Original Article

Synthesis Of Pyranodiquinoline Derivatives And Their Biological Activity Studies By Using Heterogeneous Magnetic Nano Cobalt Ferrite Catalyst

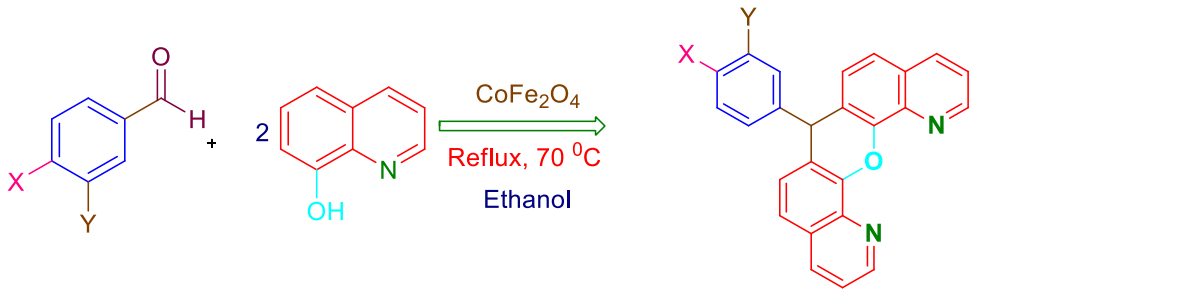
Swathi Bandaru[1], Paul Douglas Sanasi[2]

[1]Department of Chemistry, Rajiv Gandhi University of Knowledge Technologies-IIIT, Srikakulam, 532410, AP, Andhra Pradesh, INDIA, swathi.varda@gmail.com
[2]Department of Engineering Chemistry, AU College of Engineering (A), Andhra University, Visakhapatnam-530003. Andhra Pradesh, INDIA pauldouglas12@gmail.com
DOI: 10.47750/pnr.2022.13.S09.105

Abstract

One-pot cyclization of aromatic aldehyde and 8-hydroxy quinoline in the presence of nano Cobalt ferrite is presented as a flexible method for constructing 7-phenyl-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline derivatives (1a-1e). Under reflux conditions the reaction generates high yields of pyrano diquinoline derivatives. Catalyst, Heterogeneous The FT-IR, XRD, SEM, and TEM were used to characterise the nano Cobalt ferrite particles synthesised via the sol-gel citrate precursor method; the IR, MASS, 1H NMR, and 13C NMR techniques were used to analyse the structures of the synthesised pyrano diquinoline derivatives; and the hole-in-plate bio assay method was used to determine the antibacterial activity. The catalyst was recovered from the reaction mixture using a powerful Neodymium magnet and put back into service in order to produce further pyrano diquinoline derivatives.

GRAPHICAL ABSTRACT



X= H, -OCH_3, Br, Cl,
Y= H,Cl

7-phenyl-7H-pyrano[3,2-h:5,6-h']diquinoline derivatives

Key Words: Pyrano diquinoline derivatives, Nano Cobalt Ferrite Catalyst, reusable catalyst,Reflux conditions,Antibacterial and Antifungal activity.

Introduction

The chemical industry has shown a lot of interest in multicomponent reactions (MCRs) as a method for producing heterocyclic molecules. In a convergent reaction route,[1] three or more reactants react to generate a product in a single vessel, with no intermediates being isolated. This is how the vast majority of MCRs work. The[2] pyrroloquinoline derivatives are the key molecules in the natural products.[3-5] Natural products are rich

sources for the medicinal chemistry.[6-11]These derivatives exhibit antiplatelet,[12] antimalarial,[13] antischistosomal,[14] antioxidant,[15] antitumor,[16] antimicrobial,[17-18] antileishmanial[19] and HIV inhibitors.[20]

A number of methods have been carried out for the synthesis of pyranoquinoline derivatives such as triethylamine,[21] microwave assisted solvent free synthesis,[22] sodium acetate,[23]tetrahydropyrano [3, 2-c] quinoline-5-one bypotassium fluoride-alumina,[24] 2-aminochromenes by potassium fluoride-alumina,[25]4H-pyrano [3, 2-c] quinoline-5-one-3-carboxylate derivatives by potassium fluoride-alumina,[26] ethanol: pyridine (1:1),[27]nano magnesium oxide,[28]bifunctional thiourea-tertiary amines,[29] Indium chloride,[30] O-quinonemethides,[31] 2-amino-2-chromenes by sodium hydroxide,[32] tetra hydro chromene derivatives by mechanochemical ball milling,[33]pyranocoumarins and chromene derivatives by organo catalyst,[34] tetra hydro chromene derivatives by hydrated coppersulphate ($CuSO_4.H_2O$),[35] ultrasound assisted synthesis,[36]diazabicyclo [2, 2, 2] octane (DABCO),[37] molten tetra-n-butyl phosphonium bromide under solvent free conditions,[38] Lanthanum chloride,[39] Antimony (III) Sulfate ($Sb_2(SO_4)_3$),[40] egg shell,[41] but these procedures suffers disadvantages like usage of toxic solvents,[27] long reaction periods,[40] separation of catalyst and recovery of catalyst.[21, 23, 27]

These days, nano metal ferrite catalysts are often utilised in the synthesis of a broad range of organic transformations, including, for example, the synthesis of trisubstituted imidazoles using copper and cobalt ferrite. Synthesis of, -unsaturated ketones at the[42]-nanometer scale in copper ferrite, Microwave-assisted nickel-cobalt ferrite catalysed synthesis of -acetamido ketones; nano copper ferrite catalysed sonochemical synthesis of poly substituted imidazoles; nano copper ferrite catalysed improved technique for one-pot synthesis of poly substituted pyridine derivatives; Microwave-assisted synthesis of[46] and magnetic nano cobalt ferrite-catalyzed 4H-pyrano [3, 2-h] quinoline derivatives[47] magnetic Nano copper ferrite facilitated one pot synthesis of substituted quinolone derivatives under Ultra sonication.[48]

The pyranoquinoline derivatives have shown promise as an anti-agent, Alzheimer's with studies showing that they inhibit acetyl cholinesterase and inhibit cell calcium signals (Kantevari et al. 2011), protect neurons from calcium overload and free radicals (Macro-Contelles et al. 2006), and inhibit acetyl cholinesterase (Kantevari et al. 2006). (Camps et al 2009). As slow responding substances in anaphylaxis (SRS-A) antagonists (Kamikawa et al., 1996), pyrano [4, 3-b] quinoline derivatives show promise as antimalarials (Aggarwal et al., 2011) and as photoactivated antimicrobials (Hanawa et al 2004). Both antiproliferative and antitubulin actions may be seen in pyranoquinoline-containing compounds (Magedov et al 2008).

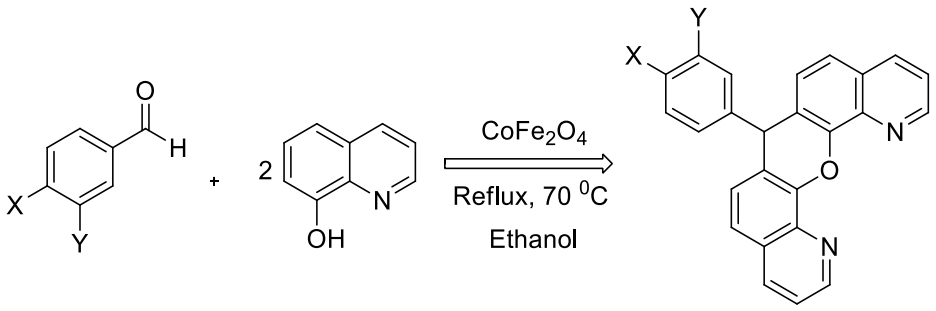
In nature, pyranoquinoline moiety may be found in certain bioactive alkaloids (Ih-Sheng Chen et al., 1997; Dagne et al., 1988). Linear analogues of coumarins, such as those found in the pyrano [2, 3-b] quinoline-2-one systems, which share the ring structure of pyranoquinolinealkaloids like khaplofoline, are included.[49] Effective inhibitors of mitotic kinesin-5, pyrano [3, 2-c] quinolinones are useful against hypersensitivity responses and immune-reaction illnesses.[50]

Green synthesis of Pyrano diquinoline derivatives by a two-component cyclization of aromatic aldehyde and 8-hydroxyquinoline in ethanol catalysed by nano Cobalt ferrite is only one example of the excellent results we are able to get without spending a fortune. Short time periods, improved yields, low mg of catalyst, magnetic recoverability, reusability, and environmental friendliness are just a few of the many benefits of this approach.

Results and Discussion

Analyzing the role of copper-cobalt ferrite catalysts in the production of pyrano diquinoline derivatives

One-pot synthesis of substituted pyrano diquinoline derivatives was carried in the presence of cobalt ferrite at a temperature of 70^0C where aromatic aldehyde and 8-hydroxyquinoline in 1:2 molar ratio were refluxed in ethanol as shown in **Scheme 1.**An observation for the formation of Pyrano diquinoline derivatives is presented in **Table 1.**



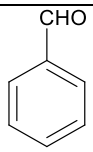
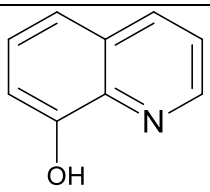
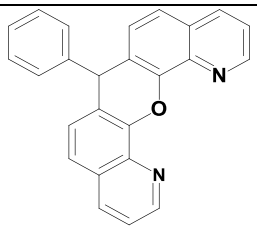
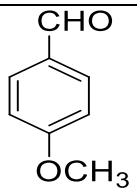
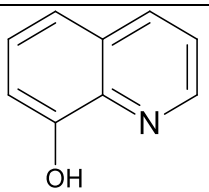
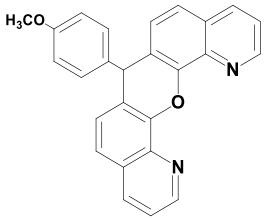
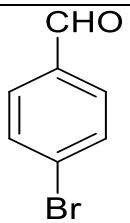
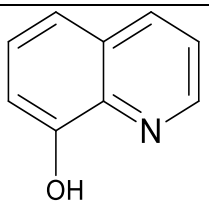
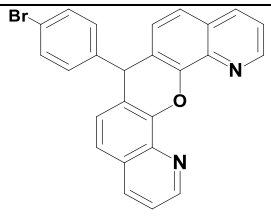
X= H, -OCH_3, Br, Cl,
Y= H,Cl

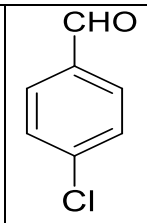
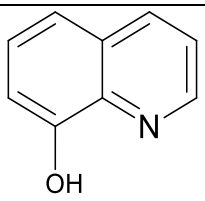
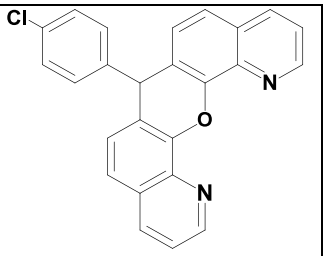
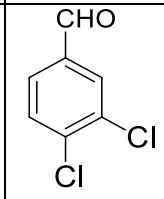
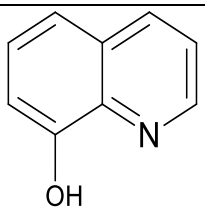
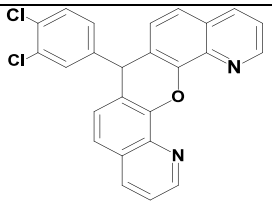
7-phenyl-7H-pyrano[3,2-h:5,6-h']diquinoline derivatives

Scheme1. Nano cobalt ferrite-catalyzed synthesis of pyrano diquinoline compounds

Table1. The production and structural characterisation of pyrano diquinoline derivatives using nanoscale Cobalt ferrite catalysts

In the presence of Nano cobalt ferrite catalyst, the reaction time, temperature, and yield of the matching product have all been tabulated in Table 1.

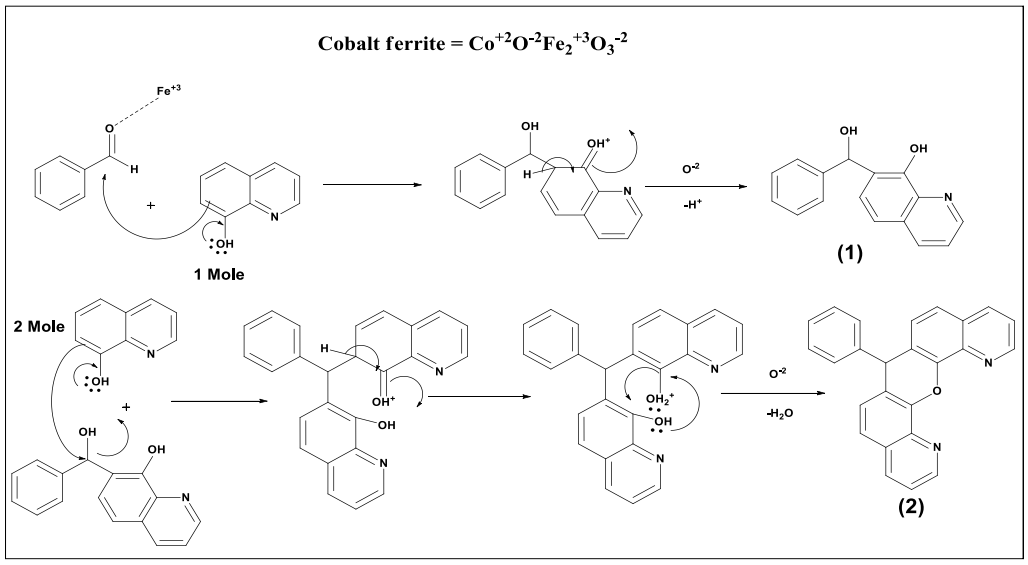
S.No	Reactants		Time (min)	Temp (^oC)	Product$^{(x, y)}$
1			120	70	 **1(a)**
2			120	70	 **1(b)**
3			120	70	 **1(c)**

4			120	70	 **1(d)**
5			120	70	 **1(e)**

x= product yield 92 (1a), y=500 mg of $CoFe_2O_4$

Rationale for the catalytic activity of the reaction

A plausible mechanism proposed for the synthesis of pyrano diquinoline derivatives catalyzed by nano cobalt ferrite ($CoFe_2O_4$) is shown in **scheme 2**. Initially, an aromatic aldehyde is activated by Lewis acid (Fe^{+3}) sites of nano metal ferrite particles and then reacts with first mole of 8-hydroxy quinoline in the presence of Lewis base (O^{-2}) sites of nano cobalt ferrite particles to form an intermediate 7-(hydroxy (phenyl) methyl)quinoline-8-ol (1). The formed intermediate (1) further reacts with second mole of 8-hydroxy quinoline in the presence of Lewis base (O^{-2}) sites of nano cobalt ferrite particles undergo cyclization followed by condensation to form pyrano diquinoline derivatives (2) smoothly.



Scheme2. Nano cobalt ferrite may provide a plausible route for the production of pyrano diquinoline derivatives.

Table 2. The role of solvent in the production of pyrano diquinoline derivatives

In the process of observing the synthesis of substituted Pyrano diquinoline derivatives, it became clear that solvents played a significant role. Table 2 provides a summary of the findings. Non-polar solvents like dioxane and carbon tetrachloride were significantly inferior than polar solvents like ethyl acetate, methanol, and ethanol. Therefore, we selected ethanol as suitable solvent and 70 ^{0}C as the optimal temperature for the reaction for the system (1a-1e).

Table 2.Effect of solvent on the synthesis of pyrano diquinoline derivatives

Entry	Catalyst used[y]	Solvents used	Yield (%)
1	$CoFe_2O_4$	Water	Trace
2	$CoFe_2O_4$	Dioxane	30
3	$CoFe_2O_4$	Carbon tetrachloride	42
4	$CoFe_2O_4$	Dichloromethane	45
5	$CoFe_2O_4$	Ethyl acetate	75
6	$CoFe_2O_4$	Methanol	86
7	$CoFe_2O_4$	Ethanol	92

Recycling of the catalyst

Catalyst reusability played an important role in heterogeneous catalysis. Pipetting off the solution from the bottom of the beaker, a powerful Neodymium magnet is used to recycle the catalyst cobalt ferrite. Once the solid has been separated, it is washed with ethyl acetate and dried. The dried catalyst is reused for further synthesis of Pyrano diquinoline derivatives.

Determination of Antibacterial and antifungal activity

The hole-in-plate bio assay method was used to analyse the antibacterial properties (Hugo et al., 1983; Vlienticket al., 1995). Pure microbial cultures were recovered in Muller Hinton broth and diluted to a concentration of 108 cells/ml. Various bacteria, including Staphylococcus aureus, Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa, Aspergillus niger, and Candida albicans, were employed for the experiments. The organisms in the broth are divided among the properly labelled Petri dishes, each receiving 0.1 ml. Four holes were drilled into the bacterium-seeded Petri plates using a sterile cork-borer with a 6mm diameter. Wells are filled with a 10% DMSO solution containing 0.5, 1, 2, 4, and 10, 20, and 30l of the sample chemical at each of those concentrations. After plating, a 24-hour incubation period was conducted at 37 degrees Celsius. After 24 hours of growth on nutrient agar broth, all bacterial cultures were tested. Slants were kept at 4 degrees Celsius. The plates were left out at room temperature for 30 minutes to facilitate diffusion of the samples, and then incubated at 37 0C for 18 hours. Zones of inhibition will be measured using a calliper once incubation has concluded. A statistical mean was determined after many studies were conducted. The zone of inhibition in millimetres is used to quantify the antibacterial and antifungal activity, which is then compared to that of gold-standard medications like vancomycin, streptomycin, and amphotericin.

Activity of pyrano diquinoline compounds against bacteria and yeast

The antibacterial, antifungal, and gram-positive **(Bacillus subtilis, Staphylococcus aureus)** and gram-negative **(Escherichia coli, Pseudomonas)** activities of the produced heterocyclic compounds were evaluated **(Aspergillus Niger and Candida Albicans)**.

Samples are tested for their antibacterial and antifungal properties at several concentrations (low, middle, and high). Standard antibiotics like streptomycin, vancomycin, and amphotericin are very efficient against bacteria and fungi. Table 3 shows that as sample concentration increases, the zone of inhibition expands, indicating that the reference medication has antibacterial action against both gram-positive and gram-negative bacteria.

Table 3. Zone of inhibition antibacterial activity of synthesized heterocyclic compounds

S. No	Sample	Concentration µl/ml	Zones of Inhibition in mm					
			Antibacterial activity				Antifungal activity	
			Gram positive		Gram negative			
			Staphyloco	**Bacillu**	**Escherichi**	**Pseudomon**	**Aspergill**	**Candid**

			ccus aureus	s subtilis	a coli	as	us Niger	a Albicans
1	1a	8	48	0	0	0	45	43
2	1b	8	21	0	0	0	21	14
3	1c	10	19	26	29	22	0	0
4	1d	10	24	33	28	21	0	0
5	1e	10	0	10	11	8	0	0
Std Drug (mm) A and C			21	18	-	-	20	19
Std Drug B			25	23	26	19	-	-

Conclusion

In this work, we describe a new strategy for synthesising pyrano diquinoline derivatives employing nano-sized CoFe2O4 as a heterogeneous catalyst. The method's many benefits include higher product yields, shorter reaction times, catalyst separation using a powerful Neodymium magnet, and catalyst recyclability and reuse.

Experimental

Materials and Methods

The chemicals utilised in this process are of the unrefined AR grade. KBr pellets were used in an infrared spectrophotometer (Perkin Elmer Spectra-880) to record spectra in the 400-4500 cm1 range, and a 400 MHz spectrometer (Bruker Avance) was used to analyse the resulting NMR spectra in a CDCl3/DMSO solvent. To validate the 13C NMR spectra in the solvent Dimethylsulphoxide (DMSO-d6), a mass spectrum was acquired at 70eV (MASPEC low resolution mass spectrometer). Using tetramethylsilane (TMS) as a reference point, chemical shifts were reported in ppm downfield and coupling constants were given in Hz (Hz)

Methodology for the Synthesis of Pyranodiquinoline Derivatives

The pyrano diquinoline derivatives were synthesised in a single 100 mL round bottomed flask using a reflux condenser and a wax bath with temperature control. Prior to the experiment, around 500 mg of the catalyst was removed, activated at 500 0C for 2 hours, and allowed to cool to room temperature. Two hours of refluxing at 70 degrees Celsius were applied to a mixture containing 10 mmol of aromatic aldehyde, 20 mmol of 8-hydroxyquinoline, 500 mg of nano metal ferrite, and 5 mL of ethanol. A TLC (n-hexane: ethyl acetate; 3:1) was used to verify that the reaction was complete before the generated reaction mixture was cooled to room temperature and ethyl alcohol was added to dissolve the result. Strong Neodymium magnets are used to externally remove the catalyst from the reaction derivative, isolating the products. Spectral methods such as IR, MASS, 1H NMR, and 13C NMR were used to characterise each product.

Spectral data of Pyrano diquinoline derivatives by using Nano Cobalt ferrite catalyst

7-phenyl-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1a)

White solid; 92% Yield; IR (KBr, cm^{-1}): 3029 (Ar-CH, str), 2863(Ar-CH, str), 1604 (C=C, str), 1277 (C=N, str), 1120 (C-O-C, str); ^{1}H NMR (500 M Hz, $CDCl_3$, δ ppm): 8.11-8.10 d(2H, Ar), 7.61-7.53 m(2H, Ar), 7.64-7.63 d(2H, Ar), 8.10-8.09 d(2H, Ar),7.53-7.45 d(2H, Ar),7.19-7.14 d(2H, Ar), 7.42-7.22 d(2H, Ar), 7.21-7.19 m(1H, Ar), 5.34 s(1H, pyranring-methine proton); $^{13}C\{^{1}H\}$NMR(125 MHz, $CDCl_3$, δ ppm): 151.86, 150.63, 145.04, 140.32, 139.76, 133.87, 131.52, 129.97, 129.24, 128.49, 125.44, 120.08, 120.00 (Ar-C),77.08; Mass: m/z [M]=360, [M+1] = 361; $C_{25}H_{16}N_2O$.

7-(4-methoxyphenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1b)

White solid; 87% Yield; IR (KBr, cm^{-1}) : 3035 (Ar-CH, str), 2926 (Ar-CH, str), 1606.34 (C=C, str), 1374 (C=N, str), 1149 (C-O-C, str); ^{1}H NMR (500 M Hz, $CDCl_3$, δ ppm): 8.10 d(2H, Ar), 7.53-7.51 m(2H, Ar), 8.08 d(2H, Ar),7.62-7.53 d(2H, Ar),7.51-7.49 d(2H, Ar), 7.12-7.10 d(2H, Ar), 6.98-6.95 d(2H, Ar), 5.53 s(1H, pyranring-methine proton),3.83 s(3H, OCH_3); $^{13}C\{^{1}H\}$NMR(125 MHz, $CDCl_3$, δ ppm): 157.32, 151.86, 150.69, 143.83,

135.14, 133.76, 131.59, 129.21, 128.45, 121.46, 120.43, 118.37, 115.03, 77.07, 55.51; Mass: m/z [M]=390, [M+1] = 391; $C_{26}H_{18}N_2O_2$.

7-(4-bromophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1c)

White solid; 85% Yield; IR (KBr, cm^{-1}) : 3035.26 (Ar-CH, str), 2926.06 (Ar-CH, str), 1605.39 (C=C, str), 1236.29 (C=N, str), 1149.53 (C-O-C, str); ^{1}H NMR (500 M Hz, $CDCl_3$, δ ppm) 8.06-8.05 d(2H, Ar), 8.04-8.03 d(2H, Ar), 8.03-8.02 m(2H, Ar),7.52-7.50 d(2H, Ar), 7.41-7.39 d(2H, Ar), 7.52-7.49 d(2H, Ar),7.08-7.05 d(2H, Ar),5.41 s(1H, pyranring-methine proton); ^{13}C{^{1}H}NMR(125 MHz, $CDCl_3$, δ ppm): 151.67, 148.99, 143.83, 134.02, 131.39, 130.63, 130.09, 129.29, 128.51, 121.60, 120.22, 120.15, 120.08, 77.05; Mass: m/z [M]=438, [M+1] = 440; $C_{25}H_{15}BrN_2O$.

7-(4-chlorophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1d)

White solid; 84% Yield; IR (KBr, cm^{-1}) : 3032.90 (Ar-CH, str), 2922 (Ar-CH, str), 1583.73 (C=C, str), 1215.90 (C=N, str), 1094.16 (C-O-C, str); ^{1}H NMR (500 M Hz, $CDCl_3$, δ ppm) 8.11-8.10 d(2H, Ar), 8.09-8.08 d(2H, Ar), 7.54-7.52 m(2H, Ar), 7.64-7.54 d(2H, Ar), 7.41-7.39 d(2H, Ar), 7.39-7.09 d(2H, Ar), 7.09-7.06 d(2H, Ar), 5.39 s(1H, pyranring-methine proton); ^{13}C{^{1}H}NMR(125 MHz, $CDCl_3$, δ ppm): 151.85, 150.69, 141.85, 138.32, 134.61, 133.01, 130.00, 129.16, 127.21, 126.70, 123.99, 122.10, 120.67, 77.06; Mass: m/z [M]=394, [M+2] = 396; $C_{25}H_{15}ClN_2O$.

7-(3, 4-dichlorophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1e)

White solid; 82% Yield; IR (KBr, cm^{-1}) : 3082.62 (Ar-CH, str), 2996.05 (Ar-CH, str), 1619.21 (C=C, str), 1281.52 (C=N, str), 1136.67 (C-O-C, str); ^{1}H NMR (500 M Hz, $CDCl_3$, δ ppm);8.11-8.10 d(2H, Ar), 7.52-7.50 m(2H, Ar), 8.09-8.08 d(2H, Ar), 7.64-7.62 d(2H, Ar), 7.54-7.52 d(2H, Ar), 7.13-7.12 d(2H, Ar), 6.95-6.91 d(2H, Ar), 7.14-7.10 s(1H, Ar), 5.54 s(1H, pyranring-methine proton); ^{13}C{^{1}H}NMR(125 MHz, $CDCl_3$, δ ppm): 151.95, 151.83, 144.00, 138.22, 134.65, 134.56, 134.16, 131.31, 129.32, 128.58, 127.61, 125.35, 122.10, 120.15, 120.08, 77.09; Mass: m/z [M]=428, [M+1] = 430; $C_{25}H_{14}Cl_2N_2O$.

Acknowledgement

I thank the author S Paul Douglas for providing financial assistance.

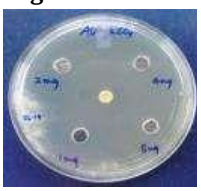
References

Mehta G, Panda G, Yadav R D &Ravikumar K, Indian J Chem, 36B, 1997, 301.

1. Ballini R, Bigi F, Conforti M L, Santis D D, Maggi R, Oppici G&Sartori G,Catal.Today,60,**2000**, 305-309.
2. (a) Domling A &Ugi I,Angew. Chem. Int.Ed,39, **2000,** 3168-3210. (b) Ugi I K, Ebert B &Horl W,Chemosphere,43,**2001,** 75-81.
3. Chen I S, Tsai I W, Teng C M, Chen J J, Chang Y L, Ko F N, Lu M C&Pezzuto J MPhytochem,46,**1997**, 525-529.
4. Wabo H K, Tane p, Connolly J D, Okunji C C, Schuster B M &Iwu M MNat.prod.Res,19,**2005**, 591-595.
5. (a) Michael J PNat. Prod. Rep. 19,**2002,**742-760 (b) Michael J PNat. Prod. Rep, 20, **2003,**476-493. (c) Micheal J PNat. Prod. Re,21,**2004,** 650-668. (d) Micheal J PNat. Prod. Rep, 22,**2005,** 627-646.
6. Koehn F E & Carter G T,Nat. Rev. Drug Discov,4,**2005,** 206-220.
7. Arve L, VoigtT &Waldmann H,QSAR & Comb. Sci,25,**2006,** 449-456.
8. Breinbauer R, Vetter I R &Waldmann H,Angew. Chem. Int. Ed,41,**2002**, 2879-2890.
9. Tan D S,Comb. Chem, 7,**2004**, 631-643.
10. Boldi A M,Curr. Opin. Chem. Biol,8,**2004**, 281-286.
11. Liao Y, Hu Y, Wu J, Zhu Q, Donovan M, Fathi R & Yang Z,Curr. Med. Chem, 10, **2003**, 2285-2316.
12. Reen Y K, Fang R C, Chung Y C, Che M T, Hsin F Y& Yang C W,. Phytochemistry, 57,**2001**, 421.
13. Kaur K, Jain M, Kaur T& Jain R,Bio org. Med. Chem,17,**2009**, 3229.
14. Rocha L G, Almeida J R G S, Macedo R O & Barbosa F J M,Phytomedicine,12,**2005**, 514.
15. Abas F, Lajis N H, Israf D A, Khozirah S &Umi K Y,Food Chemistry,95,**2006**, 566.
16. Behforouz M, Cai W, Mohammadi F, Stocksdale M G, Gu Z, Ahmadian M, Baty D E, Etling M R, Al-Anzi C H, Swaftney T M, Tanzer L R& Merriman R L,Bio org. Med. Chem,15,**2007**, 495.
17. Abd El-Rady E & El-Azab I H,Chromene: European Journal of Chemistry,3(1),**2012**, 81-86.
18. Mohamed H M,AbdEl-Wahab A H F, Ahmed K A, El-Agrody A M, Bedair A H, Eid F A &Khafagy M M,Molecules,17(1),**2012**, 971-988.
19. Abdelkhalik M M, Eltoukhy A M, Agamey S M &Elnagdi M H,Journal of Hetero cyclic Chemistry,41(3), **2004**,431-435.
20. Tois J, Vahermo M & Koskinen A,Tetrahedron Letter,46(5),**2005**, 735-737.
21. Igor V M, Madhuri M, Marcia A O, Adriana S D, Snezna R, Severine V S, Wim F A S, Nikolai M E, Pavel Y U&Eerik M E,J. Med. Chem,51, **2008,** 2561-2570.

22. Magdy A I, Hany M H, Yassin A A G & Youssef A S A,Eur. J. Chem,1,**2010**, 195-199.
23. Vetrivel N, Senniappan T S, Helen P B, Senniappan M &Thangaian D T,Med. Chem.Res,21,**2012**, 2902-291.
24. Wang X S, Zeng Z S, Shi D Q, Wei X Y &Zong Z M,Synth. Com,**2004**,3021-3027.
25. Wang X S, Shi D Q &Tu S J,Chin. J. Chem,21, **2003**, 1114-1117.
26. Wang X S, Zeng Z S, Shi D Q, Tu S J, Wei X Y &Zong Z M, Chin. J. Org. Chem, 25, **2005**,579-582.
27. El-Taweel F M A &Elagamey A A, International Journal of Organic Chemistry,3,**2013** 58-70.
28. Dalip K V, Buchi R, Braj G M, Rana R k, Mallikarjuna N N&Rajender S V,Tetrahedron,63,**2007**, 3093-3097.
29. Xiao S W, Sheng Y G &Zhaob G,Tetrahedron: Asymmetry,19,**2008**, 709-714.
30. Bo W, Xiang G, Zhong Y, Wen X H & Yong G Z,Tetrahedron Letters,56**,2015**,4334-4338.
31. Ming Z, Huan H C, Jun C & Hai Y C,Synthetic Communications,37,**2007**, 231-235.
32. Mohammad G D & Mohammad E,Green Chem. 16,**2014**, 4914.
33. Gen Z, Yaohu Z, Jiexi Y, Ru C, Shoulei W,Yunxia M &Rui W,J. Org. Chem,77,**2012**, 878-888.
34. Behbahani F K &Sadeghi M, Journal of the Korean Chemical Society,57(3),**2013**,
35. Senthil K G, Zeller M, Frasso M A, Rajendra P K J,J.Heterocyclic Chem,52(3),**2015**, 926-930.
36. Shaghyegh G &Koorosh R,ORIENTAL JOURNAL OF CHEMISTRY,29(4)**,2013**,1637-1641.
37. Sunetra J, Reshma P, Digambar K, Ajinkya P, Dattatraya C &Madhukar D,Int. J.Pharm. Sci. Rev. Res,35(2),**2015**, 75-82.
38. Javad S, Hojat V, Mohammad M K & Ahmad R K,J. Heterocyclic Chem,48,**2011**, 484.
39. Yun M, Changtao Q, Meihua X &Jie S,J. Org.Chem. 64(17),**1999**, 6462-6467.
40. Mahesh A G,Jayadevappa H, Aralihalli S &Kittappa M, Letters in Organi Chemistry,5,**2008**, 628-632.
41. Leila Y M, Fatemeh A &Farshid G,Iranian Journal of Catalysis,4(2),**2014**, 85-89.
42. Paul Douglas S, Santhipriya D, Ramesh Y, Ravikumar M, Swathi B &Jayarao k,J.Chem. Sci,126,**2014**, 1715-1720.
43. Murthy Y L N, Diwakar B S, Govindh B, Nagalakshmi K, Kasi V IV &Rajendra S,J. Chem. Sci,124(3),**2012**,639-645.
44. Paul D S, Ravi K M, Swathi B, Satyanarayana B, Surekha P, Sruthi V & Raghu B K,Modern Research in Catalysis,5,**2016**, 31-44.
45. Paul D S, Swathi B, Ravi K M, Ramesh Y, Santhi P D & Jaya Rao K,Chemical science transactions,5(2),**2016**.
46. Paul D S, Pandu N C, Ramesh Y, Satyanarayana B, Ravi K M & Swathi B,International Journal of Engineering Science and Technology (IJEST),7(12),**2015**.
47. Swathi B, Ravi K M, Satyanarayana B, Pandu N C, Ramesh Y, Sruthi V, Rajendra K J, Raghu B K & Paul D S,Green and Sustainable Chemistry. 6,**2016**, 101-109.
48. Swathi B, Raghu Babu K & Paul Douglas S,IOSR Journal of Applied Chemistry,3(1),**2018**, 28-37.
49. Nadaraj V &Thamarai S S,International Journal of Engineering, Science and Technology,3(4), 297-302.
50. Schiemann k, Zenke F, Amendt C &Finsinger D,Bioorganic & Medicinal Chemistry Letters,20(5),**2010**,1491-5

Electronic Supplementary Information of Pyranodiquinoline Derivatives (1a-1e)

Antibacterial activity		**Antifungal activity**			
Gram positive		**Gram negative**		**Antifungal**	
Bacillus subtilis	**Staphylococcus aureus**	**Escherichia coli**	**Pseudomonas**	**Aspergillus Niger**	**Candida Albicans**
-	 "Zone of inhibition of 1a Staphylococcus aureus"	-	-	 "Zone of inhibition of 1aAspergillus Niger"	 "Zone of inhibition of 1aCandida Albicans"
-	 "Zone of inhibition of 1b Staphylococcus aureus"	-	-	 "Zone of inhibition of 1bAspergillus Niger"	 "Zone of inhibition of 1bCandida Albicans"

"Zone of inhibition of 1cBacillus subtilis"

"Zone of inhibition of 1cStaphylococcus aureus"

"Zone of inhibition of 1cEscherichia coli"

"Zone of inhibition of 1cPseudomonas"

-

-

"Zone of inhibition of 1dBacillus subtilis"

"Zone of inhibition of 1d Staphylococcus aureus"

"Zone of inhibition of 1dEscherichia coli"

"Zone of inhibition of 1dPseudomonas"

-

-

"Zone of inhibition of 1eBacillus subtilis"

"Zone of inhibition of 1e Staphylococcus aureus"

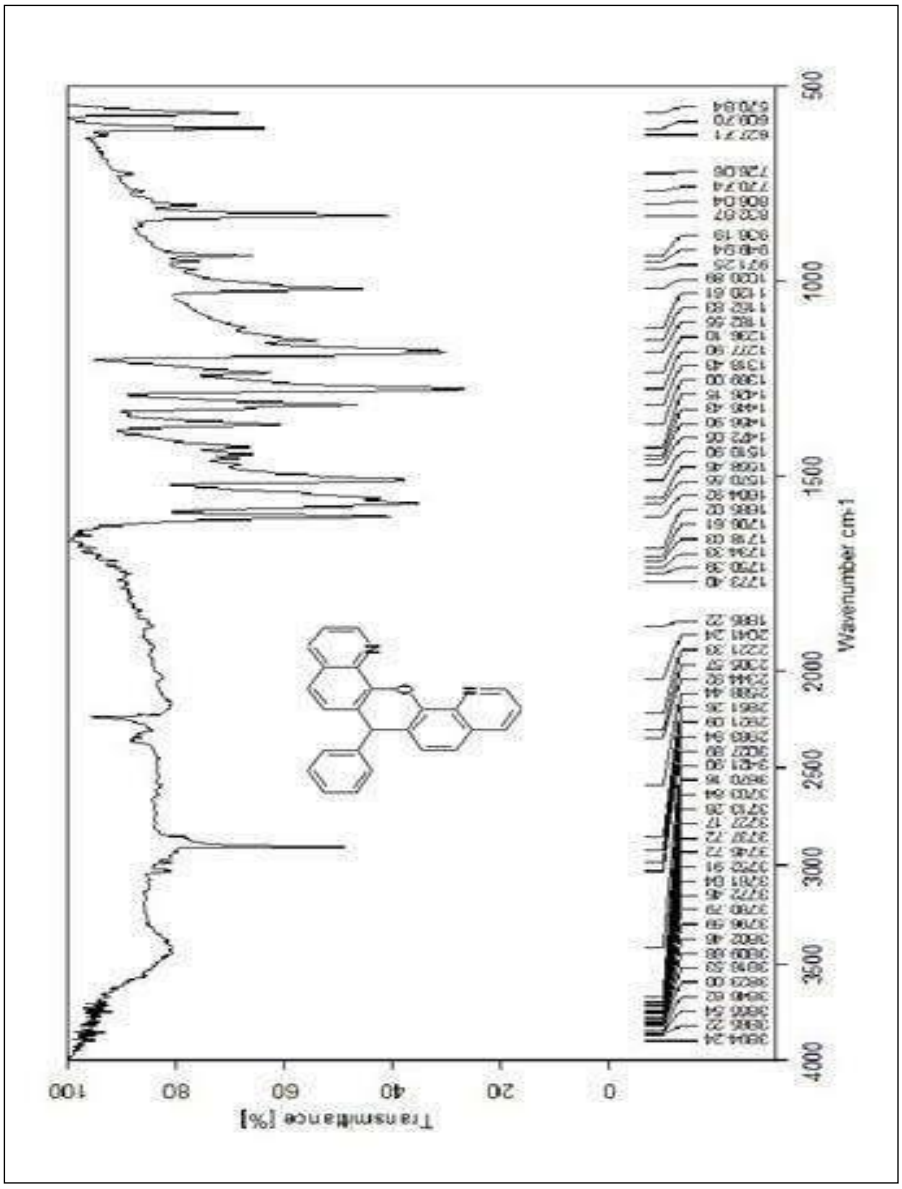
"Zone of inhibition of 1eEscherichia coli"

"Zone of inhibition of 1ePseudomonas"

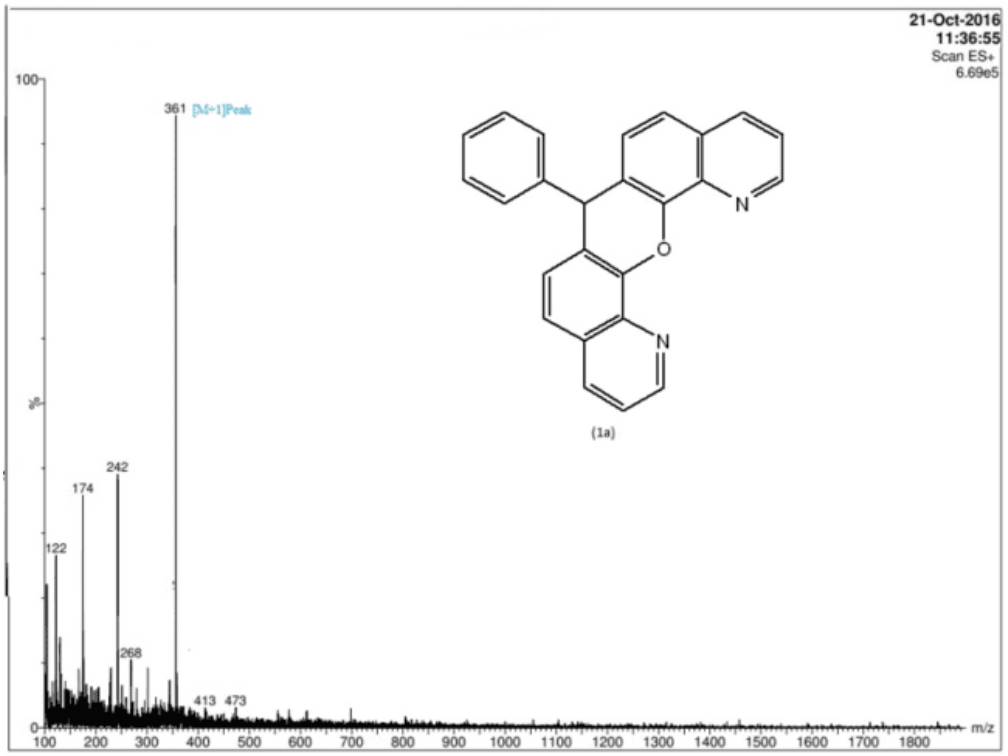
-

-

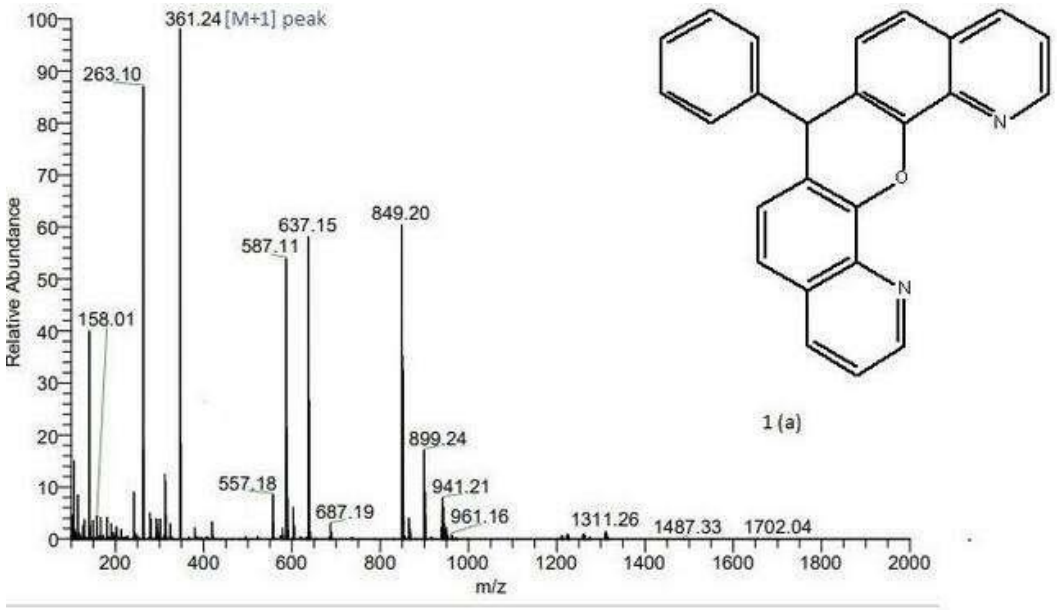
Figure 1.0 Zones of Inhibition



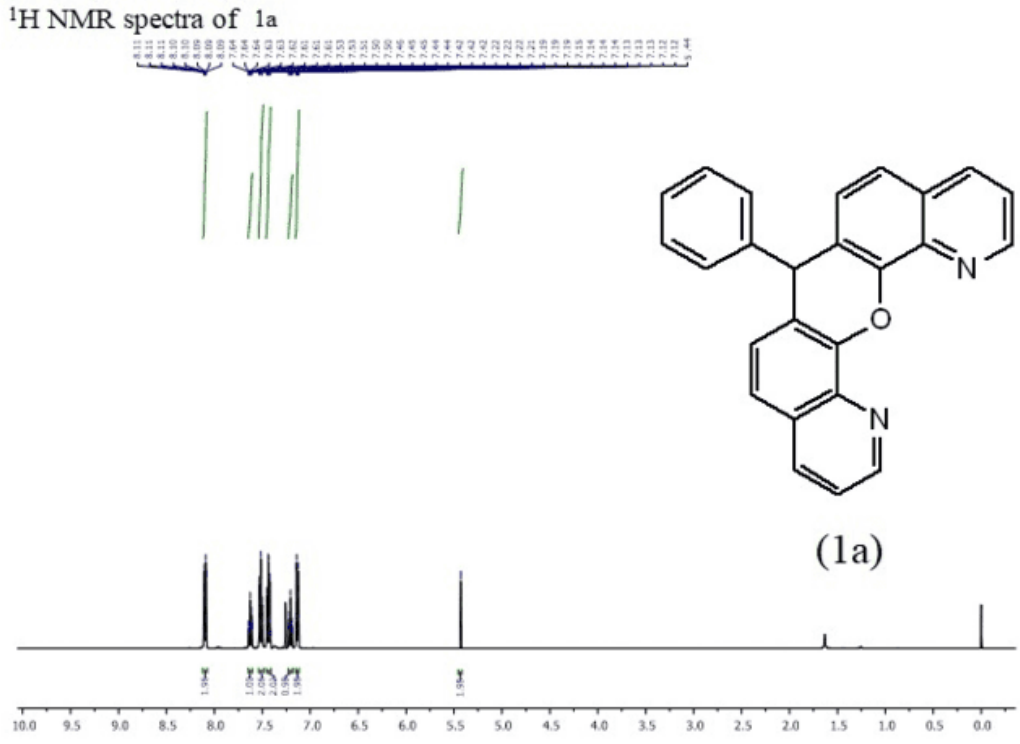
"Figure 1.1 FT-IR Spectrum of 7-phenyl-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1A)"



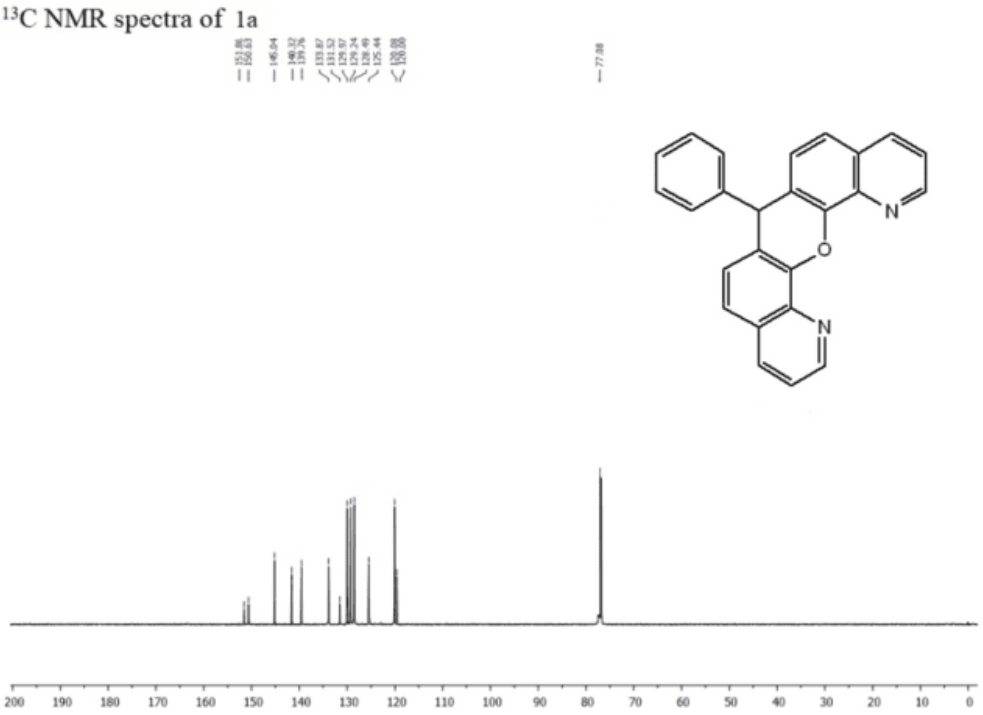
"Figure 1.2 MASS Spectrum of 7-phenyl-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1A)"



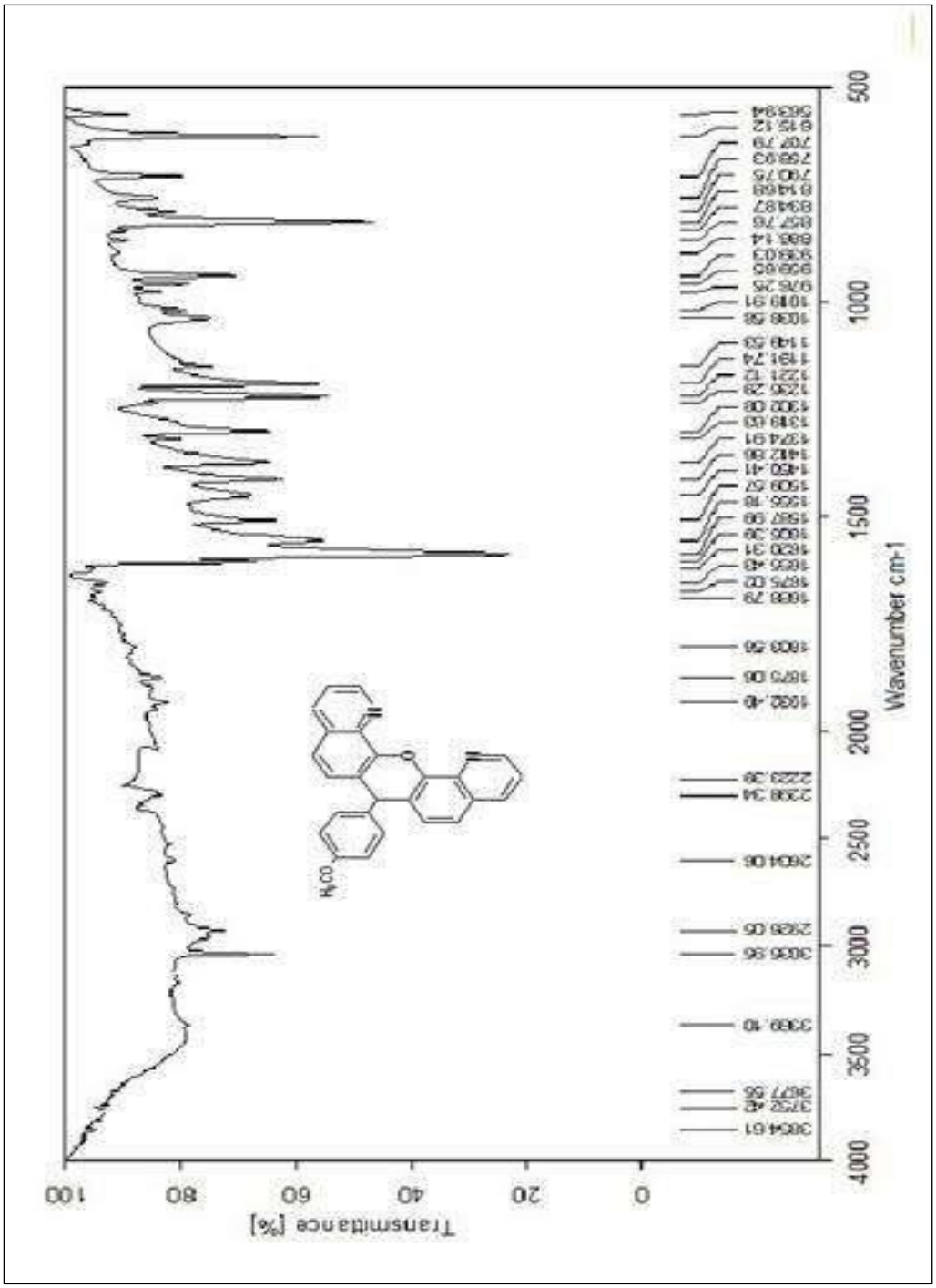
"Figure 1.3 HRMS Spectrum of 7-phenyl-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1A)"



"Figure 1.4[1]H NMR Spectrum of 7-phenyl-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1A)"

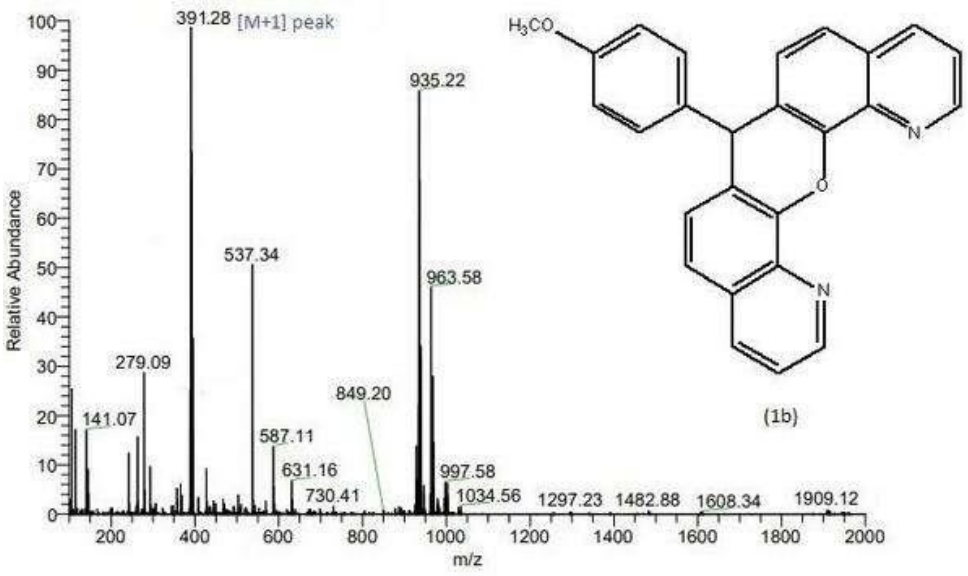


"Figure 1.5[13]CNMR Spectrum of 7-phenyl-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1A)"

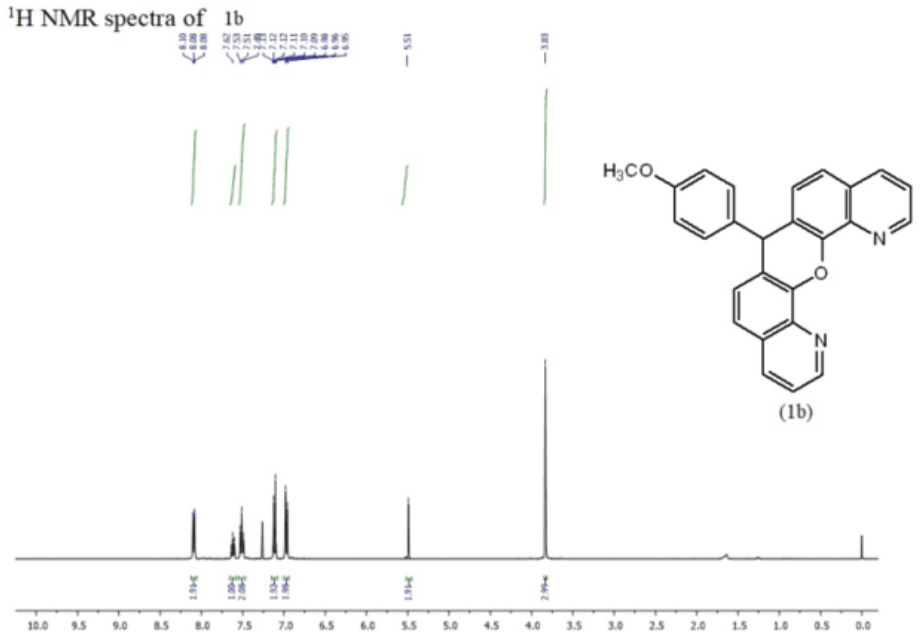


"Figure 1.6 FT-IR Spectrum of 7-(4-methoxyphenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1B)"

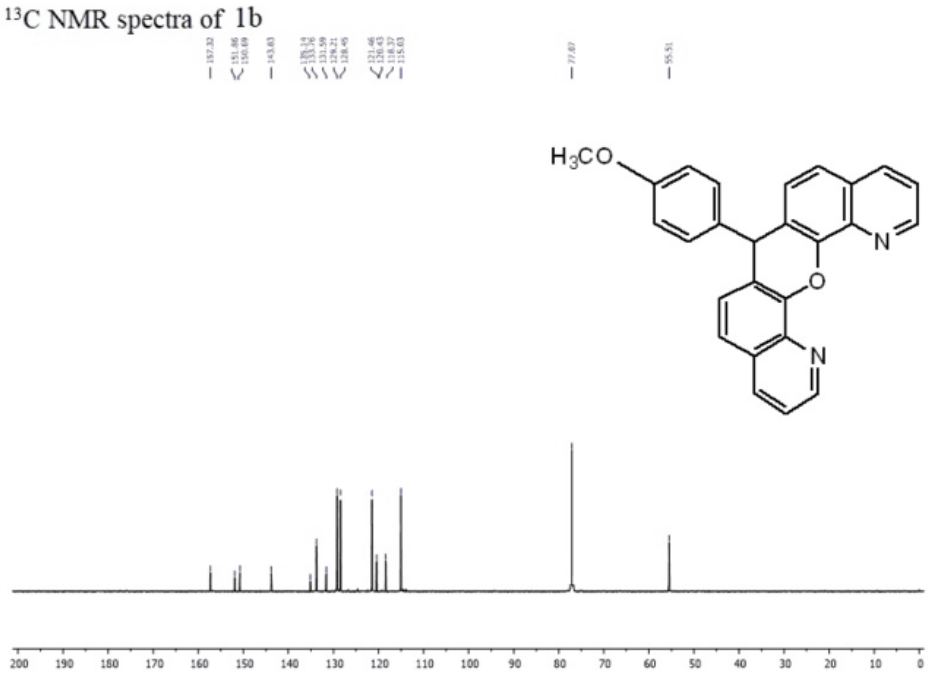
"Figure 1.7 MASS Spectrum of 7-(4-methoxyphenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1B)"



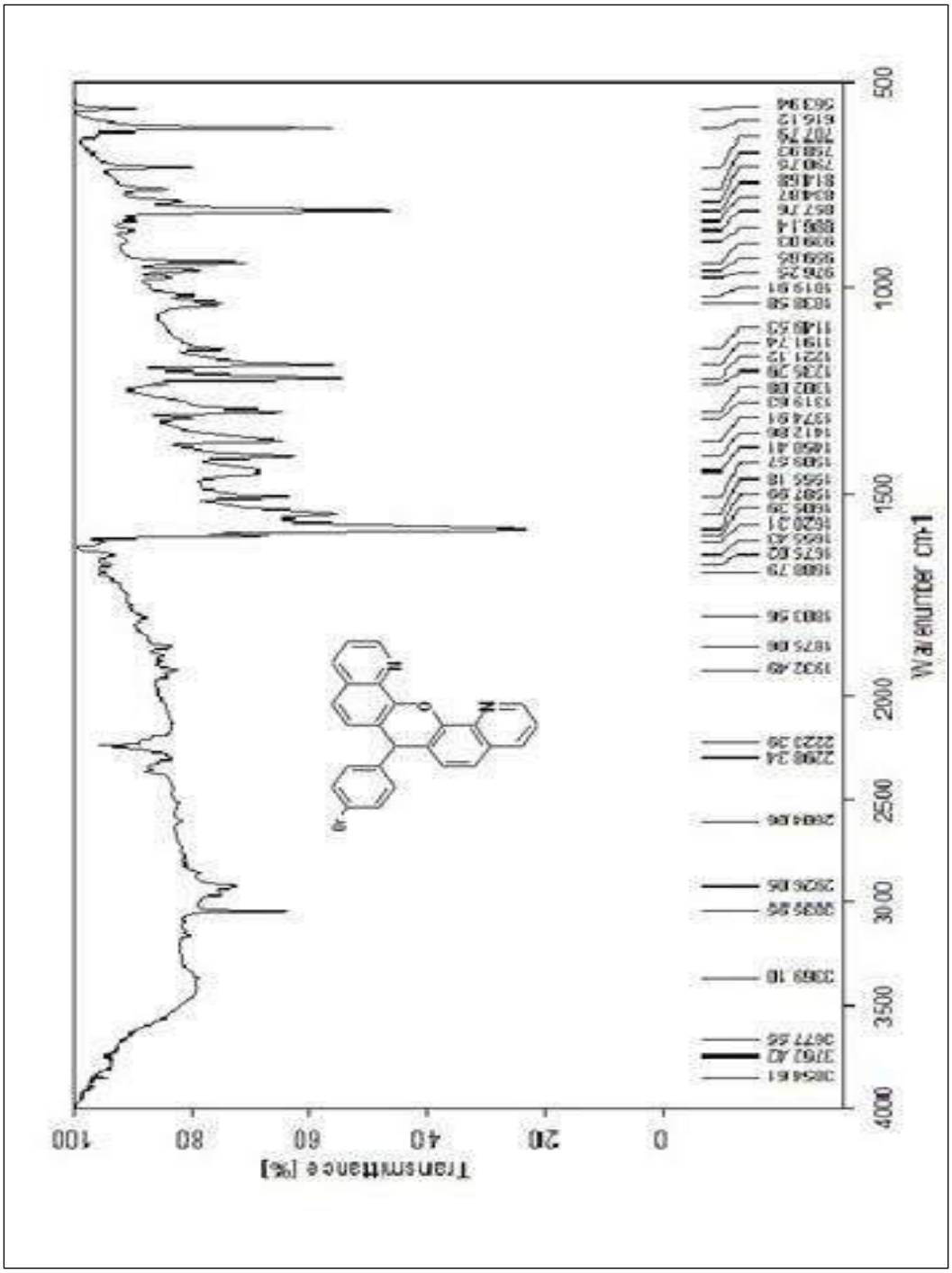
"Figure 1.8 HRMS Spectrum of 7-(4-methoxyphenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1B)"



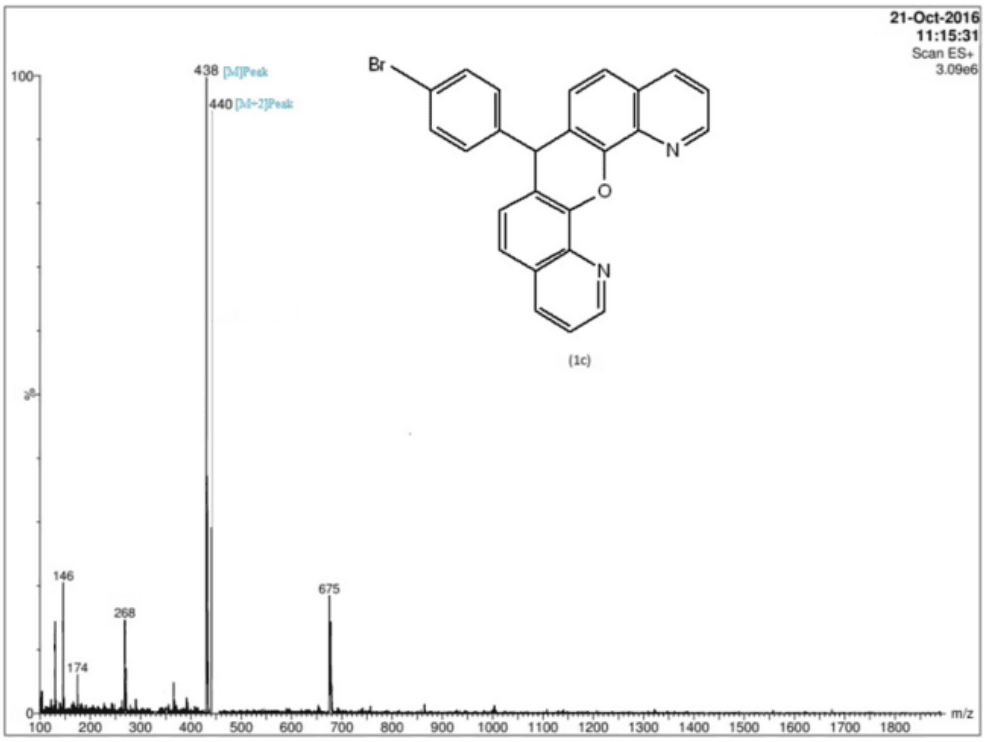
"Figure 1.9^{1}H NMR Spectrum of 7-(4-methoxyphenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1B)"



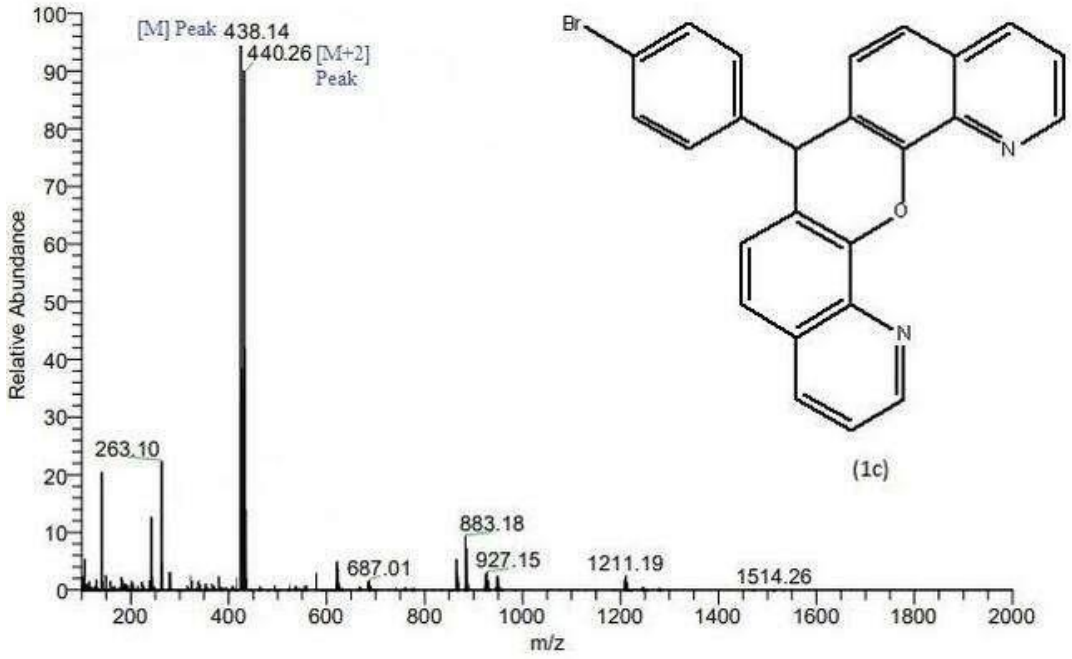
"Figure 1.10^{13}C NMR Spectrum of 7-(4-methoxyphenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1B)"



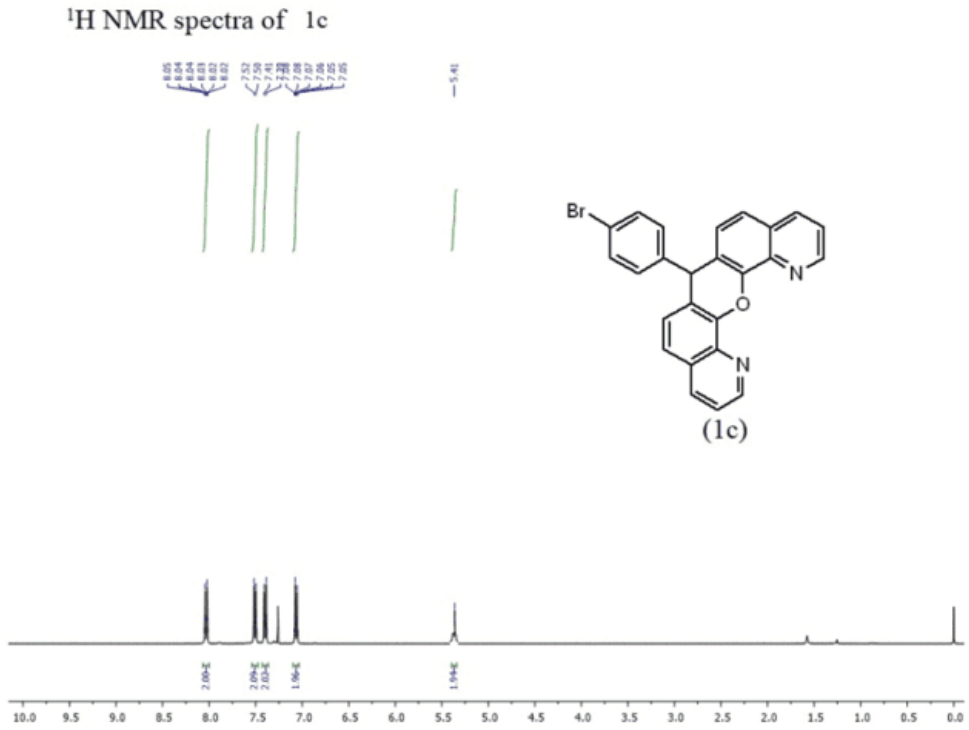
"Figure 1.11FT-IR Spectrum of 7-(4-bromophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1C)"



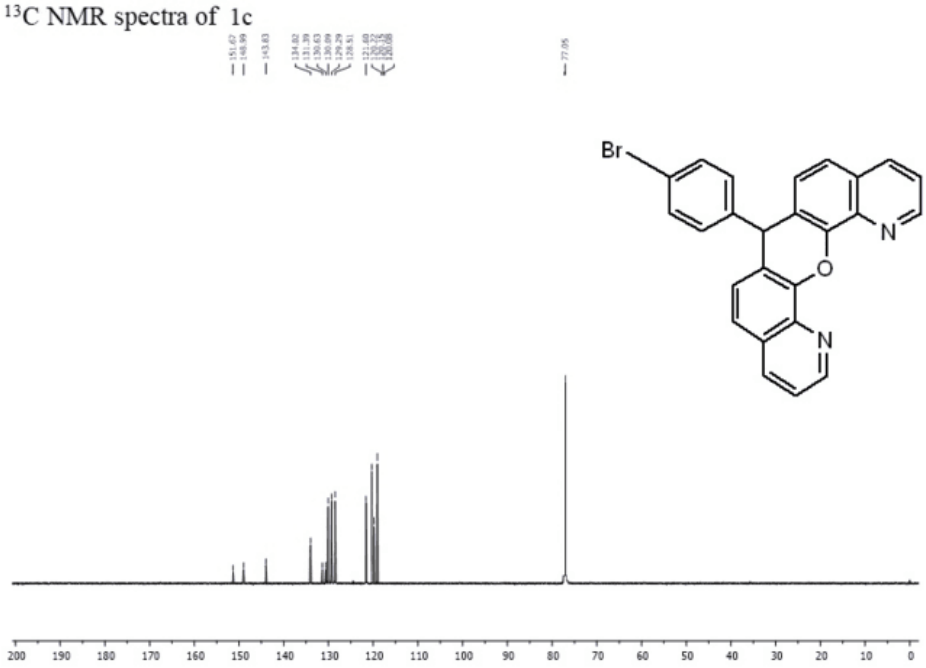
"Figure 1.12MASS Spectrum of 7-(4-bromophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1C)"



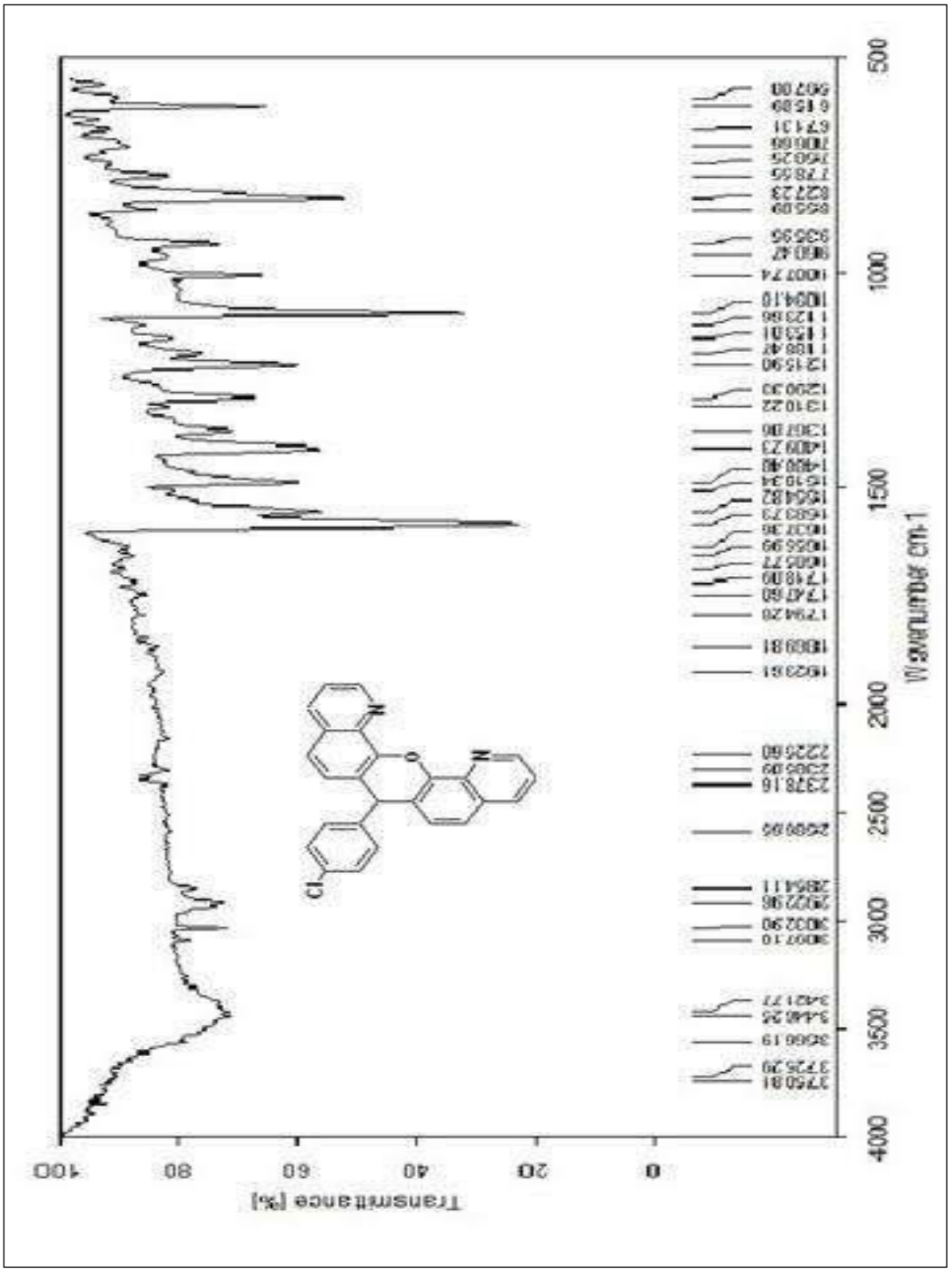
"Figure 1.13HRMS Spectrum of 7-(4-bromophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1C)"



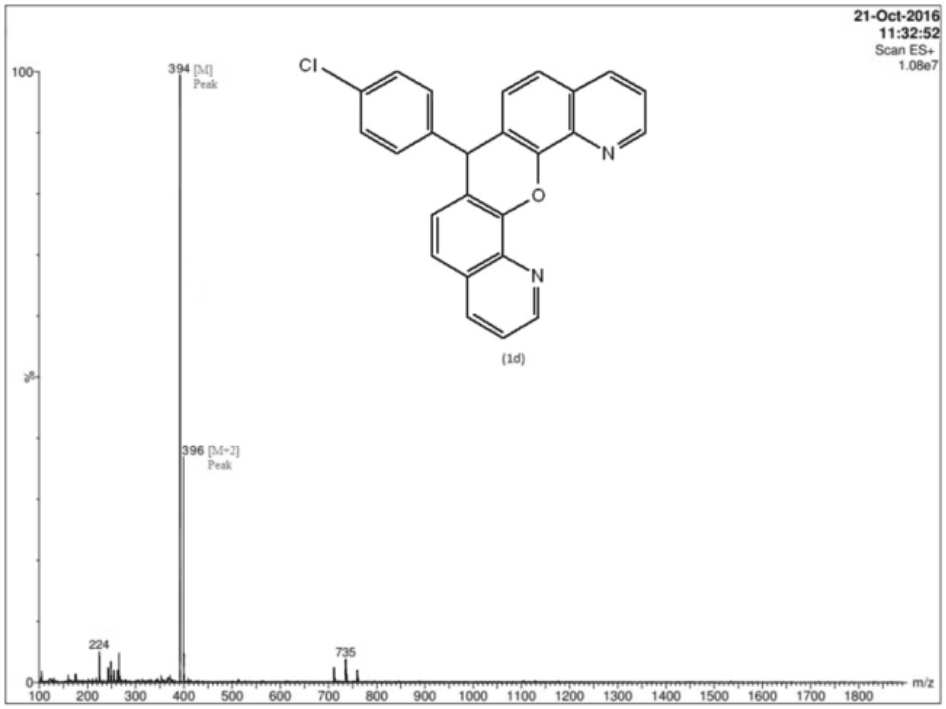
"Figure 1.14[1]H NMR Spectrum of 7-(4-bromophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1C)"



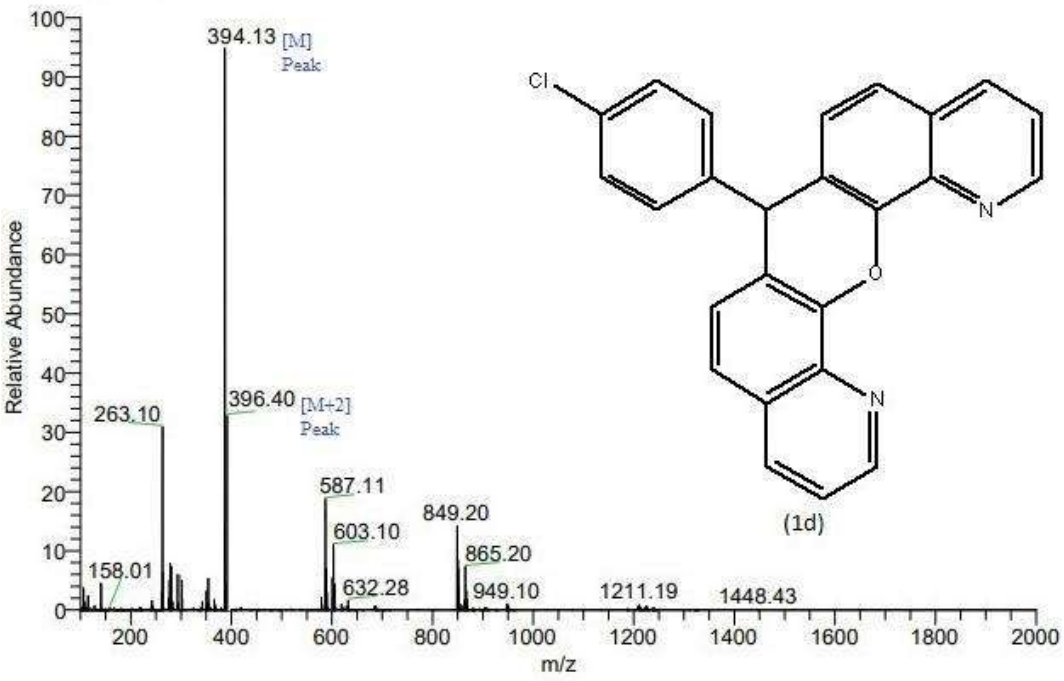
"Figure 1.15[13]C NMR Spectrum of 7-(4-bromophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1C)"



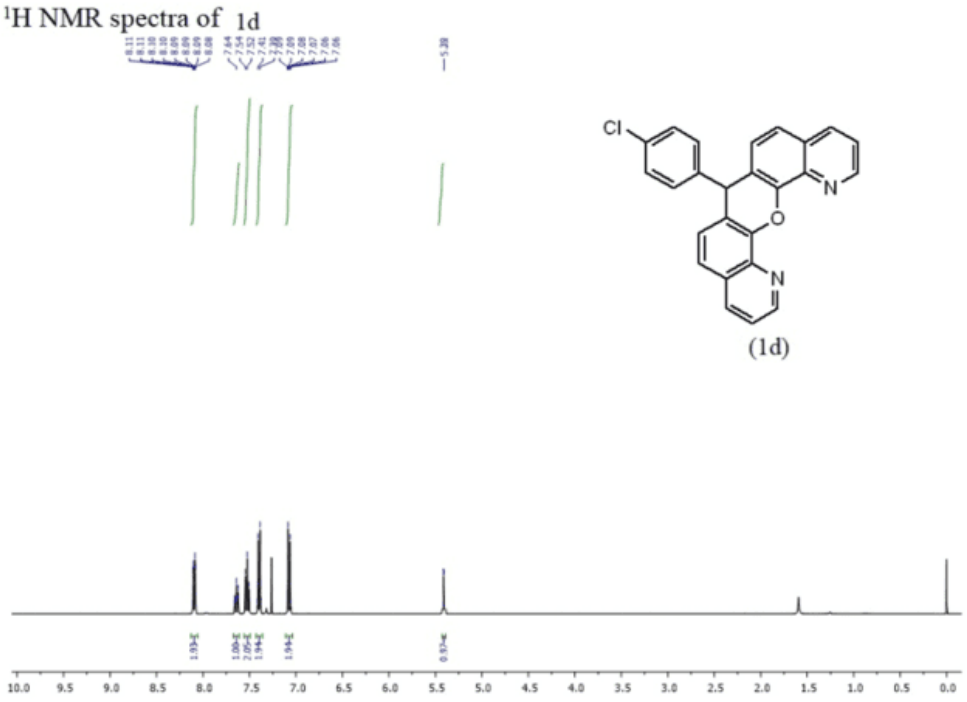
"Figure 1.6FT-IR Spectrum of 7-(4-chlorophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1D)"



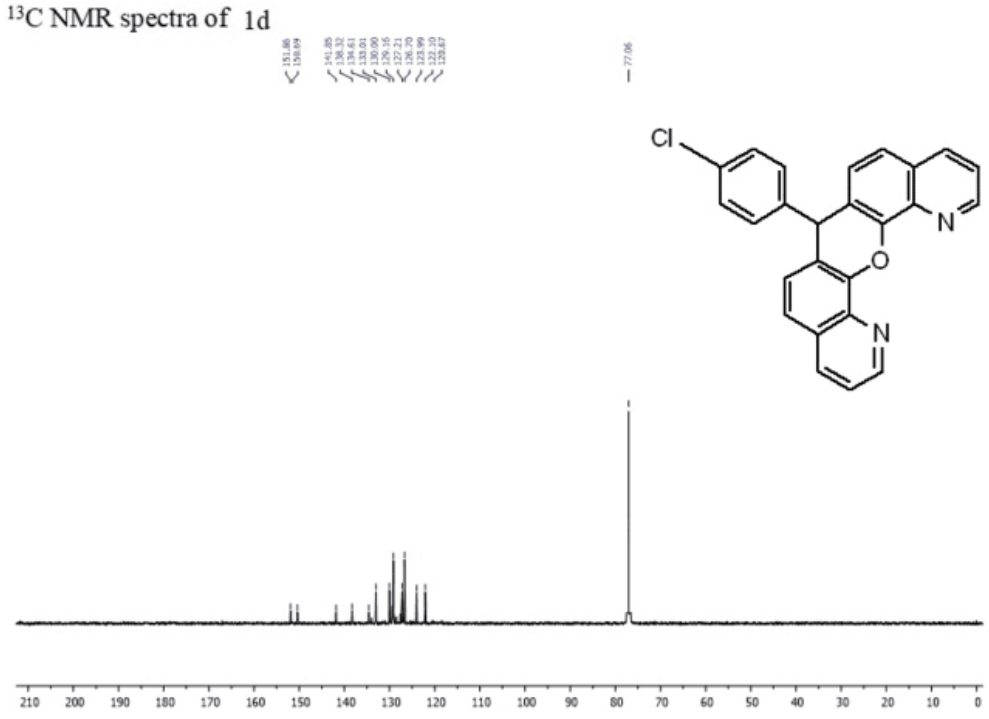
"Figure 1.17MASS Spectrum of 7-(4-chlorophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1D)"



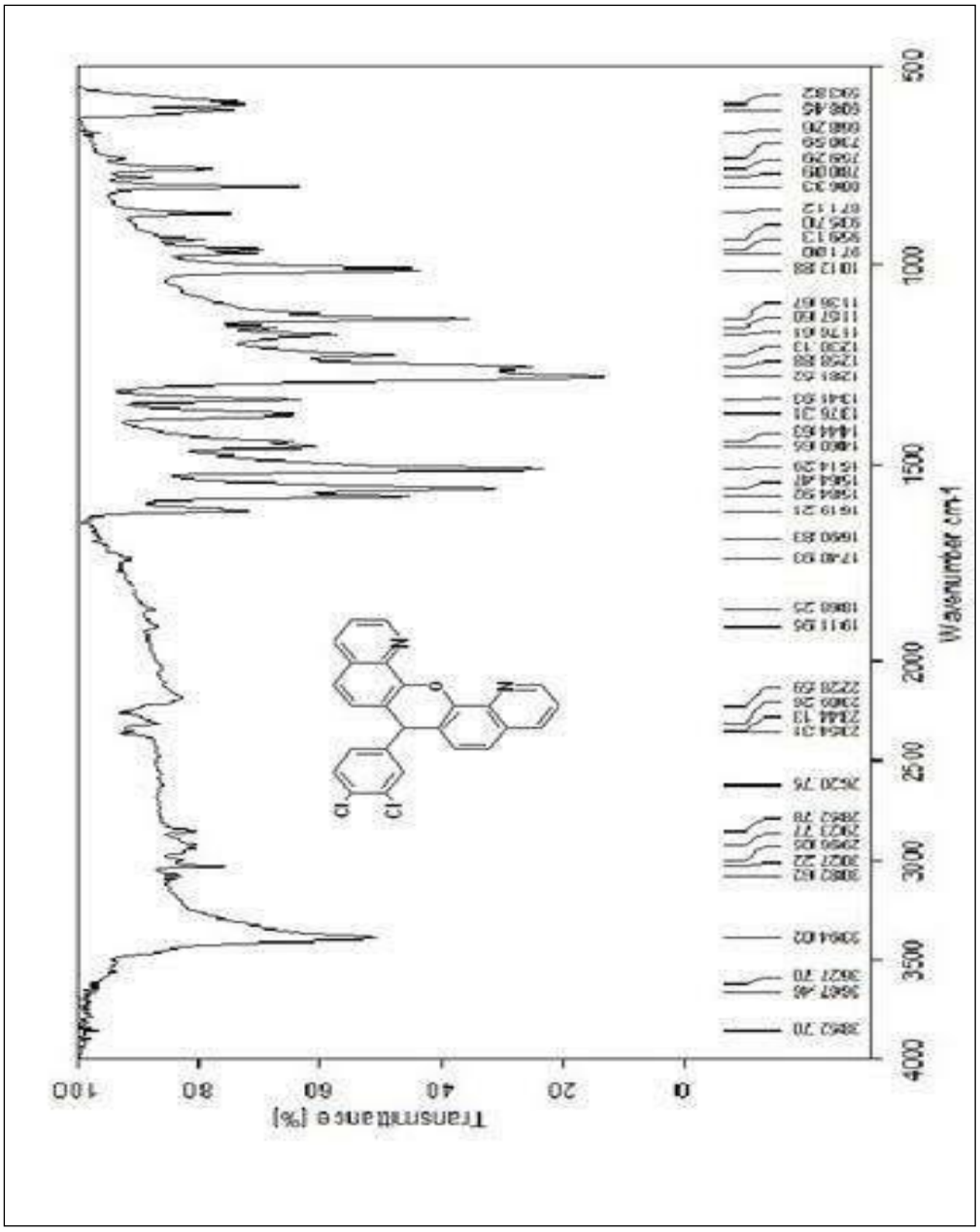
"Figure 1.18HRMS Spectrum of 7-(4-chlorophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1D)"



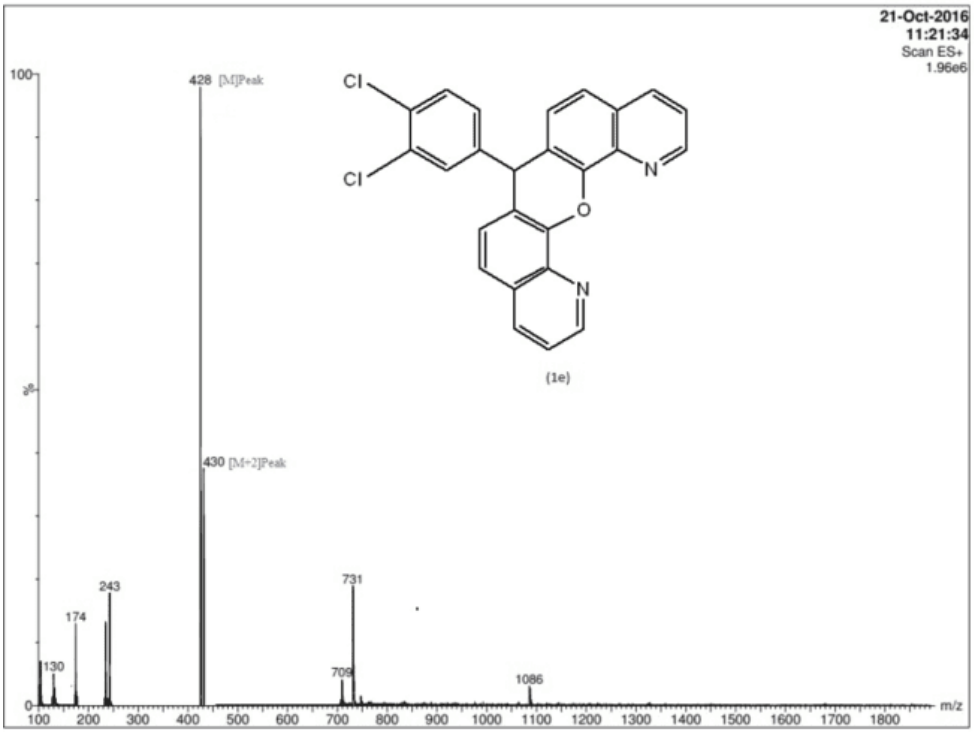
"Figure 1.19[1]H NMR Spectrum of 7-(4-chlorophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1D)"



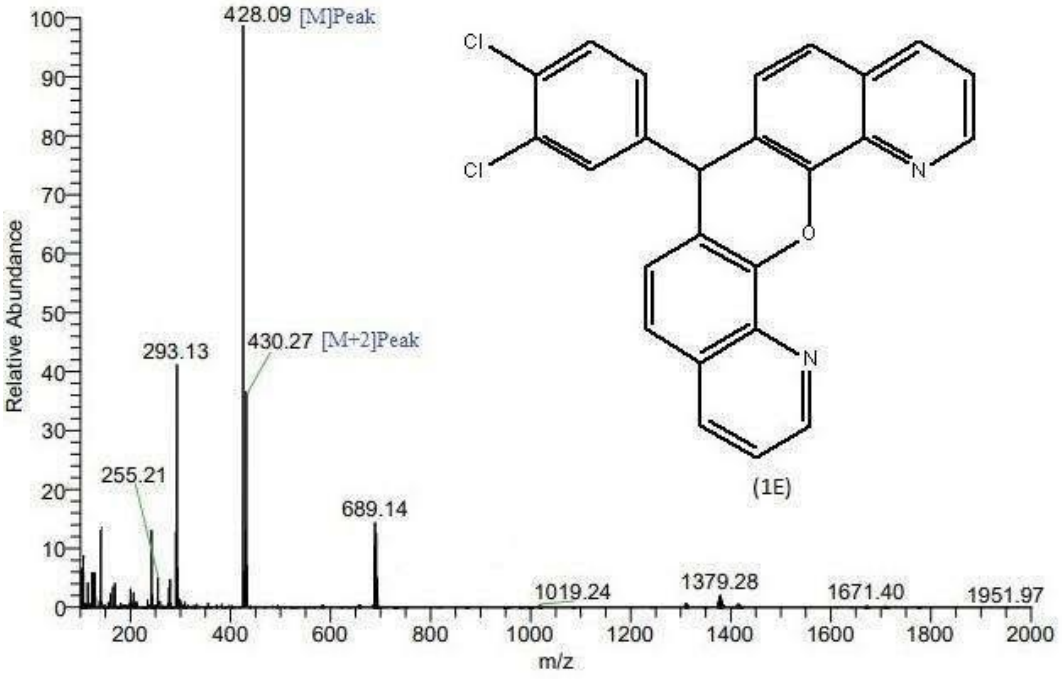
"Figure 1.20[13]C NMR Spectrum of 7-(4-chlorophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1D)"



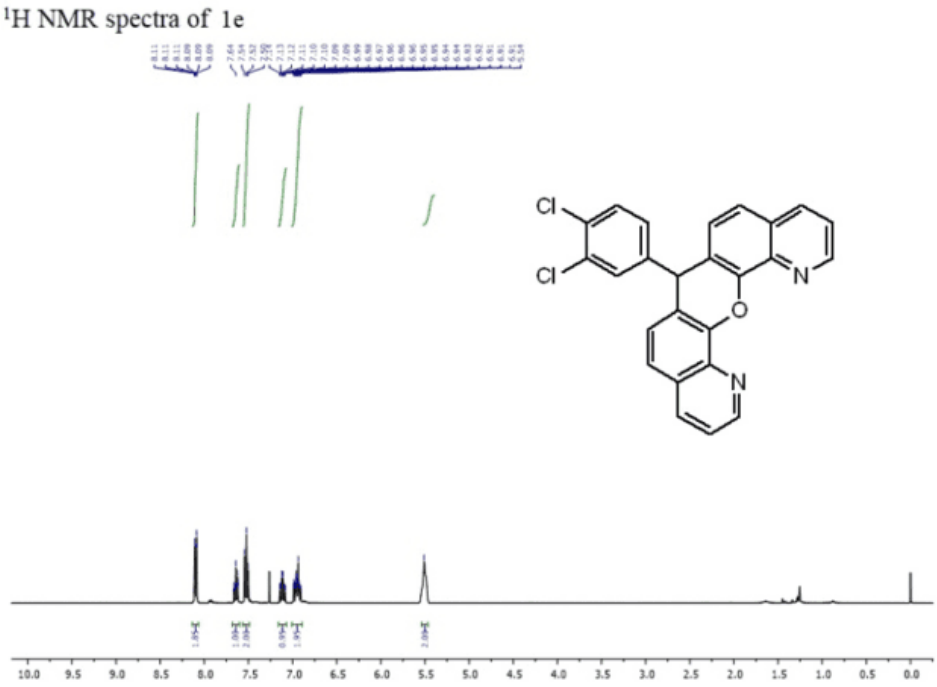
"Figure 1.21FT-IR Spectrum of 7-(3, 4-dichlorophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1E)"



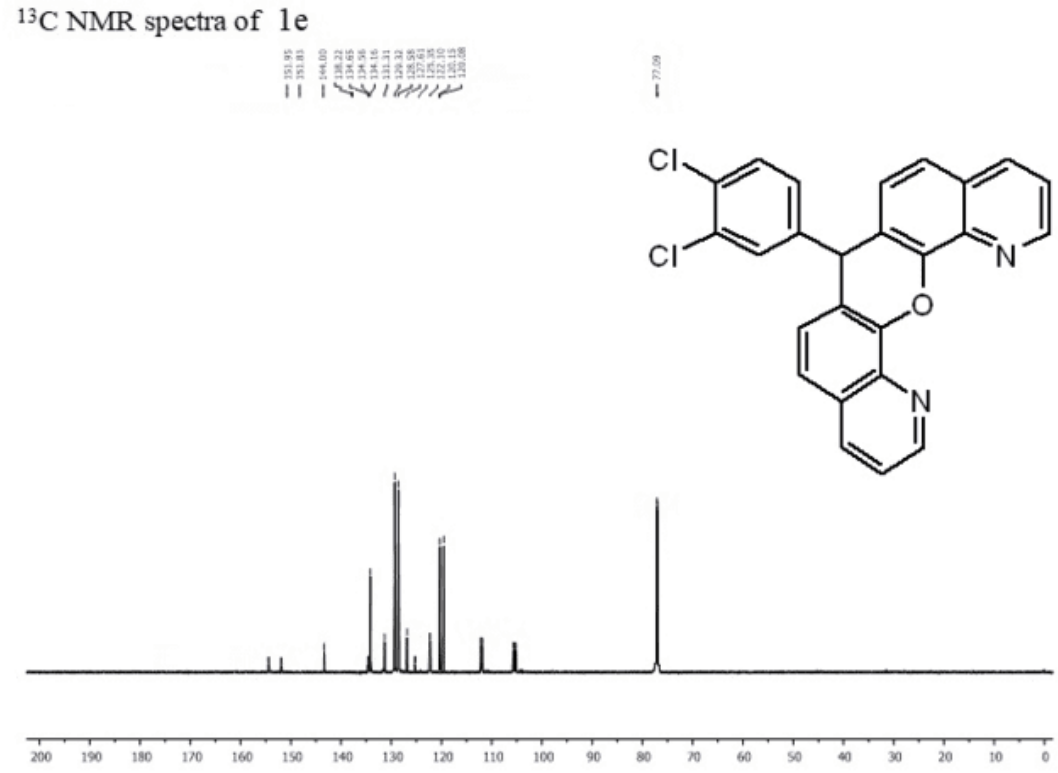
"Figure 1.22MASS Spectrum of 7-(3, 4-dichlorophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1E)"



"Figure 1.23HRMS Spectrum of 7-(3, 4-dichlorophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1E)"



"Figure 1.24[1]H NMR Spectrum of 7-(3, 4-dichlorophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1E)"



"Figure 1.25[13]C NMR Spectrum of 7-(3, 4-dichlorophenyl)-7H-pyrano [3, 2-h: 5, 6-h'] diquinoline (1E)"