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Water Based Green Lithography

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Abstract

Environmental friendly materials have aroused great attention. Lithography printing takes the most important position in traditional printing industry. So far, it is still a great challenge for lithography printing to use water based inks for mass production. Here we report the integration of green plate, green plate-making technology and water based ink to achieve water based lithography. The main problem is how to get a clear hydrophilic and hydrophobic area discrepancy on the printing plate. The key is to control the surface energy in micro-area on the printing plate. Nano materials have been developed to achieve this water based lithography.

Keywords

Lithography, Green plate-making technology, Nano-materials, Water based ink

Introduction

Environmental protection has been of considerable challenge in recent years. A primary pollution source of printing industry is the volatile organic solvent of printing ink. Although now water based ink has been used in gravure or flexography, the cost of plate-making for gravure or flexography is much higher than lithography. However, most high-volume books and magazines have been printed with offset lithography, which has become the common form of printing technology since the 1960s. The printing ink used in lithography is mainly solvent-based ink with high viscosity. The traditional printing plate is made up of disposed alumina plate coated with photosensitive materials, after exposing and being developed by chemicals the image-text areas on the plate are hydrophobic and the blank areas are hydrophilic. While printing with water based ink, all the printing plate will stain with the ink so the current used printing plate cannot be used to print with water based ink. Water based green lithography here generally means lithography using water based ink. The technology is composed by three green processes called as green plate, green plate-making and water based ink shown in Fig. 1. This new technique is of great significance as well as great challenges. The key problems include the cooperation of water based ink with printing plate, and the printing machine is also needed modified accordingly. The lithography printing machine has some rubber rollers to transfer printing ink, while for water based ink too many rollers will cause the ink transfer from oil-in-water to water-in-oil and adhere to the rollers.

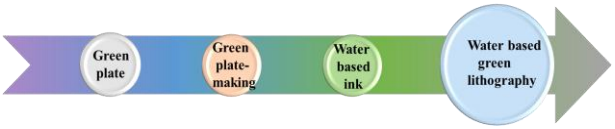

Figure 1. Process of water based green lithography

Results and discussion

Green plate substrate making

As it is known in traditional lithography, the aluminum printing plate should be disposed with electrolysis and anodic oxidation firstly before coating photosensitive materials. The electrolytic and anodic process of the plate results in waste acid discharge, and then the plate should be cleaned with alkali solution. Green plate prepared by coating nanoparticle materials instead of the chemical disposal. For the coating materials of the plate, nano-size latex particles were used to adjust the surface roughness on the plate and the contrast between hydrophilic and hydrophobic areas. The optimization of the nanoparticles in coating materials has gotten good coating surface without cracks (Fig. 2). The green plate in water based lithography is prepared by coating hydrophobic nano-materials on the cleaned aluminum plate without any chemical disposal, and the image area is inkjet printed with hydrophilic materials which can absorb water based ink.

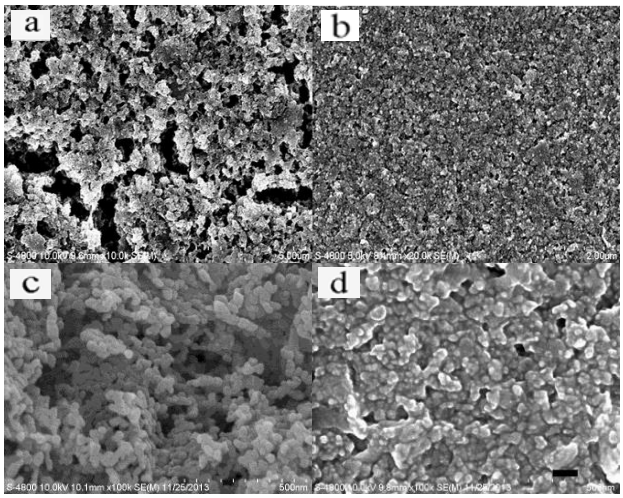

Figure 2. SEM image of a) nano-particles with instability, cracks appeared on the coating; b) nano-particles with good stability, no cracks appeared on the coating; c) and d) good coating surface, Scale bar: 100 nm.

The key points in green plate manufacture include good stability, good adhesion of the coating materials and good dispersivity of the nano-particles. For example, the particle size distribution of Fig. 3 made the printing product get worse (as shown in Fig. 4). The reason was too many large particles in the coating materials could not get proper balance between hydrophilic and hydrophobic area.

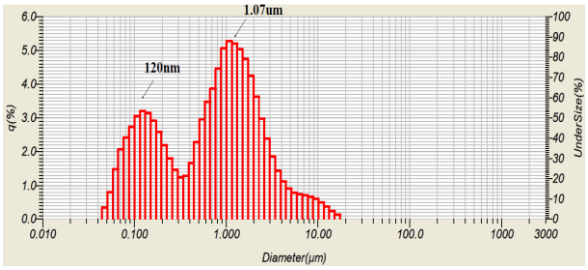

Figure 3. Poor particle size distribution image by Laser Scattering Analyzer

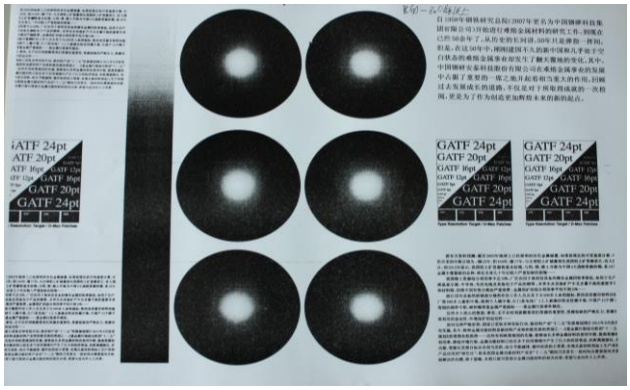

Figure 4. Printing product with poor dispersivity

After adjusting the component of the coating materials and the dispersing condition, the dispersivity were improved as Fig. 5. The large particles decreased and the small size particles got the prevail position in Fig. 5. Accordingly, a better printing result was achieved in Fig. 6.

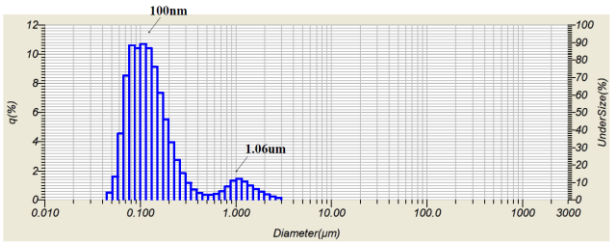

Figure 5. Good particle size distribution image by Laser Scattering Analyzer

Figure 6. Printing product with good dispersivity

With the green plate above we still cannot transfer the information from the computer to the paper or other media. The transfer process for mass production needs plate-making and printing machine. Besides the disposal of plate without pollution of organic solvents, in water based lithography the plate-making process has also been changed. Inkjet printing method was used for plate-making. Ink jet printing has aroused research interests with many virtues as non-contact, easily control and low cost. Based on the collaboration of inkjet printing and nano-materials a new plate-making method has been developed. [1].

Green plate-making technology

Green plate-making technology reduced the pollution by using ink jet printing instead of chemical disposal of traditional printing plate [1]. The technology combined the virtues of nano-materials and inkjet printing technology as shown in Fig. 7 [2-4].

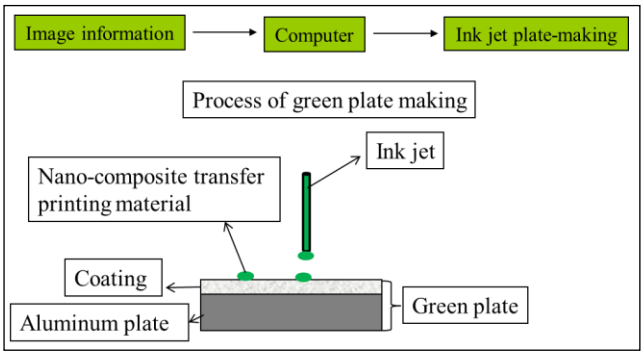

Figure 7. Key factors in Green plate-making technology

Nano-materials were applied in jet ink (seen in Fig. 8) and the coating of the plate as mentioned above, which can enhance the adhesive ability of the inkjet droplets. The jet ink was made up of nano-materials, polymer, surfactant and solvent named nano-composite transfer printing material. As Paul said, jet ink properties should match to the performance of a specific printer [5]. The composite materials usually have viscosity under 2cP and surface tension about 35 $mN{\cdot}m^{-1}$. The ingredients which affected the image resolution and press life of print plate in green plate-making technology include concentration of the selected polymer, the surface tension, size of nano-particles, surface roughness, dispersivity of the nano-particles etc.

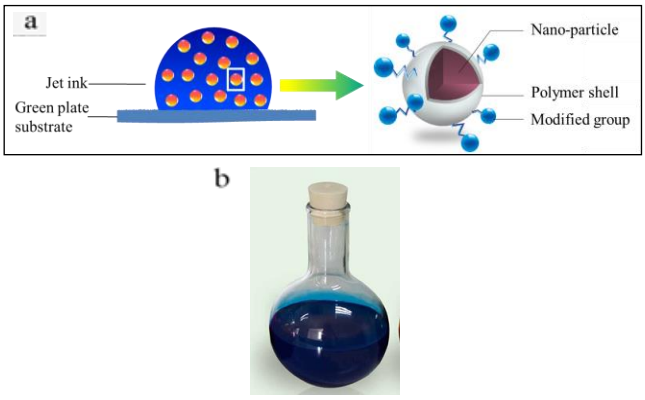

Figure 8. a) Nano-particle and b) nano-composite transfer printing materials in inkjet droplet

Specifically, the higher concentration of the polymer in jet ink usually made the ink have higher viscosity. With the increasing viscosity, the diameter of the ink jet droplets decreased. Smaller

droplets improved the resolution of the printing plate. Surface tension of the jet ink affected the spreading of the droplets on the same plate. Ink with high surface tension also limited the spread of the droplets. The press life of print plate was affected by the size of nano-particles in plate-making jet ink. The proper size was about 80 nm. The surface roughness of green plate was responsible for the sharpness of the resolution. Water-ink balance was also decided by the surface roughness of green plate. Besides the nano-composite transfer printing material, printing plate was another important composition of the technology.

The printing plate was prepared by jet nano-composite transfer printing material (act as plate-making ink) to the green plate. The coating materials on the green plate formed micro- and nano-structure to control the wettability of the jet ink. After the image was transferred onto the plate, the plate was heated for several minutes to enhance the adhesion of the droplets on the substrate. The printing plate and printing product were shown in Fig. 9.

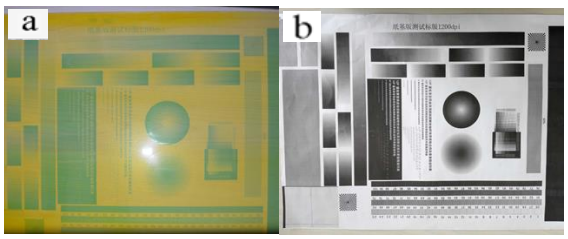

Figure 9. Printing plate and printing sample in green plate-making technology, a) Printing plate b) printing product

Besides nano-composite transfer printing material and printing plates, a new plate-making machine has also been investigated and developed. The machine has good stability and resolution for the mass production as seen in Fig. 10. The design of the machine was for automatically manufacture of printing plate. The operation of the machine was safe and convenient.

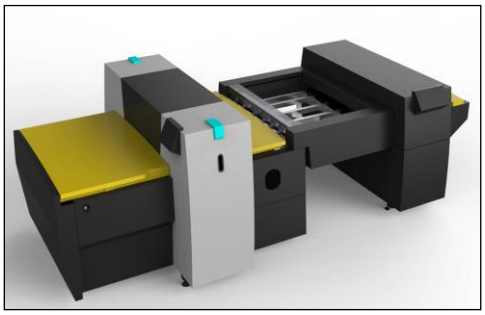

Figure 10. Plate-making machine in green plate-making technology

Without chemical disposal process as exposing and developing with alkali solution, the new technology has many advantages such as simple process, operation without darkroom, and totally environmental friendly as well as low cost. The plate for printing has image area which has an affinity for water based ink, while the non-image area can resist ink when water based ink was used in printing. The critical problem is the balance point between oil and water during printing process. The water based ink used in water based lithography is different from the common used one in gravure or flexography. It should be modulated according to the chemical composition on the printing plate.

Water based ink

Most of the water based ink used as printing ink in the market has characters as low viscosity and hard to dry. All these properties have a negative effect on the quality of water based lithography. High quality and resolution printing product needs controllable interaction between printing ink and the printing plate. The important variables of water based ink associated with viscosity, surface tension and ink miscibility [6]. For water based printing ink, it should be firstly adhered to the printing plate. Then the ink separated from the printing plate to the media as paper or plastic easily.

The viscosity of water based ink played key role in the printing process. The ingredients which can affect the viscosity include temperature, shearing rate and polymers have been investigated. From Fig. 11, Fig. 12 and Fig.13 it can be seen the difference between new water based lithography ink and ordinary lithography inks. The viscosity of water based ink was lower than the lithography ink and remained with the increasing of the temperature. But the viscosity of lithography ink has decreased dramatically with the higher temperature (Fig. 11).

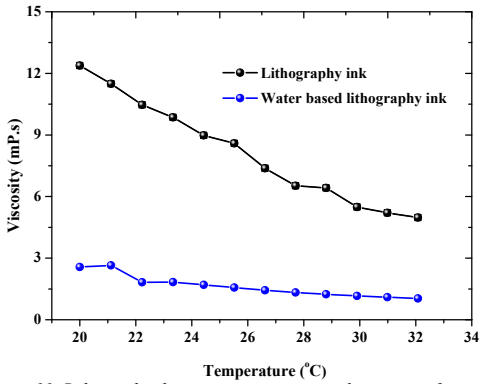

Figure 11. Relationship between temperature and viscosity of two inks

The higher shearing rate caused the viscosity reduced for all the two inks. From Fig. 12 it can be seen the lithography ink has higher viscosity than the water based ink.

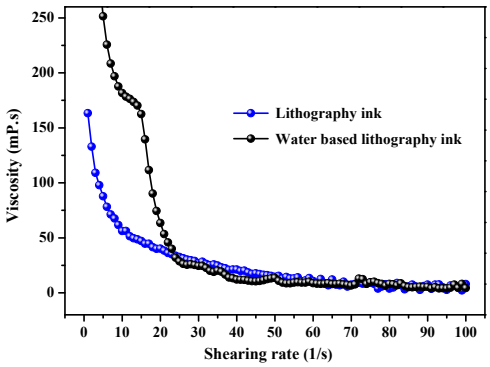

Figure 12. Relationship between shearing rate and viscosity of two inks

Different polymers have been used separately in the ink. Although under the same concentration the viscosity differed from each other with the increasing temperature.

With the green plate, green plate-making and water based ink the water based lithography also need a modified machine for the application in mass production.

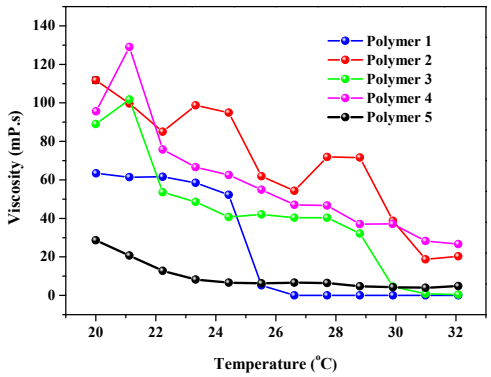

Figure 13. Relationship between temperature and viscosity of different polymers

Water based lithography machine

For water based lithography the traditional printing machine cannot be used because the water-oil balances adjusting system. A new printing machine was developed to accomplish the printing process (Fig. 14). The machine has shortened the ink transfer length and selected the roller made with proper materials for the printing process.

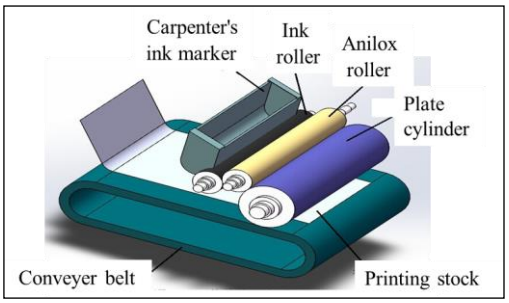

Figure 14. Printing machine for water based lithography

In summary, water based lithography was developed for green printing process. The new technology combined green plate, green plate-making, new water based ink and modified printing machine. With the technology the aluminum plate need not electrolysis and anodic oxidation but coated with nano-materials, which has the same printability as the conventional plate, without pollution or materials waste. With green plate-making method there is no exposing, developing, and fixing process, and without discharging of waste acid and alkali solution. During the printing process water based ink is used instead of solvent printing ink, which avoids the discharging of VOC. This water based green lithography is totally environmental friendly, which will shed a light on the sustainable development of printing industry.

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Author Biography

Haihua Zhou received her BS in chemistry from Shandong Normal University in 1997. She conducted research on photosensitive printing materials and received her PhD degree from Beijing Normal University, China, in 2008. Since then she has been working with Prof. Song at Institute of Chemistry, Chinese Academy of Sciences since 2008. Her work has focused on the fundamental research about green printing materials and other functional materials for printing electronics.

Yanlin Song is a professor in the Institute of Chemistry, Chinese Academy of Sciences (ICCAS) and University of Chinese Academy of Sciences (UCAS); Distinguished Young scholar and Chang Jiang scholar. Prof. Song was born in 1969. He received his Ph.D. degree from the Department of Chemistry at Peking University in 1996. Then he conducted research as a postdoctoral fellow in the Department of Chemistry of Tsinghua University from 1996 to 1998. He has been working at Institute of Chemistry Chinese Academy of Sciences (ICCAS) since 1998. His research interests include nano-materials and green-printing technology, printed electrics and photonics, fabrication and applications of photonic crystals. He has published more than 300 academic papers in scientific journals, 2 book and 8 chapters, and has been granted more than 100 patents from China, USA, European Union, Japan and Korea, etc.