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RESEARCH PAPER

Synthesis, characterization, and dye performance investigations of azo-coumarin bearing chalcone moieties

Dler Dlshad Kurda[1]
[1]Department of chemistry, College of education ,Salahaddin University-Erbil, Kurdistan Region, Iraq.

A B S T R A C T:
The preparation of several azo dyes(2a-h) involved the reaction of 4-aminoacetophenone with sodium nitrite to produce the corresponding diazonium salts, which were then permitted to react with 4-Hydroxycoumarin to produce the relevant azo dye (A). The prepared starting material (A) was then reacted with various substituted benzaldehydes to give a new series of chalcone derivatives(2a-h). Additionally, FT-IR and 1H-NMR spectra used to validate the structures of the newly synthesized compounds. Acid and dispersion dyes are employed with all azo compounds to execute dyeing on multi-fiber strips made of acetate, cotton, nylon, wool, acrylic, and polyester fibers. Each fiber was given moderate to exceptional fastness characteristics by all the synthetic dyes.

KEY WORDS: Azo-dyes, chalcones, dying performance, fastness characteristics, fiber strips
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1. INTRODUCTION:

Azo compounds are the most extensively used industrially manufactured organic dyes due to their varied applications, such as textile dyeing, biological–pharmacological activity, and organic synthesis.(Fadda et al., 1994, Raposo et al., 2005, E Hawaiz and K Samad, 2012)
Disperse dyes for polyester fabrics, reprography, functional dyes, nonlinear optical systems, photodynamic treatment, and lasers are just a few of the many essential uses for them.(Mielczarski et al., 2005, Raposo et al., 2011)
Azo dyes have a strong coloration, and they have been utilized both as dyes and pigments for a very long time (Raghav and Patel, 2001) , Depending on molecular structure and -delocalization, it can be yellow, red, orange, blue, or green. The structure and chemical formula of both the dye and the textile determine the color intensity and dye-fiber interaction. (Diler D. Kurda., 2017)
The Azo (–N=N–) group is the component of the structure of Azo-dyes that is responsible for coloration. The production of salt between the ionic groups of the dye and the ionic groups of the fiber is what causes the dye to adhere to the fiber. (Patel et al., 2007)

* **Corresponding Author:**
Dler Dlshad Kurda
E-mail: dler.kurda@su.edu.krd
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Because the majority of Azo dyes possess acid–base features, including the presence of fixed isosbestic points (which signify the number of equilibriums in such Azo dye), these dyes are utilized for the purpose of acting as acid–base indicators. (Asaad and Jour, 2014)
In recent years, Azo-functionalized dyes that contain aromatic compounds have garnered a growing amount of attention due to the extensive color palette they offer, their luminosity, the ease with which they may be produced, and their excellent dyeing ability.(Venkataraman, 2012)
Ink-jet printing, oil-soluble lightfast dyes, and toner. Due to their intriguing electrical properties, azo compounds are used in nonlinear optical elements, molecular memory storage, and organic photoconductors. (Otutu, 2013)
This project aims to synthesis and evaluate new dyes' ability to directly stain woven multi-fiber fabrics, or to introduce the Azo-chalcone system, to improve dyeing operations. Synthesis of novel azo-chalcone compounds from 4-aminoacetophenone via diazotation and coupling with 4-hydroxycoumarin. This involves an electrophilic substitution reaction in which 4-hydroxycoumarin attacks an acetophenone diazonium cation. It can be used to prepare azobenzene derivatives with active functional

groups as a precursor for further synthesis to give Azo-amide. (Hamzacebi et al., 2008), Azo-imine(Ziarani et al., 2018) and Azo-chalcone (Al-Asiri, 2000) Synthetic colors are widely used in many modern sectors, including textiles, leather, paper, and the creation of food and hair coloring. Because of delocalization, the most popular synthetic Azo dyes used for dyeing fabrics and textiles were generally highly colored, i.e. the color intensity as well as the interaction of Azo dyes with fibers rely on the structure of dyes and the dyed materials. Disperse dyes containing Azo chromophore are water-insoluble, i.e. non-ionic dyes, and are commonly used on hydrophobic fibers such as poly- ester, cellulose acetate, and nylon. (Omar et al., 2021)

2. MATERIALS AND METHODS

2.1. Experimental

Melting points were measured using an Electro-thermal melting point device, and IR spectra were obtained using KBr discs and a Shimazu FT-IR spectrometer. ^{1}H-NMR spectra were recorded on a Bruker (400MHz) with TMS as internal reference in Queen Mary- University of London-UK.

2.2. Synthesis of 3-((4-acetylphenyl) diazinyl)-4-hydroxy-2H-chromen-2-one (A):

p-Aminoacetophenone (13.5 g, 100 mMol) was dissolved in 80 mL of 3 M HCl by gentle heating. After dissolving the whole solid, the solution was cooled to 0^{o}C in an ice bath. While stirring, gently add 160 mL of newly made HNO_2 (1 M sodium nitrite solution) with a temperature below 10 degrees Celsius. The solution was stored in the ice bath before proceeding to the subsequent stage. Hydroxycoumarin (16.2 g, 100 mMol) was dissolved in 200 mL of methanolic NaOH 4%, cooled in an ice bath while stirring, and then added slowly to the diazonium salt solution (step1). The mixture was stirred for 15 minutes while precipitation occurred. The solid azo dye was recovered by vacuum filtration, washed many times with cold water, dried, and recrystallized from xylene to yield crystals of compound (1) with a lemon yellow color. (Samad et al., 2015)

$C_{17}H_{12}N_2O_4$ m.p.248-250^{o}C., yield (97%), IR (cm^{-1}): 1735.93 C=O *Str*., 1670.35 C=O *Str*., 1627.92 C=C ring, 1232.51 C-O *Str*. (1H-NMR) (ppm): 2.56(s, 3H, CH_3), 7.78- 8.12(m 8H Ar-H).

2.3. Synthesis of Chalcones 3-(4-cinnamoylphenyl) diazinyl)-4-hydroxy-2H-chromen-2-one (B1-B6):

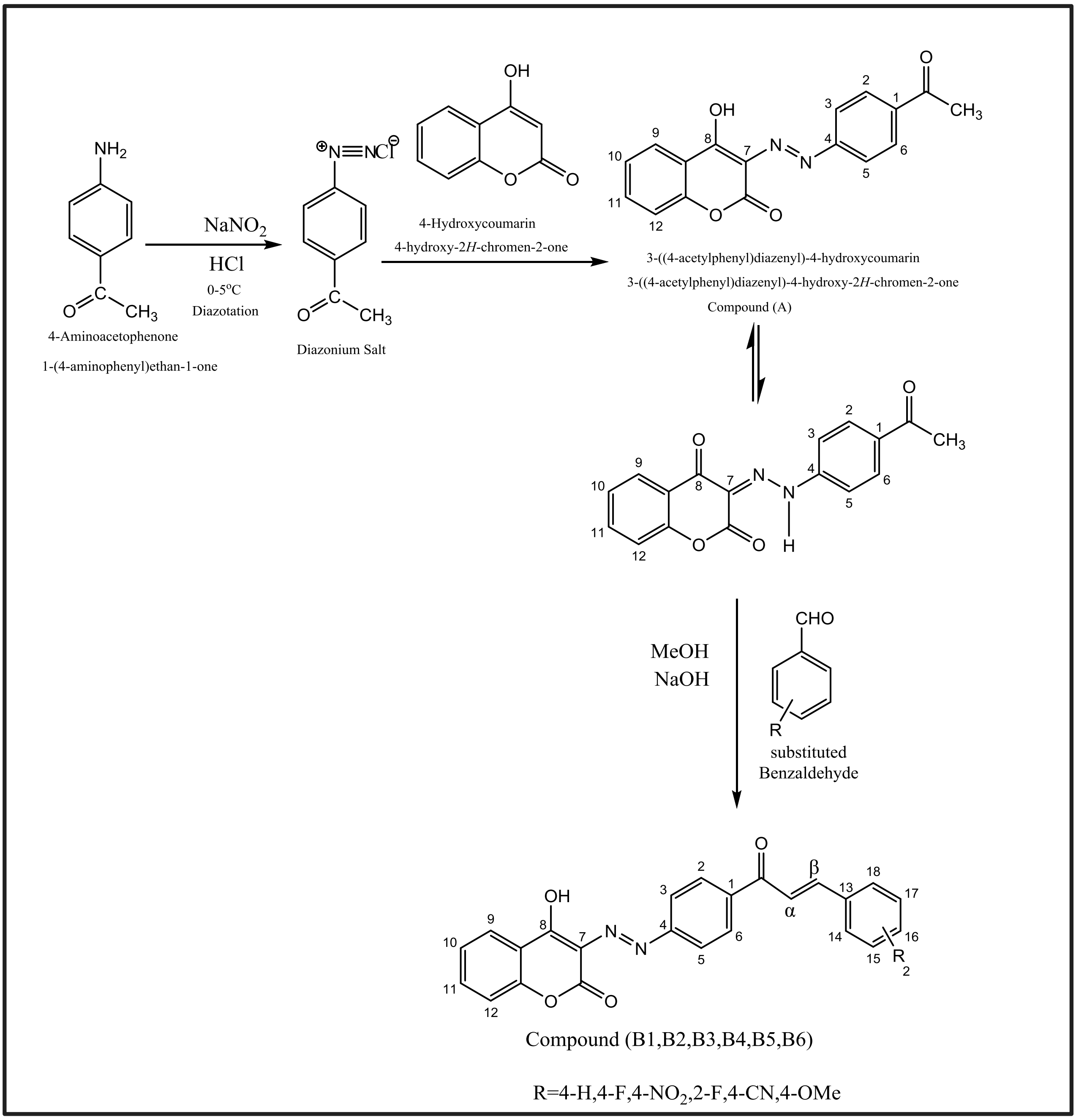
A mixture of compound (1) (2.31g, 7.5 mMol), alcoholic sodium hydroxide 4% (5 mL), and substituted benzaldehydes (7.5 mMol) in ethanol (30 mL) was stirred under reflux for (1-2) hrs. until all starting materials had reacted, and then the cooled mixture was solidified and filtered off, dried, and recrystallized from the xylene to give red colored products, which are listed in Table (1).(E Hawaiz and K Samad, 2012) , Table 1.

2.4. Applications for dying

In 100 mL of distilled water, dissolve 2 g. of the azo dye and 1 g. of an electrolyte (sodium chloride NaCl). Stir with (5 mL) of (1 M HCl) to dissolve. Put a portion of the multi-fiber strip (the use of a multi-fiber strip reduces the number of testing trials required to analyze the dyeing results.) in the solution. Boil the solution for 15 minutes on a hot plate, ensuring sure the strip is completely submerged. Remove the strip with tweezers, allow it to cool, and then rinse it with tap water. Allow the colored fiber to dry after patting it dry with a paper towel. The SDC multi-fiber test fabric is made up of several fibers, each of which is a 15 mm band. Secondary cellulose acetate (Dicel); bleached cotton; nylon 6.6; polyester (Terylene); acrylic (Courtelle); and wool worsted are the fibers. (Diler D. Kurda., 2017)

3. RESULTS

In the path of my research, we have synthesized, characterized, and experimented with dyeing applications for a new series of azo-chalcone derivatives on multi-fiber strips textile. From the starting material (A), the reaction is initiated, and the azo-chalcone derivatives (B1-B6) are displayed in bands. Scheme 1



Scheme (1): Synthetic pathway for preparation of A, B1, B2, B3, B4, B5, and B6 compounds

This numbering, which is utilized specifically for the purpose of interpreting ^{1}H-NMR spectra.
On the basis of their FT-IR, ^{1}H-NMR spectral data, structural elucidations were performed in order to verify the production of the starting materials as well as the chalcones derivatives that were intended as the target. The obtained spectral data allow for the characterization and proof of the existence of azo-linkage, carbonyl in compound (A), as well as the disappearance of the indicated methyl group (methyl ketone) and shifting of the carbonyl group in compound (B1-B6). Both of these phenomena can be traced back to the spectral data. (Sternhell et al., 1986)

Starting material (A) is used to get the reaction going, and the azo-chalcone derivatives (B1-B6) are exhibited in bands at 1670.35 cm^{-1} and 1735.93 cm^{-1}, which belong to the C=O Str. A distinctive N=N band was assigned at (1496.76) cm^{-1} (Al-Adilee et al., 2021),(Ameuru et al., 2020) and -O-H Str. of phenol group belong to coumarin was assigned between (3435.22-3106.39) cm^{-1}.(Manolov and Danchev, 1999) Compound (A) ^{1}H-NMR spectrum (figure 5) display singlet signal at 2.61 ppm belong to the three protons of (-CH_3) attached to the carbonyl group, multiple signals of aromatic protons at (7.78- 8.12) ppm for the eight protons of the two phenyl rings, and singlet broad signal at 15.42 ppm be in the possession of (OH) group. The higher chemical shift value for the OH proton is might be due to the existence of the enol tautomer (Hawaiz et al., 2012)

All chalcones (B1-B6) had FT-IR spectra with implication peaks indicating the presence of known carbonyl functional groups.

The (C=O) group is indicated by the band centered about (1689–1660) cm-1; however, the presence of (C=C) stretching conjugated to the carbonyl group causes the frequency of the (C=O) group to decrease from what would otherwise be expected (conjugated enones).(Hussein, 2014), Table 2

Table (3) shows the ^{1}H-NMR spectra of chalcones (B1-B6), which display characteristic doublet signals for, α,β - protons at (7-8) ppm, which coalesced with aromatic protons (Hussein, 2014). Clearly, the doublet for (CH_{β}) appears around (8.10-8.12) ppm in all cases. This deshielding refers to the effect of resonance of the phenyl rings that are bonded to the - carbon atom, but the (CH_{α}) completely emerged with aromatic protons, making it difficult to distinguish it at a certain number.

In addition, the ^{1}H-NMR spectra of chalcones (B2, B4, B5, and B6) introduced new singlet signals for each of them at aromatic position due to α-β-unsaturated double bond. These signals, were thought to be a good marker for the production of a series of chalcone derivatives.

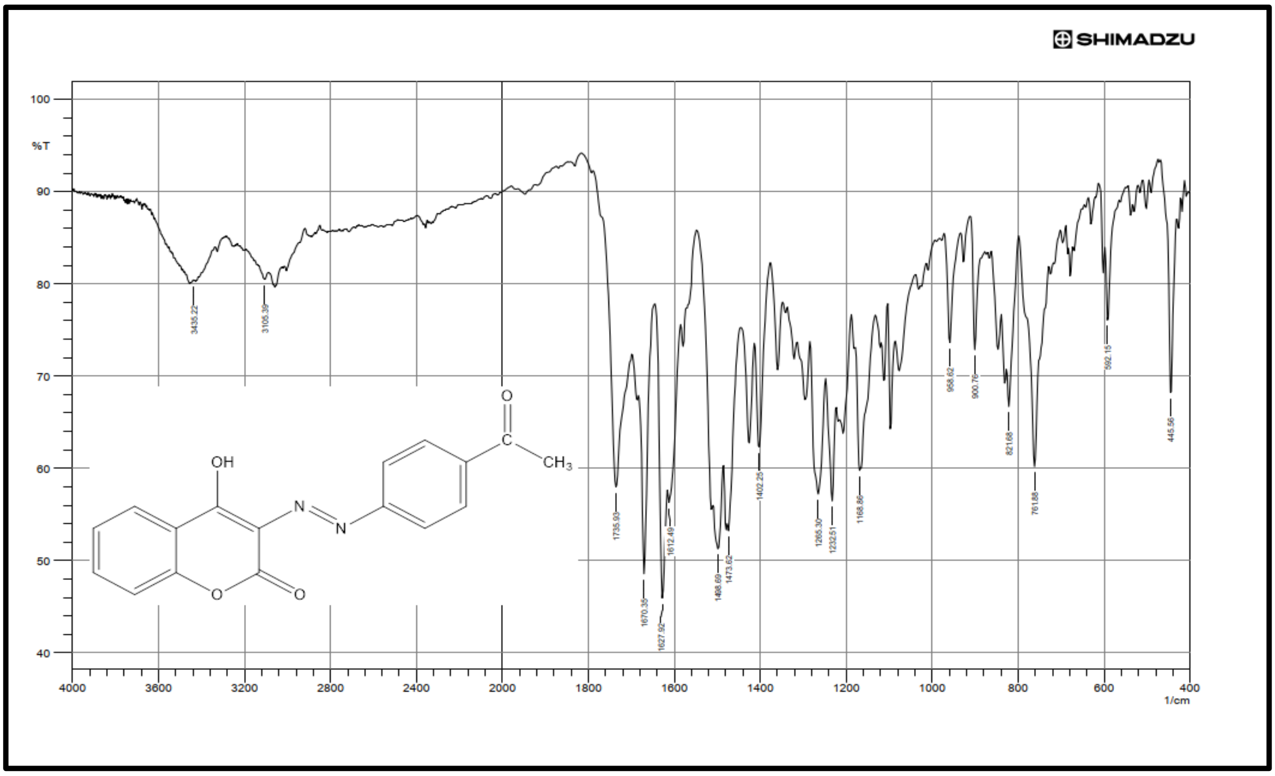


Figure 1. IR spectrum of Compound (A)

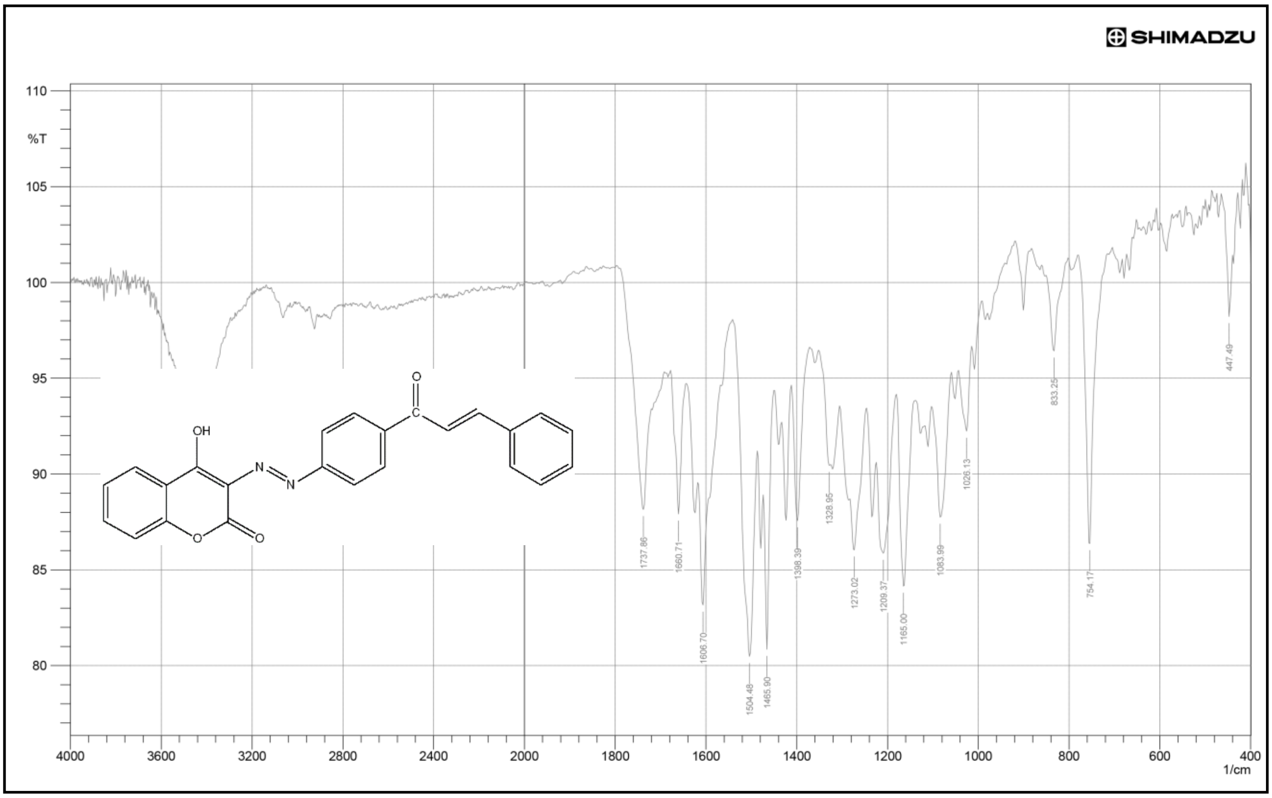


Figure 2. IR spectrum of Compound (B1)

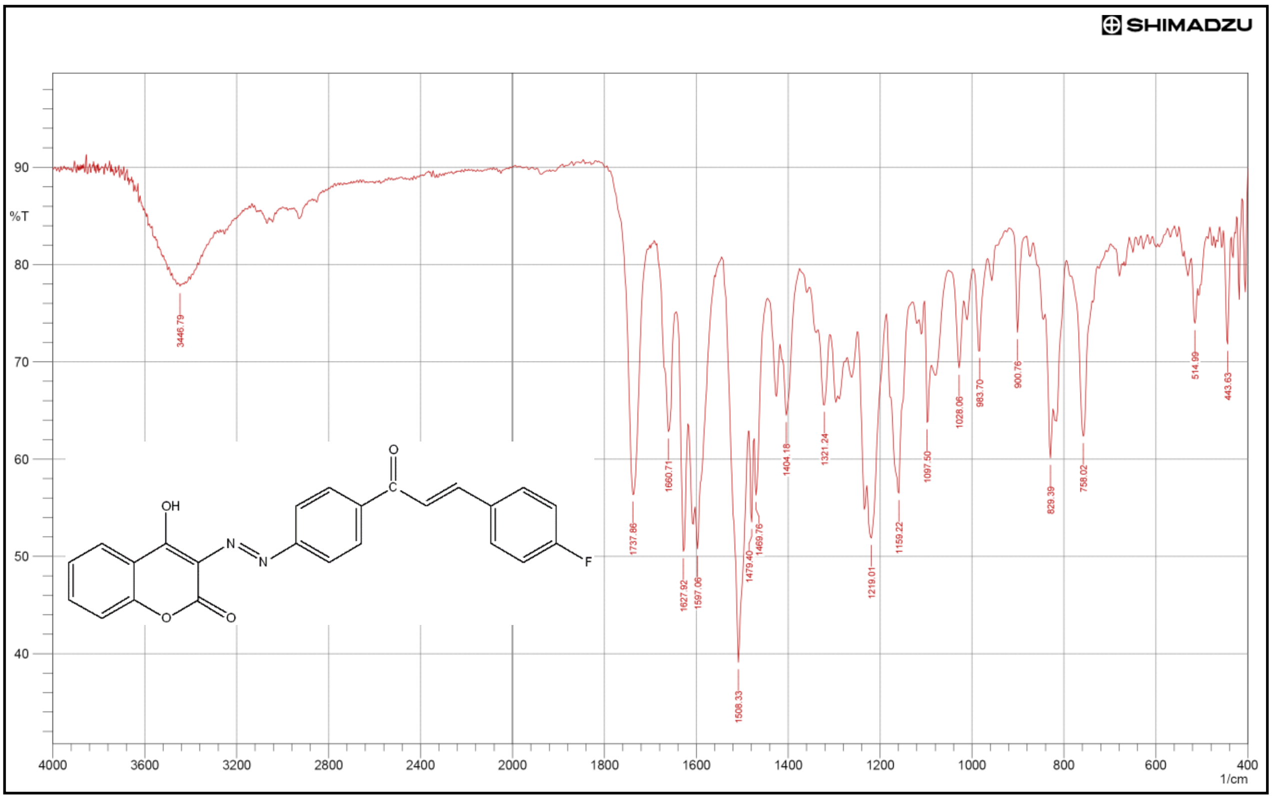


Figure 3. IR spectrum of Compound (B2)

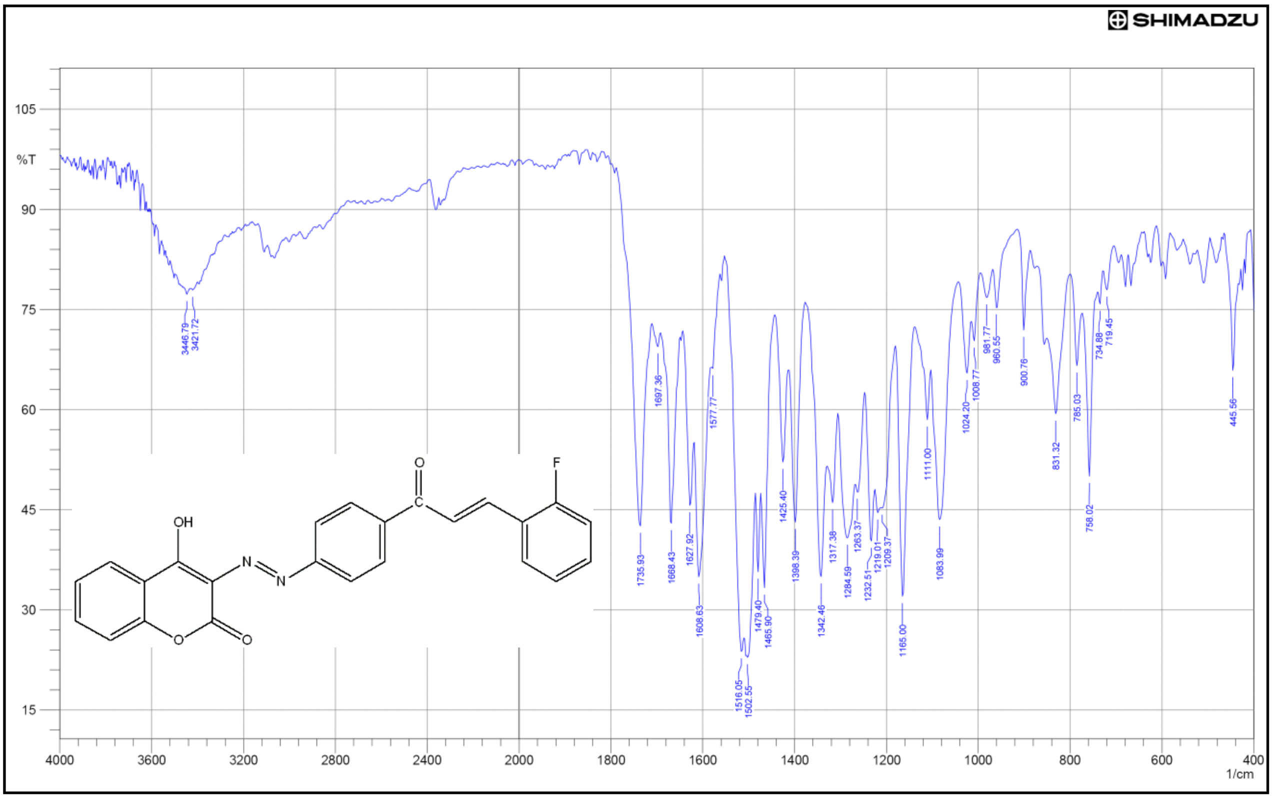


Figure 4. IR spectrum of Compound (B3)

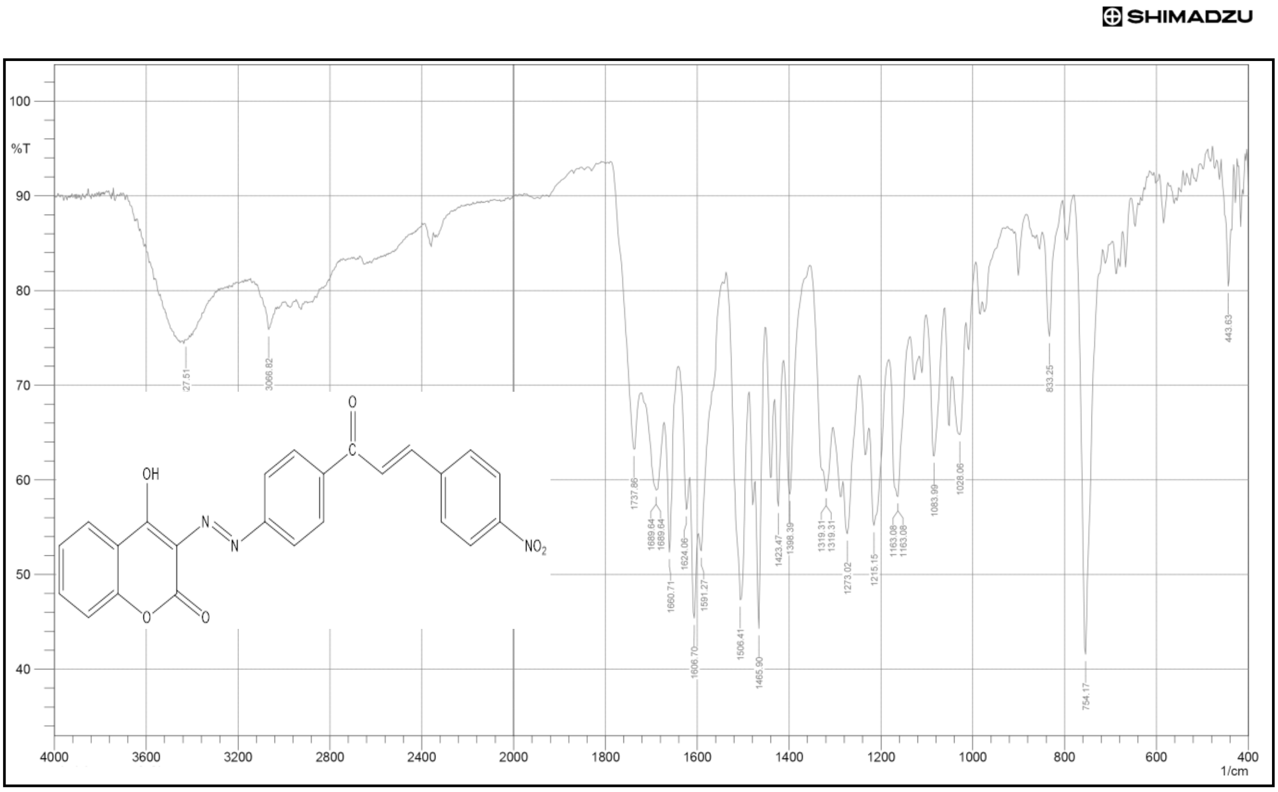


Figure 5. IR spectrum of Compound (B4)

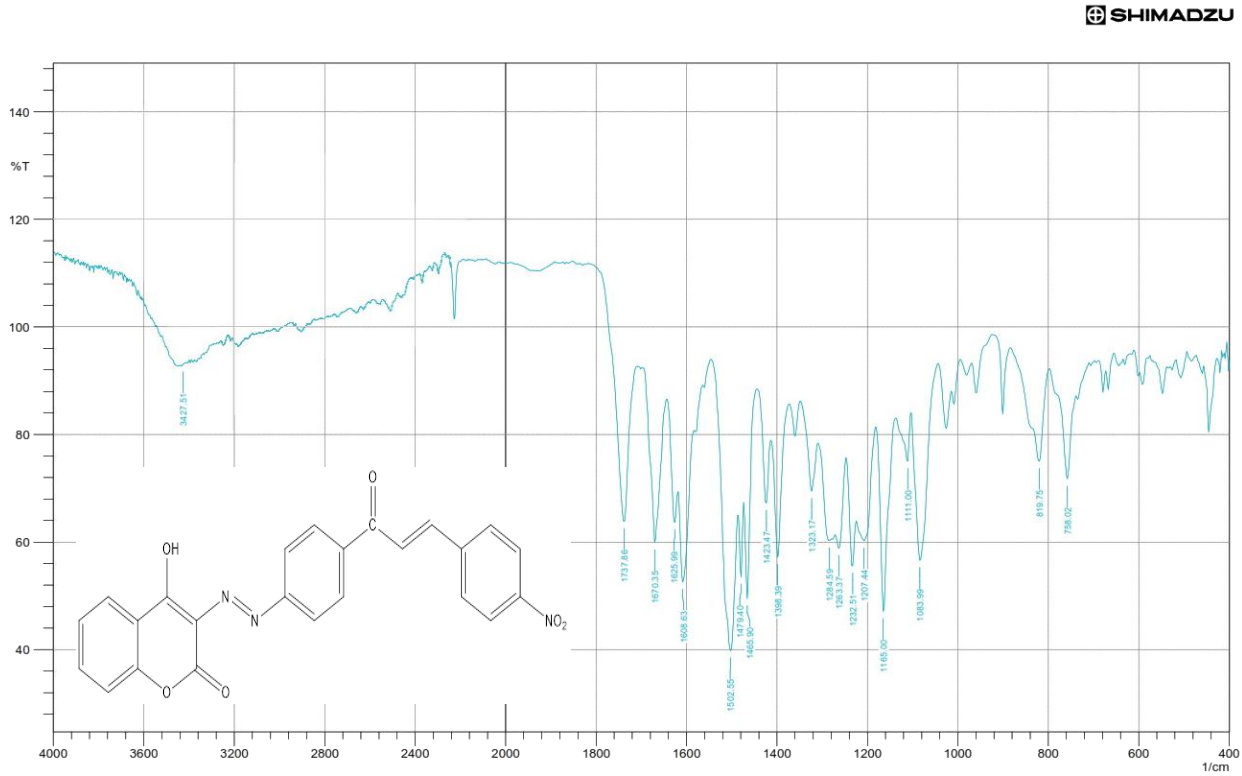


Figure 6. IR spectrum of Compound (B5)

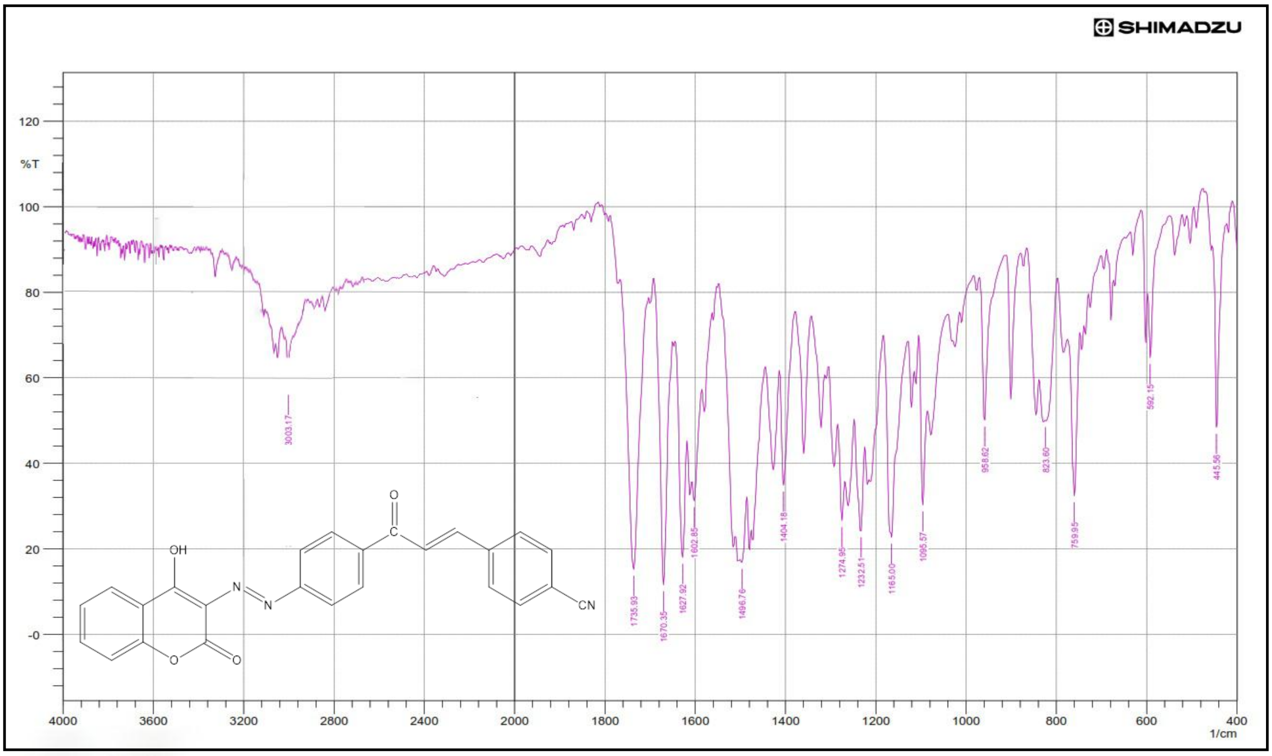


Figure 7. IR spectrum of Compound (B6)

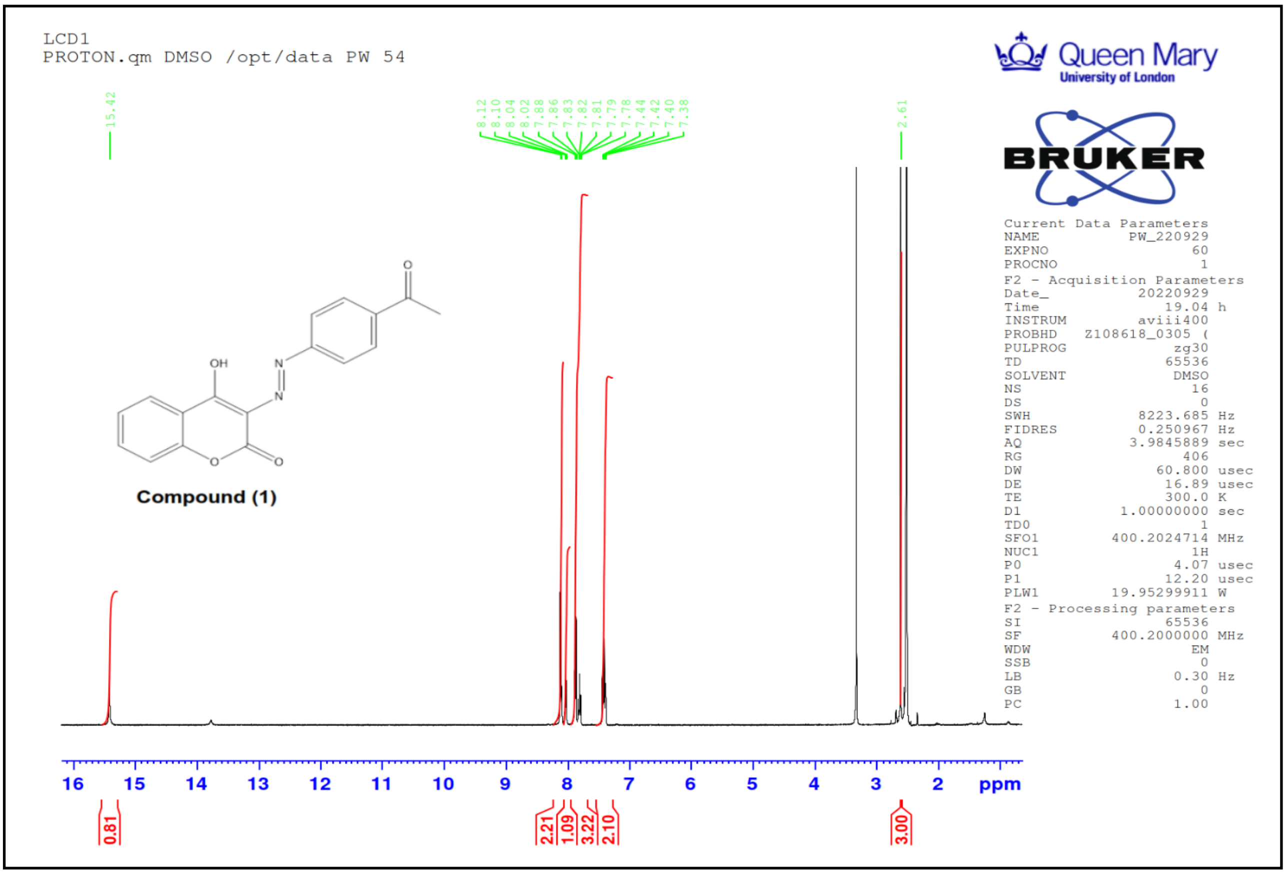


Figure 8. ^{1}H-NMR spectrum of Compound (A)

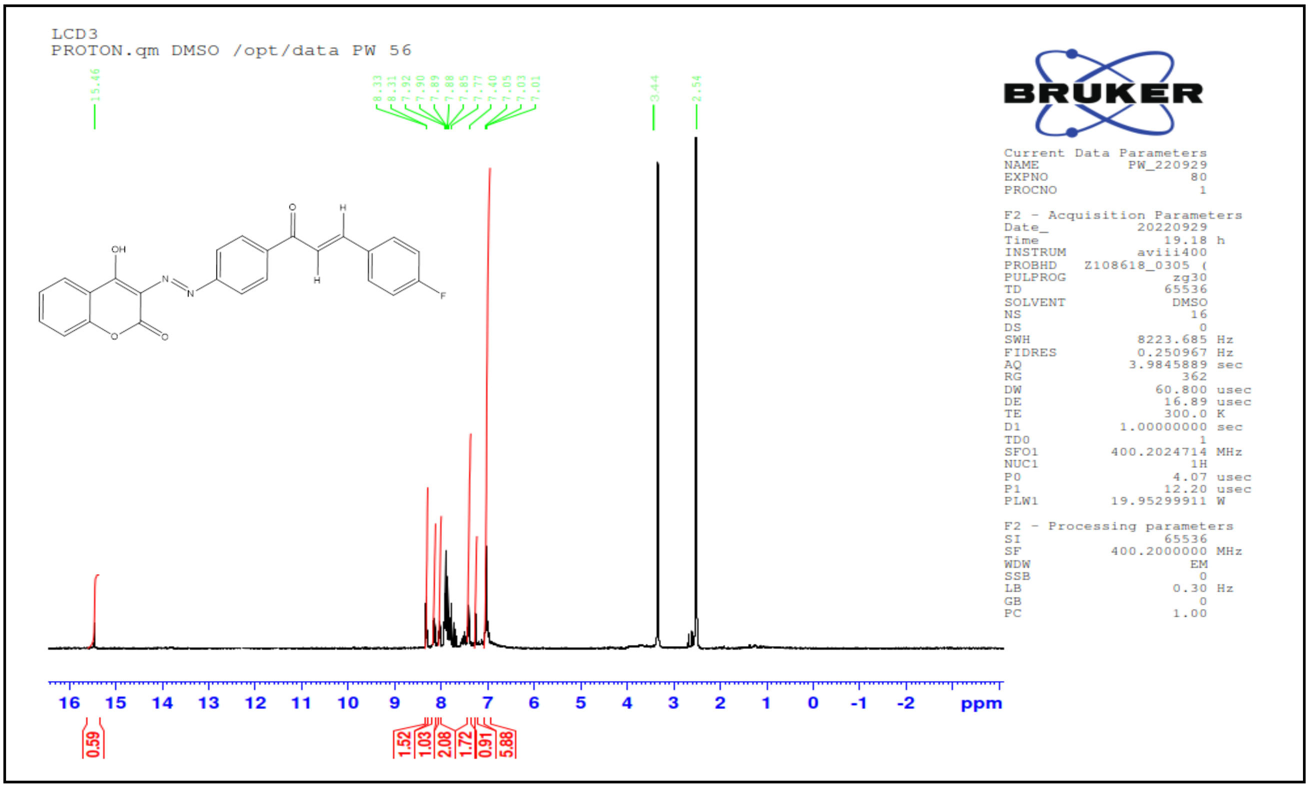


Figure 9. ^{1}H-NMR spectrum of Compound (B2)

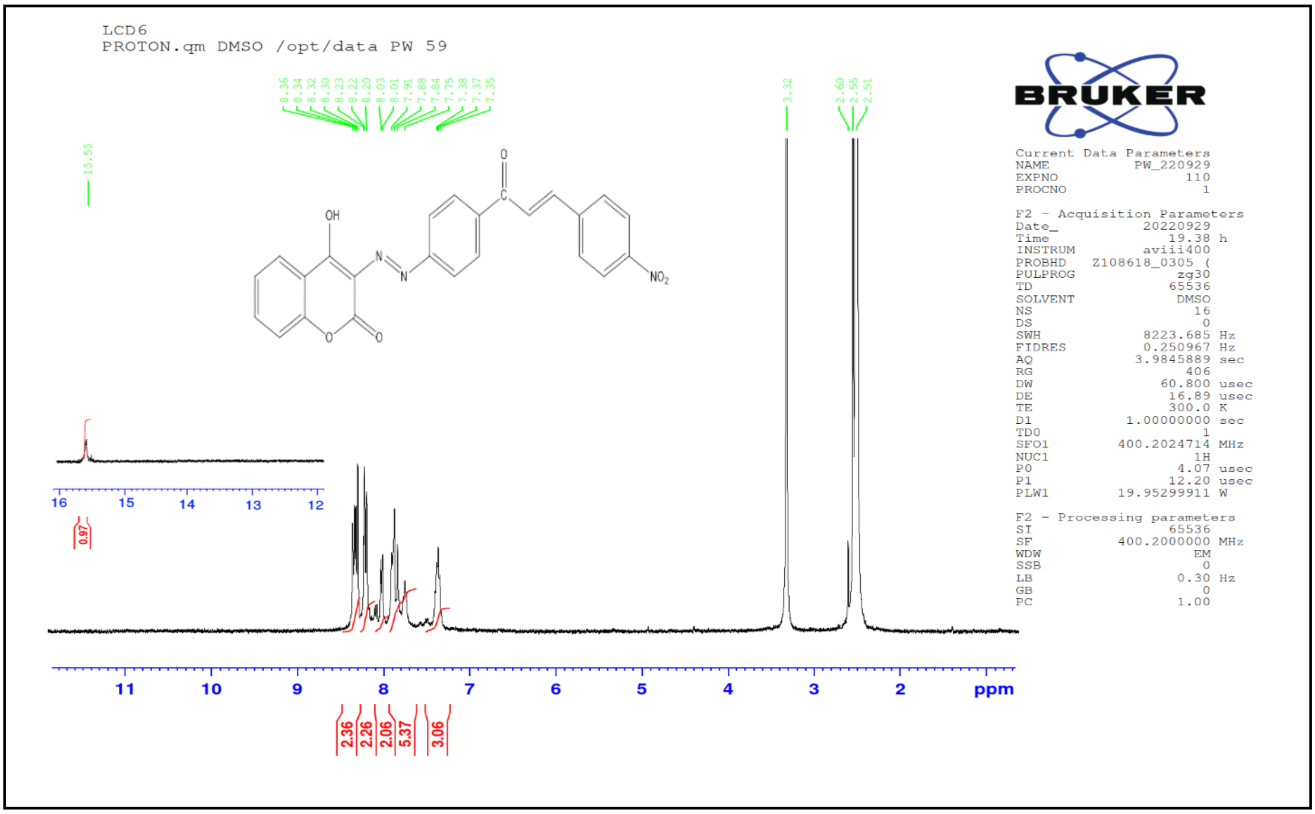


Figure 10. ^{1}H-NMR spectrum of Compound (B4)

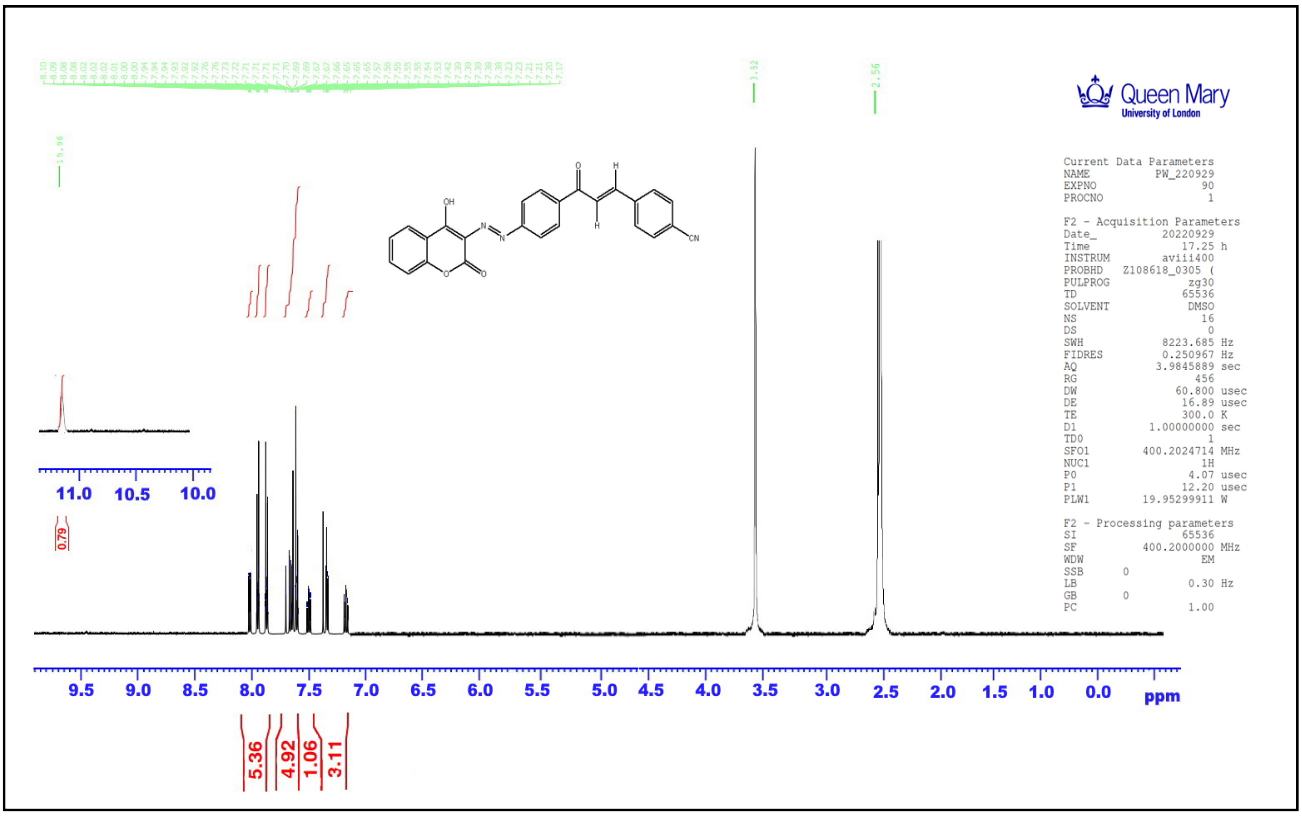


Figure 11. ^{1}H-NMR spectrum of Compound (B5)

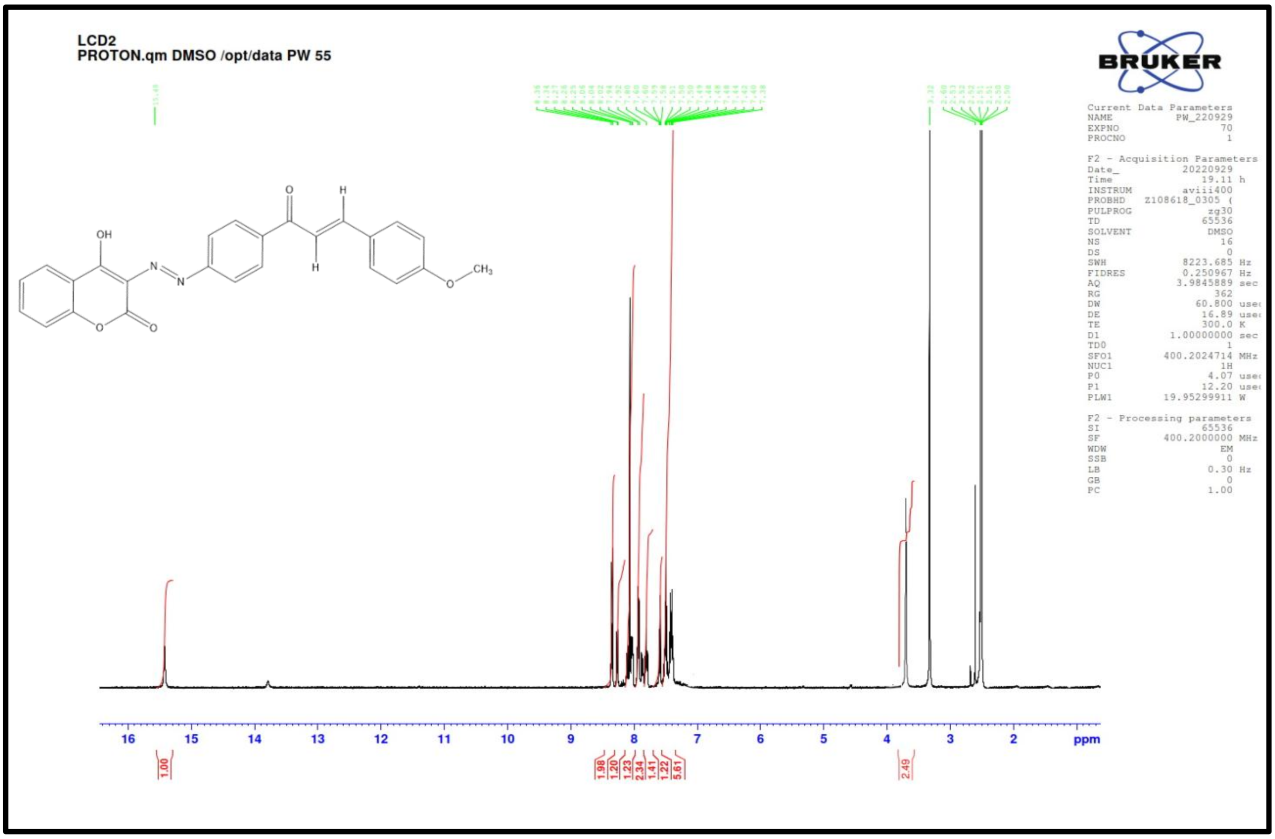


Figure 12. [1]H-NMR spectrum of Compound (B6)

Table 1. physical properties for the prepared Azo- Chalcones (B1-B6)

Prod.	R	Molecular formula	M.wt	Color	M.P /^{O}C
B1	H	$C_{24}H_{16}N_2O_4$	396.40	Yellow	>350 deco.
B2	4-F	$C_{24}H_{15}FN_2O_4$	414.39	Yellow	150-153
B3	2-F	$C_{24}H_{15}FN_2O_4$	414.39	Yellow to Orange	167-170
B4	4-NO_2	$C_{24}H_{15}N_3O_6$	441.40	Light Brown	251-254
B5	4-CN	$C_{25}H_{15}N_3O_4$	421.41	Dark Orange	125-127
B6	4-OCH_3	$C_{25}H_{18}N_2O_5$	426.43	Dark Orange	140-142

Table 2. IR data for the prepared Azo- Chalcones (B1-B6)

Prod.	Stretching absorption bands of distinctive functional groups in cm^{-1}					
	R	-C=O str. Lactone	-C=O str. Chalcone	-C=C- str. Chalcone	-N=N- str.	-OH str.
B1	H	1735.86	1660.71	1610.00	1465.90	3427.51
B2	4-F	1735.86	1660.71	1627.92	1479.40	3446.79
B3	2-F	1735.93	1668.43	1627.92	1479.40	3446.79
B4	4-NO_2	1737.86	1689.64	1660.71	1465.90	3427.51
B5	4-CN	1727.86	1670.35	1625.99	1479.40	3427.51
B6	4-OCH_3	1735.93	1670.35	1627.92	1496.76	3150.00

Table 3. The ^{1}H-NMR data for the prepared Azo-Chalcones (B2, B4, B5, and B6)

Prod.	R	δ / ppm Multiplicity Intensity Assignment
B2	4-F	15.46 (s 1H, OH of C_8), 7.01-8.33 (m 12H Ar-H and 2H of CH-α and CH-β).
B4	4-NO_2	15.55 (s 1H, OH of C_8), 7.35-8.36 (m 12H Ar-H and 2H of CH-α and CH-β).
B5	4-CN	15.96 (s 1H, OH of C_8), 7.17-8.10 (m 12H Ar-H and 2H of CH-α and CH-β).
B6	4-OCH_3	15.48 (s 1H, OH of C_8), 7.38-8.36 (m 12H Ar-H and 2H of CH-α and CH-β).

Fabrics made of acetate, Cotton, Nylon, Polyester and Wool were dyed with the colors B1, B2, B3, B4, B5 and B6. The pH of the solution used in the dyeing process was adjusted to a range of 2.2 to 4.7 with 1 M HCl.

I observe that there is a variance in the colors of the colored fabric, which results from a change in the coupling components. This is something that interesting. On the fabrics, all of the dyes produced a varied spectrum of hues, ranging from a pale yellow to a deep crimson, all of which had satisfactory levelness, brightness, and depth. (Zollinger, 2003)

The nature of the substituent that was present on the diazotized molecule was responsible for the variations that occurred in the shades that the dye had produced on the fabric. The dyeing compounds exhibited moderate to good light and washing fastness and had a fair to good resistance to light. After washing, there was a discernible improvement in the smoothness. This could be because the dye molecules have a strong ability to penetrate the cloth as well as an attractive force that draws them to the structure of the fabric. (Tehrani-Bagha and Holmberg, 2013)

4. Fastness characteristics

Tables (4-10) illustrated all of the data on the fastness qualities of light and wash. Light fastness was evaluated in accordance with BS: 1006-1378 (Sultana and Uddin, 2007), and wash fastness was evaluated in line with IS: 765-1979. (Patel and Dixit, 2014).

The light fastness was examined using a Xenon Arc Test with a Window Glass Filter, and the findings were compared to two outside solar light exposures. The findings for acetate, nylon, wool, and acrylic were moderate to good, while wash and rubbing fastness was good to exceptional for nylon, wool, acetate, acrylic, and polyester but poor for cotton. (Figure 13)

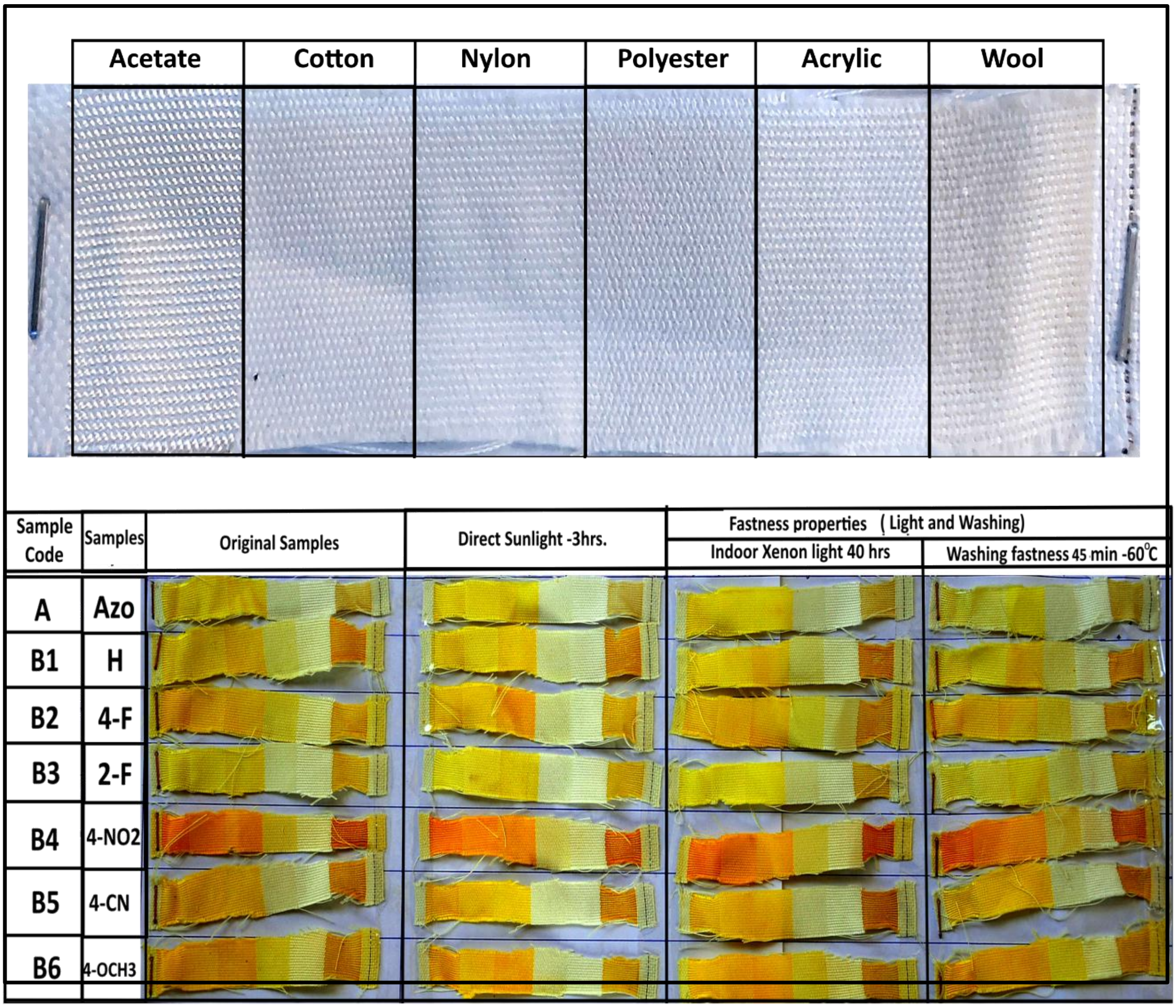


Figure 13. A portion of the multi-fiber strip without putting of the prepared azo-dyes and with putting of the prepared azo-dyes in different condition (original sample and fastness properties light and washing)

Table 4. Illustrate dyeing color &fastness properties of the dye (A)

Sample	**Fiber strips**	**Fastness properties Color model: RGB /HES codes / Color change factor**			
		Original color Direct dyeing	**Direct to sun light For 3 hrs.**	**Indoor xenon light 40 hrs.**	**Washing fastness 45 min. at 45°C**
	Acetate				
		RGB (180, 138, 0) (71%, 54%, 0%)	RGB (191, 156, 2) (75%, 61%, 1%)	RGB (152, 124, 1) (60%, 49%, 0%)	RGB (202, 196, 40) (79%, 77%, 16%)
		#B48A00 Dark Goldenrod	#BF9C02 Buddha Gold	#987C01 Yellowish Brown	#CAC428 Dirty Yellow
			6	7	3
	Cotton				
		RGB (171, 147, 0) (67%, 58%, 0%)	RGB (221, 202, 4) (87%, 79%, 2%)	RGB (181, 161, 0) (71%, 63%, 0%)	RGB (182, 168, 20) (71%, 66%, 8%)

A		#AB9300 Brown Yellow	#DDCA04 Bird Flower 5	#B5A100 Buddha Gold 8	#B6A814 Sahara 4-5
	Nylon				
		RGB (190, 160, 0) (75%, 63%, 0%)	RGB (188, 158, 2) (74%, 62%, 1%)	RGB (195, 178, 4) (76%, 70%, 2%)	RGB (179, 171, 0) (70%, 67%, 0%)
		#BEA000 Buddha Gold	#BC9E02 Buddha Gold 8	#C3B204 Brownish Yellow 7	#B3AB00 Muddy Yellow 4
	Polyester				
		RGB (155, 176, 117) (61%, 69%, 46%)	RGB (201, 227, 154) (79%, 89%, 60%)	RGB (171, 187, 122) (67%, 73%, 48%)	RGB (166, 187, 154) (65%, 73%, 60%)
		#9BB075 Iguana Green	#C9E39A Light Grey Green 6	#ABBB7A Tan Green 7	#A6BB9A Eagle 4-5
	Acrylic				
		RGB (211, 237, 174) (83%, 93%, 68%)	RGB (217, 252, 186) (85%, 99%, 73%)	RGB (217, 246, 188) (85%, 96%, 74%)	RGB (223, 255, 192) (87%, 100%, 75%)
		#D3EDAE Caper	#D9FCBA Very Light Green 6	#D9F6BC Very Pale Green 6	#DFFFC0 Very Light Green 4-5
	Wool				
		RGB (133, 111, 9) (52%, 44%, 4%)	RGB (182, 159, 57) (71%, 62%, 22%)	RGB (146, 123, 17) (57%, 48%, 7%)	RGB (115, 94, 3) (45%, 37%, 1%)
		#856F09 Corn Harvest	#B69F39 Brass 8	#927B11 Hazel 7	#735E03 Greeny Brown 5

Light fastness: (Grading: 1- poor, 2- slight, 3- moderate, 4- fair, 5- good, 6- very good, 7&8-excellent).
Wash fastness: (Grading: 1- poor, 2- fair, 3- good, 4- very good, 5- excellent).

Table 5. Illustrate dyeing color &fastness properties of the dye (B1)

Sample	**Fiber strips**	**Fastness properties Color model: RGB /HES codes / Color change factor**			
		Original color Direct dyeing	**Direct to sun light For 3 hrs.**	**Indoor xenon light 40 hrs.**	**Washing fastness 45 min. at 45^{O}C**
	Acetate				
		RGB (194, 179, 2) (76%, 70%, 1%)	RGB (195, 178, 0) (76%, 70%, 0%)	RGB (200, 179, 0) (78%, 70%, 0%)	RGB (178, 154, 2) (70%, 60%, 1%)
		#C2B302 Brownish Yellow	#C3B200 Brownish Yellow 8	#C8B300 Brownish Yellow 8	#B29A02 Brown Yellow 3-4
		RGB (159, 123, 1)	RGB (183, 164, 0)	RGB (201, 166, 0)	RGB (209, 187, 16)

B1	Cotton	(62%, 48%, 0%)	(72%, 64%, 0%)	(79%, 65%, 0%)	(82%, 73%, 6%)
		#9F7B01 Yellowish Brown	#B7A400 Buddha Gold	#C9A600 Muddy Yellow	#D1BB10 Mustard Yellow
			5	6	3
	Nylon				
		RGB (197, 139, 0) (77%, 55%, 0%)	RGB (198, 163, 0) (78%, 64%, 0%)	RGB (172, 141, 0) (67%, 55%, 0%)	RGB (162, 134, 1) (64%, 53%, 0%)
		#C58B00 Ochre	#C6A300 Buddha Gold	#AC8D00 Dark Mustard	#A28601 Dark Mustard
			5	6	3-4
	Polyester				
		RGB (178, 184, 58) (70%,72%,23%)	RGB (184, 195, 116) (72%, 76%, 45%)	RGB (168, 172, 62) (66%, 67%, 24%)	RGB (183, 191, 70) (72%, 75%, 27%)
		#B2B83A Avocado Green	#B8C374 Wild Willow	#A8AC3E Brass	#B7BF46 Avocado Green
			6	8	5
	Acrylic				
		RGB (150, 161, 92) (59%,63%,36%)	RGB (152, 170, 130) (60%, 67%, 51%)	RGB (156, 168, 106) (61%, 66%, 42%)	RGB (154, 172, 98) (60%, 67%, 38%)
		#96A15C Chelsea Cucumber	#98AA82 Sage	#9CA86A Iguana Green	#9AAC62 Iguana Green
			6	8	5
	Wool				
		RGB (153, 63, 1) (60%, 25%, 0%)	RGB (166, 84, 2) (65%, 33%, 1%)	RGB (131, 56, 0) (51%, 22%, 0%)	RGB (124, 63, 0) (49%, 25%, 0%)
		#993F01 Russet	#A65402 Rich Gold	#833800 Red Beech	#7C3F00 Red Beech
			7	8	4-5

Light fastness: (Grading: 1- poor, 2- slight, 3- moderate, 4- fair, 5- good, 6- very good, 7&8-excellent).
Wash fastness: (Grading: 1- poor, 2- fair, 3- good, 4- very good, 5- excellent).

Table 6. Illustrate dyeing color &fastness properties of the dye (B2)

Sample	Fiber strips	Fastness properties Color model: RGB /HES codes / Color change factor			
		Original color Direct dyeing	**Direct to sun light For 3 hrs.**	**Indoor xenon light 40 hrs.**	**Washing fastness 45 min. at 45^{O}C**
	Acetate				
		RGB (209, 153, 4) (82%, 60%, 2%)	RGB (212, 180, 0) (83%, 71%, 0%)	RGB (192, 148, 0) (75%, 58%, 0%)	RGB (209, 154, 0) (82%, 60%, 0%)
		#D19904 Yellow Ochre	#D4B400 Mustard	#C09400 Ochre	#D19A00 Yellow Ochre
			6	7	5
		RGB (193, 154, 1)	RGB (206, 153, 0)	RGB (200, 153, 1)	RGB (183, 148, 2)

B2	Cotton	(76%, 60%, 0%)	(81%, 60%, 0%)	(78%, 60%, 0%)	(72%, 58%, 1%)
		#C19A01 Buddha Gold	#CE9900 Yellow Ochre	#C89901 Yellow Ochre	#B79402 Yellow Brown
			7	7	5
	Nylon				
		RGB (180, 137, 0) (71%, 54%, 0%)	RGB (226, 148, 0) (89%, 58%, 0%)	RGB (189, 152, 0) (74%, 60%, 0%)	RGB (146, 122, 0) (57%, 48%, 0%)
		#B48900 Dark Goldenrod	#E29400 Gamboge	#BD9800 Yellow Brown	#927A00 Yellowish Brown
			6	7	4
	Polyester				
		RGB (157, 146, 22) (62%, 57%, 9%)	RGB (167, 181, 104) (65%, 71%, 41%)	RGB (167, 168, 14) (65%, 66%, 5%)	RGB (142, 127, 0) (56%, 50%, 0%)
		#9D9216 Yellowy Brown	#A7B568 Green Smoke	#A7A80E Sahara	#8E7F00 Yellowish Brown
			5	7	5
	Acrylic				
		RGB (158, 178, 81) (62%, 70%, 32%)	RGB (188, 215, 148) (74%, 84%, 58%)	RGB (207, 216, 99) (81%, 85%, 39%)	RGB (152, 167, 82) (60%, 65%, 32%)
		#9EB251 Green Smoke	#BCD794 Winter Hazel	#CFD863 June Bud	#98A752 Chelsea Cucumber
			5	4	5
	Wool				
		RGB (147, 92, 1) (58%, 36%, 0%)	RGB (162, 103, 0) (64%, 40%, 0%)	RGB (143, 99, 2) (56%, 39%, 1%)	RGB (150, 100, 1) (59%, 39%, 0%)
		#935C01 Chelsea Gem	#A26700 Ginger	#8F6302 Muddy Brown	#966401 Muddy Brown
			6	7	5

Light fastness: (Grading: 1- poor, 2- slight, 3- moderate, 4- fair, 5- good, 6- very good, 7&8-excellent).
Wash fastness: (Grading: 1- poor, 2- fair, 3- good, 4- very good, 5- excellent).

Table 7. Illustrate dyeing color &fastness properties of the dye (B3)

Sample	**Fiber strips**	**Fastness properties Color model: RGB /HES codes / Color change factor**			
		Original color Direct dyeing	**Direct to sun light For 3 hrs.**	**Indoor xenon light 40 hrs.**	**Washing fastness 45 min. at 45^{O}C**
	Acetate				
		RGB (202, 170, 1) (79%, 67%, 0%)	RGB (179, 173, 0) (70%, 68%, 0%)	RGB (187, 188, 0) (73%, 74%, 0%)	RGB (164, 145, 4) (64%, 57%, 2%)
		#CAAA01 Muddy Yellow	#B3AD00 Muddy Yellow	#BBBC00 Olive Yellow	#A49104 Dark Mustard
			6	5	3-4
		RGB (162, 145, 3)	RGB (181, 155, 0)	RGB (198, 154, 3)	RGB (207, 201, 43)

Sample	Fiber strips	Original color Direct dyeing	Direct to sun light For 3 hrs.	Indoor xenon light 40 hrs.	Washing fastness 45 min. at 45°C
B3	Cotton	(64%, 57%, 1%) #A29103 Dark Mustard	(71%, 61%, 0%) #B59B00 Brown Yellow 7	(78%, 60%, 1%) #C69A03 Buddha Gold 6	(81%, 79%, 17%) #CFC92B Bird Flower 3
	Nylon	RGB (175, 172, 0) (69%, 67%, 0%) #AFAC00 Mustard Green	RGB (204, 178, 3) (80%, 70%, 1%) #CCB203 Mustard 6	RGB (199, 192, 0) (78%, 75%, 0%) #C7C000 Mustard Yellow 5	RGB (148, 131, 0) (58%, 51%, 0%) #948300 Yellowish Brown 3-4
	Polyester	RGB (139, 171, 86) (55%,67%,34%) #8BAB56 Chelsea Cucumber	RGB (174, 187, 134) (68%, 73%, 53%) #AEBB86 Tan Green 5	RGB (184, 208, 150) (72%, 82%, 59%) #B8D096 Pale Olive 6	RGB (152, 149, 68) (60%, 58%, 27%) #989544 Dark Sand 2-3
	Acrylic	RGB (162, 174, 100) (64%, 68%, 39%) #A2AE64 Green Smoke	RGB (132, 145, 89) (52%, 57%, 35%) #849159 Camo 7	RGB (142, 161, 105) (56%, 63%, 41%) #8EA169 Chelsea Cucumber 7	RGB (152, 166, 91) (60%, 65%, 36%) #98A65B Chelsea Cucumber 5
	Wool	RGB (126, 92, 2) (49%, 36%, 1%) #7E5C02 Spicy Mustard	RGB (168, 131, 0) (66%, 51%, 0%) #A88300 Mustard Brown 6	RGB (121, 73, 0) (47%, 29%, 0%) #794900 Antique Bronze 7	RGB (139, 100, 0) (55%, 39%, 0%) #8B6400 Muddy Brown 4-5

Light fastness: (Grading: 1- poor, 2- slight, 3- moderate, 4- fair, 5- good, 6- very good, 7&8-excellent).
Wash fastness: (Grading: 1- poor, 2- fair, 3- good, 4- very good, 5- excellent).

Table 8. Illustrate dyeing color &fastness properties of the dye (B4)

Sample	Fiber strips	Fastness properties Color model: RGB /HES codes / Color change factor			
		Original color Direct dyeing	**Direct to sun light For 3 hrs.**	**Indoor xenon light 40 hrs.**	**Washing fastness 45 min. at 45^{O}C**
	Acetate	RGB (200, 38, 0) (78%, 15%, 0%) #C82600 Thunderbird	RGB (205, 54, 0) (80%, 21%, 0%) #CD3600 Sinopia 8	RGB (151, 22, 3) (59%, 9%, 1%) #971603 Burnt Red 7	RGB (151, 22, 3) (59%, 9%, 1%) #971603 Burnt Red 4-5
		RGB (225, 87, 0)	RGB (207, 82, 2)	RGB (190, 74, 0)	RGB (190, 74, 0)

B4	Cotton	(88%, 34%, 0%)	(81%, 32%, 1%)	(75%, 29%, 0%)	(75%, 29%, 0%)
		#E15700 Bamboo	#CF5202 Tawny	#BE4A00 Burnt Orange	#BE4A00 Burnt Orange
			7	7	4
	Nylon	RGB (223, 123, 0) (87%, 48%, 0%)	RGB (201, 131, 1) (79%, 51%, 0%)	RGB (223, 123, 0) (87%, 48%, 0%)	RGB (223, 123, 0) (87%, 48%, 0%)
		#DF7B00 Mango Tango	#C98301 Meteor	#DF7B00 Mango Tango	#DF7B00 Mango Tango
			6	8	5
	Polyester	RGB (186, 189, 108) (73%,74%, 42%)	RGB (200, 181, 40) (78%, 71%, 16%)	RGB (200, 181, 40) (78%, 71%, 16%)	RGB (200, 181, 40) (78%, 71%, 16%)
		#BABD6C Olive Green	#C8B528 Old Gold	#C8B528 Old Gold	#C8B528 Old Gold
			6	6	3-4
	Acrylic	RGB (180, 198, 99) (71%,78%, 39%)	RGB (162, 171, 82) (64%, 67%, 32%)	RGB (153, 148, 66) (60%, 58%, 26%)	RGB (153, 148, 66) (60%, 58%, 26%)
		#B4C663 Wild Willow	#A2AB52 Husk	#999442 Dark Sand	#999442 Dark Sand
			7	6	3-4
	Wool	RGB (145, 39, 0) (57%, 15%, 0%)	RGB (190, 62, 1) (75%, 24%, 0%)	RGB (124, 2, 1) (49%, 1%, 0%)	RGB (117, 22, 2) (46%, 9%, 1%)
		#912700 Brown Red	#BE3E01 Mahogany	#7C0201 Dark Red	#751602 Cedar Wood
			6	8	5

Light fastness: (Grading: 1- poor, 2- slight, 3- moderate, 4- fair, 5- good, 6- very good, 7&8-excellent).
Wash fastness: (Grading: 1- poor, 2- fair, 3- good, 4- very good, 5- excellent).

Table 9. Illustrate dyeing color &fastness properties of the dye (B5)

Sample	**Fiber strips**	**Fastness properties Color model: RGB /HES codes / Color change factor**			
		Original color Direct dyeing	**Direct to sun light For 3 hrs.**	**Indoor xenon light 40 hrs.**	**Washing fastness 45 min. at 45^{O}C**
	Acetate	RGB (121, 83, 0) (47%, 33%, 0%)	RGB (180, 106, 0) (71%, 42%, 0%)	RGB (182, 103, 0) (71%, 40%, 0%)	RGB (184, 138, 0) (72%, 54%, 0%)
		#795300 Antique Bronze	#B46A00 Ginger	#B66700 Ginger	#B88A00 Dark Goldenrod
			6	6	3-4
		RGB	RGB	RGB	RGB

B5	Cotton	(152, 93, 1) (60%, 36%, 0%)	(198, 163, 1) (78%, 64%, 0%)	(194, 131, 0) (76%, 51%, 0%)	(187, 142, 0) (73%, 56%, 0%)
		#985D01 Chelsea Gem	#C6A301 Buddha Gold	#C28300 Pirate Gold	#BB8E00 Ochre
			5	6	4
	Nylon				
		RGB (153, 116, 1) (60%, 45%, 0%)	RGB (227, 201, 0) (89%, 79%, 0%)	RGB (205, 139, 0) (80%, 55%, 0%)	RGB (191, 138, 0) (75%, 54%, 0%)
		#997401 Yellowish Brown	#E3C900 Citrine	#CD8B00 Ochre	#BF8A00 Ochre
			4	6	4
	Polyester				
		RGB (152, 145, 73) (60%,57%, 29%)	RGB (191, 209, 127) (75%, 82%, 50%)	RGB (177, 197, 102) (69%, 77%, 40%)	RGB (137, 144, 76) (54%, 56%, 30%)
		#989149 Dark Sand	#BFD17F Greenish Beige	#B1C566 Wild Willow	#89904C Camo
			5	5	3-4
	Acrylic				
		RGB (172, 185, 129) (67%, 73%, 51%)	RGB (152, 179, 126) (60%, 70%, 49%)	RGB (184, 195, 127) (72%, 76%, 50%)	RGB (132, 146, 93) (52%, 57%, 36%)
		#ACB981 Tan Green	#98B37E Lichen	#B8C37F Wild Willow	#84925D Moss
			7	8	4-5
	Wool				
		RGB (173, 90, 0) (68%, 35%, 0%)	RGB (151, 60, 3) (59%, 24%, 1%)	RGB (119, 35, 0) (47%, 14%, 0%)	RGB (140, 79, 0) (55%, 31%, 0%)
		#AD5A00 Rich Gold	#973C03 Russet	#772300 Chestnut	#8C4F00 Chelsea Gem
			7	7	5

Light fastness: (Grading: 1- poor, 2- slight, 3- moderate, 4- fair, 5- good, 6- very good, 7&8-excellent).
Wash fastness: (Grading: 1- poor, 2- fair, 3- good, 4- very good, 5- excellent).

Table 10. Illustrate dyeing color &fastness properties of the dye (B6)

Sample	**Fiber strips**	**Fastness properties Color model: RGB /HES codes / Color change factor**			
		Original color Direct dyeing	**Direct to sun light For 3 hrs.**	**Indoor xenon light 40 hrs.**	**Washing fastness 45 min. at 45^{O}C**
	Acetate				
		RGB (179, 119, 0) (70%, 47%, 0%)	RGB (189, 101, 1) (74%, 40%, 0%)	RGB (235, 171, 1) (92%, 67%, 0%)	RGB (138, 52, 1) (54%, 20%, 0%)
		#B37700 Mustard Brown	#BD6501 Orange Brown	#EBAB01 Bee Yellow	#8A3401 Rust Brown
			6	5	3-4

B6	Cotton	RGB (141, 87, 0) (55%, 34%, 0%)	RGB (197, 140, 1) (77%, 55%, 0%)	RGB (201, 116, 0) (79%, 45%, 0%)	RGB (207, 154, 0) (81%, 60%, 0%)
		#8D5700 Chelsea Gem	#C58C01 Ochre	#C97400 Dirty Orange	#CF9A00 Yellow Ochre
			7	6	3-4
	Nylon				
		RGB (175, 116, 0) (69%, 45%, 0%)	RGB (211, 129, 1) (83%, 51%, 0%)	RGB (186, 110, 0) (73%, 43%, 0%)	RGB (178, 115, 1) (70%, 45%, 0%)
		#AF7400 Mustard Brown	#D38101 Meteor	#BA6E00 Indochine	#B27301 Mustard Brown
			6	8	5
	Polyester				
		RGB (163, 153, 2) (64%, 60%, 1%)	RGB (182, 178, 91) (71%, 70%, 36%)	RGB (161, 143, 0) (63%, 56%, 0%)	RGB (150, 134, 0) (59%, 53%, 0%)
		#A39902 Brown Yellow	#B6B25B Sandy Brown	#A18F00 Dark Mustard	#968600 Yellowish Brown
			7	8	5
	Acrylic				
		RGB (181, 191, 76) (71%, 75%, 30%)	RGB (201, 229, 152) (79%, 90%, 60%)	RGB (192, 197, 79) (75%, 77%, 31%)	RGB (169, 173, 76) (66%, 68%, 30%)
		#B5BF4C Avocado Green	#C9E598 Green Thumb	#C0C54F Turmeric	#A9AD4C Brass
			6	8	5
	Wool				
		RGB (156, 101, 1) (61%, 40%, 0%)	RGB (153, 113, 0) (60%, 44%, 0%)	RGB (133, 62, 0) (52%, 24%, 0%)	RGB (148, 95, 1) (58%, 37%, 0%)
		#9C6501 Corn Harvest	#997100 Yellowish Brown	#853E00 Red Beech	#945F01 Muddy Brown
			7	5	5

Light fastness: (Grading: 1- poor, 2- slight, 3- moderate, 4- fair, 5- good, 6- very good, 7&8-excellent).
Wash fastness: (Grading: 1- poor, 2- fair, 3- good, 4- very good, 5- excellent).

5. CONCLUSION

This paper discusses the synthesis of azo-chalcone compounds obtained from 3-((4-acetylphenyl) diazinyl)-4-hydroxy-2H-chromen-2-one, as well as their use on multi-fiber fabric. The incorporation of the chalcone group into the newly synthesized azo compound will result in an increase in conjugation and the production of brighter colors on acetate, nylon, wool, acrylic, and polyester fibers; however, these hues will not give good results to cotton fiber. The azo-chalcone dyes that were generated for this research showed good to exceptional dyeing characteristics on acetate, nylon, wool, acrylic, and polyester materials.

According to the findings of the test for fastness qualities and the change in shade, the dyes do not have low affinity for the cotton fiber, but they have a good to exceptional affinity for the nylon, wool, and acrylic fibers.

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