Research Paper

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Optimization of cost in manufacturing of Reactive dye

Engineering

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ABSTRACT

Fiber reactive dyes are important in dyeing textiles because they are unequally in their ability to confer bright wet fast shades on cotton fabric. While fiber reactive dyes are commonly employed for this purpose, the use of these dyes can introduce high costs and environmental concerns. For example, their fixation levels can be as low as 50% and high salt levels are typically needed to achieve desired shades. Thus, a mechanism for increasing fixation and exhaustion efficiencies in an economical way would enhance the value of these dyes to the textile industry. With these points in mind, studied a reactive dye modification that holds promise for achieving desirable exhaustion and fixation efficiencies. Specifically, the reactivity and affinity of some widely used reactive dye. In laboratory dyeing studying it was determined that modified dye gave the best results in affinity and shade depth assessments. It remained to be shown that these dye could be applied in an industrial dyeing setting.

This thesis research focuses on applying the modified dye in a Commercial-scale manufacturing setting in order to further assess the benefits of the modified dye. In preliminary studies, laboratory-scale dyeings were conducted to further investigate the color strength relationships between the modified and commercial dyes. An optimized batch dyeing procedure was developed for the application of the modified dye, including optimal temperature, salt and alkali concentrations, time, and bath ratio. It is clear that high fixation levels and deep shades are obtained using the modified dye at lower dyeing temperatures and salt levels than commonly employed for the commercial dyes.

1.0 Introduction

The synthetic dye industry today is vast and contains many groups of dying processes and dyes. From the synthesis of biological stains used in the preparation of microscope slides to the production of acetate rayon dyes and nylon dyes used in the preparation of commercial textiles, the industry continues to develop new processes and dyes to serve the needs and wants of humanity. One area of early synthetic dye chemistry though, azo dyes, remains one of the largest and most important to the industry. The birth of azo dyes came in 1858, the same year Perkin started his factory for the production of mauve , although their value was not appreciated until Bottiger produced congo red, the first direct cotton dye, in 1884 . Johann Peter Griess had made the original discovery that a diazo compound could be derived from the reaction of nitrous acid with aromatic amines. Upon experimentation, he further concluded that this diazo compound could couple to another aromatic amine resulting in the formation of a dye. This area of chemistry has been greatly expanded and refined and now includes trisazo, tetrakisazo and polyazo dyes. The arenediazonium ion, containing the -N=N- chromophore, serves as a weak electrophile which may perform an electrophilic aromatic substitution on an aromatic ring to produce a vast and diverse array of different dyes. Upon referral to the above discussion of the chemistry behind the colors, one can see how these dyes with their great amounts of conjugated bonds serve as excellent dyes.

2.0 Experimental work

Manufacturing Process for manufacturing of Reactive blue 250 involves five step processes. The raw material requires for that processes are H-Acid, Vinyl Sulphon, Ortho Anicidine Vinyl Sulphon, Hydrochloric acid, sodium nitrite and Sodium Hydroxide. The processes involve are diazotization and coupling.

2.1 First Diazotization:-

Vinyl Sulfone (Acetanilide based) charged to an M.S.R.L. reaction vessel along with water and ice to maintain temperature between 0 to 5 0C. Then Hydrochloric Acid was added followed by Sodium Nitrite powder gradually till diazotization completed, which can be confirmed by starch iodide paper. Starch iodine paper will convert in to purple color if diazotization not complete (if excess nitrite will present in reaction mass). If all nitrite will consumed than there will not any change on iodine paper. Any excess nitrite will be removed by adding Sulfamic Acid just before coupling.

2.2 Prepare Clear Solution of H-Acid:-

H– Acid (1 Hydroxy 8 amino 3, 6 di sulphonic acid) was charged to a M.S.R.L. reaction vessel along with Caustic lye and maintained at Temperature at 15 – 200 C and pH at 6.5 to 6.8 stir it till clear brown solution appeared.

2.3 First Coupling:-

Prepared clear slurry of H-Acid was charged in to the diazotized vinyl sulfone, and stirred for 6 to 8 hrs keeping the temperature between 0 to 5 ^{o}C by adding of ice

2.4 Second Diazotization:-

As mention in first coupling, Vinyl Sulfone (Ortho Anicidine Based) charged to a M.S.R.L. reaction vessel along with water and ice to maintain temperature between 0 to 5 ^{o}C. Then Hydrochloric Acid was added followed by Sodium Nitrite powder gradually till diazotization completed, any excess nitrite was removed by adding Sulfamic Acid just before coupling. Keep temperature between 0 to 5 ^{o}C throughout the diazotization reaction.

2.5 Second Coupling:-

Charge diazo of O.A.V.S. to the first coupling mass and stir for 3 hours keeping temperature 0 to 5 0C pH of the coupling mass was raised by addition of sodium bicarbonate and maintained temperature at 0 to 5 0C by addition of ice. Properties of dye (Strength, tone etc.) was checked before starting spray drying, if any correction needed apply. At last transferred batch to spray dryer.

2.6 Spray Drying:-

The standardized dye liquid of reactive Blue 250 is transferred to the spray drying holding tank and spray dry. After drying in to spray dryer the crude dye was packed in plastic bags to avoid contamination from moisture and dust.

3.0 Experimental Work:

Experimental work for this study is done at R& D department of Kiri Dyes and Chemical Ltd. At Vatva. Before taking any raw material for use it was tested in quality control laboratory of the industry. After Preparation of dye dying on cotton is done as per standard procedure. All testing of dyeand dyed cotton done with different instrument as per

Table 3.1 Material Balance											
	Materials input							Materials output			
	H-Acid	V.S	$NaNO_2$	OAVS	NaOH	Na_2CO_3	HCl	Dye + Salt	H_2O	CO_2	ANY OTHER
Existing Process	39.05	28.67	13.52	32.06	16.32	32.91	40.86	133.48	52.67	17.24	
Exp.-1	39.05	28.67	13.52	31.73	16.32	26.60	40.86	126.00	52.67	17.24	0.84
Exp.-2	39.05	28.67	13.52	31.73	9.72	27.00	40.85	120.00	46.34	24.19	
Exp.-3	38.27	28.67	13.78	32.06	10.62	33.00	40.85	126.00	45.79	24.99	
Exp.-4	37.49	28.67	13.78	32.06	10.34	33.00	40.85	125.00	45.86	24.85	
Exp.-5	37.49	28.67	13.52	32.06	8.73	32.91	28.12	131.92	32.35	17.24	
Exp.-6	374.93	286.69	135.16	320.64	87.32	329.09	281.23	1319.17	323.49	172.38	

4.0 Result :

After performing the experiment the crude dye is tested in the liquid as well as in powder form with and without dying on cotton. The test method for prepared dye is tested for its strength in liquid form by its simadzu value tested by UV 1601 Spectrophotometer with standard sample.

After drying into oven the dye in powder form is used for dying on cotton of 2% shade (2 Gms of dye per 100 Gms of cotton).

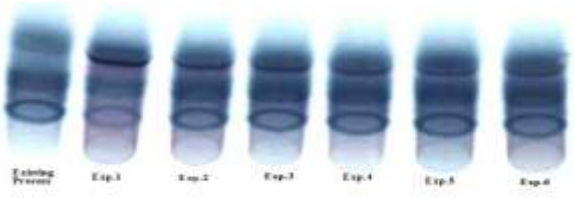

Figure 4.1: THIN LAYER CHROMATOGRAPHY REPORT OF 2% DYE SOLUTION

After performing the experiments and checking the results, the quantity of HCl was reduced to 31% and quantity of NaOH was reduced to approximately 50 % as per stoichometric requirement. The quantity of acid and alkali charged was excess compared to stoichometric requirement, so this excess acid and alkali may formed more salt in the reaction mass. Ultimately, reducing the strength of dye. Also excess acid shows high acidic pH; hence reaction was very difficult to control the reaction properly. The effect of reducing the quantity of acid in the reaction mass, also effect the exhaustion and fixation property of dye on fiber. In the Reactive dye manufacturing process Diazotization and Coupling were the main reactions. HCl and NaOH were the important reactants to carryout above reactions. Which fix the percentage completion of reaction, and also the pH of the reaction mass. These are the important factors for the reaction. pH is very sensitive property in dye. As per procedure clear brown solution of sodium salt of H-Acid was prepared with pH of 6.5 to 6.8. For this preparation quantity of NaOH required was 16.32 gms. as per stoichometric, but actual requirement was 8.73 gms., which was almost half of the stoichometric quantity. Since pH control is the main parameter, the consumption of NaOH is not given much importance. So, only pH is maintained irrespective of quantity of NaOH consumed.

5.0 COST ANALYSIS

Table: 5.1 Cost Analysis of Raw Material

Cost Analysis for 100 Kg. of Product					
		As Per Existing Method		As Per Modified Method	
Raw Material	Cost of Raw material in Rs.	Quantity of Raw material Required	Total Cost in Rs.	Quantity of Raw material Required	Total Cost in Rs.
H-Acid	275.00	39.05	10738.75	37.49	10309.75
V.S	125.00	28.67	3583.75	28.67	3583.75
$NaNO_2$	26.00	13.52	351.52	13.52	351.52
OAVS	220.00	32.06	7053.2	32.06	7053.2
NaOH	24.00	16.32	391.68	8.73	209.52
$NaHCO_3$	11.00	32.91	362.01	32.91	362.01
HCl	2.00	40.86	81.72	28.12	56.24
		TOTAL	22562.63		21925.99
		Difference	636.64		

Table: 5.2 Product Revenue Comparison Analysis

Product Revenue Comparison Analysis (per 100 Kg. of dye)				
A	Selling Price rise due to improved dye quality (2%)			
	As Per Existing Method		As Per Modified Method	
	Selling Price Rs./Kg	Quantity of Product Formed in Kgs.	Selling Price Rs./Kg	Quantity of Product Formed in Kgs.
	175.00	133.48	178.50	131.91
Total Revenue		23359.00	23545.94	
Difference			186.94	
Over all profit			(186.94+636.64)	823.58
B	Same Selling Price with improved dye quality			
	As Per Existing Method		As Per Modified Method	
	Selling Price Rs./Kg	Quantity of Product Formed in Kgs.	Selling Price Rs./Kg	Quantity of Product Formed in Kgs.
	175.00	133.48	175.00	131.91
Total Revenue		23359.00	23084.25	
Difference			- 274.75	
Over all profit			361.89	

The Raw material cost is reduced to 636.64 Rs. /100 Kg. of dye Produced. For 1 ton of batch saving is of 6366.40 Rs.. Now, final production was reduced to 1.18 % as per modified method, but quality of product was of less salt content compared to existing process. So selling price of product is increase from 2% to 5% depending on salt content. Selling price of product as per existing process is 175.00 Rs. /Kg. and as per modified method (2% increase) is 178.50 Rs. /Kg. If we consider selling price as per salt content profit of Rs. 186.94 Rs. /100 Kg. of dye selling. It means that Rs. 1869.40 per ton. Thus Rs. 3, 73,880 per year. So over all saving per year is Rs. 16, 47,160.

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