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DETERMINATION OF FOUNTAIN SOLUTION'S FUNCTIONALITY

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Abstract: The aim of this paper is to determine functionality of the fountain solutions prepared with various amounts of IPA. For the purpose of this research, two sets of the fountain solutions, FS1 and FS2,were prepared and characterized by measuring pH value, electrical conductivity and surface tension. In addition, the Pruefbau MZ II Multipurpose Printability Testing System was used to determine amount of the fountain solution needed to cover nonprinting areas on the printing plate and disable adsorption of the printing ink. To detect chemical wear of the printing plate by the fountain solution, potentiodynamic polarization measurements were performed. Results showed that solutions FS1 have higher pH value and higher electrical conductivity than solutions FS2.In both sets it is visible trend of increasing pH value and decreasing electrical conductivity by addition of IPA. The surface tension is lowest by FS1 in which 4 %vol of IPA is added, even more the whole FS1 set has lower surface tension than the lowest surface tension measured in set FS2 (measured in sample with 12.5 %vol of IPA). The contact angle values were in good correlation to the surface tension values (calculated Spearman's correlation coefficient was 1 for FS1 and 0.9 for FS2). In simulated printing process, better spreading of the solution on the printing plate surface was achieved using FS2, where for almost all solution samples even 5 μl were enough to reach optimal area coverage. The electrochemical measurements showed that there is no corrosion for all investigated fountain solution samples. From *a* research one could conclude that investigated samples do not cause corrosion of the aluminum based lithographic printing plates. The addition of the IPA causes reduction of the surface tension that leads to lower contact angle measured when applying fountain solution onto the nonprinting areas of the lithographic printing plate. The simulation of the printing process using the Pruefbau MZ II Multipurpose Printability Testing System could be used as a tool in defining amount of fountain solution needed to disable adsorption of the printing ink, but the process should be fine tuned.
Keywords: lithography, fountain solution, printability testing, surface tension, contact angle

INTRODUCTION

Lithography is a printing technique in which selective adsorption of printing ink on the printing plate is achieved by opposite surface properties of printing and nonprinting areas. It is a two liquids technique where beside printing ink fountain solution must be used to enable nonprinting areas to repel the printing ink [10]. Fountain solution is composed of water and some additives including buffer and surface-active substances.

The buffer solution must keep the fountain solution in defined pH value (4.5 – 5.5) as lower or higher pH value would significantly influence printing process and/or stability of the printing plate. Surface-active substances are added in order to decrease surface tension of the solution and enable coverage of the nonprinting areas on a printing plate with lower amount of the solution. Most commonly used surface active substance in lithography is propan-2-ol (isopropyl alcohol, IPA), but due to its bad influence on ecology and human health [6], in recent years fountain solutions with lower IPA amount or even without IPA (alcohol free fountain solution) have been developed [2].

Furthermore, with the increase of the environmental behavior, some governments have issued guidelines to reduce amounts of alcohol in fountain solutions [7].

MATERIAL AND METHODS

For the purpose of this research two sets of commercial fountain solutions were prepared. First set (FS1) was prepared using concentrate, which is used for composition of the low alcohol or alcohol free (without use of IPA) fountain solution and the second set (FS2) is made of concentrate in which lower amounts of the IPA should be added (to 12 % vol). Each set consists of five samples by changing the amount of the IPA. The FS1 was made by adding 4 % vol of the concentrate (as proposed by the producer) in the distilled water and then adding 0, 1, 2, 3 and 4 % vol of IPA. The FS2 was made by adding 2.5 % vol of concentrate (proposed amount of the producer is 2 – 3 % vol) in the distilled water and adding 2.5, 5, 7.5), 10 and 12.5 % vol of IPA.

Characterization of the fountain solutions was performed by measuring pH value, electrical conductivity and by calculating surface tension. Surface tensions of prepared fountain solution samples were calculated using stalagmometric method (drop weight method). This method is one of the most commonly used to determine surface tension of a liquid. The method is based on the Tate's law (1) [5]:

$$mg = 2\pi r\sigma \qquad (1)$$

where m is mass of the liquid droplet, g is gravitational acceleration, r is radius of the nozzle and σ is surface tension of the liquid.

Alternatively, as the surface tension is proportional to the weight of the drop, the surface tension of the unknown liquid could be compared to a reference liquid of known surface tension (2).

$$\sigma_s = \sigma_r \frac{m_s}{m_r} \qquad (2)$$

where σ_s is surface tension of an unknown liquid, σ_r is surface tension of referent liquid, m_s is mass of droplet of the unknown liquid, m_r is mass of droplet of the referent liquid.

The surface tension for the purpose of this paper was calculated using equation (3), which is derived from the (2) introducing number of droplets in the same volume of liquid.

$$\sigma_s = \sigma_r \frac{n_r \rho_s}{n_s \rho_r} \qquad (3)$$

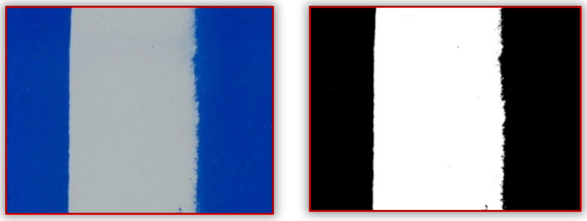
where σ_s is surface tension of an unknown liquid, σ_r is surface tension of referent liquid,n_s is number of droplets of the unknown liquid, n_r is number of droplets of the referent liquid, ρ_s is density of the unknown liquid, ρ_r is density of the referent liquid.

The density of the liquids was calculated using pycnometer and as a referent liquid water was used.

The pH value was measured by pH meter "WTW" GmbH pH 340/SET – 1 and conductivity was measured using "WTW" GmbH LF 330/SET. To determine interaction between fountain solution samples and printing plate contact angle (CA) on the nonprinting areas of a conventional aluminum based printing plate. The printing plate was exposed by a metal-halide lamp for 60 pulses (the exposure unit calculates amount of energy on the plate surface) and developed in fresh sodium based alkaline developer for ten seconds.

The contact angles were measured using Dataphysics' OCA 30 unit. This unit highly automated to disable influence of the operator on the results. It is equipped with an automated dispense unit to use drops of defined volume, automated movement of sample table, video system to enable measurement of the contact angle at precisely defined time after initial solid-liquid contact. These features enable better control of the measurements as they have significant influence on CA results [1]. Measurements were conducted using the Sessile drop method, at 24°C with drop volume of 1 µl. CA computations were made using Laplace-Young fitting method. In addition to the contact angle computation, to detect interaction between printing plate's nonprinting areas and fountain solution, printing simulation was performed. The Pruefbau MZ II Multipurpose Printability Testing System, equipped with the offset attachment (to enable offset printing simulation) was used for the printing simulation. This laboratory unit enables printing in precisely defined conditions regarding amount of fountain solution and printing ink, printing speed and printing pressure. For the purpose of this experiment, the printing speed was 1 ms^{-1}, printing pressure was 150 Ncm^{-2} and the amount of the fountain solution was 4, 5 and 6 µl.The printed plate samples were developed and dried at room temperature (24°C) just before the start of the printing process simulation.

The plate samples were then scanned using Epson Perfection V750 Pro and analyzed using ImageJ image analysis software [3]. The ImageJ is an open source software and is constantly been developed to meet needs of the users. The images were converted into a black & white and then area not covered by printing ink was calculated (Figure 1).



a) b)

Figure 1: Images of printing plate samples:
a) original image, b) converted image

To detect possible chemical wear of the printing plate in the fountain solution a potentiodynamic polarization was performed. The potentiodynamic polarization was conducted using Ametec VersaSTAT3 Potentionstat and Galvanostat. The measurements were conducted in a standard three-electrode electrochemical cell. The electrochemical cell consists of saturated calomel electrode (SCE), graphite counter electrode and working electrode (plate samples). The prepared fountain solution samples were used as the electrolyte was. The potentiodynamic polarization was performed in potential range of ±250mV from the open circuit potential measured one hour after plate sample was immersed in the electrolyte. The measurement were conducted at temperature of 24°C.

RESULTS AND DISCUSSION

In Figure 2 one could see the results of the pH value and electrical conductivity of prepared fountain solution samples. Both sample sets have similar results, the pH value is stable, i.e. does not significantly change by addition of IPA. Nevertheless, pH value increases with the increase of the IPA amount added as could be seen in Figure 2b, where amounts of the IPA are higher. This is probably due to a slight dissociation of the IPA in water.

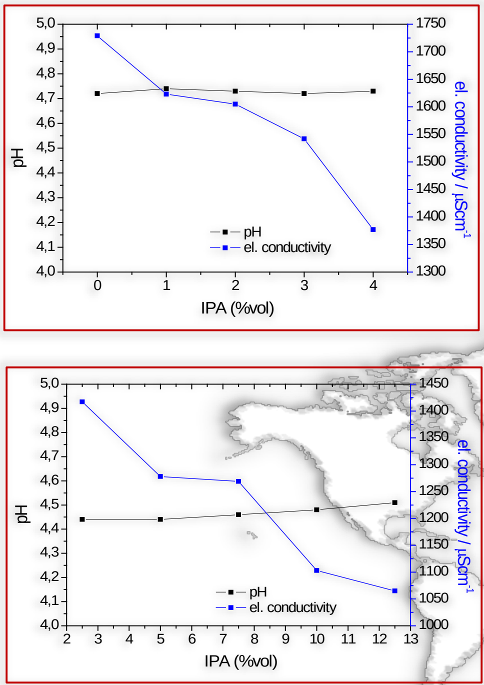


Figure 2: pH value and electrical conductivity of solutions: a) FS1, b) FS2

On the other hand, IPA amount significantly influence electrical conductivity, causing it to decrease. At both samples the electrical conductivity decreases for nearly 400 µScm^{-1}, but as FS1 (Figure 2a) has a higher initial value, the decrease is about 5% lower. The decrease of the electrical conductivity is probably caused by low dissociation of the IPA in water and therefore decreasing the fraction of the ions in the solution.

The influence of the IPA amount in a solution on its surface tension and interaction with the printing plate surface is presented in Figure 3. It could be seen that decrease of the surface tension with the amount of the IPA added is more present in the FS2 in comparison to the FS1. Furthermore, adding more than3 %vol in FS1 is not efficient as sample with 4 % vol has almost the same surface tension as previous sample (Figure 3a). On the other hand, the trend of the surface tension value of FS2 samples show that further addition of IPA would probably decrease surface tension of solution even more (Figure 3b).

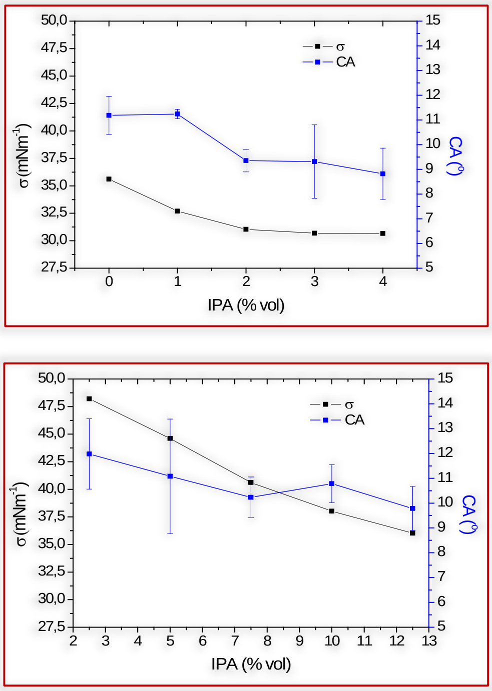
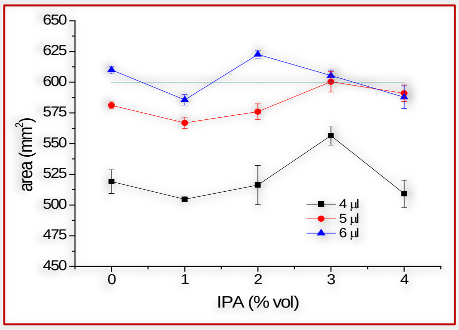


Figure 3: Surface tension and CA of solutions: a) FS1, b) FS2

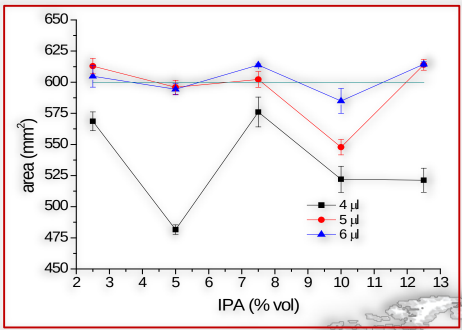
The FS1 solutions were made of commercial concentrate that could be used even without adding IPA, so it has in its composition some surfactants with lower hazardous influence than IPA (according to the technical data sheet glycol derivates are present in concentration of 15-25% [8]). The FS2 solutions were made of concentrate in which no glycol derivates are present, according to the safety data sheet [9].

The increase of the IPA amount in a fountain solution causes decrease of the contact angle when applying the solution onto nonprinting areas of the lithographic printing plate. The CA is lower when using FS1 in comparison to the one measured using FS2. The surface tension and the CA correlate, as could be seen when calculating the Spearman's correlation coefficient. The calculated results were $r_s = 1$ for FS1 and $r_s = 0.9$ for FS2.

In Figure 4 one could see the results of the calculated area covered by the fountain solution before inking. The green line at 600 mm^2 is denotes optimal wetting of the printing plate's nonprinting areas. It could be seen (Figure 4) that 4 µl of the solution is not enough for preventing inking of the area for both solution sets. Increasing volume of the fountain solution applied the area not covered by printing ink increases. Using solutions from set FS1 it could see increase of the area without inking when using 4 and 5 µl, with exception of solution with 4 % vol of IPA (Figure 4a). Use of 6 µl causes more area without ink than optimal, meaning too much of solution was applied on the printing plate's surface causing spreading of the fountain solution out of the zone where fountain roller passed over printing plate's surface. Although results of the contact angle and surface tension of investigated solutions imply lower functionality of FS2 set, results of the area not covered with ink show that even 5 μl is enough to reach optimal area of the printing plate covered by fountain solution (Figure 4b).



a)



b)

Figure 4: Area of the nonprinting areas covered with the fountain solution: a) FS1, b) FS2

The electrochemical measurements showed that in all solutions in the investigated potential spectra (±250 mV) from open circuit potential current is lower than 1 mA. If the current is lower than 1 μA, the corrosion of the material is very slow and it is not significant to the exploitation of printing plate [4].

CONCLUSIONS

This research was conducted to determine functionality of the two fountain solutions, one proposed to use IPA and the other to be used with low amount or even without addition of IPA. Furthermore, printing process simulation by a printability tester was introduced as a tool in defining fountain solution functionality.

From this research it could be concluded that investigated samples do not cause greater corrosion of the aluminum based lithographic printing plates, i.e. it does not influence. The addition of the IPA causes reduction of the surface tension that leads to lower contact angle measured when applying fountain solution onto the nonprinting areas of the lithographic printing plate. The simulation of the printing process using Pruefbau MZ II Multipurpose Printability Testing System could be used as a tool in defining amount of fountain solution needed to reject printing ink, but the process should be fine tuned.

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Note

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