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Microwave assisted synthesis of new coumarin based 3-cyanopyridine scaffolds bearing sulfonamide group having antimicrobial activity

N C Desai*, H M Satodiya, K M Rajpara, V V Joshi & H V Vaghani

Division of Green Chemistry, Department of Chemistry, DST-FIST Sponsored Department,
Maharaja Krishnakumarsinhji Bhavnagar University, Mahatma Gandhi Campus, Bhavnagar 364 002, India

E-mail: dnisheeth@rediffmail.com

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A new coumarin based 3-cyanopyridine scaffolds bearing biologically active sulfonamide group has been inserted using both conventional and microwave method. Initial step involves the synthesis of 2-amino-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(aryl)nicotinonitriles **5a-m** by reacting 3-acetyl-6-fluoro-2*H*-chromen-2-one **3**, various aromatic aldehydes **4a-m**, malononitrile and ammonium acetate. Finally compounds **5a-m** are reacted with benzenesulfonyl chloride to afford targeted compounds **7a-m**. These compounds have been characterized by means of IR, ^{1}H NMR, ^{13}C NMR and mass spectra. Newly synthesized compounds **7a-m** have been screened for their antibacterial and antifungal activities against *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Staphylococcus pyogenes*, *Candida albicans*, *Aspergillus niger and Aspergillus clavatus*. Compounds **7c**, **7d**, **7i**, **7j** and **7l** are found to possess significant activity against tested organisms.

Keywords: Coumarin, 3-cyanopyridine, sulfonamide, antimicrobial activity, microwave

Infectious diseases caused by bacteria and fungi affect millions of people worldwide and therefore the discovery of novel synthetic product as antimicrobials is the prerequisite of present health scenario, and continuous effort in development of same is very much required[1]. In drug designing programs an essential component of the search for new leads is the synthesis of molecules, which are novel yet resemble known biologically active molecules by virtue of the presence of critical structural features. There are a number of reports that synthetic coumarin and its derivatives have shown a wide spectrum of biological activity[2-4]. Novobiocin and chlorobiocin have established as antimicrobials containing a coumarin skeleton[5]. Several 3-(2-pyridyl)coumarins and 3-(3-pyridyl)coumarins have known for their antifungal activity[6,7].

On the other hand, sulfonamide group is considered as a pharmacophore which is present in a number of biologically active sulfa drugs, particularly in antimicrobial therapy[8-11]. Sulfonamides exert their effect by targeting on dihydropteroate synthase (DHPS) enzyme, which catalyzes folic acid pathway in bacteria and some eukaryotic cells[12] but is not present in human cells[13]. The use of sulfanilamide in therapy as a single agent is almost obsolete today due to the development of bacterial resistance to its effects and the development of more effective antimicrobial agents. However, clinical treatment with sulfonamides has undergone a revival with the use of a combination of sulfamethoxazole and trimethoprim to treat urinary tract bacterial infections[14]. These findings encouraged us to explore the synthesis of sulfonamide containing coumarin based 3-cyanopyridine scaffolds to examine their antibacterial and antifungal properties. The design concepts have been drawn in **Figure 1**, which explains the structural similarity of our new target compounds with commercially available drugs.

In the last few years microwave induced organic reactions have gained popularity as a non conventional technique for rapid organic synthesis[15], large number of reports have appeared in literature proving the utility of microwave in the field of organic reaction[16,17]. Recently reported studies on the microwave irradiation for the synthesis of hetero-cyclic compounds revealed that it is safe, rapid econo-mical viable and eco-friendly method for chemical transformation[18]. Pollution free synthesis, shorter reaction time, easy work-up and minimum use of solvent are the major advantages of this technique[19]. We have reported here the microwave induced synthesis and antimicrobial evaluation of new

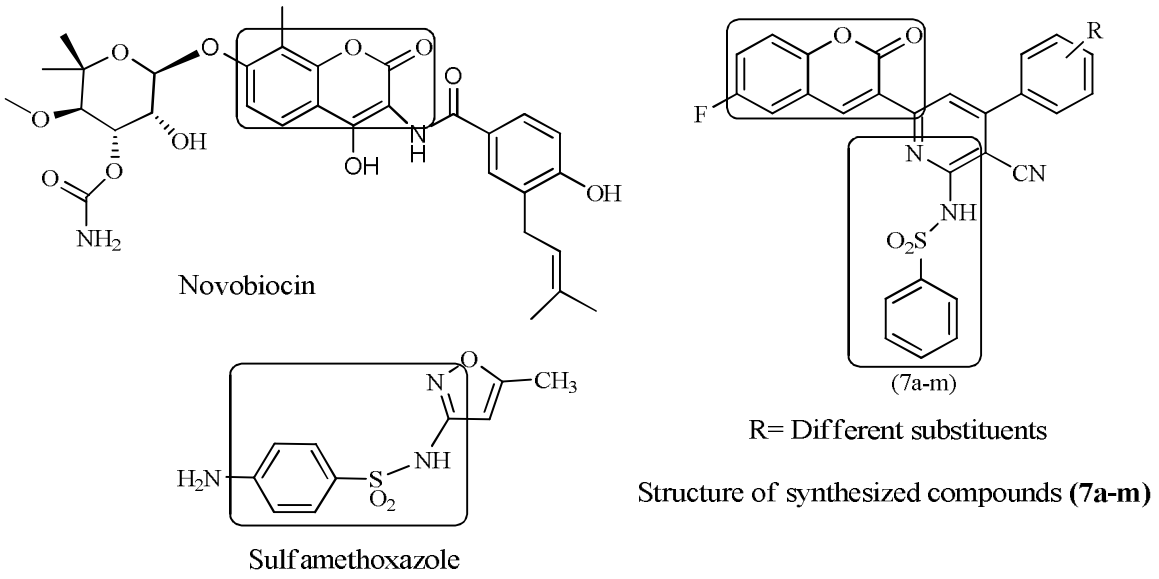


Figure 1 — Structural similarity between commercially available drugs and targeted compounds

N-(3-cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(aryl)pyridin-2-yl)benzenesulfonamides. The coumarin nucleus in these compounds is attached by pyridine moieties at C-3 position and second position of pyridine ring has been linked with phenyl ring by sulphonamide group.

Results and Discussion

A facile and efficient approach for the synthesis of title compounds has been developed. The comparison between conventional and microwave method, reaction time and % yield of targeted compounds are shown in **Table I**. The reaction time for each reaction was differed based on the functional groups present on reactant and their electronic effects. In the first step 3-acetyl-6-fluoro-2*H*-chromen-2-one **3** was synthesized by reaction of 5-fluoro-2-hydroxybenzaldehyde **1** with ethyl acetoacetate **2**. Second step involves the synthesis of 2-amino-4-(aryl)-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)nicotinonitriles **5a-m** by reacting 3-acetyl-6-fluoro-2*H*-chromen-2-one **3** with appropriate aromatic aldehydes **4a-m**, malononitrile and ammonium acetate.

Finally 2-amino-4-(aryl)-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)nicotinonitriles **5a-m** were reacted with benzenesulfonyl chloride in presence of dry pyridine and acetic anhydride to give *N*-(3-cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(aryl)pyridin-2-yl)benzenesulfonamide **7a-m**. The synthetic route of compounds is outlined in **Scheme I**. The comparison of classical and microwave methods clearly revealed that the reaction time was reduced considerably from hours to minutes in microwave irradiation method. Microwave irradiation resulted in increased yield of the products in the range of 15-20%.

Structural features of the synthesized compounds were determined with the help of FTIR, ^{1}H NMR, ^{13}C NMR and mass spectral studies. In IR spectrum of the compounds *N*-(3-cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(aryl)pyridin-2-yl)benzenesulfonamides **7a-m**, disappearance of band at 3150-3100 cm^{-1} of –NH_2 gave confirmation about the formation of -SO_2NH- linkage in title compounds which showed characteristic absorption bands around 1210-1160 cm^{-1}.

Moreover, absorption bands ranging from 1270-1250 cm^{-1} and 2220-2200 cm^{-1} indicated the presence of C-O-C in coumarin and cyano group on pyridine ring in all synthesized compounds. In addition, presence of fluorine atom on coumarin ring was proved on the basis of peak showed around 1200-1100 cm^{-1}. A signal displayed at 2240-2210 cm^{-1} gave the conformation of cyano group present at pyridine ring in all compounds.

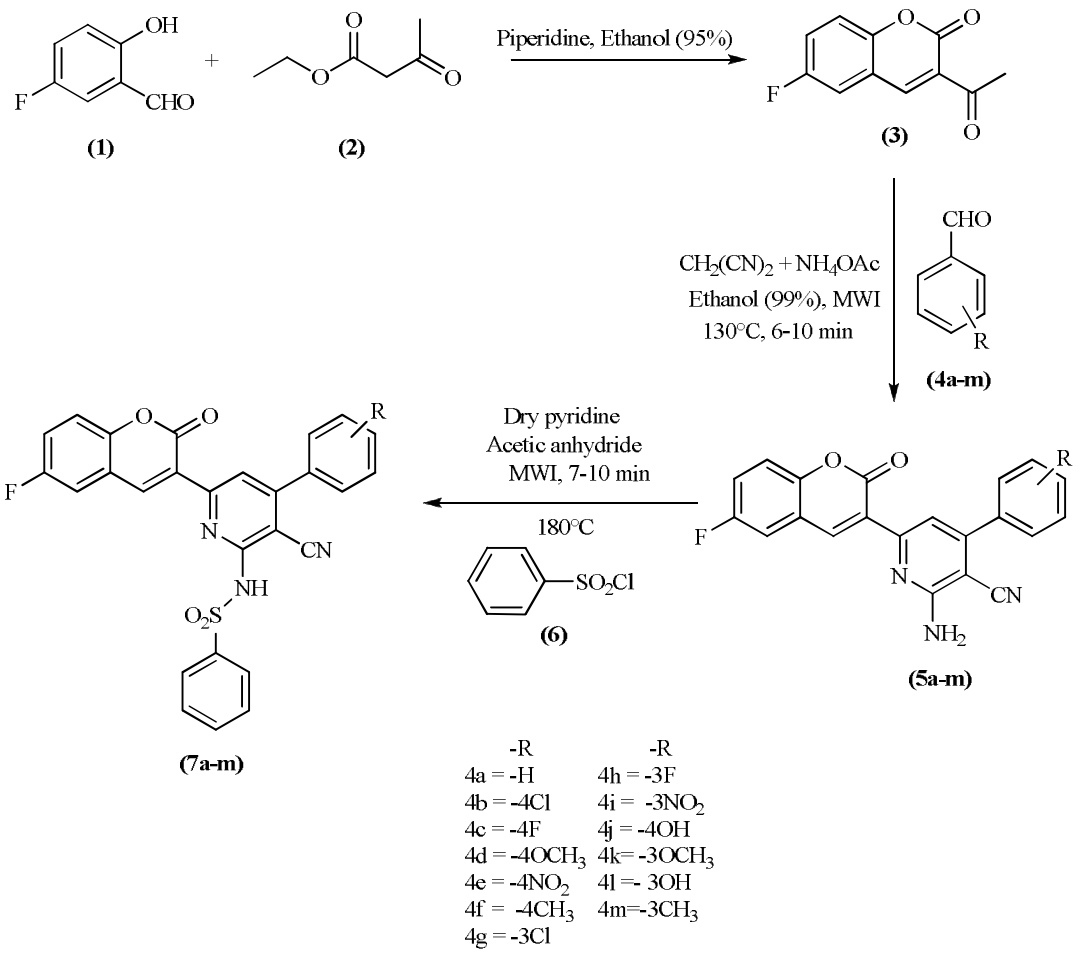
The ^{1}H NMR data of all compounds revealed the signal between δ 7.10- 8.75 for aromatic protons of all the targeted compounds. Protons of primary amine in compounds **5a-m** showed singlet at δ 6.75-6.90. A characteristic singlet at δ 9.10-9.20 assigned by disappearing signal showed by proton of primary amine in compounds **5a-m** which indicates that primary amine was converted into sulfonamide group. Furthermore methoxy group present in compounds **7d** and **7k** showed singlet at around δ 3.85. In case of

Table I — Reaction conditions for compounds **5a-m** and **7a-m**

Compd	Reaction time		Yield (%)		Solvent for crystallization
	Microwave method (min)	Conventional method (hr)	Microwave method	Conventional Method	
5a	6	10	82	69	Methanol
5b	9	12	70	63	Chloroform
5c	10	11	79	70	Chloroform
5d	7	19	79	68	Benzene
5e	6	15	80	67	Ethyl acetate
5f	6	11	75	69	Methanol
5g	8	15	78	69	Methanol
5h	6	14	87	72	Benzene
5i	7	12	80	57	Ethyl acetate
5j	9	10	81	69	Ethyl acetate
5k	9	13	75	62	Ethyl acetate
5l	7	16	70	62	Benzene
5m	6	14	80	65	Methanol
7a	8	19	73	55	Methanol
7b	8	20	82	63	Chloroform
7c	8	22	75	70	Methanol
7d	9	21	78	63	Methanol
7e	7	20	80	71	Ethyl acetate
7f	8	19	70	61	Chloroform
7g	8	24	75	63	Chloroform
7h	9	20	70	58	Chloroform
7i	10	26	71	64	Benzene
7j	9	26	66	60	Methanol
7k	9	29	72	59	Benzene
7l	7	28	72	60	Benzene
7m	10	23	79	65	Methanol

compounds **7f** and **7m** singlet displayed at around δ 2.52 was due to presence of methyl group. ^{13}C NMR of targeted compounds were assigned signals at δ 164.9-165.7 to carbon of pyridine ring attached with -NH-SO_2- group. Carbon attached with cyano group showed signal around δ 100.5. All aromatic carbons displayed signal between δ 110.0-155.0. The other signals and peaks of ^{1}H NMR, ^{13}C NMR and IR are in complete agreement with the assigned structures and are listed in the Experimental Section.

In the present communication, we have concentrated on the effect of various substituents on phenyl ring attached to 4-position of cyanopyridine ring. The individual minimum inhibitory concentration (MIC, μg/mL) obtained for compounds **7a-m** are presented in **Table II**. Compounds **7c** (4-F), **7d** (4-OCH_3), **7i** (3-NO_2) and **7l** (3-OH) exhibited maximum activity while compounds **7e** (4-NO_2), **7h** (3-F), **7j** (4-OH), **7k** (3-OCH_3) were found to possess good activity against *E.coli*. Compound **7c** (4-F) showed excellent activity, while compounds **7d** (4-OCH_3), **7h** (3-F), **7j** (4-OH) and **7i** (3-NO_2) showed moderate activity against *P. aeruginosa.* In case of *S. aureus*, compounds **7d** (4-OCH_3) and **7j** (4-OH) exhibited very good activity, while **7c** (4-F), **7g** (3-Cl), **7k** (3-OCH_3) were equipotent as compared to standard drug. Compounds **7c** (4-F), **7d** (4-OCH_3) and **7l** (3-OH) showed good activity against *S. pyogenes*. For antifungal activity, compounds **7c** (4-F), **7d** (4-OCH_3), **7h** (3-F) displayed good activity, while compounds **7j** (4-OH) and **7i** (3-NO_2) exhibited excellent activity against *C. albicans.* Compounds **7d** (4-OCH_3) and **7l** (3-OH) displayed good activity, while compounds **7c** (4-F) and **7j** (4-OH) were found to possess very good activity against



Scheme I — Synthetic pathway of coumarin derivatives **7a-m**

A. niger. Compounds **7e** (4-NO_2), **7f** (4-CH_3) and **7l** (3-OH) possessed good activity against *A. clavatus*. The enhancement of activity of these compounds was due to the presence of methoxy, methyl, nitro and hydroxyl groups in title compounds. The discussion and comparison of antibacterial and antifungal activity is based on standard drugs ampicillin and griseofulvin respectively.

Antimicrobial assay

The newly synthesized compounds **7a-m** were screened for their antibacterial activity against Gram-positive bacteria (*S. aureus* (MTCC-96), *S. pyogenes* (MTCC-442)) and Gram-negative (*E. coli* (MTCC-443), *P. aeruginosa* (MTCC-1688)). All MTCC cultures were collected from Institute of Microbial Technology, Chandigarh. The activity of compounds was determined as per National Committee for Clinical Laboratory Standards (NCCLS) protocol using Mueller Hinton Broth (Becton Dickinson, USA)[20-23]. Compounds were screened for their antibacterial activity as primary screening in six sets against *E. coli*, *S. aureus*, *P. aeruginosa* and *S. pyogenes* at different concentrations of 1000, 500, 250 µg/mL. The compounds found to be active in primary screening were similarly diluted to obtain 200, 100, 50, 25 and 12.5 µg/mL concentrations for secondary screening to test in a second set of dilution against all microorganisms. Inoculum size for test strain was adjusted to 10^6 CFU/mL (Colony Forming Unit per milliliter) by comparing the turbidity (turbidimetric method). Mueller Hinton Broth was used as a nutrient medium to grow for test bacteria. 2% DMSO was used as a diluent/vehicle to obtain the desired concentration of synthesized compounds and standard drugs to test upon standard microbial strains. The control tube containing no antibiotic was immediately subcultured [before inoculation] by spreading a loopful evenly over a quarter of plate of medium suitable for the growth of test organisms. The tubes were then put for incubation

Table II — *In vitro* antibacterial and antifungal activities of compounds **7a-m**

Compd	Minimum inhibitory concentration (MIC) in µg/mL±SD[a]				Minimum inhibitory concentration (MIC) in µg/mL±SD[b]		
	E.c. MTCC 443	*P.a.* MTCC 1688	*S.a.* MTCC 96	*S.p.* MTCC 442	*C.a.* MTCC 227	*A.n.* MTCC 282	*A.c.* MTCC 1323
7a	1000±3.25	200±3.68**	1000±2.81	200±3.10	1000±2.28	500±1.98	500±3.68
7b	250±1.77**	500±2.78	500±1.75**	500±4.38*	1000±3.40**	1000±2.26*	1000±3.55*
7c	50±3.53	50±2.01*	250±4.12	100±2.46	500±3.48	50±4.87**	1000±2.40**
7d	50±1**	100±2.03*	200±3.80*	100±2.18**	500±2.19**	100±3.46*	500±1.21
7e	100±2.43**	500±3.77	500±2.28	1000±3.11	1000±3.21	500±1.91	100±2.10**
7f	250±1.45	250±4.01	1000±2.48*	1000±3.07*	1000±3.14**	500±1.29**	100±3.40***
7g	1000±2.62*	250±1.12**	250±3.25*	500±2.28*	1000±1.06*	1000±5.10	>1000
7h	100±3.40*	100±2.46*	500±2.76	250±3.68	500±1.21	500±2.39***	500±4.35*
7i	50±3.04	200±1.12	500±1.20*	1000±3.22	1000±1.08*	1000±1.56	>1000
7j	100±2.48	100±2.08***	200±3.48**	100±3.57	250±4.51	50±1.36*	500±1.06**
7k	100±1.19**	250±1.03	250±1.77**	200±3.10*	1000±1.40**	500±1.26**	200±2.29
7l	50±2.31*	100±3.11**	1000±1.09***	100±4.02**	250±1.49*	100±2.43	100±3.29*
7m	500±2.09*	250±3.75*	500±2.01**	500±2.23	1000±3.68	500±3.46**	500±4.27*
Amp.	100±1.08	100±1.00	250±1.52	100±2.06	—	—	—
Gre.	—	—	—	—	500±0.58	100±1.00	100±1.15

± *SD* standard deviation, ***P < 0.001 extremely significant, **P < 0.01 moderately significant,
*P < 0.05 significant. All values are presented as mean of 6 experiments (n = 6). All significant differences are considered from control value 0.00. 2% DMSO used as control and its antibacterial activity is nil or zero.
[a] *E.c.- Escherichia coli*, *P.a.- Pseudomonas aeruginosa*, *S.a.- Staphylococcus aureus*, *S.p.- Streptococcus pyogenes.*
[b] *C.a.- Candida albicans*, *A.n.- Aspergillus niger*, *A.c.- Aspergillus clavatus.*
Amp.- ampicillin, Gre.- griseofulvin

at 37°C for 24 hr for bacteria. The highest dilution (lowest concentration) preventing appearance of turbidity was considered as minimum inhibitory concentration (MIC, µg/mL) i.e. the amount of growth from the control tube before incubation (which represents the original inoculum) was compared. A set of tubes containing only seeded broth and solvent controls were maintained under identical conditions so as to make sure that the solvent had no influence on strain growth. The result of this was greatly affected by the size of inoculum. The test mixture should contain 10^6 CFU/mL organisms. Standard drug used in the present study was 'ampicillin' for evaluating antibacterial activity which showed 100, 100, 250 and 100 µg/mL MIC against *E. coli*, *P. aeruginosa*, *S. aureus* and *S. pyogenes* respectively.

The same compounds **7a-m** were tested for antifungal activity as primary screening in six sets against *C. albicans* (MTCC 227), *A. niger* (MTCC 282) and *A. clavatus* (MTCC 1323) at various concentrations of 1000, 500, 250 µg/mL. The compounds found to be active in primary screening were similarly diluted to obtain 200, 100, 50, 25 and 12.5 µg/mL concentrations for secondary screening to test in a second set of dilution against all microorganisms. Griseofulvin was used as a standard drug for antifungal activity, which showed 500, 100 and 100 µg/mL MIC against *C. albicans*, *A. niger* and *A. clavatus* respectively. For fungal growth, in the present protocol, we have used sabourauds dextrose broth at 28°C in an aerobic condition for 72 hr.

Statistical analysis

Standard deviation value is expressed in terms of ±SD. On the basis of calculated value by using One-way ANOVA method followed by independent two sample *t* test, it has been observed that differences below 0.001 levels are considered statistically significant. Compounds **7a-m** were screened for their antibacterial and antifungal activities in six sets (*n*) against bacteria and fungi used in the present protocol.

Experimental Section

All reactions except those in aqueous media were carried out by standard techniques for the exclusion of moisture. Melting points were determined on an electro thermal melting point apparatus and were reported in **Table III**. TLC on silica gel plates

Table III — Physical and analytical data of newly synthesized compounds (**5a-m)** and **(7a-m)**

Compd	R	Mol. Formula	m.p. (°C)	Elemental analysis Calcd % (Found)		
				C	H	N
5a	H	$C_{21}H_{12}FN_3O_2$	170-72	70.58 (70.42	3.38 3.24	11.76 11.62)
5b	4-Cl	$C_{21}H_{11}ClFN_3O_2$	210-12	64.38 (64.19	2.83 2.74	10.73 10.59)
5c	4-F	$C_{21}H_{11}F_2N_3O_2$	165-67	67.20 (67.11	2.95 2.81	11.20 11.12)
5d	4-OCH_3	$C_{22}H_{14}FN_3O_3$	230-32	68.21 (68.05	3.64 3.48	10.85 10.72)
5e	4-NO_2	$C_{21}H_{11}FN_4O_4$	195-97	62.69 (62.61	2.76 2.69	13.93 13.85)
5f	4-CH_3	$C_{22}H_{14}FN_3O_2$	157-59	71.15 (71.05	3.80 3.68	11.32 11.18)
5g	3-Cl	$C_{21}H_{11}ClFN_3O_2$	198-200	64.38 (64.21	2.83 2.69	10.73 10.65)
5h	3-F	$C_{21}H_{11}F_2N_3O_2$	261-63	67.20 (67.07	2.95 2.80	11.20 11.09)
5i	3-NO_2	$C_{21}H_{11}FN_4O_4$	211-13	62.69 (62.58	2.76 2.64	13.93 13.84)
5j	4-OH	$C_{21}H_{12}FN_3O_3$	149-51	67.56 (67.44	3.24 3.07	11.26 11.12)
5k	3-OCH_3	$C_{22}H_{14}FN_3O_3$	244-46	68.21 (68.05)	3.64 3.48	10.85 10.72)
5l	3-OH	$C_{21}H_{12}FN_3O_3$	172-74	67.56 (67.44)	3.24 3.07	11.26 11.12)
5m	3-CH_3	$C_{22}H_{14}FN_3O_2$	155-57	71.15 (71.05)	3.80 3.68	11.32 11.20)
7a	H	$C_{27}H_{16}FN_3O_4S$	285-87	65.18 (65.13)	3.24 3.23	8.45 8.42)
7b	4-Cl	$C_{27}H_{15}ClFN_3O_4S$	268-71	60.96 (60.95	2.84 2.80	7.90 (7.86)
7c	4-F	$C_{27}H_{15}F_2N_3O_4S$	291-93	62.91 (62.85	2.93 2.90	8.15 8.09)
7d	4-OCH_3	$C_{28}H_{18}FN_3O_5S$	>300	63.75 (63.69	3.44 3.42	7.97 7.90)
7e	4-NO_2	$C_{27}H_{15}FN_4O_6S$	244-47	59.78 (59.75	2.79 2.77	10.33 10.34)
7f	4-CH_3	$C_{28}H_{18}FN_3O_4S$	190-93	65.74 (65.71	3.55 3.51	8.21 8.19)
7g	3-Cl	$C_{27}H_{15}ClFN_3O_4S$	>300	60.96 (60.91	2.84 2.80	7.90 7.85)
7h	3-F	$C_{27}H_{15}F_2N_3O_4S$	288-90	62.91 (62.89	2.93 2.92	8.15 8.13)
7i	3-NO_2	$C_{27}H_{15}FN_4O_6S$	>300	59.78 (59.75	2.79 2.76	10.33 10.31)
7j	4-OH	$C_{27}H_{16}FN_3O_5S$	265-67	63.15 (63.13	3.14 3.09	8.18 8.11)
7k	3-OCH_3	$C_{28}H_{18}FN_3O_5S$	280-83	63.75 (63.68	3.44 3.38	7.97 7.92)
7l	3-OH	$C_{27}H_{16}FN_3O_5S$	>300	63.15 (63.09	3.14 3.11	8.18 8.12)
7m	3-CH_3	$C_{28}H_{18}FN_3O_4S$	210-12	65.74 (65.69	3.55 3.48	8.21 8.17)

(Merck, 60, F_{254}) was used for purity checking and reaction monitoring. Column chromatography on silica gel (Merck, 70–230 mesh and 230–400 mesh ASTH for flash chromatography) was applied when necessary to isolate and purify the reaction products. Elemental analysis (% C, H, N) was carried out by a Perkin-Elmer 2400 CHN analyzer. IR spectra of all compounds were recorded on a Perkin-Elmer FT-IR spectrophotometer in KBr. ^{1}H NMR spectra were recorded on Varian Gemini 300 MHz and ^{13}C NMR spectra on Varian Mercury-400, 100 MHz in DMSO-d_6 as a solvent and tetramethylsilane (TMS) as an internal standard. All chemical shifts were expressed in ppm. Mass spectra were scanned on a Shimadzu LCMS 2010 spectrometer. Anhydrous reactions were carried out in oven-dried glassware in nitrogen atmosphere.

General procedure for the preparation of 3-acetyl-6-fluoro-2*H*-chromen-2-one, 3.

5-Fluoro-2-hydroxybenzaldehyde (1mmol) and equivalent amount of ethyl aceto acetate (1 mmol) was dissolved in 95% ethanol. The reaction mixture was stirred for 10 minutes after adding 2-3 drops of piperidin as catalyst. After completion of reaction (as observed by TLC), the mass was poured to the crushed ice. The product was extracted from solution with ethyl acetate. The solvent was evaporated and the crude product was recrystallized from ethanol.

General procedure for the synthesis of 2-amino-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(aryl)-nicotinonitrile derivatives, 5a-m.

Conventional method

A mixture of compound 3-acetyl-6-fluoro-2*H*-chromen-2-one **3** (2 mmol), malononitrile (2 mmol), substituted aromatic aldehydes (2 mmol) **4a-m** and ammonium acetate (8 mmol) in 10 mL ethanol (95%) were heated under reflux for specified time given in **Table I**. Excess ethanol (95%) was distilled out and the residual product was poured into 100 mL cold water. The solid obtained was separated by filtration, dried and crystallized from appropriate solvent given in **Table I**.

Microwave method

A mixture of 3-acetyl-6-fluoro-2*H*-chromen-2-one **3** (2 mmol), malononitrile (2mmol), substituted aromatic aldehydes (2 mmol) **4a-m** and ammonium acetate (8 mmol) in ethanol (95%) (10 mL) was introduced into microwave reaction vessel equipped with a magnetic stirrer (Synthos-3000). The vessel was sealed and the reaction mixture was irradiated by 350 W for a specified time given in **Table I**. The solid product was washed with cold water and crystallized from appropriate solvent given in **Table I**.

General procedure for the synthesis of *N*-(3-cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(4-aryl)pyridin-2-yl)benzenesulfonamides, 7a-m.

Conventional method

A mixture of 2-amino-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(aryl)nicotinonitriles **5a-m** (2 mmol), benzenesulfonyl chloride (2 mmol) and 4 mL of dry pyridine were refluxed in 5 mL acetic anhydride for specified time given in **Table I**. After completion of the reaction, mixture was poured into 100 mL of ice-cold water and the solid product was precipitated out, which was filtered, washed with cold water and recrystallized from appropriate solvent given in **Table I**.

Microwave method

2-Amino-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(aryl)nicotinonitriles **5a-m** (2 mmol), and benzenesulfonyl chloride (2 mmol) were added to a mixture of 4 mL of dry pyridine and 10 mL of acetic anhydride. The mixture was irradiated in microwave reaction vessel equipped with a magnetic stirrer at 350 W for specified time given in **Table I**. The reaction mixture was then poured into 50 mL of ice-water and solid obtained was filtered and crystallized from appropriate solvent given in **Table I**.

3-Acetyl-6-fluoro-2*H*-chromen-2-one, 3.

Yield: 75%; m.p. 210-14°C; IR (KBr): 3020, 1701, 1200,1160 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.55 (s, 1H, C_4 proton of coumarin), 2.30 (s, 3H, proton of –$COCH_3$), 7.00-7.30 (m, 3H, Ar-H); ^{13}C NMR (100 MHz, DMSO-d_6): δ 198.1 (1C, -*C*O-CH_3), 162.0 (1C, *C*=O), 159.1 (1C, *C*-F), 148-114.2 (7C, Ar-C), 30.1 (1C, -CH_3); LCMS: *m/z* 206.04 (M^+); Anal. Calcd. For $C_{11}H_7FO_3$: C, 64.08; H, 3.42; N, 0.00; Found: C, 64.02; H, 3.36; N, 0.00%.

2-Amino-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-phenylnicotinonitrile, 5a.

IR (KBr): 3117, 2219, 1688, 1645, 1603, 1598, 1590, 1519, 1260, 1140 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.67 (s, 1H, C_4 proton of coumarin), 8.09 (s, 1H, C_5 proton of pyridine), 7.58-7.80 (m, 5H,

phenyl ring), 7.41-7.55 (m, 3H, C_5, C_7 and C_8 proton of coumarin), 6.90 (s, 2H, $-NH_2$); ^{13}C NMR (100 MHz, DMSO-d_6): δ 163.0 (1C, *C*=O), 161.5 (1C, *C*-NH_2), 159.0 (1C, *C*-F), 155-115.1 (16C, Ar-C), 112.7 (1C, *C*≡N), 98.5 (1C, -*C*-C≡N); LCMS: *m/z* 357.09 (M^+).

2-Amino-4-(4-chlorophenyl)-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)nicotinonitrile, 5b.

IR (KBr): 3122, 2220, 1685, 1647, 1608, 1596, 1593, 1520, 1260, 1144, 832 cm^{-1}; ^1H NMR (300 MHz, DMSO-d_6): δ 8.70 (s, 1H, C_4 proton of coumarin), 8.10 (s, 1H, C_5 proton of pyridine), 7.55-7.82 (m, 4H, phenyl ring), 7.35-7.49 (m, 3H, C_5, C_7 and C_8 proton of coumarin), 6.87 (s, 2H, $-NH_2$); ^{13}C NMR δ 163.5 (1C, C=O), 161.3 (1C, *C*-NH_2), 160.0 (1C, *C*-F), 156-114.2 (16C, Ar-C), 112.9 (1C, *C*≡N), 96.5 (1C, -*C*-C≡N); LCMS: *m/z* 391.05 (M^+).

2-Amino-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(4-fluorophenyl)nicotinonitrile, 5c.

IR (KBr): 3119, 2218, 1682, 1644, 1609, 1597, 1590, 1528, 1263, 1142 cm^{-1}; ^1H NMR (300 MHz, DMSO-d_6): δ 8.72 (s, 1H, C_4 proton of coumarin), 8.01 (s, 1H, C_5 proton of pyridine), 7.60-7.74 (m, 4H, phenyl ring), 7.29-7.49 (m, 3H, C_5, C_7 and C_8 proton of coumarin), 6.82 (s, 2H, $-NH_2$); ^{13}C NMR (100 MHz, DMSO-d_6): δ 163.7(1C, *C*=O), 161.8(1C, *C*-NH_2), 161.0 (1C, *C*-F), 160.3 (1C, *C*-F), 157-113.2 (15C, Ar-C), 111.9 (1C, *C*≡N), 97.0 (1C, -*C*-C≡N); LCMS: *m/z* 375.08 (M^+).

2-Amino-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(4-methoxyphenyl)nicotinonitrile, 5d.

IR (KBr): 3121, 2215, 1680, 1643, 1603, 1595, 1590, 1530, 1260, 1147 cm^{-1}; ^1H NMR (300 MHz, DMSO-d_6): δ 8.65 (s, 1H, C_4 proton of coumarin), 8.20 (s, 1H, C_5 proton of pyridine), 7.54-7.70 (m, 4H, phenyl ring), 7.32-7.47 (m, 3H, C_5, C_7 and C_8 proton of coumarin), 6.76 (s, 2H, $-NH_2$), 3.85 (s, 3H, $-OCH_3$); ^{13}C NMR (100 MHz, DMSO-d_6): δ 163.9 (1C, C=O), 162.0 (1C, *C*-NH_2), 161.0, (1C, *C*-F), 157-113.2 (16C, Ar-C), 112.0 (1C, *C*≡N), 97.3 (1C, -*C*-C≡N), 55.9 (1C, -O*C*H_3); LCMS: *m/z* 387.10 (M^+).

2-Amino-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(4-nitrophenyl)nicotinonitrile, 5e.

IR (KBr): 3119, 2211, 1673, 1647, 1603, 1592, 1585, 1522, 1355, 1255, 1143 cm^{-1}; ^1H NMR (300 MHz, DMSO-d_6): δ 8.62 (s, 1H, C_4 proton of coumarin), 8.28 (s, 1H, C_5 proton of pyridine), 7.58-7.67 (m, 4H, phenyl ring), 7.30-7.45 (m, 3H, C_5, C_7 and C_8 proton of coumarin), 6.72 (s, 2H, $-NH_2$); ^{13}C NMR (100 MHz, DMSO-d_6): δ 164.0 (1C, *C*=O), 162.0 (1C, *C*-NH_2), 160.8 (1C, *C*-F), 158-114.0 (16C, Ar-C), 112.2 (1C, *C*≡N), 97.5 (1C, -*C*-C≡N); LCMS: *m/z* 402.07 (M^+).

2-Amino-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-*p*-tolylnicotinonitrile, 5f.

IR (KBr): 3121, 2217, 1677, 1642, 1600, 1590, 1581, 1519, 1253, 1139 cm^{-1}; ^1H NMR (300 MHz, DMSO-d_6): δ 8.69 (s, 1H, C_4 proton of coumarin), 8.20 (s, 1H, C_5 proton of pyridine), 7.60-7.67 (m, 4H, phenyl ring), 7.30-7.42 (m, 3H, C_5, C_7 and C_8 proton of coumarin), 6.75 (s, 2H, $-NH_2$), 2.50 (s, 3H, $-CH_3$); ^{13}C NMR (100 MHz, DMSO-d_6): δ 164.0 (1C, *C*=O), 161.7 (1C, *C*-NH_2), 161.0 (1C, *C*-F), 158-114.0 (16C, Ar-C), 111.9 (1C, *C*≡N), 97.2 (1C, -*C*-C≡N), 21.8 (1C, -*C*H_3); LCMS: *m/z* 371.10 (M^+).

2-Amino-4-(3-chlorophenyl)-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)nicotinonitrile, 5g.

IR (KBr): 3119, 223, 1687, 1645, 1608, 1598, 1596, 1520, 1260, 1148, 832 cm^{-1}; ^1H NMR (300 MHz, DMSO-d_6): δ 8.90 (s, 1H, C_4 proton of coumarin), 8.05 (s, 1H, C_5 proton of pyridine), 7.51-7.85 (m, 4H, phenyl ring), 7.35-7.49 (m, 3H, C_5, C_7 and C_8 proton of coumarin), 6.80 (s, 2H, $-NH_2$); ^{13}C NMR (100 MHz, DMSO-d_6): δ 163.7 (1C, C=O), 161.3 (1C, 1C, *C*-NH_2), 160.4 (1C, *C*-F), 156-113.7 (16C, Ar.C), 112.5 (1C, *C*≡N), 96.3 (1C, -*C*-C≡N); LCMS: *m/z* 391.05 (M^+).

2-Amino-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(3-fluorophenyl)nicotinonitrile, 5h.

IR (KBr): 3115, 2220, 1681, 1643, 1610, 1597, 1590, 1528, 1263, 1141 cm^{-1}; ^1H NMR (300 MHz, DMSO-d_6): δ 8.73 (s, 1H, C_4 proton of coumarin), 8.00 (s, 1H, C_5 proton of pyridine), 7.60-7.76 (m, 4H, phenyl ring), 7.30-7.49 (m, 3H, C_5, C_7 and C_8 proton of coumarin), 6.80 (s, 2H, $-NH_2$); ^{13}C NMR (100 MHz, DMSO-d_6): δ 163.0 (1C, *C*=O), 162.2 (1C, *C*-NH_2), 161.5 (1C, *C*-F of phenyl ring), 160.3(1C at *C*-F of coumarine ring), 157-113.2 (15C, Ar-C), 112.0 (1C, *C*≡N), 97.0 (1C, -*C*-C≡N); LCMS: *m/z* 375.08 (M^+).

2-Amino-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(3-nitrophenyl)nicotinonitrile, 5i.

IR (KBr): 3114, 2210, 1671, 1643, 1602, 1594, 1587, 1525, 1360, 1254, 1140 cm^{-1}; ^1H NMR (300 MHz, DMSO-d_6): δ 8.60 (s, 1H, C_4 proton of coumarin), 8.21 (s, 1H, C_5 proton of pyridine), 7.60-7.67 (m, 4H, phenyl ring), 7.30-7.45 (m, 3H, C_5, C_7

and C_8 proton of coumarin), 6.70 (s, 2H, -NH_2); ^{13}C NMR (100 MHz, DMSO-d_6): δ 164.2 (1C, *C*=O), 161.9 (1C, *C*-NH_2), 160.5 (1C, *C*-F), 158-114.0 (16C, Ar.C), 112.7 (1C, *C*≡N), 97.0 (1C, -*C*-C≡N); MS: *m/z* 402.07 (M^+).

2-Amino-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(4-hydroxyphenyl)nicotinonitrile, 5j.

IR (KBr): 3550, 3117, 2214, 1668, 1642, 1601, 1589, 1525, 1251, 1146 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.68 (s, 1H, C_4 proton of coumarin), 8.24 (s, 1H, C_5 proton of pyridine), 7.64-7.67 (m, 4H, phenyl ring), 7.30-7.48 (m, 3H, C_5, C_7 and C_8 proton of coumarin), 6.62 (s, 2H, -NH_2), 5.05 (br s, 1H, -OH); ^{13}C NMR (100 MHz, DMSO-d_6): δ 164.6 (1C, *C*=O), 161.9 (1C, *C*-NH_2), 160.8 (1C, *C*-F), 158.0-114.5 (16C, Ar-C), 113.0 (1C, *C*≡N), 97.5 (1C, -*C*-C≡N); LCMS: *m/z* 402.07 (M^+).

2-Amino-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(3-methoxyphenyl)nicotinonitrile, 5k.

IR (KBr): 3122, 2219, 1681, 1641, 1601, 1595, 1593, 1459, 1263, 1144 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.65 (s, 1H, C_4 proton of coumarin), 8.21 (s, 1H, C_5 proton of pyridine), 7.54-7.70 (m, 4H, phenyl ring), 7.32-7.43 (m, 3H, C_5, C_7 and C_8 proton of coumarin), 6.76 (s, 2H, -NH_2), 3.85 (s, 3H, -OCH_3); ^{13}C NMR (100 MHz, DMSO-d_6): δ 163.9 (1C, C=O), 161.3 (1C, *C*-NH_2), 161.0, (1C, *C*-F), 158-113.2 (16C, Ar-C), 112.0 (1C, *C*≡N), 97.8 (1C, -*C*-C≡N), 56.0 (1C, -O*C*H_3); LCMS: *m/z* 387.10 (M^+).

2-Amino-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(3-hydroxyphenyl)nicotinonitrile, 5l.

IR (KBr): 3552, 3120, 2218, 1669, 1641, 1601, 1597, 1589, 1262, 1142 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.70 (s, 1H, C_4 proton of coumarin), 8.21 (s, 1H, C_5 proton of pyridine), 7.64-7.65 (m, 4H, phenyl ring), 7.34-7.48 (m, 3H, C_5, C_7 and C_8 proton of coumarin), 6.61 (s, 2H, -NH_2), 5.04 (br s, 1H, -OH); ^{13}C NMR (100 MHz, DMSO-d_6): δ 164.4 (1C, *C*=O), 161.6 (1C, *C*-NH_2), 160.6 (1C, *C*-F), 158.5-114.7 (16C, Ar-C), 113.0 (1C, *C*≡N), 97.3 (1C, -*C*-C≡N); LCMS: *m/z* 402.07 (M^+).

2-Amino-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-m-tolylnicotinonitrile, 5m.

IR (KBr): 3125, 2211, 1677, 1642, 1601, 1595, 1582, 1256, 1144 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.69 (s, 1H, C_4 proton of coumarin), 8.28 (s, 1H, C_5 proton of pyridine), 7.60-7.65 (m, 4H, phenyl ring), 7.30-7.45 (m, 3H, C_5, C_7 and C_8 proton of coumarin), 6.72 (s, 2H, -NH_2), 2.53 (s, 3H, -CH_3); ^{13}C NMR (100 MHz, DMSO-d_6): δ 164.9 (1C, *C*=O), 161.6 (1C, *C*-NH_2), 161.2 (1C, *C*-F), 158-114.5 (16C, Ar-C), 111.9 (1C, *C*≡N), 97.0 (1C, -*C*-C≡N), 21.8 (1C, -*C*H_3); LCMS: *m/z* 371.10 (M^+).

***N*-(3-Cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-phenylpyridin-2-yl)benzenesulfonamide, 7a**.

IR (KBr): 3069, 2223, 1685, 1641, 1619, 1584, 1493, 1250, 1204, 1142 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.88 (s, 1H, C_4 proton of coumarin), 8.03 (s, 1H, C_5 proton of pyridine), 7.50-7.80 (m, 10H, proton of phenyl ring), 7.15-7.40 (m, 3H, coumarin), 5.03 (s, 1H, -NH-SO_2-linkage); ^{13}C NMR (100 MHz, DMSO-d_6): δ 164.9 (1C, -*C*-NH-SO_2-), 163.0 (1C, *C*=O), 159.7 (1C, *C*-F), 155-116 (22C, Ar-C), 113.2 (1C, -*C*≡N), 100.5 (1C, -*C*-C≡N); LCMS: *m/z* 497.08 (M^+).

***N*-(4-(4-Chlorophenyl)-3-cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)pyridin-2-yl)benzene sulfonamide, 7b**.

IR (KBr): 3070, 2220, 1680, 1646, 1620, 1582, 1490, 1254, 1200, 1143, 832 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.82 (s, 1H, C_4 proton of coumarin), 8.00 (s, 1H, C_5 proton of pyridine), 7.50-7.82 (m, 9H, proton of phenyl ring), 7.13-7.41 (m, 3H, coumarin), 5.00 (s, 1H, -NH-SO_2-linkage); ^{13}C NMR (100 MHz, DMSO-d_6): δ 165.0 (1C, -*C*-NH-SO_2-), 163.6 (1C, *C*=O), 159.7 (1C, *C*-F), 155-115 (22C, Ar-C), 113.2 (1C, -*C*≡N), 100.5 (1C, -*C*-C≡N); LCMS: *m/z* 531.05 (M^+).

***N*-(3-Cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(4-fluorophenyl)pyridin-2-yl)benzene-sulfonamide, 7c**.

IR (KBr): 3074, 2228, 1684, 1649, 1621, 1579, 1492, 1250, 1202, 1140 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.79 (s, 1H, C_4 proton of coumarin), 8.05 (s, 1H, C_5 proton of pyridine), 7.52-7.85 (m, 9H, proton of phenyl ring), 7.18-7.40 (m, 3H, coumarin), 9.17 (s, 1H, -NH-SO_2-linkage); ^{13}C NMR (100 MHz, DMSO-d_6): δ 165.2 (1C, -*C*-NH-SO_2-), 163.4 (1C, *C*=O), 162.0-159.7 (2C, *C*-F), 155.0-113.0 (21C, Ar-C), 113.5 (1C, -*C*≡N), 100.9 (1C, -*C*-C≡N); LCMS: *m/z* 515.08 (M^+).

***N*-(3-Cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(4-methoxyphenyl)pyridin-2-yl)benzene sulfonamide, 7d**.

IR (KBr): 3071, 2230, 1683, 1648, 1624, 1577, 1493, 1463, 1252, 1200, 1141 cm^{-1}; ^{1}H NMR (300

MHz, DMSO-d_6): δ 8.80 (s, 1H, C_4 proton of coumarin), 8.09 (s, 1H, C_5 proton of pyridine), 7.48-7.86 (m, 9H, proton of phenyl ring), 7.15-7.40 (m, 3H, coumarin), 9.20 (s, 1H, -NH-SO_2-linkage), 3.83 (s, 3H, -OCH_3); ^{13}C NMR (100 MHz, DMSO-d_6): δ 165.7 (1C, -*C*-NH-SO_2-), 163.6 (1C, *C*=O), 162.3 (1C, *C*-F), 155.0-113.2 (22C, Ar-C), 113.7 (1C, -*C*≡N), 100.9 (1C, -*C*-C≡N), 56.02 (1C, -OCH_3); LCMS: *m/z* 527.10 (M^+).

***N*-(3-Cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(4-nitrophenyl)pyridin-2-yl)benzene sulfonamide, 7e**.

IR (KBr): 3070, 2232, 1683, 1651, 1624, 1579, 1525, 1510, 1493, 1350, 1255, 1198, 1145 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.87 (s, 1H, C_4 proton of coumarin), 8.04 (s, 1H, C_5 proton of pyridine), 7.50-7.85 (m, 9H, proton of phenyl ring), 7.18-7.42 (m, 3H, coumarin), 9.11 (s, 1H, -NH-SO_2-linkage); ^{13}C NMR (100 MHz, DMSO-d_6): δ 165.2 (1C, -*C*-NH-SO_2-), 163.1 (1C, *C*=O), 162.0 (1C, *C*-F), 155.5-113.2 (22C, Ar-C), 113.9 (1C, -*C*≡N), 100.0 (1C, -*C*-C≡N); LCMS: *m/z* 527.10 (M^+).

***N*-(3-Cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-p-tolylpyridin-2-yl)benzenesulfonamide, 7f**.

IR (KBr): 3067, 2219, 1686, 1645, 1620, 1583, 1491, 1253, 1202, 1142 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.80 (s, 1H, C_4 proton of coumarin), 8.01 (s, 1H, C_5 proton of pyridine), 7.48-7.81 (m, 9H, proton of phenyl ring), 7.20-7.48 (m, 3H, coumarin), 9.13 (s, 1H, -NH-SO_2-linkage), 2.50 (s, 3H, -CH_3); ^{13}C NMR (100 MHz, DMSO-d_6): δ 165.0 (1C, -*C*-NH-SO_2-), 163.8 (1C, *C*=O), 162.2 (1C, *C*-F), 155.5-113.2 (22C, Ar-*C*), 113.8 (1C, -*C*≡N), 100.1 (1C, -*C*-C≡N), 21.3 (1C, -*C*H_3); LCMS: *m/z* 511.10 (M^+).

***N*-(4-(3-Chlorophenyl)-3-cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)pyridin-2-yl)benzene sulfonamide, 7g**.

IR (KBr): 3073, 2217, 1682, 1647, 1621, 1582, 1492, 1251, 1203, 1145, 831 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.83 (s, 1H, C_4 proton of coumarin), 8.00 (s, 1H, C_5 proton of pyridine), 7.51-7.85 (m, 9H, proton of phenyl ring), 7.13-7.48 (m, 3H, coumarin), 9.18 (s, 1H, -NH-SO_2-linkage); ^{13}C NMR (100 MHz, DMSO-d_6): δ 165.3 (1C, -*C*-NH-SO_2-), 163.5 (1C, *C*=O), 159.9 (1C, *C*-F), 155.0-115.3 (22C, Ar-C), 113.2 (1C, -*C*≡N), 100.8 (1C, -*C*-C≡N); LCMS: *m/z* 531.05 (M^+).

***N*-(3-Cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(3-fluorophenyl)pyridin-2-yl)benzene sulfonamide, 7h**.

IR (KBr): 3075, 2225, 1683, 1649, 1624, 1580, 1493, 1260, 1201, 1143 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.77 (s, 1H, C_4 proton of coumarin), 8.03 (s, 1H, C_5 proton of pyridine), 7.54-7.88 (m, 9H, proton of phenyl ring), 7.18-7.42 (m, 3H, coumarin), 9.11 (s, 1H, -NH-SO_2-linkage); ^{13}C NMR (100 MHz, DMSO-d_6): δ 165.2 (1C, -*C*-NH-SO_2-), 163.5 (1C, *C*=O), 162.1-159.7 (2C, *C*-F), 155.0-113.2 (21C, Ar-C), 113.6 (1C, -*C*≡N), 100.3 (1C, -*C*-C≡N); LCMS: *m/z* 515.08 (M^+).

***N*-(3-Cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(3-nitrophenyl)pyridin-2-yl)benzene sulfonamide, 7i**.

IR (KBr): 3071, 2232, 1684, 1652, 1624, 1580, 1526, 1510, 1493, 1350, 1251, 1198, 1145 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.81 (s, 1H, C_4 proton of coumarin), 8.04 (s, 1H, C_5 proton of pyridine), 7.45-7.85 (m, 9H, proton of phenyl ring), 7.19-7.38 (m, 3H, coumarin), 9.18 (s, 1H, -NH-SO_2-linkage); ^{13}C NMR (100 MHz, DMSO-d_6): δ 165.1 (1C, -*C*-NH-SO_2-), 163.3 (1C, *C*=O), 162.1 (1C, *C*-F), 155.4-113.1 (22C, Ar-C), 113.8 (1C, -*C*≡N), 100.1 (1C, -*C*-C≡N); LCMS: *m/z* 527.10 (M^+).

***N*-(3-Cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(4-hydroxyphenyl)pyridin-2-yl)benzene sulfonamide, 7j**.

IR (KBr): 3600, 3069, 2223, 1686, 1641, 1620, 1584, 1493, 1252, 1200, 1143 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.80 (s, 1H, C_4 proton of coumarin), 8.03 (s, 1H, C_5 proton of pyridine), 7.42-7.80 (m, 9H, proton of phenyl ring), 7.12-7.40 (m, 3H, coumarin), 9.19 (s, 1H, -NH-SO_2-linkage), 4.89 (s, 1H, -OH); ^{13}C NMR (100 MHz, DMSO-d_6): δ 164.9 (1C, -*C*-NH-SO_2-), 163.1 (1C, *C*=O), 159.7 (1C, *C*-F), 155.0-116.1 (22C, Ar-C), 113.2 (1C, -*C*≡N), 100.5 (1C, -*C*-C≡N); LCMS: *m/z* 513.08 (M^+).

***N*-(3-Cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(3-methoxyphenyl)pyridin-2-yl)benzene sulfonamide, 7k**.

IR (KBr): 3073, 2233, 1683, 1650, 1623, 1577, 1495, 1463, 1257, 1208, 1143 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.82 (s, 1H, C_4 proton of coumarin), 8.04 (s, 1H, C_5 proton of pyridine), 7.49-

7.86 (m, 9H, proton of phenyl ring), 7.15-7.40 (m, 3H, coumarin), 9.16 (s, 1H, -NH-SO_2-linkage), 3.84 (s, 3H, -OCH_3); ^{13}C NMR (100 MHz, DMSO-d_6): δ 165.7 (1C, -*C*-NH-SO_2-), 163.6 (1C, *C*=O), 162.4 (1C, *C*-F), 155.2-113.5 (22C, Ar-C), 113.7 (1C, -*C*≡N), 100.9 (1C, -*C*-C≡N), 56.0 (1C, -OCH_3); LCMS: *m/z* 527.10 (M^+).

***N*-(3-Cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(3-hydroxyphenyl)pyridin-2-yl)benzene sulfonamide, 7l**.

IR (KBr): 3603, 3070, 2228, 1689, 1640, 1621, 1585, 1490, 1252, 1200, 1141 cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.82 (s, 1H, C_4 proton of coumarin), 8.04 (s, 1H, C_5 proton of pyridine), 7.41-7.82 (m, 9H, proton of phenyl ring), 7.10-7.40 (m, 3H, coumarin), 9.20 (s, 1H, -NH-SO_2-linkage), 4.89 (s, 1H, -OH); ^{13}C NMR (100 MHz, DMSO-d_6): δ 165.0 (1C, -*C*-NH-SO_2-), 163.1 (1C, *C*=O), 159.6 (1C, *C*-F), 155.2-116.0 (22C, Ar-C), 113.1 (1C, -*C*≡N), 100.6 (1C, -*C*-C≡N); LCMS: *m/z* 513.08 (M^+).

***N*-(3-Cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-m-tolylpyridin-2-yl)benzenesulfonamide, 7m**.

IR (KBr): 3068, 2219, 1688, 1641, 1620, 1584, 1491, 1254, 1201, 1142cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.81 (s, 1H, C_4 proton of coumarin), 8.01 (s, 1H, C_5 proton of pyridine), 7.45-7.81 (m, 9H, proton of phenyl ring), 7.20-7.50 (m, 3H, coumarin), 5.18 (s, 1H, -NH-SO_2-linkage), 2.52 (s, 3H, -CH_3); ^{13}C NMR (100 MHz, DMSO-d_6): δ 165.2 (1C, -*C*-NH-SO_2-), 163.8 (1C, *C*=O), 162.1 (1C, *C*-F), 155.4-113.0 (22C, Ar-*C*), 113.8 (1C, -*C*≡N), 100.0 (1C, -*C*-C≡N), 21.2 (1C, -*C*H_3); LCMS: *m/z* 511.10 (M^+).

Conclusion

Compounds **7a-m** have been synthesized by both classical and microwave assisted methods. The later method proved much more efficient in reducing reaction time as well as increasing the overall yield of the reactions. To the best of our knowledge, this is the first report on synthesis of *N*-(3-cyano-6-(6-fluoro-2-oxo-2*H*-chromen-3-yl)-4-(aryl)pyridin-2-yl)benzene-sulfonamides **7a-m** by microwave technique. The newly synthesized compounds were tested for their antibacterial and antifungal activities. Some compounds showed moderate or weak activity, whereas compounds **7c**, **7d**, **7i**, **7j** and **7k** showed excellent activity.

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