New D2T2 Photo Printing Material: Advanced Techniques and Excellent Properties

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Abstract

We have developed a new thermal photo printing paper with improved image quality and handling properties, successfully reducing environmental pollution caused during its production processes. The paper uses a laminated base paper having the same level of enhanced whiteness as film photo print paper. The multiple layers containing a heat insulation layer are coated on this paper by the application of the aqueous dispersion system developed by FUJIFILM. Compared with conventional thermal photo paper, the new paper has a better image quality (5% increase in whiteness and 20% in gloss). The new printing paper production method contributed to increasing the moisture content in the new paper, leading to reducing the surface resistance to approximately one-thousand that of previous types of printing paper and thus improving the antistatic property. This property can prevent the freshly printed sheets of thermal photo paper from sticking together, allowing for a much easier handling. The application of our coating technology based on the aqueous dispersion system has eliminated the need for using organic solvents, thereby reducing environmental pollution caused during paper manufacturing processes.

1. Introduction

The dye diffusion thermal transfer system (D2T2 system) is a photo printing paper production method and features greater convenience and the capability of producing high quality images. It has been used in many applications such as home-use printers, ID card makers, and printers for recreational purposes. To enable the heat transfer type printer head of the D2T2 system to print images efficiently, printing paper needs to have heat insulation. We have developed a new time-honored aqueous multi-layered coating technique that enabled printing paper with high heat insulation property. The new technique combined with photo-based material techniques also enabled us to offer high-quality image printing capabilities such as smooth tone reproductivity, higher maximum density, enhanced whiteness, and a high degree of luster. The printing paper is also easy to handle. This paper reports the details of our new technique as well as the printing paper.

2. Outline of the D2T2 System

This chapter explains the principle of how to create images by the D2T2 system. The D2T2 system consists of a roll of ink ribbon having different ink portions including dyes and receiver printing paper having receiver layers that receive dyes transferred from the ink ribbon. Images are created by (1) superposing a portion of the ink ribbon and printing paper and (2) heating the portion from its backside with the thermal head. Thus, the dyes in the ink portions are diffusion transferred to the receiver printing layers. The ink ribbon consists of a thin PET support layer, three ink portions (yellow, magenta, and cyan), and a surface protection layer. The three ink portions are sequentially transferred to create a color picture.

Figure 1 shows a configuration diagram of the D2T2 system. The receiver layer of the printing paper and an ink portion of the ink ribbon are superposed and sandwiched between the thermal print head (TPH) and the platen roller. Then the ink portions are heated in accordance with the image information with the thermal head to transfer the dyes to the receiver layer of the printing paper while the ink ribbon is being moved in a longitudinal direction. Printing finishes after a total of four repetitive operations (once for the transfer of the three colors, and once for the surface protection layer).

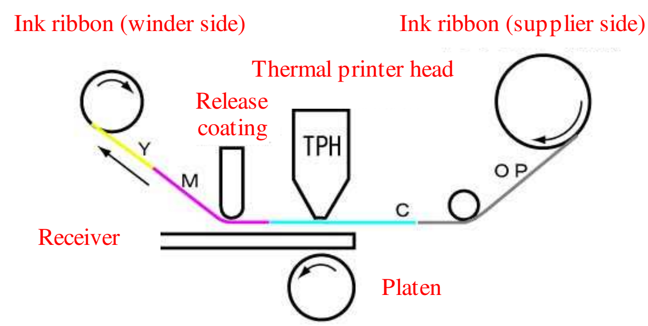

Figure 1. *Schematic diagrams of the D2T2 system*

Figure 2 shows the characteristic curves of the newly developed printing paper. The horizontal axis shows the amount of impressed force, and the vertical axis shows visual density (equivalent to the transferred amount of dye). In the figure, the parameters 0.7 ms and 2.0 ms refer to the pulse periods that correspond to high-temperature high-speed printers and low-temperature, low-speed printer, respectively.

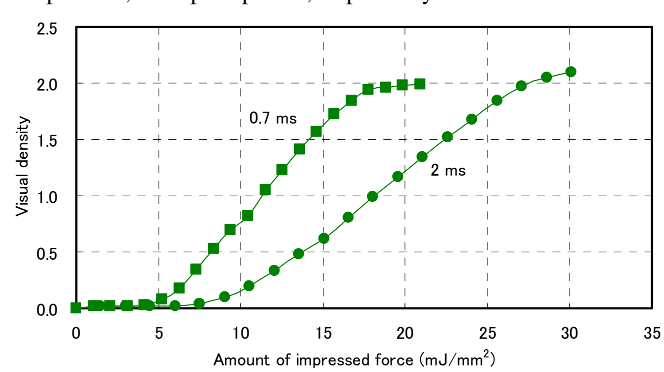

Figure 2. *Characteristic curves of the newly developed printing paper (Parameters 0.7 ms and 2.0 ms refer to pulse periods)*

3. Development of New Printing Paper

The receiver paper receives the dyes transferred from the ink ribbon to create images. Consequently, a desirable printing method needs to have higher dye transfer performance, in which as much dye as possible is transferred with the least amount of heat. To achieve higher transfer performance, you need to consider two key factors: (1) higher heat insulation that allows the heat supplied from the thermal head to be stored in the vicinity of the surface of the printing paper and (2) good acceptability to effectively receive the dyes diffused from the ink ribbon. This is why the receiver paper consists of a basic layer, insulation layer, and a receiver layer: The basic layer is coated with the insulation layer and the receiver layer. A conventional printing paper typically consists of a base layer (such as coated paper), an insulating layer of void films (such as polypropylene film containing air bubbles), and a polymer receiver layer with a high dye acceptability, which has been dissolution treated and coated in an organic solvent.

This time, we have developed a unique insulation technique and used it to design a new layer composition. We have also adopted, for the first time in the world, a multi-layer coating system, in which aqueous coating is applied to all the component layers. Our new technique virtually uses no organic solvents, thereby contributing to the reduction of environmental load. We have also succeeded in utilizing our high-precision multi-layer coating technique we have long cultivated through the production processes for silver salt photographic materials. The following details how to design the printing paper and how to implement the new technique.

3.1 Layer Composition of the New Printing Paper

Conventional printing paper consists of a base layer (coated paper), an intermediate layer of void film, and a top receiver layer formed by solvent coating. The newly developed printing paper consists of a paper base laminated with polyethylene on both sides and three layers of an intermediate layer, insulating layer, and receiver layer: The three layers are formed by aqueous multi-layer coating. Figure .3 shows the cross-section of the new receiver paper.

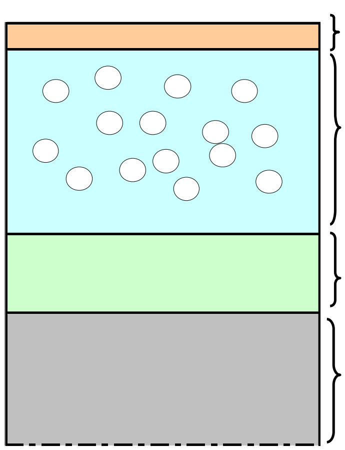

Figure 3. *Cross-sectional view of the new paper*

The properties of each layer are detailed as follows:

3.2 Receiver Layer

The receiver layer receives the dyes diffused from the ink ribbon to create pictures. The receiver layer needs to have high dye acceptability. Furthermore, the receiving polymer needs to be supplied as aqueous diffusing materials because aqueous coating liquids are used to form the receiver layer.

We looked for a material that satisfies these requirements from polymer-dispersed materials such as vinyl chloride, acrylic, and polyester materials, finding that vinyl chloride materials are best suited to the requirement. We further selected vinyl chloride-acryl acid ester copolymer material mixed with acrylic acid ester.

Figure 4 shows why the vinyl chloride-based material is preferable. The figure also reveals that the lower the glass transition temperature of the receiver polymer, the higher the transfer performance.

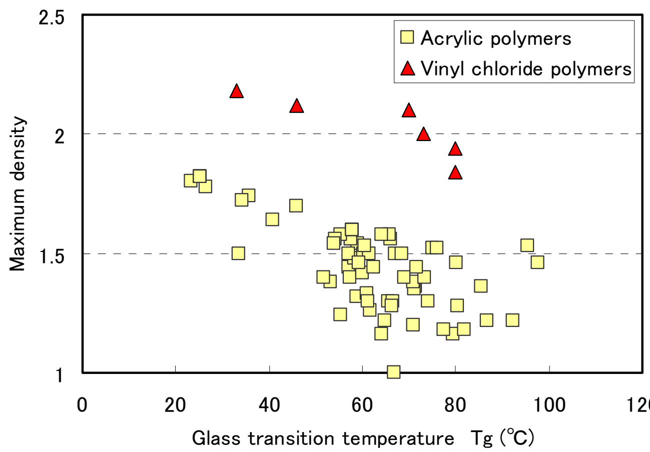

Figure 4. *Relationship between Tg and the maximum density*

Mold release capability is also required for the receiver layer. This capability refers to the property that allows the receiver layer to be detached easily after the layer and the ink ribbon are heated in a contact state. When the glass transition temperature of the receiver layer is lowered, the transfer density increases, but the mold release capability decreases, increasing the peel force between the printing paper and the ink ribbon. When the peel force increases, peel vibrations occur, generating noise or image failures such as separation lines (also called ‘sticking’ or ‘banding’).(See Photo 1) In the worst-case scenario, adhesion occurs between the receiver paper and the ink ribbon. As a result, the ink layer causes cohesive failure and is transferred to the printing paper.

We attempted to find a release agent that simultaneously satisfies the requirements for higher acceptability and mold releasing capability, eventually finding an effective fluorine-based release agent, which were then applied to the receiver layer. Figure 5 shows the effect of the added release agent. The figure shows that the force required to peel off the ink ribbon from the receiver paper after printing decreases with the increasing amount of release agent.

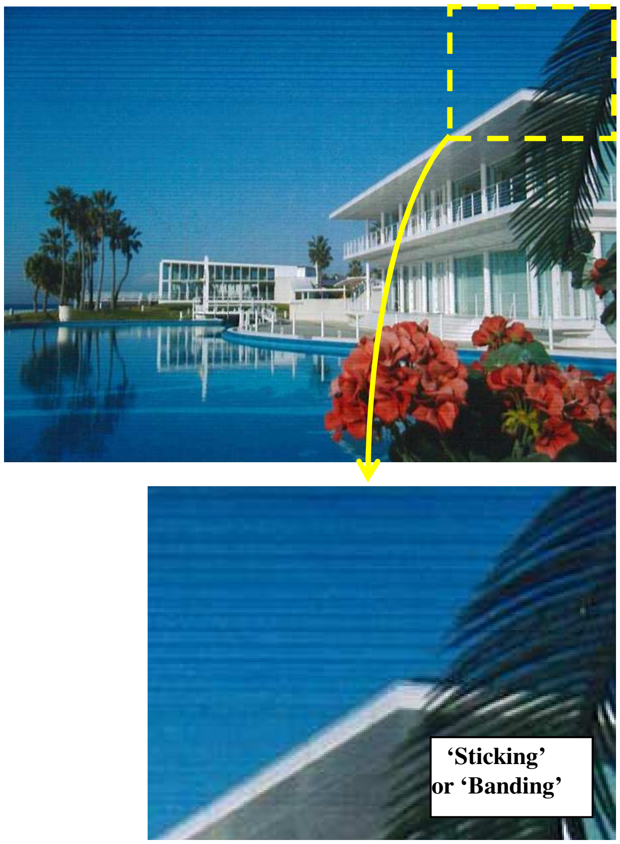

Photo 1. *Image failure example (stuck or banding)*

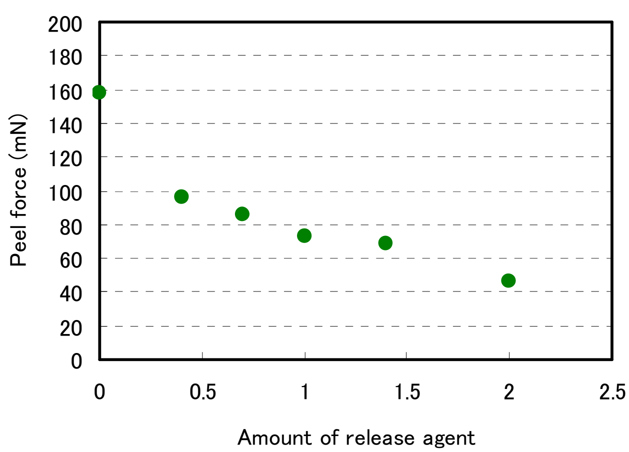

Figure 5. *Relationship between the amount of release agent and peeling force*

3.3 Heat Insulation Layer

The insulation layer is a layer that serves to prevent the heat diffusion from the thermal head and to facilitate the dye transfer from the ink ribbon to the receiver paper. The main components are hollow polymer particles and binding materials. To achieve a higher level of heat insulation, air can be used as a preferable insulation material because it has a low thermal conductivity. In conventional receiver paper, the air inside its void film serve as a heat insulator. In the new paper, we have employed hollow polymer particles that contain air in the polymer particles as a heat insulation material. The hollow polymer particles have enabled aqueous coating because they can be diffused in water. Hollow polymer particles contain water while diffused in air, whereas it forms a layer of air when dried after coating.

Figure 6 shows the relationship between the amount of holes in the insulation layer and transfer density. The amount of holes(or the amount of the air in the holes) and the transfer density increase with the increasing amount of transferred dyes.

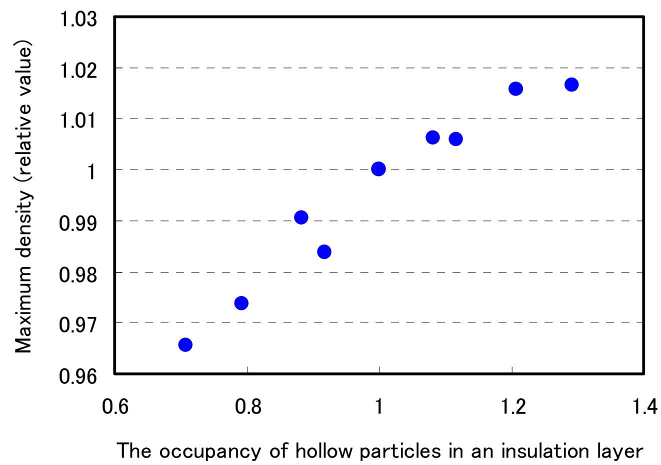

Figure 6. *Relationship between the occupancy of hollow particles and maximum transfer density*

3.4 Intermediate Layer

In the D2T2 system, the receiver layer of the printing paper and an ink portion of the ink ribbon are superposed and sandwiched between the thermal head and platen roller. They are then heated and pressurized for picture printing. In this case, the thermal head should preferably exert a slight force on the contact portion between the ink ribbon and the thermal head so that the thermal head can come in uniform and stable contact with the ink ribbon. Thus, the printing paper needs to have elasticity. The new paper has an intermediate layer mainly made of resilient SBR with a low glass transition temperature so that the printing paper can achieve this flexibility.

3.5 Base Material

The base layer of the new printing paper is made of dual-sided resin coating paper (WP paper) used as the silver salt color paper for film applications. This is because we aimed to add the same texture as that of the silver salt color paper to the D2T2 printing paper. We also aimed to add such features as whiteness, smoothness, and conductivity (electricity charging ability) to the new printing paper.

The hollow particles in the insulation layer of the printing paper serve as scattering substances, giving the printing paper a white-tinged color although the color of the paper is also affected by the color of the base material. The optimal design of the titanium dioxide, ultramarine (cyanide dye), and the fluorescent whitener included in the base material have achieved a bright, favorably yellow-less white color (see Table 1).

The paper-manufacturing techniques cultivated from the production processes of silver salt color paper as well as our polyethylene laminate processing technique have allowed us to give homogeneity to the base layer and smoothness to its surfaces. Utilization of these techniques has enabled us to develop a new printing paper with a high degree of luster that cannot be achieved by conventional coated paper-based printing paper (see Table 1).

Table 1. Comparison of whiteness and luster between our previous paper and new printing paper

	Our previous paper	New printing paper
Whiteness(ISO)	87%	92%
Luster (45°reflection ratio)	73%	92%

The back side of the base layer is coated with conductive material for anti-static purposes. This coating treatment drastically reduced surface electrical resistivity to about 1/1000 that of conventional printing paper. Conventional printing paper is easily charged and problems when taken out from the collector because its photographic paper sheets do not slide smoothly. These problems have been solved with the new printing paper.

Photo 2 shows two groups of printed pictures: one for conventional printing paper and the other for the new printing paper. The left picture (conventional printing paper) shows that no printed pictures were arranged neatly because they were electrically charged and did not slide easily. On the other hand, printed pictures were neatly arranged in the right picture (new printing paper). This feature of the new printing paper has greatly contributed to the improvement of working efficiency.

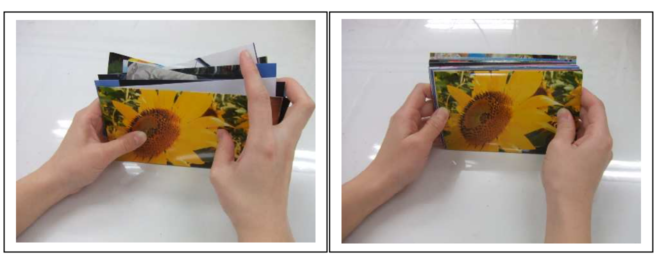

Photo 2. *Comparison of antistatic effect between conventional printing paper and the new printing paper*

4. Comparison with a Common Dry Printing System

We compared the new D2T2 material-based printing system with the IJ system, another dry printing system commonly used for photo printing applications, in terms of application aptitude.

In general, the D2T2 system features its simple system configuration and space saving. Furthermore, it excels in maintenance because its running operation is simply based on replacing the receiver paper and the ink ribbon, providing low-cost, high quality printing. Since these features of easy maintenance and convenience allow for labor-saving from the view point of system handling, the new printing system is specifically suited for KIOSK terminal devices for self-service printing or identification photograph-box applications, thus providing low-cost, high-quality printing services.

On the other hand, the IJ system is comparatively not superior to the D2T2 system in hardware cost, easy maintenance, and space-saving. The system, however, features lower material cost and high degree of freedom in printing size and is, therefore, suitable for the applications in which various paper sheet sizes are required, or a vast amount of paper sheets are printed, for example, in "mini labos."

We think these systems have their own area of application in the photo market depending on applications and types of usage. Thus, we can conclude that the development of our new printing material has enhanced the features of the D2T2 system mainly in the field of self-service printing and simultaneously provided higher quality dry printing.

5. Conclusion

We have developed a new type of D2T2 printing paper that features improved whiteness, a high degree of luster, antistatic capability, and high working efficiency. We used organic solvent-free aqueous coating liquid to form all the component layers coated on the base layer, drastically reducing the emission of environmental pollutants during printing paper production processes.

References

[1] Shigeaki Ohtani and Shigeru Shibayama, Development of FUJIFILM Quality Thermal Photo Paper: A New Thermal Photo printing Material, Proc. TDPF, pg. 66. (2009).

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