Green Plate Making Technology based on Nano-Materials

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Abstract

Printing is one of the industries that have great impact on China's economy. At present, laser typesetting technology, a technology that mainly relied on photosensitive, still takes a leading position in China's printing industry. The laser typesetting technology requires complex processes such as exposure, development, photographic fixing, and processing, which results in the high cost and time-consuming problem, as well as serious environmental pollution due to the chemical washing process. In order to reduce such pollution, the green plate making technology based on nano-materials has been developed. The plate making process is to jet the nano-composite transfer printing materials on super hydrophilic print plate with special nano- and micro-structure. The technology has many advantages such as convenience, environmental friendly and low cost. In this paper, the research results of the nano-composite material and the print plate are presented.

Print has been developed with the growth of civilization [1]. At present, laser typesetting technology has been widely used in China's printing industry which relies on photosensitive materials with complex processes [2, 3]. The processes include two steps: transferring the images to the films and then films to the print plates. The transfer steps are mainly based on the photosensitive image mechanism. Both the films and print plates need exposure and development processes. After exposure and development, the photosensitive materials in the non-image area of the films and the print plates are wasted. The wasted photosensitive materials and alkali development solution have caused serious environmental pollution. Currently, the annual chemical discharge from printing industry in China has reached hundreds of thousands of tons, containing hundreds of tons of silver and tens of tons of aluminum [4].

Inspired by the research of information storage, we think the traditional information recording mode could also be translated to the digital mode of “0” and “1”. As far as the printing process is concerned, the display of surface properties can be exactly defined by two opposite areas, one is the image area (ink receptive, “1”) and the other is the non-image area (ink rejective, “0”). Based on this idea, we put forward a kind of photo stable plate making technology, which is pollution free and low cost. This process was realized through the control of the interfacial properties between the nano-composite transfer printing materials and the plate with different nano-scale roughness. Thus, green plate making technology is achieved. The green plate making technology takes advantage of inkjet technology, which has been used in many fields, such as radio frequency identification (short for RFID), electronics, printing biomedical materials, conductive silver patterns and pyroelectric effects [5-9]. The oleophilic image is formed by jetting the nano-composite transfer printing material onto the super hydrophilic print plate. In order to control the wetting and dewetting characters of the nano-composite material, the print plate is modified by super hydrophilic material. This manuscript will focus on the nano-composite transfer printing material and the printing plate, which are key factors to print resolution and press life.

Nano-composite transfer printing material used as jet ink was prepared by mixing polymers, nano-particles, and additives under room temperature while violent stirring. One typical composite for the nano-composite transfer printing material includes 10 wt% polyacrylic resin, 1 wt% nano-silicon dioxide, 0.5 wt% cationic fixing agent and ethanol. The resulting mixture was filtered through micro-filtration membrane. The diameter of the remaining particles must be no more than 200 nm. Parameters such as surface tension, viscosity, and concentration of nano-composite transfer printing material are important factors for the spread of the material on the plate.

Surface tension was important for controlling the spread of the material in plate making. The proper surface tension for jet ink was about 35 $mN \cdot m^{-1}$[10]. Surface tension of the nano-composite transfer printing material should match the performance of a specific printer. Unless stated otherwise, the surface tension reported in this paper was performed on OCA 20 dataphysics from Germany at ambient temperature.

The spread of the nano-composite material was important for the resolution of the print plate, which was closed related to its wetting and dewetting behavior. The nano-composite transfer printing material was jetted on the aluminum plate by a 1μl injector. Different polymers were used to find the relationship between the surface tension and the spread radius of dot.

From Fig.1, it can be seen that with the increase of the surface tension of the nano-composite transfer printing material the radius of dot decreased. The result was consistent with the result predicted by Yang equation:

$$\gamma_s - \gamma_1 = \gamma_2 \cos\theta \qquad (1)$$

$$\cos\theta = \frac{\gamma_s - \gamma_1}{\gamma_2} \qquad (2)$$

Where γ_s is the surface energy of aluminum, θ is the water contact angle, γ_1 is the surface tension between aluminum surface and nano-composite transfer material, and γ_2 is the surface tension between nano-composite material and air. As γ_s and γ_1 kept constant, θ would increase when γ_2 increased. Thus the spread of the nano-composite transfer material could be well controlled.

Viscosity was also a key character of inkjet ink. According to the standards of inkjet technology, the viscosity of jet ink should be about 2 cP. Viscosity of the nano-composite transfer printing material was measured by rotational viscometer (Shanghai, China). The viscosity influences the spread of the nano-composite transfer printing material on the plate, which is related to the properties and concentration of polymers and additives. By controlling the spread of nano-composite transfer material, the print resolution

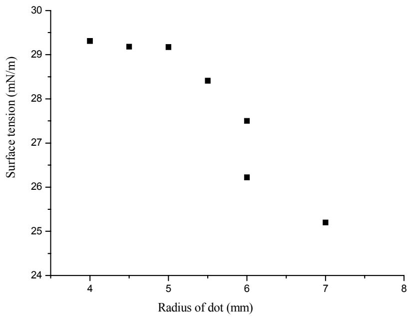

Fig. 1 Effect of surface tension on spread radius.

could be regulated. Because the spread of nano-composite transfer material will result in large dot on the print plate. Large dot means low resolution. And with the increase of viscosity the spread of nano-composite transfer material will be controlled. So the dot on the plate becomes small. Then the resolution is improved.

The print plate was the aluminum plate treated by electrolysis and anodic oxidation to form nano- and micro-structures. The proper electrolysis and anodic oxidation conditions have been studied. Water contact angle was measured by OCA 20 dataphysics from Germany at room temperature. Surface roughness was measured by Surtronic 25 from Taylor Hobson Ltd, England. Nano- and micro-structures on the print plate played key roles in the interface characters, press life, and print resolution. The results of Fig.2 reveal that low current density causes less nano-hole than high current density does during anodic oxidation process. Thus under higher temperature the anodic oxidation solution could fabricate more nano-holes. The nano- and micro-structure of the substrate is closely related with the wettability of interface, which greatly influences the print resolution. Typically, the water contact angle was controlled below 10 degree.

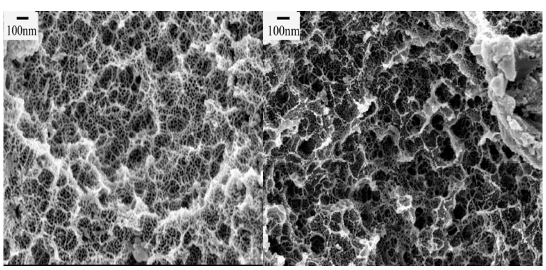

Fig. 2 SEM images of plates prepared under different current density. Left: low current density; Right: high current density.

By controlling the surface roughness and wettability of the plate, the quality of images could be improved. For example, the printed samples in Fig.3 showed different resolution from plates with different surface roughness.

Fig. 3 Print samples produced by printing plates with different roughness; Left: the plate with proper surface roughness; Right:the plate with wrong surface roughness.

In conclusion, green plate making technology based on nano-materials abandons the idea of sensitization imaging, which will not only shorten the plate making process but also reduce the cost greatly. Compared to the existing plate making technology, the new method has comprehensive advantages, such as low cost, pollution free and readily preparation. It is expected that the green plate making technology would play an active role in the green process of printing industry in China.

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Haihua Zhou received her BS in Shandong Normal University (1997) and her PhD in inorganic chemistry from Beijing Normal University (2008). Since then she has worked in the Institute of Chemistry, Chinese Academy of Sciences in Beijing. Her work has focused on the photosensitive materials and plate making technology.