Trends in the synthesis and application of some reactive dyes: A review

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Abstract

From last 25 years that many researchers have developed the novel reactive dyes with modification in structure of reactive dyes. In the present review paper concentrated development of reactive dyes. The review paper is focused on the highlight such dyes have having excellent dyeing properties and wet-fastness properties. This review paper express the monstrous impression of reactive dyes on the textiles coloration industry. Particularized details are given regarding evolution in the chemistry of reactive structure systems. It is additionally mentioned pointed out that advance research is mandatory to enhance dye fixation and wet-fastness properties. Reactive dyes have been used for the past hundred years for dyeing of cellulosic fabrics. A reactive dye has a chromophore, which is a group or an atom that is responsible for the dye's colour. It has a component which reacts with the fabric or substrate. They have excellent fastness features due to the presence of covalent bonds that takes place during dyeing. The dyeing industry is dominated by the parties who can create dyes having excellent dyeing efficiency, stable, can be resistant to chemical actions and be affordable. In this review on development of synthesis reactive dyes has been provided. This review paper concentrated on research of reactive groups type.

Keywords: reactive dyes, synthesis, cotton, fixation, fastness.

Tendências na síntese e aplicação de alguns corantes reativos: Uma revisão

Resumo

Nos últimos vinte e cinco anos, muitos pesquisadores desenvolveram novos corantes reativos com modificações na estrutura dos corantes reativos. No presente artigo de revisão, concentrou-se o desenvolvimento de corantes reativos. O artigo de revisão está focado no destaque que tais corantes têm com excelentes propriedades de tingimento e propriedades de resistência à umidade. Este artigo de revisão expressa a impressão monstruosa de corantes reativos na indústria de coloração têxtil. Detalhes particulares são dados sobre a evolução na química de sistemas de estrutura reativa. Além disso, é mencionado que pesquisas avançadas são necessárias para melhorar a fixação do corante e as propriedades de resistência à umidade. Os corantes reativos têm sido usados nos últimos cem anos para tingir tecidos celulósicos. Um corante reativo tem um cromóforo, que é um grupo ou átomo responsável pela cor do corante. Tem um componente que reage com o tecido ou substrato. Possuem excelentes características de solidez devido à presença de ligações covalentes que ocorrem durante o tingimento. A indústria de tingimento é dominada pelas partes que podem criar corantes com excelente eficiência de tingimento, estáveis, resistentes a ações químicas e acessíveis. Nesta revisão, o desenvolvimento de corantes reativos de síntese foi fornecido. Este artigo de revisão concentrou-se na pesquisa do tipo grupos reativos.

Palavras-chave: corantes reativos, síntese, algodão, fixação, solidez.

1. Introduction

The highly successful class of synthetic dyes are reactive dyes due to ease of application, excellent wet-fastness

properties, acceptable price, and brilliancy in shades (Renfrew; Taylor, 1990). Due to high wet-fastness, brilliancy and range of hues reactive dyes have become very popular (Zhang et al., 2005).The first reactive dye was introduced by I.C.I. in 1956 that is dichloro-s-triazine dyes (Chatwal, 2002).Many reactive dyes molecules have mono or hetero-reactive group are called bifunctional dyes, these dyes have good fastness properties and higher fixation value (Ahmed, 1982).

Reactive dyes are the second biggest classes of synthetic dyes, 50% of the world's fibers/fabric is being coloured with reactive dyes (Ahmed, 1982; Mortazavi-Derazkola, 2017; Agarwal; Rastogi, 2018). Reactive dyes are mostly used for dyeing of cellulosic fibers and small amount of silk and wool fibers (Shankarling et al., 2017; Shindy, 2017). Much of the academic literature concerning to reactive dyes has focused on novel chromophores and, nearly always, it is these that have been make use of in new products.

Reactive dyes have recently incurred the highest annuity expenditure of all the dyes used in the textile industry, demonstrating their value as a dye synthesis dyes. Although, a few adversaries side, equally low dye take-up, the maximum salt used, and the large capacity of wastewater released, forever subsist in the use of reactive dyes (Hunter; Renfrew, 1999; Sriklkit; Santifuengkul, 2000; Lewis, 2014).

In this review subject covered synthesis of novel reactive dyes (not commercial yet), reactive group chemistry and application on different fibers.

2. Literature review

2.1 Developments of reactive dyes

Much of the literature subjecting to reactive dyes has focused on including chromophores and, nearly each time, it is such that have been utilized in new product. Many times, structure development of new chemical groups have been modified in that one may optimize selected properties, like strength, wet fastness. and shade. Although many patents have showed regarding dyes with new reactive systems, little similar material have been abused commercially. Conceivably the most unusual innovation in reactive dyes area has been introduction of a novel range of reactive dyes based upon quinoxaline reactive group.

Khatri et al. (2015) described that following are widely used group for synthesis of reactive dyes.

• Trichloropyrimidine,aminochloro-s-triazine,

• Sulphatoethylsulphone,

•Dichloroquinoxaline,aminofluoro-s- triazine,

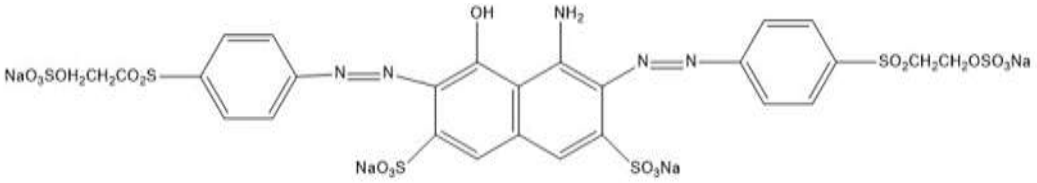
•Difluorochloropyrimide,

•Dichlorotriazin

Dichlorotriazin based reactive dyes are cheapest class of dyes, trichloropyrimidine dyes were introduced in 1958 named Drimarene dyes (Bayer, 2023). Monochlorotriazine and vinylsulphone based reactive dyes are largest major reactive class in reactive dyes and in addition bi-functional reactive dyes and tri-functional reactive dyes along good exhaust properties have accustom to the textiles industry.

The usage of two reactive groups in a dye structure resulted highest fixation for exhaust dyeing (Shore, 2002; Smith, 2003). Multiple reactive dyes available in industry contain two reactive groups. Such reactive dyes are familiar as bifunctional and hetero-bifunctional.

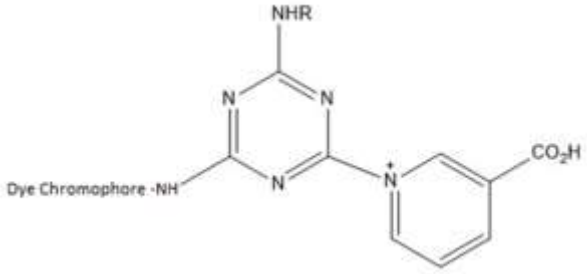
The bi-functional reactive dyes have excellent reactivity with the fibre resulted highest fixation and excellent fastness properties for example CI Reactive Black 5 (structure 1) is containing two sulphatoethylsulphone precursor groups (Taylor, 2000). Reactive Black 5 when apply on cotton fabric with cold pad batch method 90% fixation value.



Structure 1. CI Reactive Black 5. Source: Authors, 2023.

The hetero-bifunctional reactive dyes mostly used in pad-batch dyeing method because of better fixation approx. 95% (Luttringer, 1993). Introducing more than two reactive group in dyes molecules theoretically increase the fixation value of dyes. Because of additional reactive groups in dye structure the substantivity and migration properties of dyes is changed. So that idea of supplementary reactive groups have been more of researchers interest. The first commercially available trifunctional reactive dye created by Hoechst was CI Reactive Red 181. Reactive dyes with hetero-bifunctional properties include Remazol Red BS and Cibacron Red C-2G. Although they have been developed by researchers, tetra- and pentafunctional dyes are not yet commercially available (Lewis, 2009).

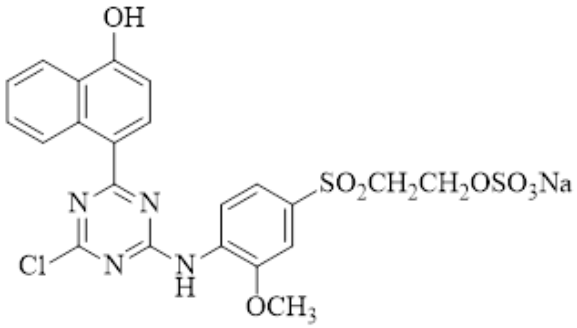
By using the term Kayacelon React, Nippon Kayaku created a (structure 2) dye that is frequently reactive with aminonicotinotriazine. This dye belongs to the class of homo-functional reactive dyes having a bis reactive system (Renfrew, 1999). These dyes suitable for neutral and high temperature exhaust dyeing.



Structure 2. Kayacelon React. Source: Authors, 2023.

Burling Industries (USA) succeed reactive dyes have phosphonic acid and carboxylic acid reactive groups. These dyes are not commercially successful due to tendering of cotton (Nkeonye; Olawande, 1994). Reactive dyes are mostly used in printing, continuous, semi-continuous and batchdyeing method. Several new vinyl sulphone forerunner blend aryl groups have been expressed in resent development application.

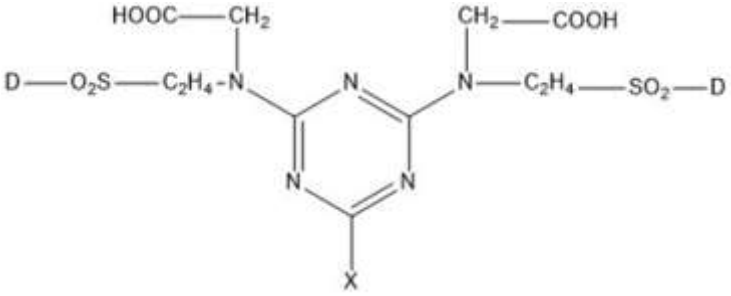
Dalal et al. (1997) have been synthesized bifunctional reactive azo dyes derived from 2-chloro-4-[4′-(β-sulphatoethyl)-sulphonyl-2-methoxyanilino]-6-(4″-hydroxy-1″-naphthyl)-s-triazine. These reactive dyes were created and have a high degree of fixing. The chemical link between cellulose and a vinyl sulphone, which is particularly resistant to acid hydrolysis, gives synthetic colours their exceptional durability. The MCT and VS groups' presence boosts the dye's substantivity and demonstrates great wash off and high degrees of fastness. These synthetic dyes exhibit various hues on fabrics, moderate to good light fastness, medium to excellent wash and rubbing fastness, and very good to outstanding exhaustion when applied to silk, wool, and cotton fabric.



Structure 3. Bifunctional reactive dyes synthesized by Dalal et al. (1997).

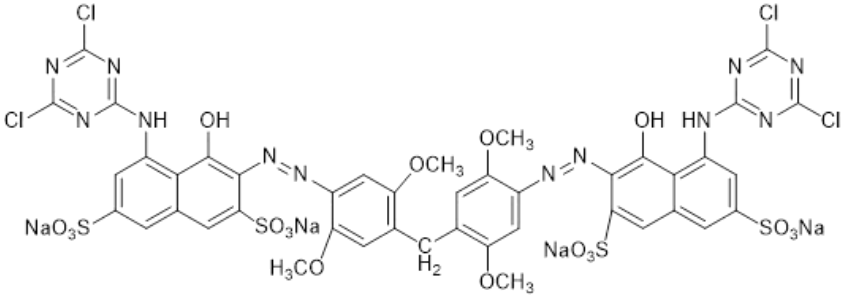
Reactive dyes containing the bis-(N-carboxymethylamino) monoquaternary-triazine-bis-ethylsulphone [bis-(N-CMA)-MQT-bis-ES] and connected derivatives have been prepared by Lewis et al.(2006). The dyes were created by combining the vinyl sulphone dye with glycine, then condensing it with cyanuric chloride to create bis-NCMA-MCT-bis-ES dye, which was then further reacted with more nicotinic acid to create bis-N-CMA-MQT-bis-ES dyes.

Each dye was applied to cotton cloth under unique circumstances, including pH and dyeing temperature. Using CZE, it was possible to definitively determine where -elimination occurred and how CMA-ES-N-triazinyl crosslinked dye behaved on materials. A pH of 5 at a boil for 30 minutes produced the ideal-elimination activity to produce two molecules of vinyl sulphone dye. The CMA-ES-N-triazinyl crosslinked dyes were studied on cotton fabric using various dyeing techniques. The fixing value of the CMA-ES-N-triazinyl dyes is quite good.



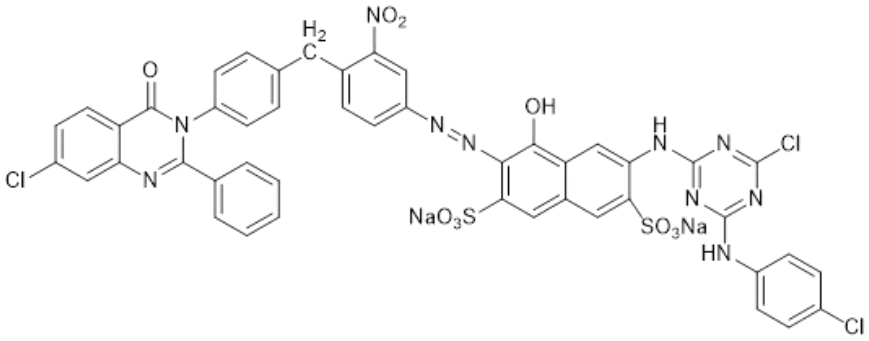
Structure 4. Reactive dyes synthesized by Lewis et al. (2006).

Patel et al. (2009) have been prepared by coupling tetrazotized 4,4′-methylene bis-2,5-dimethoxy aniline with different cyanurated coupling components such as H-acid, J-acid, N-methyal J-acid and Gamma acid. All synthesized dyes gave excellent uniformity colouration on cotton, silk, and wool fibers. When these dyes apply to cotton at in the presents of Glauber's salt solution and fixation with sodium carbonat additions, total fixation efficiencies 92% were obtained.



Structure 5. 4,4′-methylene bis-2,5-dimethoxy aniline based reactive dyes prepared by Patel et al. (2009).

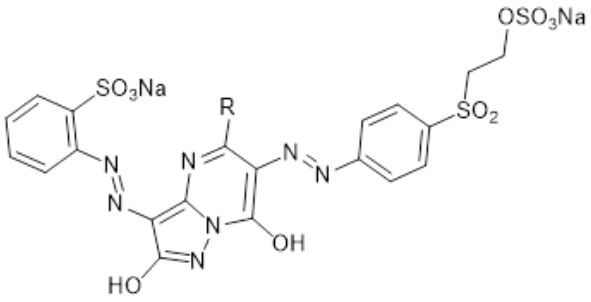
Patel et al. (2011) have been studied some novel quinazolinone based monoazo reactive dyes. Dyes were prepared by coupling of diazotized 3-{4-[4-amino -2-nitrobenzyl]-3-nitrophenyl}-7-chloro-2-phenylquinazolin-4(3H)-one with different p-chloro anilino cyanurated coupling components. All synthesized dyes were studied on silk, wool, and cotton fibres. The degree of levelness after washing display good penetration and excellent affinity of dyes with silk, wool, and cotton fibres. The presents of s-triazine reactive group improved the exhaustion and fixation value. The dyes, applied at 2% shades gave the 80% fixation on cotton, 83% fixation on wool and 81% fixation on cotton fibres. Synthesized dyes have excellent fastness properties, Higher molecular weight of these dyes showed the higher value of rubbing fastness.



Structure 6. Quinazolinone based monoazo reactive dyes by Divyesh R. Patel et al[24].

Youssef et al. (2011) have been synthesized disazo reactive dyes derived from sulfatoethylsufone pyrazolo[1,5-a]pyrimidine derivatives. The chromophoric intermediates coupling reaction with diazotized PABSES reactive system expended the corresponding disazo pyrazolo-pyrimidine based sulfatoethylsulfone SES reactive dyes. The degree of sulfonation and the reactive vinyl sulfone derivatives of synthesized dyes showed good substantivity.Synthesized dyes were applied on silk, wool, and cotton fibers.

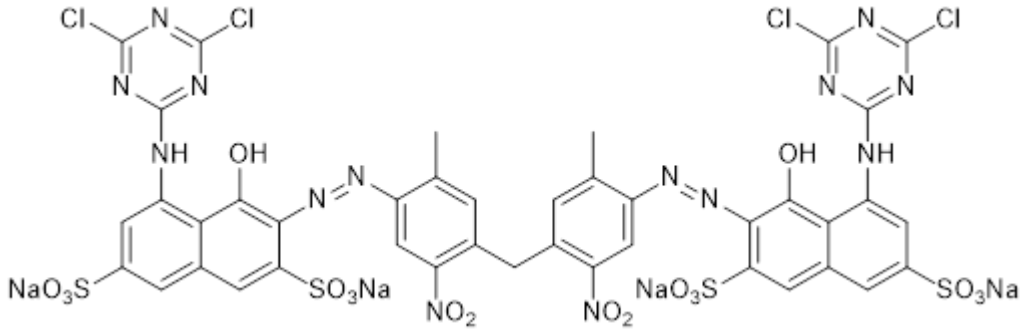
With used of 20 g/L alkali and 60 ºC dyeing temperature dyes have higher exhaustion fixation value in cotton dyeing. Dyes have good affinity for wool due to monosulfonated dyes, the blocked VS(SES) group is a temporarily sulfonated group makes these dyes slightly hydrophilic. The exhaustion and fixation value of dyes showed higher due to presents of NH_2 group in chromophoric structure. Synthesized models of heterocyclic reactive dyes could support to reduce the dye effluent load.



Structure 7. Bisazo reactive dyes prepared by Patel et al. (2011).

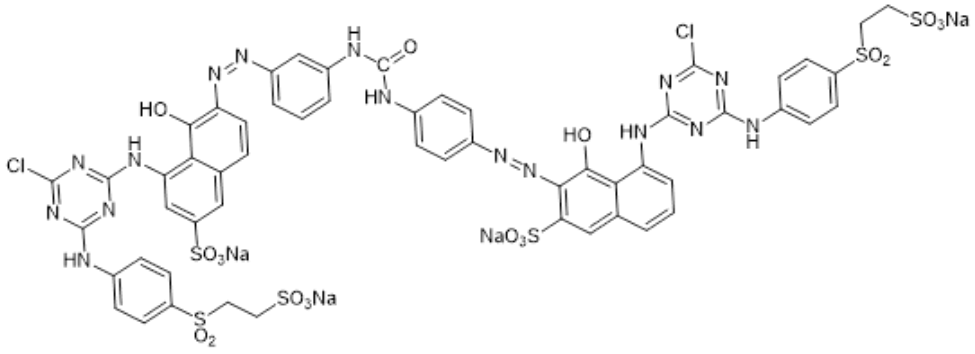
Patel et al. (2016) studied some newly synthesized bisazo reactive dyes. All bisazo reactive dyes were prepared by the coupling of tetrazotised 4,4′-methylene-bis(2-methyl-5-nitro anilin with different cyanurated coupling components like H-acid, K-acid, Gamma acid, N-methyl Gamma acid, J acid, N-methyl J-acid, N-phenyl J-acid, and Chicago acid. All dyes were applied on hydrophilic fibres like silk, wool, and cotton, gave yellow to purple hues with good depth and levelness. The variation in the hues depends upon the coupling components used. The rate of diffusion is high in synthesized dyes gives the diffusion of the dye molecule within the fabric is rapid resulted very good fixation values. All synthesized dyes have excellent solubility. The size of the dye molecule

and the nature and position of the substituent presents on the coupling ring effect on washing fastness of dyes. The substantivity of dyes with the fabric observed good gives good fastness properties.



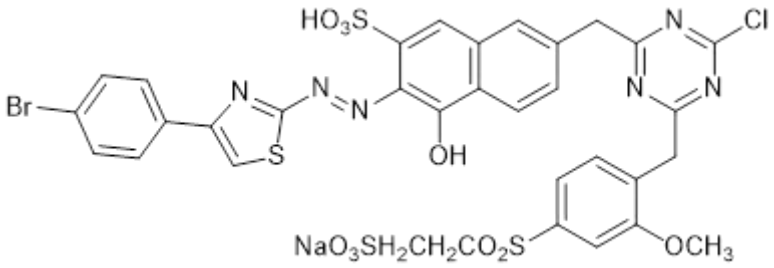
Structure 8. Bisazo reactive dyes prepared by Patel et al. (2016).

Ali et al. (2012) have been prepared disazo and polyazo ureido reactive dyes incorporating different reactive systems were synthesized and studied on cotton fabric. Ureido diamine intermediate was used for synthesized dyes. Bis-monochlotriazine reactive system based dyes have recently become a popular subject for attention (Lewis et al., 2012). These dyes exposed excellent exhaustion values at low salt concentration due to fixed high molecular structure under several neutral exhaustion conditions. These synthesized dyes have contain bis(monochlorotriazine), bis(monochlorotriazine/sulphatoethyl sulphone or the bis(sulphatoethysuphone) reactive system, the variability in the fixation dyeing situation resulted in synthesized dyes having good fixation efficiency than those with dischlorotriazine reactive dyes. The fastness properties of the ureido reactive dyes were fair to good.



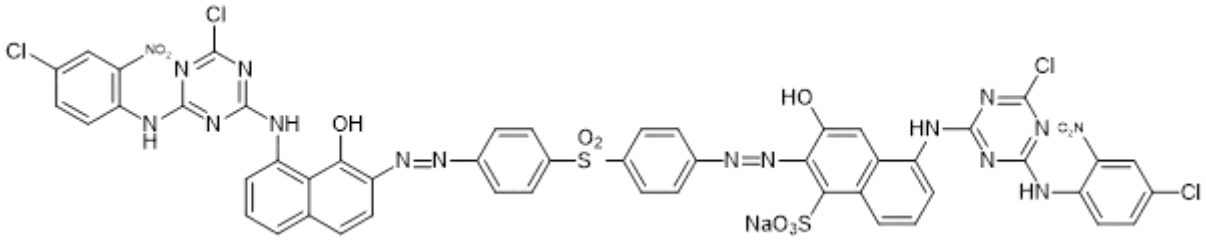
Structure 9. Ureido reactive dyes prepared by Ali et al. (2012).

Ezeribe et al. (2013) have been synthesized bifunctional reactive dyes via 4-(4-Phenyl)-1,3-Thiazol-2-Amine and 4-(4-bromophenyl)-1,3-Thiazol-2-Amine. Diazo components of 4-(4-Phenyl)-1,3-Thiazol-2-Amine and 4-(4-bromophenyl)-1,3-Thiazol-2-Amine were coupled with J-Acid and other coupling components, to be obtain the reactive dyes. 70% exhaustion was reported at a 9.5 pH and 60 min dyeing period at 70 °C on cotton fabric. The introduction of bromine group in dye molecule affecting dyeability of dyes, resulted good dye exhaustion and excellent fastness properties.



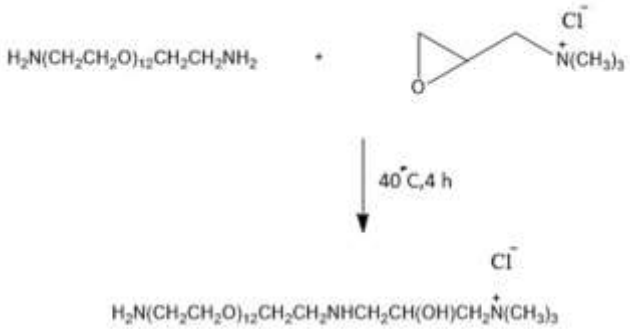
Structure 10. Ureido reactive dyes prepared by Ali et al. (2013).

Patel et al. (2015) synthesized reactive dyes based on 4,4′-Diamino Diphenylsulphone. All hot brand synthesized dyes were applied on silk, wool, and cotton fabric. Tetrazotised 4,4′-Diamino Diphenylsulphone coupling with various cyanurated coupling component. Ten dyes were synthesized with different coupling component. Synthesized dyes when applied on cotton fiber with 1:4 MLR, 20% Glauber salt, 10% Soda ash, 100 ºC Temperature, 90 min dyeing time with 2.0% dyeing shade resulted 65-76% exhaustion and 78-92% fixation. All dyes have good wet fastness properties.



Structure 11. Hot brand bisazo reactive dyes prepared by Patel et al. (2015).

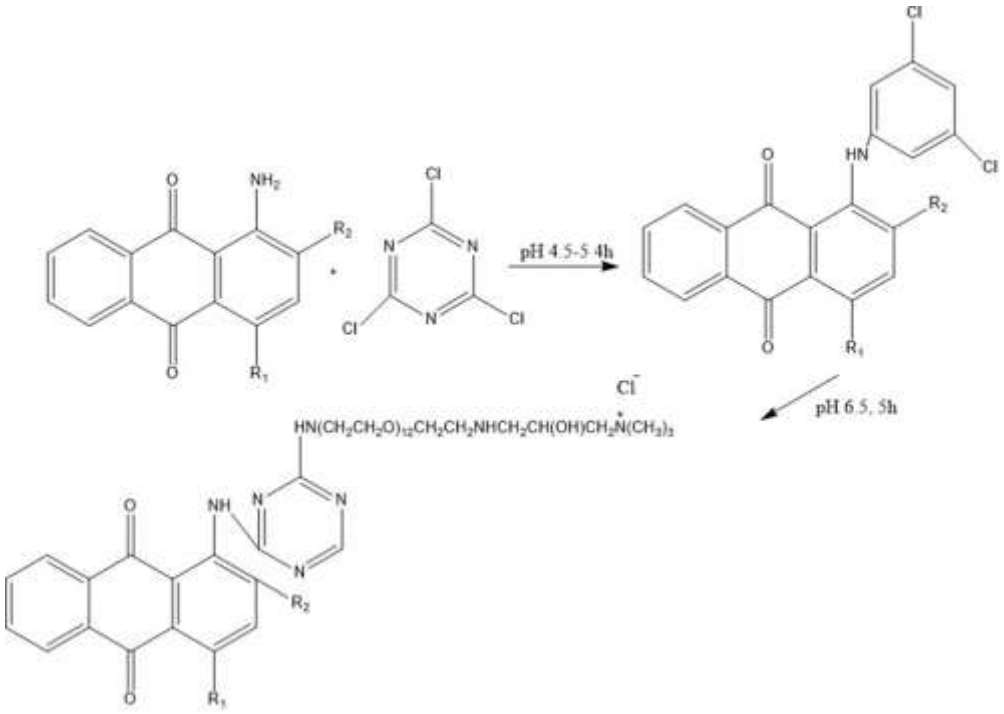
A series of cationic reactive dyes have containing quaternary ammonium and polyetheramine as soluble groups and monochlorotriazine as a reactive group have been synthesized by Wang et al. (2016) and applied to cellulose fibre by salt-free exhaust dyeing. For the synthesis of dyes (Scheme 1) reaction mixture of (0.05 mol) 30 gm polyetheramine ED600 and water were heated at 60 ºC. Then an aqueous solution, resulted product use in the next reaction. In the scheme 2, 1-aminoanthraquinone 3.35 g (0.015 mol) and 50 mL of acetone were added to the flask and stirred to dissolve maintained temperature at 5 ºC for 5 h, after the reaction was ended first stage product was add 28.5 g (0.015 mol 39.5%) dropwise with adjusted between 6.5 and 7.0 with 20% sodium hydroxide solution. The temperature of reaction mixture was increased to 50 ºC. Red syrupy liquid after removed water then purified by stirring with propan-2-ol and filtered.



Scheme 1. Source: Authors, 2023.

Using a dye to liquor ratio of 30:1, cotton was dyed. Using the exhaust method, it was determined how pH affected the dyeing process. By utilising a buffer solution containing monosodium phosphate and citric acid, the

pH of the dyebath was maintained at 4, 6, 7, and 8. Adding sodium hydroxide produced a pH of 10, and adding sodium carbonate produced an alkaline pH. Over 70% of the materials were exhausted, which was significantly more than with commercial reactive dyes. Over the heterogeneous surface of the cellulose, the anionic dyes are absorbed in accordance with the Freunlich adsorption isotherms. Intake of the cationic reactive dyes The production of a single layer of dye on the surface of the cellulose fibre is mediated by coulomb interaction between the negatively charged fibre surface and the cationic dyes, and the exhaust serves as an authenticator for the Langmuir adsorption isotherm.

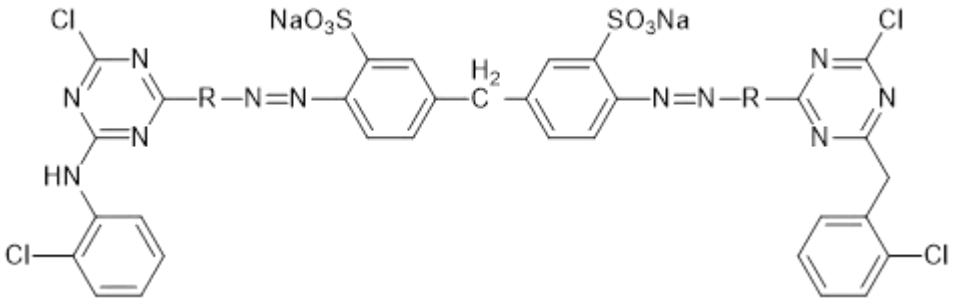


R1= H, NH_2 R2=H, Br

Scheme 2. Source: Authors, 2023.

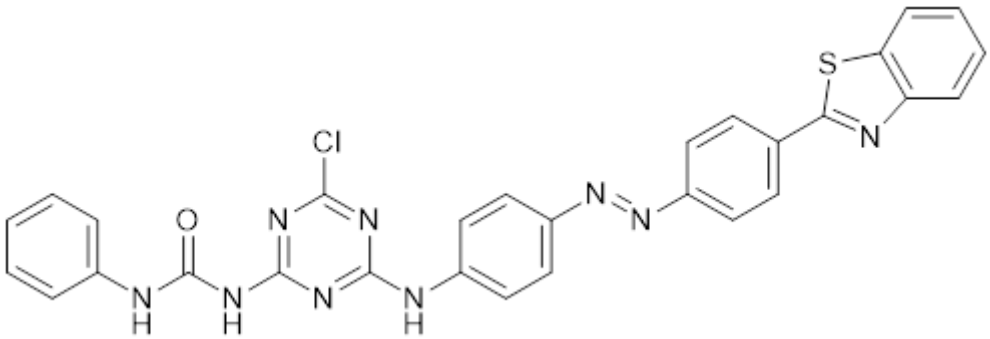
With no adsorption taking place, fixation and exhaustion were reduced as the reactive dye concentration increased. The amino group, the hydroxy and carboxylic groups, and depending on the dyebath pH, were ionised during the exhaust process. At pH 4, the K/S value was at its maximum; as pH values rose, the K/S value fell. The cationic reactive dyes initially absorb dye and cellulose fibre in an acidic environment thanks to ion-ion attraction. Under alkaline conditions, the deprotonated amine residue left behind by the polyetheramine chain will also react with the monochlorotriazine residue, creating more sites for the dye to react and enhancing dye uptake. The highest substantivity of cellulose is provided by cationic reactive dyes with polyetheramine groups. Hot brand reactive dyes are commercially important in reactive dyeing.

The s-triazine ring is an significant conjugated heterocycle to whom electronic properties are felicity different from those benzene because of the alternate substitution of -CH- group by N atoms. Gamit et al. (2017) prepared Some new reactive dyes based on 5.5′-Methylenebis(2-Aminobenzenesulfonic Acid). The dyeing performance of dyes have been examined on silk,wool and cotton. 5.5′-Methylenebis(2-Aminobenzenesulfonic Acid) used as tetrazonium salt different cyanurated component like Bronner acid, Koch acid, Sulphotobias acid, K-acid etc. used as coupling components resulted new reactive dyes. Synthesized dyes gave violet to yellow shade on silk, wool, and cotton fibres. The presents of triazine group of dye molecule improve the fixation and fastness properties.



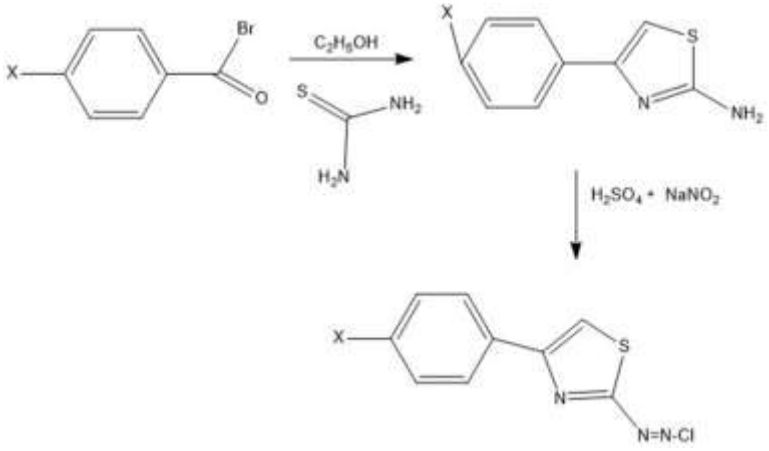
Structure 12. Reactive dyes prepared by Gamit et al. (2017).

Lokhnadwala et al. (2017) introduced various reactive dyes from benzothiazoloe derivative. Different benzothiazole derivatives were prepared with para amino benzoic acid, 2-amino thiophenol, poly phosphoric acid and diazonium salt of resulted amino compound was coupling with several primaryamine. Further reaction with cyanuric chloride and Phenylurea resulting various reactive dyes. All dyes were applied on silk and wool fabric with 2% shade have excellent fixation value and fastness properties.



Structure 13. Reactive dyes prepared by Lokhnadwala et al. (2017).

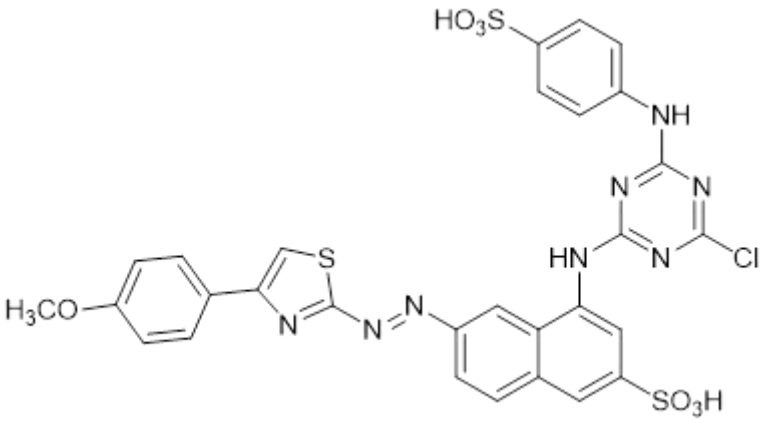
Mohamed & El-Megied (2018) have been synthesized new reactive dyes based on thiazol moiety, these dyes were applied to cotton fabric. The dyes were synthesised in two stags. For synthesis of dyes cynurated H-acid used as a coupling compound which react with 4-aminobenzensulphonic acid, 4-phenylthiazol-2-amine and 4-(4-methoxyphenyl) thiazol-2-amine were used as a diazonium salts the resultant MCT (monochlorotriazine) reactive dyes were formed. Synthesized MCT dyes showed higher value of fixation and colour fastness on cotton fabric. Dyes intermediates prepared as follow reaction



X= OCH_3

Synthesis of intermediates. Source: Authors, 2023.

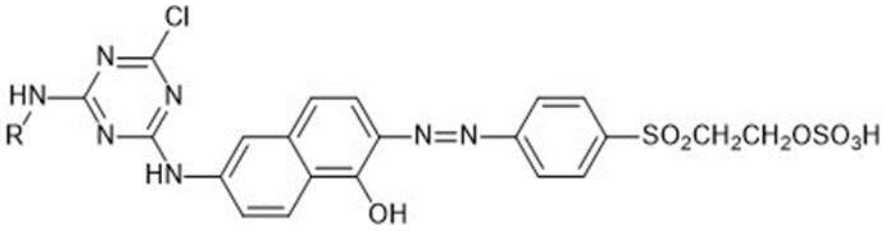
Coupling component prepared by adding cyanuric chloride in 1:1 molar to 1-amino-8-naphthol-3,6-disulphonic acid(H-acid) with 6-7 pH. The diazonium salt was coupled with coupling compoundes 4-phenylthiazol-2-amine and 4-(4-methoxyphenyl) thiazol-2-amine with 5 pH. The synthesised MCT dyes were evaluated on cotton fabrics dyes showed higher value of exhaustion and fixation value.



Structure 14. MCT reactive dyes prepared by Mohamed & El-Megied (2018).

The antibacterial activity of synthesised azo reactive dyes was predicted *in vitro* via the disk diffusion method by using *Staphylococcus aureus* as the gram-positive bacteria and *Escherichia coli* as the gram-negative bacteria. The synthesised dyes showed higher antibacterial activity against gram-positive bacteria than against gram-negative bacteria whatever can be attributed to the cell wall structure of the gram-positive bacteria this may be explained to the molecular structure of thiazole and the NH group which aids the adsorbtion onto the bacterial surface, perforation into the cell membrance, certainly destruction of the cell membrane, begetting bacterial death.

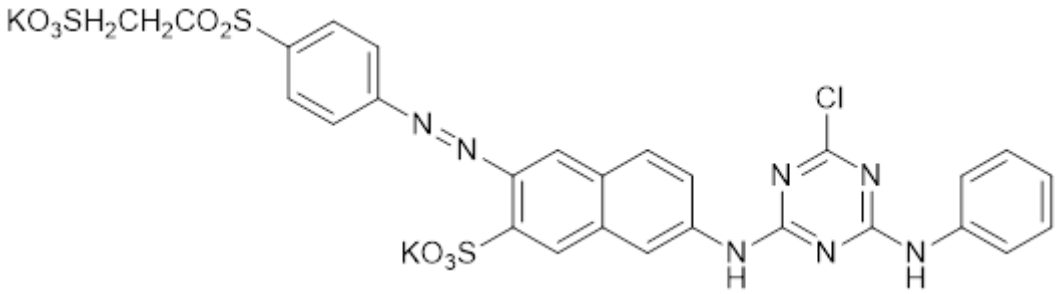
Wei et al. (2019) have been synthesized reactive dyes through the introduction of benzene sulfonamide derivatives into the triazine ring. Benzene sulfonamide and derivatives were condensed with cyanuric chloride to synthesize a novel series of hetro-bifunctional reactive dyes. 4-(β-sulfatoethysulfonyl) aniline used as the diazo component, condensing cyanuric chloride with benzene sulfonamide and J-acid used as coupling component. Dyes substituted with benzene sulfonamide derivatives gives better light fastness, after the introduction of the sulfonamide group the dyes showed weak fluorescence. Synthesized dyes studied on cotton fabric 1-2% owf color shade at 100 g/L sodium sulphate and 10 g/l sodium carbonate under 75 ºC for 90 min. The dyeing results showed that the all dyes have good light fastness properties and excellent fixation value.



Structure 15. Reactive dyes based on sulfonamide derivatives prepared by Wei et al. (2019).

Where R is benzene sulfonamide derivatives. An interesting paper published in 2018 showed that 2-ethoxy-4-chloro-s-triazine, applied to cotton fabric at 70 ºC gives 87% fixation value (Zhang et al., 2019). Four KM-type ethoxy containg reactive dyes and 14 comparative dyes were synthesized, J-acid, H-acid and Gamma acid used a coupling component. 1-aminonenzen-4-(2-sulphoethyl)-sulphone was diazotized than coupled with J-acid intermediates containing an anilino, 4-sulophenyl-1-anilino,ethylamino or ethoxy group to synthesized J-acid mono azo reactive dyes. After the introduction of reactive dyes in triazine ring gives better fixation value and excellent fastness properties. The hydrolysis reaction rate was also studied, the rate of the hydrolysis

reaction was affected by the temperature. The temperature is high the rate of hydrolysis reaction is also fast. The ethoxy containing K-HR dyes was sensitive to pH when pH is raised from 9 to 11 the hydrolysis of K-HR hasted. When the pH 7.0 no hydrolysed dyes were ascertained. The reactivity of the C-Cl bond in triazine ring was bettered by the introduction of ethoxy group.



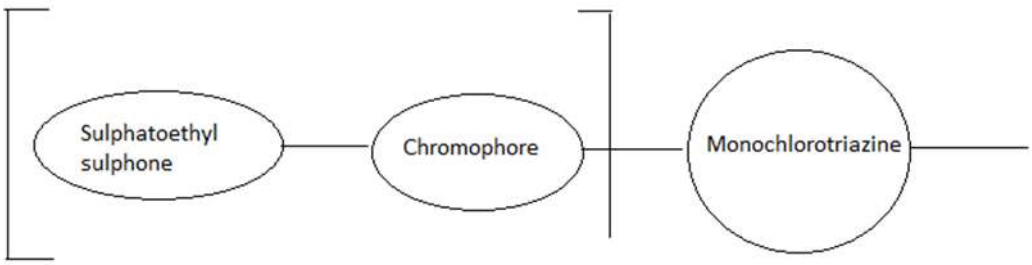
Structure 16. KM-type ethoxy containing reactive dyes prepared by Zhang et al. (2019).

All ethoxy-containing reactive dyes achieved finest along the adding of 10 g/L The highest fixation was achieved at 75 ºC, in the J-acid series dyes the introduction of ethoxy group can enlarged electrophilic substitution reactivity of the KM-type dye at bottom temperatures because of the smaller electron-donating ability of the ethoxy group including with the alkylamino and phenylamino groups, by that expanding the fixation.

Zhang et al. (2019) also synyhesized KM-OR1 type dyes which contains two sulphonic acid group, second sulphonic group when introduced into the substituted triazine structure the molecular planarity is negatively damaged by the considerable size of the aryl substituents. Including perform to extend when dye molecules have higher planarity. As a result, the accumulation state of the dye molecules is devasted and accordingly there is a highest dyeing rate, having the effect that in exhaustion and fixation.

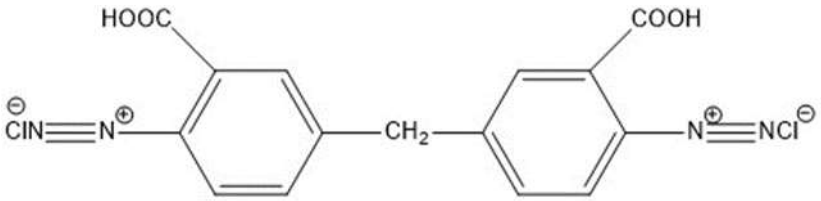
A series of trisazo hetero bi-functional reactive dyes synthesized by Mokhtari et al. (2005) dyes containing both a sulphatoethylsuphone and a monochlorotriazine reactive group. All dyes strong in chromophorically but were dull in shade (violet). Dyes applied on cotton by exhaust dyeing method require low salt due to high substantivity, dyes have good build-up properties. Two hetero bi-functional reactive dyes containing reactive group sulphatoethylsulphonyl and 2-chloro-4-alkylthio-s-triazinyl group have been synthesized by Pasha & Taylor (2013) and dyeing properties and fastness properties compared with commercial dyes. The abstraction of synthesized substituted anywhere perhaps introduced into a dye molecule as a linking group. The dye fiber bond developed under alkaline conditions, resulted better build up and fixation value.

Dye researchers are unquestionably going in the area of chromophores that are extra strongly assimilate to decrease the affect of colour in outflow during part shades along dye combination. It should be reported be achievable to idiomatic exceeding fixation ability by bring to gather additional reactive group in molecule of the dye. In operation that access can be interfering to the disturbing effect that extra functional groups can have on relocating, guide to less fixation, mainly at higher depths, and low build-up. The (structure 17) results solely from the linking in conjunction of two similar, economic, reactive dye units via a reactive chlorotriazinyl bridge, and consequently consist of two units of chromopher and three of reactive group.



Structure 17. Source: Authors, 2023.

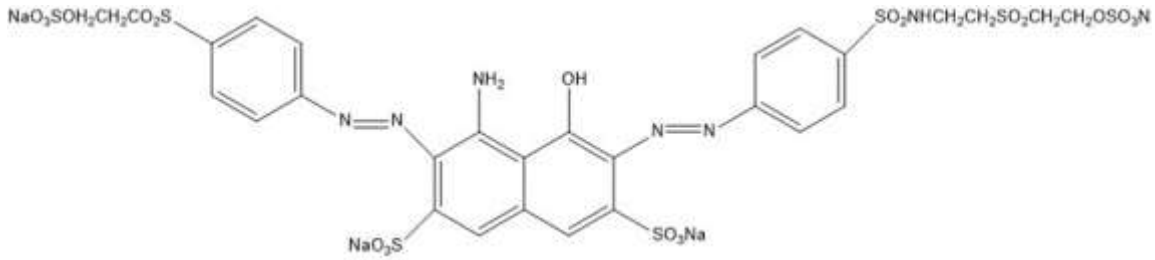
Some Hetropolyfunctional Reactive dyes introduced by Patel et al. (2020) containing monochlorotriazine and sulfatoethylsulfone reactive system. Dyes are accused to expose high reactivity and very good fixation value. Novel dyes have been prepared from coupling of tetrazotized 4,4`-methylene bis(2-carboxy aniline) with several 4-(ethylsufurate sulfonyl)anilino cyanurated coupling component. These dyes gave violet to yellow shade (depends upon coupling component) on silk, wool and cotton fibers and also have excellent fastness properties. Dyes have higher percentage of exhaustion, fixation, and fastness properties due to the presents of s-triazine and vinyl sulfone reactive systems in dye molecules. 4,4`-methylene bis(2-carboxy aniline) was synthesized with (0.1 mol of Anthranilic acid) and 3% aqueous solution of formaldehyde solution at 60 ºC resulted products used for tetrazotization.



Structure 18. Tetrazotized 4,4`-methylene bis(2-carboxy aniline. Source: Authors, 2023.

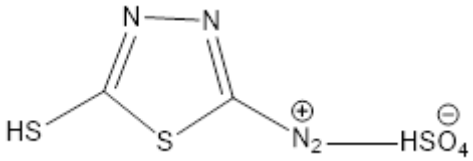
Tetrazotized component coupled with Different cyanurated coupling component such as H-acid, Gamma Acid, J-acid, N-methyl J-acid, N-phenyl J-acid, Chicago acid, S-acid, K-acid, Bronner acid, Peri acid, Laurent acid, Koch acid, Naphthionic acid and Tobias acid. The visible absorption of nove l dyes have been recorded between 555 to 420 nm. The absorption value of dyes depends upon the introduction of electron attaching and donating groups at the acceptable position in the coupler ring. Group like C=C, C=O and N=N are efficient of absorbing visible or ultraviolet radiation between 800-200 nm. Dyes were applied on cotton, silk, and wool fibers. Dye synthesized with coupler H-acid has the highest K/S value for silk fiber, dyes prepared from N-methyl J-aid and J-acid resulted highest K/S value for wool and cotton fibers.

Yang et al. (2021) have been synthesized reactive dyes containing Benzsulfonamide Moiety. Synthesized dyes have azo and Benzsulfonamide auxochromic groups. The new synthesized dyes exposed upgraded substantivity and fixation value of cotton fabric. The synthesized reactive dyes molecules producing -SO_2NH- bridging group appears to be encouraging applicant for application to dyeing of fabric. The establishment of sulfonamide group in prepared molecules of dyes relationship and consequently to upgrade the exhaust property of the dye conceivably a good process for new designing of reactive dyes.



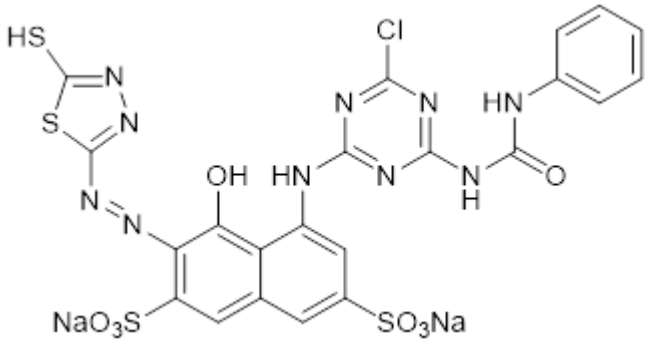
Structure 19. Reactive dyes prepared by Yang et al. (2021).

Desai et al. (2021) have been prepared mono azo reactive dyes derived from 1,3,4-thiazol moiety and studied dyeing performance on cotton fabric. 2-amino 5-mercapto 1,3,4-thiazole used as diazonium salt, coupling component were prepared by condensation of cyanuric chloride, H-acid, and phenyl urea. The performance of this type of reactive dyes on cotton fabric was big upgraded by used thiazol moiety in reactive structure.



Structure 20. Amino diazoniumsulphate salt. Source: Authors, 2023.

The declare to express excellent fixation connected with enough fastness properties.



Structure 21. Reactive dyes prepared by Desai et al. (2021).

Huang et al. (2021) synthesized five monochloro-s-triazinyl reactive dyes and five m-carboxypyridium-s-triazinyl reactive dyes, several chromophores were used. The main object of this study was kinetic study of dyes and found the order of group was -OCH_3> -$CH_3NSO_2CH_3$>- N-methyl phenyl> -NHCN> -OH. It is observed that the highest the electron donating value of thesubstituent on meta-position to the triazine ring, the lowest the rate of hydrolysis constant.

Patel & Tandel (2022) synthesized some bifunctional reactive dyes with the use of phenyl urea. All dyes were applied on cotton fabric with exhaust, printing and cold batch method. Phenyl urea have good solubility and resulted excellent fastness properties. Synthesized dyes gives 65% absorbance in printing method. Also, one interesting paper published by Patel & Tandel (2022) bi functional reactive dyes synthesis and antibacterial activity study in this paper pheny urea derivatives were used, and all dyes have good anti bacterial activity as well as excellent wet fastness properties.All dyes light orange to yellow in colour, dyes have good fixation value in CPB (77%), and printing application (64%). Presents of phenyl urea gives good light and wash fastness properties on cotton fabric.

Souhangir et al. (2021) prepared novel Fluorescent reactive dyes using Coumarine-Benimidazol. (3-(1H-benzo[d]imidazole-2-yl)-7-(diethylamino)-2H-chromen-2-one condensed with cyanuric chloride. Reactive dyes prepared by substituting sulfanilic acid and nicotinic acid in to condensed product. Synthesized dyes have highest quantum yield and 83% exhaustion value on cotton fabric. Fluorescent dyes high colorfastness. The pollution free technology of dyeing have been studied by Gao et al. (2023). Three new reactive dyes were designed and synthesized; dyes contained planar multi-conjugated system with several reactive groups. All dyes have good dyeing performance. The fabric of cotton react as an oil-water separation in to process of dyeing, the dye micelles absorb instantly and transfer in to cotton fabric.

4. Conclusions

Synthesis of reactive dyes and application have been described. The market for reactive dyes will carry on with to expand. It is noticeable that several structure systems gives the colorist many possibilities for getting maximum fixation value and fastness properties on different fibers. Reactive dyes are mostly designed as bi-functional or multifunction structure due to their excellent wet-fastness properties.

The development of a strategy to modified the fastness and fixation of azo dyes is of great priority and current interest. Furthermore, use of more quantities of salt and alkali is large described as ecologically unfavorable and therefore the progress of novel modification in dyes structure and using minimum salt for application is desirable.

There is still considerable range for further development to maximize the reward of reactive dye structure.

5. Auhors' Contributions

Manoj J Patel: project structuring, writing, corrections and submission. *R C Tandel*: project structuring, writing and corrections. *Srujal A Sonera*: project structuring, writing and corrections. *Sagar K Bairwa*: project structuring, writing and corrections.

6. Conflicts of Interest

No conflicts of interest.

7. Ethics Approval

Not applicable.

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