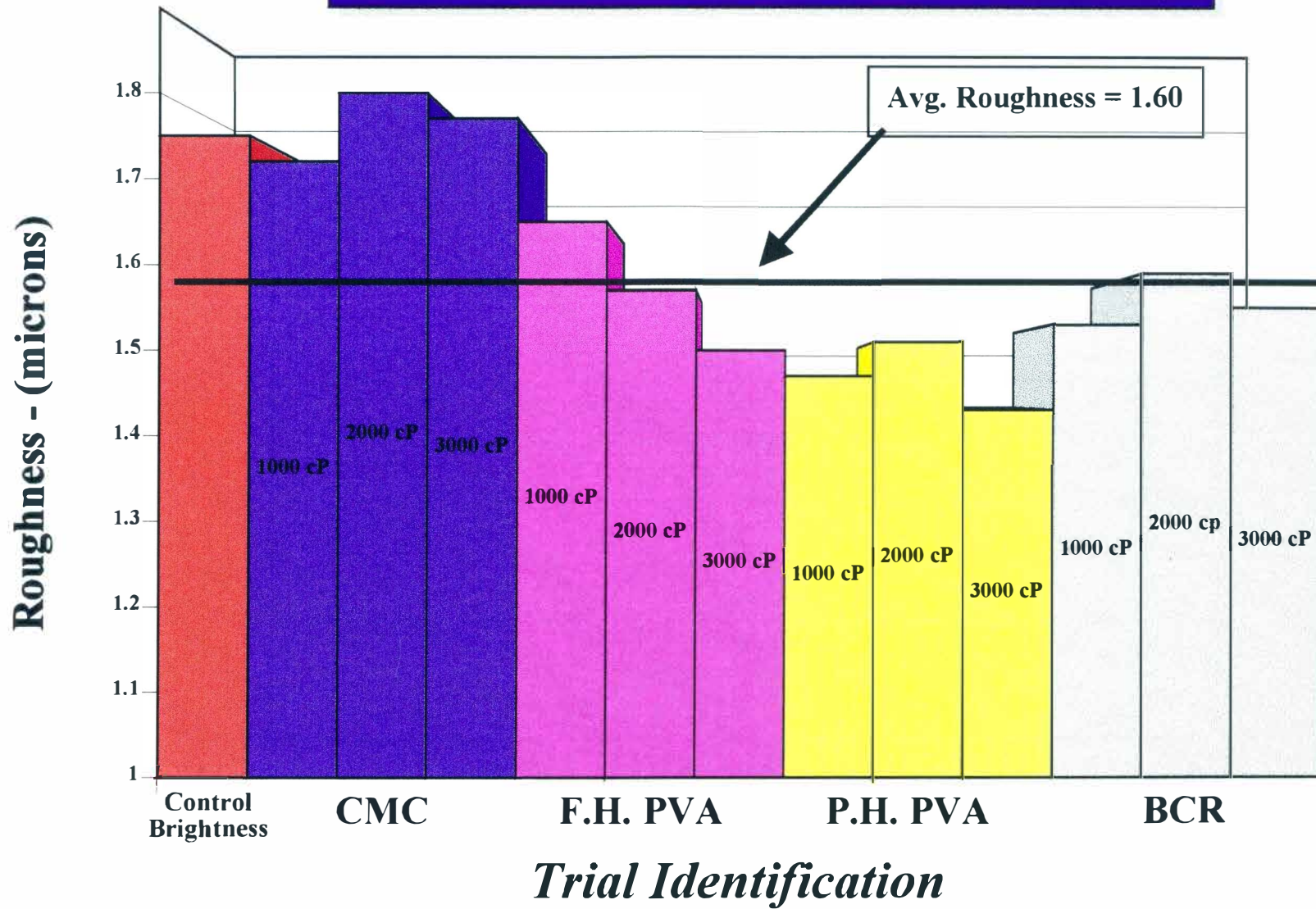


# Sheffield Roughness of Trial Samples

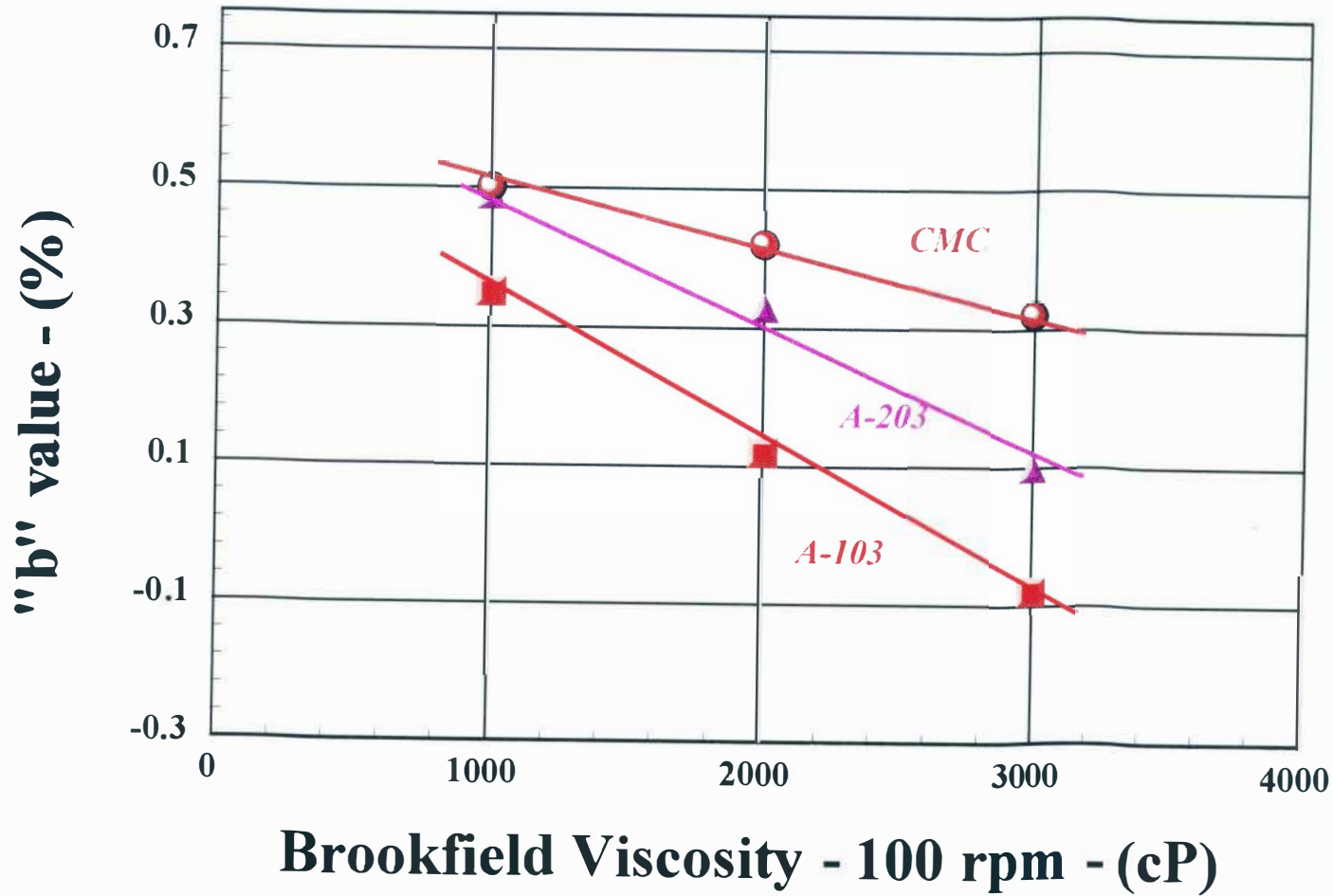




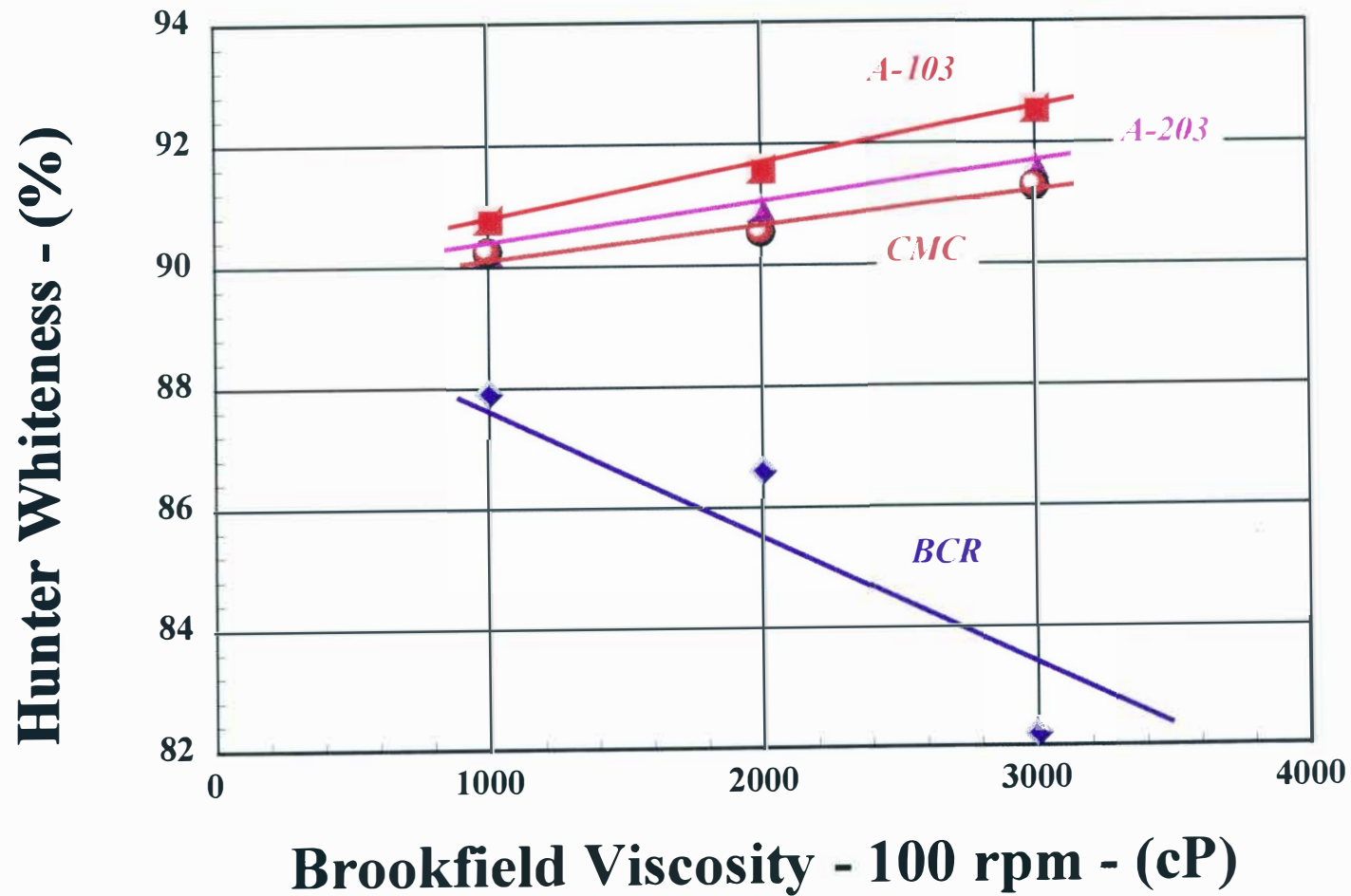
# Parker Print Surf Roughness of Trial Samples



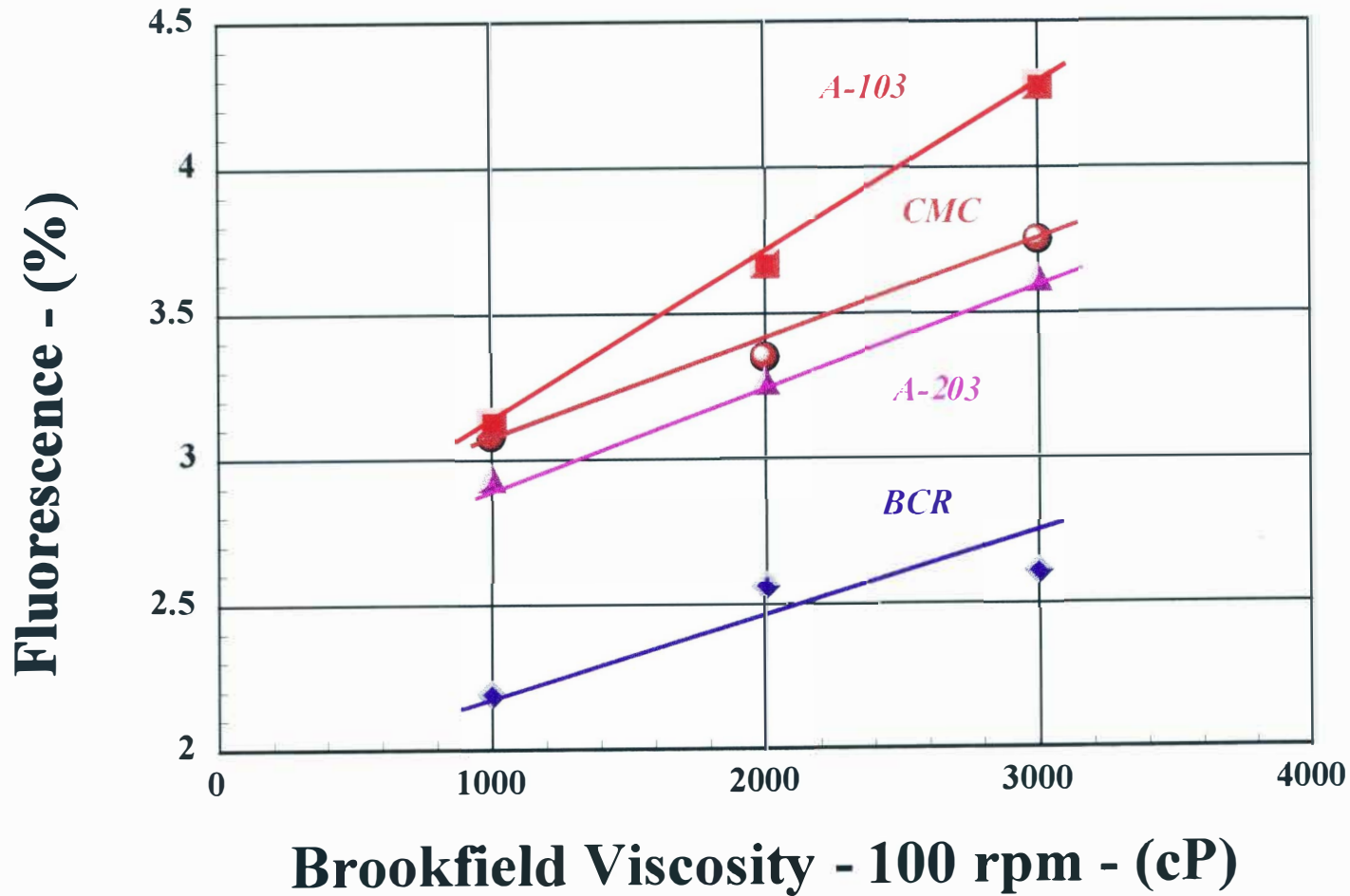
# "b" Color Value with UV Component vs. Brookfield Viscosity



# Whiteness of Coated Paper vs. Brookfield Viscosity



# Fluorescence of Coated Paper vs. Brookfield Viscosity



## CONCLUSIONS

On the basis of the experimental results, several conclusions were made. A step-wise increase in coating viscosity induced the increase in both fluorescence and whiteness values for all formulations tested, with the exception of the BCR formulation. In accordance with previous research, the coated papers containing fully hydrolyzed PVA experienced the greatest whiteness and fluorescence readings.

Formulations containing the modified FWA (BCR) were subject to a shift in color from blue to yellow. Whether this was due to actual dye over-saturation or some other chemical incompatibility with the FWA was not determined. Regardless of what occurred, the coating was yellow when exposed to a pure UV source, and whiteness values decreased with increasing viscosity. Normally, coatings containing FWAs will appear blue when exposed to a pure UV light source.

A summary of the conclusions made in the research project are as follows:

- (1) The formulations containing PVA and CMC experienced an increase in fluorescence and whiteness with an increase in coating viscosity;
  - (2) The fully hydrolyzed PVA formulations had the greatest degree of whiteness and fluorescence;
- and
- (3) The BCR formulation was apparently over-saturated with dye. This was the reason for the decrease in whiteness as viscosity increased.



## LITERATURE CITED

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2. Muller, F. Loewe, D., and Hunke, B., "Optical Brighteners - Recent Findings Regarding Properties and Behavior in Paper", Allgemeine Papier-Rundshaw, No. 6, 1991, pp. 191-203.
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4. Parkes, D. and Traser, G., "Strategies for Maximizing Whiteness of Coated Papers".

# APPENDIX I

- Experimental Coating Formulations -

The table area is a large grid with approximately 10 columns and 15 rows. The content is extremely faint and illegible, appearing as a light gray pattern against the white background. It is intended for recording experimental coating formulations.

## THESIS COATING FORMULATIONS

### Formula 1 of 6

Ingredient	Solids Content, %	Coating Formula, dry parts	Amount for 5000 g batch @ 60% TS	
			Amount Dry, gm	Amount as Recd., gm
Engelhard Ultragloss 90 No. 1 Clay	70.00%	85	2172	3102.9
SMI Alboglos Percipated CaCO <sub>3</sub>	70.00%	15	383.3	547.6
Dow 638NA S-BR Latex	50.00%	16	408.9	817.8
Nopecote C-104 Lubricant	50.00%	0.5	12.77	25.54
Aquaquest 2120 Dispersant	55.00%	0.1	2.56	4.65
Sunrez 700C Insolubolizer	35.00%	0.8	20.44	58.4
Alcogum L-23 Viscosity Modifier	25.00%			
Airvol 103 (Cooked at 10% solids)	10.00%			
Airvol 203 (Cooked at 10% solids)	10.00%			
Aqualon 7LT Carboxymethyl Cellulose	100.00%			
Leucophor L Hexasulfo FWA	100.00%			
Leucophor BCR Modified FWA	100.00%			
Water	0.00%			
<b>TOTALS</b>		117.4	2999.97	4556.89

**TOTAL SOLIDS = 66%**

<b>Total Required for Each Trial</b>	911.5 g
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# THESIS COATING FORMULATIONS

## Formula 2 of 6

Ingredient	Solids Content, %	Coating Formula, dry parts	Amount for 5000 g batch @ 60% TS	
			Amount Dry, gm	Amount as Recd., gm
Engelhard Ultragloss 90 No. 1 Clay	70.00%	85	434.4	620.6
SMI Alboglos Percipated CaCO <sub>3</sub>	70.00%	15	76.7	109.6
Dow 638NA S-BR Latex	50.00%	16	81.8	163.6
Nopecote C-104 Lubricant	50.00%	0.5	2.56	5.12
Aquaquest 2120 Dispersant	55.00%	0.1	0.51	0.93
Sunrez 700C Insolubolizer	35.00%	0.8	4.09	11.69
Alcogum L-23 Viscosity Modifier	25.00%	0.6	3.05	12.2
Airvol 103 (Cooked at 10% solids)	10.00%			
Airvol 203 (Cooked at 10% solids)	10.00%			
Aqualon 7LT Carboxymethyl Cellulose	100.00%			
Leucophor L Hexasulfo FWA	100.00%			
Leucophor BCR Modified FWA	100.00%			
Water	0.00%			79.4
<b>TOTALS</b>		<b>118</b>	<b>603.11</b>	<b>1003.14</b>

ITEM	DRY	RECD.
Std. Formula	606.1	911.5
T1	606.1	911.5
Alcogum	3.05	12.2
Total	609.15	935.9

1015.3	-935.9	79.4
Total Dry/0.6	Total Recd.	Water to Add

# THESIS COATING FORMULATIONS

## Formula 3 of 6

Ingredient	Solids Content, %	Coating Formula, dry parts	Amount for 5000 g batch @ 60% TS	
			Amount Dry, gm	Amount as Recd., gm
Engelhard Ultragloss 90 No. 1 Clay	70.00%	85	434.4	620.6
SMI Alboglos Percipated CaCO <sub>3</sub>	70.00%	15	76.7	109.6
Dow 638NA S-BR Latex	50.00%	16	81.8	163.6
Nopecote C-104 Lubricant	50.00%	0.5	2.56	5.12
Aquaquest 2120 Dispersant	55.00%	0.1	0.51	0.93
Sunrez 700C Insolubilizer	35.00%	0.8	4.09	11.69
Alcogum L-23 Viscosity Modifier	25.00%	0.6	3	12
Airvol 103 (Cooked at 10% solids)	10.00%			
Airvol 203 (Cooked at 10% solids)	10.00%			
Aqualon 7LT Carboxymethyl Cellulose	100.00%	1	4.95	4.95
Leucophor L Hexsulfo FWA	100.00%	1		19.8
Leucophor BCR Modified FWA	100.00%			
Water	0.00%			75.2
<b>TOTALS</b>		<b>120</b>	<b>608.01</b>	<b>1023.49</b>

TOTAL	DRY	RECD.
Std. Formula	606.1	911.5
CMC	4.95	4.95
FWA		19.8
T1	611.05	936.25
Alcogum	3	12
Total	614.05	948.25

1023.4	-948.3	75.2
Total Dry/0.6	Total Recd.	Water to Add

# THESIS COATING FORMULATIONS

## Formula 4 of 6

Ingredient	Solids Content, %	Coating Formula, dry parts	Amount for 5000 g batch @ 60% TS	
			Amount Dry, gm	Amount as Recd., gm
Engelhard Ultragloss 90 No. 1 Clay	70.00%	85	434.4	620.6
SMI Alboglos Percipated CaCO <sub>3</sub>	70.00%	15	76.7	109.6
Dow 638NA S-BR Latex	50.00%	16	81.8	163.6
Nopecote C-104 Lubricant	50.00%	0.5	2.56	5.12
Aquaquest 2120 Dispersant	55.00%	0.1	0.51	0.93
Sunrez 700C Insolubolizer	35.00%	0.8	4.09	11.69
Alcogum L-23 Viscosity Modifier	25.00%	0.5	2.63	10.5
Airvol 103 (Cooked at 10% solids)	10.00%	1	4.95	49.5
Airvol 203 (Cooked at 10% solids)	10.00%			
Aqualon 7LT Carboxymethyl Cellulose	100.00%			
Leucophor L Hexasulfo FWA	100.00%	1		19.8
Leucophor BCR Modified FWA	100.00%			
Water	0.00%			31.5
<b>TOTALS</b>		<b>119.9</b>	<b>607.64</b>	<b>1022.84</b>

Airvol 103 cooked at 150 C for 45 min.

TOTAL	DRY	RECD.
Std. Formula	606.1	911.5
PVA - 103	4.95	49.5
FWA		19.8
T1	611.05	980.8
Alcogum	2.63	10.5
Total	613.7	991.3

1022.8	-991.3	31.5
Total Dry/0.6	Total Recd.	Water to Add

# THESIS COATING FORMULATIONS

## Formula 5 of 6

Ingredient	Solids Content, %	Coating Formula, dry parts	Amount for 5000 g batch @ 60% TS	
			Amount Dry, gm	Amount as Recd., gm
Engelhard Ultragloss 90 No. 1 Clay	70.00%	85	434.4	620.6
SMI Alboglos Percipated CaCO <sub>3</sub>	70.00%	15	76.7	109.6
Dow 638NA S-BR Latex	50.00%	16	81.8	163.6
Nopecote C-104 Lubricant	50.00%	0.5	2.56	5.12
Aquaquest 2120 Dispersant	55.00%	0.1	0.51	0.93
Sunrez 700C Insolubolizer	35.00%	0.8	4.09	11.69
Alcogum L-23 Viscosity Modifier	25.00%	0.5	2.5	10
Airvol 103 (Cooked at 10% solids)	10.00%			
Airvol 203 (Cooked at 10% solids)	10.00%	1	4.95	49.5
Aqualon 7LT Carboxylmethyl Cellulose	100.00%			
Leucophor L Hexsulfo FWA	100.00%	1		19.8
Leucophor BCR Modified FWA	100.00%			
Water	0.00%			31.8
<b>TOTALS</b>		<b>119.9</b>	<b>607.51</b>	<b>1022.64</b>

Airvol 203 cooked at 150 C for 45 min.

TOTAL	DRY	RECD.
Std. Formula	606.1	911.5
PVA - 203	4.95	49.5
FWA		19.8
T1	611.05	980.8
Alcogum	2.5	10
Total	613.6	990.8

1022.6	-990.8	31.8
Total Dry/0.6	Total Recd.	Water to Add

# THESIS COATING FORMULATIONS

## Formula 6 of 6

Ingredient	Solids Content, %	Coating Formula, dry parts	Amount for 5000 g batch @ 60% TS	
			Amount Dry, gm	Amount as Recd., gm
Engelhard Ultragloss 90 No. 1 Clay	70.00%	85	434.4	620.6
SMI Alboglos Percipated CaCO <sub>3</sub>	70.00%	15	76.7	109.6
Dow 638NA S-BR Latex	50.00%	16	81.8	163.6
Nopecote C-104 Lubricant	50.00%	0.5	2.56	5.12
Aquaquest 2120 Dispersant	55.00%	0.1	0.51	0.93
Sunrez 700C Insolubolizer	35.00%	0.8	4.09	11.69
Alcogum L-23 Viscosity Modifier	25.00%	0.95	4.63	18.5
Airvol 103 (Cooked at 10% solids)	10.00%			
Airvol 203 (Cooked at 10% solids)	10.00%			
Aqualon 7LT Carboxymethyl Cellulose	100.00%			
Leucophor L Hexasulfo FWA	100.00%			
Leucophor BCR Modified FWA	100.00%	1		20
Water	0.00%			67.9
<b>TOTALS</b>		<b>119.35</b>	<b>604.69</b>	<b>1017.94</b>

TOTAL	DRY	RECD.
Std. Formula	606.1	911.5
BCR - FWA		20
T1	606.1	931.5
Alcogum	4.63	18.5
Total	610.73	950

1017.9	-950	67.9
Total Dry/0.6	Total Recd.	Water to Add