A New Technology of Reusable Plate using TiO_2 Photocatalysis

Yasuharu Suda*, Toyohumi Shimada*, and Mitsuru Tabuchi*

Keywords:printing plate, reusable, imaging

Abstract: Authors build reusable printing plate having coated photo-catalysis (titanium dioxide) layer on its surface. This surface shows superhydrophilicity after UV (ultra-violet) irradiation and it functions as non-image area without "grains" found in conventional PS plates. This plate is verified to be reusable with the process of writing print image with organic compound which can be decomposed by the joint action of the photo-catalysis and UV irradiation. Images are erased and the plate recovers superhydrophilicity by UV irradiation after the print job. Discussion also covers several optical writing methods such as ink-jet, UV, and IR (infrared).

Introduction

There is an argument about comparison between Computer to Plate and Computer to Press. However, when the Reusable Plate Technology is added to the Computer to Press, this argument will come to an end. The Reusable Plate Technology realizes a short delivery and flexible production schedule in addition to non-plate-change, reduction of make-ready time, cost reduction of short run printing.

Characteristics of Titanium Dioxide (TiO_2) Photocatalysis

Titanium dioxide (TiO_2) is known as an excellent photocatalysis. There exists two distinct photo-induced effect on TiO_2 surface irradiated by ultra-violet (UV) light.

---

*Mitsubishi Heavy Industries, LTD.

Photocatalytic decomposition of organic compounds

Firstly, TiO_2 breaks down organic compounds photocatalytically under UV irradiation. Because TiO_2 is a semiconductor with a band gap of about 3.0eV, UV light with wavelengths shorter than 400nm can excite pairs of electrons and holes. The photogenerated electrons react with oxygen molecules (O_2) to produce ・O_2^- radical anions, and the photogenerated holes react with water to produce ・OH radicals (Figure 1). These two types of radicals act to decompose organic compounds.

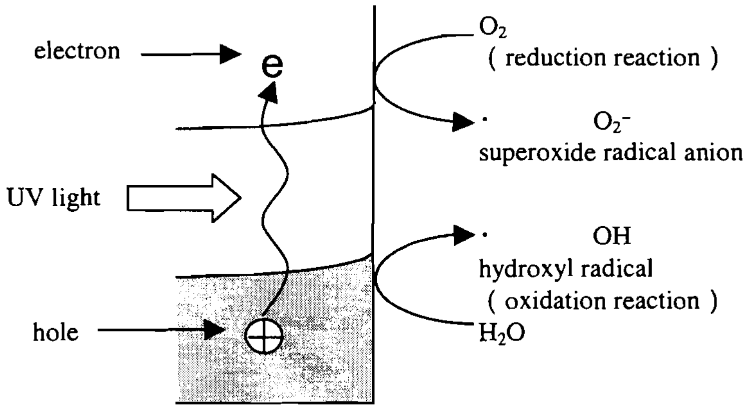


Figure 1. Mechanism of photocatalytic reaction

Photo-induced hydrophilicity

The second effect, photo-induced hydrophilicity, was discovered in 1995[1)]. When UV is irradiated to TiO_2 surface, water drop on the surface spreads. The longer TiO_2 surface is irradiated by UV light, the smaller the contact angle of water becomes, and the contact angle finally approaches zero. This high wettability of TiO_2 surface is called "superhydrophilicity". Though this superhydrophilic surface is maintained for a few hours to about a week even if UV irradiation is stopped. After that, the contact angle increases gradually, and finally, it will return to the hydrophobicity before UV irradiation. However, after reconversion from superhydrophilicity to hydrophobicity, the superhydrophilicity will be recovered again by UV irradiation. The mechanism shown in Figure 2 is proposed for this superhydrophilicity[2)]. Thus, surface O^{2-} anions are oxidized by holes and transformed from the anions to oxygen atoms.

The oxygen atoms are ejected, creating oxygen vacancies. Simultaneously, Ti^{4+} cations are reduced toTi^{3+} state by electrons. Also, water molecules in gas phase occupy these oxygen vacancies, forming surface hydroxyls, which make the TiO_2 surface hydrophilic.

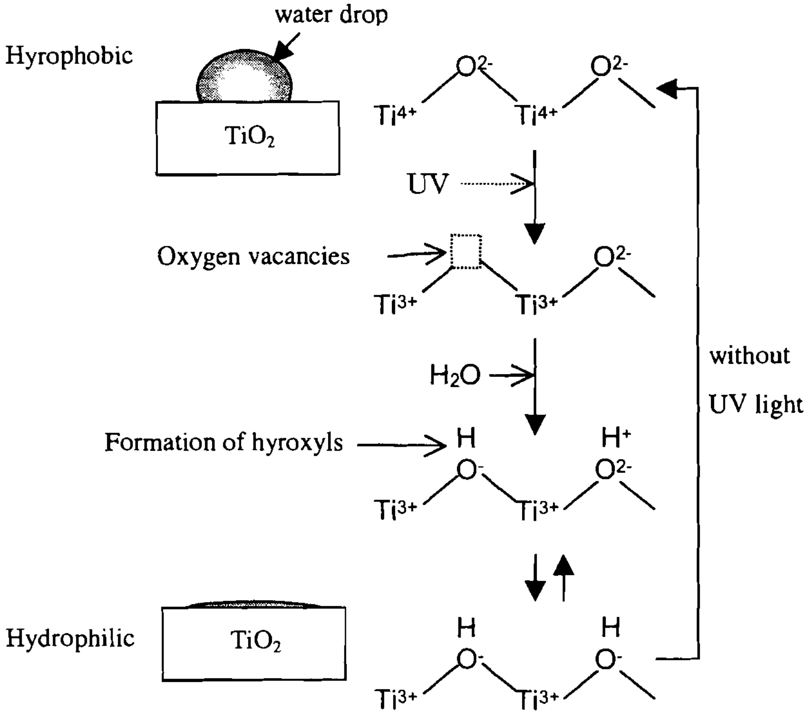


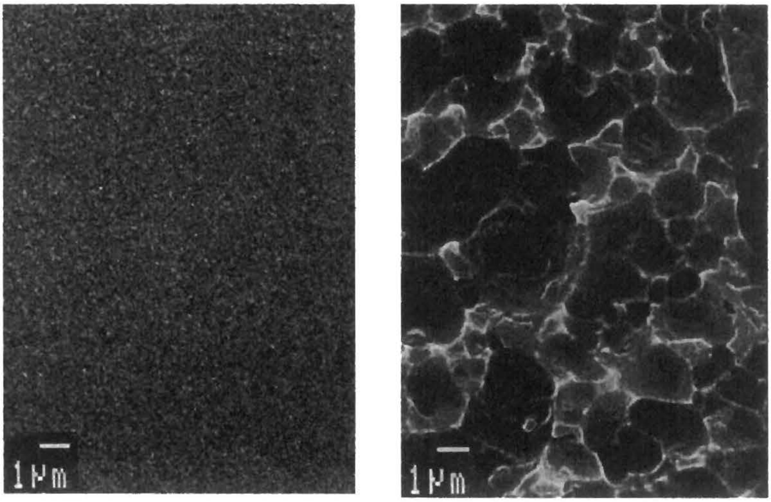
Figure 2. Mechanism of photo-induced hydrophilicity

Application to Reusable Plate

Though the photocatalytic decomposition essentially differs from the photo-induced hydrophilicity, these two phenomena can take place simultaneously on the same TiO_2 surface. The authors directed their attention to these phenomena and examined the application of TiO_2 to the reusable plate.

Concept of TiO_2 reusable plate

As previously described, the reconversion from hydrophilicity to hydrophobicity takes place if we leave TiO_2 plates without UV irradiation. However, it is found that the reconversion on the TiO_2 surface is not practical in plate making, since the reconversion takes a long time. So, the authors applied organic compound that can be easily decomposed by TiO_2 photocatalysis to make the TiO_2 surface hydrophobic for a short period of time. The surface coated with this organic compound becomes hydrophobic and it functions as image area. The surface irradiated by UV light becomes superhydrophilic and it functions as non-image area without "grains" found in conventional PS plates. Figure 3 shows scanning electron microscopy (SEM) photographs of TiO_2 plate and PS plate.



a)non-image area of TiO_2 plate b)non-image area of PS plate
Figure3. SEM photographs of TiO_2 plate and PS plate

Images that consists of the organic compound are erased and the plate recovers superhydrophilicity by UV irradiation after the print job.

The following three imaging methods are considered to form the print image on TiO_2 plate surface by using the organic compound.

1) Imaging method by UV irradiation
Figure 4 shows the flow chart for the plate making by the UV irradiation. First, coat the organic compound on the entire plate surface after making the superhydrophilicity by UV illumination on the entire plate surface. Also, adhere or react the organic compound to the plate surface by heating if required. Next, image the non-image area with UV light. The organic compound on the surface irradiated by the UV is decomposed by the photocatalysis and the

superhydrophilic surface appears, while the organic compound exists on the surface where the UV is not irradiated to show the hydrophobicity. The plate surface forms the hydrophobic image area and the superhydrophilic non-image area, thus starting the printing. After printing and cleaning the ink on the plate surface, decompose the organic compound that forms the image area and recover the superhydrophilicity. The plate is prepared again by coating the organic compound on this superhydrophilic surface.

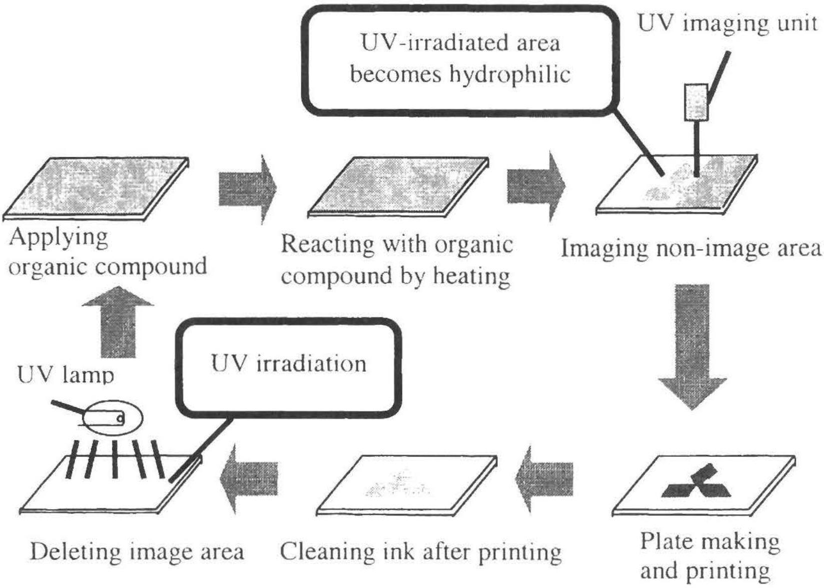


Figure 4. Plate making flow by UV irradiation imaging

2) Imaging methdo by "ink-jet"
Figure 5 shows the flow chart for the plate making by ink-jet imaging. First, image with the ink-jet head using the organic compound after the superhydrophilicity is made by UV illumination on the entire plate surface. After that, adhere or react the organic compound to the plate by heating if required. As a result, the plate surface forms the hydrophobic image area and the superhydrophilic non-image area, thus starting the printing.

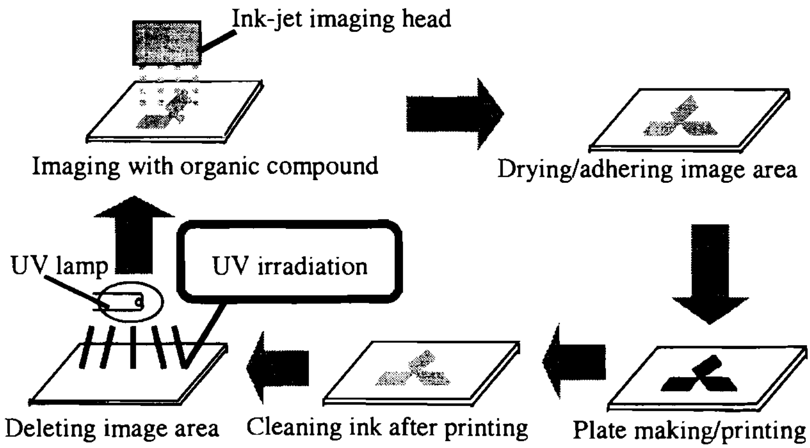


Figure 5. Plate making flow by ink-jet imaging

After printing and cleaning the ink on the plate surface as well as the UV imaging method, recover the superhydrophilicity of plate surface by UV irradiation. The plate can be reused by imaging with the ink-jet on this superhydrophilic surface.

3) Imaging method by infrared (IR) laser
Figure 6 shows the flow chart of plate making by IR imaging method. First, coat the organic compound on the entire plate surface after the superhydrophilicity is made by UV illumination on the entire plate surface. At this time, the organic compound does not react or adhere to the plate surface. Next, the organic compound in the image area is heated by IR laser beam to adhere to the plate surface.

After that, the organic compound on the non-image area is eliminated by ink tack or cleaning with fountain solution before starting the printing. The plate surface forms the hydrophobic image area and the superhydrophilic non-image area.

After printing and cleaning the ink on the plate surface, the organic compound that forms the image area is decomposed by UV irradiation and the superhydrophilicity on TiO_2 plate surface is also recovered. The plate can be reused by coating the organic compound on this superhydrophilic surface.

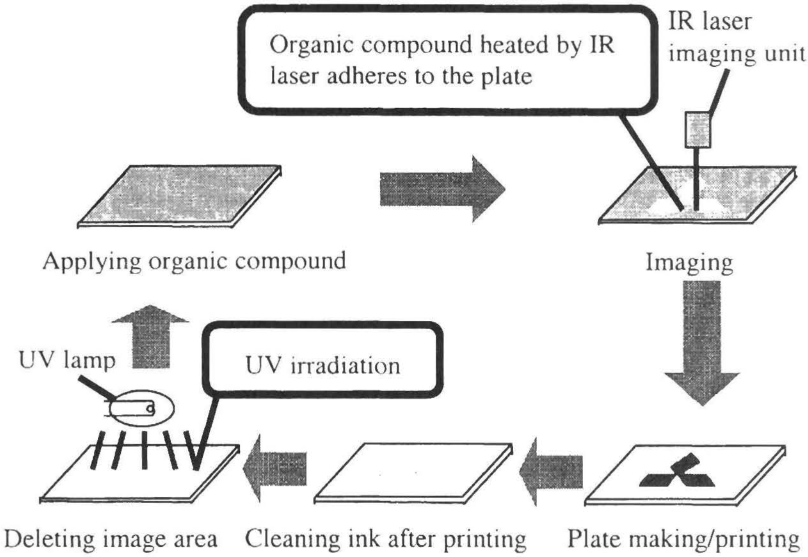


Figure 6. Plate making flow by IR imaging method

Verification of Reusability

Verification of the principle

Figure 7 shows the test results that verified the principle that TiO_2 plate is reusable. First, the plate surface exhibits the hydrophobicity that the contact angle of water is 80°or more by coating and heating the organic compound. After that, the contact angle of water on the plate surface becomes 10°or less by UV irradiation. Thus the hydrophobic plate surface is converted into hudrophilic surface by UV light. Next, the hydrophilic surface is reconverted into hydrophobic surface by coating organic compound. Then, pairs of conversion and reconversion can be repeated 50 times. As a result, when TiO_2 is applied to the reusable plate, it is shown that the plate can be reused of 50 times.

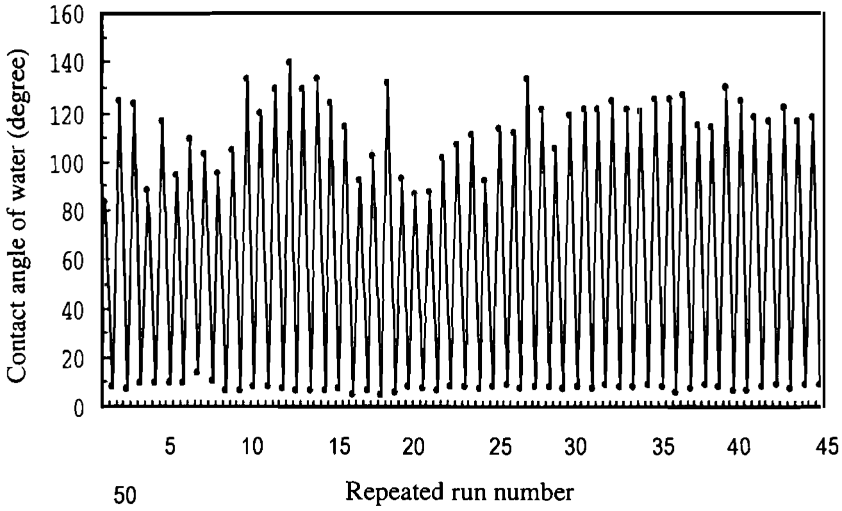
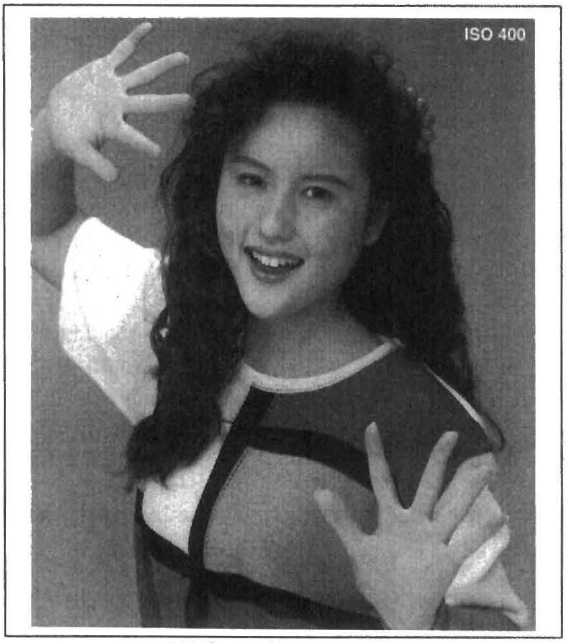


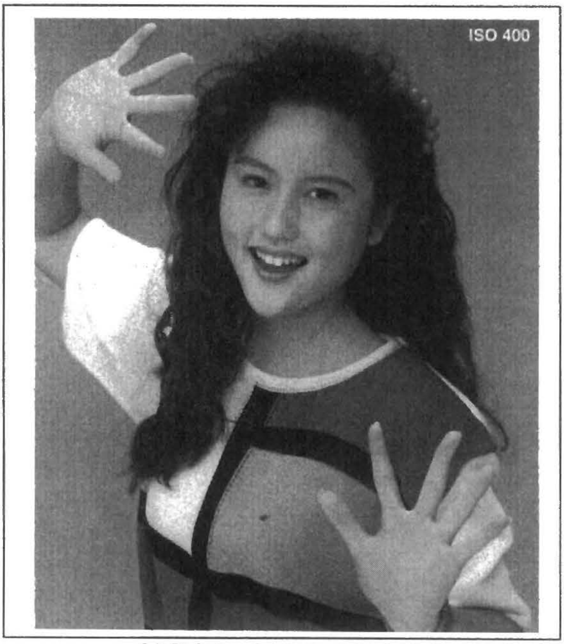
Figure7. Reusability of TiO_2 plate

Verification of reusability by printing

Next, the printing has been actually performed to check the reusability of TiO_2 plate. First, the entire plate surface was made to the superhydrophilicity of contact angle of water of 10°or less by UV illumination on TiO_2 plate surface. Next, after coating the organic compound to the plate, it is mounted to Mitsubishi sheet-fed press and the plate is imaged with IR laser beam of wave length 830nm. After that, when the printing is started, the organic compound on the non-image area is removed by ink tack and the image appeared (Figure 8-a). After the printing is finished, the ink on the plate is washed with washing agent and the UV is irradiated. At this time, entire TiO_2 plate surface was made to the contact angle of water of 10°or less. Then, after coating the organic compound we can start second plate-making similarly. Figure 8-b shows the image that was printed by reused TiO_2 plate. The plate reusability was verified.



a) Print using new plate



b) Print using reused plate

Figure 8. Printing samples for new plate and reused plate

Conclusions

In this research, the authors have prepared the printing plate coated with TiO_2 photocatalysis and performed verification about the reusability of this plate. As a result, the followings are cleared.

1) TiO_2 surface after UV irradiation shows superhydrophilicity and it functions as non-image area without "grains" found on PS plate surface.
2) It has been verified that TiO_2 plate can be used for printing by forming the image area using organic compound that can be decomposed with the action of photocatalisis by UV irradiation.
3) The superhydrophilicity of plate surface could be recovered by decomposing the organic compound in image area under UV illumination after cleaning the ink on the plate surface. Also, this TiO_2 plate has been used for the next printing and a clear image was obtained. Thus, it has been verified that TiO_2 plate is reusable.

Also, the authors have reviewed the following three imaging methods.

· Ink-jet is simplest.

· UV imaging gives high image quality though the imaging device is expensive.

· IR imaging can be realized by the combination of current technologies.

Reference

1) Fujishima, A., Rao, T. N., Tryk, D. A. "Titanium dioxide photocatalysis" J. Photochemistry and Photobiology (2000) Vol. 1, No. 1, pp.1-21.

2) Fujishima, A. Engineering Materials (1997) Vol. 45, No. 10, pp. 26-30.