A Non-Silver Dry-Processed Graphic Arts Film

M. C. Tam, H. Sonnenberg and A. L. Pundsack

Keywords: Particle Migration Imaging, Heat Development, Imagesetter, Silverless Film, Graphic Arts Film, Printing Plate

Abstract

A new non-silver dry-processed graphic arts film is described. The new film contains a monolayer of submicron-sized selenium particles embedded in a polymer matrix. Film processing involves brief heating of the film which reduces the viscosity of the polymer matrix to allow the exposed charged selenium particles to migrate in depth to yield a high-resolution optical image. By eliminating the wet chemical processing of conventional silver films, the new materials provide an environmental friendly alternative for many graphic arts applications. This paper discusses the materials, the imaging processes, their imaging properties as well as their plate-making and printing characteristics.

Introduction

A non-silver dry-processed electrophotographic imaging film based on particle migration imaging technologies[1-6] will be described. The imaging material offers high-resolution, laser-sensitivity, fast dry processing involving heat only and without any effluent, room-light handling, excellent shelf life and image stability.

Two types of materials based on this technology will be characterized. They exhibit spectral sensitivity in either the blue-green (scanner film VSX) or red to near IR (imagesetter film VIX). This paper describes these materials, imaging process steps, the imagesetting and plate-making characteristics. By eliminating the need for the chemical processing of conventional silver-based products, this technology provides an environmentally sound alternative for many prepress graphic arts applications.

Xerox Graphic Systems, 2660 Speakman Drive, Mississauga, Ontario, Canada L5K 2L1

Imaging Process Steps

Film Structure The film structure is shown schematically in Figure 1 and consists of a semi-transparent metallized substrate, a softenable matrix polymer layer, a monolayer of photosensitive selenium particles, and an overcoating layer.

The essential structural difference between scanner films VSX and imagesetter VIX films is that the overcoat of the latter has photosensitive organic pigment particles dispersed in it; in addition its matrix polymer layer is doped with a charge (hole) transport material. In appearance, the VSX film is reddish in colour whereas the VIX film looks bluish.

The conducting substrate is 100 or 175 µm thick polyester aluminized to 50% optical transmission. The matrix polymer layer, 1-2 µm thick, is a custom-synthesized styrene-based copolymer; for VIX film it doped with a hole transport molecule to provide the photodischarge properties essential to the imaging process as described later. The selenium monolayer consists of nearly-close-packed amorphous selenium spheres, 0.35 µm in diameter, embedded just a few tens of nanometers below the surface of the matrix polymer. The overcoat, 0.5-1.0 µm thick, is a styrene-based copolymer selected for abrasion-resistance, optical transparency, coatability. For VIX films, X-metal free phthalocyanine (x-H_2Pc) is used as the photosensitive organic pigment to achieve red and infrared imaging sensitivity.

The films are fabricated by solution-coating the conductive base with the matrix polymer using conventional slot-die technique and then thermally evaporating the selenium onto it in a vacuum chamber. Finally the overcoat is solution-coated onto the structure.

Imaging Process Steps The imaging process steps for scanner films VSX are uniform negative corona charging, imagewise exposure, and development by brief heating of the film as shown schematically in Fig. 2. The light-struck particles gain a substantial net charge. Upon heat-softening of the matrix polymer, the charged particles migrate towards the substrate and disperse in depth in the matrix polymer, resulting in a D_{min} (minimum optical density) region. The unexposed uncharged particles remain in their original monolayer configuration, giving a D_{max} (maximum optical density) region.

Fig. 3 shows schematically the imaging process steps for the imagesetter films VIX. Absorption of infrared radiation by the IR pigment particles in the overcoat results in photodischarge which neutralizes surface charge in exposed areas, rendering these areas insensitive to further light exposure. Blue light exposure in step 3 causes the Se particles to become negatively-charged due to injection of the photogenerated holes out of Se particles. The resulting charge pattern yields an electric field between Se particles and the film surface. Uniform negative recharging reverses the charge polarity so that an electric field now exists between the negatively-charged Se particles and the grounded substrate. Heat development allows the charged Se particles migrate and disperse in depth, resulting in a D_{min} region. The uncharged Se particles in the areas which have previously been discharged by IR radiation remain in their original monolayer configuration, giving a D_{max} region. Note that the VIX imaging process is negative-working.

Imagesetting Characteristics

Imagesetter Modifications A commercial imagesetter was modified to accept the VIX imaging process. The imagesetter, based on a capstan architecture, uses a 10 mW infrared laser diode @ 780 nm as the imaging source, a 25 µm spot size and up to 19" film width. It has a resolution and throughput speed combination from 1000 dpi @ 10.5"/min to 2540 dpi @ 4.1 "/min. Fig. 4 shows a schematic diagram illustrating the film path of the modified imagesetter. The modifications involve the addition of the following.

1. a first assembly consisting of a charging scorotron (similar to that commonly used in photocopiers) and mounting brackets.
2. a second assembly consisting of a blue light exposure lamp, a scorotron for negative recharging, a heater and two pinch rollers.

There were no changes to the optical system and laser system. The modified imagesetter runs on a Quadra 800 Macintosh system with 32 MB RAM, 400 MB hard disk and a SyQuest 88 MB external drive. Photoshop and Quark Xpress were used to generate output images. Finished ready-to-use colour separation films were generated, at the click of the mouse, from the modified imagesetter using imagesetter VIX films without the need of chemical processing or a dark room. The VIX color separation films were subsequently used to expose plates from which high quality color prints were produced.

Imaging Properties Table 1 summarizes the basic imaging properties of VSX and VIX films. Curves (a) and (b) of Fig. 5 show the typical D-LogE curve for VSX and VIX films respectively. Note that the optical density values include the density of the aluminum layer of 0.3. The imaging sensitivity is comparable with silver-halide films and is compatible with the sensitivity requirements of commercial imagesetters. The VSX film exhibits high imaging sensitivity in the blue-green spectral region; it can be exposed with an Argon laser @ 488 nm. The imaging sensitivity of VIX films extends from the red to near infrared spectral region; it can be exposed with HeNe laser at 630 nm or solid state diode laser @ 670 nm or 780 nm. Figs. 6 and 7 show the spectral sensitivity of VSX and VIX films respectively. Film processing is a fast dry process involving heat only. The development temperature is typically in the range of 100-115°C for 1-5 seconds. Both films have high resolution (>228 lp/mm). Fig. 8 shows a photomicrograph of a digital image of VSX film exposed at 4000 dpi, 250 lpi in an imagesetter which used an Argon laser and an external drum architecture. A pixel of 6-7 µm was clearly resolved. The shelf life and image stability are excellent because, before and after imaging, the film consists of essentially uncharged particles of an inert material in an inert matrix.

The optical absorption spectra of the D_{max} and D_{min} areas for VSX and VIX films are shown in Figs. 9 and 10 respectively. The increased absorption observed in VIX films in the 350-400 nm region is caused by the IR pigments in the overcoat and the charge transport molecules in the matrix polymer layer. To reduce the optical absorption in the UV region, the amount of IR pigment and charge transport material in the film structure were minimized.

Plate-Making and Printing Characteristics

Positive and negative offset plates from several manufactures (Hoechst, 3M, Fuji Photo, Kodak, Anitec) were exposed with VSX and VIX films using existing exposure equipments. The results showed that high quality plates could be produced but with reduced exposure latitude compared with conventional silver films. Because of the lower D_{max}, the plates exposed with the new films should be exposed to yield a visual solid step 1-2 (Stouffer 21-step gray scale) rather than to a solid step 4-5 as recommended by the plate manufacturers to avoid scumming on the press. Because of its higher D_{min}, the new films also require a longer exposure time, typically about 2X and 5X respectively for VSX and VIX films compared with conventional silver films.

Digital color separation VSX and VIX films have been generated from modified imagesetters. The films were subsequently used to expose plates from which high quality color prints were produced. Fig. 11 compares the tone reproduction curves at 150 lpi for VSX, VIX and silver films.

A series of experiments were carried out to determine the effect of exposure on the plate life. A test form consisting of five UGRA step wedges was contacted to VSX, VIX and silver films respectively. The exposure which resulted in a visual solid step 1 on the test plate (Kodak KNA-3) was determined for each film type. The UGRA step wedge images on the VSX, VIX as well as the silver films were then exposed to the test plate using multiples of the step 1 exposure. The test plate was run on a web press to 87K impressions. Print samples were pulled periodically and evaluated. The results (Table 2) indicate that it is possible to achieve prolonged runs with the VSX and VIX materials at exposures less than the manufacturers recommended level. Similar conclusions were also obtained from another experiment in which the plate was successfully run to 337K impressions.

Conclusions

A new silverless heat-developable graphic arts film has been developed. Their imaging structure, imaging process steps, imaging characteristics as well as the plate-making and printing characteristics have been described. The new films offer high-resolution, laser-sensitivity, fast dry processing involving heat only, room-light handling, excellent shelf life and image stability. Digital color separation films have been generated from the new films using modified imagesetters. The separation films were subsequently used to expose plates from which high quality color prints were produced.

Acknowledgements

We thank E. Sanderson of Rochester Institute of technology for conducting the printing experiments.

References

1. W. L. Goffe, *Photogr. Sci. Eng.* 15: 304 (1971).

2. M. C. Tam, P. S. Vincett, A. L. Pundsack, P. Soden, G. J. Kovacs, and D. S. Ng, *Photogr. Sci. and Eng.* 28, 217-224 (1984)

3. P. S. Vincett, G. J. Kovacs, M. C. Tam, A. L. Pundsack, and P. Soden, *J. Imaging Sci.* **30**: 183-191 (1986)

4. M. C Tam, A. L. Pundsack, R. W. Gundlach, P. S. Vincett, G. J. Kovacs, C. A. Jennings, and R. O. Loutfy, *J. Imaging Sci.* **32**: 247-254 (1988).

5. M. C. Tam, R. O. Loutfy, G. J. Kovacs, A. L. Pundsack, J. Meester and H. Aboushaka, *J. Imaging Science and Technology*, **36**, 81-87 (1992)

6. M.C. Tam, J. Meester, A.L. Pundsack, H. Aboushaka, and A. Jones, Proceedings IS&T's Eighth International Congress on Advances in Non-Impact Printing Technologies, Williamsburg, Virginia, 424-428, Oct. 25-30, 1992.

	VSX	VIX
Imaging sensitivity	~10 erg/cm2 @ 440 nm	~ 50-100 ergs/cm2 @ 630, 670, 780 nm
D_{max}	2.0	1.85
D_{min}	0.8	0.9
D_{max}-D_{min}	1.2	0.95
Resolution	>228 lp/mm	>228 lp/mm
Film processing	115°C, 1-5 sec	100°C, 1-5 sec
Room-light handling	Yes	Yes

Table 1 Properties of VSX and VIX films

UGRA Step Exposed	Imp	Original UGRA			VSX UGRA			VIX UGRA		
		3%	40 %	D	3%	40 %	D	3%	40 %	D
0.5	0	Y--	44	0.86	Y	67	1.05	Y--	61	0.97
	36	Y--	52	1.07	Y-	74	1.16	N	66	1.09
	71	N	46	1.14	Y-	72	1.15	N	65	1.09
	87	N-	42	1.14	Y--	74	1.17	N	66	1.14
0.71	0				Y	70	1.07	Y-	66	0.95
	36				Y	78	1.18	Y-	74	1.08
	71				Y	76	1.13	Y-	73	1.08
	87				Y	77	1.18	Y-	73	1.13
1	0	Y	64	0.88	Y	71	1.04	Y	70	0.97
	36	Y	80	1.08	Y	82	1.12	Y	76	1.08
	71	Y	79	1.08	Y	79	1.11	Y	74	1.07
	87	Y	82	1.14	Y	81	1.13	Y	77	1.15
2	0	Y	62	0.93	Y	73	0.95	Y	76	0.97
	36	Y	76	1.11	Y	83	1.14	Y	81	1.08
	71	Y	77	1.13	Y	80	1.11	Y	80	1.05
	87	Y	77	1.15	Y	82	1.14	Y	80	1.14
3	0	Y	64	0.93	Y	77	0.93		Fog	
	36	Y	75	1.16	Y	85	1.13		Fog	
	71	Y	77	1.12	Y	82	1.10		Fog	
	87	Y	81	1.15	Y	84	1.14		Fog	

Note: Y Halftones were visible with no break
Y- Halftones were visible with a minor break
N No dots

Table 2 The effect of plate exposure on runlength for VSX, VIX and silver halide films

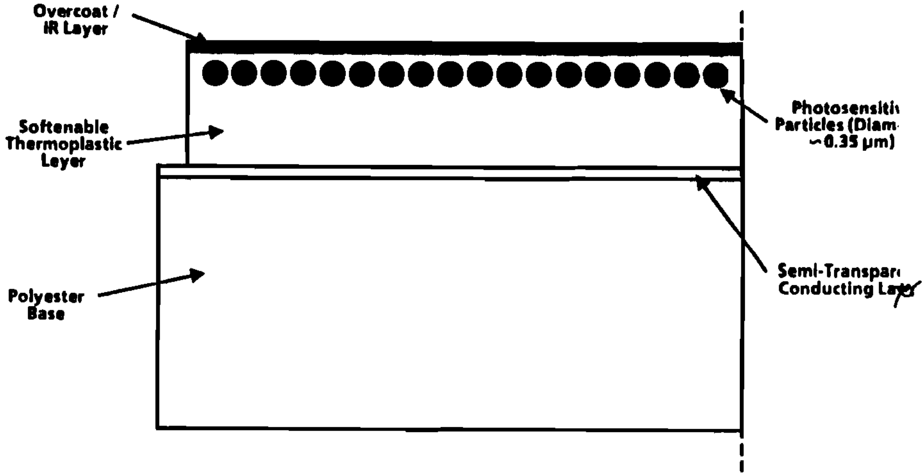

Fig. 1 Film structure

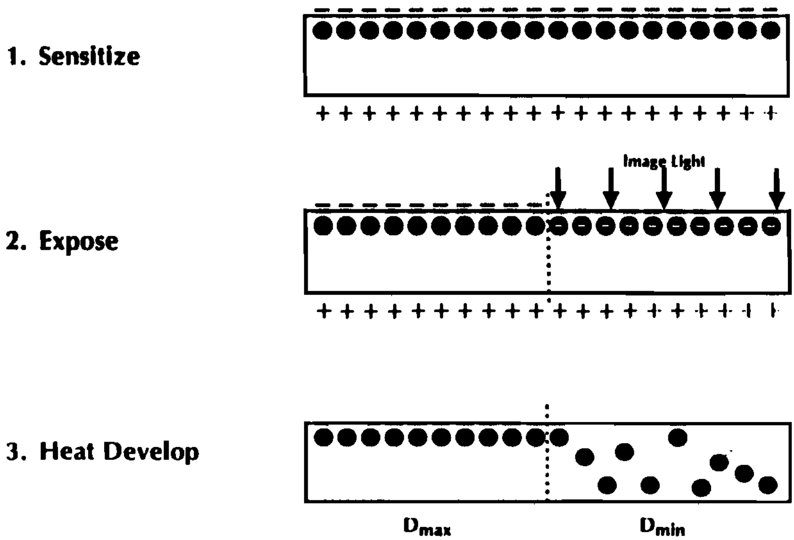

Fig. 2 Imaging process steps for scanner film VSX

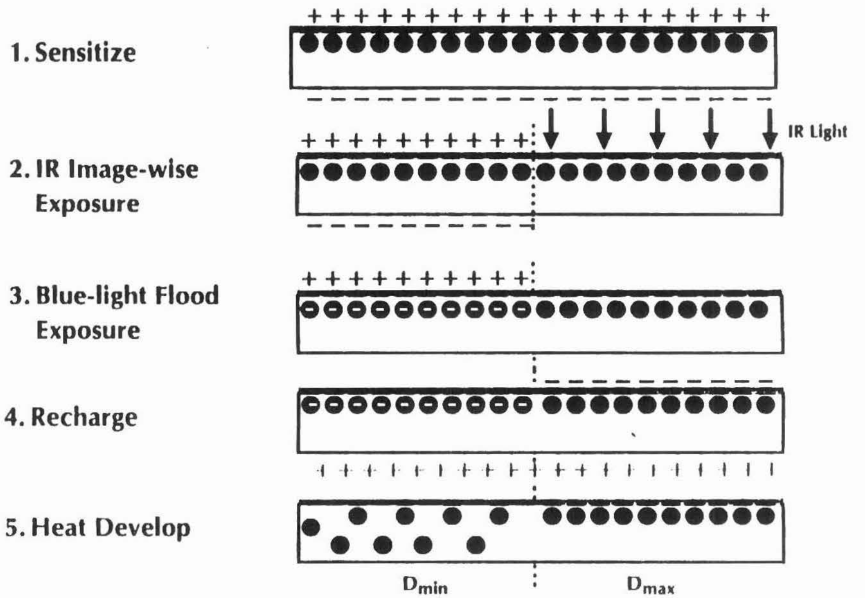

Fig. 3 Imaging process steps for imagesetter film VIX

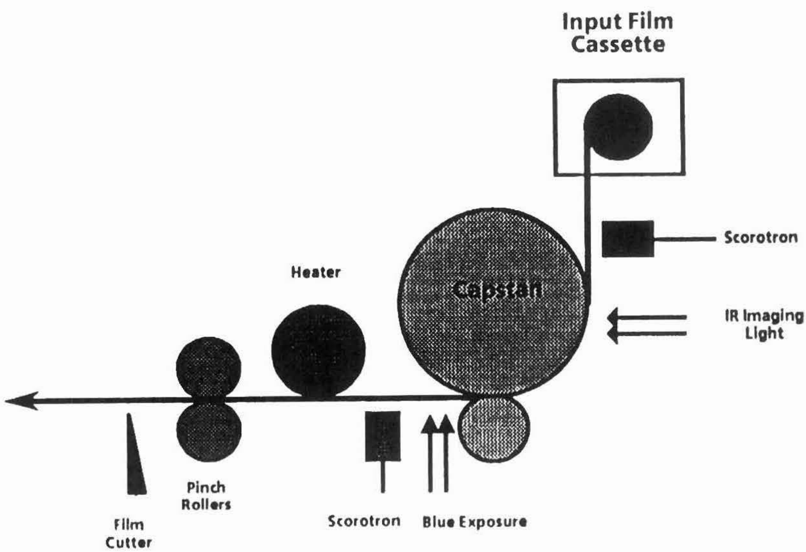

Fig. 4 Schematic diagram showing film path of a modified imagesetter

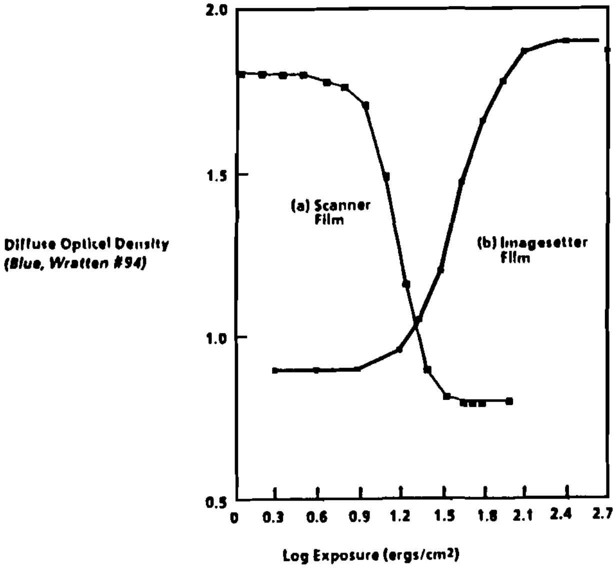

Fig. 5 D-LogE curves: (a) VSX film; (b) VIX film

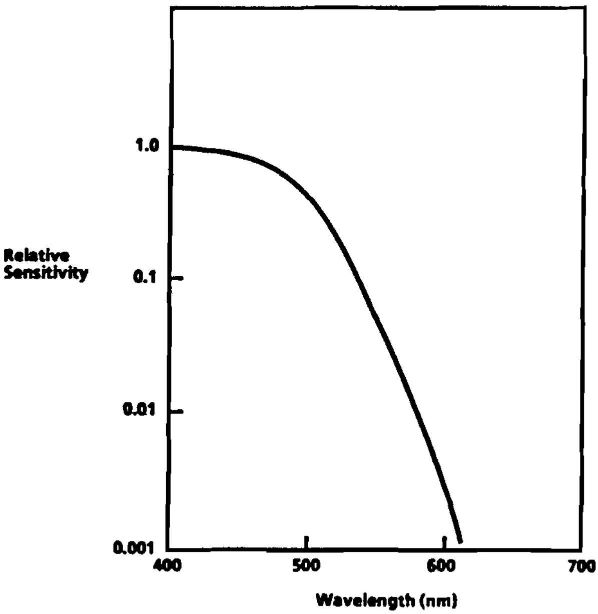

Fig. 6 Spectral sensitivity of scanner film VSX

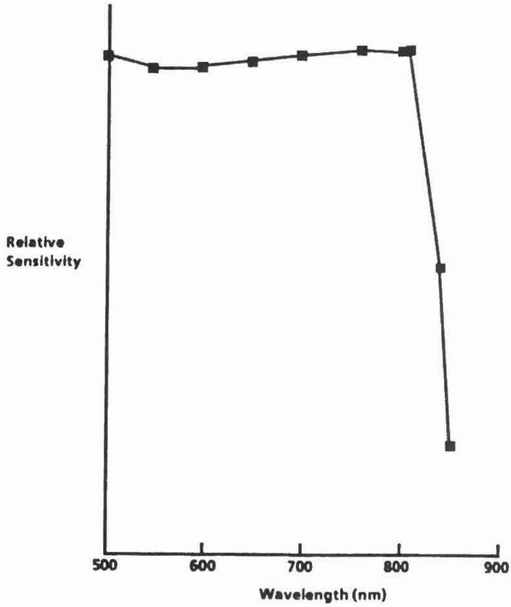

Fig. 7 Spectral sensitivity of imagesetter film VIX

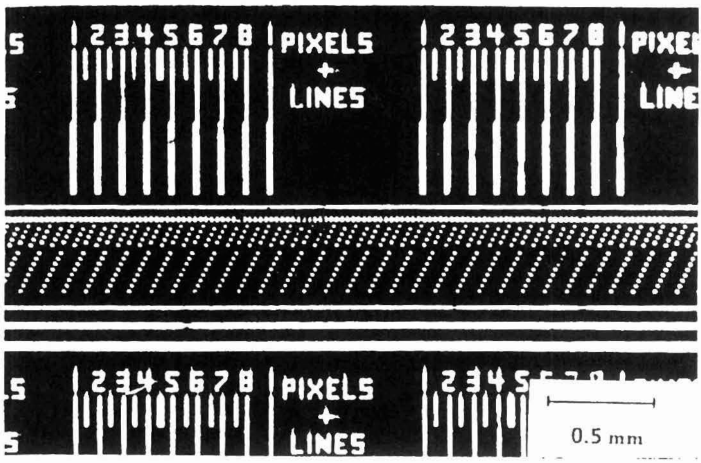

Fig. 8 Photomicrograph of a digital image generated on VSX film at 4000 dpi, 250 lpi

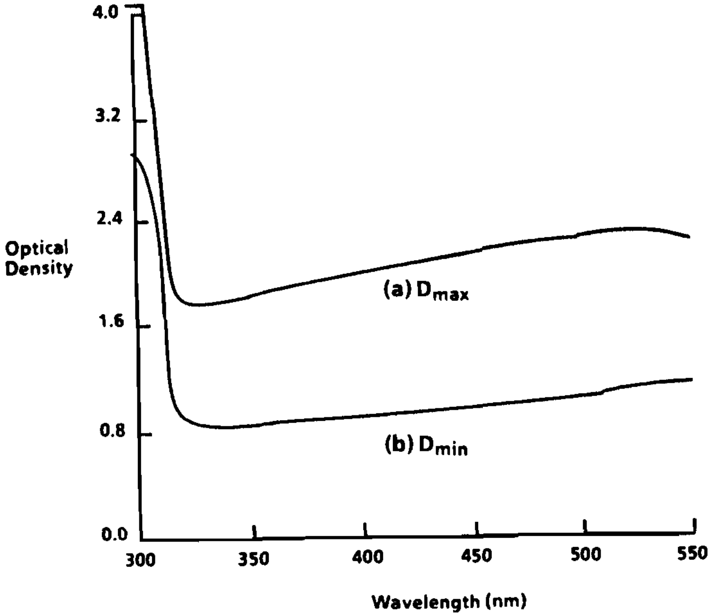

Fig. 9 Optical absorption curves for VSX film: (a) D_{max}; (b) D_{min}

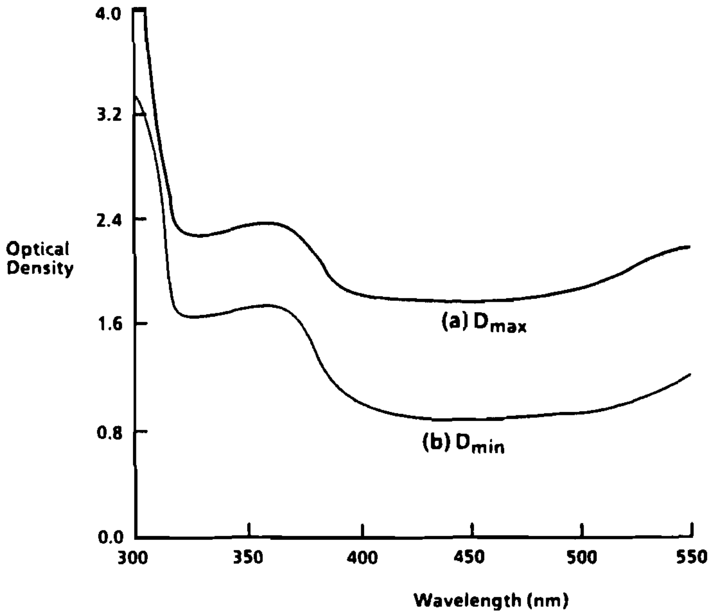

Fig. 10 Optical absorption curves for VIX film: (a) D_{max}; (b) D_{min}

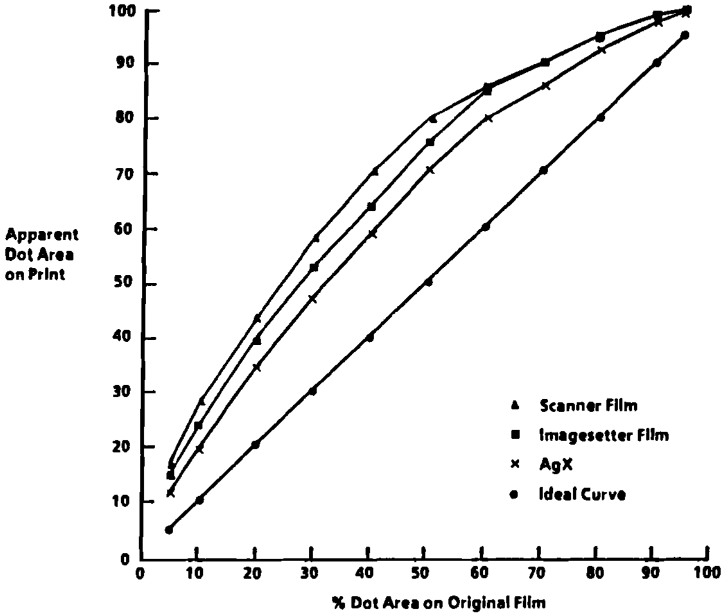

Fig. 11 Tone reproduction curves at 150 lpi