Silicone Surfactant for Waterborne Inkjet Ink

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1. Introduction

In March 2015, we celebrated our 60th year in business. At the same time, exports of our core product, Solbin, a combination of vinyl chloride and vinyl acetate copolymer resins, have been increasing in Asia, primarily for gravure ink and inkjet ink applications. Today, our entire company is driving forward with international expansion. As one part of this move, we are taking this opportunity to introduce our silicone surfactant (wetting/penetrating agent) called Silface.

Inkjet printing has spread beyond household-use, and continues to evolve in various industries, including signage, commercial printing, digital textile printing, and high-speed printing models for businesses. As a result, the range of inkjet printing media has expanded from paper that easily absorb ink, such as regular paper and inkjet printer paper, to offset printing media that do not absorb ink easily, such as art paper, coated paper, and cast paper, as well as to media that do not absorb ink at all, such as PVC, PET, and PP film.

Waterborne inkjet inks contain water, a high surface-tension vehicle, so it is difficult for the ink to wet low-surface energy substrates such as these. On the other hand, with ink vehicles that contain both water and solvents, the low-boiling point solvents will vaporize first, which will cause the ratio of water and solvents in the vehicle to change. Therefore, when printing substrates with poor absorbency, it has been shown that it is necessary to control both the surface tension and the contact angle of the solid-liquid interface during the drying process after the ink impacts the substrate.

In this article, we propose a solution to this problem using our Silface silicone surfactant.

2. Development Background

Our silicone surfactant results in excellent wetting with mixed water-organic solvent type inkjet inks, making it an inkjet ink wetting agent that contributes to excellent printability when printing on substrates with relatively low absorbency, such as PVC or coated paper. In this article, the term organic solvent refers to high-boiling point organic solvents.

Recently, attempts have been made to replace offset printing with inkjet printing. Unlike offset printing, inkjet printing methods do not require a plate, so are highly economical when it comes to printing short-runs of many different products. With standard high-grade alcohol type nonion surfactants, however, inkjet printing has trouble achieving as high a picture quality as offset printing. Therefore, a surfactant that provides excellent printability is desirable for substrates with low absorbency.

3. New Silicone Surfactant Properties

Even when the water to organic solvent ratio changes, our inkjet ink silicone type wetting agent continues to provide an excellent wetting property, allowing for excellent coloring, smoothness and high-speed printing. Given these properties, the surfactant is extremely effective in practice, particularly for mixed water-organic solvent type inkjet inks. In particular, it displays extremely good printability with no color mixing and a high print density when printing on substrates with relatively low absorbency, such as PVC and coated paper.

Figure 1 shows an image of printed dots. Here, the wetting will be poor if the contact angle of the ink droplets on the substrate (recording medium) immediately after impact is high, and a small number of dots will not be able to cover the sub-

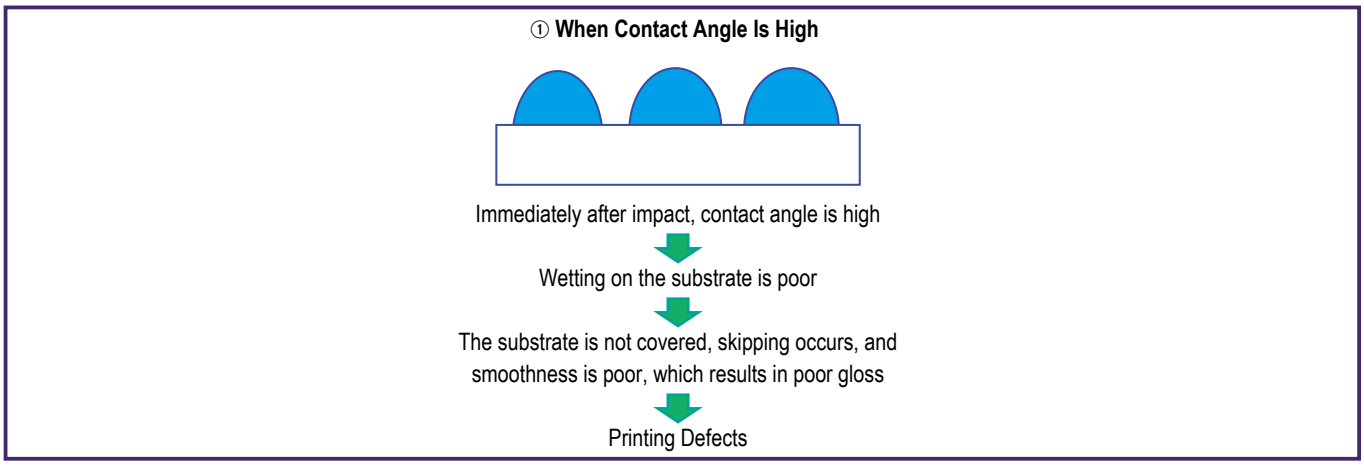


Figure 1 Contact Angle and Printing Image ①

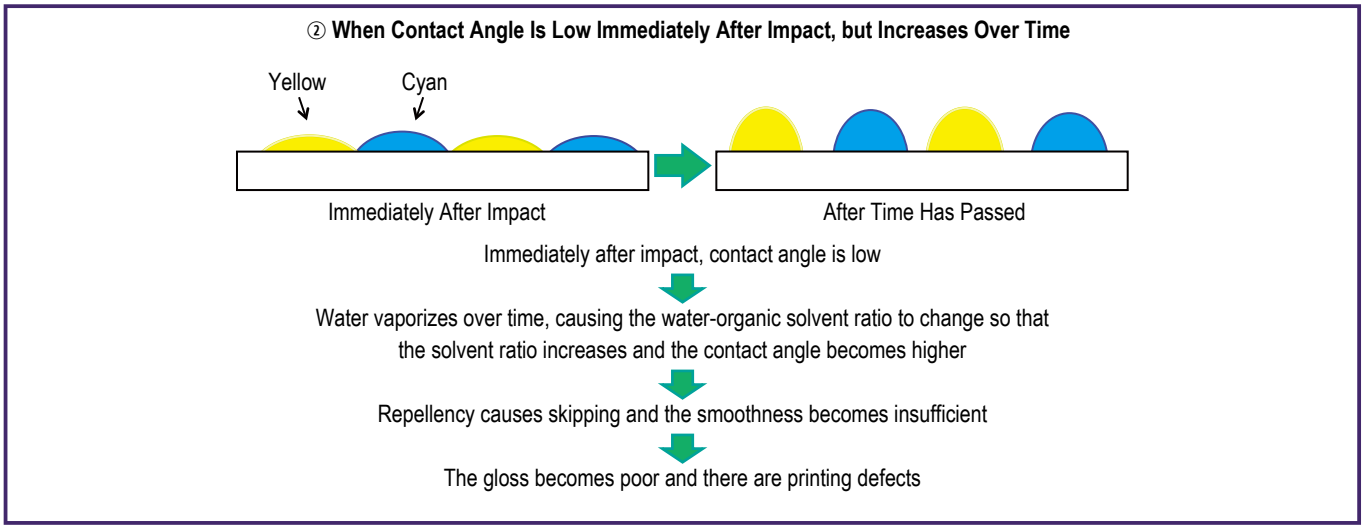


Figure 1 Contact Angle and Printing Image ②

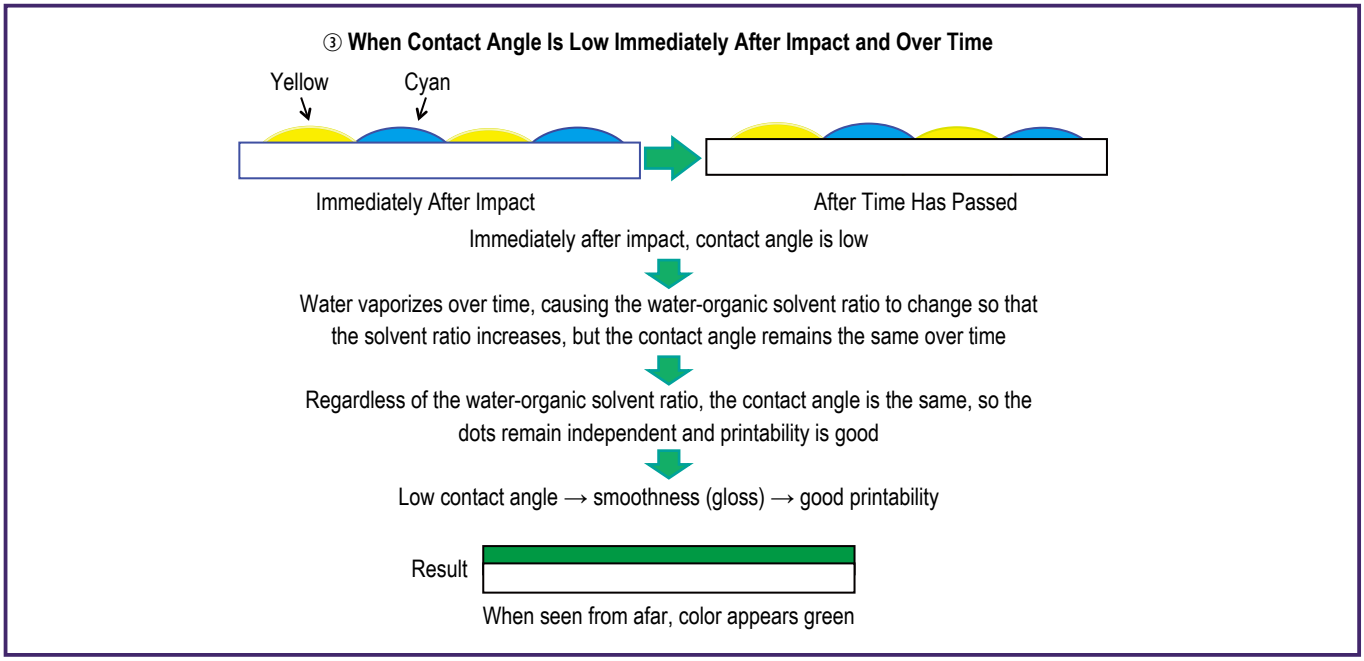


Figure 1 Contact Angle and Printing Image ③

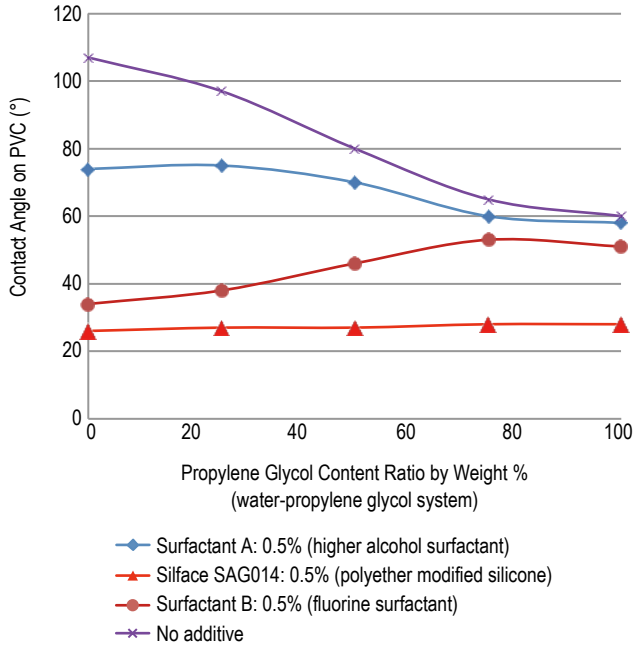


Figure 2 Relationship Between Propylene Glycol Content Weight (%) and Contact Angle

strate, which will lead to skipping. Poor smoothness means poor gloss, which results in printing defects (Fig. 1 ①).

In addition, even if the contact angle immediately after impact is low, the water in the mixed water-organic solvent system will vaporize as time passes, causing the solvent ratio to increase. As a result, the contact angle will increase, which will cause repelling, the substrate will not be coated, and we will see skipping. In addition, the smoothness will be insufficient and the gloss will be poor, which will result in printing defects (Fig. 1 ②).

Immediately after ink droplets of different colors impact the substrate (in the case of water-rich mixed water-organic solvent systems) or after a certain amount of time passes after impact (in the case of solvent-rich mixed water-organic solvent systems), as long as the ink dries in a low, stable contact angle state, the low contact angle inks of different colors will remain in an independent state, so there will be no color mixing and good smoothness will be maintained. As a result, the ink appears glossy and will appear as a single color with a good print quality when looked at from afar (when yellow and cyan dots are lined up they appear green) (Fig. 1 ③).

It is effective to add a surfactant with the physical properties shown in Figure 2 to achieve this type of performance. In Figure 2, the horizontal axis shows the ratio of propylene glycol (water-propylene glycol system) by content weight and the vertical axis shows the contact angle on PVC. The contact angle allows us to quantify the degree of wetting, where a large value indicates poor wetting and a small value indicates good wetting.

Silface SAG014 contains a balance of special hydrophobic and hydrophilic groups, so provides an excellent wetting property to both waterborne and organic solvent type inks. Therefore, regardless of the ratio of water to organic solvents, Silface SAG014 is able to provide a constant contact angle reduction effect. In other words, ① immediately after the ink droplet impacts the substrate (water-rich systems) or ② after time passes and the water has vaporized (propylene glycol-rich systems), because the printed dot contact angle is stable, each dot remains independent so that there is no color mixing when the colors are different. The coverage is also good when the color is solid. Moreover, the low contact angle means the ink becomes smooth (glossy). As a result, the ink exhibits excellent printability.

Similarly, when using ethylcellosolve as the solvent and OK Top Coated Paper (Oji Paper Co., Ltd.) as the substrate, we see good printability because Silface SAG503A provides a stable contact angle reduction effect regardless of the water to solvent ratio.

In this way, the provision of a stable contact angle reduction effect is one method for achieving good printability even when the ratio of water to organic solvents in the vehicle changes. In addition, it is important to select the appropriate type of surfactant to be added, which depends on the type of organic solvent being used. It is also important to have a fairly low value for dynamic surface tension (the surface tension as it shifts towards an equilibrium over time).

Figure 3 shows the dynamic surface tension when various surfactants are added to the vehicle (propylene glycol : water = 25 : 75) at 0.5% by weight. SAG014 results in a low dynamic surface tension, so we can assume the moment the ink droplet impacts the substrate it will have a low contact angle. In addition, SAG014 also allows the ink to wet the inkjet nozzle head appropriately, which provides stable ink jetting when the ink is

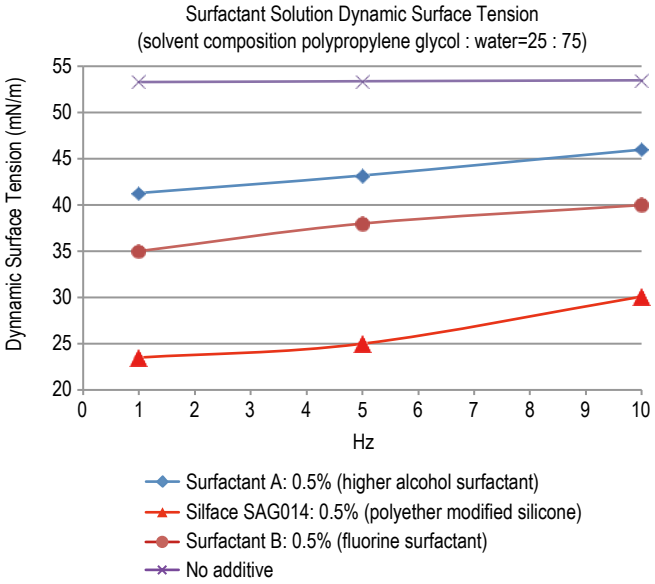
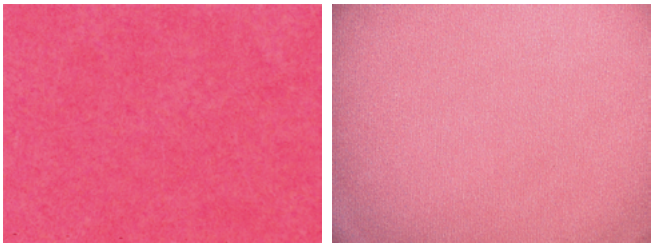


Figure 3 Dynamic Surface Tension of a Solvent Containing 25% Propylene Glycol by Weight



Silface SAG503A **Surfactant F (fluorine type)**

Figure 4 Printing Samples Using Different Surfactants (substrate: OK top coated paper, ×75 magnification)

jetted at high-frequency. As a result, the ink can be used with high-speed printing, and provides for excellent printability.

Similarly, when using ethylcellosolve as the organic solvent, Silface SAG503A results in a low dynamic surface tension, so can be used for high-speed printing and provides for excellent printability. Figure 4 shows an enlarged image of inks containing Silface SAG503A and surfactant F when inkjet printed on OK Top Coated Paper. We can see that Silface SAG503A results in less dot skipping, the print density is high, and the printability is good.

4. Closing

Ecological waterborne inkjet ink is expected to grow in the future, particularly from industrial applications. In response to the various demands for ink surface tension control, we are expanding the grades of our Silface silicone surfactant in aims of meeting the demands of the market.