



Forensic analysis of Toners by Thin Layer Chromatography and High Performance Thin Layer Chromatography

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Abstract

The counterfeiting of printed documents is most common phenomenon in the modern world. The aim of the present research is to examine suspected documents from their ink components. 28 raw and processed toners were analyzed for their colored ink components by thin layer chromatography and high performance thin layer chromatography. Chloroform was efficient to extract all dye components from the inks. The separation was performed using two separate mobile phases. It is possible to differentiate toner cartridges by TLC and HPTLC.

Keywords: Questioned documents, Forensic analysis of Ink, Toner, TLC, and HPTLC.

Introduction

The chemical examination of toners helps to determine whether the whole document is produced by the same class of toners, to establish purported date of the document; or to determine the source of a document¹. The above questions can be answered by differentiating two toners formulations.

Ink formula is a defined as a definite recipe or set of ingredients and their quantities that the manufacturer specifies for the final toners product. These ingredients include colorants (dyes and pigments) and vehicle (volatile solvents, resins, etc) as two major components².

The present study deals with the qualitative analysis of colored components of toners by thin layer chromatography (TLC) and high performance thin layer chromatography (HPTLC). TLC method is successfully used for the comparative analysis of the toner but could not be used as an identification method until used for the comparison with a complete set of standards. HPTLC has been reported to be an automated form of TLC and has an inbuilt mechanism to store the database of analyzed toners samples which can be used for the comparison and identification.

Much of the work has been reported on the analysis of colored component of toner toners by thin layer chromatography³⁻⁵ but limited work has been carried out to recognize the discrimination potential of high performance thin layer chromatography to analyze toners⁶⁻⁸. By keeping the above facts in minds, the present study is aimed to determine the discriminating potential of thin layer chromatography (TLC) and high performance thin layer chromatography (HPTLC) in order to differentiate the colored components of the toner toners samples.

Materials and Methods

An attempt has been made in the present study to classify the toners on the basis of the colorants (dyes and pigments) by using thin layer chromatography (TLC) and high performance thin layer chromatography (HPTLC).

Collection of sample: Twenty eight raw as well as processed toner samples have been collected and were marked serially (Table-1). The raw toners were taken directly from the ink cartridge whereas a text was designed for the collection of processed toner sample. The text comprised of paragraphs in four colors, that is, cyan, magenta, yellow and black. The designed text was printed on A4 size sheets from different models of laser jet printers/photocopiers.

Sample preparation: The sample preparation of raw and processed toner samples were done separately and marked serially. In raw toner samples, 0.5 micrograms of each of four colors, that is, cyan, magenta, yellow and black were added into a test tube and mixed using 3 ml chloroform. In processed toner samples, total eight alphabets of four colors (two alphabets from each color) were selected from each printed document. Modified *Munson's technique* was used (Tandon *et al.* 1995) to remove toners from the processed toner samples. An aluminum foil was placed on the selected alphabets and the heat was applied on the back of sheet with a soldering rod (30 W) for 1-2 minutes. 2-3 lifts were sufficient to remove an adequate amount of sample. In another test tube, extracts of all four colors of each ink sample were mixed together using 2 ml chloroform. This was done because when a colored image (or printed stroke) was observed microscopically, all four colors visualized as series of dots. For example, if yellow color is examined under the microscope, it is visualized as multiple dots of cyan, magenta,

yellow and black color dots. However, they are not of equal intensity on substrate, but intensity of colors does not affect the results. Thus samples are considered as mixture of all colors. Also, the four colors, that is, cyan, magenta, yellow and black were used for printing the picture in layers. Hence, 4-colors were analyzed after mixing⁹⁻¹⁰. The similar process was done for the preparation of all the colored toners (raw and processed). The prepared mixture extracts were analyzed using thin layer chromatography (TLC) and high performance thin layer chromatography (HPTLC).

Solvent and stationery phase: The solvents used have been purchased from Loba Chemie Pvt. Ltd., Laboratory Reagent, Mumbai, India while the stationery phase from Merck, Germany. Ten different solvent systems (Table-2) were tried, of which two solvent systems (code I and II) were found to be efficient to separate all the toner samples. Both the solvent systems were kept in separate glass chambers for saturation for 35 minutes at normal room temperature. The precoated silica gel G-60 F254 non fluorescent aluminum plates (6.5 x 20 cm) were used as the stationery phase.

Thin layer chromatography: The toner sample was spotted on precoated silica gel non- fluorescent aluminum plate 60 F254 (6.5 x 20 cm) with the help of fine capillary tube. Separate capillary tube was used for each sample. The spotted plate was kept for drying at normal room temperature for 15-20 minutes. The dried spotted plate was placed gently in the saturated solvent chamber and was solvent was allowed to raise up to 5 cm mark on the plate.

High Performance Thin Layer Chromatography: Instrumentation: HPTLC instrument consists of CAMAG (Muttenz, Switzerland) Linomat V as an sample applicator along with 100 µl applicator syringe (Hamilton, Switzerland). Chromatography was performed on 6.5 cm x 20 cm non fluorescent aluminum TLC plates precoated with silica gel 60-F254 (E. Merck, Darmstadt, Germany). CAMAG TLC scanner 4 was used for scanning the plates.

Sample application: The 3 µl of each prepared sample was sprayed on the plate in the form of narrow bands of 6 mm length. During spraying a continuous stream of nitrogen gas was flowing parallel which helped to evaporate the extraction solvent from the bands. The bands were applied 15 mm above from the bottom and 15 mm away from left edge of the plate.

Mobile phase and Development: Spotted plates were developed by means of two separate mobile phases consisting of ethyl acetate: ethanol: distilled water (70:35:30) and chloroform: methanol: n-hexane: acetic acid (85:25:5:1) respectively. The development was carried out in twin-trough glass chambers equilibrated with 10ml of the mobile phase. The mobile phase was allowed to move up at a distance of 5 cm on plates. The plates were dried after development. A similar

process was carried out for all the toner samples.

Densitometry analysis: The densitometry scanning was performed with CAMAG TLC scanner 4 in the absorbance-reflectance mode under control by win CATS planar chromatography software (CAMAG, Switzerland). The bands were scanned at 540 nm. The samples showing absorbance at respective wavelength were recorded in the software in the form of 3D graphs (Figure-1).

Visualization of spots: The developed chromatograms were visualized under visible and ultraviolet light (short and long wavelength) and are shown in Figure-2a to 2f. The developed visible and fluorescent spots/bands were recorded and their hR_f values were calculated as following:

$$hR_f = \frac{\text{Distance travelled by solute}}{\text{Distance travelled by solvent}} \times 100$$

The result obtained were tabulated in Table-3

Results and Discussion

Analysis by Thin Layer Chromatography: Mixture of four colors, that is, cyan, magenta, yellow and black (CMYK) of twenty eight toner samples have been analyzed using thin layer chromatography (TLC) and results obtained were observed in visible light and ultra violet light (short and long wavelength). The results have been interpreted on the basis of differences in the number, color and hR_f values of spots.

In solvent I, twenty one toner samples were differentiated from each other on the basis of the differences in the number, color and hR_f value of the developed spots in the day light and ultra violet light (short and long wavelength). Remaining seven samples were put into three groups on the basis of similar number, color and hR_f value of the spots.

In solvent II, the sixteen samples were differentiated from each other on the basis of the differences in the number, color and hR_f value of the developed spots in the day light and ultra violet light (short and long wavelength). Remaining twelve samples were differentiated into six groups as they had similar number, color and hR_f value of the spots.

Analysis by High Performance Thin Layer Chromatography: Two solvent systems [I and II] were used for the analysis of colored toners. In both solvent systems I and II all toner samples were differentiated from each other on the basis of the differences in the number, color and hR_f value of the developed spots in the visible light at 540 nm (Table-4).

TLC has successfully differentiated toner samples on the basis of the differences in the number, color and hR_f value of spots.

However, some toner samples were not classified because they had similar chromatographic profiles. This might be because of two reasons; first being the same type of dye might have been used by various manufacturers during ink formulation. Secondly, the toner ink might have been manufactured in bulk by one company and distributed under different brand names. For better differentiation and classification, the samples were analyzed by HPTLC and encouraging results were obtained. More spots were detected when the chromatograms were scanned at 540 nm in absorption/ reflectance mode in UV-VIS spectrophotometer (Table-5). This was due to the high sensitivity of the densitometer which has detected even those spots which were not visible to the naked eyes. It was interesting to find that with increased number of spots different models of the similar make were also differentiated (Figure-3). The complete differentiation of toner inks by TLC and HPTLC with solvent I and II have been showed in Table 6. In future studies bulk samples of different ink types could also be analyzed by HPTLC.

Conclusion

28 raw and processed toners were analyzed by thin layer chromatography (TLC) and high performance thin layer chromatography (HPTLC). Chloroform was used as an extraction solvent. Two solvent systems (code I and II) were used in combination to differentiate toner samples completely. The differentiation was done on the basis of the differences in the number, color and R_f value of the developed spots. However, significant results have been obtained from the HPTLC chromatograms. It is possible to distinguish toner cartridges on the basis of the differences in the number, color and R_f value of the spots.

Acknowledgement

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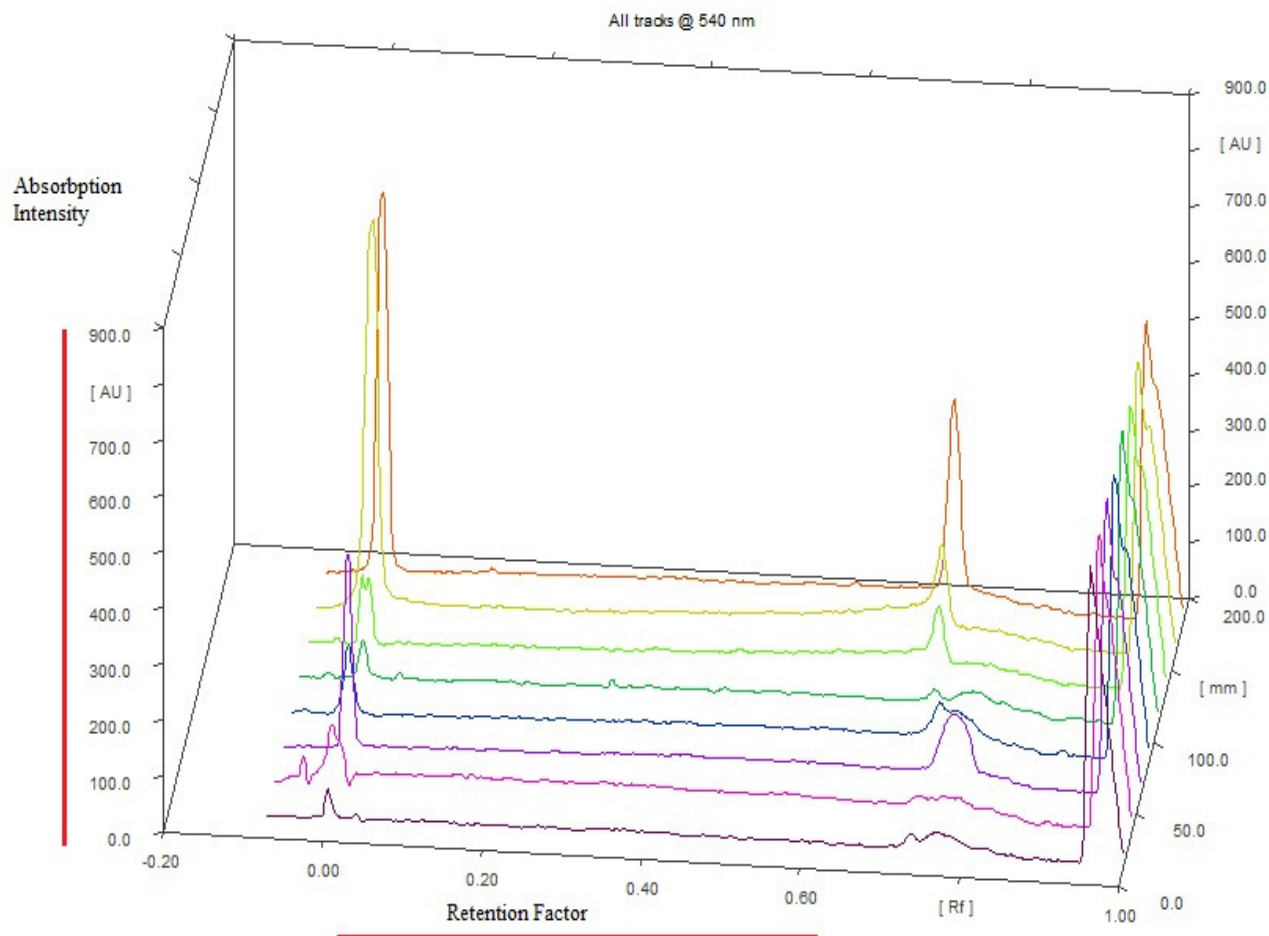


Figure-1

HPTLC 3D spectra of processed toners (sample number 11-14 and 17) and raw toners (sample number 9-11) with Solvent System I

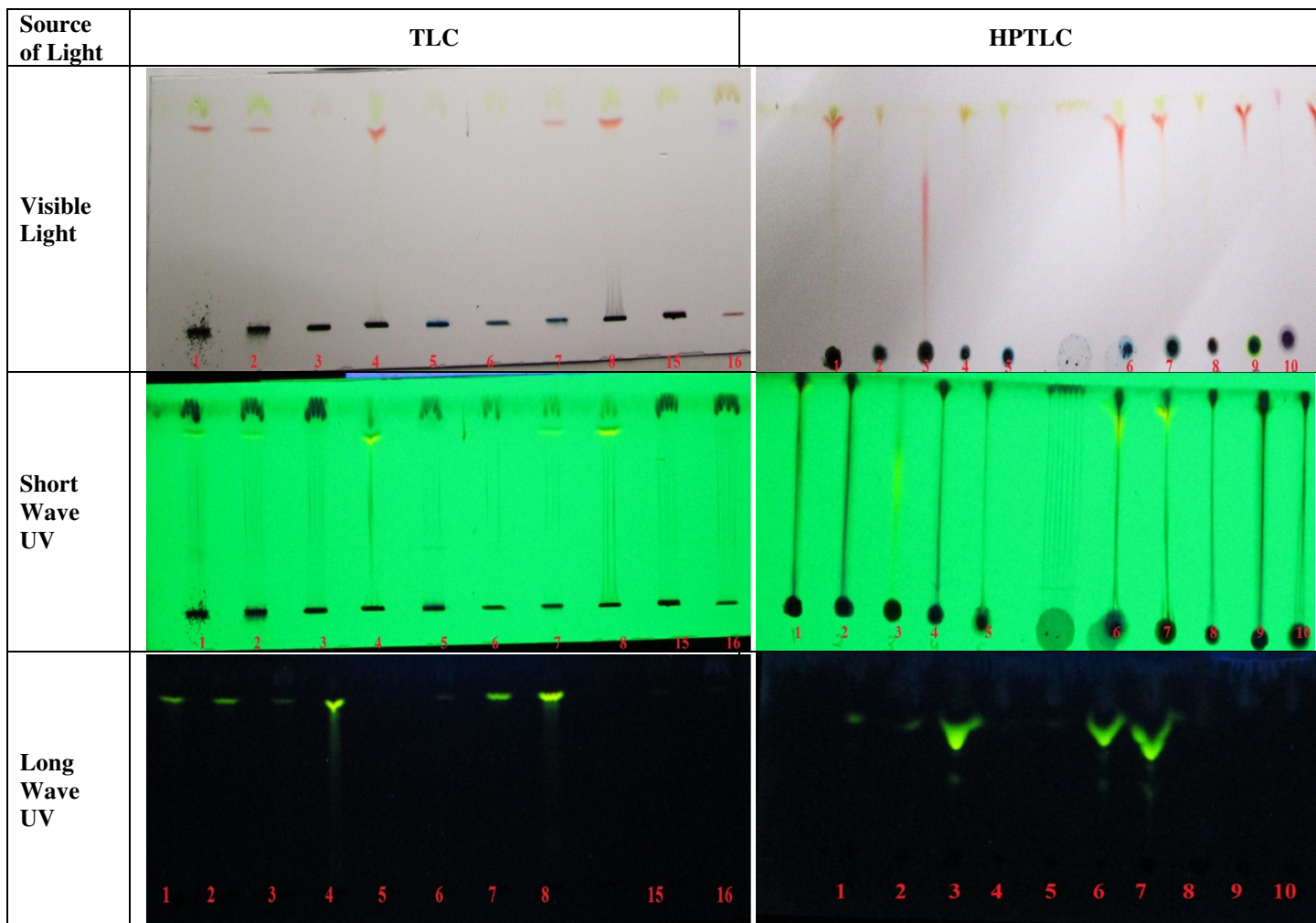


Figure-2
 Differentiation of toner samples by TLC and HPTLC with solvent system I and II

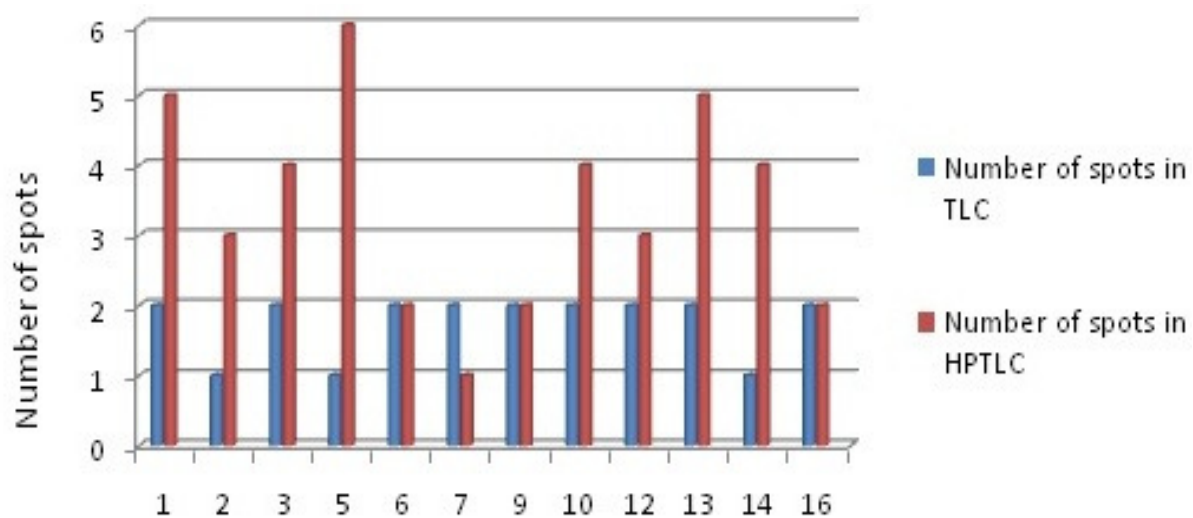


Figure-3
 Differentiation of different models of same make by TLC and HPTLC

Table-1
Description of toner samples

Model of Machine	Type of Toner	
Konica Minolta Bizhub c450	Raw	Processed
Konica Minolta Bizhub c450	Raw	Processed
Konica Minolta Bizhub c220	Raw	Processed
XEROX 252 PRO C751 EX	Raw	Processed
Konica Minolta Bizhub c220	Raw	Processed
Konica Minolta Bizhub c224e	Raw	Processed
Konica Minolta Bizhub c654	Raw	Processed
Xerox 7425	Raw	Processed
Konica Minolta Bizhub 6000	-----	Processed
Konica Minolta Cannon oce-231	-----	Processed
Xerox250	-----	Processed
Konica Minolta Bizhub 6500	-----	Processed
Konica Minolta Bizhub 6501	Raw	Processed
Konica Minolta Bizhub c280	Raw	Processed
Xerox7245	-----	Processed
Konica Minolta Bizhub c450	-----	Processed
Doculour-12	-----	Processed
Universal colour	Raw	-----
Doculour-12	Raw	-----
Doculour-12	Raw	-----
Doculour-12	Raw	-----
Xerox 50	Raw	-----
Xerox LDH	Raw	-----
HP Laserjet 1500L	Raw	-----
Xerox DC-12	Raw	-----
Canon CLC 300	Raw	-----
Universal colour	Raw	-----
Doculour-12	Raw	-----

Table-2
Description of solvent systems used

Solvent System Codes	Solvent System	Ratio(ml)
I	Ethyl acetate : Ethanol : Distilled water	70:35:30
II	Chloroform : Methanol : n-Hexane :Acetic acid	85:25:5:1
III	n-Butanol :Ethanol :Distilled water	90:15:20
IV	Dichloroethane :Acetone	12:24
V	Carbon Tetra Chloride : Ethyl Acetate	90:33
VI	N-Butanol : Propanol : Acetic acid	60:15:5
VII	N-Butanol :Ethanol :Distilled water: Acetic acid	70:35:30:5
VIII	N-Butanol :Acetone :Distilled water:	40:50:10
IX	Etthyl acetate : Ethanol : Chloroform	2:2:10
X	Isoamyl Alcohol : Acetone : Distilled water: Ammonia	15:15:5:1

Table-3
Thin Layer Chromatography of toners

Solvent system (code)	TLC Result with solvent system I and II(1-28)								
	Under Day Light			Under Short U.V Light			Under long UV light		
	No of Spots	Color of spots	hR _f	No of Spots	Color of Spots	hR _f	No of Spots	Color of Spots	hR _f
I	1	Yellow	91.1	-	-	-	-	-	-
	1	Magenta	88.0	1	Yellow	88.0	1	Green	88.0
II	1	Yellow	84.0	-	-	-	-	-	-
I	1	Magenta	93.3	-	-	-	-	-	-
II	1	Magenta	78.0	-	-	-	-	-	-
I	1	Yellow	84.4	-	-	-	-	-	-
	1	Magenta	48.8	1	Yellow	48.8	1	Green	48.8

Solvent system (code)	TLC Result with solvent system I and II(1-28)								
	Under Day Light			Under Short U.V Light			Under long UV light		
	No of Spots	Color of spots	hR _f	No of Spots	Color of Spots	hR _f	No of Spots	Color of Spots	hR _f
II	1	Yellow	78.0	-	-	-	-	-	-
	1	Orange	54.0	1	Yellow	54.0	1	Green	54.0
I	1	Magenta	93.3	-	-	-	-	-	-
II	1	Magenta	80.0	-	-	-	-	-	-
I	1	Yellow	93.3	-	-	-	-	-	-
II	1	Yellow	80.0	-	-	-	-	-	-
I	1	Yellow	93.3	-	-	-	-	-	-
	1	Magenta	84.4	1	Yellow	84.4	1	Green	84.4
II	1	Yellow	78.0	-	-	-	-	-	-
	1	Orange	58.0	1	Yellow	58.0	1	Green	58.0
I	1	Yellow	95.5	-	-	-	-	-	-
	1	Magenta	88.0	1	Yellow	88.0	1	Green	88.0
II	1	Yellow	76.0	-	-	-	-	-	-
	1	Orange	52.0	1	Yellow	52.0	1	Green	52.0
I	1	Yellow	93.3	-	-	-	-	-	-
II	1	Yellow	80.0	-	-	-	-	-	-
I	1	Yellow	88.0	-	-	-	-	-	-
	1	Orange	77.0	1	Yellow	77.0	1	Green	77.0
II	1	Yellow	90.0	-	-	-	-	-	-
	1	Orange	92.0	1	Yellow	92.0	1	Green	92.0
I	1	Yellow	86.6	1	Yellow	66.6	1	Green	66.6

Solvent system (code)	TLC Result with solvent system I and II(1-28)								
	Under Day Light			Under Short U.V Light			Under long UV light		
	No of Spots	Color of spots	hR _f	No of Spots	Color of Spots	hR _f	No of Spots	Color of Spots	hR _f
	1	Orange	66.6	-	-	-	-	-	-
II	1	Yellow	82.0	-	-	-	-	-	-
I	1	Orange	54.0	1	Yellow	54.0	1	Green	54.0
	1	Yellow	88.0	-	-	-	-	-	-
II	1	Yellow	82.0	-	-	-	-	-	-
I	1	Yellow	86.6	-	-	-	-	-	-
	1	Orange	66.6	1	Yellow	66.6	1	Green	66.6
II	1	Yellow	84.0	-	-	-	-	-	-
	1	Orange	54.0	1	Yellow	54.0	1	Green	54.0
I	1	Yellow	93.3	-	-	-	-	-	-
	1	Magenta	91.1	-	-	-	-	-	-
II	1	Yellow	78.0	-	-	-	-	-	-
I	1	Pink	95.5	-	-	-	-	-	-
II	1	Pink	82.0	-	-	-	-	-	-
I	1	Magenta	88.0	-	-	-	-	-	-
II	1	Magenta	86.0	-	-	-	-	-	-
I	1	Yellow	91.1	-	-	-	-	-	-
	1	Orange	71.1	1	Yellow	71.1	1	Green	71.1
II	1	Yellow	84.0	-	-	-	-	-	-
	1	Orange	56.0	1	Yellow	56.0	1	Green	56.0
I	1	Magenta	91.0	-	-	-	-	-	-

Solvent system (code)	TLC Result with solvent system I and II(1-28)								
	Under Day Light			Under Short U.V Light			Under long UV light		
	No of Spots	Color of spots	hR _f	No of Spots	Color of Spots	hR _f	No of Spots	Color of Spots	hR _f
II	1	Magenta	88.0	-	-	-	-	-	-
I	1	Yellow	91.1	-	-	-	-	-	-
	1	Magenta	88.0	-	-	-	-	-	-
II	1	Yellow	78.0	-	-	-	-	-	-
I	1	Yellow	86.0	-	-	-	-	-	-
	1	Magenta	73.3	-	-	-	-	-	-
II	1	Yellow	81.2	-	-	-	-	-	-
	1	Magenta	14.6	-	-	-	-	-	-
I	1	Yellow	86.0	-	-	-	-	-	-
	1	Magenta	73.3	-	-	-	-	-	-
II	1	Yellow	81.2	-	-	-	-	-	-
	1	Magenta	14.6	-	-	-	-	-	-
I	1	Yellow	86.0	-	-	-	-	-	-
	1	Magenta	73.3	-	-	-	-	-	-
II	1	Yellow	79.0	-	-	-	-	-	-
	1	Magenta	17.7	-	-	-	-	-	-
I	1	Yellow	91.1	-	-	-	-	-	-
	1	Magenta	75.0	-	-	-	-	-	-
	1	Blue	91.1	-	-	-	-	-	-
II	1	Yellow	76.8	-	-	-	-	-	-
	1	Magenta	14.6	-	-	-	-	-	-

Solvent system (code)	TLC Result with solvent system I and II(1-28)								
	Under Day Light			Under Short U.V Light			Under long UV light		
	No of Spots	Color of spots	hR _f	No of Spots	Color of Spots	hR _f	No of Spots	Color of Spots	hR _f
	1	Blue	65.0	-	-	-	-	-	-
I	1	Yellow	88.0	-	-	-	-	-	-
	1	Magenta	75.0	-	-	-	-	-	-
II	1	Yellow	79.0	-	-	-	-	-	-
	1	Magenta	17.7	-	-	-	-	-	-
I	1	Yellow	88.0	1	Yellow	66.6	1	Green	66.6
	1	Pink	66.6	-	-	-	-	-	-
II	1	Yellow	79.0	-	-	-	-	-	-
	1	Pink	54.0	1	Yellow	54.0	1	Green	54.0
	1	Blue	75.0	-	-	-	-	-	-
I	1	Yellow	91.1	-	-	-	-	-	-
II	1	Yellow	79.0	-	-	-	-	-	-
I	1	Magenta	86.0	-	-	-	-	-	-
II	1	Magenta	80.0	-	-	-	-	-	-
I	1	Yellow	88.0	-	-	-	-	-	-
	1	Pink	68.8	1	Yellow	68.8	1	Green	68.8
II	1	Yellow	79.0	-	-	-	-	-	-
	1	Pink	59.0	1	Yellow	59.0	1	Green	59.0
	1	Blue	77.0	-	-	-	-	-	-
I	1	Yellow	91.1	-	-	-	-	-	-
	1	Magenta	77.7	-	-	-	-	-	-
II	1	Yellow	79.0	-	-	-	-	-	-
	1	Magenta	19.8	-	-	-	-	-	-

Table-4
High Performance Thin Layer Chromatography of toners

Sample No.	Solvent system (code)	HPTLC (1-28)								
		Under Day Light			Under Short U.V Light			Under long u.v light		
		No of Spots	Color of spots	hR _f	No of Spots	Color of Spots	hR _f	No of Spots	Color of Spots	hR _f
1.	I	1	Yellow	90.6	-	-	-	-	-	-
		1	Orange	79.2	1	Yellow	79.2	1	Green	79.2
		1	Magenta	81.1	-	-	-	-	-	-
	II	1	Yellow	78.2	1	Yellow	78.2	1	Green	78.2
2	I	1	Magenta	88.7	-	-	-	1	Green	88.7
	II	1	Magenta	74.5	-	-	-	1	Green	74.5
3	I	1	Yellow	86.8	-	-	-	-	-	-
		1	Orange	75.4	1	Yellow	75.4	1	Green	75.4
		1	Magenta	77.4	-	-	-	-	-	-
	II	1	Yellow	76.4	1	Yellow	76.4	1	Green	76.4
4	I	1	Yellow	88.7	-	-	-	-	-	-
	II	1	Yellow	76.4	-	-	-	-	-	-
5	I	1	Yellow	90.6	-	-	-	1	Green	90.6
	II	1	Yellow	74.5	-	-	-	1	Green	74.5
6	I	1	Yellow	88.7	-	-	-	-	-	-
		1	Orange	77.4	1	Yellow	77.4	1	Green	77.4
		1	Magenta	78.4	-	-	-	-	-	-
	II	1	Yellow	78.2	1	Yellow	78.2	1	Green	78.2
		1	Orange	63.3	-	-	-	-	-	-
7	I	1	Yellow	88.7	-	-	-	-	-	-

Sample No.	Solvent system (code)	HPTLC (1-28)								
		Under Day Light			Under Short U.V Light			Under long u.v light		
		No of Spots	Color of spots	hR _f	No of Spots	Color of Spots	hR _f	No of Spots	Color of Spots	hR _f
		1	Orange	77.4	1	Yellow	77.4	1	Green	77.4
		1	Magenta	78.4	-	-	-	-	-	-
		1	Yellow	80.0	1	Yellow	80.0	1	Green	80.0
	II	1	Orange	63.4	-	-	-	-	-	-
		1	Yellow	90.6	-	-	-	-	-	-
8	I	1	Yellow	78.2	-	-	-	-	-	-
		1	Orange	63.3	-	-	-	-	-	-
	II	1	Yellow	96.0	1	Yellow	96.0	1	Green	96.0
9.	I	-	-	-	-	-	-	-	-	-
	II	1	Yellow	95.0	1	Yellow	95.0	1	Green	95.0
10.	I	-	-	-	-	-	-	-	-	-
	II	1	Yellow	90.9	1	Yellow	90.9	1	Green	90.9
11.	I	1	Orange	85.5	-	-	-	-	-	-
		1	Yellow	88.0	1	Yellow	88.0	1	Green	88.0
	II	1	Yellow	96.0	1	Yellow	96.0	1	Green	96.0
12.	I	1	Yellow	90.9	1	Yellow	90.9	1	Green	90.9
		1	Orange	85.5	-	-	-	-	-	-
	II	1	Yellow	96.0	1	Yellow	96.0	1	Green	96.0
13	I	1	Yellow	89.1	1	Yellow	83.6	1	Green	83.6
		1	Orange	83.6	-	-	-	-	-	-
		1	Magenta	85.5	-	-	-	-	-	-
	II	1	Yellow	74.2	1	Yellow	74.2	1	Green	74.2

Sample No.	Solvent system (code)	HPTLC (1-28)								
		Under Day Light			Under Short U.V Light			Under long u.v light		
		No of Spots	Color of spots	hR _f	No of Spots	Color of Spots	hR _f	No of Spots	Color of Spots	hR _f
		1	Orange	60.0	-	-	-	-	-	-
14	I	1	Yellow	89.1	-	-	-	-	-	-
		1	Orange	83.6	1	Yellow	83.6	1	Green	83.6
		1	Magenta	85.5	-	-	-	-	-	-
	II	1	Yellow	76.4	1	Yellow	76.4	1	Green	76.4
		1	Orange	63.3	-	-	-	-	-	-
15	I	1	Yellow	90.9	1	Yellow	90.9	1	Green	90.9
	II	1	Yellow	98.0	-	-	-	1	Green	98.0
16.	I	1	Magenta	88.7	1	Yellow	88.7	1	Green	88.7
	II	1	Yellow	96.0	1	Yellow	96.0	1	Green	96.0
17.	I	1	Yellow	89.1	-	-	-	-	-	-
		1	Orange	83.6	1	Yellow	83.6	1	Green	83.6
	II	1	Yellow	96.0	1	Yellow	96.0	1	Green	96.0
18	I	1	Yellow	89.2	-	-	-	-	-	-
		1	Orange	83.6	-	-	-	-	-	-
	II	1	Magenta	83.6	-	-	-	-	-	-
	1	Magenta	52.0	-	-	-	1	Green	52.0	
19	I	1	Yellow	90.7	1	Yellow	90.7	1	Green	90.7
	II	1	Magenta	87.0	-	-	-	1	Green	52.0
	1	Magenta	52.0	-	-	-	-	-	-	
20	I	1	Yellow	90.7	1	Yellow	90.7	1	Green	90.7

Sample No.	Solvent system (code)	HPTLC (1-28)								
		Under Day Light			Under Short U.V Light			Under long u.v light		
		No of Spots	Color of spots	hR _f	No of Spots	Color of Spots	hR _f	No of Spots	Color of Spots	hR _f
		1	Magenta	87.0	-	-	-	-	-	-
	II	1	Magenta	54.0	-	-	-	1	Green	54.0
21	I	1	Yellow	90.2	1	Yellow	90.2	1	Green	90.2
		1	Magenta	90.0						
	II	1	Magenta	52.0	-	-	-	1	Green	52.0
22	I	1	Magenta	85.1	-	-	-	-	-	-
		1	Blue	90.7	-	-	-	1	Green	90.7
	II	1	Blue	98.2				1	Green	98.2
23	I	1	Yellow	87.0	-	-	-	1	Green	87.0
	II	1	Magenta	52.0	-	-	-	1	Green	52.0
24	I	-	-	-	-	-	-	-	-	-
	II	1	Blue	98.2	-	-	-	1	Green	98.2
25	I	1	Yellow	90.6	1	Yellow	90.6	1	Green	90.6
	II	1	Yellow	98.0	-	-	-	1	Green	98.0
26	I	1	Blue	88.9	-	-	-	-	-	-
	II	1	Magenta	98.0	-	-	-	1	Green	98.0
27	I	1	Yellow	87.0	-	-	-	1	Green	87.0
		-	-	-	-	-	-	1	Green	72.7
	II	1	Blue	90.0	-	-	-	1	Green	90.0
28	I	1	Yellow	81.5	-	-	-	1	Green	81.5
	II	1	Yellow	96.0	-	-	-	1	Green	96.0
		1	Magenta	52.0	-	-	-	-	-	-

Table-5
High Performance Thin Layer Chromatography of Toners at 540 nm with Solvent System I

No of spots	hR _f values
5	64,68,78,84,100
3	73,81,84
4	63,80,81,84
6	16,37,42,61,70,82
6	17,22,33,39,77,82
2	63,75
1	63
4	47,53,68,80
2	74,81
4	66,72,83,86
3	74,84,87
3	74,80,85
5	73,80
4	65,73,82,85
6	24,54,61,75,84,100
2	68,81
4	32,73,80,83
3	14,77,85
5	23,73,78,80,99
5	73,81,86,91,99
4	77,85,90,99
3	73,81,99
4	61,73,80,99
3	66,79,99
4	77,86,89,98
4	80,86,89,99
3	77,86,99
8	10,30,48,61,74,85,89,99

Table-6
Differentiation of toner samples by TLC and HPTLC with solvent system I and II

Chromatographic Method	Solvent I	Solvent II
TLC		
HPTLC (540 nm)	21 28	16 28

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