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Synthesis of new bis-1,3-oxazepine-4,7-dione derivatives containing tow azo groups and preliminary evaluation of their antibacterial activity

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Abstract

In this work new bisazo bis -1,3-oxazepine - 4,7- dione derivatives have been synthesized via cycloaddition reaction type [2+5→7] of phthalic and maleic anhydrides to some synthesized bisazoimine derivatives .

ortho-Tolidine was converted to the corresponding bisazoaldehyde derivative **1** via coupling reaction with phenoxide anion of 2-hydroxybenzaldehyde. Aldehyde groups in bisazoaldehyde derivative **1** was condensed with different primary amines and only one hydrazine derivative (cyclohexylamine, phenylhydrazine, 2,4-dimethylaniline, 4-methoxyaniline, aniline and 4-bromoaniline) in presense of glacial acetic acid as catalyst in absolute ethanol to give bis-azoimine derivatives **2a-f** respectively. The resulting bisazoimine derivatives **2a-f** were then introduced in [2+5→7] cycloaddition reaction with each phthalic and maleic anhydrides in dry benzene to give new bisazo bis-1,3-oxazepine-4,7-dione derivatives **3a-f** and **4a-f** respectively.

All the synthesized target compounds **3a-f** and **4a-f** have been characterized by (C.H.N.) elementary micro analysis and the spectroscopic methods including FT-IR , ^{1}H NMR for compounds **3a-e** and **4a-e** and ^{13}C NMR for compounds (**3a**, **4a** and **4e**). The last step included preliminary evaluation of antibacterial activity for all target compounds **3a-f** and **4a-f** which were tested against *Staphylococcus aureous* (Gram positive) and *Escherichia coli* (Gram negative), these activities have been determined in ***vitro*** using disc diffusion method (Agar), the results revealed that some of compounds showed measurable activity as shown in table (9).

Keywords: bisazoimines , bisoxazepines, antibacterial activity , ازوايمينات ثنائية, اوكسازبينات ثنائية , فعالية ضد البكتريا

الخلاصة

تم من خلال هذا العمل تحضير مشتقات ثنائية الازو ثنائية - 3,1 - اوكسازبين-4, 7-دايون وذلك بأستعمال تفاعل الاضافة الحلقية [2+5←7] لانهيدريدالفثالك و الماليك الى بعض مشتقات الايمين الثنائية الحاوية على مجموعتي أزو المحضرة .

تم أولا, تحويل مركب ***اورثو***-توليدين إلى مشتق ثنائي ألازوالديهايد **1** وذلك من خلال تفاعل الازدواج مع ايون الفينوكسيد السالب لمركب 2- هيدروكسي بنزالديهايد.ان تكاثف مجموعتي الالديهايد في مشتق الأزوالديهايد الثنائي المحضر**1** مع مجموعتي الأمين في امينات اولية متنوعة ومشتق هيدرازين واحد (سايكلوهكسيل امين, فنيل هيدرازين,2,4- ثنائي مثيل انيلين,4- ميثوكسي انيلين, انيلين,4- بروموانيلين) بوجود حامض الخليك الثلجي كعامل مساعد في الأيثانول المطلق أدى إلى تكوين مشتقات الازوايمين الثنائية **2a-f** على التوالي. تم إدخال مشتقات الازوايمين الثنائية المحضرة **2a-f** في تفاعل إضافة حلقية نوع [2+5←7] مع كل من انهيدريدالفثالك و الماليك في البنزين الجاف فتم الحصول على مشتقات 3،1- اوكسازبين - 7,4-دايون ثنائية جديدة تحتوي في تركيبها على مجموعتي أزو **3a-f** و**4a-f** على التوالي .

تم تشخيص مركبات الاوكسازبين الثنائية المحضرة **3a-f** و**4a-f** بوساطة التحليل الكمي العنصري الدقيق (C.H.N.) وكذلك بالطرق الطيفية المتضمنة مطيافية الأشعة تحت الحمراء ومطيافية الرنين النووي المغناطيسي للبروتون ^{1}H NMR للمركبات **3a-e** و **4a-e**, كما تم تشخيص المركبات (**3a، 4a ، 4e**) بمطيافية ^{13}C NMR .

تضمت الخطوة الأخيرة من البحث تقييم أولي للفعالية ضد البكتريا لجميع المركبات النهائية **3a-f** و**4a-f** والتي اختبرت فعاليتها ضد بكتريا *Staphylococcus aureous* الموجبة لصبغة كرام وبكتريا *Escherichia coli* السالبة لصبغة كرام وتم تعيين هذه الفعاليات خارج الجسم باستعمال طريقة الانتشار في الوسط الغذائي (الاكار). دلت النتائج المستحصلة بأن بعض المركبات أظهرت فعالية عالية وكما موضح في جدول (9).

1. Introduction

Oxazepine refers to any unsaturated seven-membered ring containing an oxygen and nitrogen atom.The1,3-oxazepine is a branch of many types of the heterocyclic oxazepine[1,2].The core structure of 1,3-oxazepine-4,7-dione consists of a seven-membered ring along with two carbonyl groups.

Recently, the cycloaddition reaction type [2+5 →7] is used in synthesis of 1,3-oxazepine[3,4] and 1,3-oxazepane[3,5] rings. This type of cycloaddition reactions produces various 1,3-oxazepine derivatives. [2+5 →7] cycloaddition reaction involves addition of imine group as two-membered component to cyclic anhydrides such as phthalic, maleic and succinic anhydrides as five-membered components to form seven-membered ring. Benzoxazepine derivatives have a wide spectrum of biological activities including antibacterial[6,7],antifungal[8], antiviral[9],anticonvulsant[10] and anticancer[11]. Amoxapine is use as a drug for sorrow and schizophrenia[12] .

Azo dyes constitute one of the largest and most varied groups of synthetic organic dyes in use today[13]. The pharmacological use of azo compounds originates from the discovery of the antibacterial action of Prontosil on streptococcal infections by Dog-magk[14] furthermore, azo compounds were reported to show a variety of biological activities including antibacterial[15], antifungal[16], pesticidal[17], antiviral and anti-inflammatory activities[18]. Other applications include merging technologies like liquid crystals, organic photoconductors and non-linear optics[19] and pH indicators[20].

2. Experimental

2.1. General

The chemicals used in this work were obtained from Merck, Fluka and Sigma-Aldrich and were used without further purification. Silica TLC plates were used with an aluminum backing (0.2 mm, 60 F_{254}). The reactions were monitored by TLC and visualized by development of the TLC plates with an alkaline potassium permanganate dip or with Iodine vapor. Melting points were determined by Electro thermal Stuart melting point apparatus, GOWLLANDS, England and were uncorrected. The elemental analyses were recorded using E.A.G.E.R.-100, Carlo Erba, Italy, measurements were made at Metu Central Laboratory, Orta DoGu Teknik Üniversitesi, Turkey. Infrared spectra were recorded on SHIMADZU FTIR-8400S Infrared Spectrophotometer as potassium bromide discs. ^{1}H NMR spectra were recorded on Fourier transform Varian spectrometer, operating at 300 MH_Z with tetramethylsilane as internal standard and DMSO-d_6 as solvent, measurements were made at Metu Central Laboratory, Orta DoGu Teknik Üniversitesi, Turkey. ^{13}C NMR spectra were recorded on Fourier transform Varian spectrometer, operating at 75 MH_Z with tetramethylsilane as internal standard and DMSO-d_6 as solvent, measurements were made at Metu Central Laboratory ,Orta DoGuTeknik Üniversitesi, Turkey. Autoclave was used to sterilize agar media, supplied from Prestige Medical-England.Incubator was used to maintain different temperature required for the growth of organism, supplied from Memert-Germany**.** Bisazoaldehyde derivative **1** was prepared following the method described by Acton [21].

2.2. Synthesis methods

2.2.1. General procedure for Synthesis of bisazoimine derivatives (2a-f)

Bisazoaldehyde derivative **1** (0.002 mol, 0.956g) was dissolved in absolute ethanol (20 mL) containing two drops of glacial acetic acid, then equimolar amount (0.004 mol) of primary amines and only one hydrazine derivative (cyclohexylamine, phenylhydrazine, 2,4-dimethylaniline, 4-methoxyaniline, aniline and 4-bromoaniline) were added. The reaction mixture was refluxed with stirring on a water bath at 70 ^{0}C for (12-18 h.) . TLC (Et_2O:*n*- hexane , 2 : 1) showed that the reaction was completed. The mixture was allowed to cool down to room temperature and the colored precipitate was filtered, then recrystallized from ethanol. Table (1) shows the structures , molecular formulas, molecular weights, melting points, yield % and R_f values of the synthesized compounds **1** and **2a-f**.

2.2.2. General procedure for synthesis of bisazo bis -1,3- oxazepine-4,7-dione derivatives (3a-f)

A mixture of equimolar amounts of bisazoimine derivatives **2a-f** (0.0006 mol) and phthalic anhydride (0.0012 mol, 0.1776 g) in dry benzene (20 mL) was refluxed with stirring on a water bath that 75^{0}C for (17-24 h.) . TLC (EtOAc : *n*-hexane , 2 : 1) showed that the reaction was completed. Then, the solvent was removed under reduced pressure and the resulting colored solid was washed well with ether and recrystallized from ethanol.Table (2) shows the structures, molecular formulas, molecular weights, melting points, yield % and R_f values of the synthesized compounds **3a-f** . The (C.H.N.) elementary micro analysis data of the synthesized compounds **3a-f** was lisited in table (4).

2.2.3.General procedure for synthesis of bisazo bis -1,3-oxazepine-4,7-dione derivatives (4a-f)

A mixture of equimolar amounts of bisazoimine derivatives **2a-f** (0.0006 mol) and maleic anhydride (0.0012 mol, 0.1176 g) in dry benzene (20 mL) was refluxed with stirring on a water bath at 75°C for (17-24h.). TLC (EtOAc :*n*- hexane,2 : 1) showed that the reaction was completed . Then, the solvent was removed under reduced pressure and the resulting colored crystalline solid was washed well with ether and recrystallized from ethanol. Table (3) shows the structures, molecular formulas, molecular weights , melting points, yield % and R_f values of the synthesized compounds **4a-f** . Table (4) shows the (C.H.N.) elementary microanalysis data of the synthesized compounds **4a-f** .

Table (1): physical properties and other characteristics for the synthesized Azoaldehyde derivative (1) and bisazoimine derivatives (2a-f)

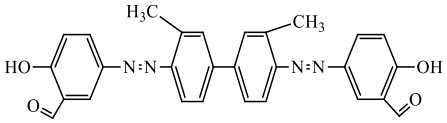
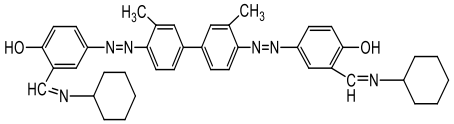
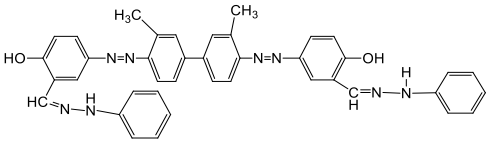
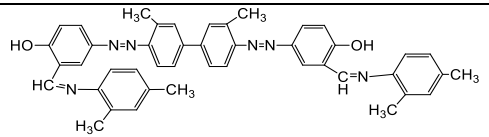
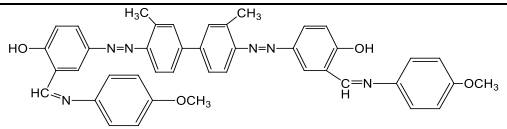
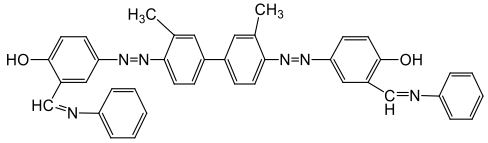
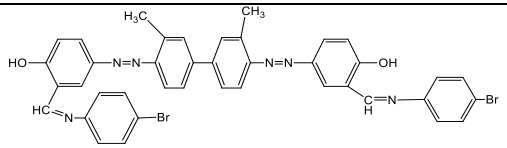
Com. no.	Structural formula	M.F.	M.Wt. g/mol	M.P. ^{0}C	Color	Yield %	R.T. (*h.*)	R_f
1		$C_{28}H_{22}N_4O_4$	478	>300	Pale orange	61	-	0.78 (cloroform:benzene) 1:1
2a		$C_{40}H_{44}N_6O_2$	640	150-152	red	91	12	0.85 (Et_2O: *n*-hexane) 2:1
2b		$C_{40}H_{34}N_8O_2$	658	240-242	red	83	16	0.79 (Et_2O:*n*-hexane) 2:1
2c		$C_{44}H_{40}N_6O_2$	684	248-250	orange	79	15	0.71 (Et_2O: *n*-hexane) 2:1
2d		$C_{42}H_{36}N_6O_4$	688	230-232	orange	87	13	0.85 (Et_2O: *n*-hexane) 2:1
2e		$C_{40}H_{32}N_6O_2$	628	170-172	dark orange	89	16	0.67 (Et_2O:*n*-hexane) 2:1
2f		$C_{40}H_{30}N_6O_2Br_2$	786	210-212	brown	79	18	0.65 (Et_2O:*n*-hexane) 2:1

Table (2): physical properties and other characteristics for the synthesized bis-1,3-oxazepine derivatives (3a-f)

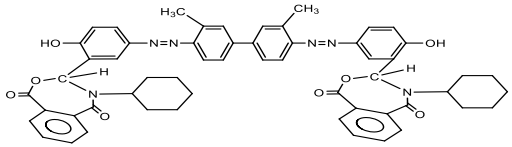
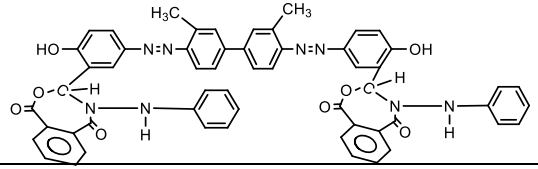
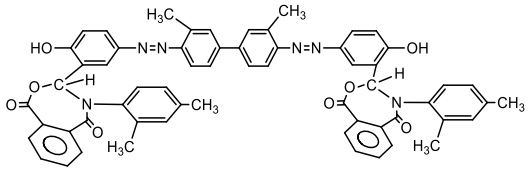
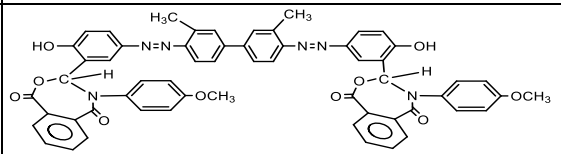
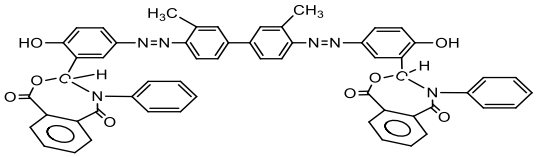
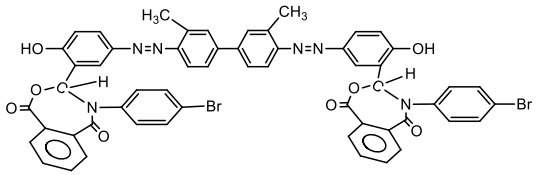
Com. no.	Structural formula	M.F.	M.Wt. g/mol	M.P. ^{0}C	Color	Yield %	R.T. *(h).*	R_f
3a		$C_{56}H_{52}N_6O_8$	936	222-224	dark brown	68	17	0.69 (EtOAc:*n*-hexane) 3:1
3b		$C_{56}H_{42}N_8O_8$	954	232-233	dark red	68	24	0.74 (EtOAc:*n*-hexane) 3:1
3c		$C_{60}H_{48}N_6O_8$	980	230-232	orange	63	23	0.54 (EtOAc:*n*-hexane) 3:1
3d		$C_{58}H_{44}N_6O_{10}$	984	188-190	dark brown	68	24	0.71 (EtOAc:*n*-hexane) 3:1
3e		$C_{56}H_{40}N_6O_8$	924	221-222	orange	63	23	0.76 (EtOAc:*n*-hexane) 3:1
3f		$C_{56}H_{38}N_6O_8Br_2$	1082	245-247	brown	73	22	0.78 (EtOAc:*n*-hexane) 3:1

Table (3): physical properties and other characteristics for the synthesized bis-1,3-oxazepine derivatives (4a-f)

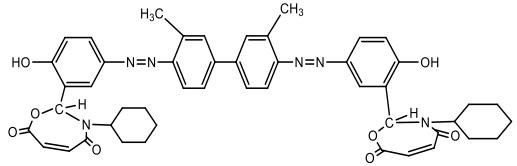
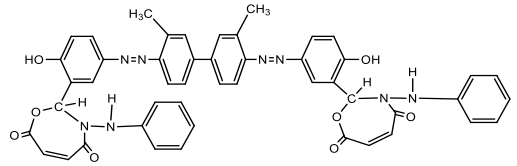
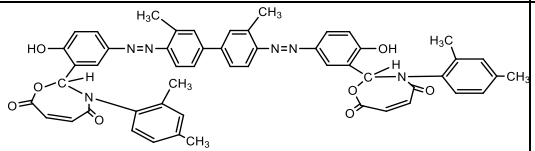
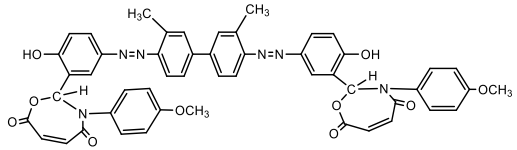
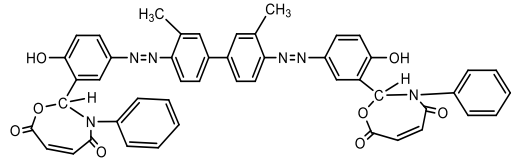
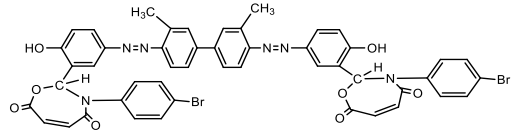
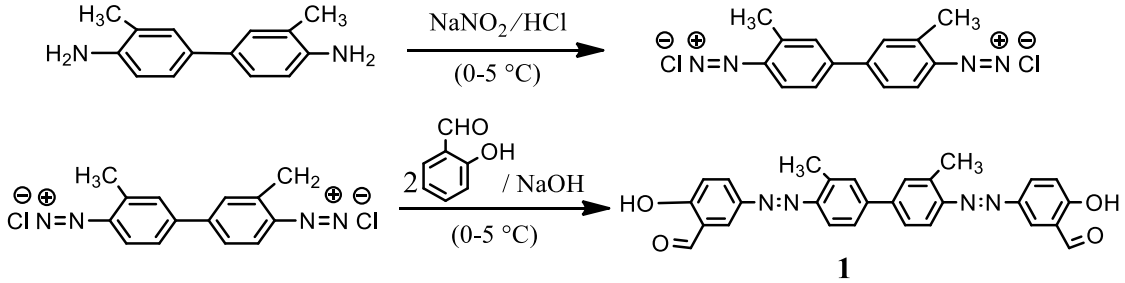
Com .no.	Structural formula	M.F.	M.Wt. g/mol	M.P. ^{0}C	Color	Yield %	R.T. *(h.)*	R_f
4a		$C_{48}H_{48}N_6O_8$	836	200-202	brown	74	17	0.81 (EtOAc:*n*-hexane) 3:1
4b		$C_{48}H_{38}N_8O_8$	854	203-205	dark brown	59	24	0.63 (EtOAc:*n*-hexane) 3:1
4c		$C_{52}H_{44}N_6O_8$	880	176-177	orange	66	21	0.58 (EtOAc:*n*-hexane) 3:1
4d		$C_{50}H_{40}N_6O_{10}$	884	185 - 187	brown	63	20	0.77 (EtOAc:*n*-hexane) 3:1
4e		$C_{48}H_{36}N_6O_8$	824	217-219	red	63	21	0.65 (EtOAc:*n*-hexane) 3:1
4f		$C_{48}H_{34}N_6O_8Br_2$	982	235-237	red	61	22	0.68 (EtOAc:*n*-hexane) 3:1

Table (4) : (C.H.N.) analysis data of bis -1,3- oxazepine-4,7-dione derivatives (3a-f) and (4a-f)

Com. no.	M.Wt. g/mol	Calculated/Found		
		C %	H %	N %
3a	936	71.79 71.10	5.55 5.38	8.97 8.45
3b	954	70.44 69.75	4.40 4.12	11.74 11.32
3c	980	73.46 73.17	4.89 4.48	8.57 8.93
3d	984	70.73 70.38	4.47 4.28	8.53 8.34
3e	924	72.72 72.48	4.32 4.21	9.09 8.53
3f	1082	62.10 61.55	3.51 2.86	7.76 6.09
4a	836	68.89 68.23	5.74 5.14	10.04 10.24
4b	854	67.44 67.15	4.44 4.03	13.11 12.92
4c	880	70.90 70.50	5.00 5.05	9.54 9.10
4d	884	67.87 67.24	4.52 4.16	9.50 9.22
4e	824	69.90 69.33	4.36 4.19	10.19 9.91
4f	982	58.65 58.05	3.46 3.62	8.55 8.28

3. Results and Discussion

A coupling reaction between the bisdiazonium salt of ***ortho***-tolidine and equimolar quantity of phenoxide salt of 2-hydroxybenzaldehyde as coupling reagent at (0-5)°C afforded bis azoaldehyde derivative **1** as indicated in scheme (1).



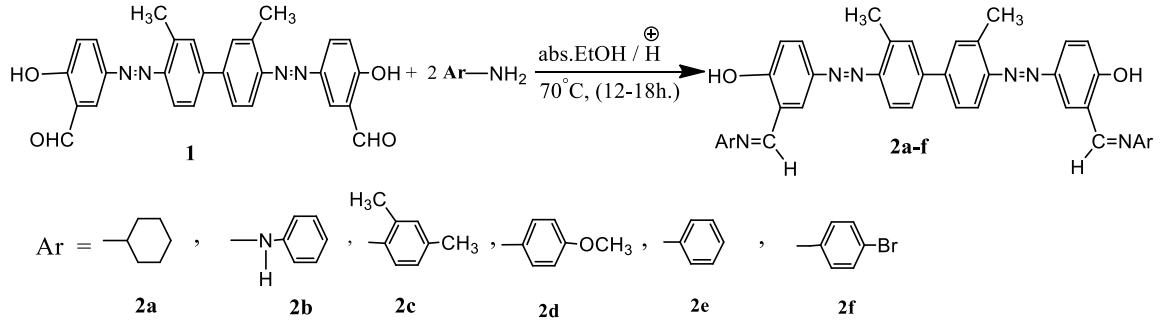
1

Scheme (1): Synthesis of bisazoaldehyde derivative 1

FT-IR spectrum, fig.(2) of bisazoaldehyde derivative **1** showed disappearance of the sharp bands at (3468,3410) cm^{-1} and (3373,3338) cm^{-1} attributed to the asymmetric and symmetric stretching vibrations of amino groups ($-NH_2$) in ***o***-tolidine, the spectrum also showed disappearance of the sharp and strong band at 1624 cm^{-1} due to the scissoring bending vibration of ($-NH_2$) groups and appearance of sharp and strong band at 1653 cm^{-1} assigned to the stretching vibration of carbonyl groups(C=O), this band was shifted towards lower frequency due to intramolecular hydrogen

bonding with ***ortho***-hydroxy group[22], the spectrum also appeared broad band at 3416 cm^{-1} attributed to the stretching vibration of hydroxy group. Other bands with their interpretation were summarized in table (5).

A condensation reactions between bisazoaldehyde derivative **1** and some selective primary amines and only one hydrazine dreivative (cyclohexylamine, phenylhydrazine, 2,4-dimethylaniline, 4-methoxyaniline, aniline and 4-bromoaniline) respectively in the presence of two drops of glacial acetic acid as catalyst in absolute ethanol resulted formation of bis-azoimine derivatives **2a-f** as shown in scheme (2).



Scheme (2) : Synthesis of bis-azoimine derivatives 2a-f

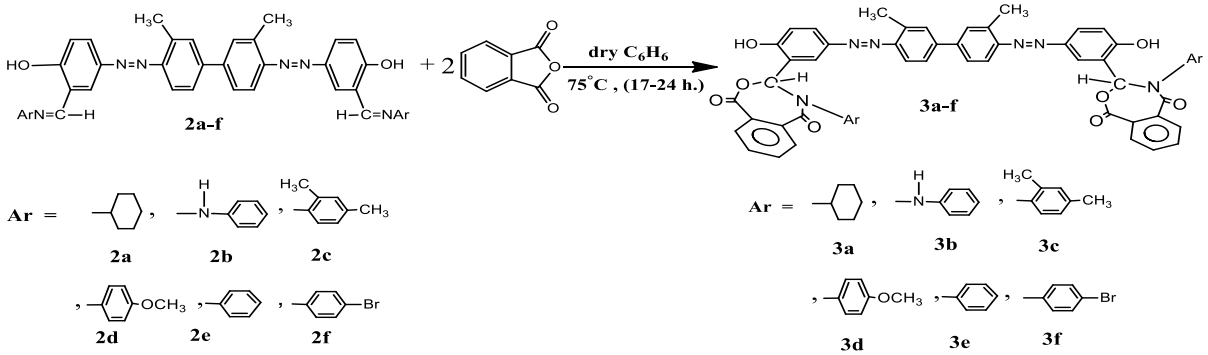
FT-IR spectra, figs.(3) - (8) at **υ** (cm^{-1}) (KBr) of all synthesized bis-azoimine derivatives **2a-f** illustrate good evidence that the reactions happened successfully by disappearing the strong band at 1653 cm^{-1} belong to the stretching vibration of (C=O) group and appearing strong band at lower frequencies at the general range (1629-1600) cm^{-1} attributed to the stretching vibration of imine groups (C=N). Other characteristic bands with their interpretation were summarized in table (5).

Table (5) : FT-IR data of the synthesized bisazoaldehyde dreivative 1 and bis - azoimine derivatives 2a-f in cm^{-1}

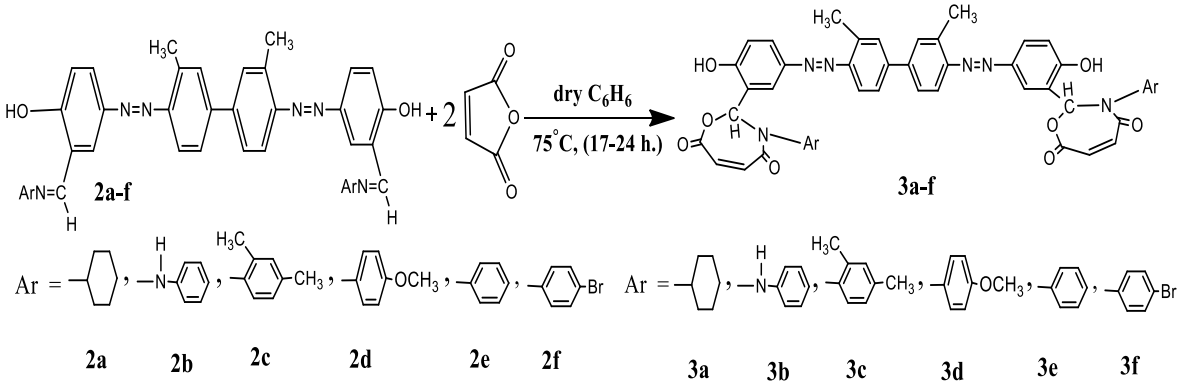
Com.no.	FT-IR bands
1	3416 and 3251 (υ_{O-H}), 3045 ($\upsilon_{C-H,benzene\ rings}$), 2922 ($\upsilon_{as.C-H,CH_3}$), 2835 ($\upsilon_{s.C-H,CH_3}$),2758 ($\upsilon_{C-H,aldehyde}$),1653($\upsilon_{C=O}$),1602, 1518 and1471 ($\upsilon_{C=C,benzene\ rings}$),1461($\delta_{as.C-H,\ CH_3}$),1375 ($\delta_{s.C-H,\ CH_3}$),1329 and 1278 (υ_{C-N}),1103 ($\upsilon_{C-O,phenol}$), 895,837,756 and 698($\delta_{o.o.p\ C-H,\ benzene\ rings}$).
2a	3444 (υ_{O-H}), 3036 ($\upsilon_{C-H,\ benzene\ rings}$), 2928 ($\upsilon_{as.C-H,CH_{2,cyclohexane}}$), 2854 ($\upsilon_{s.C-H,CH_{2,cyclohexane}}$),1629 ($\upsilon_{C=N}$), 1598 and1489($\upsilon_{C=C,benzene\ rings}$), 1448 ($\delta_{sciss.C-H,CH2,\ cyclohexane}$) ,1379 ($\delta_{s.\ C-H,CH_3}$),1346 and 1284 ($\upsilon_{C-N}$),1103 ($\upsilon_{C-O,phenol}$) ,889,833,749 and 692 ($\delta_{o.o.pC-H,\ benzene\ rings}$).
2b	3423 (υ_{O-H}),3307 (υ_{N-H}) ,3034 and 3001 ($\upsilon_{C-H,\ benzene\ rings}$),2943 ($\upsilon_{as.\ C-H,CH_3}$), 2899 ($\upsilon_{s.\ C-H,\ CH_3}$),1600 ($\upsilon_{C=N}$),1572 and 1489 ($\upsilon_{C=C,benzene\ rings}$),1442 ($\delta_{as.\ C-H,CH_3}$), 1398 ($\delta_{s.\ C-H,\ CH_3}$), 1348 and 1288 (υ_{C-N}),1105($\upsilon_{C-O,phenol}$),852,827, 786, 746 and 690 ($\delta_{o.o.pC-H,benzene\ rings}$).
2c	3435(υ_{O-H}),3037 and 3010 ($\upsilon_{C-H,benzene\ rings}$),2970 ($\upsilon_{as.\ C-H,\ CH_3}$), 2872($\upsilon_{s.\ C-H,\ CH_3}$),2812 ($\upsilon_{C-H,imine}$),1612 ($\upsilon_{C=N}$),1582 and 1487($\upsilon_{C=C,benzene\ rings}$),1442 ($\delta_{as.\ C-H,\ CH_3}$),1396 ($\delta_{s.\ C-H,\ CH_3}$),1350,1282 ($\upsilon_{C-N}$),1105 ($\upsilon_{C-O,phenol}$),896,835, 823,717 and 671($\delta_{o.o.p.\ C-H\ ,benzene\ rings}$).
2d	3433 (υ_{O-H}), 3041 and 3001($\upsilon_{C-H,benzene\ rings}$), 2943 ($\upsilon_{as.\ C-H,\ CH_3}$), 2899 ($\upsilon_{s.\ C-H,\ CH_3}$),2833 ($\upsilon_{C-H,imine}$), 1618 ($\upsilon_{C=N}$), 1599,1506 and 1485 ($\upsilon_{C=C,benzene\ rings}$),1442 ($\delta_{as.\ C-H,\ CH_3}$) ,1398 ($\delta_{s.\ C-H,\ CH_3}$),1348 and 1288 (υ_{C-N}),1105 ($\upsilon_{C-O,phenol}$),1031 ($\upsilon_{s.C-O-C,ether}$) 902,877, 835, 788, 756 and 717 ($\delta_{o.o.p\ C-H\ ,benzene\ rings}$).

2e	3431(υ_{O-H}),3034($\upsilon_{C-H,\ benzene\ rings}$), 2920 ($\upsilon_{as.\ C-H,\ CH_3}$),2848 ($\upsilon_{s.\ C-H,\ CH_3}$),1618 ($\upsilon_{C=N}$), 1593,1572 and 1485 ($\upsilon_{C=C,benzene\ rings}$),1456 ($\upsilon_{as.\ C-H,\ CH_3}$),1438 ($\upsilon_{N=N}$),1398 ($\upsilon_{s.\ C-H,\ CH_3}$) 1350 and 1282 ($\upsilon_{C-N}$), 1103 ($\upsilon_{C-O,phenol}$),895,871,821,783,758 and 690 ($\delta_{o.o.p.C-H\ ,benzene\ rings}$).
2f	3433 (υ_{O-H}), 3041 ($\upsilon_{C-H,benzene\ rings}$), 2953 ($\upsilon_{as.\ C-H,\ CH_3}$), 2922($\upsilon_{s.\ C-H,\ CH_3}$) ,1616 ($\upsilon_{C=N}$), 1587,1572 and 1483 ($\upsilon_{C=C,benzene\ rings}$),1458($\delta_{as.\ C-H,\ CH_3}$), 1435 ($\upsilon_{N=N}$), 1394 ($\delta_{s.\ C-H,\ CH_3}$), 1350 and 1282 ($\upsilon_{C-N}$), 1103 ($\upsilon_{C-O,phenol}$),1072 ($\upsilon_{C-Br}$),889 ,875, 825, 777, 740 and 694 ($\delta_{o.o.p.C-H\ ,benzene\ rings}$).

Tow series of bis-1,3-oxazepine derivatives **3a-f** and **4a-f** were obtained via a (2+5→7) cycloaddition reaction between equimolar amount of phathalic anhydride and maleic anhydride respectively as five-membered components and the synthesized bis-azoimine derivatives **2a-f** as two-membered components in dry benzene as indicated in schemes (3) and (4).

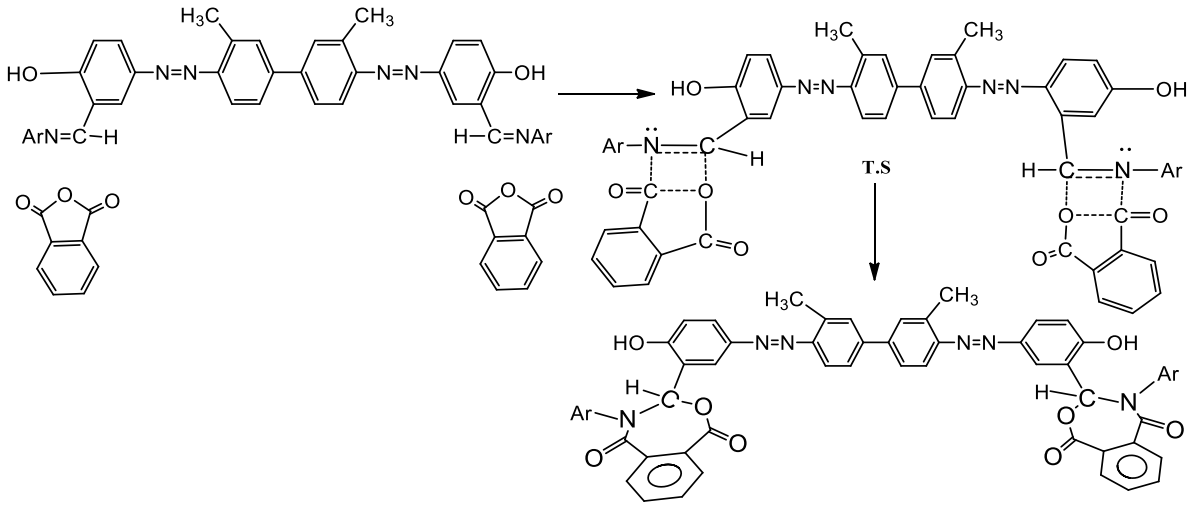


Scheme (3) : Synthesis of bisazo bis-1,3 oxazepine- 4,7-dione derivatives 3a-f



Scheme (4) : Synthesis of bisazo bis- 1,3 oxazepine- 4,7-dione derivatives 4a-f

The cycloaddition is believed to proceed via formation of four- membered cyclic transition state (i.e. concerted process) in which the participating orbitals should be in the same plane[23] as indicated in scheme (5).



Scheme (5) : Approximate transition state geometry for addition of phathalic anhydride to imine groups

(C.H.N.) elementery micro analysis, table (4) of bisazo bis -1,3 oxazepine derivatives **3a-f** and **4a-f** showed good agreement between the calculated and found values.

FT-IR spectra, figs.(9) - (14) of compounds **3a-f** illustrate good evidence that the cycloaddition reactions happened successfully through disappearing the strong band at the general range (1629-1600) cm^{-1} which attributed to υ (C=N) and appearing of one or two bands at frequency relatively higher than that of (C=N) group at (1714 and 1656) cm^{-1}, 1693 cm^{-1}, 1689 cm^{-1}, 1691 cm^{-1}, (1707 and 1680) cm^{-1} , (1716 and 1649) cm^{-1} and (1716 and 1656) cm^{-1} respectively attributed to the stretching vibrations of carbonyl groups (O=C-O) and (O=C-N) inside oxazepine ring respectively.It is important to refer that appearance only one band for stretching of (C=O) groups inside oxazepine ring due to the vibration coupling interactions. Other caracteristic bands with their interpretation were summarized in table (6).

Table (6) : FT-IR data of the synthesized bisazo bis -1,3-oxazepine-4,7-dione derivatives (3a-f)

Com. no.	FT-IR bands
3a	3363 (υ_{O-H}), 3051 ($\upsilon_{C-H,benzene\ rings}$),2928 ($\upsilon$as.C-H,$CH_{2,cyclohexane}$),2854 ($\upsilon_{s.}$ C-H,$CH_{2,\ cyclohexane}$), 1714 ($\upsilon_{C=O,O=C-O,oxazepine}$), 1656 ($\upsilon_{C=O,\ O=C-N,oxazepine}$),1597 and 1481($\upsilon_{C=C,benzene\ rings}$), 1452 ($\delta_{sciss.}$ C-H,$CH_{2,\ cyclohexane}$), 1371($\delta_{s.}$ C-H, CH_3), 1278 (υ_{C-N}), 1103 ($\upsilon_{C-O,phenol}$),891, 831,759 and 702 ($\delta_{o.o.p.C-H,benzene\ rings}$).
3b	3497 (υ_{O-H}), 3288 (υ_{N-H}), 3034 ($\upsilon_{C-H,benzene\ rings}$), 2953 ($\upsilon_{as.}$ C-H, CH_3),2874 ($\upsilon_{s.}$ C-H, CH_3), 1693 ($\upsilon_{C=O,O=C-O\ and\ O=C-N,oxazepine,\ vib.coupling}$), 1597,1572 and 1487 ($\upsilon_{C=C,benzene\ rings}$), 1396 ($\delta_{s.}$ C-H, CH_3), 1274(υ_{C-N}), 1115 ($\upsilon_{C-O,phenol}$), 806,748,694 ($\delta_{o.o.p.C-H,\ benzene\ rings}$).
3c	3406(υ_{O-H}), 3080and 3012($\upsilon_{C-H,benzene\ rings}$),2974($\upsilon_{as.}$ C-H, CH_3),2897 ($\upsilon_{s.}$ C-H, CH_3), 2816($\upsilon_{C-H,oxazepine}$), 1691 ($\upsilon_{C=O,O=C-O\ and\ O=C-N,oxazepine,vib.coupling}$), 1587and 1404 ($\upsilon_{C=C,benzenerings}$),1494($\upsilon$as.$NO_2$), 1280 ($\upsilon_{C-N}$),1070 ($\upsilon_{C-O,phenol}$),908,829,800,740 and 673($\delta_{o.o.p.C-H,\ benzene\ rings}$).
3d	3427(υ_{O-H}), 3101and 3014($\upsilon_{C-H,benzene\ rings}$),2923 ($\upsilon$as. C-H, CH_3),2870(υs. C-H, CH_3), 1707 ($\upsilon_{C=O,O=C-O,oxazepine}$), 1680($\upsilon_{C=O,O=C-N,oxazepine}$),1514($\upsilon_{C=C,benzene\ rings}$),1394($\delta$s. C-H, CH_3), 1284and1255(υ_{C-N}),1072($\upsilon_{C-O,phenol}$),1030(υs.$_{C-O-C,ether}$) 902, 827,787,759 and 702 ($\delta_{o.o.p.C-H,benzene\ rings}$).

3e	3319 (υ_{O-H}),3130 and 3055 ($\upsilon_{C-H,benzene\ rings}$),2985 and 2923($\upsilon_{as}$.C-H, CH_3),2875(υ_s. C-H, CH_3),1716 ($\upsilon_{C=O,O=C-O,oxazepine}$),1649 ($\upsilon_{C=O,\ O=C-N,oxazepine}$), 1602,1543,1506,1491 and 1454($\upsilon_{C=C,benzenerings}$), 1440 ($\delta_{as}$. C-H, CH_3), 1394(δ_s. C-H, CH_3), 1330 and 1242 (υ_{C-N}), 1087 ($\upsilon_{C-O,phenol}$),891,827,750 and 690 ($\delta_{o.o.p.C-H,benzenerings}$).
3f	3315(υ_{O-H}), 3055 ($\upsilon_{C-H,benzene\ rings}$), 2924 ($\upsilon_{as}$. C-H, CH_3),2860 (υ_s C-H, CH_3), 1716($\upsilon_{C=O,\ O=C-O,oxazepine}$),1656($\upsilon_{C=O,\ O=C-N,oxazepine}$), 1610,1548 and 1485 ($\upsilon_{C=C}$),1386 ($\delta_s$. C-H, CH_3) 1282 and 1247 (υ_{C-N}),1111($\upsilon_{C-O,phenol}$), 1074 (υ_{C-Br}),885, 819, 796, 763, 732 and 698 ($\delta_{o.o.p.C-H,benzene\ rings}$).

FT-IR spectra, figs.(15) - (20) of compounds **4a-f** provide good evidence that the cycloaddition reactions took place successfully through disappearing the strong band at the general range (1629-1600) cm^{-1} which assigned to υ (C=N) and appearing one or two bands at frequency relatively higher than that of (C=N) group at (1703 and 1656) cm^{-1},1691 cm^{-1},(1716 and 1641) cm^{-1},1701 cm^{-1}, 1699 cm^{-1} and 1705 cm^{-1} respectively attributed to the stretching vibrations of carbonyl groups (O=C-O) and (O=C-N) inside oxazepine ring respectively. It is important to refer that appearance only one band for stretching of (C=O) groups inside oxazepine ring due to the vibration coupling interactions. Other characteristic bands with their interpretation were lisited in table (7).

Table (7) : FT-IR data of the synthesized bisazo bis -1,3-oxazepine- 4,7-dione derivatives 4a-f

Com. no.	FT-IR bands
4a	3236 (υ_{O-H}), 3055 ($\upsilon_{C-H,\ benzene\ rings}$), 2935 (υas.C-H,$CH_{2,cyclohexane}$), 2858 (υs.C-H,$CH_{2,cyclohexane}$) , 1703 ($\upsilon_{C=O,O=C-O,oxazepine}$), 1656 ($\upsilon_{C=O,\ O=C-N,oxazepine}$),1591, 1523 and 1481 ($\upsilon_{C=C,benzene\ rings}$),1375 (δs. C-H, CH_3), 1313 and 1280 (υ_{C-N}),1097 ($\upsilon_{C-O,phenol}$), 846 ,742 and 704 ($\delta_{o.o.p.C-H,benzene\ rings}$).
4b	3498 (υ_{O-H}), 3360 (υ_{N-H}), 3095 ($\upsilon_{C-H,\ benzene\ rings}$),2939 (υas. C-H, CH_3), 2838 (υs. C-H, CH_3), 1691 ($\upsilon_{C=O,O=C-O}$and O=C-N,oxazepine,vib.coupling), 1572 and 1516 ($\upsilon_{C=C,benzene\ rings}$), 1392 (δs. C-H, CH_3) 1365 and 1267 (υ_{C-N}),1118($\upsilon_{C-O,phenol}$), 869, 749 and 716 ($\delta_{o.o.p.C-H,benzene\ rings}$).
4c	3429 (υ_{O-H}), 3087and3019($\upsilon_{C-H,benzene\ rings}$),2976 and 2920 (υas.C-H, CH_3), 2860 (υs. C-H, CH_3), 1716 ($\upsilon_{C=O,O=C-O,oxazepine}$), 1641 ($\upsilon_{C=O,\ O=C-N,oxazepine}$),1604,1547 and1489 ($\upsilon_{C=C,benzene\ rings}$),1458 (δas. C-H, CH_3),1379 (δs.C-H, CH_3),1344 and 1287 (υ_{C-N}) ,1105 ($\upsilon_{C-O,phenol}$),893,854,825,810,767 and 712 ($\delta_{o.o.p.C-H,benzene\ rings}$).
4d	3265and 3203 (υ_{O-H}),3063 and3018($\upsilon_{C-H,benzene\ rings}$)2952 and2922 (υas. C-H, CH_3),2843 (υs. C-H, CH_3), 1701 ($\upsilon_{C=O,O=C-O}$and O=C-N,oxazepine,vib.coupling), 1622($\upsilon_{C=C,oxazepine}$), 1550,1523,1506 and1404 ($\upsilon_{C=C,benzene\ rings}$), 1325 ($\delta_s$. C-H, CH_3) , 1305 and 1278 (υ_{C-N}),1176 (υ.C-O,phenol) 1033($\upsilon_{s.C-O-C,ether}$),887,833,817,803, and 756 ($\delta_{o.o.p.C-H,benzene\ rings}$).
4e	3275and 3207 (υ_{O-H}),3101 and 3009($\upsilon_{C-H,\ benzene\ rings}$), 2879 (υs. C-H, CH_3), 2854($\upsilon_{C-H,oxazepine}$),1699 ($\upsilon_{C=O,O=C-O}$and O=C-N,oxazepine,vib.coupling),1626 ($\upsilon_{C=C,oxazepine}$), 1545 and 1494 ($\upsilon_{C=C,benzenerings}$), 1448 (δas. C-H, CH_3), 1325 and 1269 (υ_{C-N}),1153 ($\upsilon_{C-O,phenol}$) ,900,850,832,759 and 715 ($\delta_{o.o.p.C-H,benzene\ rings}$).
4f	3510, 3425, 3357,3279 and 3200 (υ_{O-H}),3080 and 3014 ($\upsilon_{C-H,benzenerings}$), 2942 (υas C-H, CH_3), 2870 (υs. C-H, CH_3),1705 ($\upsilon_{C=O,O=C-O}$and O=C-N,oxazepine,vib.coupling),1624 ($\upsilon_{C=C,oxazepine}$), 1576,1543,1516 and 1491 ($\upsilon_{C=C,benzene\ rings}$), 1392 (δs. C-H, CH_3), 1315 and 1257 (υ_{C-N}),1107 ($\upsilon_{C-O,phenol}$), 1074 (υ_{C-Br}),900,858,767,736 and 682 ($\delta_{o.o.p.C-H,benzenerings}$)

^{1}H NMR spectra of bis-1,3-oxazepine derivatives

^{1}H NMR spectrum fig. (21) , (300 MHz, DMSO) of compound **3a** showed the following signals at δ (ppm) : The signal at (1.061-1.344) ppm attributed to protons (a) in cyclohexane rings,(quintet, 4H, 4×Ha). The signal at (1.401-1.591) ppm belong to protons (b) in cyclohexane rings,(quintet, 8H, 8×Hb). The signal at 1.70 ppm due to protons (c) in cyclohexane rings,(quartet, 8H, 8×Hc). The signal at 1.811 ppm assigned to protons (d) in cyclohexane rings,(quintet, 2H, 2×Hd). The signal at (2.442-2.569) ppm attributed to DMSO solvent. The singlet signal at 2.889 ppm assigned to methyl groups protons,(6H, 2×CH_3). The signal at (3.675-3.690) ppm due to H_2O in DMSO. The signals of aromatic protons and protons of (C-H) groups inside oxazepine rings appeared at the range (6.850-9.140) ppm. The signals of phenolic hydroxy groups protons appeared at 10.447 ppm as sharp,(11.382-11.993),14.114 and 14.665 ppm as broad, (2H, 2×H-O).

The interpretation of ^{1}H NMR spectra for other bis- 1,3- oxazepine derivatives (**3b-e)** was carried out following the interpretation described for bis- 1,3- oxazepine derivative **3a** and listed in table (8).

^{1}H NMR spectrum, fig. (26), (300 MHz, DMSO) of compound **4a** showed the following signals at δ (ppm): The signal at (1.021-1.352) ppm attributed to protons (a) in cyclohexane rings,(quintet, 4H, 4×Ha). The signal at (1.395-1.582) ppm belong to protons (b) in cyclohexane rings,(quartet, 8H, 8×Hb). The signal at (1.684-1.800) ppm attributed to protons (c) in cyclohexane rings,(quartet, 8H, 8×Hc). The signal at 1.885 ppm due to protons (d) in cyclohexane rings,(quintet, 2H, 2×Hd). The signal of DMSO solvent appeared at (2.439-2.570) ppm. The two signals at (2.713 -2.736) ppm and 2.878 ppm assigned to methyl groups protons,(6H, 2×CH_3). The broad signal at (3.338 - 3.613) ppm belong to H_2O in DMSO solvent. The spectrum illustrates good evidence that the cycloaddition reaction happened successfully and formed the desired product, oxazepine derivative **4a**, by appearing two doublet signals at (6.220 - 6.261) ppm and (6.446 - 6.488) ppm assigned to olefinic (C-H) protons (e and f) respectively inside oxazepine rings. The signal at 6.088 ppm may be due to olefinc (C-H) proton (e) in *cis* position to (C=O) group, so its signal is shifted towards high field region.The signals of aromatic protons and protons of (C-H) inside oxazepine rings appeared at the range (6.848 - 9.202) ppm. The two signals at 10.374 ppm and 11.625 ppm belong to protons of phenolic hydroxy groups, (2H, 2×H-O).

The interpretation of ^{1}H NMR spectra for other bis- 1,3- oxazepine derivatives (**4b-e)** was carried out following the interpretation described for bis- 1,3- oxazepine derivative **4a** and listed in table (8).

^{13}C NMR spectra of bis-1,3-oxazepine derivatives (3a, 4a and 4e)

^{13}C NMR spectrum, fig. (31), (75 MHz, DMSO) of compound **3a** showed the following signals at δ (ppm): 17.79 (C1, 2×C1), 25.18 (C2, 2×C2), 25.75 (C3, 4×C3), 32.52 (C4, 4×C4), 48.41 (C5, 2×C5). The spectrum appeared twelve signals at the range (118.98 - 145.76) attributed to aromatic carbons and carbons (C-N) of oxazepine rings. The signal at 168.09 ppm attributed to carbons of (O=C=O) groups for oxazepine ring. The signal at (168.33 -168.64) ppm assigned to carbons of (O=C-N) groups for oxazepine rings.

Appearance of signals of carbonyl groups carbon atoms in the down field region illustrates good evidence for formation of oxazepine rings.

^{13}C NMR spectrum, fig. (32), (75 MHz, DMSO) of compound **4a** showed the following signals at δ (ppm) : The signal at 17.79 ppm attributed to methyl groups carbons (2C, 2× CH_3). The signals at (24.77, 32.16 and 45.45) ppm attributed to carbons of cyclohexane rings. The signal of aromatic carbons, olefinic carbons and carbons (C-N) of oxazepine rings appeared at the rings (116.21-149.75) ppm. The signals at (163.83-167.57) ppm assigned to carbons of (O=C=O) groups of oxazepine rings. The signals at 190.97 belong to carbons of (O=C=N) groups of oxazepine rings.

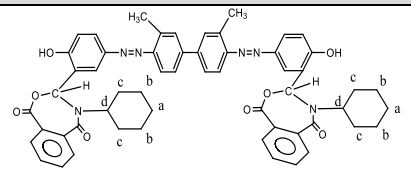
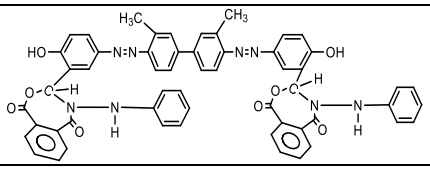
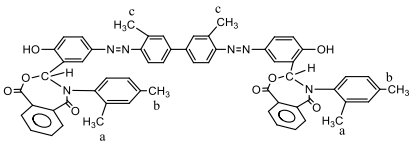
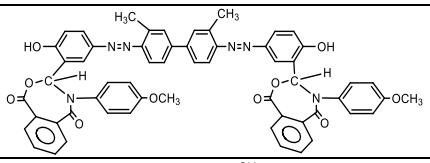
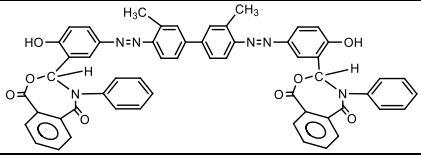
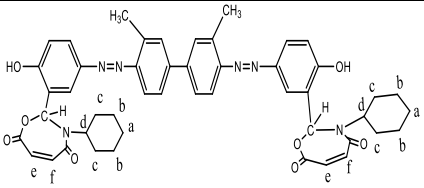
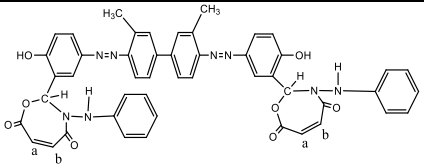
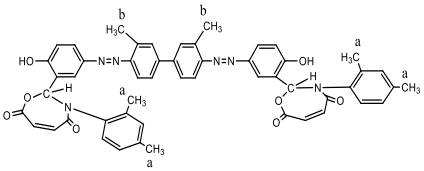
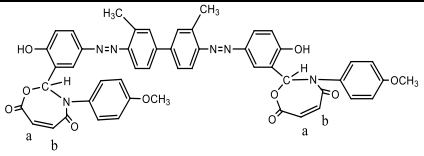
Appearance of signals of carbonyl groups carbon atoms in the down field region illustrates good evidence for formation of oxazepine rings.

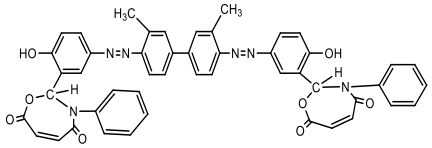
^{13}C NMR spectrum, fig. (33), (75 MHz, DMSO) of compound **4e** showed the following signals at δ (ppm): The signal at 17.80 ppm assigned to methyl groups carbons (2C, 2× CH_3). The signal of

aromatic carbons, olefinic carbons and carbons (C-N) of oxazepine rings appeared at the range (119.97-145.88) ppm. The signals at 163.68 ppm and 167.33 ppm attributed to carbons of (O=C=O) groups inside oxazepine rings. The signal at 191.06 ppm assigned to carbons of (O=C-N) groups inside oxazepine rings.

Appearance of signals of carbonyl groups carbon atoms in the down field region illustrates good evidence for formation of oxazepine rings.

Table (8): ^{1}H NMR data of the synthesized bis- 1,3- oxazepine derivatives (3a-e) and (4a-e)

Com. no.	Structure	δ (ppm)
3a		1.061-1.344 (quintet, 4H, 4×Ha), 1.401-1.591 (quintet, 8H, 8×Hb), 1.70 (quartet, 8H, 8×Hc), 1.811 (quintet, 2H, 2×Hd), 2.442-2.569 (DMSO solvent), 2.889 (s, 6H, 2×CH_3), 3.675-3.690 (H_2O in DMSO), 6.850-9.140 (Ar-H and C-H protons of oxazepine rings),10.447, 11.382-11.993, 14.114 and 14.665 (2H, 2×H-O phenolic).
3b		2.403-2.569 (DMSO solvent), 2.735 (s, 6H, 2×CH_3), 3.228-3.496 (H_2O in DMSO), 4.221-4.293 and 4.526 (2H, 2×N-H), 6.769-8.257 (Ar-H and C-H protons of oxazepine rings), 10.627 and 11.143 (2H, 2×H-O phenolic).
3c		2.437-2.570 (DMSO solvent), 2.636 (s, 3H , 3×Ha), 2.705- 2.728 (s, 3H , 3×Hb), 2.771-2.796 (s, 6H , 6×Hc), 3.145-3.625 (H_2O in DMSO solvent), 7.157-7.880 (Ar-H and C-H protons of oxazepine rings), 12.894-13.482$_{br}$ (2H, 2×O-H O phenolic).
3d		2.437 - 2.570(DMSO solvent), 2.722- 2.728 and 2.771- 2.795 (6H, 2×CH_3), 3.091- 3.547 (H_2O in DMSO solvent 3.733 and 3.819 (6H, 2×CH_3O), 6.918 - 9.179 (Ar-H and C-H protons of oxazepine rings), 12.939 - 13.334$_{br}$ (2H, 2×O-H phenolic).
3e		2.436-2.569 (DMSO solvent), 2.787 (s, 6H, 2×CH_3), 3.274- 3.404 (H_2O in DMSO solvent), 7.044 - 9.189 (Ar-H and C-H protons of oxazepine rings),10.329 and 10.386 (2H, 2×O-H phenolic).
4a		1.021-1.352 (quintet, 4H, 4×Ha), 1.395-1.582 (quartet, 8H, 8×Hb), 1.684-1.800 (quartet, 8H, 8×Hc), 1.885 (quintet, 2H, 2×Hd), 2.439-2.570 (DMSO solvent), 2.713 -2.736 and 2.878 (6H, 2×CH_3), 3.338 - 3.613(H_2O in DMSO solvent), 6.220-6.261(d, 2H, 2×He), 6.446-6.488 (d, 2H, 2×Hf), 6.848-9.202 (Ar-H and C-H protons of oxazepine rings), 10.374 and 11.625 (2H, 2×H-O phenolic).
4b		2.404 -2.575 (DMSO solvent), 2.729-2.774 (6H, 2×CH_3), 3.120 - 3.501(H_2O in DMSO), The signal of (N-H) protons may be interacted with the broad signal of H_2O in DMSO. 5.973 (2H, 2×Ha), 6.106 (2H, 2×Hb), 6.773 -8.617 (Ar-H and C-H protons of oxazepine rings), 10.594 and 11.123 (2H, 2×H-O phenolic).
4c		2.430-2.575 (DMSO solvent), 2.723-2.735 (6H, 6×Ha), 2.770 - 2.793 (6H, 6×Hb), 3.136-3.921(H_2O in DMSO solvent) 6.178 and 6.311 (4H, 4× C-H olefinic C-H protons in structure of oxazepine rings), 7.155-9.148 (Ar-H and C-H protons of oxazepine rings), 10.391 (s, 2H, 2×H-O phenolic) .
4d		2.437-2.570 (DMSO solvent), 2.765-2.785 (s, 6H, 2×CH_3), 3.308-3.665 (H_2O in DMSO solvent), 3.798-3.813 and 3.880-3.969 (6H, 6×H_3C-O), 6.211- 6.282 (t, 2H, 2×Ha), 6.382-6.515 (2H, 2×Hb), 6.833- 9.165 (Ar-H and C-H protons of oxazepine rings), 10.388 - 10.479 and 13.356-13.555 (2H, 2×O-H phenolic).

4e		2.436-2.570 (DMSO solvent), 2.739-2.780 (6H, 2×CH_3), 3.307-3.496 (H_2O in DMSO solvent), 6.196 -6.498) (4H, 4×C-H, olefinic protonsinside oxazepine rings) 7.065 -9.180 (Ar-H and C-H protons of oxazepine rings), 10.395 and 11.524 (2H, 2×H-O phenolic) .

Antibacterial activity

Pharmacological or biological activity is an expression describing the beneficial or adverse effects of a drug on living matter. The synthesized compounds were screened for their antibacterial activity using Staphylococcus aureous and Escherichia coli .

1. Staphylococcus aureous

Staphylococcus aureous is also known as golden cluster seed. It is a Gram positive bacteria and it is found in water, dust and air[24]. S. aureous may cause skin infections that look like pimples or boils, swollen and painful[25].

2.Escherichia coli

often abbreviated as E. coli, is a type of bacteria commonly found in the digestive systems of animals. One specific strain can cause serious digestive system upset, however, leading to diarrhea and nausea, which can leave an infected person weak and dehydrated. It may also produce a toxin that damages the kidneys and weakens the small intestine walls in children. Part of the reason that this bacteria is so dangerous is because there is no effective cure for an infection[26]

Antibacterial tests

In this work, the antibacterial test was carried out according to the disc diffusion method. All synthesized bis-1,3-oxazepine compounds **3a-f** and **4a-f** were assayed for their antibacterial activity in **vitro** against one strain of Gram-positive bacteria (Staphylococcus aureous) and one strain of Gram-negative bacteria (Escherichia coli). Prepared agar and petridishes were sterilized by autoclaving for 15 min. at 121^{o}C. The agar plates were surface inoculated uniformly from the both culture of the tested microorganism. In the solidified medium suitably spaced apart holes were made all 6 mm in diameter. These holes were filled with 40 µL of the prepared compounds (5 mg of the compound dissolved in 1mL of DMSO solvent). These plates were incubated at 37 ^{o}C for 24h. for both bacteria. The zones of microbial growth inhibition around the discs were measuredin (mm). The results of preliminary screening tests are presented in table (9).

Table (9):The antibacterial activities of the synthesized bis-1,3- oxazepine compounds 3a-f and 4a-f

Bacteria	Staphylococcus aureous (Gram-positive)	Escherichia coli (Gram-negative)
Com. no.	Diameter of inhibition zone in (mm)	
3a	14	-
3b	-	-
3c	-	-
3d	22	-
3e	13	16
3f	16	20
4a	11	14
4b	-	-
4c	-	13
4d	15	-
4e	20	-
4f	-	11

Key of symbols :

Highly active = +++ (inhibition zone > 19 mm)
Moderately active = ++ (inhibition zone 18-15 mm)
Slightly active = + (inhibition zone 14-11 mm)
Inactive = - (inhibition zone <5 mm)

Gentamycin as control drug	Staphylococcus aureous (Gram-positive)	Escherichia coli (Gram-negative)
	Diameter of inhibition zone in (mm)	
10 Mg/mL	18	15
100 Mg/mL	23	19

From the data obtained , it is found clearly that compounds **3d** and **4e** show higher activity against Gram-positive bacteria (*Staphylococcus aureous*). Compounds **3f** and **4e** appeared medium activity. Compound **3a**, **3e** and **4a** showed weak activity, while the other compounds **3b**, **3c**, **4b**, **4c** and **4f** show no activity against this type of bacteria.

In case of Gram-negative (*Escherichia coli*), it is found that only compound **3f**, which containing azo group, shows higher activity. Compound **3e** showed medium activity. Compounds **4a**, **4c** and **4f** appeared weak activity, while the other compounds **3a**, **3b**, **3c**, **3d**, **4b**, **4d** and **4e** show no activity against this type of bacteria.

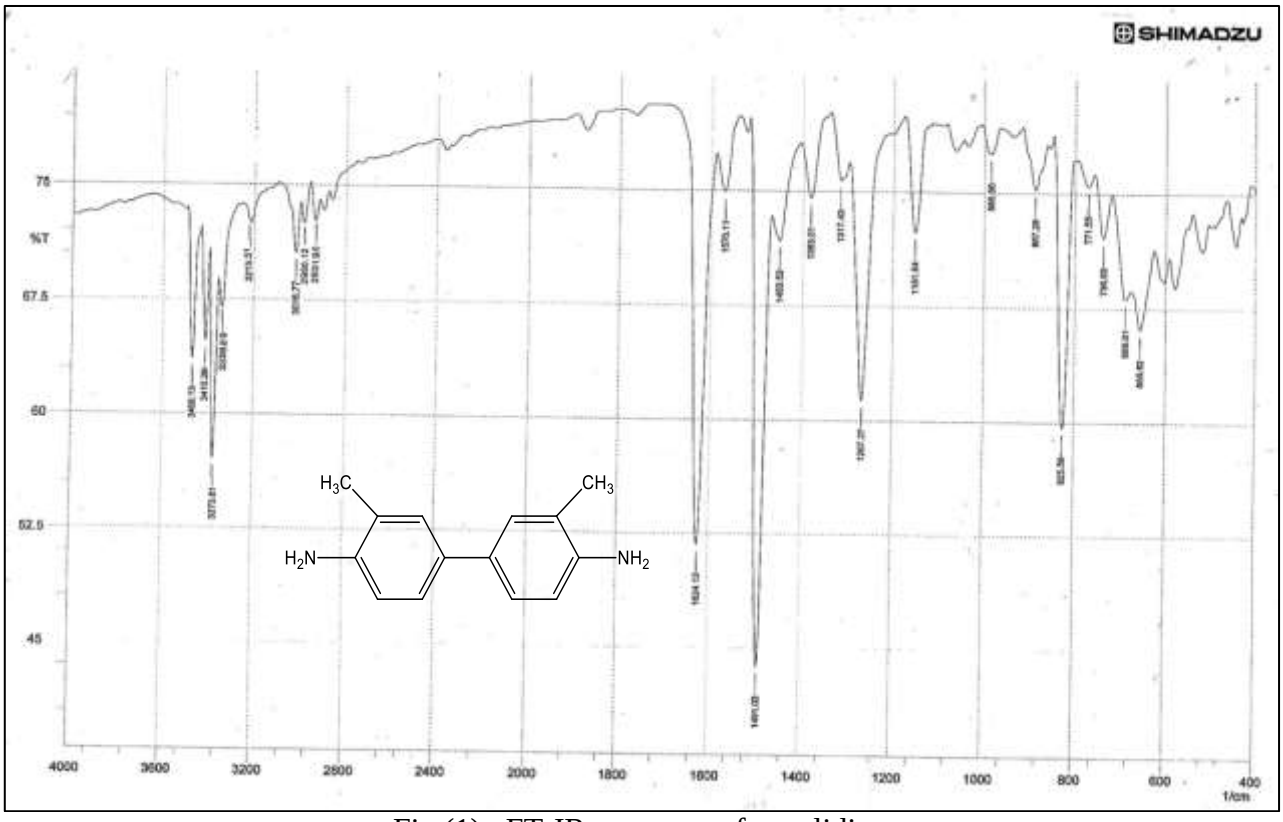


Fig.(1) : FT-IR spectrum of *o*- tolidine

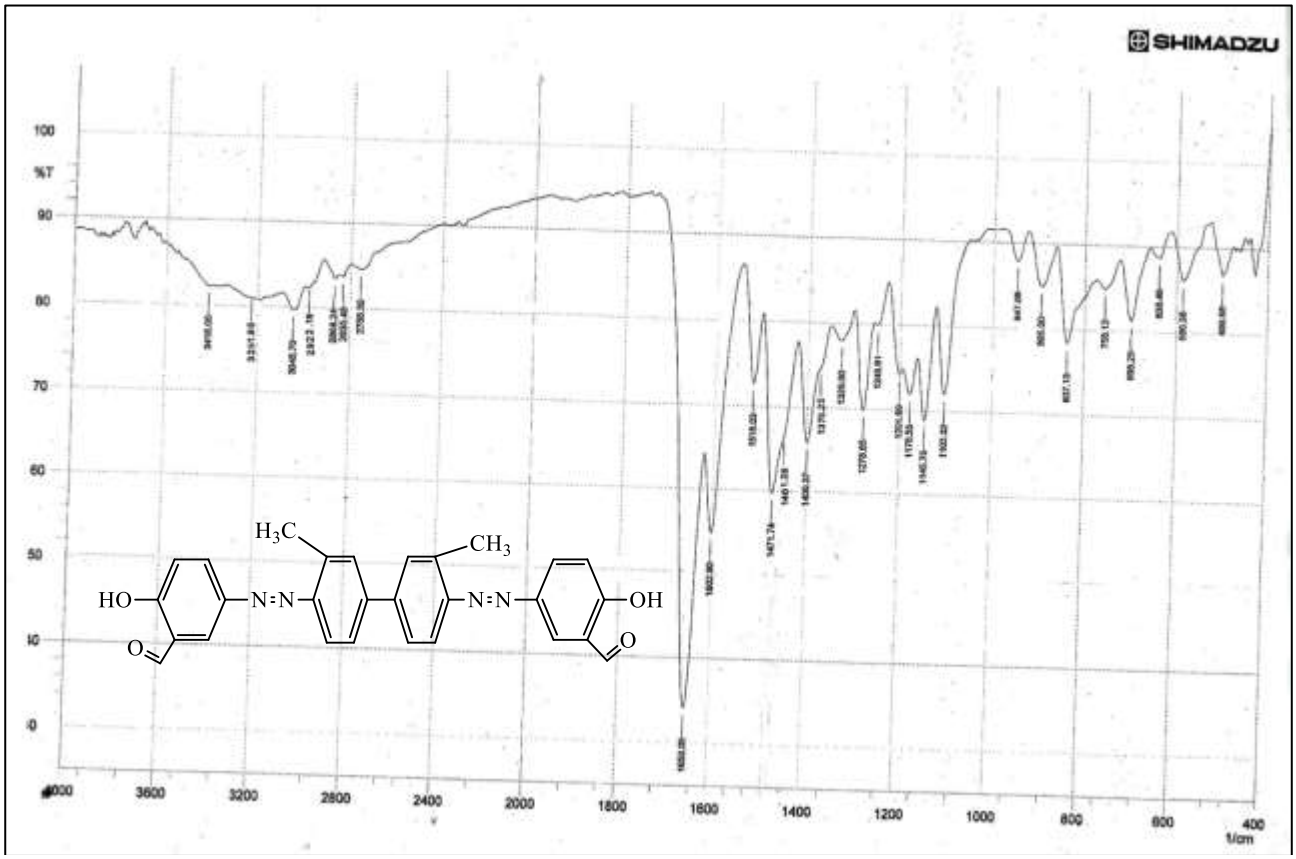


Fig.(2) : FT-IR spectrum of compound 1

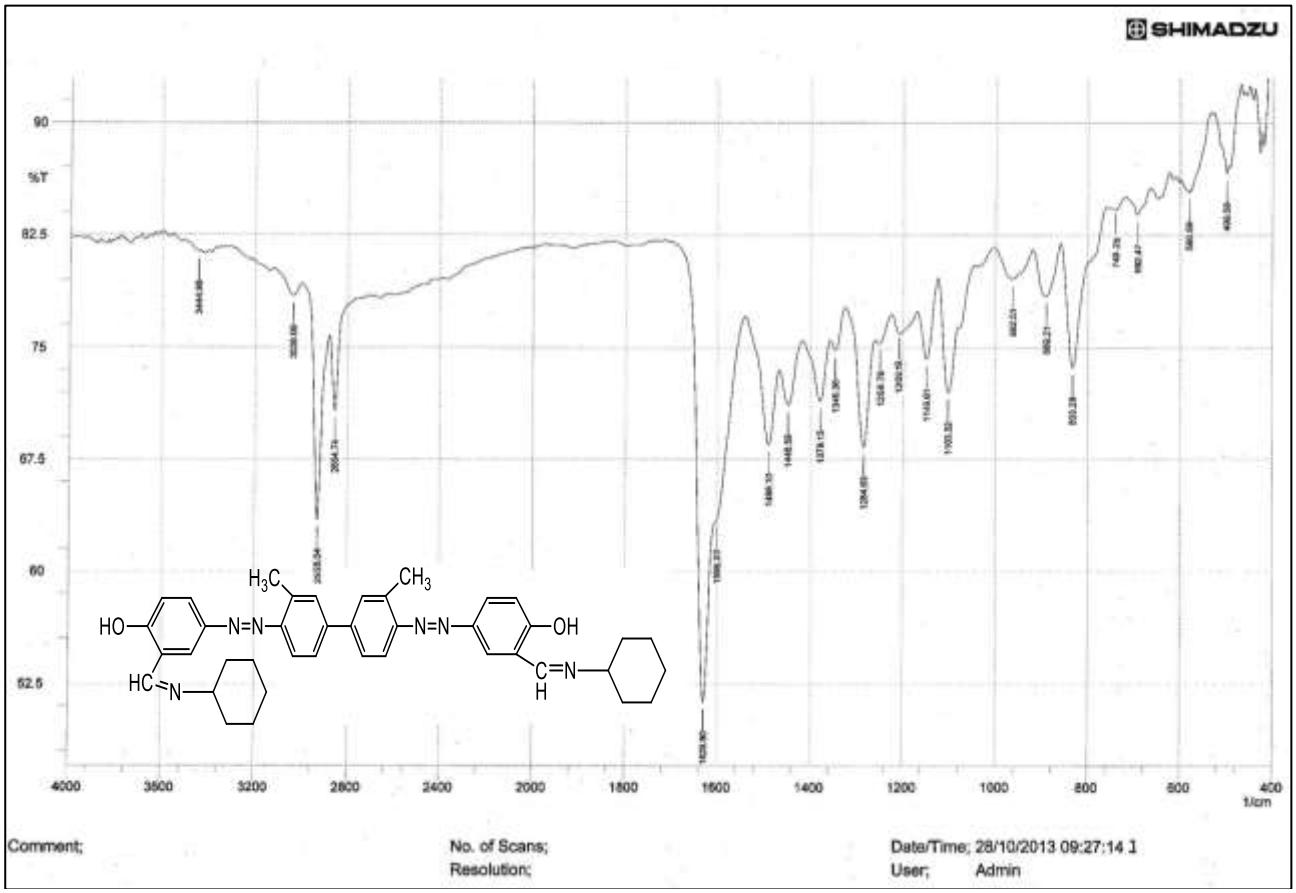


Fig.(3) : FT-IR spectrum of compound 2a

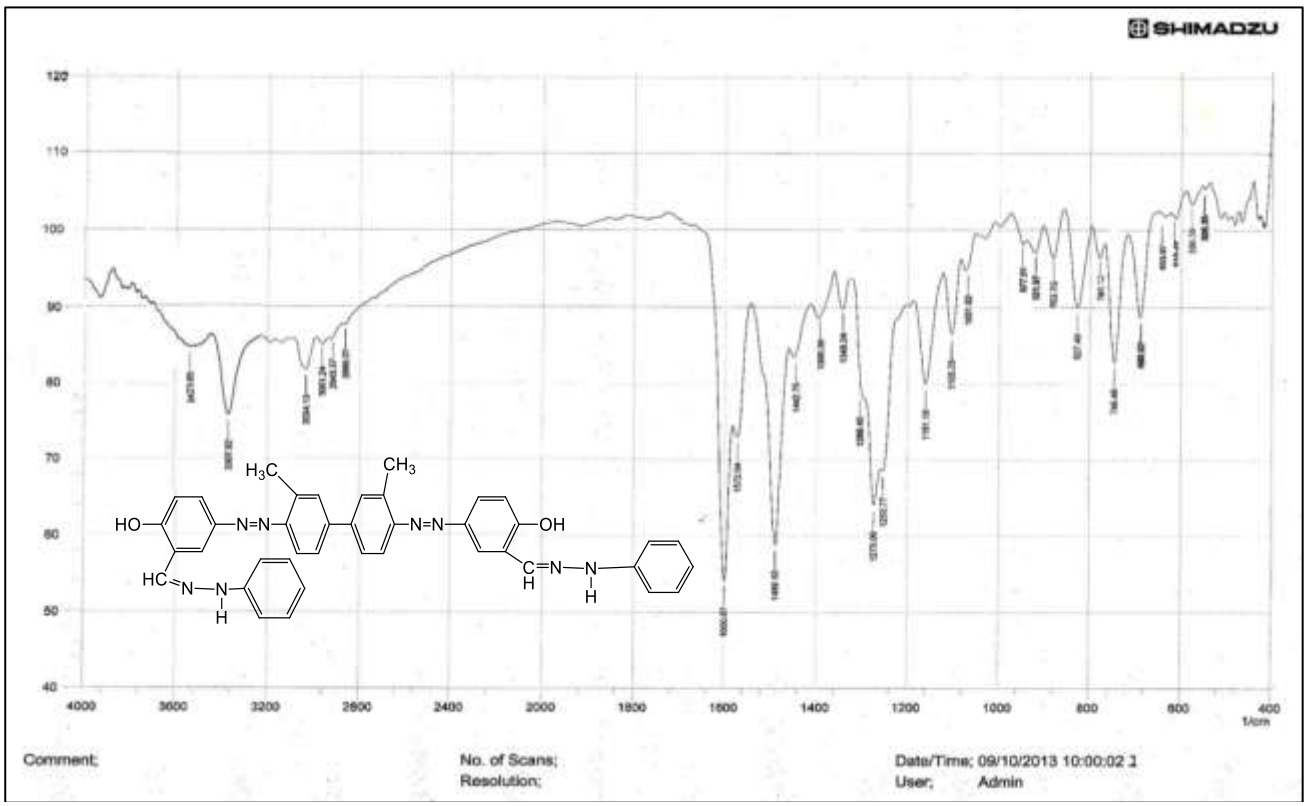


Fig.(4) : FT-IR spectrum of compound 2b

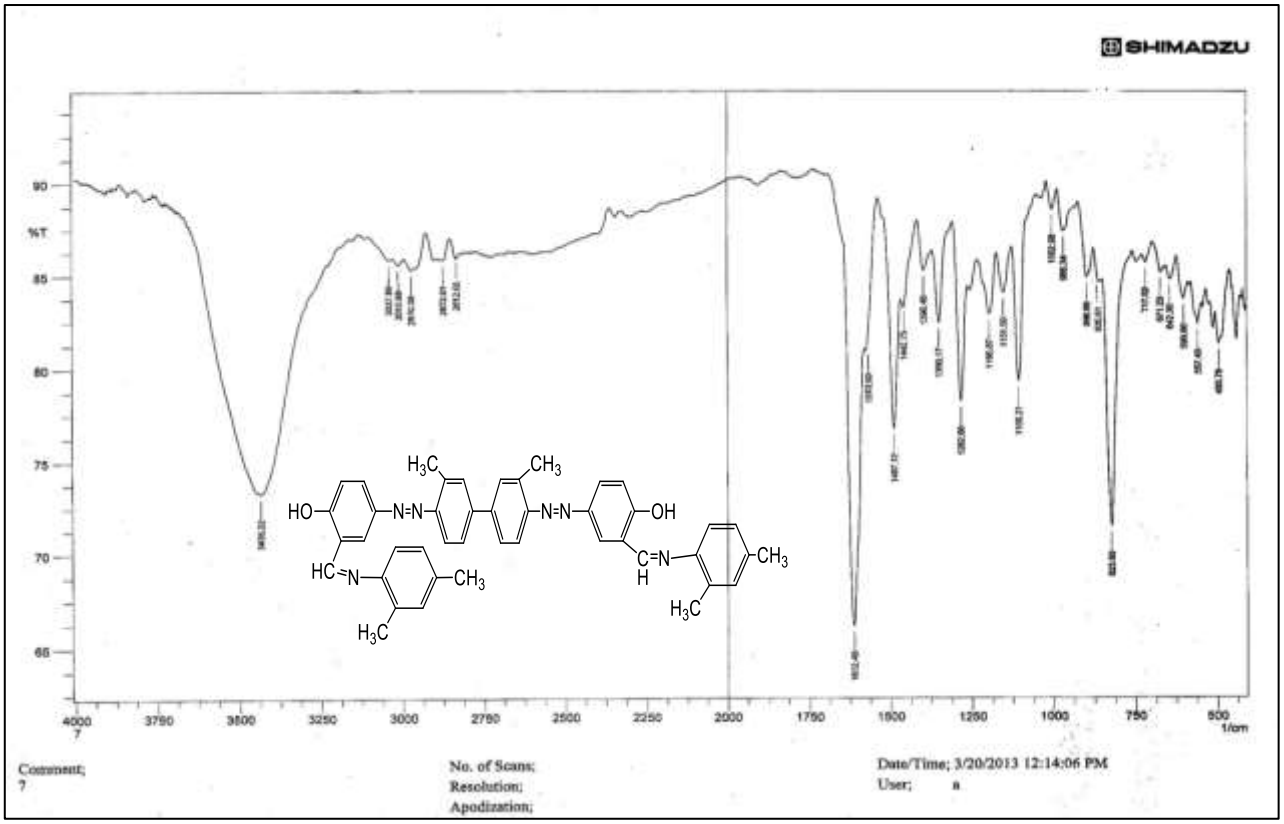


Fig.(5) : FT-IR spectrum of compound 2c

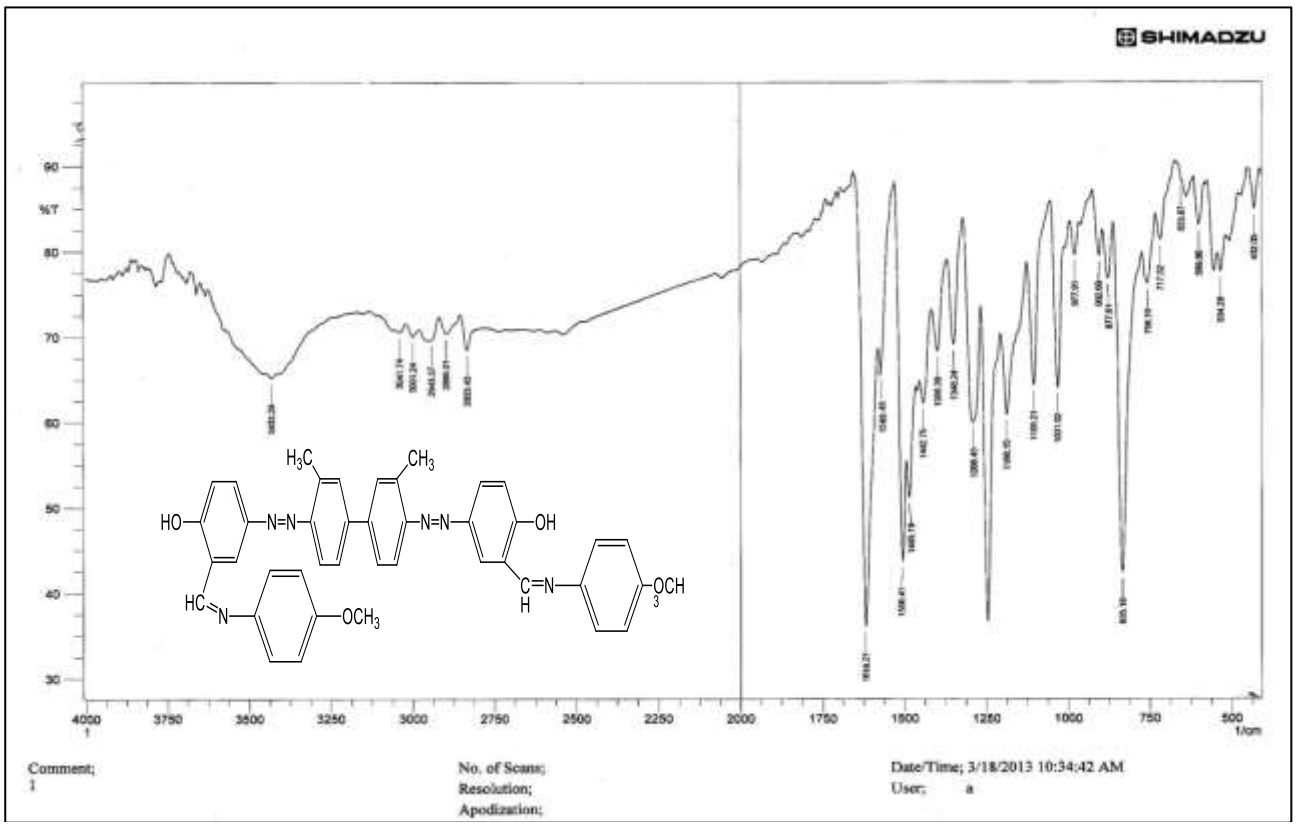


Fig.(6) : FT-IR spectrum of compound 2d

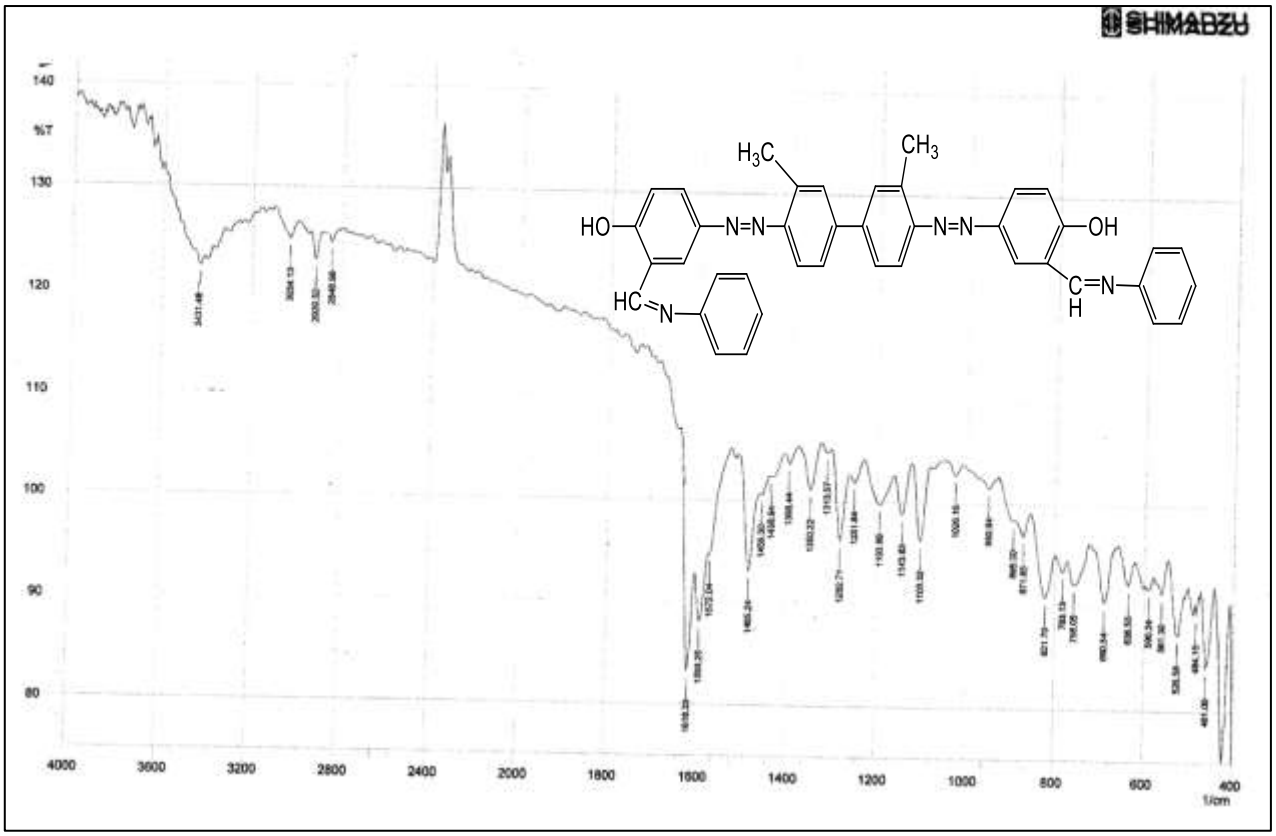


Fig.(7) : FT-IR spectrum of compound 2e

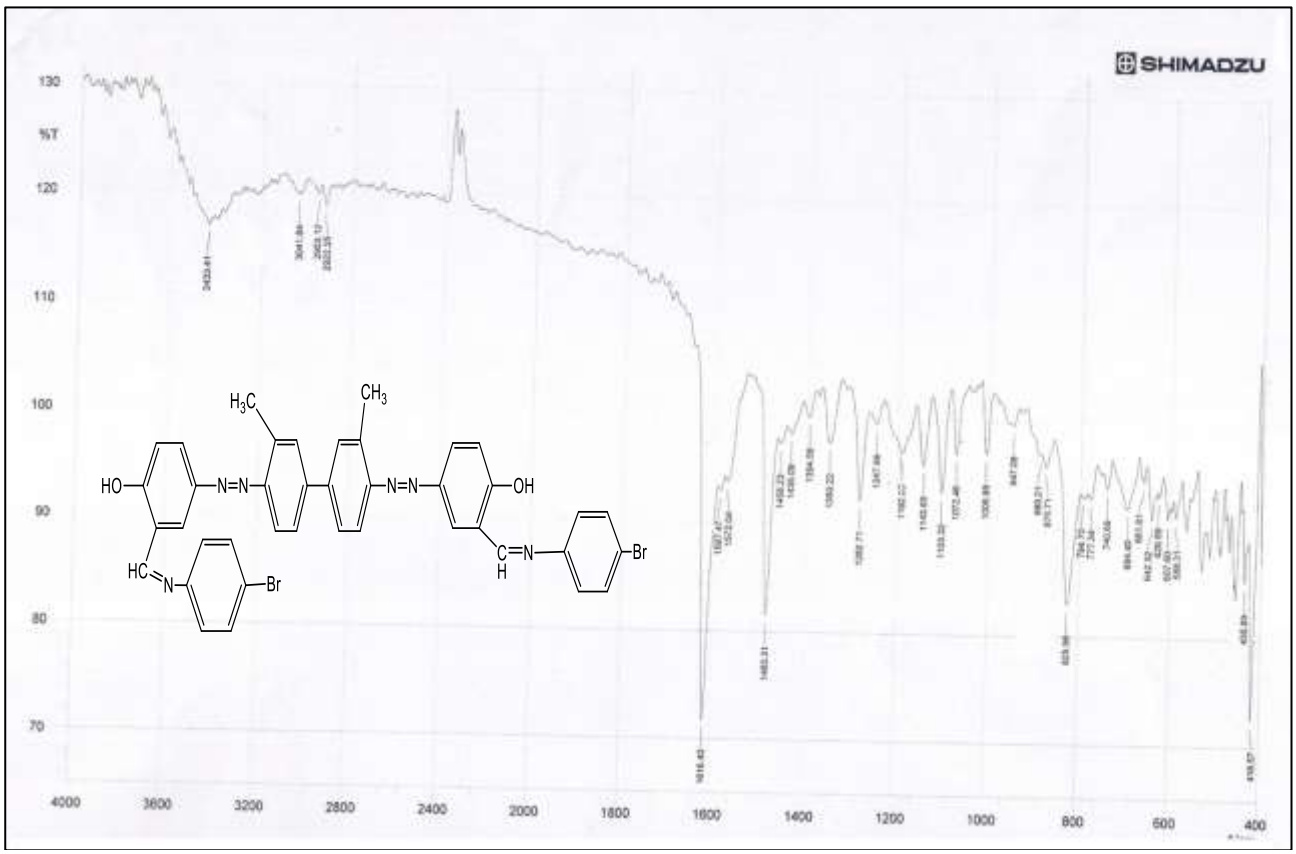


Fig.(8) : FT-IR spectrum of compound 2f

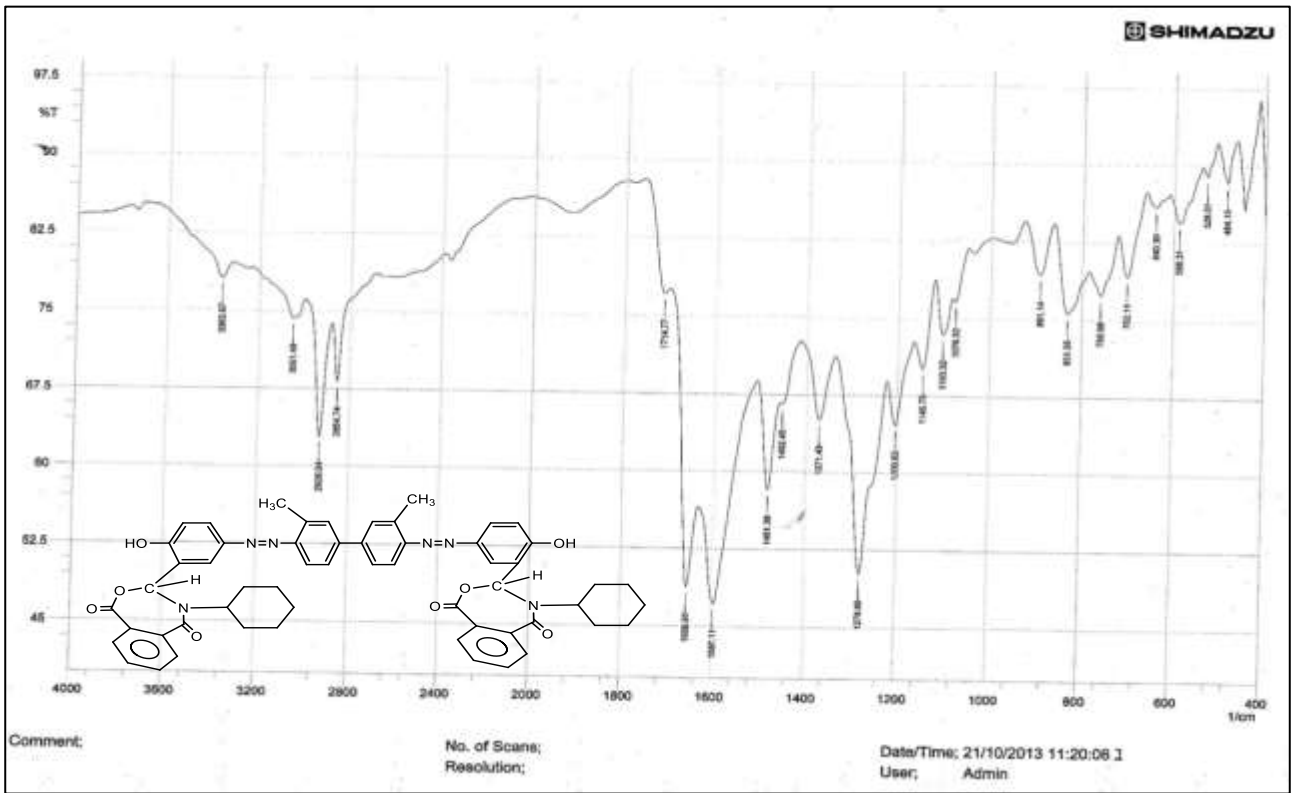


Fig.(9) : FT-IR spectrum of compound 3a

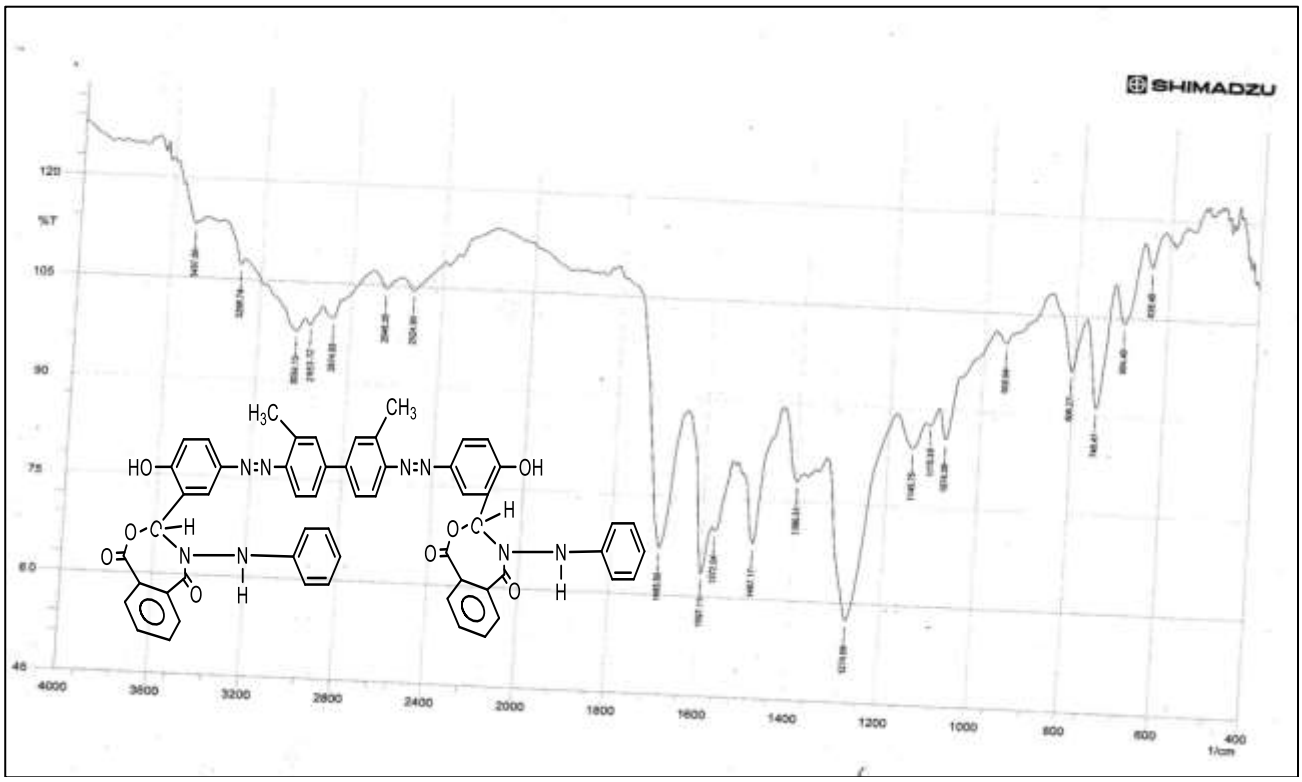


Fig.(10) : FT-IR spectrum of compound 3b

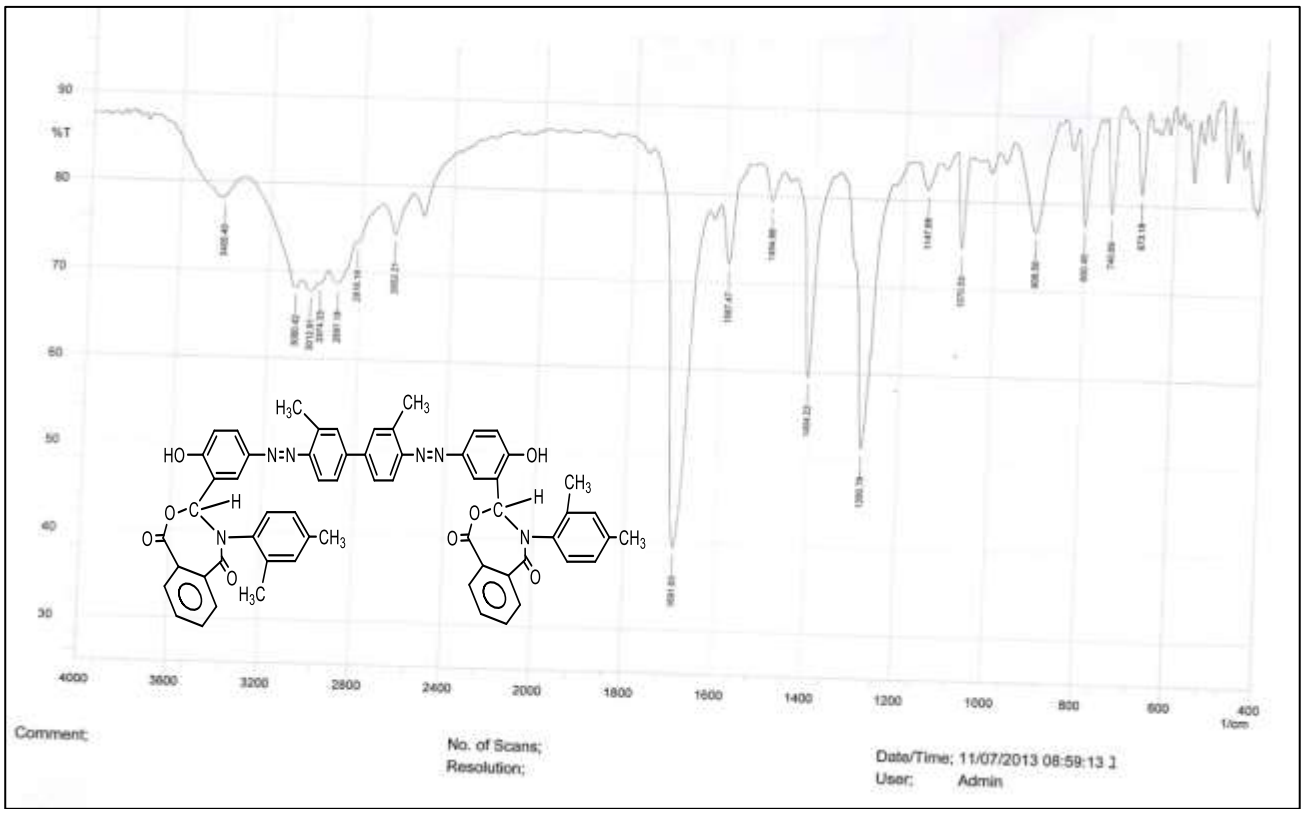


Fig.(11) : FT-IR spectrum of compound 3c

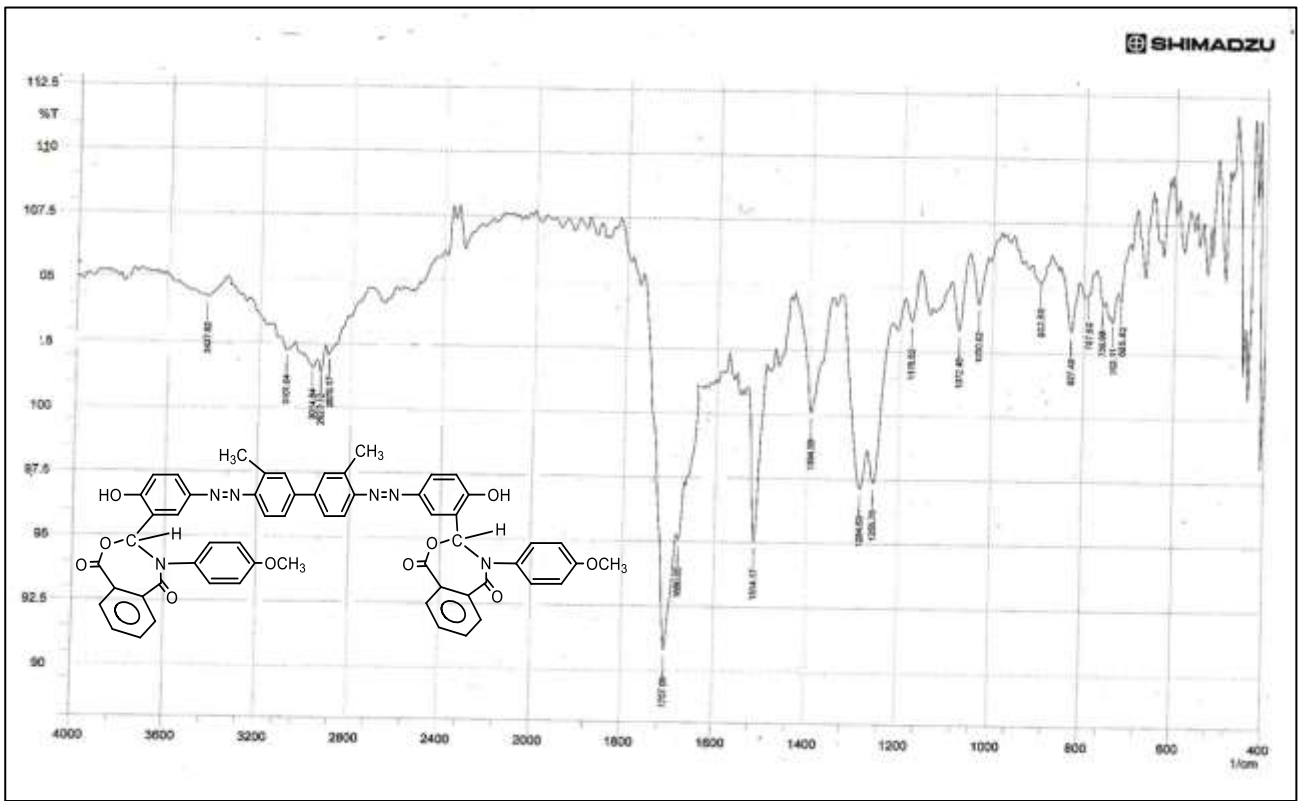


Fig.(12) : FT-IR spectrum of compound 3d

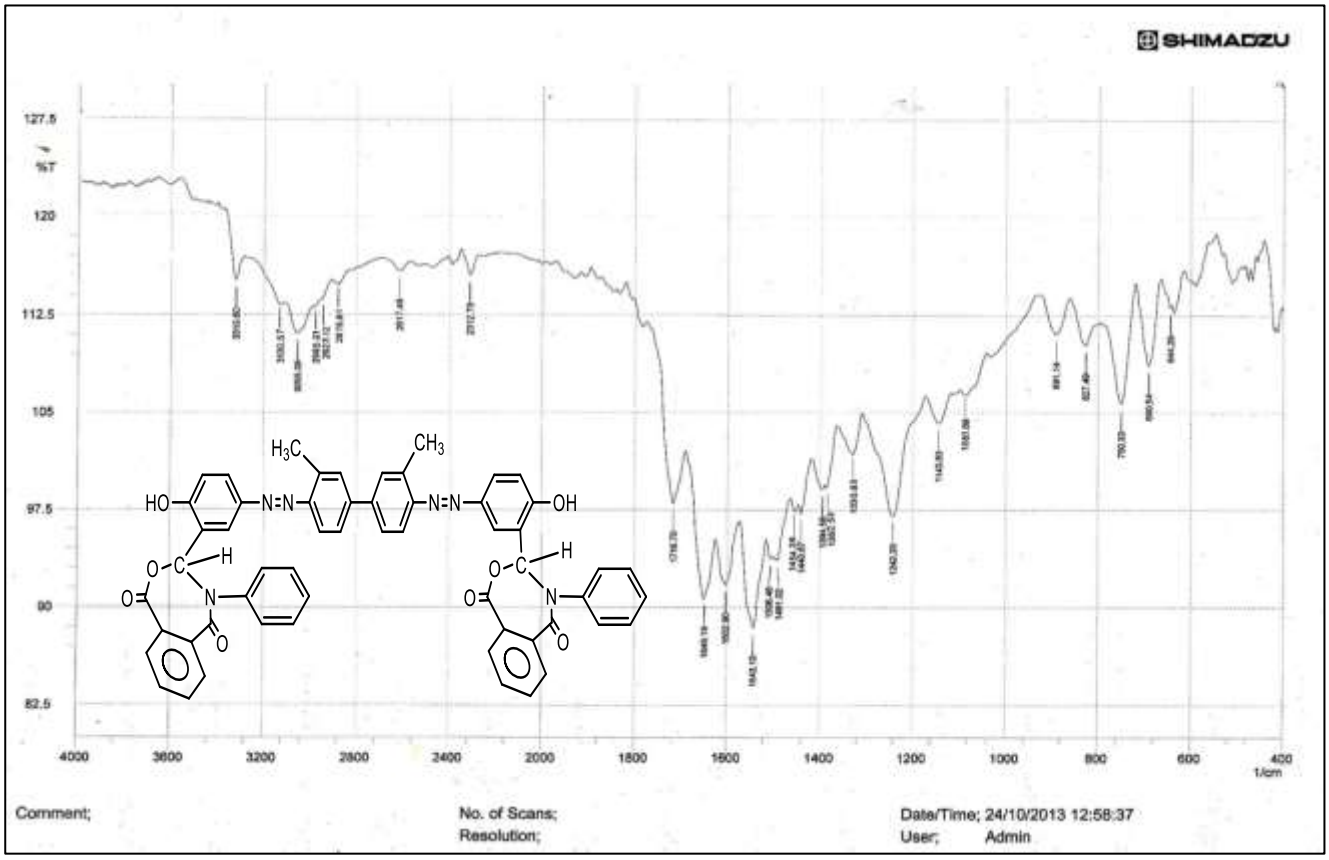


Fig.(13) : FT-IR spectrum of compound 3e

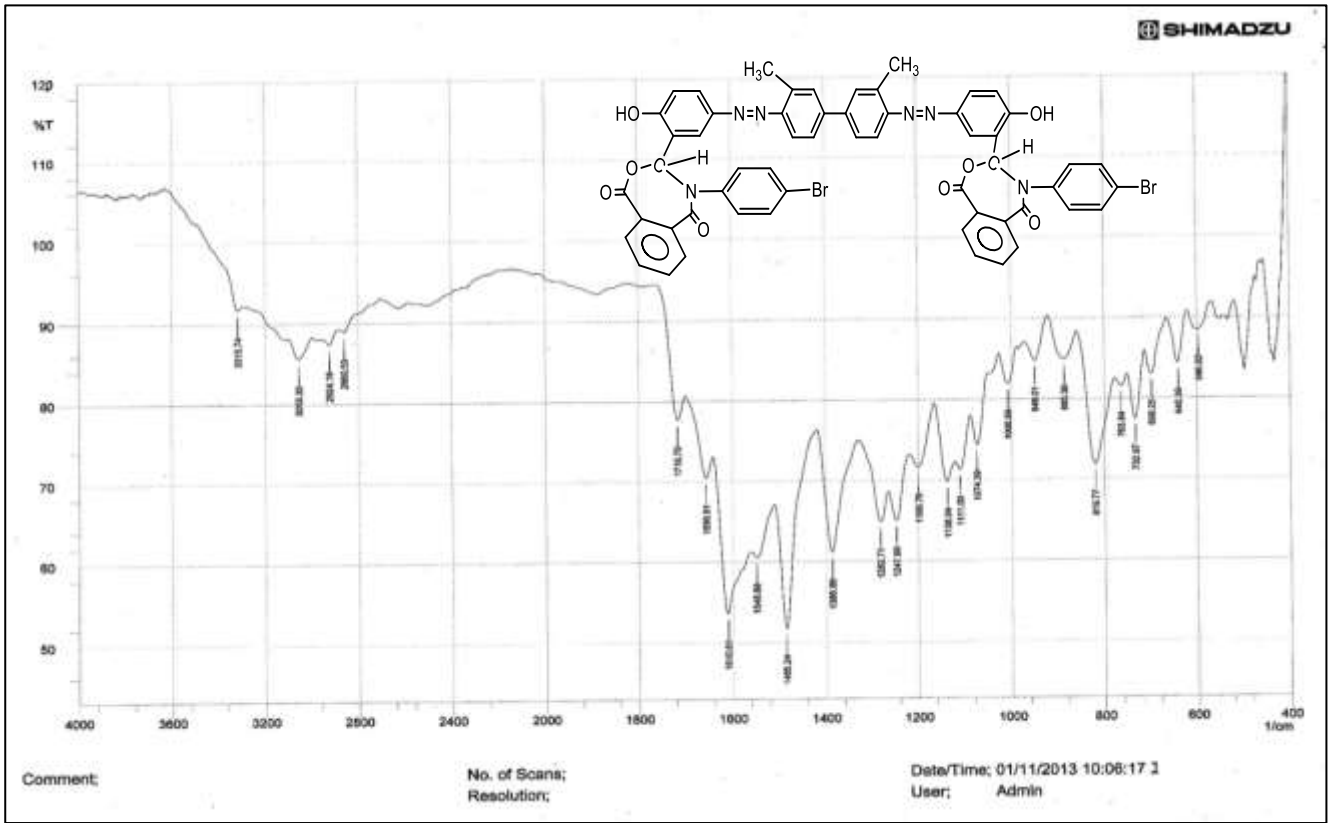


Fig.(14) : FT-IR spectrum of compound 3f

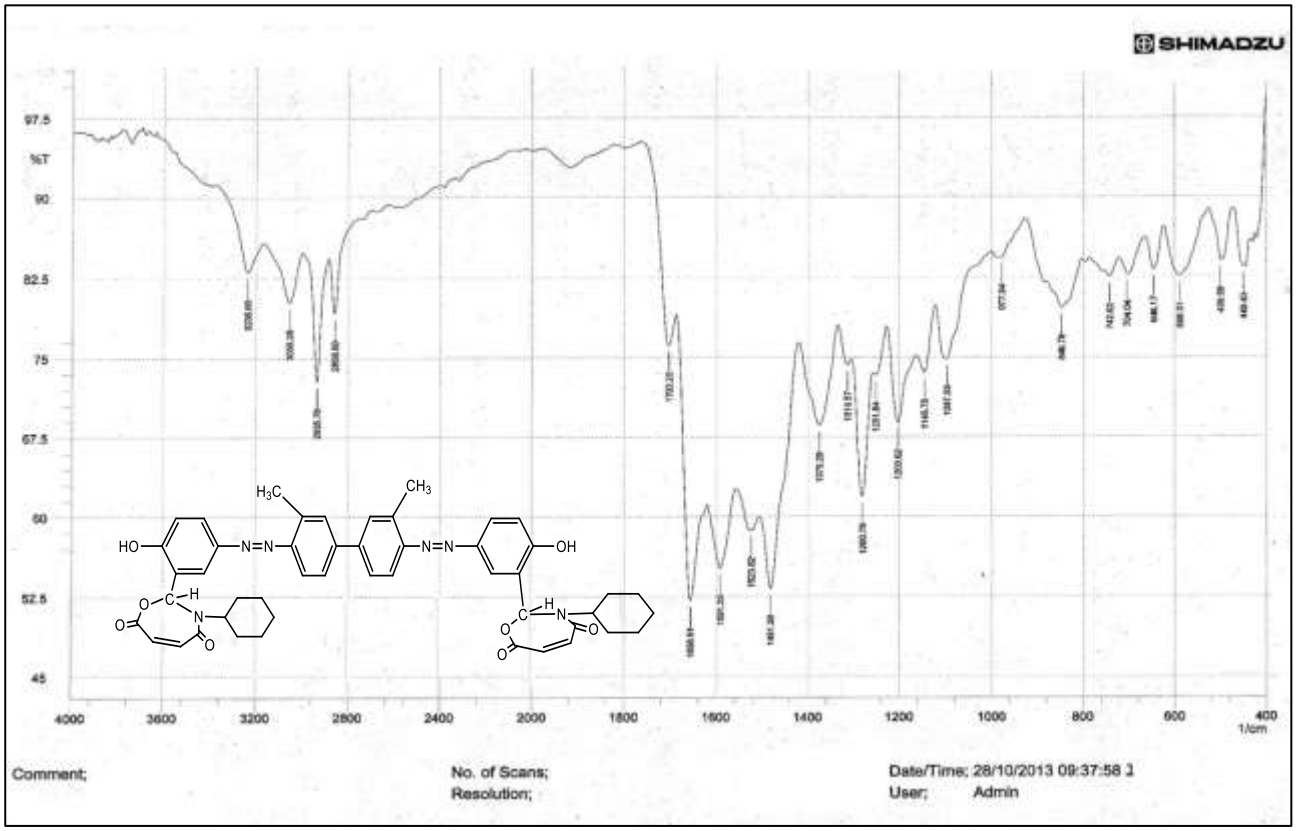


Fig.(15) : FT-IR spectrum of compound 4a

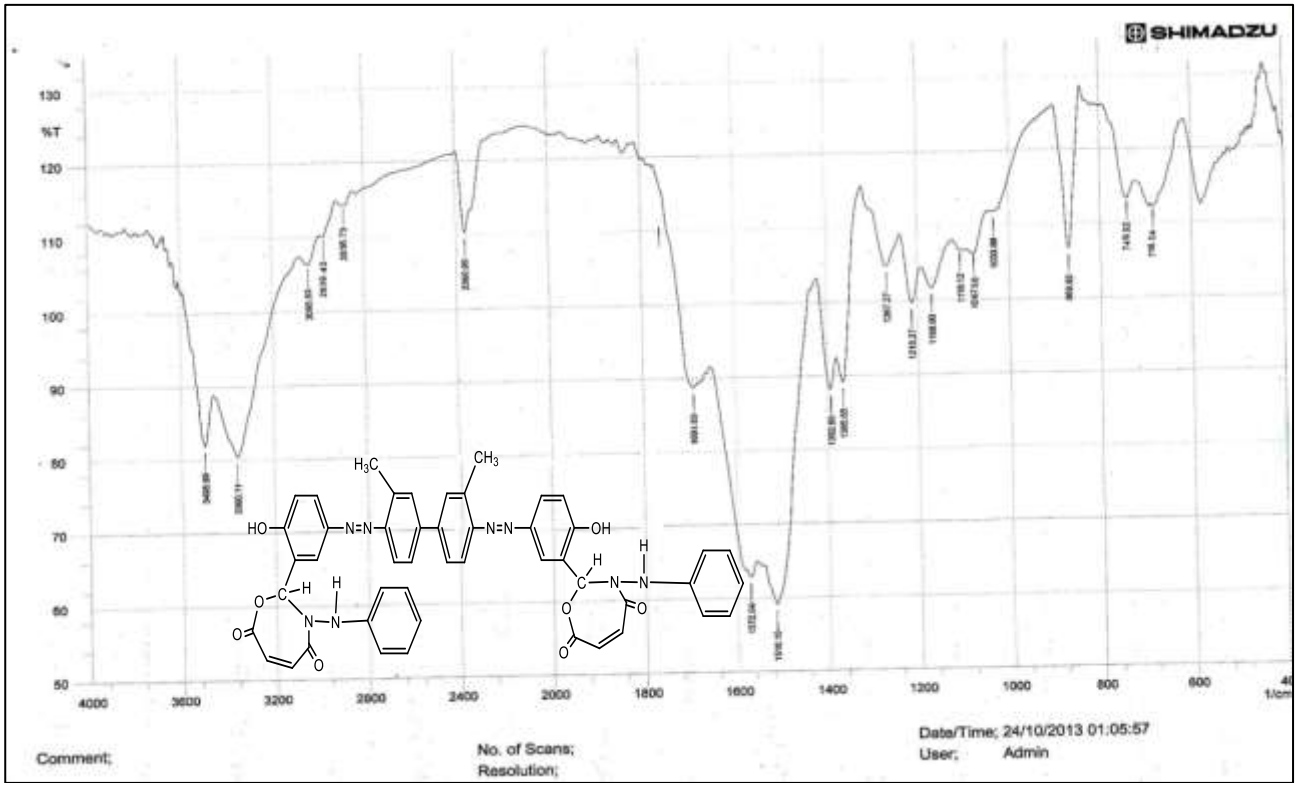


Fig.(16) : FT-IR spectrum of compound 4b

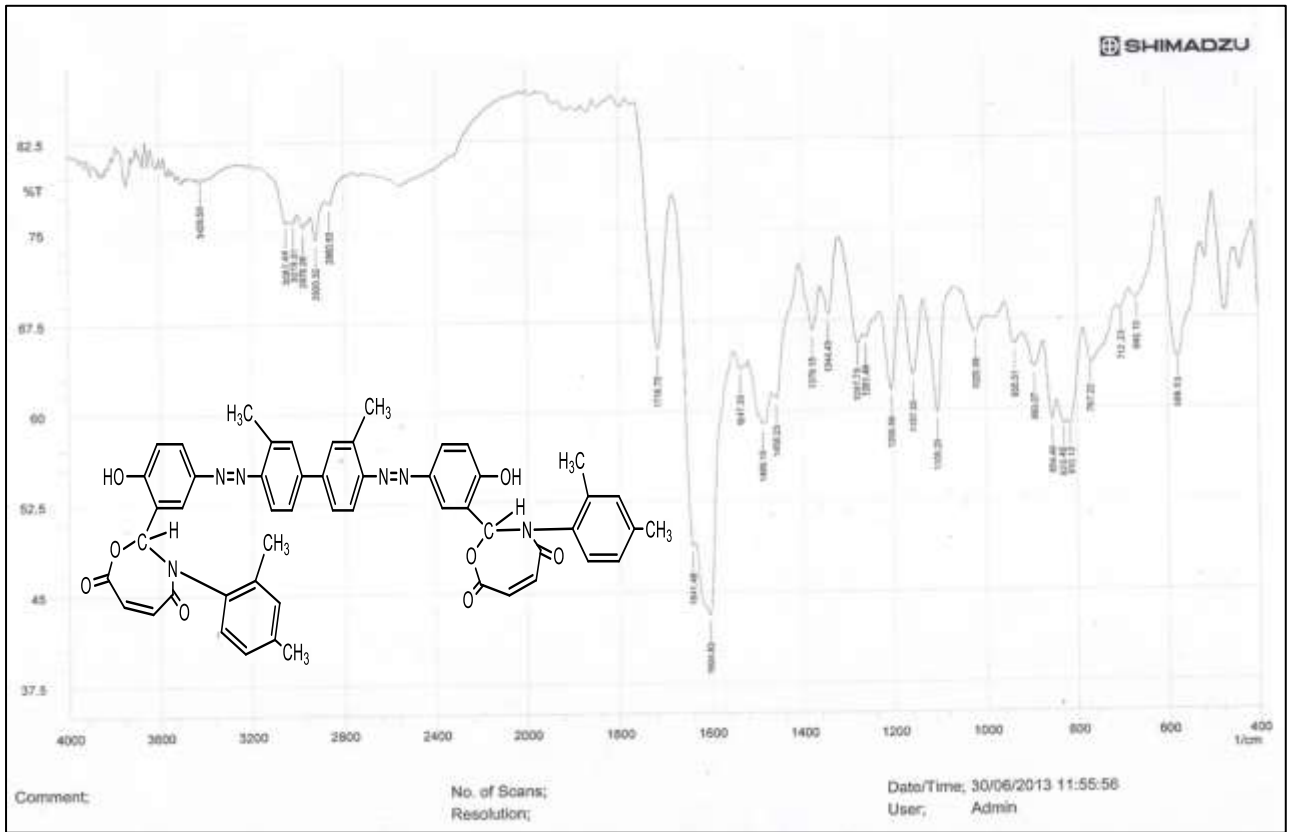


Fig.(17) : FT-IR spectrum of compound 4c

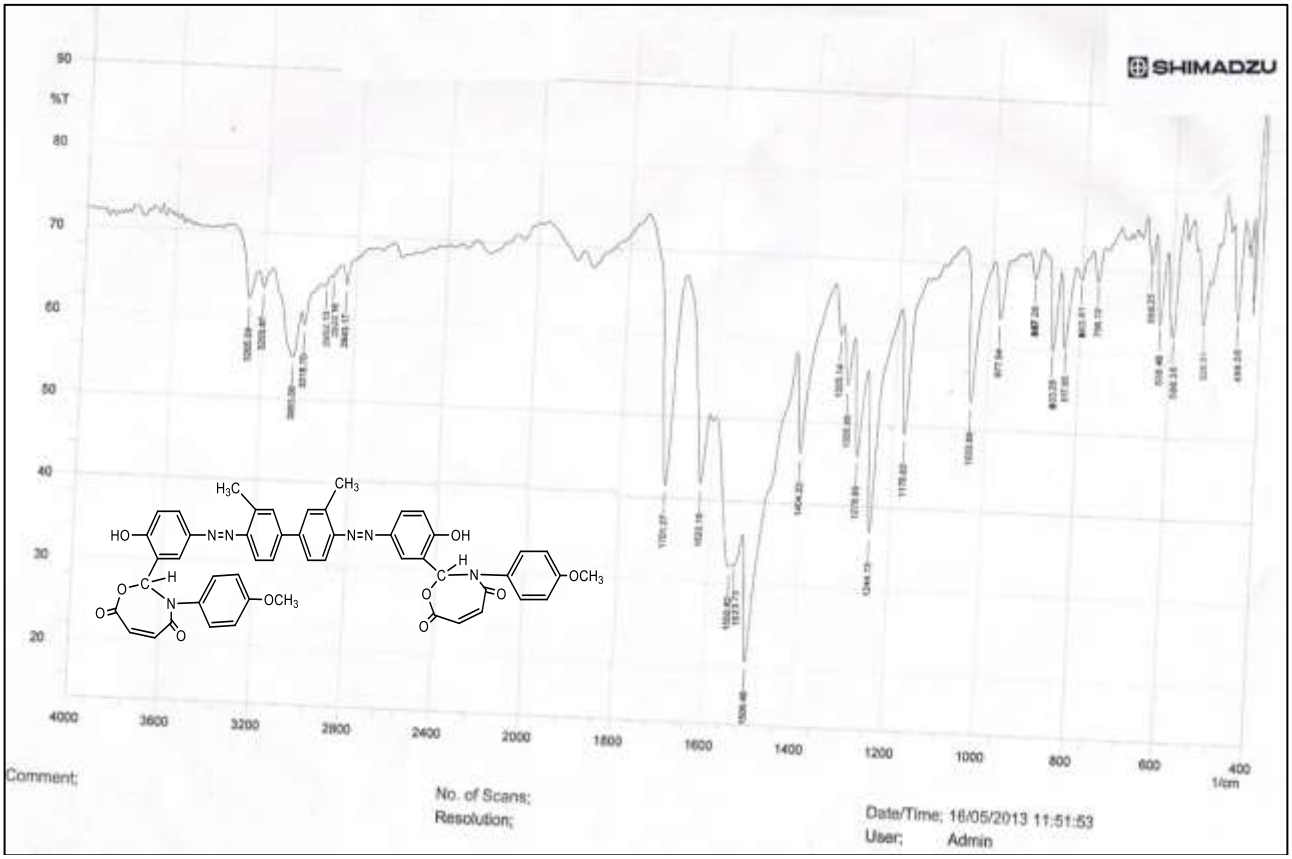


Fig.(18) : FT-IR spectrum of compound 4d

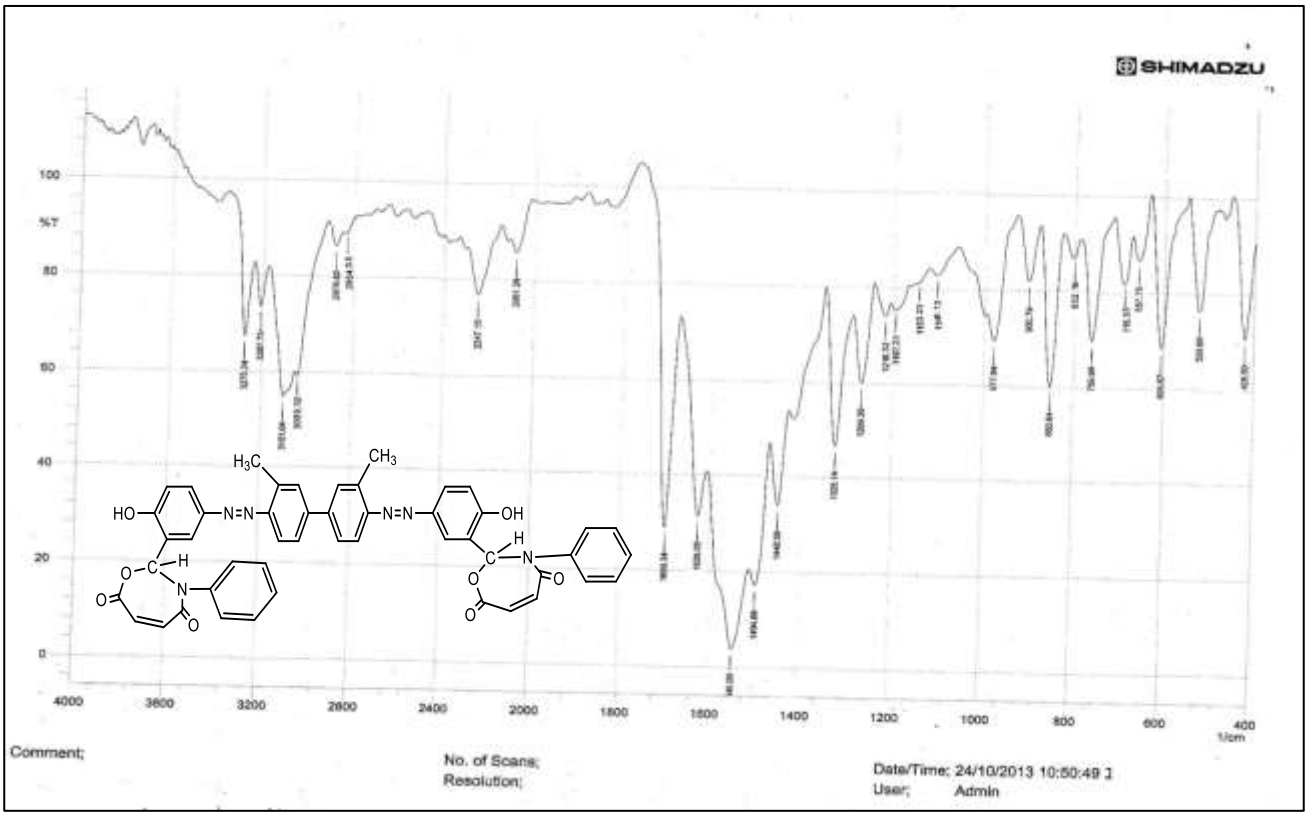


Fig.(19) : FT-IR spectrum of compound 4e

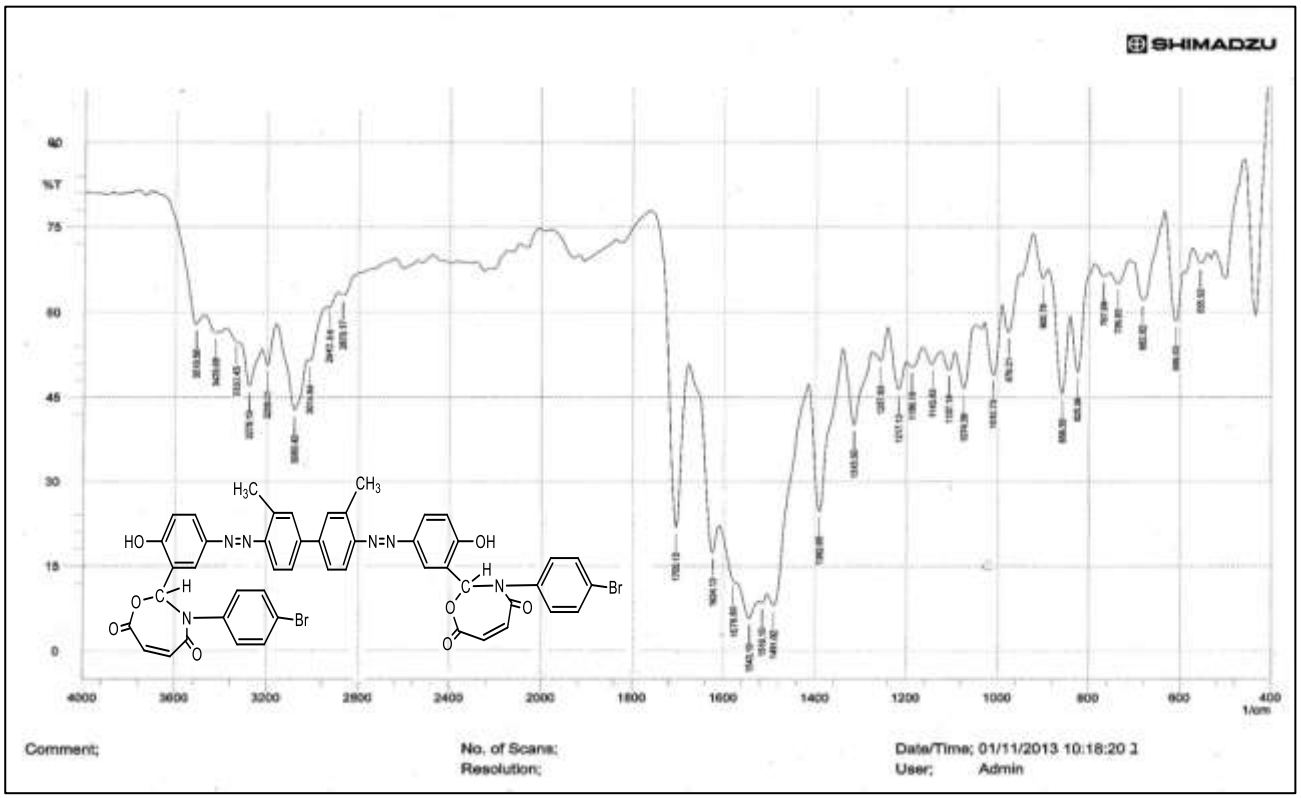


Fig.(20) : FT-IR spectrum of compound 4f

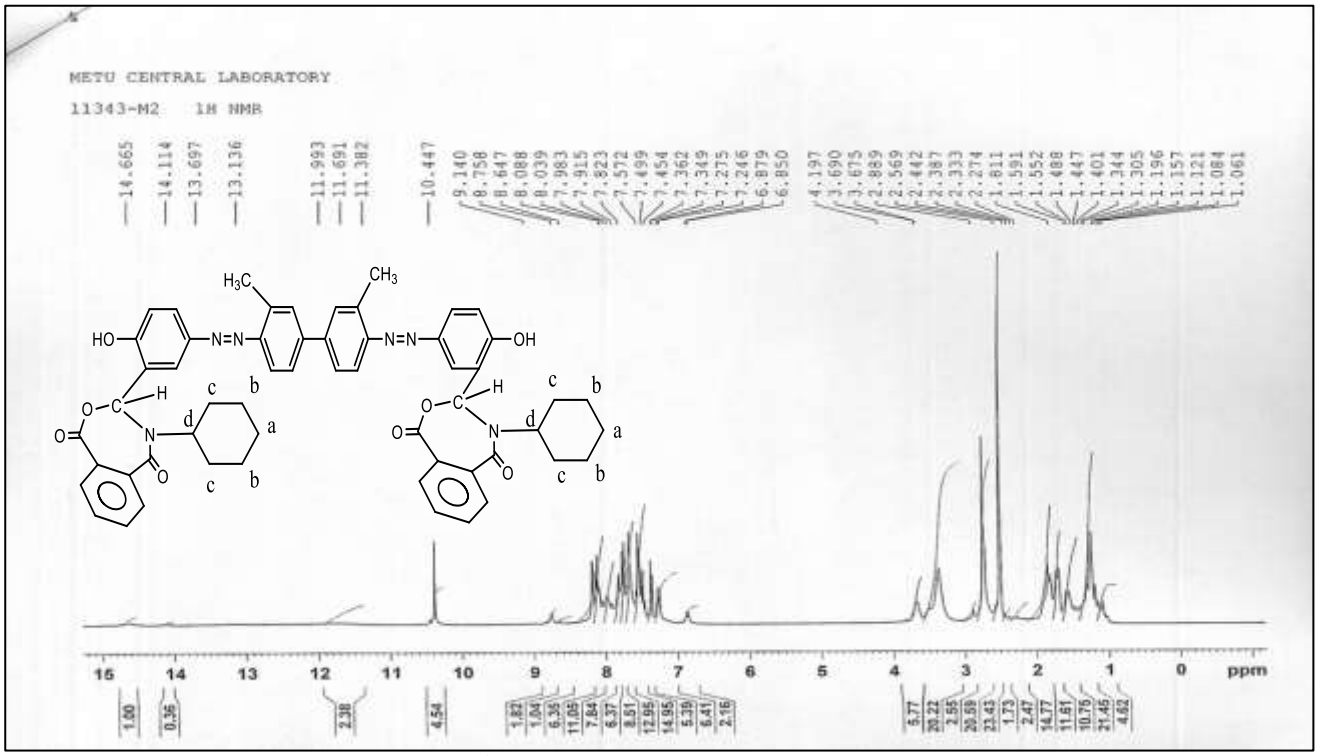


Fig.(21) : ^{1}H NMR spectrum of compound 3a

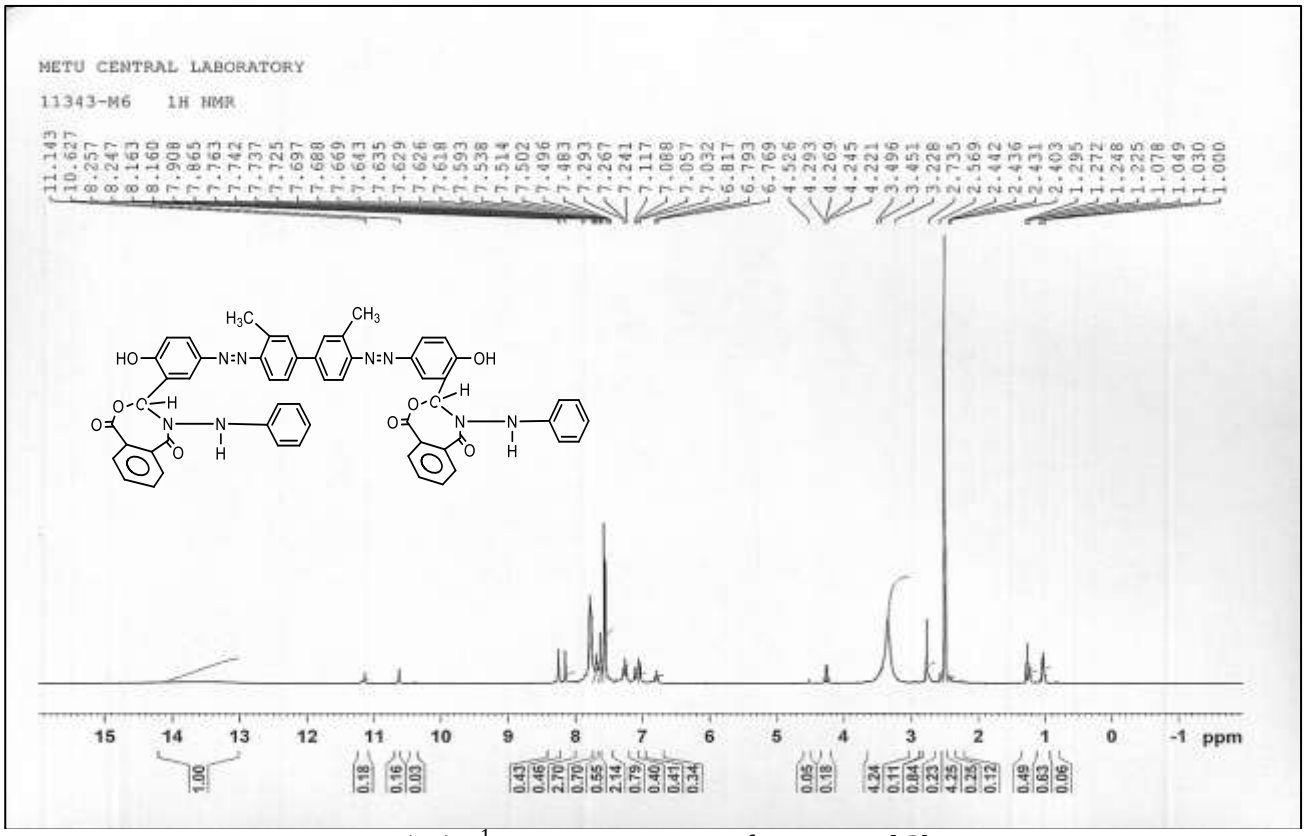


Fig.(22) : ^{1}H NMR spectrum of compound 3b

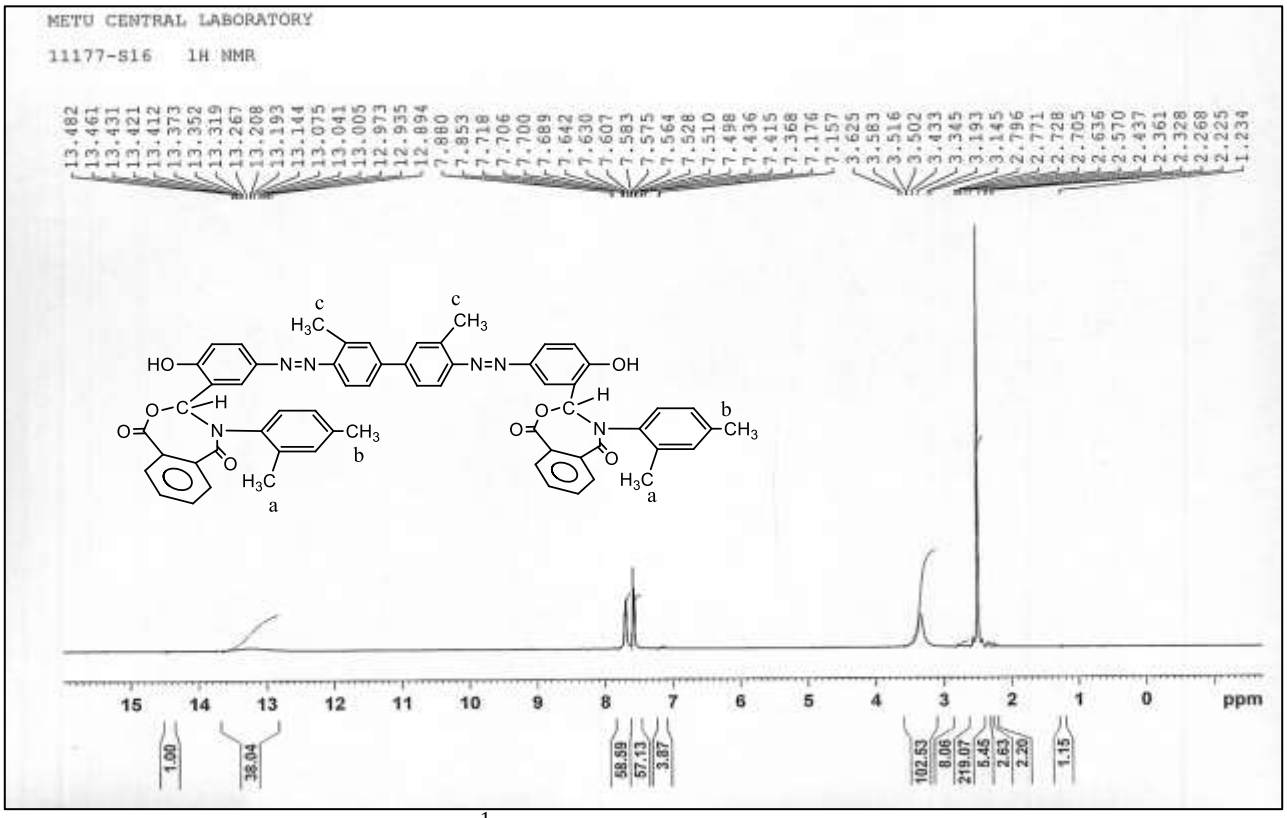


Fig.(23) : ^{1}H NMR spectrum of compound 3c

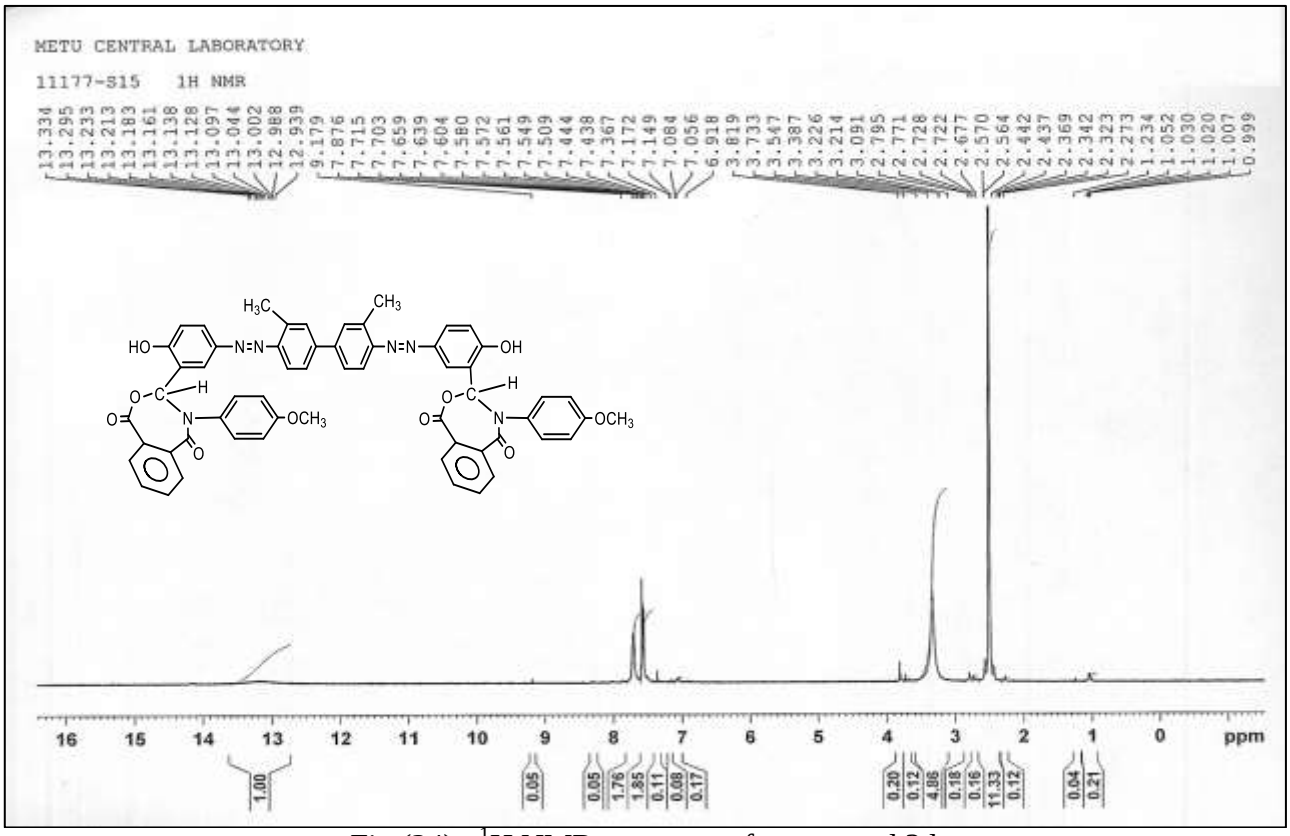


Fig.(24) : ^{1}H NMR spectrum of compound 3d

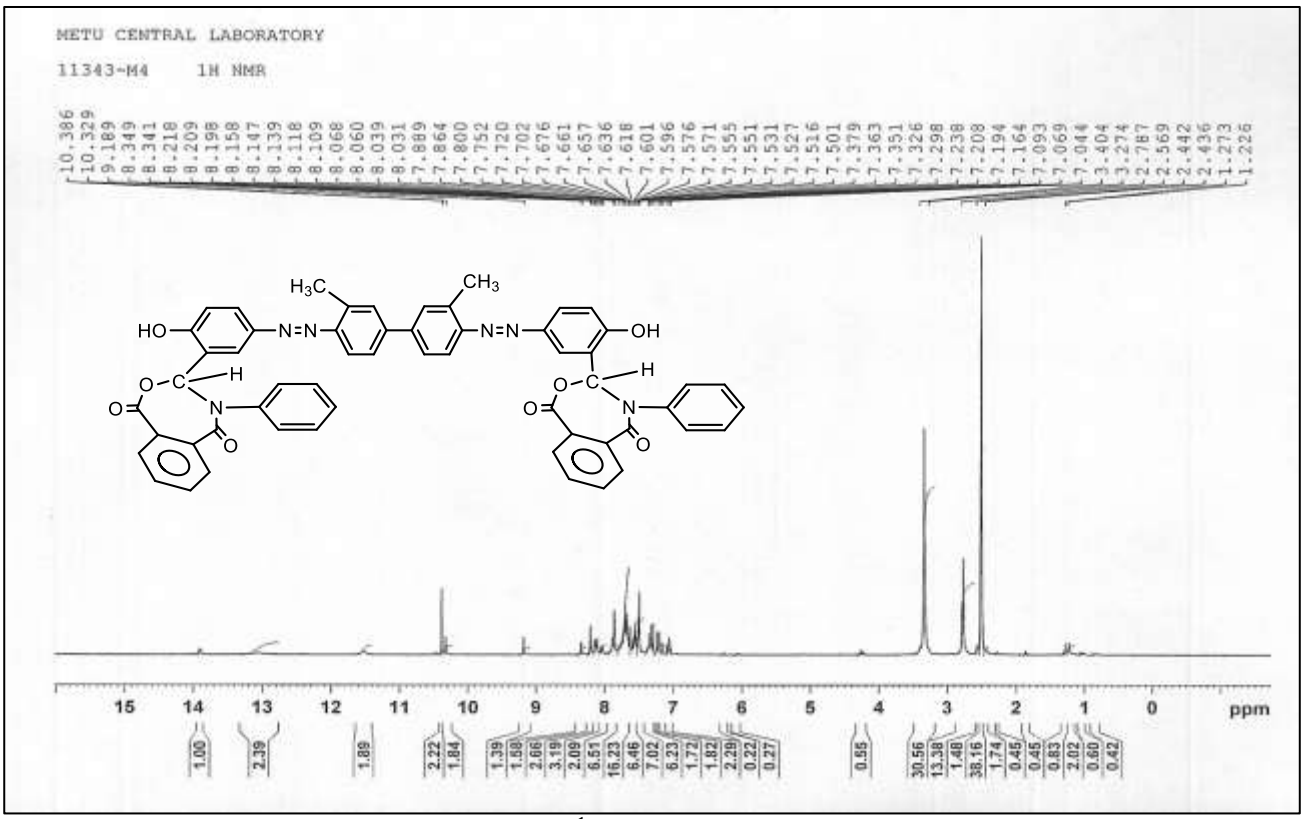


Fig.(25) : ^{1}H NMR spectrum of compound 3e

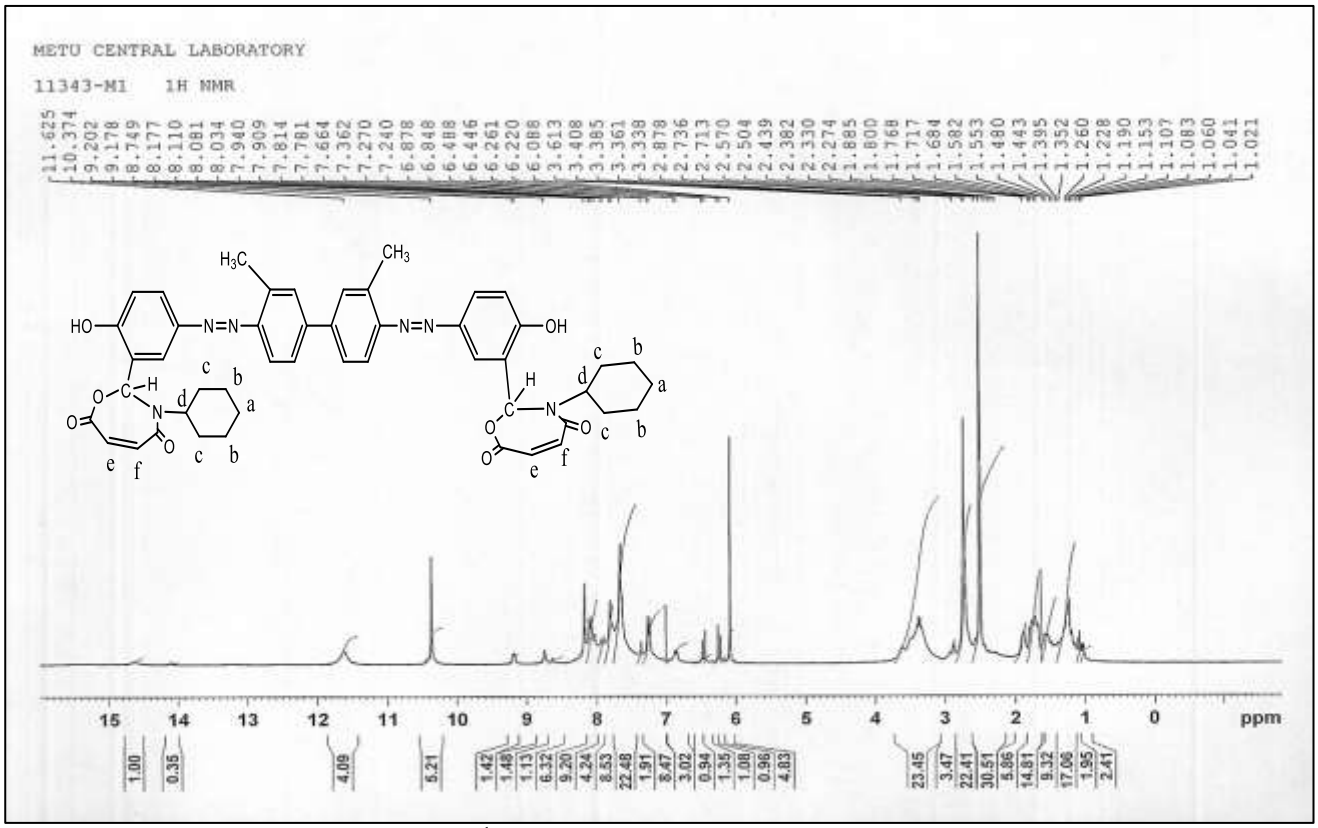


Fig.(26) : ^{1}H NMR spectrum of compound 4a

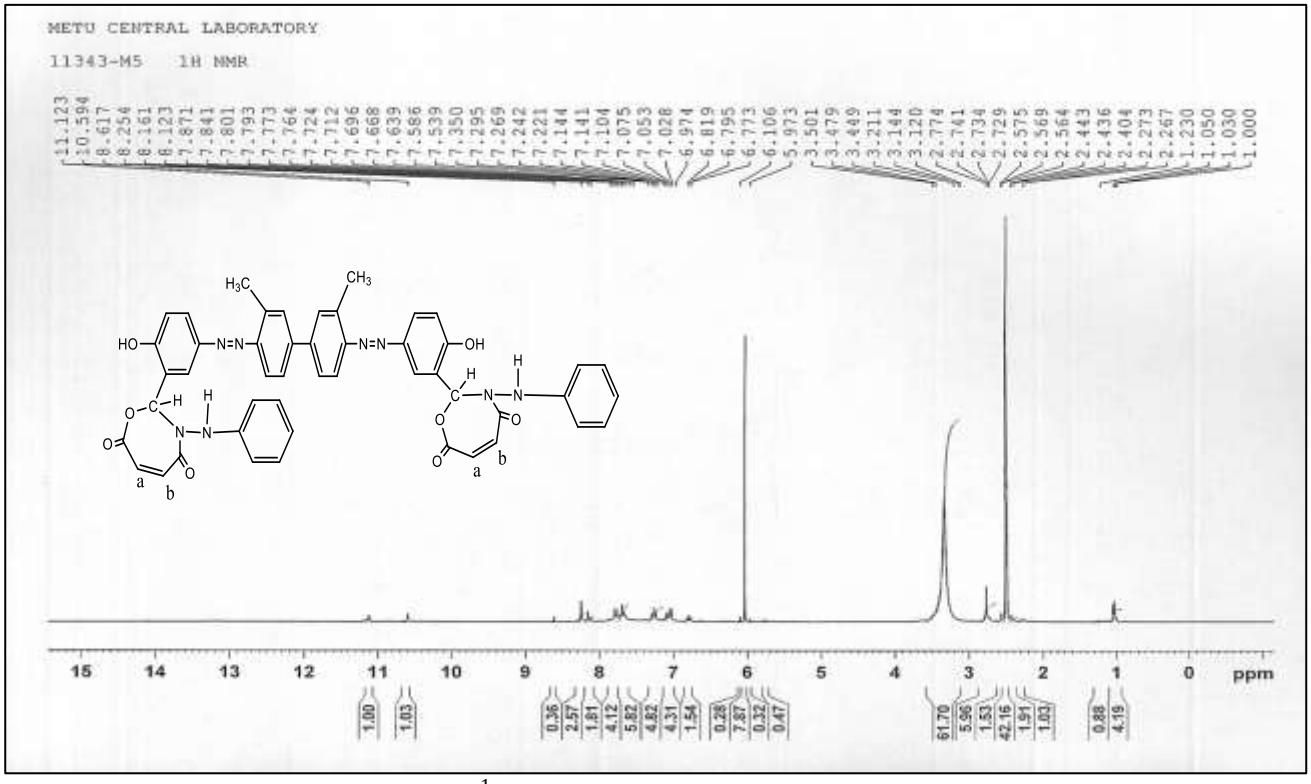


Fig.(27) : ^{1}H NMR spectrum of compound 4b

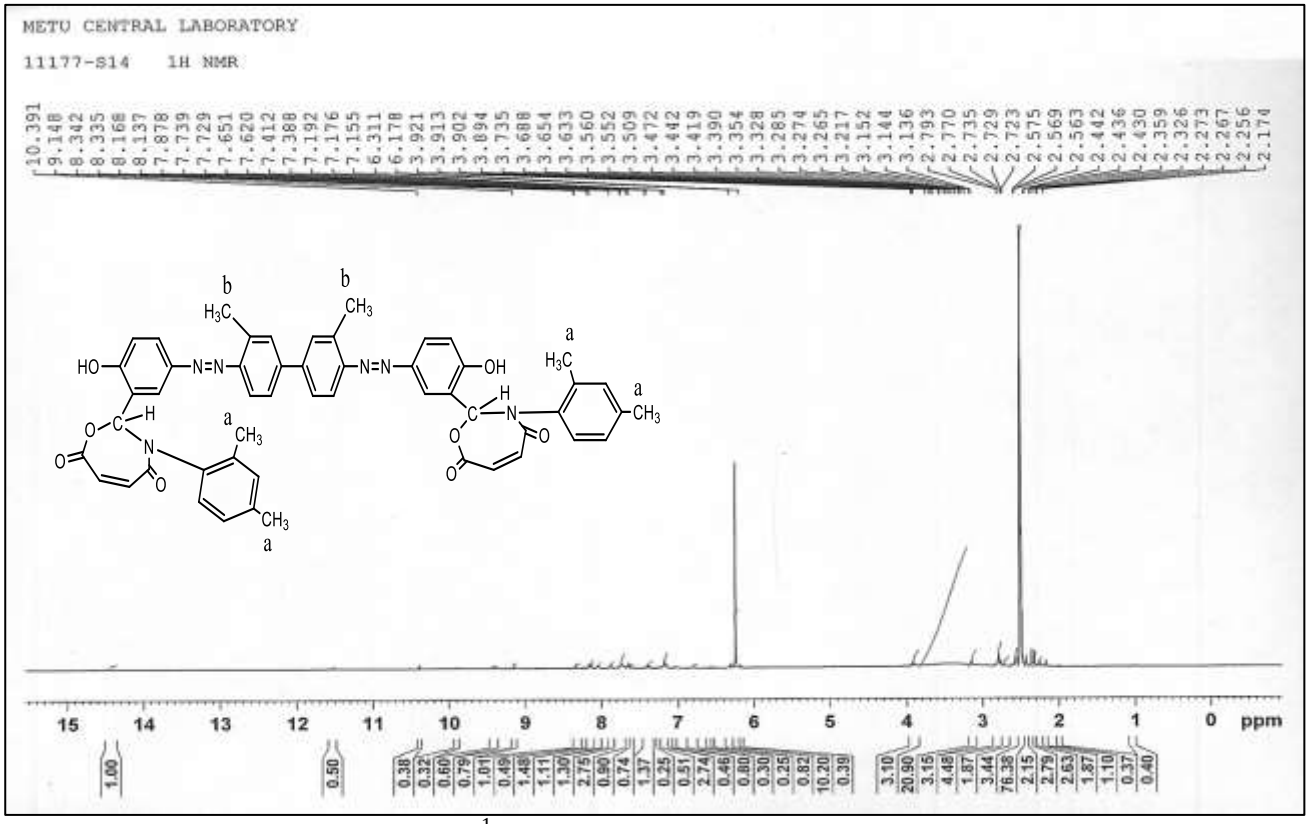


Fig.(28) : ^{1}H NMR spectrum of compound 4c

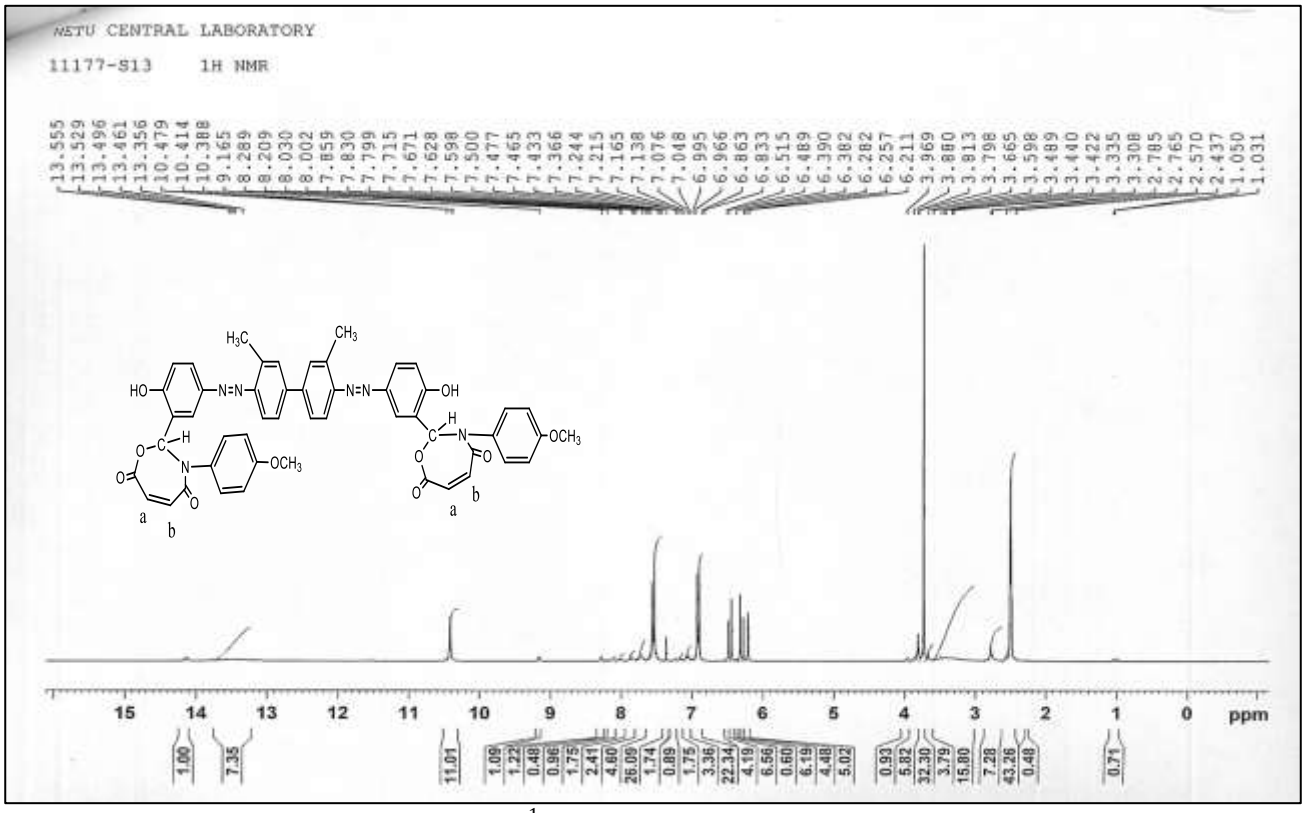


Fig.(29) : ^{1}H NMR spectrum of compound 4d

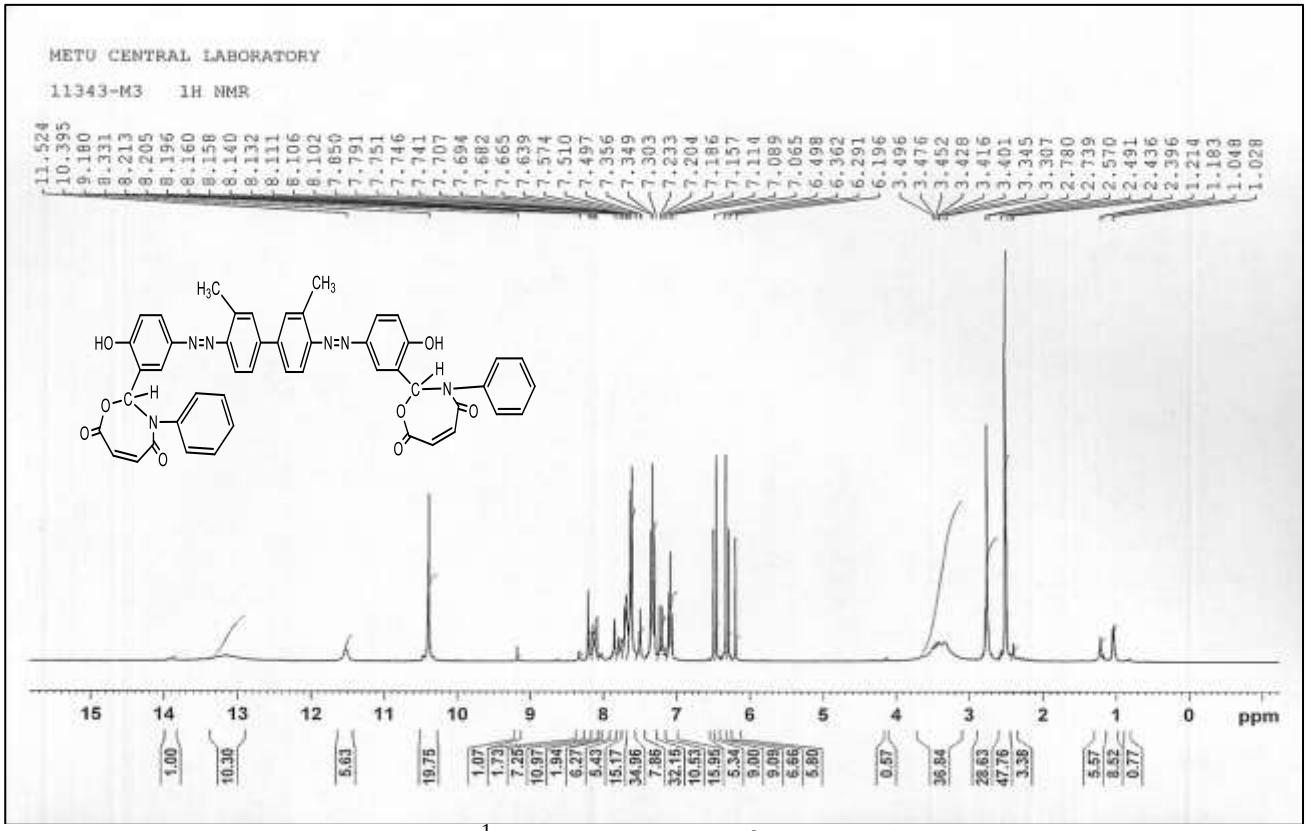


Fig.(30) : ^{1}H NMR spectrum of compound 4e

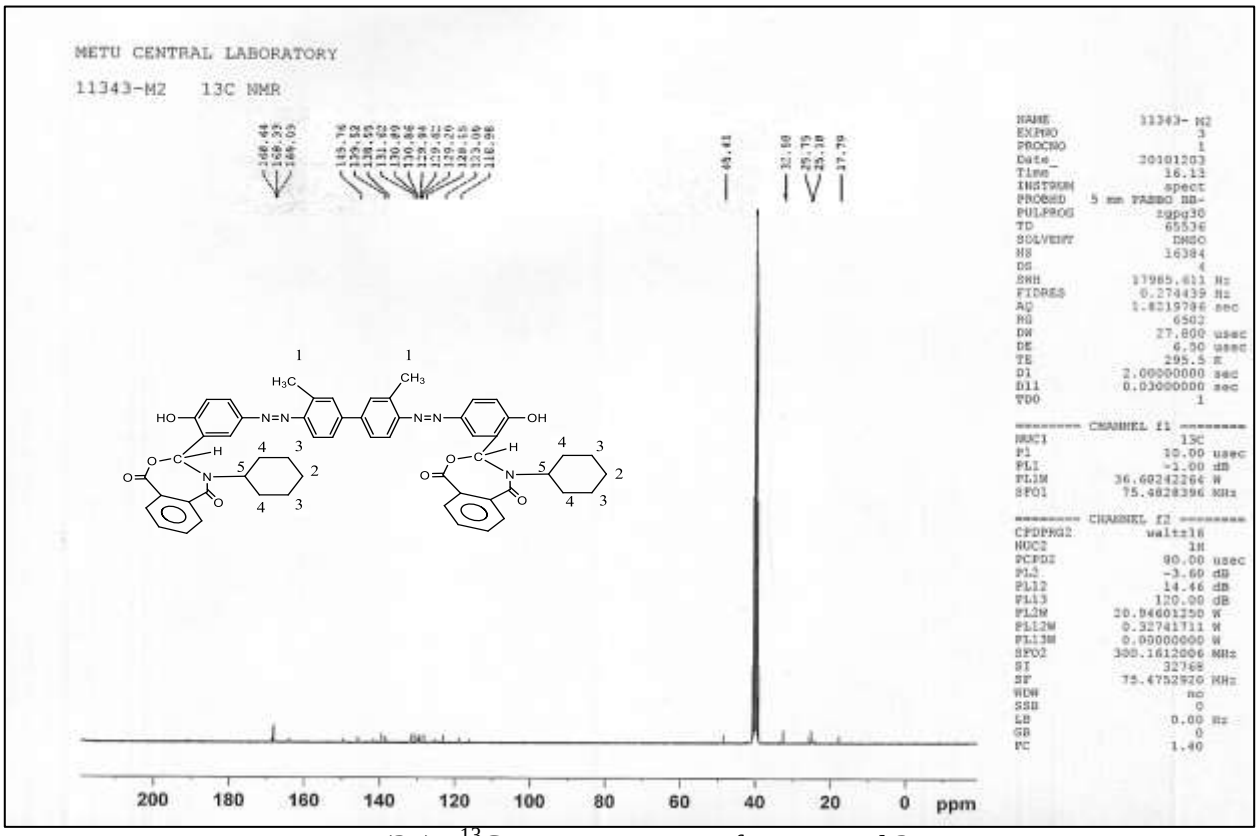


Fig.(31) : ^{13}C NMR spectrum of compound 3a

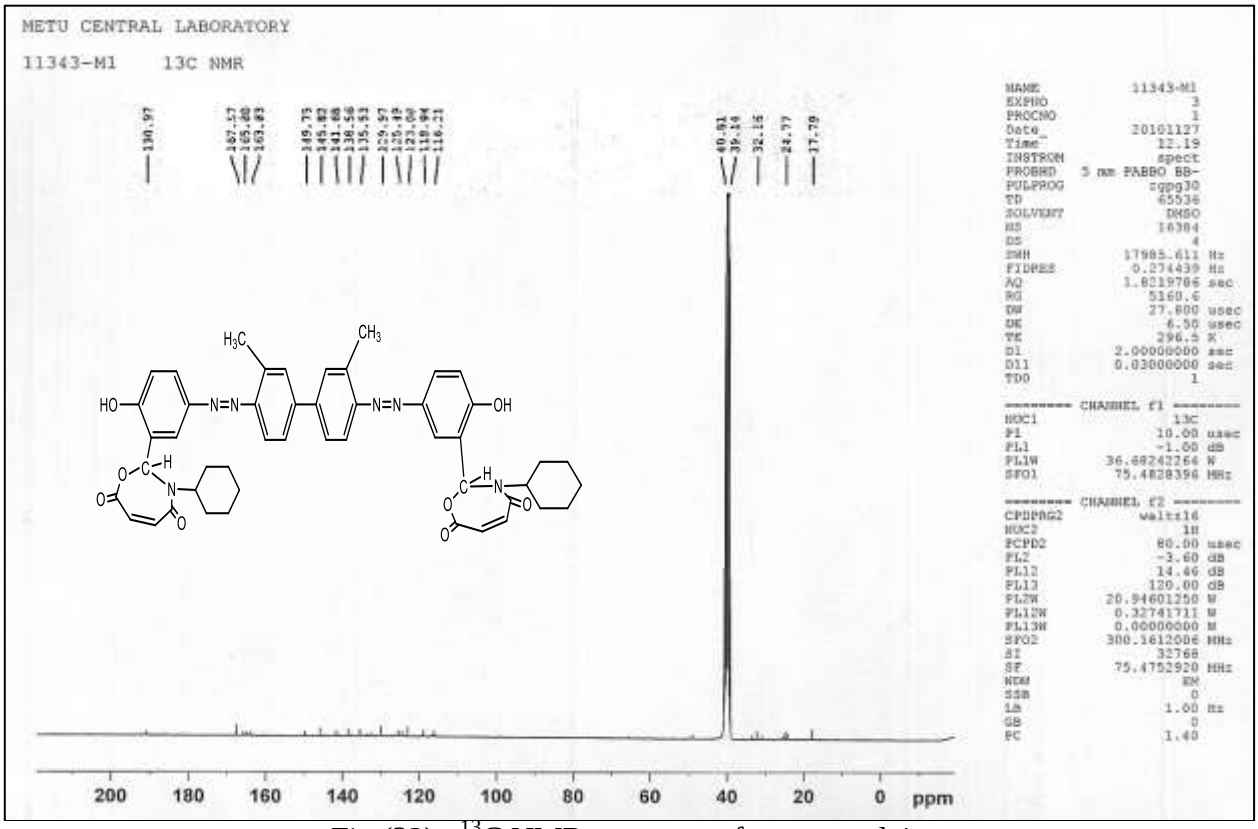


Fig.(32) : ^{13}C NMR spectrum of compound 4a

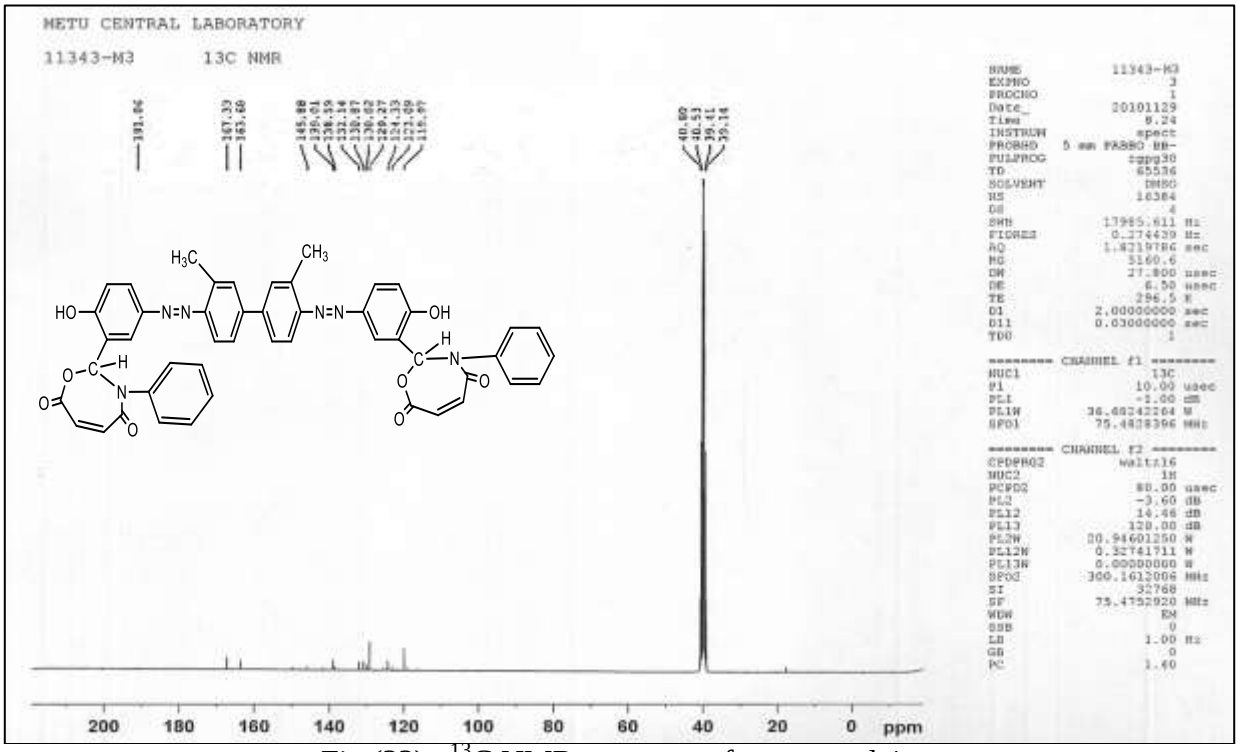


Fig.(33) : ^{13}C NMR spectrum of compound 4e

Fig.(34) :Antibacterial activity of the synthesized compounds (3a, 3b,3c, 3d, 3e, 3f, 4a, 4b, 4c, 4d, 4e, 4f) against Staphylococcus aureous

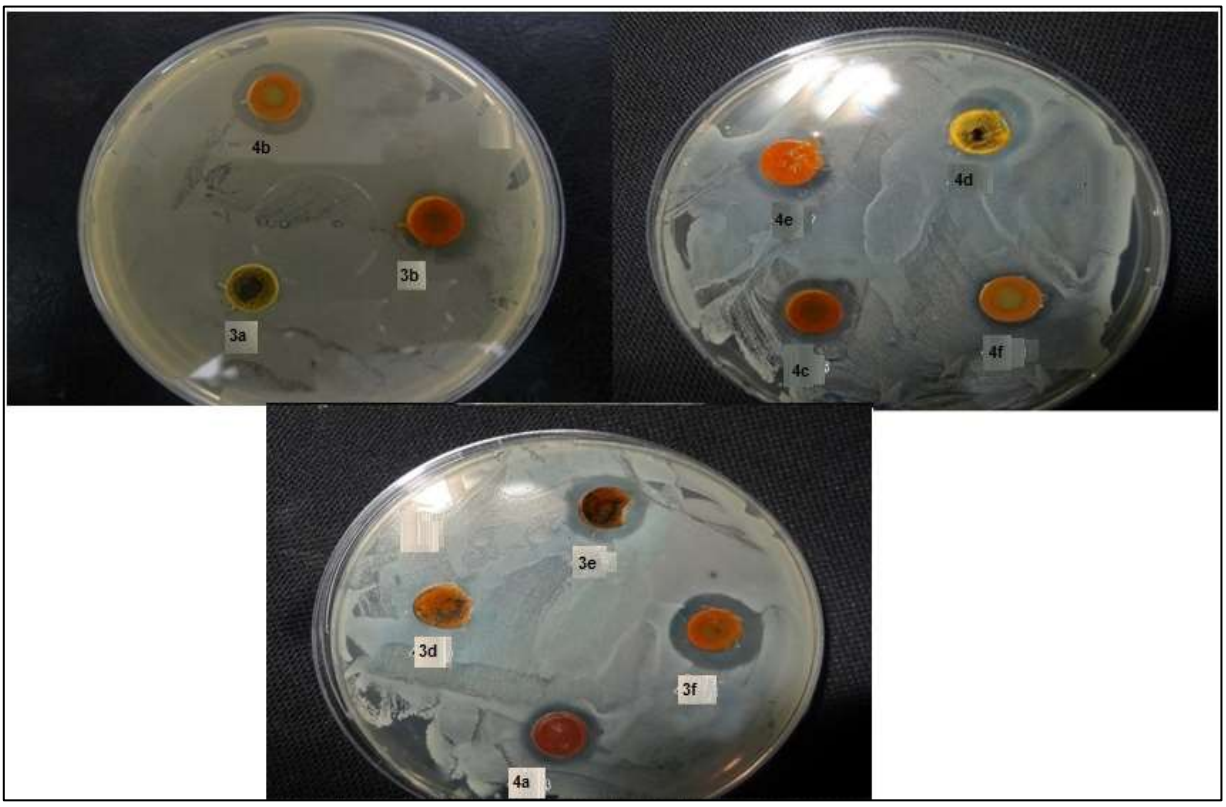


Fig.(35) : Antibacterial activity of the synthesized compounds (3a, 3b, 3c, 3d, 3e, 3f, 4a, 4b, 4c, 4d, 4e, 4f) against *E.coli*

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