Novel Black Dye Composition for Inkjet Application

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Abstract

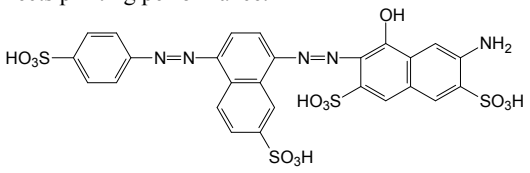
There are certain performance requirements placed on dye-based colorants for inkjet ink applications. These include high color strength and bright shade, long-term storage stability, high light and water fastness. Moreover, metal-free derivatives are preferable from an environmental standpoint. Reactive dyes are intrinsically bright, with moderate fastness properties and are less harmful to human. However, this type of dye has poor long-term storage stability, owing to reactive group hydrolysis. This reaction causes dye precipitation, leading to clogging and damaging to print head and shade changes problems.

Dye with carboxyl group have been studied have high water fastness performance [1,2]. In this paper, a series of black dye composition is discussed which navy component contains carboxyl groups and demonstrates improved water and light fastness. These compositions are readily soluble in aqueous solutions shows good printing performance.

Introduction

Ink jet printing is a non-impact printing method; its features include sharp, non-feathering patterns, good water-fastness and light-fastness, and optical density. Printing properties are also desirable, such as fast drying and good storage stability, printing smoothness, and non-clogging. Dyes for inkjet printing should display high water solubility, thermal and chemical stability, good light stability and performance, high purity and low toxicity. The work described here on black dyes composition is aimed at neutral black with good light-fastness to gas fading, as presented by Mario Fryberg [3].

Food Black 2 (**1**) is a heavy black dye used commercially in ink jet printing is still widely used [4]. This dye has good solubility but poor water fastness and light fastness [5]. C.I. Direct Black 168 (**2**) shows good light-fastness but low solubility [6,7].
C I Reactive Black 5 (**3**) has strong chromophore but poor storage stability. This dye hydrolyses and releases sulphate during storage thus affects printing performance.



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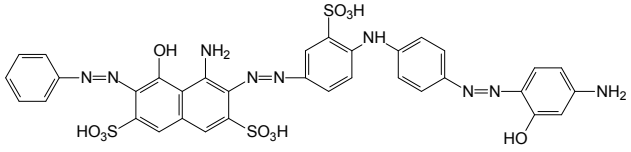

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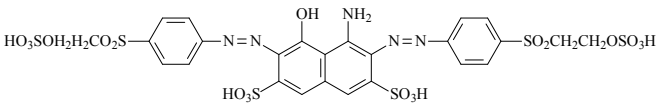

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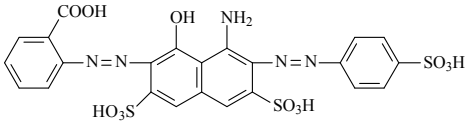
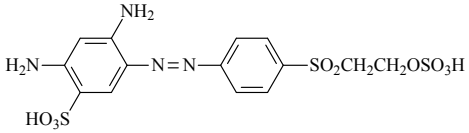
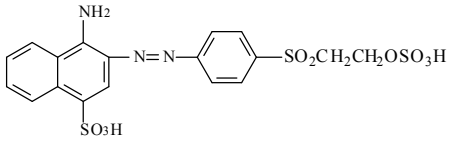
A new approach aimed at producing a new navy component (I-1) of black dye composition, which based on the coupler H-acid (1-Amino-8-naphthol-3, 6-disulfonic acid) coupling with p-amino benzene sulfonic acid and anthranilic acid diazonium. Dye was purified and followed shading by Yellow (II-1) Orange (III-1) and Red (IV-1) component to get a black composition. This mixture black exhibits a neutral black shade with good solubility, medium light fastness and storage stability.



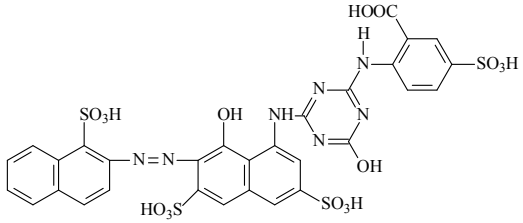
I-1



II-1



III-1



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Experimental

Dye composition

Proprietary compositions dye A, B and C are formulated. These dyes performances are use in comparisons to the general marketed black ink compositions from marketplace, namely dye D (Reactive Black 5) and E (Bayscript Black SP).

	Dyestuff composition				
	A	B	C	D	E
DYE 1				3%	
DYE 2	3%	2.5%	2.5%		
DYE 3		0.36%	1.15%		
DYE 4		1.33%	1.03%		
DYE 5		0.11%			
DYE 6					16%

DYE 1 represents the C.I. Reactive Black 5.
DYE 2 represents the diazo compound of formula (I-1)
DYE 3 represents the compound of formula (II-1)
DYE 4 represents the compound of formula (III-1).
DYE 5 represents the compound of formula (IV-1).
DYE 6 represents the Bayscript Black SP.

Ink formulation

The ink compositions and formulation used for printing are detailed in Table 1.

Table 1: Ink composition

	Proprietary			References	
	A	B	C	D	E
Dyestuff composition	3%	4.3%	4.68%	3%	16%
DEG	10%	10%	10%	10%	10%
DEGMBE	10%	10%	10%	10%	10%
Glycerin	7%	7%	7%	7%	7%
S-465	1%	1%	1%	1%	1%
PROXEL-XL2	0.3%	0.3%	0.3%	0.3%	0.3%
DI-water	68.7%	67.4%	67.0%	68.7%	55.7%

The above Abs./λmax(100ppm): denotes the above preparation of the ink composition having a concentration of 100ppm(100mg/l), and is tested at the wave length where the greatest UV absorbing wave length is λmax, and the UV absorbance of it is Abs.

Printing Test

Printer: EPSONSTYLUS PHOTO 830U PRINTER,
Printing paper: PLAIN PAPER
Printing setting: Normal printing

Light Fastness Test

AATCC test method 16E,
Testing-total energy 85KJ.

Water Fastness Test

Adding 200g of pure water to a beaker, and to the beaker shredded printed papers of area 5cm*5cm are immersed straight up in the pure water for a minute. Next, the square papers are taken out and allowing the excess water to drip for a minute by sitting them straight up, and after the papers are baked dry under a temperature of 60℃. Furthermore the color difference of before and after washing is examined with the use of DATACOLOR color spectrometer, where larger the magnitude of DE larger the color difference is between before and after washing, which means poor water fastness.

Results and discussion

Comparison of light and water fastness

Results of light and water fastness test are displayed in Table 2

Table 2: Light fastness and water fastness test result:

Ink recipe	Change of DE under water fastness	Change of DE under light fastness
Sample group A	16.3	2.99
Sample group B	------	5.18
Sample group C	------	4.51
Comparative group D	19.0	3.42
Comparative group E	------	7.44

Note 1: Change of DE under water fastness --- the smaller the change in DE the smaller the color difference is between before and after washing, meaning good water fastness.
Note 2: Change of DE under light fastness --- the smaller the change in DE the smaller the color difference is between before and after exposure, meaning good light fastness.

It can be seen that the ink composition only contains navy component (I-1) had lower DE variation compare to Reactive Black 5 and the black composition B and C had a lower DE variation compare to commercial Bayscript Black SP. It means the black composition can get better light and water fastness compare to comparative samples. It means dye contains carboxyl group in ortho-position near by azo chromophore might be formed interact hydrogen boding with the hydroxyl group to protect chromophore decomposed under testing light.

Conclusion

From the above test results, compositions B and C derived from the novel navy composition displayed good light and water fastness, and demonstrated satisfactory color strength/blackness compared to commercial product. These new dyes presents an opportunity in resolving the long-term stability issue commonly seen in the inkjet ink industry.

Reference

1. U.S. Patent No. 4,963,189
2. U.S. Patent No. 5,062,893
3. Mario Fryberg, Rev. Prog. Color., 35(2005) 2.
4. D J Thompson, R W Kenyon and D Thorp, GB2103231 (ICI;1982)
5. Stephen F. Pond, Inkjet Technology and product development strategies, (2000) 177.
6. U.S. Patent No. 5,062,892
7. W. Bauer, J. Geisenberger and H. Menzel, Novel Black Colorants for Ink Jet Application , NIP14: Proc. Int. Conf. Digital Print. Technol., Toronto,Canada (1998) 99.

Author Biography

Hsiao-San Chen received his B.E. and Master Degrees from Fun-Cha University (Taiwan), Textile Department in 1990 and 1992, respectively. His worked for Everlight Chemical Industry Corporation (ECIC) since 1994 with focus on the reactive dyes synthesis. He received Ph.D. degree from UMIST (U.K), Textile Department with ECIC's financial support. Dr. Chen serves as Inkjet Group Leader in the R&D Department.