Surfactants in Emerging Technologies

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edited by

Milton J. Rosen

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Surfactant Research Institute
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Preface

On June 6, 1986, a conference on "The Role of Surfactants in New and Emerging Technology," organized by Professor Milton J. Rosen of the Department of Chemistry and sponsored by the National Science Foundation, was held at Brooklyn College of The City University of New York. About sixty representatives from industry, academia, and government attended. This volume is based on the proceedings of that conference.

The conference was held because the past several years had seen a rapid expansion of surfactant use into a number of new, important areas of technology. It was therefore felt that the time had come to examine the position of surfactants in these new growth areas, the needs for surfactant research to facilitate advances in those areas, and the resources (or lack thereof) available to meet those needs.

The program consisted of a morning plenary session at which invited speakers each discussed surfactant utilization in a particular area of technology. Eight areas were discussed: (1) biotechnology, (2) electronic printing, (3) high-technology electronic ceramics, (4) magnetic recording, (5) microelectronics, (6) non-

conventional energy production, (7) novel pollution control methods, and (8) novel separation techniques. In the afternoon, there were two 1-hour sessions of group discussions. These sessions consisted of eight simultaneous, small discussion groups, each devoted to one area discussed in the morning session. The morning plenary session's speaker acted as discussion leader with a rapporteur to record the proceedings. Since there were two afternoon sessions, each conference attendee had the opportunity to participate in two group discussions. The findings of each of these group discussions were presented by the rapporteurs at a final plenary session that concluded the conference.

Two constantly recurring themes were apparent in the group duscussions and in conversations with individual conferees: (1) the need for more fundamental research on the mechanisms by which surfactants perform their function in these new technological areas, e.g. charge development at interfaces in solutions of surfactants in hydrocarbons, and (2) the need for surfactants designed specifically for these new applications. One problem is the difficulty, or lack, of communication between surfactant users and surfactant producers. Communication is difficult because of the large amounts of proprietary information involved in the use of surfactants for these purposes. Another problem is the small sales volumes involved, which makes surfactant producers reluctant to undertake the research and development needed to meet application needs.

Milton J. Rosen

Contributors

LECTURERS

MARK S. CHAGNON Integrated Magnetics Inc., Chelmsford, Massachusetts

MELVIN D. CROUCHER Xerox Research Centre of Canada, Mississauga, Ontario, Canada

ROBERT DONADIO Integrated Magnetics Inc., Chelmsford, Massachusetts

PATRICK G. GRIMES Exxon Research and Engineering Co., Annandale, New Jersey

JEFFREY H. HARWELL Institute for Applied Surfactant Research, and School of Chemical Engineering and Materials Science, University of Oklahoma, Norman, Oklahoma

WILLIAM H. LINDENBERGER NALCO Chemical Co., Naperville, Illinois

SAUL L. NEIDLEMAN Cetus Corporation, Emeryville, California

MELVIN POMERANTZ IBM, T. J. Watson Research Center, Yorktown Heights, New York

JOHN F. SCAMEHORN Institute for Applied Surfactant Research, and School of Chemical Engineering and Materials Science, University of Oklahoma, Norman, Oklahoma

ELLEN S. TORMEY Ceramics Process Systems Corp., Cambridge, Massachusetts

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Melvin D. Croucher

Xerox Research Centre of Canada
Mississauga, Ontario, Canada

ABSTRACT

With the advent of microcomputer technology there has been an increased demand for improved methods of obtaining hardcopy output of electronically stored documents. Two of the technologies that have emerged to meet this demand are electrographic and ink-jet printing. The common feature in these two printing processes is that they both use liquid developers to produce marks on paper. However, the methods used by these technologies to convert electronic signals to hardcopy differ dramatically. In this paper we briefly review the salient features of both electrographic and ink-jet printing. This is followed by a description of the liquid developers that are used in these two printing systems, their materials design criteria and physico-chemical characteristics. Finally, we delineate some possible future developer materials trends with special emphasis being given to the role of surfactants in these liquid marking materials.

1.0 INTRODUCTION

The placement of electronic document creation and management systems into the office environment is occurring with increasing frequency. These devices allow documents to be created, manipulated and stored in electronic form. This technological change has resulted in a demand for improved methods of obtaining hard copy images of these electronic signals, consequently, numerous printing technologies have emerged to meet this demand. They include ink-jet, laser, thermal transfer and electrographic printing as well as the more traditional impact printers.

The major electronic printer options that are presently available are shown in fig. 1 where the writing energy, which is the energy required at the print head to generate images, is plotted against the number of process steps required to generate the output print. It can be seen that impact printing is a simple process, and therefore reliable, but requires considerable energy. Laser printing on the other hand requires little energy to form images but it is a complex process. This complexity contributes to its lower reliability. An advantage of these technologies is that they are capable of printing on plain paper. This lack of sensitivity to the paper structure occurs because the marking inks are "dry" which enables thick layers to be placed on the surface of the paper, so obscuring its texture.

Fig. 1 also shows that the technological advances that are sought in electronic printing devices are process simplicity, reliability and a decrease in the energy required to form images. Of the printing systems presently available, ink-jet and electrography are the clear leaders in these areas. Both of these marking devices use liquid toners to develop images on paper, consequently, the images are sensitive to the paper structure. Therefore, both technologies require special papers on which to print. This is usually considered to be a disadvantages for these printing systems relative to dry marking processes. A major advantage of these systems however, is their ability to produce

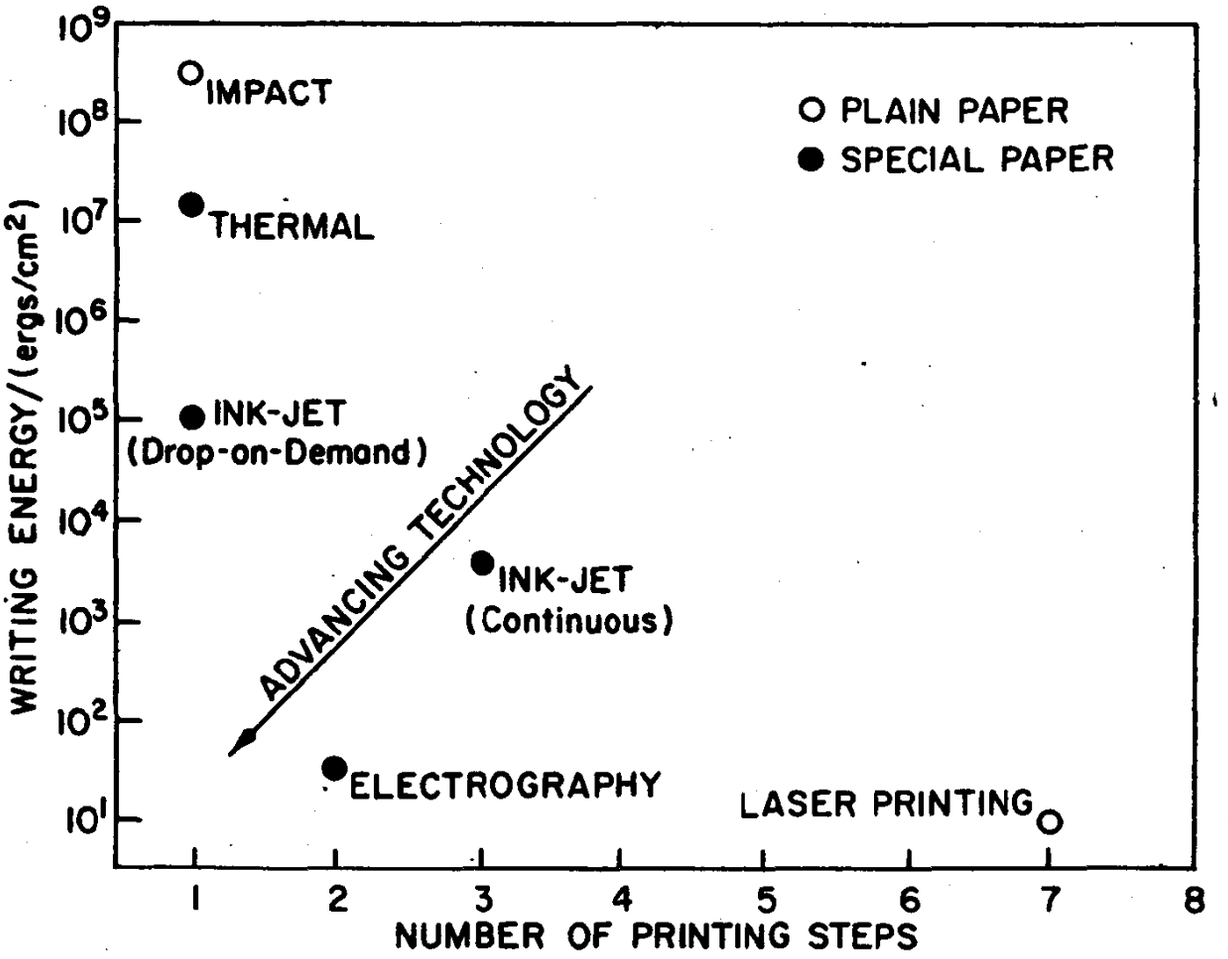

FIG. 1 *The writing energy is shown plotted against the number of process steps for a variety of printing technologies. This has been adapted from A. H. Sporer in "Advances in Non-Impact Printing Technologies for Computer and Office Applications", Ed. J. Gaynor, p. 1338, Van Nostrand Reinhold, 1982.*

color prints and numerous color printing systems based on these technologies are now sold commercially. It is in color printing that liquid marking systems seem to have found their niche.

In this paper we will briefly review the salient features of both electrographic and ink-jet printing. This will be followed by a description of the liquid developers that are used in these printing technologies, their materials design criteria and their physico-chemical and imaging characteristics. Finally, we discuss possible future developer materials trends with special emphasis being given to the role of surfactants in these liquid marking technologies.

2.0 BRIEF REVIEW OF LIQUID PRINTING TECHNOLOGIES

Although both ink-jet and electrographic printing systems are both liquid based technologies that are driven electronically, they operate on completely different principles. In this section we describe the working principles of these printing engines in order to understand their liquid toner requirements.

2.1 ELECTROGRAPHIC PRINTING

A schematic diagram of an electrographic printing system is shown in fig. 2. In this printing method a latent electrostatic image is deposited onto dielectric coated paper (i.e. paper that can hold an electrostatic charge pattern) by an array of metal stylii which are selectively discharged according to the electronic input the stylii receive. The ions that form the latent image are caused by the dielectric breakdown of the air between the stylii and the paper. The physics of this process is beyond the scope of this report but it has been discussed by numerous authors[1-4]. This latent image on dielectric paper then passes through a development zone in which

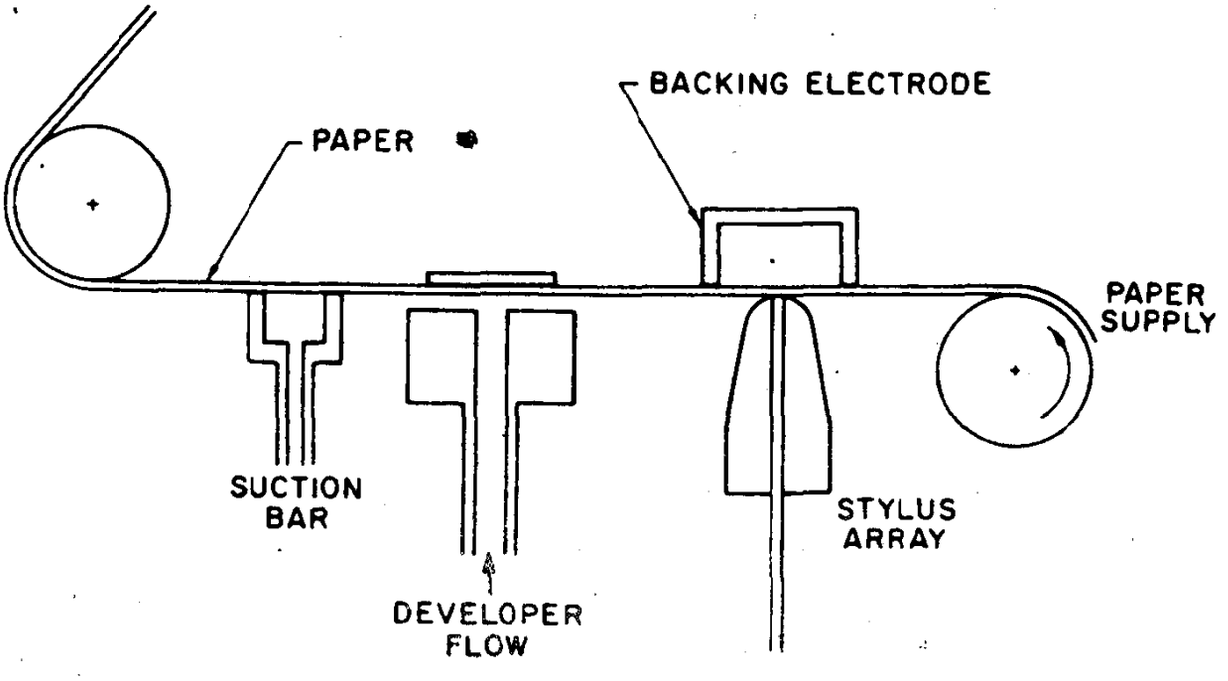

FIG. 2 *Schematic diagram of an electrographic printer.*

liquid developer comes into contact with this electrostatic charge pattern.

Under the influence of an electric field the particles that form the liquid developer undergo electrophoresis. Since the particles are electrostatically charged with the opposite polarity to that of the latent electrostatic image, the charge on the paper is neutralised by the developer to give a legible hard copy output. Once out of the development zone the hydrocarbon fluid on the paper evaporates rapidly leaving a dry image.

2.2 *INK-JET PRINTING*

Ink-jet printing is in principle an extremely simple and elegant method of placing marks on paper. In this printing process a uniform train of ink droplets is generated by a Rayleigh instability. These ink droplets are then deflected onto paper to produce text and graphics.

Numerous variations of ink-jet printers exist although only two modes of operation appear to have been widely studied. These are shown schematically in fig. 3. The first method is known as the drop-on-demand system in which droplets of ink are generated as needed by a piezoelectric crystal, and are ejected from 20-80 μm nozzles producing a stream of ink droplets with a velocity of ~ 3 m sec^{-1}. In order to produce characters on paper the droplets are assigned the correct trajectory by the writing head. The second type of jet system is known as synchronous ink-jet printing in which ink droplets are produced continuously. This is achieved by pressurising the ultrasonically attenuated jet to ~ 3 x 10^5 Pa which produces a stream of droplets (~ 10^6 per second) with a velocity of ~ 20 m sec^{-1}. The ink drops that are to be used to generate characters are inductively charged and deflected in a high voltage electric field to a specific position on paper. The uncharged ink droplets pass undeflected through the electric field to be caught in a gutter and recirculated through the fluidic circuit.

In the case of electrography, individual electrostatically charged ink particles (< 2 μm diameter) that are suspended in a