Jettability of phthalocyanine dye ink formulations

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Abstract

In this research, different water based dye ink formulations made of phthalocyanine blue were examined for suitability for inkjet printing. In this process, Z number, a dimensionless combination measure of specific gravity, surface tension and viscosity was used to assess jettability. The specific gravity, surface tension and viscosity of nine different water based ink formulations were measured and used to calculate the Z number. The ink is considered to be suitable for ink jetting, if Z number is in the range 2≦Z≦14.

Introduction

Inkjet printing techniques have been gaining attention recently because of their unique features, such as simplicity of fabrication, compatibility with different substrates, feasibility of non-contact and additive patterning, low temperature processing and low cost [Bao, 1999], [Rozenberg, 2002].

In the piezoelectric inkjet printer, it uses a piezoelectric material in an ink-filled chamber behind each nozzle instead of a heating element [1].

In order to generate a droplet, two conditions need to be fulfilled. First, the kinetic energy must be higher than the surface energy of the drop. This is correlated with Weber number ($We = v^2 \rho a / \gamma$). The second condition is that the kinetic energy should be higher than the viscous dissipation. This is described by the Reynolds number ($Re = v \rho a / \eta$). Oh number combines these two conditions. Oh number characterizes the propagation of the pressure wave and its attenuation by viscous dissipation:
$Oh = \sqrt{We} / Re = \eta / (\gamma \rho a)^{1/2}$ [Derby, 2011].

Fromm identified the Ohnesorge number Oh, as the appropriate grouping of physical constants to characterize drop generation in an inkjet printer. The reciprocal value of this number, the parameter defined as Z=1/Oh was used by Fromm [Fromm, 1984]. Empirically it was shown that fluids are ink jet printable within the range 2≦Z≦14.

Materials and Methods

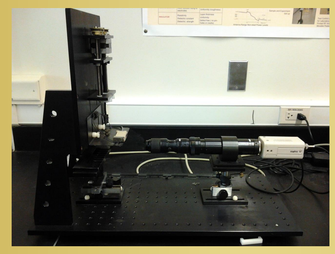
•Water-based phthalocyanine dye was used. The isopropyl alcohol (IPA) and ethylene glycol (EG) was added to the dye in order to decrease the surface tension and increase the viscosity.

•Nine different dye ink formulations were measured in this work, they were: dye, dye with 2%wt IPA/EG, dye with 5%wt IPA/EG, dye with 10%wt IPA /EG and dye with 15%wt IPA/EG.

Specific gravity (pycnometer)

Viscosity (Rheometer)

Surface tension (FTA200)



Dimatix Material Printer

Results

Specific gravity of dye: 1.0536 g / ml

Table 1: Surface tension [mN/m] of phthalocyanine solutions

Dye	Dye + 2%wt IPA	Dye + 5%wt IPA	Dye + 10%wt IPA	Dye + 15%wt IPA	Dye+ 2%wt EG	Dye + 5%wt EG	Dye + 10%wt EG	Dye + 15%wt EG
66.88	54.13	46.54	34.93	27.23	60.56	61.63	62.21	63.61

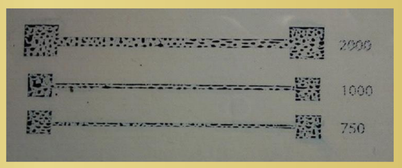
Table 2: Viscosity [cP] of phthalocyanine dye inks

Dye	Dye + 2%wt IPA	Dye + 5%wt IPA	Dye + 10%wt IPA	Dye + 15%wt IPA	Dye+ 2%wt EG	Dye + 5%wt EG	Dye + 10%wt EG	Dye + 15%wt EG
1.32	1.44	1.59	2.02	2.36	1.48	1.53	1.64	1.83

Table 3: Z number of phthalocyanine dye inks

Dye	Dye + 2%wt IPA	Dye + 5%wt IPA	Dye + 10%wt IPA	Dye + 15%wt IPA	Dye+ 2%wt EG	Dye + 5%wt EG	Dye + 10%wt EG	Dye + 15%wt EG
29.55	24.37	20.46	13.96	10.55	25.08	24.47	23.20	20.56

The ink (Dye with 15%IPA) was printed on the PET substrate of 100 μm gage by Dimatix Materials Printer DMP-2800.



The PET was treated by UV (UVO Cleaner Model 144 AX) for 15min UV time and 6min cooling down time to increase its surface energy. The UV oven creates a stream of ozone to oxidize the surface of PET, and thus increase its surface energy. The drop spacing and percent of each drop also has to be considered when printing with the. For the drop spacing, 15 μm and 20 μm were used and 16V and 40V were chosen for controlling percent of each drop.

Conclusions

Different water based dye ink formulations made of phthalocyanine blue were examined for inkjet jettability and printability. Based on the results, IPA is more efficient in surface tension, viscosity and Z number modification compared to the EG. Two of the ink formulations (phthalocyanine blue with 10% isopropyl alcohol and phthalocyanine blue with 15% isopropyl alcohol) were found to result in best Z number, thus the best jettability. However, this ink formulation caused the ink crawling due to ink and PET surface energy mismatch. PET treated with ozone improved the print quality.

References

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