

Photomedia for Ink Jet Printing

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Abstract

With the rapid development of digital photography, there is now an increasing demand for the development of printing systems capable of producing digital images equivalent to those produced by silver halide technology. With the latest developments in photorealistic ink jet printing, very high quality photographic images can now be produced. There is now greater emphasis on the development of matched ink and media systems. These in combination with printer and software developments, all contribute to the quality of the digital images produced. Ink/media combinations are now being developed which will provide silver halide levels of performance.

The dye based ink system has required the development of chromophores with much greater photostability, particularly for the light inks (magenta and cyan), which are now included in most photocartridges. Pigment ink systems still have much greater durability however, it is more difficult to obtain compatible photomedia for such inks.

The development of more durable photomedia has presented a significant challenge. These media can either be based on the traditional resin coated photographic substrates, which contain a polyethylene barrier layer, or on glossy coated substrates which can have increased ink absorption capacity. For all these media rapid dry times and excellent image quality are essential features. One further requirement is for silver halide levels of durability to provide images which do not fade when displayed over long periods and which can be archived for long periods without any noticeable change.

Introduction

The different photomedia types will be considered and their ability to be matched to the aqueous ink systems, present in most small format ink jet printers, will be reviewed. Ink jet printing has allowed photographic images to be printed onto virtually any material, capable of absorbing the ink and which can be fed through the printers. There is a huge range of media types available from high gloss films, canvas, vinyl, textiles and also a wide range of coated and plain papers. The selection of media plays a critical role in determining the quality of the image produced.

For any given ink system, dye or pigment based, the media can influence colour density brightness, hue, uniformity of the image and dry time. The receiver layers or surface coatings applied to the substrate play a very important role in determining the image properties and in particular the image durability. The chemistry of the coating can interact with the ink either when the image is exposed to light or in the dark, when an image is archived over a long period.

The development of digital minilabs will also require better photomedia to meet customers expectations of photo quality images. This paper will focus on the development of photographic media types for ink-jet printing.

Factors Which Influence Photo Quality

The main factors which influence the production of digital images are shown in figure 1. The ink and media are the two components which have the greatest influence on the image properties.

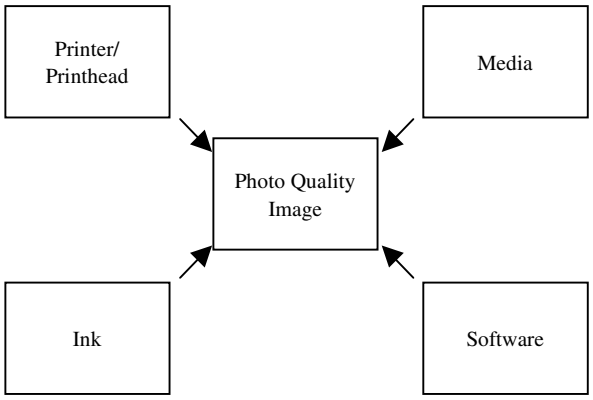

Figure 1. The key components responsible for producing the Image

The printer and printhead in combination with the colour management software also play an important role. With better cooperation between the ink and media manufacturers, in the development phase, the quality of the products will improve particularly the image quality and also the image permanence.

Photomedia for Digital Imaging

Photographic image quality on desktop (SOHO) printers has improved very rapidly and all the major OEMs have now targeted photorealistic printing as one of the major market segments for future ink jet printers. Dye diffusion thermal transfer (D2T2) and colour laser printers can also produce photographic quality images. However, the low cost and versatility of ink jet together with the excellent image quality which can now be achieved, have all contributed to the evolvement of ink jet as the key digital imaging technology for photo quality printing.

A wide range of photomedia has also been developed for the printers. For the purposes of this review these have been classified into two groups.

Photomedia Based on Resin Coated Papers

The first category is the resin coated media (see figure 2) where a paper substrate (rawbase) is coated with polyethylene on both sides and then several aqueous coatings are applied onto the primed surface of the TiO^2 filled PE (frontside). The two side PE coated paper is now the most commonly used substrate for Analogue Photography.[1] This provides a very durable substrate capable of producing a high gloss finish. In addition, there are no issues with cockling of the base. Curl can be controlled by adjusting the backcoat on the rawbase.

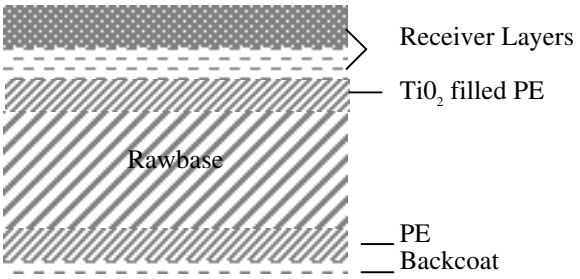

Figure 2. Resin (PE) Coated Photopaper

This PE layer requires a pretreatment or a thin sub-layer to provide adhesion for the aqueous coatings to be applied to the front side. The formulation of the receiver layers, applied to this surface, helps to determine the image properties. The coating formulations need also to be carefully matched to the ink systems. To obtain the highest quality photo images printer dedicated media are required.

Paper Glossy Media

The second group of media is classified as paper glossy media. In this group there is no barrier layer, as in the resin coated media, instead there is usually an aqueous coating of a pigmentary smoothing layer applied directly onto the base paper. See i) and ii) below. Alternatively the receiver layers are coated directly onto the rawbase, see iii) below. Examples of these types of media are shown in figure 3.

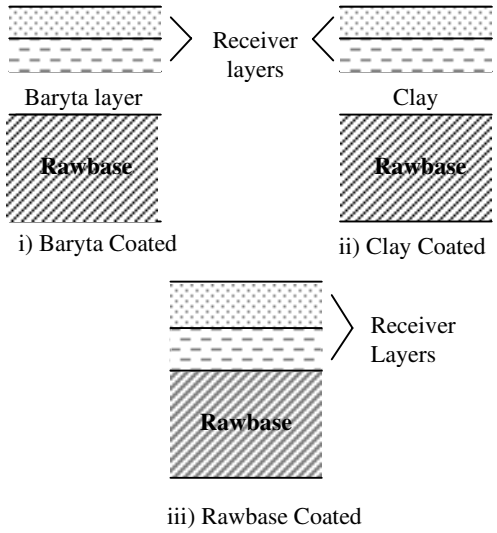

Figure 3. Paper Glossy Media

These have been split into 3 categories and examples of these types of media are shown above.

i) Baryta Coated

A 10-30 μm layer of barium sulphate, in a cross-linked gelatin binder, is applied to a rawbase paper. This was introduced to analogue photography over one hundred years ago[2]. These papers were surpassed by the polyelythene or resin coated substrates due to drying problems, sensitivity of the substrate to photographic emulsions, applied to the surface, and issues with cockle and curl. These substrates are used in black and white photography and Felix Schoeller still manufactures these baryta papers.

Advantages for baryta coated photomedia are the high reflectivity and brightness of the baryta surface, also baryta produces a very smooth surface. This provides an ideal surface for coating receiver layers and can provide high gloss photomedia. The baryta layer also offers some additional ink absorption capacity, however, there can be issues with cockle if the aqueous ink penetrates into the paper causing deformation of the cellulosic fibre structure.

ii) Clay Coated Papers

For the traditional printing industry[3] (off-set, lithographic, gravure etc) a wide range of clay coated papers are available. The clay coating provides a smooth surface capable of producing a glossy surface after coating aqueous receiver layers onto the clay surface. These tend not to be as good as the baryta coated papers

for brightness and gloss, but can still provide a good glossy photopaper. They can also have problems with cockle and curl.

iii) Coating Rawbase Substrate

By coating the receiver layers directly onto rawbase one processing step can be removed. As long as the rawbase has a relatively smooth surface, similar to that produced by photobase, then a reasonably good quality photomedia results. Gloss, brightness and ink absorption may be reduced, compared to i) and ii) above and also cockle and curl can be a problem.

Ultimately the PE/resin coated substrates provide the highest quality photopapers for both the analogue and digital photographic industries. By having a hydrophobic barrier layer protecting the rawbase there are no problems with paper cockle.

Ink Systems for Digital Photography

There are two main types of ink system to consider for producing a digital image by ink jet. These are summarised below (see figure 4). The colorants and their properties are described in previous papers [4, 5].

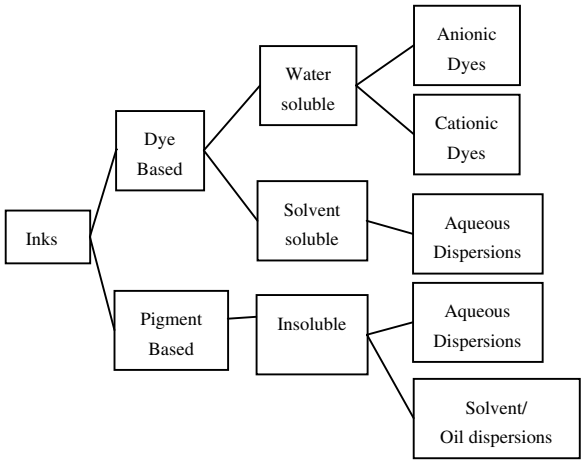

Figure 4. Ink Systems Used for Ink-Jet

Most current printers contain dye-based systems and the majority of ink systems are aqueous. The dyes are mainly water soluble and anionically charged. Pigment inks are becoming more popular due to their enhanced durability and as further work continues into the operability of such ink systems, then pigment based inks could become more important for the production of digital images.

One other important feature of ink systems for photorealistic printing is that often two additional light inks (light cyan and light magenta) are included in the photocartridge. These are much less durable in terms of image stability.

Influence of the Inks on Photomedia Requirements

Depending on the nature of the ink systems then different media are required. The OEMs have all opted for different approaches in terms of designing media for their ink systems. The most recent photo quality printers have ink systems which have been developed in conjunction with new photomedia to produce almost photographic quality images. Figure 5 indicates some of the media types for the two main ink types.

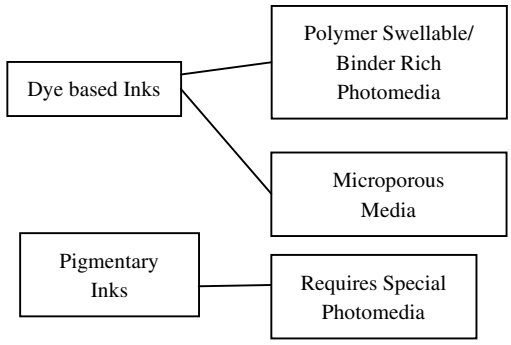

Figure 5. Photo Media Requirements for Ink Systems

The water swellable polymers or binders typically gelatin, PVOH, PVP or combinations of these polymer systems were very popular until recently. These gave very high gloss photo quality prints. As the speed of printers has increased the rate of ink laydown has proved too great for most of these types of media and so, microporous mainly pigment based media, have been developed. The high gloss of the binder rich systems is a distinct advantage in comparison to the pigmentary microporous receiver layers. The development of microporous systems has taken time and these are also difficult systems to formulate and coat onto both the resin coated and paper glossy substrates.

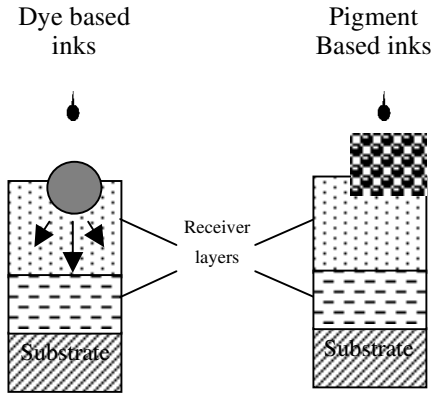

Figure 6. Ink Interaction with Binder Receiver Layers

The dye based ink systems are quickly absorbed into the top layer (image receiving layer) and the ink vehicle is absorbed into the lower layers. The dye molecules diffuse and spread through the top layer giving a good image quality, although the dry time may be slow. For pigmentary inks the colorant or pigment particles largely remain on the surface with limited spreading of the ink. The image can readily be smudged by rubbing the surface.

Ink Interaction with Microporous Coatings

The development of microporous technology has resulted in media, which are instantly dry on printing. The ink absorption mechanism involves the inks being absorbed into microcapillaries created by the alumina or silica particles. This drying mechanism is shown in figure 7.

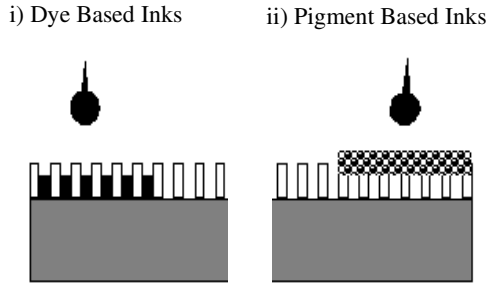

Figure 7. Interaction of Inks with Microporous Layers

The colorants are normally fixed in the topcoat or upper receiving layer and the lower layers are largely responsible for the ink absorption capacity.

Pigmentary inks can also have problems penetrating these surface structures (see ii) above), resulting once again in the pigment particles residing mainly on the surface. This leads to poor ink spread, print gloss loss and smudging of the image when touched.

Properties	**AgX**	**Ink Jet Photomedia**
Gloss	✓	✓
Image Quality	✓	✓
Chroma	✓	✓
Lightfastness	✓	✓
Cost	✓	*x*

Figure 8. Contrast between ink jet & silver halide

The development of pigment compatible glossy photomedia is a difficult target and presents different challenges to that of the dye based ink systems.

Image Properties of Ink Jet versus Silver Halide

One of the major advantages of ink jet is that the image production and paper it's printed on are functionally seperated. The resin coated photobase, which is the predominant substrate in AgX technology, has also proved popular for producing photo quality ink jet images. The various properties are contrasted in the table below (see figure 8).

One advantage for ink jet over AgX is chroma. The chroma produced by the ink jet colorants is generally better than that for most AgX prints. The image durability however is reduced and this has led to a lot of R&D activity into developing colorants and media with provide higher levels of image permanence. In addition to light stability, images need to be archivable (i.e. can be stored under certain conditions for long periods of time without any noticeable deterioration in the image). Images also need to be stable under high humidity conditions and resistant to ozone. Dark fading can also be a problem particularly when a chemical interaction occurs between the colorant and the media. Certain cationic fixing agents can have a detrimental effect on colorants particularly magenta dye chromophores[5].

Research is ongoing to develop more durable ink jet images.

This includes the development of: -

i) More durable dye systems.
ii) Pigmentary ink systems
iii) More durable photomedia.
iv) Matched ink/media sets.

The cost of AgX prints is still considerably less than that of ink jet images. With the development of digital minilabs, to process digital images, the cost of producing such images will most likely be reduced in the future.

Conclusions

There are a vast number of substrates available for ink jet printing. With the further development of the printers and associated colour management software and the move towards digital minilabs then there will be increased demand for ink jet systems to match AgX. In order to achieve such performance then high quality photo substrates such as those currently used in analogue photography i.e. resin coated substrates will also be likely to dominate the high end ink jet photo quality media. Proofing applications will also require such media with slightly different requirements for the gloss levels.

The ink systems have been greatly enhanced over the last years and now more focus is being placed on the further improvement in the media. The development of receiver layers matched to the future ink systems offers

the best opportunity for achieving the ultimate goal of silver halide image quality using an ink jet printer.

References

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Biography

Aidan Lavery received his BSc and PhD in chemistry from Queen's University Belfast in 1980 and 1984. He then did two years postdoctoral studies on transition metal chemistry at Edinburgh University before taking up an academic position, as a lecturer in Chemistry at Huddersfield University where he lectured for three years 1986-1988. In 1988 he joined ICI/Zeneca where he spent 11 years being promoted to the position of Group Leader of the Physical Science team developing ink jet systems.

At the beginning of 1999 he took up his current position with Felix Schoeller Digital Imaging as Head of R&D for media development.

His interests have included the development of colorants media and inks for ink jet. He also has a keen interest in understanding ink/media interactions. *Contact: alavery@felix-schoeller.com*