

## Binder Effects on the Creaseability of Pigment Coated Paperboard

SINAN SONMEZ<sup>1,3,\*</sup>, EMRE DOLEN<sup>2</sup> and PAUL D. FLEMING<sup>3</sup>

<sup>1</sup>Department of Printing Education, Faculty of Technical Education, University of Marmara, Goztepe Campus, Istanbul 34722, Turkey

<sup>2</sup>Department of Analytical Chemistry, Faculty of Pharmacy, University of Marmara, Goztepe Campus, Istanbul 34722, Turkey

<sup>3</sup>Department of Paper Engineering, Chemical Engineering and Imaging, Western Michigan University, Kalamazoo, MI 49008, USA

\*Corresponding author: E-mail: ssonmez@marmara.edu.tr

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The primary reason to pigment coating on paperboard is to improve the surface appearance and printability of the paperboard. However, printability is not the only property desired in paperboard. Workability is also important because it also affects productivity and efficiency. Creaseability is the most important property that affects workability. Accurate paperboard package dimensions and predictable foldability characteristics are factors affected by creaseability and they will affect product quality. The aim of this study is to investigate the effects of the proportion of binder in pigment coating mixtures on the creaseability of coated paperboards. The stiffness and creasing values of coated paperboard were compared.

**Key Words:** Paperboard, Coating, Latex, Creasing.

### INTRODUCTION

Creasing is accomplished using machinery specific to the task, which create round edge creases. A crease is made using creasing rules. These rules are thin strips of metal with smooth rounded edges which indent the board surface and push it into an accurately cut a matching groove on the underside of the paperboard<sup>1</sup>. Creasing is formed when the paperboard is pressed into a channel with a blade. This process creates a flexible deformation on the paperboard and allows accurate folding without forming a crack. During the creasing operation, paperboard is partially delaminated or cleft into thin layers, which prevents the tearing of layers at the outside of the fold (Fig 1).

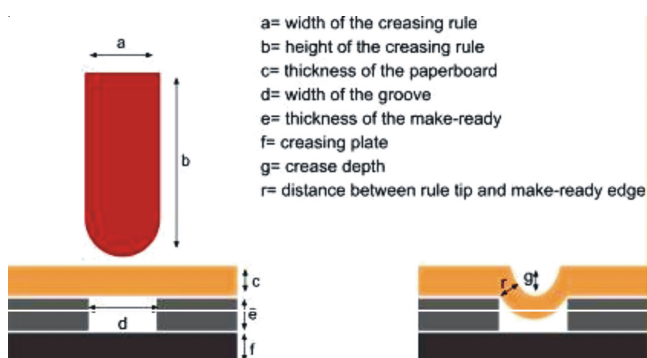
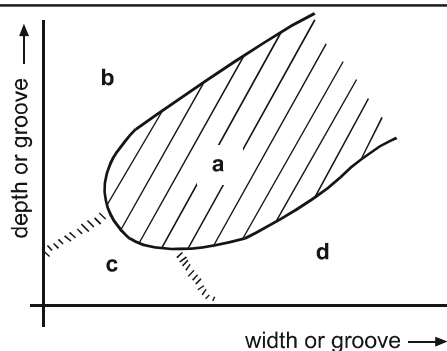


Fig. 1. Creasing cutaway view

The careful control of folding and forming is the most important factor to ensure an undamaged paperboard in the creasing operation<sup>2</sup>. It is especially important to obtain permanent deformation of the paperboard, delamination between the plies, through the elastic properties of the paperboard surface. The elastic properties of paperboards can be induced to release the top interface and open up, sometimes creating cracks<sup>3</sup>.

Different paperboard types show different behaviours in the same crease conditions. But, a correct adjustment obtains a good-quality formation of the crease on the surface of the paperboard<sup>4</sup>. The crease depth, which is how far the rule presses the paperboard into the channel, affects the quality of creasing. An extremely deep crease will increase cracking on the paperboard as much as an extremely shallow crease. The board will reach the channel bottom at a certain creasing depth and the board will be additionally compressed in thickness by the rule. A specific pressure, depending on the board quality and on the total die design, is needed to complete the cutting and creasing actions<sup>5</sup> (Fig. 2).

The process of creasing is easier for bulky paperboards. Sizes of the folding parts can increase much more with a certain base weight and stiffness degree. If the folding part is wider, it will create a crease that is irregular and less flexible, between the creasing knife and line of folding. Also, the paperboards must have resistant surface layers and bendable pigment coating for formation of the crease. Because of these



- a Good crease  
 b Sharp creasing --- cracking  
 c Unsufficient creasing --- cracking  
 d Inaccurate crease

Fig. 2. Paperboards' creasing areas and possible problems

factors, fiber compounds and the number of layers are important. The pigment coating must be elastic enough in order to prevent the crease from cracking in certain areas<sup>6,7</sup>.

Paperboards are coated with a pigment coating formulation in order to obtain a good printed surface. This pigment coating formulation includes pigments, binders (latexes) and additives. Coated paperboards need to be durable so that they can be folded by press machines and other processes. The durability of coated paperboard depends in part on the properties of the latex in the pigment coating formulation<sup>8</sup>. It is also related to the strength of the binder. Increasing the amount of the binder increases the durability of the coated paperboard. Latex is generally used in the pigment coating formulations as the primary binder. It is obtained by a synthetic rubber or plastic emulsion polymerization. The latexes used in pigment coating mixtures are classified under 3 groups as follows: (a) styrene butadiene (SB), (b) styrene *n*-butyl acrylate (SA), (c) polyvinyl acetate (PVA).

Styrene-acrylic binders (SA) are often popular in high end board coatings. Styrene-acrylic binders latexes<sup>9</sup> are latexes of modified styrene (hard monomer) and *n*-butyl acrylate (soft monomer) at varying ratios ranging from 40/60-60/40.

In addition to pigment coating formulation properties, crease numbers and position are two important parameters that determine the quality of creased paperboard. Binders also influence resistance against peeling and cracking of the surface of the paperboard during the press operations<sup>10</sup>.

In recent years, the improvement of the creaseability properties of paperboard has come into prominence. Therefore, the aim of this study is to show the effect of varied binder amounts in pigment coating formulations on the creasing of paperboard.

## EXPERIMENTAL

This study is divided into three phases: (1) pigment coating formulations development, (2) application to base paperboards and (3) testing of roughness, stiffness and creasing properties of the coated paperboards.

A commercial base paperboard was used as the base substrate for coating. The base substrate characteristics are given

in Table-1. The solids (%) of mineral pigments and binders according to their manufactures are given in Table-2. In Table-3, specifications of binder quantities are seen.

TABLE-1  
WEIGHTS OF BASE PAPERBOARD LAYERS

Layers	Weight (g/m <sup>2</sup> )
Bottom layer	55
Center layer	164
Protective layer	15
Top layer	18

TABLE-2  
MINERAL PIGMENT PROPERTIES

Pigments and binders	Solid (%)	Particle size	Brightness (%)	pH
Kaolin (BASF, Nuclay)	68	78-82 % (below 2 μm)	88	7.5
CaCO <sub>3</sub> (Omya, Hydrocarb 90)	76	90 % (below 2 μm)	93	9.5
TiO <sub>2</sub> (Tronox, R-KB-2)	94	0.3 μm	95	7.5

TABLE-3  
BINDER PROPERTIES

Binders	Dry matter (%)	Viscosity (mPa.s)	Density (g/cm <sup>3</sup> )	pH
Latex (BASF, Acronal S 360 D)	50 ± 1	370	1.02	8 ± 0.50

**Coating formulations and application methods:** All base paperboard had been coated with starch by the paperboard manufacturer. Prepared formulations were coated on the base paperboards by a K-control coater laboratory coater using a #4 rod. The base paperboards were coated with two layers, a pre-coat and a top-coat. On the pre-coat layer, the pigments, binder and additives remained invariable throughout the study. However, the styrene acrylate latex as a binder was used in different combinations on top-coat layers, whereas pigments and additives remained invariable until the end of study. The pigment coating formulation is given in Table-4.

TABLE-4  
PIGMENT COATING FORMULATIONS

Coating formulations	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
Ingredients	Dry parts added									
Kaolin	50	50	50	50	50	50	50	50	50	50
CaCO <sub>3</sub>	50	50	50	50	50	50	50	50	50	50
Latex	2	4	6	8	10	12	14	16	18	20

Pigment coating formulations were prepared using a dispersive and dry solid content which were adjusted to 60-62 % with pH values of 8-9. Viscosities of coating colours were measured by a Brookfield viscosimeter. After mixing for 0.5 h, the pH, solid contents and viscosity of pigment coating formulations were measured. The viscosity values were 200-400 cP. After the coating process, the coated paperboard samples were calendered. The process of calendering was applied until the coated base paperboards had enough brightness. In this process, temperature and pressure were kept constant through the end of the study.

**Paperboard testing:** All the coated paperboard samples were conditioned for 24 h at 50 % relative humidity and 23 °C before any measurements were made. The calendered-coated paperboards were tested for PPS roughness, stiffness and creaseability. Paper roughness was measured by PPS ME-90 (1000 Pa, soft backing) based on TAPPI T555-OM-99. The creasing was applied to the calendered paperboard surface using a Marbach Hydraulic Laboratory Press. The creasing values of creased paperboard were measured using a Pira Crease and Board Stiffness instrument. Pira can assess the creasing quality of carton boards using a Pira board creaser conforming to BS 4818. The images of creasing cracks on calendered coated paperboards were viewed with an Olympus SZ Pt optical microscope at 120 times.

**RESULTS AND DISCUSSION**

Fig. 3 demonstrated that roughness values changed depending on the binder ratio in pigment coating formulations. Low or high binder ratios in pigment coating formulations increased the roughness values of coated paperboard. Coated paperboards with coating formulations including high amounts of binder had the highest roughness values. This negatively affects the print surface. The better roughness values were obtained in F6 which includes 12 parts binder in the pigment coating formulation.

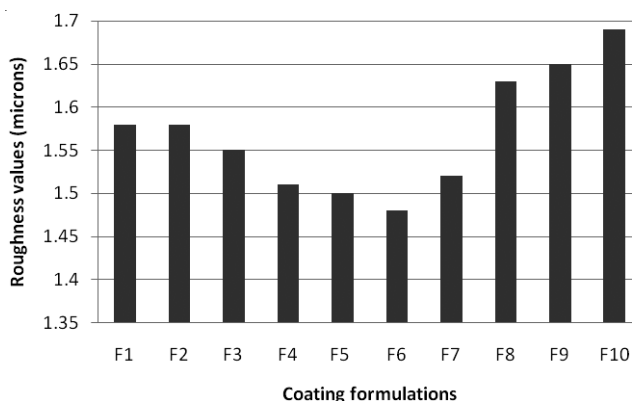


Fig. 3. Roughness values of calendered-coated paperboard samples

The stiffness values in both machine direction and cross direction changed depending on the binder ratio in the pigment coating formulations. The stiffness increased in the samples until F8 which included 16 parts binder in the pigment coating formulation. The stiffness values of F9 and F10, which included high binder ratios, were shown to decrease. The stiffness values of the machine direction of coated paperboards were higher than the cross direction of coated paperboards (Figs. 4 and 5).

The stiffness is related to the thickness of the material, tension and the abilities of interior and exterior layers to resist pressure. If the thickness, raw material type and weight of the layers change, the stiffness changes in an important proportion as well. While the highest creasing value in machine directions of the coated paperboards was obtained from F6, which contained 12 parts binder in the pigment coating formulation, the highest creasing value in cross direction of the coated paperboard was obtained from F7 which contained 14 parts

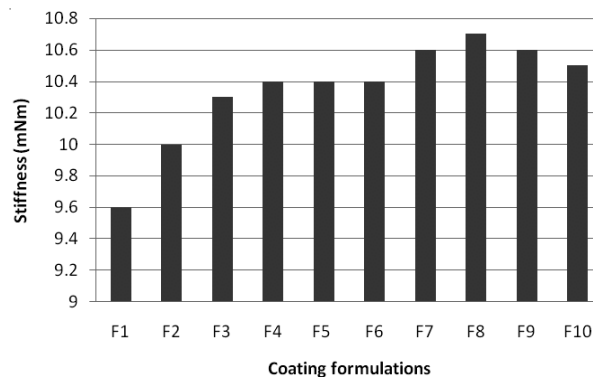


Fig. 4. Machine direction (MD) stiffness values of calendered-coated paperboard samples

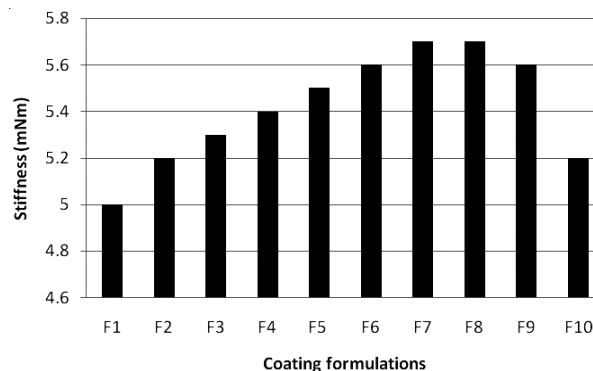


Fig. 5. Cross direction (CD) stiffness values of calendered-coated paperboard samples

binder in the pigment coating formulation. The lowest creasing value in machine and cross direction of coated paperboards was obtained from N2 which contained 4 parts binder in the pigment coating formulation (Figs. 6 and 7).

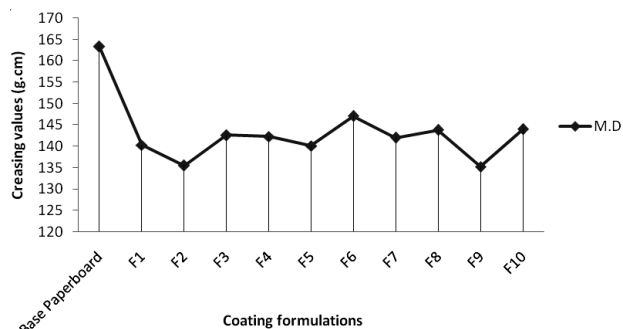


Fig. 6. Machine direction creasing values of calendered-coated paperboard samples

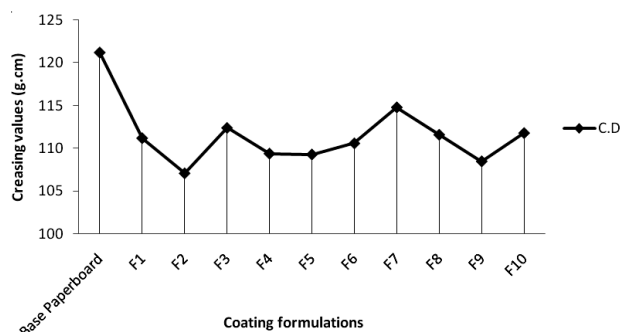


Fig. 7. Cross direction creasing values of calendered-coated paperboard samples

The creasing cracks of coated paperboard increased depending on the binder ratio in the pigment coating formulations. The reduction continued until F9 and F10, which included a high binder ratio in the pigment coating formulations. The images obtained with the optical microscope on crease areas showed clearly that the cracking on coated paperboard occur on the top-coat layer (Fig. 8a-b).

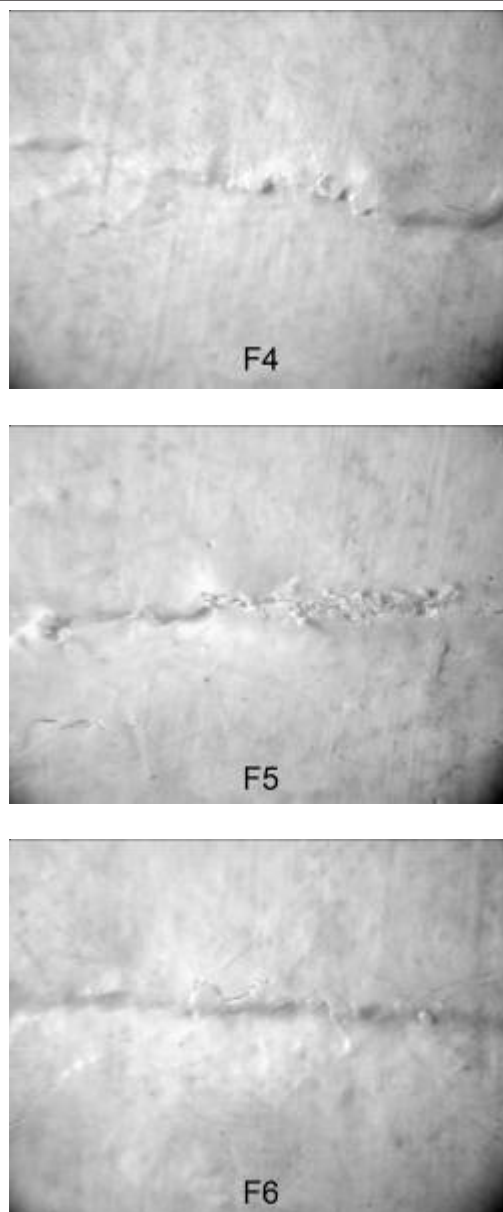
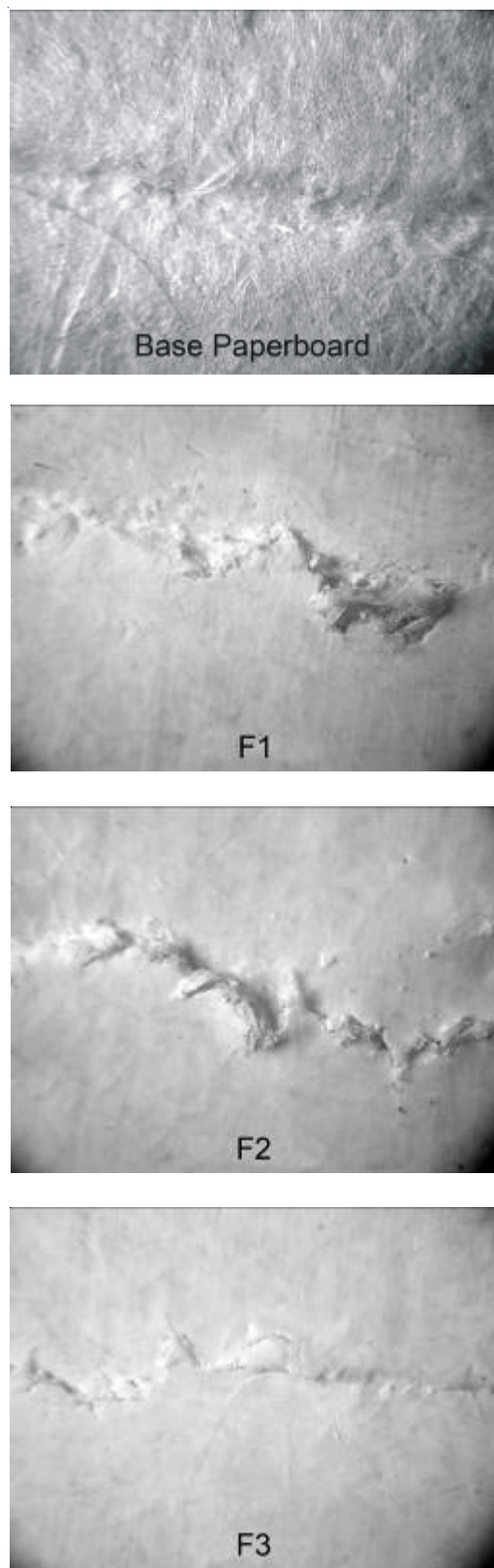


Fig. 8a. Views of creasing on calendared-coated paperboards after the creasing process

Pigment coating has reduced the resistance of the paperboard. The increasing of binder amount in the pigment coating formulations demonstrates that binders have an important influence on the creasing of paperboard. Particularly, low and high binder ratios in the pigment coating formulations were shown to increase cracking on coated paperboard.

The stiffness value of the coated paperboards in machine direction increases or decreased directly, according to the amount of binder in the pigment coating formulations.

Roughness values showed that surface smoothness changed depending on the ratio of binder in the pigment coating formulations. High levels of binder in the pigment coating formulations reduced the surface smoothness of coated paperboard.

While an optimum ratio of binder in the pigment coating formulations has been determined, different binder requirements related to various mineral pigments have been kept in view.

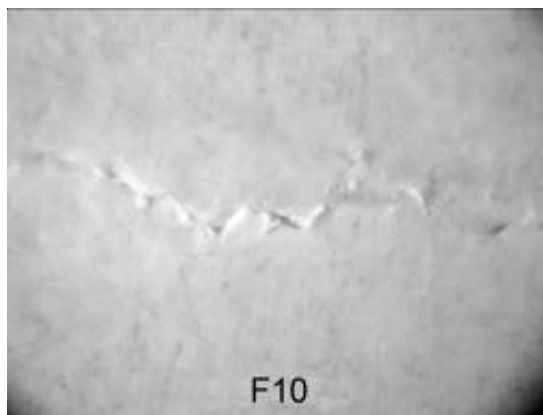
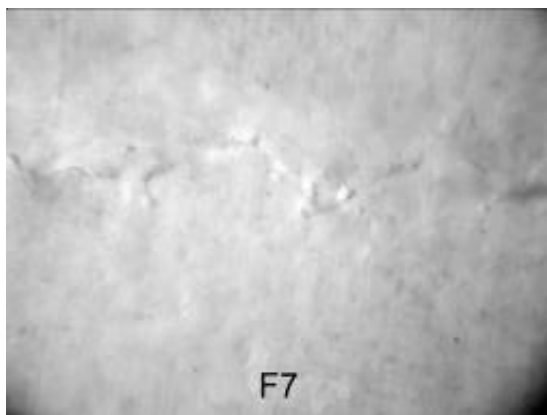
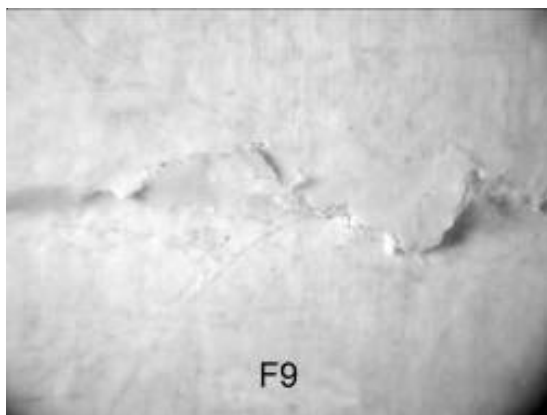
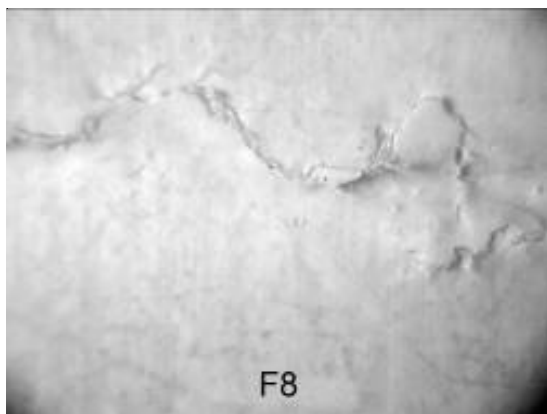


Fig. 8b. Views of creasing on calendered-coated paperboards after the creasing process



#### ACKNOWLEDGEMENTS

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