Matte Finish on Thermal Prints

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Abstract

In recent years, thermal transfer systems have been developed to obtain prints from pictures generated electronically from a color video camera. According to one way of obtaining such prints, an electronic picture is subjected to color separation by color filters. The respective color-separated images are converted into electrical signals. These signals are processed on to produce cyan, magenta, and yellow signals. These signals are transmitted to a thermal printer. To obtain the print, a cyan, magenta, or yellow dye-donor element is placed face-to-face with a dye-receiving element. The two are inserted between a thermal printing head and a platen roller. A line-type thermal printing head is used to apply heat from the back of the dye-donor media. The thermal printing head's many heating elements are heated up sequentially in response to one of the cyan, magenta, or yellow signals. The process is repeated for the other two colors. A color hard copy is thus obtained that corresponds to the original picture viewed on a screen. Subsequent to printing of the dyes, a transferable overprotective layer, or laminate, might be applied to the printed image. This overprotective layer is designed to protect the printed image from contamination by foreign material, such as fingerprints, as well as improving resistance to light fade.

Introduction

Reflection prints of images are usually found with two finishes-a high gloss surface or a low gloss, matte surface. Increasing the degree of scatter of incident light can create a low gloss surface; therefore the reflected light seen by the observer is diffused. Scattering can be accomplished by texturing the surface or by placing particles beneath the surface of the laminate or over-protective layer, which differ in refractive index from the surrounding medium. The particle diameter not only determines the degree of gloss but also the texture of the surface. Particles between 10 and 50 μm in diameter are used in the photographic industry to produce a 60-degree gloss value ranging between 20 and 40 units. In the past, if a matte finish was desired on a thermal print, it was accomplished through the use of matte sprays or by matte surface applications through post-printing processors. Both of these solutions are costly and add complexity to the process.

Matte surfaces might also be generated on dye-diffusion thermal prints by heating the transferable protective layer to differing temperatures in a design pattern, such as a checkerboard. Low temperatures applied evenly over the protective layer give a high gloss print. A matte finish can be obtained by printing high and low temperatures in a pattern over the surface of the protective layer. The differing temperatures cause a varying thickness of the protective layer, which scatters light, much like particles protruding from a surface.

Experimental Procedures

A method for generation of a matte surface was developed by the incorporation of thermally expandable, polymeric microspheres into the overprotective or laminate layer of a thermal donor. EXPANCEL microspheres, made by Expancel Inc., can be used for imparting low gloss by scattering light.[1,2] These microspheres have a core filled with isopentane or isobutane surrounded by an impermeable wall of co-polymer such as vinylidene chloride and acrylonitrile. Figures 1 and 2 show the unexpanded microspheres incorporated into the protective layer of the donor material prior to application to the imaged receiver.

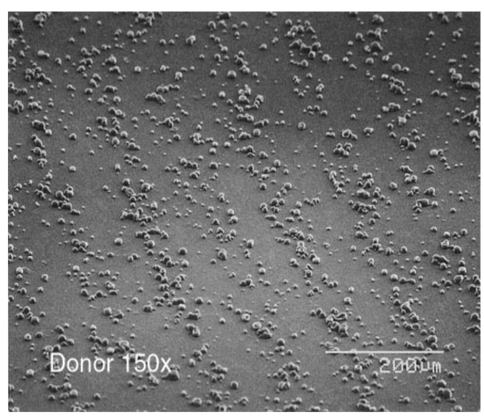

Figure 1.

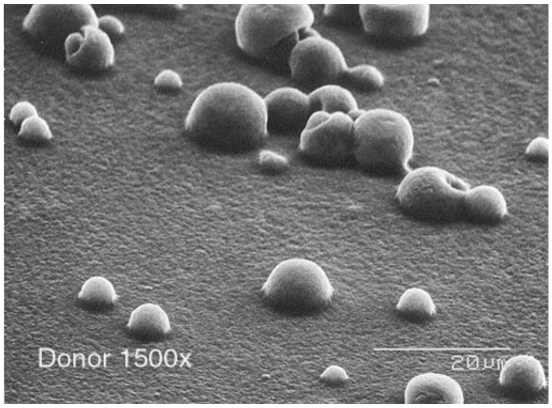

Figure 2.

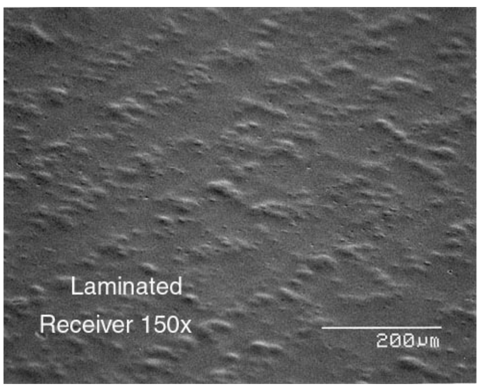

Figure 3.

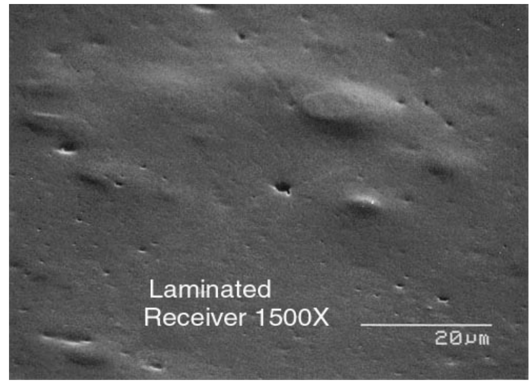

Figure 4.

When the temperature of the protective layer exceeds the glass transition temperature of the wall, the microsphere expands in size as a result of the increased internal pressure from the expanding hydrocarbon gas. Microspheres having a mean diameter of 8 μm, when coated, will expand to 20 μm or more, when the protective layer is heated during application. The expanded size of the microsphere is retained as the temperature of the microsphere decreases below the glass transition temperature of the wall. Polyvinylacetal functions as the binder and the protective layer of the laminate. Figures 3 and 4 illustrate the surface topography of a receiver surface following application of the overprotective layer.

In addition to altering the surface texture of the imaged material the application of the laminate to the surface of the imaged receiver forces the microspheres beneath the surface of the protected print, where they may function as light-scattering entities because of the refractive index difference between microspheres and laminate binder. All or a portion of each microsphere may be forced beneath the surface of the protected print.

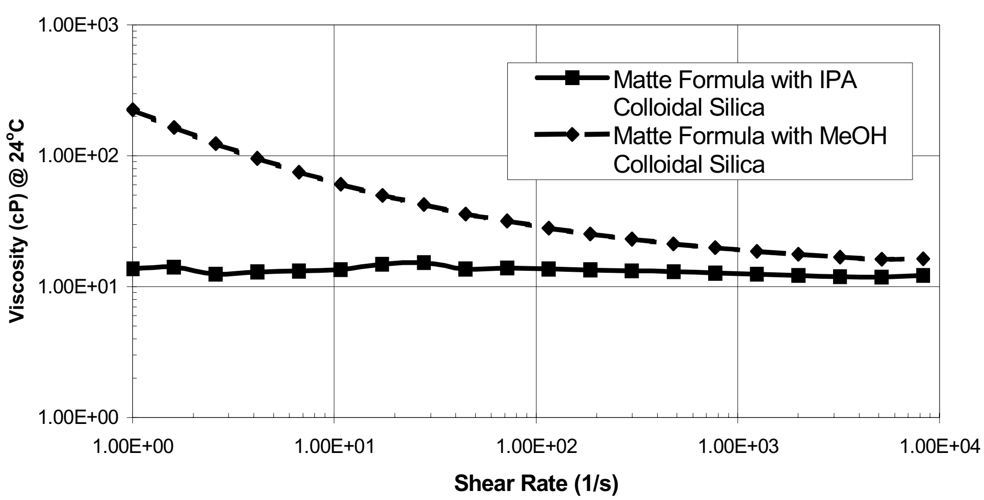

Figure 5.

In addition to a polymeric binder and microspheres, the overprotective layer contains colloidal silica to improve the tear-resistance characteristics of the laminated part of the protective layer from the unlaminated, part during printing. The colloidal silica is a commercially available dispersion using isopropanol as the carrier. Initial formulations of the laminate coating solution exhibited severe settling of the microspheres during the coating operation. Replacement of the isopropanol-based colloidal silica dispersion with a methanol-based colloidal silica dispersion results in a coating solution that exhibits high viscosity at low shear. This change stabilized the microspheres to settling. Viscosities in excess of 200 cP are possible under low shear conditions. Application of shear equivalent to that achieved during gravure coating results in a reduction of coating solution viscosity to approximately 15 cP. Figure 5 illustrates the coating solution rheology resulting from the change in colloidal silica in the presence of the EXPANCEL microspheres.

Image Artifacts Relating to Gravure Cylinder Engraving

Gravure cylinders are used for coating liquid compositions on moving supports. The amount of liquid deposited by the gravure cylinder is a function of the recessed cells on the surface of the cylinder. Formulations containing particles, such as beads or microspheres, which are dispersed but not dissolved into the formulation are particles that can interact with the engraving process in such a manner that the expected high-quality coating is not achieved. Incorporation of thermally expandable microspheres can create an objectionable image artifact when the illuminating light source orientation and the coating direction coincide. This artifact can be eliminated by specifically defining the engraving dimensions for the gravure cylinder with respect to the particle size range used in the coating formulation.[3] To successfully eliminate the image artifact, it is necessary to control the ratio of the particle diameter (D_B) to the engraved channel depth (D_O) where:

$$D_B / D_o \text{ is } < 0.5 \text{ or } > 1.1 \quad (1)$$

Next, we can calculate the correct channel width (W_C).

$$W_C = \{2\tan \Theta 2\} D_B \quad (2)$$

where $D_B < 0.5$ or DO > 1.1, and Θ is the engraving stylus angle. Figures 6a and 6b illustrate the regularity of the coated overprotective layer prior to application to the imaged receiver. This regularity can create objectionable image artifacts. Figures 7a and 7b illustrate the randomness of the coated overprotective layer after redefining the engraved dimensions for the gravure cylinder with respect to the particle size range. This randomness eliminates the objectionable image artifact.

Elimination of Laminate Application Artifacts

When the matte laminate is applied to the printed receiver by energy from the thermal printhead, the large microspheres protruding from the donor surface are being forced into the receiver as they expand in size. The influx of energy into the donor receiver system is critical because, not only must the temperature of the donor and receiver surface be increased above the glass transition temperature of each, but, also, sufficient pressure needs be applied to force the expanding microspheres at least partially below the surface. The line-enabled width was increased just for the matte lamination step to apply as much energy as possible without burning the print surface or generating other defects. The paper speed was reduced, relative to the line time, spreading out the energy delivered during the main pulse over a smaller area. An algorithm for parasitic resistance between elements of the thermal printhead was added to the printing of the laminate plane for improved uniformity of the matte surface.

In image areas of high density, a defect referred to as “oil slick” appeared as a differential in the 60-degree gloss.

The elimination of this “oil slick” defect was achieved by adjusting the look-up-table slope and intercept in the high-density response areas. An additional defect known as “scale” is the result of incomplete adhesion of the polyvinylacetal in the overprotective layer to the surface of the receiver. The cause for this defect is due to insufficient contact between the laminate and receiver surfaces and insufficiently applied energy. The defect appears as very small bubbles under the applied laminate and is quite objectionable to the viewer. Alteration of the line time and paper speed, in conjunction with a 15% reduction in the coverage of the microspheres eliminated the defect.

When viewing prints laminated with the matte overprotective layer, the color gamut of the matte finish appears to be much lower than its glossy counterpart. The scattered light from the surface of the matte print is lost to the observer as well as traditional colorimeters. By using a colorimeter with an integrating sphere, we find the color gamut of the matte finish is almost equal to that of the glossy finish.

Variable Gloss Laminate

A distinct advantage could be achieved if a single spool of donor ribbon were capable of producing finishes that varied from glossy to matte. Initial attempts were the blending of various sizes of microspheres. While this method did produce a variable gloss, the dynamic operation range was too short, and the range of values did not include both glossy and matte. Further work was done where, in addition to size, the wall-softening temperature was also taken into consideration.[4] Inclusion of softening temperature and size resulted in a dynamic operating range that spanned both glossy and matte finishes. Table 1 illustrates the advantage achieved when combining microspheres of different size and thermal responses to increase the gloss range of the applied laminate.

Figure 6(a) *Figure 6(b)*

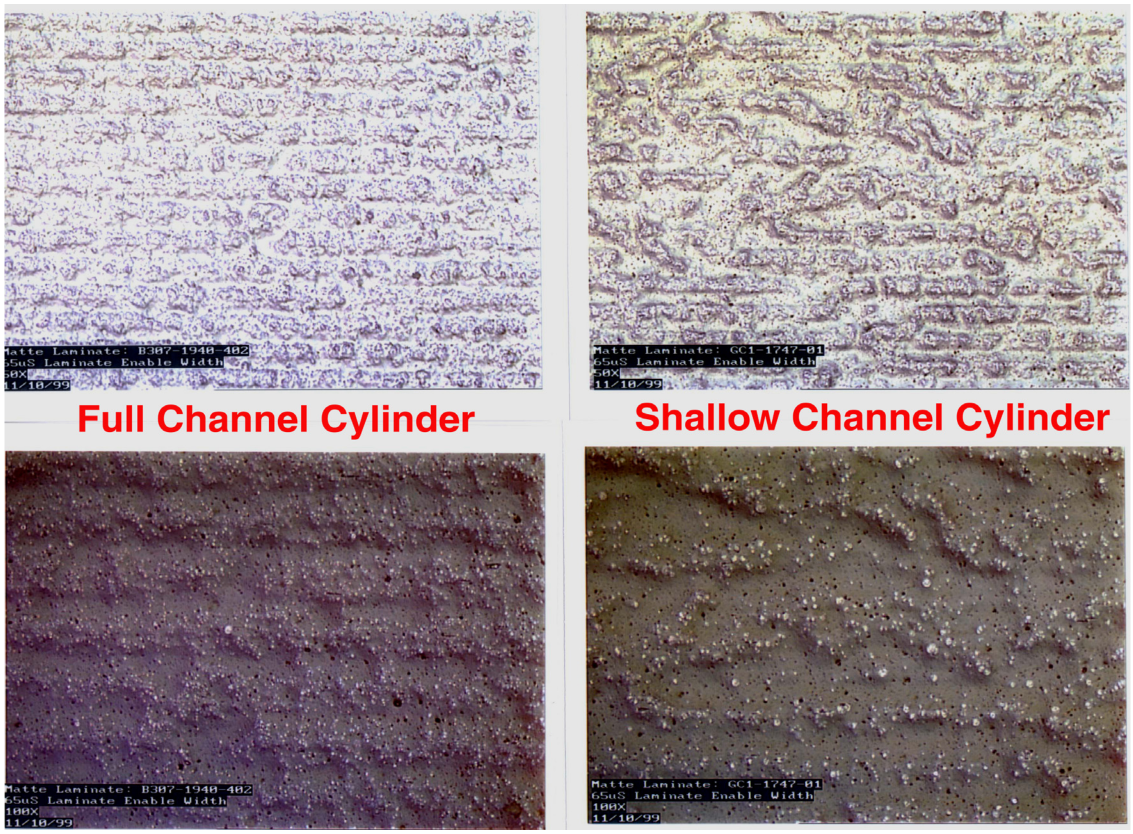

Figure 7(a) *Figure 7(b)*

Table 1.

Overprotective Layer Configuration	Print Energy (mJ/pixel)	60° Gloss Value
Blending of Sizes	0.191	58
	0.258	31
Blending of Size and Thermal Response	0.191	69
	0.258	32

We find that a matte finish, similar in appearance to a traditional, silver halide N surface photographic paper, can be produced in the print with expandable microspheres coated in the heat-transferable over-protective layer. The measured surface topography of both prints is similar.

References

1. K. K. Lum, B. C. Campbell, and M. L. Gray, *Process for controlling the gloss of a thermal dye transfer image,* U. S. Patent 6,184,181 (2001).
2. W. H. Simpson, J. J. Hasteiter, Jr., and B. C. Campbell, *Dye-donor element with transferable protection overcoat*, U.S. Patent 6,346,502 (2002).
3. L.S. Flosenzier and J. J. Hastreiter, Jr., *Method for specifying engraving of a gravure cylinder for coatings containing particle dispersions*, U.S. Patent 6,240,844 (2001).
4. W. H. Simpson and J. J. Hastreiter, Jr., *Dye-donor element containing transferable protection overcoat*, U. S. Patent 6,362,132 (2002).

Biography

Jacob J. Hastreiter Jr. (Jake) began working in the Research Laboratories at Eastman Kodak in 1966. He is employed as a Research Technologist in the Thermal Media Laboratory of the Eastman Kodak Company Research Laboratories. He has numerous patents in the areas of silver halide photographic processing and thermal imaging. Jake received his AAS degree in Chemical Technology from Erie County Technical Institute in Buffalo, New York.