New black dye for inkjet ink application

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Abstract

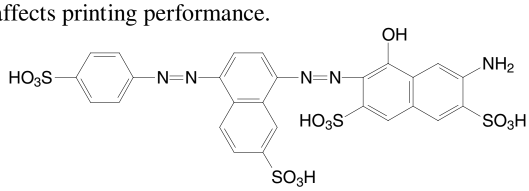
There are certain performance requirements placed on dye-based colorants for inkjet ink applications. These include high color strength and bright shade, long-term storage stability, and high light fastness. Moreover, metal-free derivatives are preferable from an environmental standpoint. Reactive dyes 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 damage to print head and shade changes problems.

In this paper, a modified black dye is discussed. It is derived from Everzol® Black GSP, and demonstrates improved storage stability and color strength. In addition, it is metal-free and resulting prints display improved light fastness. This dye is readily soluble and 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 is aimed at neutral black with good light-fastness and resistance to gas fading, as presented by Mario Fryberg [1].

Food Black 2 (**1**), an early black dye used commercially in ink jet printing, is still widely used [2]. This dye has good solubility but poor water fastness and light fastness [3]. C.I. Direct Black 168 (**2**) shows good light-fastness but low solubility [4,5]. C I Reactive Black 31 (**3**) has good light fastness but poor storage stability. This dye hydrolyses and releases sulphate during storage thus affects printing performance.



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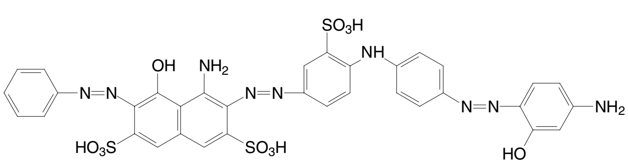

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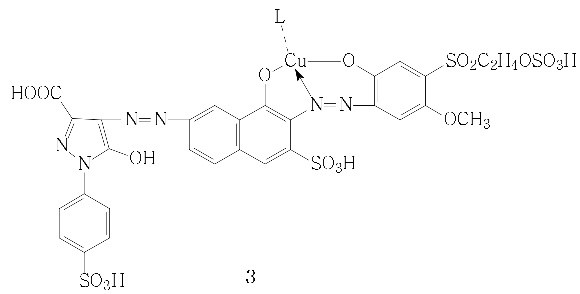

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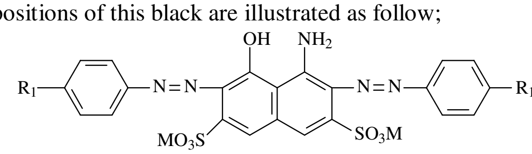
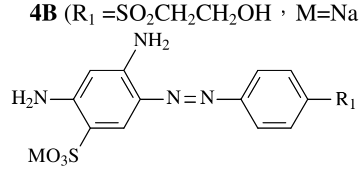
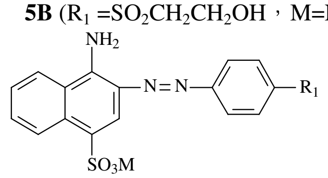
Accordingly a new approach aimed at producing a new black dye composition (**4A and 4B, 5A and 5B, 6A and 6B**) , derived from *Everzol*® Black GSP (**4**) and produced by Everlight, is reported. This mixture exhibits a neutral black shade with good solubility, medium light fastness and storage stability. The compositions of this black are illustrated as follow;



4 ($R_1 = SO_2CH_2CH_2OSO_3Na$，M=Na)
4A ($R_1 = SO_2CHCH_2$, M=Na or Li)
4B ($R_1 = SO_2CH_2CH_2OH$，M=Na or Li)



5 ($R_1 = SO_2CH_2CH_2OSO_3Na$，M=Na)
5A ($R_1 = SO_2CHCH_2$, M=Na or Li)
5B ($R_1 = SO_2CH_2CH_2OH$，M=Na or Li)



6 ($R_1 = SO_2CH_2CH_2OSO_3Na$，M=Na)
6A ($R_1 = SO_2CHCH_2$, M=Na or Li)
6B ($R_1 = SO_2CH_2CH_2OH$，M=Na or Li)

Experimental

Dye composition

Proprietary inkjet ink compositions, A and B, are formulated. These inks performances are use in comparison to the commonly used black inks from the marketplace, namely inks C and D (i.e., Direct Black 168 category).

Ink formulation

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

Table 1: Ink composition

Ink / Components	Proprietary		References	
	A	B	C	D
DYE	4.8%	5.0%	3.7%	3.75%
DEG	10%	10%	10%	10%
DEGMBE	10%	10%	10%	10%
Glycerin	7%	7%	7%	7%
S-465	1%	1%	1%	1%
PROXEL-XL2	0.3%	0.3%	0.3%	0.3%
DI-water	52.9%	52.7%	54%	53.95%
Abs./λmax (100ppm)	0.149/592 nm	0.149/598 nm	0.148/618 nm	0.146/573 nm

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.

Solubility Test: at constant temperature

(1). Obtaining a fixed amount of X g of dye (X represents the concentration necessary for the dye to dissolve in (g/l)), if it is to test a solubility of 100g/l, then 15g of dye is obtained and added to 150cc of distilled water in a 250ml beaker, and is stirred thoroughly with a glass rod.

(2). On a magnetic stirrer, it is stirred thoroughly then heated to a temperature of 80℃ for 5 min with an allowed deviation of ±2 ℃.

(3). After a piece of TOYO No.1 filter paper and the magnetic funnel are pre-wetted, it is dried under vacuum and poured into the dye tester solution immediately, then vacuum dried.

(4). To analyze the result, the filter paper is dried by convection in air.

Results and discussion

Comparison of light fastness

The printing blackness, printing performance and light fastness of test were showing in Table 2.

Table 2: Result of printing and solubility test

Inks / Testing Results	Proprietary		References	
	A	B	C	D
Blackness (Color Strength?)	1.14	1.17	1.12	1.15
Color deference Delta E	7.2	5.3	5.1	21.4
Light-fastness ISO	2	2~3	2~3	1

The results show that ink B is superior to others, which could be due to the hydroxyl ethyl group having improved affinity on paper. The light-fastness from inks A and B are similar to Direct Black 168 but much better than certain widely used black dye on the market place, because inks A and B have strong chromophore. Poor fastness causes color difference.

Solubility

The results of solubility test are displayed in Table 3

Table 3: The results of solubility at constant temperature:

		Solubility Test			
		200g/L		300g/L	
		Filterability	Filter Paper Residue	Filterability	Filter Paper Residue
Proprietary	A	OK	OK	OK	OK
	B	OK	OK	OK	OK
References	C	OK	OK	No Good	Plenty of dyes
	D	OK	Has residues	OK	Has residual particles

It can be seen that the inks A and B of 300g/L solubility is better than the references.

Conclusion

From the above test results, inks A and B formulated from modified Reactive Black GSP display good properties such as light-fastness and solubility, and demonstrate satisfactory color strength/blackness compared to other commercial products. The new dyes presents an opportunity in resolving the long-term stability issue commonly seen in the inkjet ink industry.

Reference

1. Mario Fryberg, Rev. Prog. Color., 35(2005)2.
2. D J Thompson, R W Kenyon and D Thorp, GB2103231 (ICI;1982)
3. Stephen F. Pond, Inkjet Technology and product development strategies, (2000) 177.
4. U.S. Patent No. 5,062,892
5. 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.

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.