Temperature Effects on Liquid Electrophoretic Inks

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Abstract

In liquid electrophotograpy inks are colloidal solutions of toner particles suspended in a dielectric liquid together with typically micellar toner charging components. Toner particles and charging agents are in physicochemical equilibrium with toner acquiring charge that may be temperature dependent. Viscous dissipative forces are primarily governed by carrier liquid viscosity which is also temperature dependent. Measurements of time dependent currents at high fields indicate that viscosity effects dominate temperature behaviour of Indigo electroinks.

Introduction

In electrophoretic printing ink toner particles are moved from place to place under influences of electrical forces. The driving force is electrical and depends on the charge placed on a particle, while the opposing dissipative forces are primarily due to viscosity of surrounding medium. Balance of these forces leads to electrophoretic mobility of toner particles that determines how fast charge can be transferred from one place to another. In liquid electrophotograpy inks are colloidal solutions of toner particles suspended in a dielectric liquid together with typically micellar toner charging components. Toner particles and charging agents are in physicochemical equilibrium with toner acquiring charge that may be temperature dependent. Viscous dissipative forces are primarily governed by carrier liquid viscosity which is also temperature dependent. Understanding the interplay of these factors leads to better control over electrophotographic presses and guidelines for design of better inks. In this report we present data that show that changes in the mobility of toner particles with temperature depend primarily on carrier liquid viscosity, however viscosity changes are not sufficient in explaining conductivity of charge depleted ink samples indicating temperature dependence of micellar disproportionation that leads to thermal charge generation.

Electrophoretic mobility of toner particles in liquid inks is typically measured by a conductivity measurement. A voltage pulse is applied between two electrodes with ink between them. At the beginning of the pulse there is high current (high conductivity). As time progresses current falls as internal polarization of the cell occurs decreasing the electric field particles are subjected to, and charge is being depleted. Eventually a steady state conductivity value is reached. That is dependent on charge regeneration in the bulk of the liquid due to thermal processes and electrochemical reactions at electrode surfaces. Figure 1 represents typical time evolution of apparent ink conductivity. The peak value is of critical importance for speed of transport of toner particles, while the final (DC) value represents minimal load on power supplies.

Experimental conditions

In order to investigate temperature effects a special measurement cell was built. It consists of two parts. One containing signal cell electrode, a thermoelectric element, control thermistor and a heatsink, and the other of similar construction, but containing electrode that supplies voltage pulse and the plastic housing that surrounds it acts as a reservoir to fill the cell. The voltage pulse assembly acts as a pedestal platform that the signal assembly is placed on for measurement. Figure 2 shows the cell assemblies. When assembled, electrodes are parallel and spaced apart forming a cell which is filled with ink. Temperature of each of the two electrodes is controlled independently using thermo-electric (Peltier) elements that are driven by microprocessor controller. Measurements were conducted in the 20 to 40 degrees C range. After introduction into the sample cavity, ink equilibrated in temperature with electrodes within half a minute.

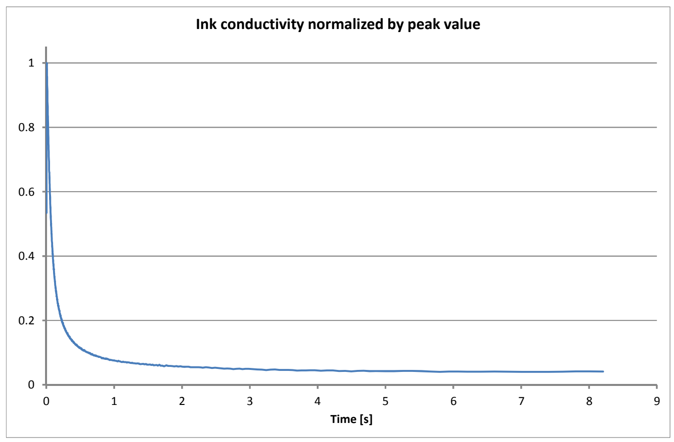

Figure 1. Typical conductivity time evolution in response to high voltage pulse.

Figure 2. Electrophoretic measurement cell

Typical HP electroink was used in this experiment. Peak and DC conductivities were measured at several temperatures and normalized by carrier liquid viscosity at that temperature and the value at 30 degrees C. If chemical interaction equilibria are not temperature dependent then values normalized in that way should remain constant with temperature.

Results

Results shown in figure 3 demonstrate that the peak conductivity temperature effect is dominated by viscosity effects. This indicates strong bonding between charges and toner particles that are not highly affected by temperature. On the other hand the DC conductivity is affected by other factors than carrier liquid viscosity. More than likely indicating temperature dependence of disproportionation process that regenerates charge in the bulk of the liquid.

Predictability of peak conductivity behaviour allows for precise control of press operation. The phenomena involved in DC conductivity need to be further studied for general understanding, but are not a major factor in press operation.

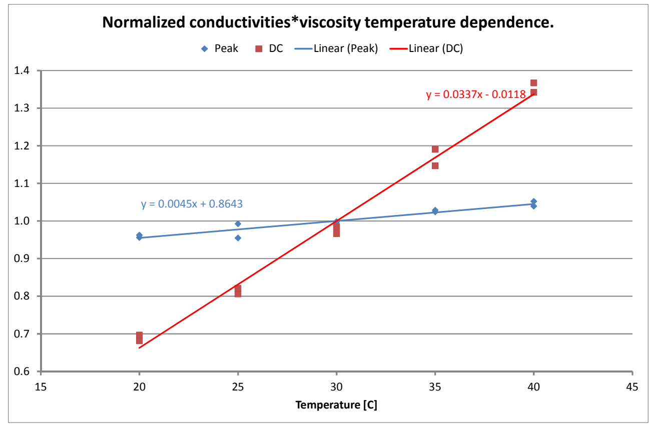

Figure 3.Temperature behaviour of electroink conductivities.

Author Biography

Henryk Birecki is a Senior Scientist at Hewlett Packard Laboratories. He received PhD in physics from MIT in 1976 and joined HP Labs in 1978. While at HP he worked on displays, optical computing, optical recording and other mass storage technologies. He managed projects on optical recording materials and devices and organized international conferences on the subject. Since 2006 he's been working on printing technologies.