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Synthesis of New Disperse Dyes Based on Enaminones Derivatives: Part 4. A comparison between the substituent groups and their potential effects

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Abstract

We go over the new dispersed dyes that we created and investigated by varying the substituent groups in this review. Here, we demonstrate how well these new dispersed dyes work when used to polyester fabric dyeing. Here, we also discuss how effective these dyes are against different kinds of bacteria and cancer cells based on the differences in the substituent groups. The dyes produced pleasing and encouraging outcomes.
***Keywords*:** disperse dyes, dyeing performancem antibacterial, anticancer.

1. Introduction

One of the most significant industrial dyes for dying synthetic fibres, such polyester, is disperse dyes [1-34]. Given that dispersed dyes are among the most widely used produced dyes, we developed eleven new dispersed dyes and utilised cutting-edge scientific techniques to demonstrate their chemical makeup [3, 6]. Then, we dyed polyester fabrics with these new dispersed dyes and investigated the stability characteristics of the resulting dyed materials. We investigated the anti-tumor and anti-bacterial properties of these novel colours in addition to their potential use against bacteria. The existence of an electron-withdrawing group on stability and colour depth properties, as well as whether or not it contributes to antibacterial and anti-cancer properties, will be covered in this paper.

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2. Chemistry

In accordance with our published research, the new dyes were created (Scheme 1). Proton ^{1}H NMR spectrum data indicates that the NH groups for dyes 1b–1f are located at δ 14.20, 14.23, 14.21, 14.20, and 14.18, respectively. The matching δ values for the CHO groups for dyes 1b–1f are 10.00, 10.00, 10.00, 10.00, and 10.02. The aromatic protons for dyes 2a–2e finally show up around \ 7.11 to ~δ 8.68. Proton ^{1}H NMR spectrum data indicates that the NH groups for dyes 2a–2e are located at δ 14.55, 14.67, 14.71, 14.70, and 14.83, respectively. The matching δ values for the CHO groups for dyes 2a–2e are 10.18, 10.16, 10.18, 10.17, and 10.23. The aromatic protons for dyes 2a–2e finally show up around \ 7.12 to ~δ 8.96.

3. Dye uptake

Because of the chromophores in their structures, dyes 1a–f and 2a–e demonstrated good colour depth and levelling properties after being applied to polyester fabrics (Table 1). Polyester textiles with good evenness, brightness, and colour depth had a good affinity for the dyes based on the colour coordinates. The colour properties of dyed samples with and without an electron-withdrawing group are compared in Table 1. Under ideal reaction circumstances, dyed samples with non-electro-withdrawing groups show lower K/S values but brighter colour with nearly the same chroma and hue angle as the electron-withdrawing group.

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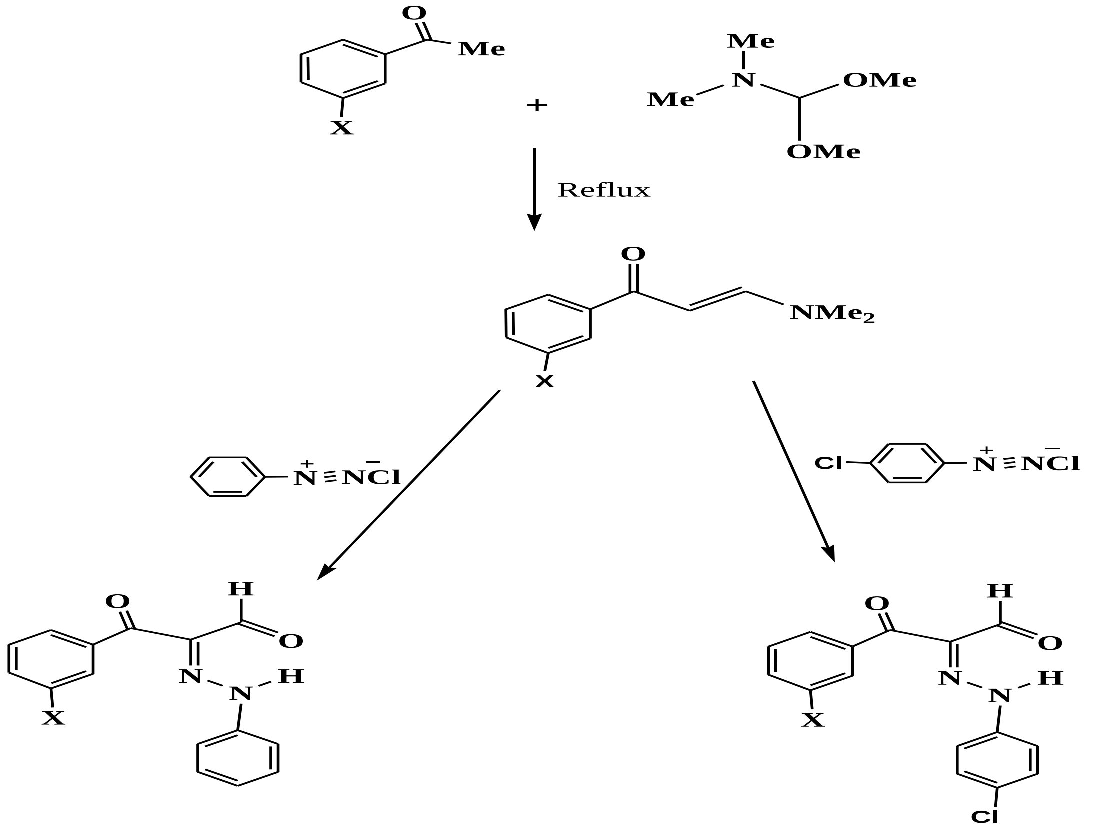

1a, X= H
b, X= CH_3
c, X= OCH_3
d, X= Cl
e, X= Br
f, X= NO_2

2a, X= H
b, X= OCH_3
c, X= Cl
d, X= Br
e, X= NO_2

Scheme 1: Chemical structures of dyes [3,6]

Table 1. Color strengths for dyes 1a-f and 2a-e.

Dye No	K/S	*L**	*a**	*b**	*References*
1**a**	16.55	83.37	-9.72	74.00	
1**b**	15.83	77.30	1.52	73.74	6
1**c**	15.79	78.48	-1.65	70.36	
1**d**	16.32	81.87	-6.71	75.37	
1**e**	15.62	78.38	1.13	71.56	
1**f**	15.51	77.41	2.03	71.72	
2**a**	15.51	71.68	4.89	68.37	
2**b**	14.33	72.01	1.54	67.49	3
2**c**	11.97	74.01	0.24	70.08	
2**d**	14.31	74.58	-3.86	63.02	
2**e**	12.14	73.00	1.69	67.33	

4. Fastness properties

The covalent connection between the dye and the fibre and the strong dye–dye interaction energy that can stop dye molecules from migrating to the fibre surface may be responsible for the good fastness properties. All of the dyes had significant colour yields because of their outstanding material compatibility with the fibre (*c.f* table 2).

Table 2. Fastness properties for dyes 1a-f and 2a-e

Dye No	Rubbing fastness		Washing fastness				Light fastness	*References*
	Dry	Wet	St.	St.*	St**	Alt.		
1**a**	4	4	4	4	4	4	4	
1**b**	4	4	4	4	4	4	3-4	
1**c**	4	4	4	4	4	4	3	6
1**d**	4	4	4	4	4	4	4	
1**e**	4-5	4-5	4	4	4	4	4	
1f	3-4	3-4	4	4	4	4	3-4	
2a	3-4	3-4	4	4	4	4	3-4	
2b	4	4	4	4	4	4	4	
2c	4	3-4	4	4	4	4	4	3
2d	4	4	4	4	4	4	3-4	
2e	3-4	3-4	4	4	4	4	3-4	

5. Antimicrobial activities

Three microbes *Staphylococcus aureus* , *Escherichia coli* and *Candida albicans* were used to investigate the antimicrobial properties of the recently synthesized dispersion dyes 1a–f and 2a–e. Table 3 show that, In general, the introduction of an electron-withdrawing group (–Cl) on the benzene ring resulted in increased antimicrobial activities.

Table 3. The antimicrobial activity of dyes 1a-f and 2a-e

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Dye No	*Staphylococcus aureus*	*Escherichia coli*	*Candida albicans*	*References*
1a	19	16	20	
1b	15	14	8	
1c	13	0	16	6
1d	12	0	14	
1e	16	14	17	
1f	12	0	0	
2a	24	29	27	
2b	25	22	28	
2c	15	24	19	3
2d	28	27	27	
2e	21	25	26	

6. Anticancer activities

Four human cell lines were used to investigate the anticancer properties of the recently synthesized dispersion dyes 1a–f and 2a–e: HepG-2 for hepatocellular carcinoma, HCT-116 for colon carcinoma, MCF-7 for breast cancer, and A-549 for lung cancer. Using a range of disperse dye concentrations, the IC_{50} values—the concentration required to stop 50% of the culture's growth after 48 hours of exposure to the tested disperse dyes were calculated.

It was evident from the findings in tables 4 and 5 that adding an electron-withdrawing group (–Cl) to the benzene ring enhanced its anticancer properties.

Table 4. Antitumor activities of dyes 1a-f and 2a-e

Dye No.	Cytotoxic activity (IC_{50} µg/ml)		
	HepG-2	**HCT-116**	**Ref.**
1a	1.73 ±0.16	1.93 ±0.34	6
1b	3.99 ± 0.49	6.79 ±0.67	
1c	3.27 ±0.36	3.71 ±0.52	
1d	22.85 ±0.87	33.55 ±1.73	
1e	6.57 ±0.59	12.12 ±0.83	
1f	42.12 ±1.82	54.63 ±5.11	
2a	1.48 ± 0.08	3.48 ± 0.14	3
2b	99.07 ± 2.88	60.39 ± 1.29	
2c	2.48 ± 0.09	3.89 ± 0.18	
2d	6.38 ± 0.54	8.92 ± 0.87	
2e	9.23 ± 0.78	14.28 ± 0.98	

Table 5. Antitumor activities of dyes 1a-f and 2a-e

Dye No.	Cytotoxic activity (IC_{50} µg/ml)		
	MCF-7	**A-549**	**Ref.**
1a	3.93 ±0.34	2.88 ±0.13	6
1b	7.45 ±0.54	7.09 ±0.34	
1c	6.80 ±0.51	3.65 ±0.15	
1d	36.39 ±3.43	28.55 ±1.86	
1e	14.11 ±0.95	9.22 ±0.47	
1f	69.74 ±4.06	60.54 ±4.32	
2a	1.99 ± 0.11	2.91 ± 0.23	3
2b	27.10 ±1.82	50.60 ± 2.34	
2c	3.39 ± 0.25	5.03 ± 0.67 µ	
2d	10.03 ± 1.09	13.67 ± 0.93	
2e	21.76 ± 1.43	24.60 ± 1.73	

7. Conclusions

In this review, we review the series of new dispersed dyes that we prepared and studied by changing the substituent groups. We present here the effectiveness of these new dispersed dyes when we used these dyes in dyeing polyester fabrics. We also review here the effectiveness of these dyes according to the difference in the substituent groups against groups of bacteria and groups of cancer cells. The dyes showed satisfactory and promising results.

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