Supplementary Information (SI) for Green Chemistry.
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Supporting Information

Photo-promoted radical cascade cyclization of 4-(allylamino)-3-cyanocoumarins: access to sulfonylated pyrido[3,2-*c*]coumarin derivatives

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1.General information

Unless otherwise specified, all reagents are obtained from commercial sources and can be used without further purification. Silica gel for column chromatography was purchased from Qingdao Haiyang Chemical Co., Ltd. Reactions were stirred using Teflon-coated magnetic stir bars. Thinlayer chromatography (TLC) was used to monitor the reaction. The experiments were conducted in sealed 10 mL or 25 mL Schlenk tube for gram-scale synthesis. The experiments under 450-460 nm light irradiation were performed using two 25 W JG LED lamps from Xuzhou Ai Jia Electronic Technology Co., Ltd. The distance from the light source to the irradiation vessel was approximate 2-3 cm, and no filter was used in our study. A fan was employed to ensure reactions remained at or near room temperature when using LED. Melting points were determined using a Büchi B-540 capillary melting point apparatus. spectra were recorded on a Varian spectrometer in $CDCl_3$ or DMSO-d_6 using tetramethylsilane (TMS) as internal standards. Data are reported as follows: Chemical shift (number of protons, multiplicity, coupling constants). Coupling constants were quoted to the nearest 0.1 Hz and multiplicity reported according to the following convention: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, dd = doublet of doublets, dt = doublet of triplets, td = triplet of doublets, ddd = doublet of doublet of doublets, brs = broad singlet. HRMS spectra were recorded on a Bruker Impact II UHR-QTOF. Fluorescence quenching experiments were performed on Hitachi F7000 FL

2. Light-promoted reaction equipment.

The experiments under 450-460 nm light irradiation were performed using 25 W JG LED lamp from Xuzhou Ai Jia Electronic Technology Co., Ltd. The distance between the light source and the irradiation glass vessel is 4-5 cm, and no filter was used in our study. A fan was employed to ensure reactions remained at or near room temperature when using LEDs.

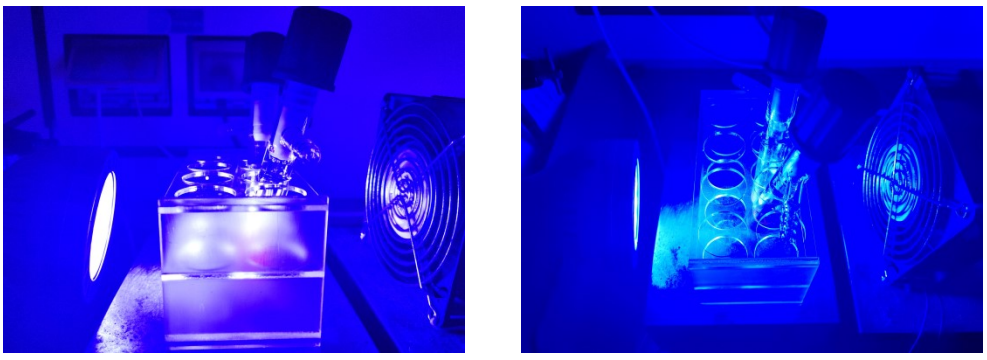
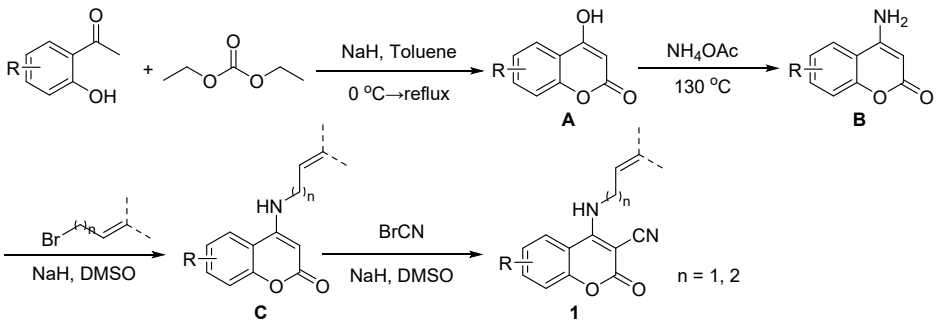


Figure S1 Photograph of the Reaction Setup (Blue LED, 450-460 nm)

3. General procedure for synthesis of products

(1) General Procedure for the Synthesis of 1.



Step 1: Take a 100 mL single-necked round-bottomed flask, at room temperature, add o-hydroxyacetophenone (10 mmol, 1.36 g), toluene (40 mL), and put it in an ice bath with stirring for about 10 min; then add NaH (50 mmol, 1.2 g) in batches, and continue to stir the reaction for about 30 min, and the reaction solution turned from colorless to yellowish-green. Then, diethyl carbonate (20 mmol, 1.18 g) was added dropwise to the reaction solution in toluene solution (10 mL); after the dropwise addition was completed, the reaction was transferred to room temperature and stirred for about 30 min, and then the reaction was transferred to an oil bath and refluxed for 4 h. The reaction process was monitored by thin-layer chromatography (ethyl acetate/petroleum ether=1/1, v/v), and the reaction was completed by cooling the reaction to room temperature and then adjusting the pH to about 3 by dropwise addition of 2N of dilute hydrochloric acid to the reaction solution under an ice bath, and filtering. The pH of the solution was adjusted to about 3 by dropwise addition of 2N dilute hydrochloric acid under an ice bath, and then filtered and dried to obtain a yellow solid of **A**. [1]

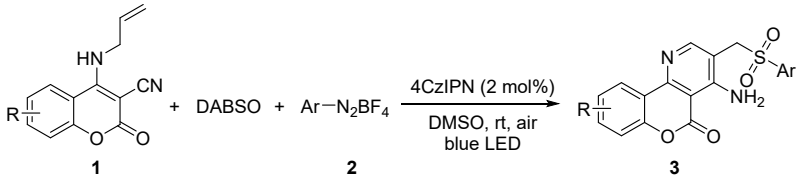
Step 2: A mixture of 4-hydroxycoumarin (1 equiv.) and ammonium acetate (20 equiv.) was stirred at 130 °C overnight. After completion of the reaction, water (50 ml) was added. The mixture was stirred for 20 min, filtered and concentrated in vacuo. The residue was successively washed with water and ethanol to give **B**. [2]

Step 3: At room temperature, sodium hydride (60 %) (20.0 mmol, 400 mg) and 10 mL dimethyl sulfoxide (DMSO) were added to a 100 mL single-mouth round-bottom flask, and the magnetic

stirring was performed at room temperature for 20 min. Subsequently, the DMSO solution of 4-aminocoumarin (10.0 mmol, 1.61 g) was added, and the stirring was continued for 20 min after dropping. Then, 3-bromopropene (15.0 mmol, 1.81 g) was added slowly. After the dripping is completed, the mixture was stirred at room temperature for 1 h by magnetic stirring. The reaction process was monitored by thin layer chromatography (petroleum ether / ethyl acetate = 1 / 1, v / v). After the reaction, water was added to quench the reaction, extracted with ethyl acetate (40 mL × 4). The combined organic layers were washed with brine (40 mL× 3), dried over anhydrous Na_2SO_4, and concentrated in vacuo. The crude product was purified by silica gel column chromatography (petroleum ether / ethyl acetate = 3: 1, v / v) to obtain yellow solid **C**.

Step 4: Sodium hydride (60 %) (20.0 mmol, 800 mg) was added to a 100 mL two-port round-bottom flask for nitrogen protection. Subsequently, 10 mL dimethyl sulfoxide (DMSO) was added and magnetically stirred at room temperature for 20 min. The DMSO solution of 4- (allylamino) coumarin (10.0 mmol, 2.01 g) was added and stirred for 20 min. Then, the DMSO solution of cyanogen bromide (20.0 mmol, 2.1 g) was added dropwise. After dropping, the mixture was magnetically stirred for 1 h at room temperature. The reaction process was monitored by thin layer chromatography (petroleum ether / ethyl acetate = 1 / 1, v / v). After the reaction, water was added to quench the reaction, extracted with ethyl acetate (40 mL × 4). The combined organic layers were washed with brine (40 mL× 3), dried over anhydrous Na_2SO_4, and concentrated in vacuo. The crude product was purified by silica gel column chromatography (petroleum ether / ethyl acetate = 2: 1, v / v) to obtain a white solid **1**

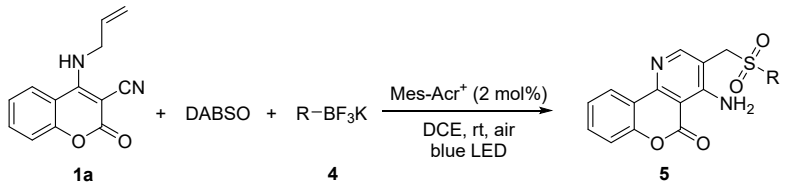
(2) General Procedure for the Synthesis of 3.



1 (0.3 mmol), **2** (0.6 mmol, 2 equiv.), DABSO (0.6 mmol, 2 equiv.), 4CzIPN (2 mol%), and 2 mL DMSO were added in a 10 mL schlenk-tube. Then the mixture was stirred at rt for 48 h in the

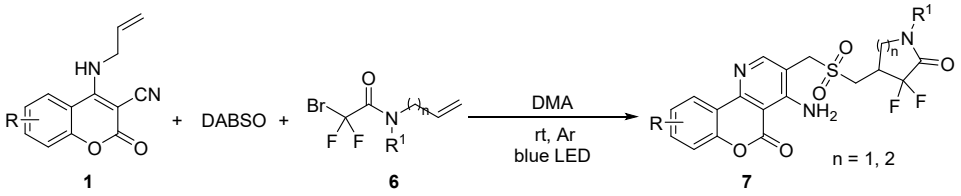
photochemical reactor with 25 W blue LED as light source under air atmosphere. After the reaction completed, the reaction mixture was diluted with H_2O (15 mL) and extracted with CH_2Cl_2 (20 mL × 4). The combined organic layers were washed with brine (30 × 3mL), dried over anhydrous Na_2SO_4, and concentrated in vacuo. The residue was purified by column chromatography on silica gel with petroleum ether/ethyl acetate to afford the desired product **3**

(3) General Procedure for the Synthesis of 5.



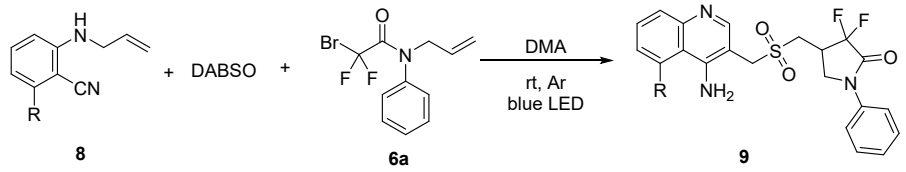
1a (0.3 mmol), **4** (0.6 mmol, 2 equiv.), DABSO (0.6 mmol, 2 equiv.), Mes-AcrClO$_4$ (2 mol%), and 2 mL DCE were added in a 10 mL schlenk-tube. Then the mixture was stirred at rt for 48 h in the photochemical reactor with 25 W blue LED as light source under air atmosphere. After the reaction completed, the solvent was removed under reduced pressure by rotary evaporator. Then, the residue was purified by silica gel column chromatography to give the desired products **5**.

(4) General Procedure for the Synthesis of 7.



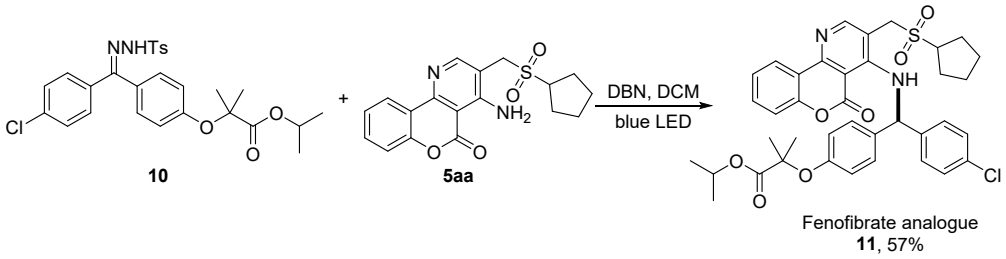
1 (0.3 mmol), **6** (0.45 mmol, 1.5 equiv.), DABSO (0.45 mmol, 1.5 equiv.), and 2 mL DMA were added in a 10 mL schlenk-tube. Then the mixture was stirred at rt for 12 h in the photochemical reactor with 25 W blue LED as light source under Ar atmosphere. After the reaction completed, the reaction mixture was diluted with H_2O (15 mL) and extracted with CH_2Cl_2 (20 mL × 4). The combined organic layers were washed with brine (30 × 3mL), dried over anhydrous Na_2SO_4, and concentrated in vacuo. The residue was purified by column chromatography on silica gel with petroleum ether/ethyl acetate to afford the desired product **7**

(5) General Procedure for the Synthesis of 9.



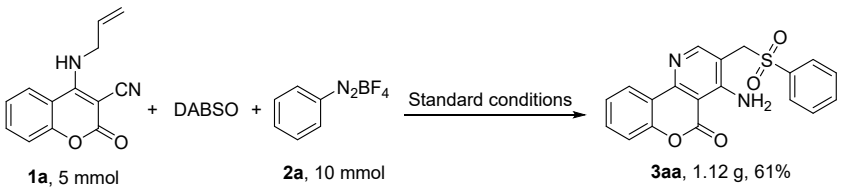
8 (0.3 mmol), **6a** (0.45 mmol, 1.5 equiv.), DABSO (0.45 mmol, 1.5 equiv.), and 2 mL DMA were added in a 10 mL schlenk-tube. Then the mixture was stirred at rt for 12 h in the photochemical reactor with 25 W blue LED as light source under Ar atmosphere. After the reaction completed, the reaction mixture was diluted with H_2O (15 mL) and extracted with CH_2Cl_2 (20 mL × 4). The combined organic layers were washed with brine (30 × 3mL), dried over anhydrous Na_2SO_4, and concentrated in vacuo. The residue was purified by column chromatography on silica gel with ethyl acetate/dichloromethane to afford the desired product **9**

(6) General Procedure for the Synthesis of 11.



5aa (0.3 mmol), **10** (0.6 mmol, 2 equiv.), DBN (0.6 mmol, 2 equiv.) and 2 mL DCM were added in a 10 mL schlenk-tube. Then the mixture was stirred at rt for 10 h in the photochemical reactor with 25 W blue LED as light source. After the reaction completed, the solvent was removed under reduced pressure by rotary evaporator. Then, the residue was purified by silica gel column chromatography to give the desired products **11**.

(7) Gram Procedure for the Synthesis of 3aa

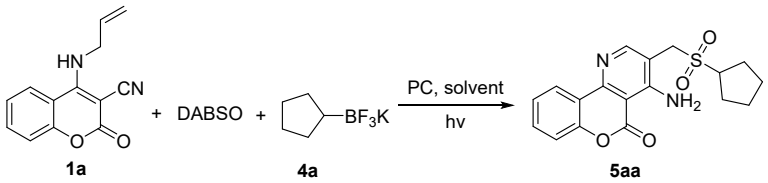


1a (5 mmol), **2a** (10 mmol, 2 equiv.), DABSO (10 mmol, 2 equiv.), 4CzIPN (2 mol%), and 40 mL DMSO were added in a 100 mL schlenk-tube. Then the mixture was stirred at rt for 96 h in the

photochemical reactor with 25 W blue LED as light source under air atmosphere. After the reaction completed, the reaction mixture was diluted with H_2O (50 mL) and extracted with CH_2Cl_2 (50 mL × 4). The combined organic layers were washed with brine (50 × 3mL), dried over anhydrous Na_2SO_4, and concentrated in vacuo. The residue was purified by column chromatography on silica gel with petroleum ether/ethyl acetate to afford the desired product **3aa**.

4. Optimization of reaction conditions.

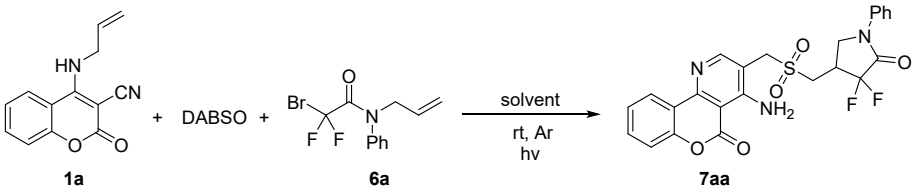
Table S1 Optimization of reaction conditions of 5aa. [a]



Entry	Light source	Photocatalyst	Solvent	Yield[b] (%)
1	blue light	4CzIPN	DMSO	42
2	blue light	EoSin Y	DMSO	23
3	blue light	$Ru(bpy)Cl_2$	DMSO	30
4	blue light	*fac*-$Ir(ppy)_3$	DMSO	0
5	blue light	$Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6$	DMSO	54
6	blue light	Mes-Acr^+	DMSO	58
7	blue light	Mes-Acr^+	MeCN	56
8	**blue light**	**Mes-Acr^+**	**DCE**	**71**
9	blue light	Mes-Acr^+	DMF	36
10	blue light	Mes-Acr^+	DCM	59
11	blue light	Mes-Acr^+	THF	15
12	blue light	-	DCE	0
13	white light	Mes-Acr^+	DCE	63
14	purple light	Mes-Acr^+	DCE	65
15	green light	Mes-Acr^+	DCE	68
16	red light	Mes-Acr^+	DCE	35
17[c]	blue light	Mes-Acr^+	DCE	0
18[d]	blue light	Mes-Acr^+	DCE	trace

[a] **1a** (0.3 mmol), **4a** (0.6 mmol, 2 equiv.), DABSO (0.6 mmol, 2 equiv.), PC (2 mol%), solvent (3 mL), at room temperature under an air atmosphere and 25 W blue LED irradiation for 48 h. [b] Isolated yield. [c] Without additional light. [d] Ar instead of air.

Table S2 Optimization of reaction conditions of 7aa. [a]

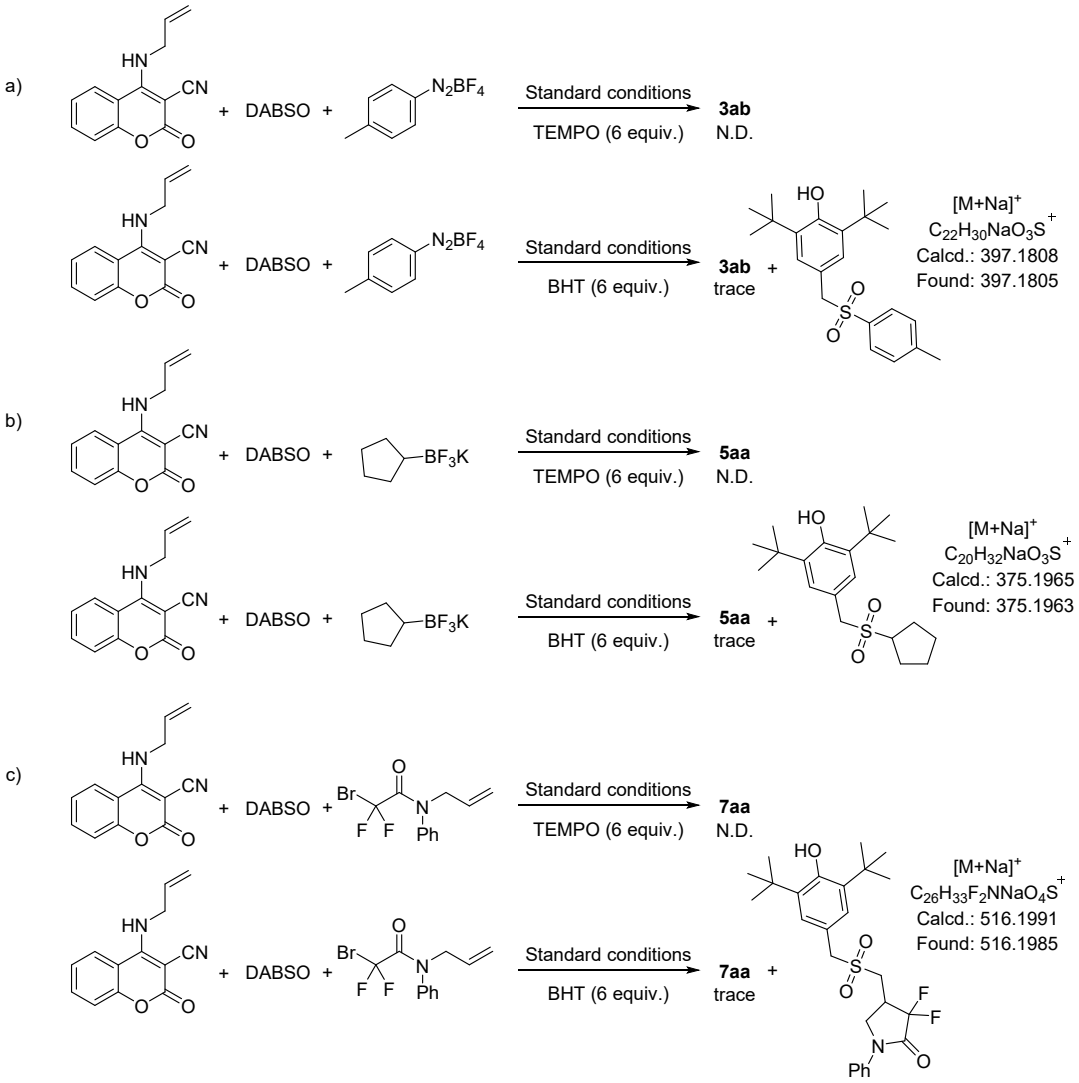


Entry	Light source	Solvent	Yield[b] (%)
1	blue light	MeCN	35
2	blue light	DMF	69
3	blue light	DCM	41
4	blue light	DMSO	trace
5	blue light	THF	trace
6	**blue light**	**DMA**	**93**
7	blue light	MeOH	48
8	blue light	DCE	21
9	white light	DMA	77
10	purple light	DMA	84
11	green light	DMA	65
12	red light	DMA	51
13[c]	blue light	DMA	90
14[d]	blue light	DMA	88
15[e]	blue light	DMA	78
16	-	DMA	0

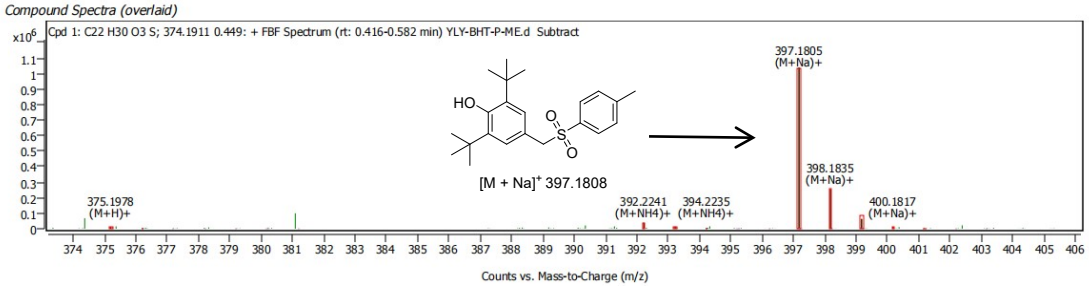
[a]**1a** (0.3 mmol), **6a** (0.45 mmol, 1.5 equiv.), DABSO (0.45 mmol, 1.5 equiv.), solvent (3 mL), at room temperature under an Ar atmosphere and 25 W blue LED irradiation for 12 h. [b] Isolated yield. [c] Na_2CO_3 (2 equiv.). [d] K_2CO_3 (2 equiv.). [e] air instead of Ar.

5. Mechanistic studies.

(1) Radical trapping Experiment.



HRMS-ESI (m/z): $[M + Na]^+$ Calcd for $C_{22}H_{30}NaO_3S^+$ 397.1808; Found 397.1805

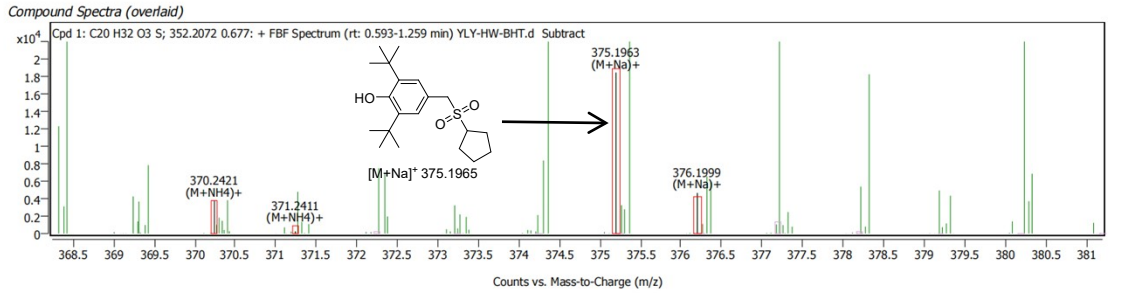


Compound ID Table

Name	Formula	Species	RT	RT Diff	Mass	CAS	ID Source	Score	Score (Lib)	Score (Tgt)
	C22 H30 O3 S	(M+H)+ (M+NH4)+ (M+Na)+	0.449		374.1911		FBF	98.61		98.61

MassHunter Qual 10.0
(End of Report)

HRMS-ESI (m/z): $[M + Na]^+$ Calcd for $C_{20}H_{32}NaO_3S^+$ 375.1965; Found 375.1963

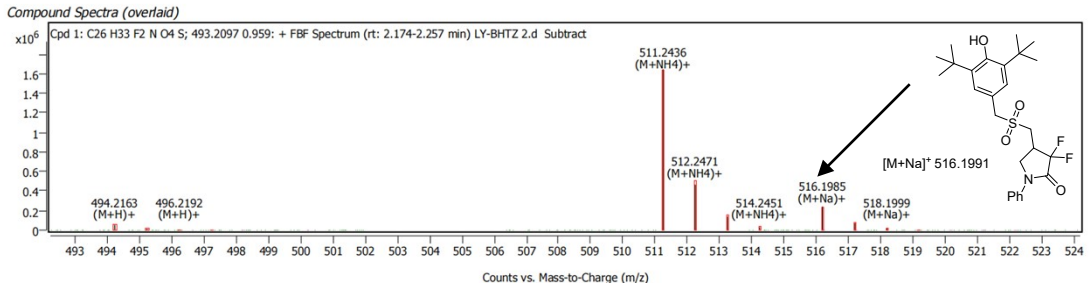


Compound ID Table

Name	Formula	Species	RT	RT Diff	Mass	CAS	ID Source	Score	Score (Lib)	Score (Tgt)
	C20 H32 O3 S	(M+NH4)+ (M+Na)+	0.677		352.2072		FBF	73.26		73.26

MassHunter Qual 10.0
(End of Report)

HRMS-ESI (m/z): $[M + Na]^+$ Calcd for $C_{26}H_{33}F_2NNaO_4S^+$ 516.1991; Found 516.1985



Compound ID Table

Name	Formula	Species	RT	RT Diff	Mass	CAS	ID Source	Score	Score (Lib)	Score (Tgt)
	C26 H33 F2 N O4 S	(M+H)+ (M+NH4)+ (M+Na)+	0.959		493.2097		FBF	99.18		99.18

MassHunter Qual 10.0
(End of Report)

(2) Stern-Volmer quenching

a:

Formulation solution:

4-(allylamino)-3-cyanocoumarin (**1a**, 11 mg) was dissolved in DMSO in a 10 mL volumetric flask to set the concentration to be 5 mM. 4-methylphenyldiazonium tetrafluoroborate (**2b**, 10 mg) was dissolved in DMSO in a 10 mL volumetric flask to set the concentration to be 5 mM. DABSO (12 mg) was dissolved in DMSO in a 10 mL volumetric flask to set the concentration to be 5 mM. Photocatalyst 4CzIPN (4 mg) was dissolved in DMSO (100.0 mL) to set the concentration to be 0.05 mM.

Experimental procedure:

A Hitachi F-7000 fluoresence spectrometer was used to record the emission intensities. All the

solutions were excited at 380 nm and the emission spectra were recorded between 400 and 700 nm. The samples were prepared by mixing 4CzIPN (0.05 mM) and different amounts of quenchers (**1a**, **2b** and DABSO) in DMSO (total volume = 2.0 mL) in a light path quartz fluorescence cuvette. Then the emission intensity was collected and the results were presented in Figure S2-S6. I_0 and I represent the intensities of the emission in the absence and presence of the quencher at 540 nm. The observations indicate that the fluorescence intensity of 4CzIPN significantly decreases along with the increasing of concentration of **2b**

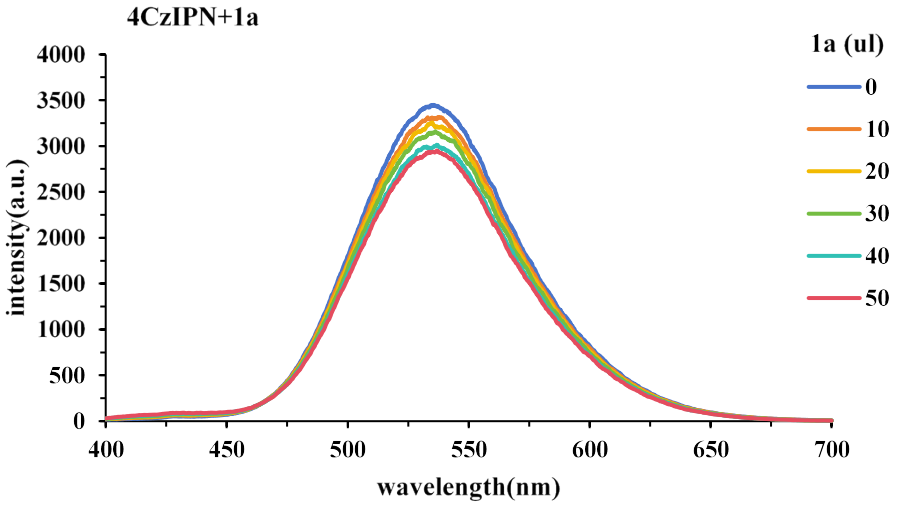


Figure S2 Quenching of 4CzIPN fluorescence emission in the presence of **1a**.

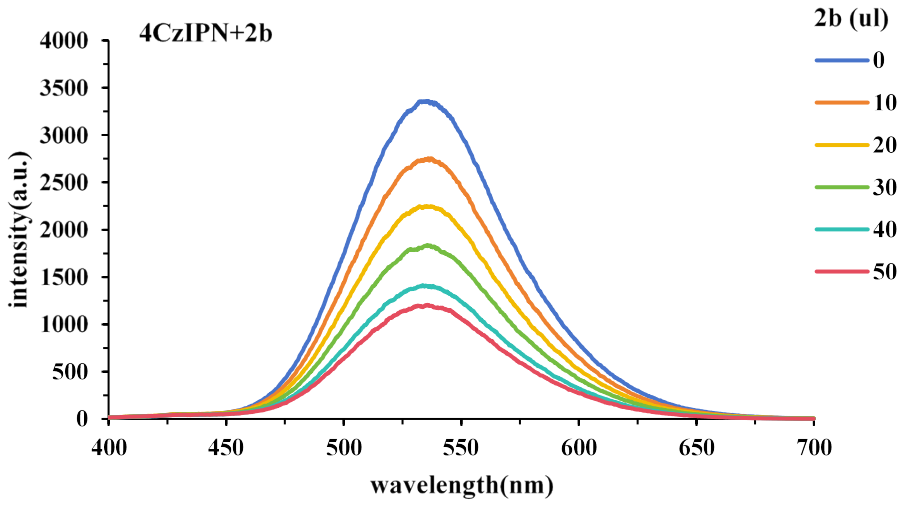


Figure S3 Quenching of 4CzIPN fluorescence emission in the presence of **2b**

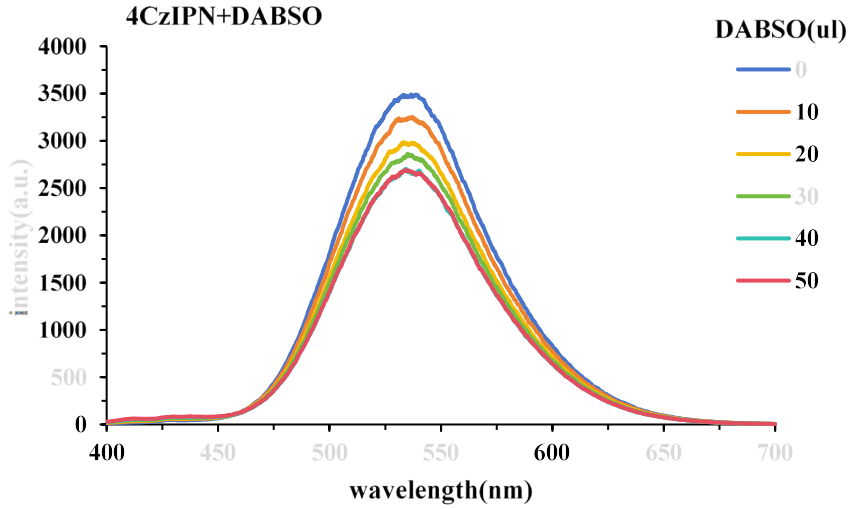


Figure S4 Quenching of 4CzIPN fluorescence emission in the presence of **DABSO**

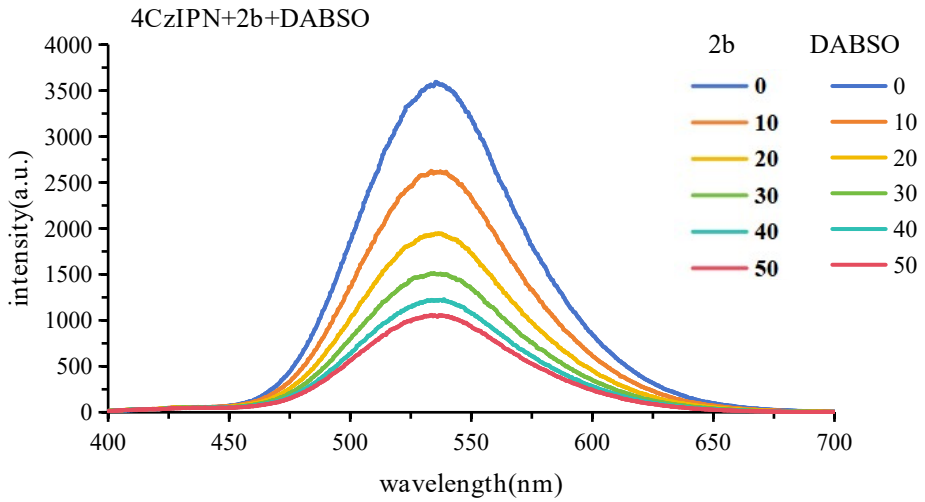


Figure S5 Quenching of 4CzIPN fluorescence emission in the presence of **2b** and **DABSO**

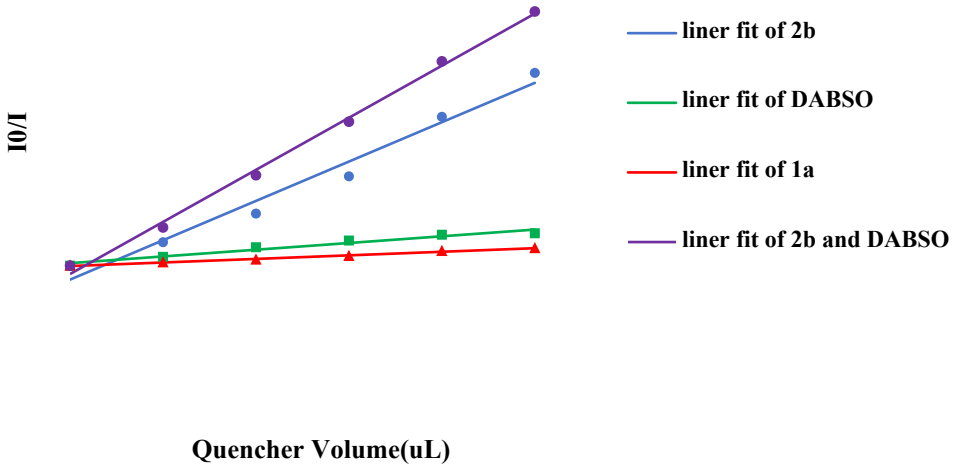


Figure S6. Stern-Volmer analysis for 4CzIPN with **1a**, **2b** and DABSO

b:

Formulation solution:

4-(allylamino)-3-cyanocoumarin (**1a**, 11 mg) was dissolved in DCE in a 10 mL volumetric flask to set the concentration to be 5 mM. cyclopentyltrifluoroborate (**4a**, 9 mg) was dissolved in DCE in a 10 mL volumetric flask to set the concentration to be 5 mM. DABSO (12 mg) was dissolved in DCE in a 10 mL volumetric flask to set the concentration to be 5 mM. Photocatalyst Mes-AcrClO$_4$ (2 mg) was dissolved in DCE (100.0 mL) to set the concentration to be 0.05 mM.

Experimental procedure:

A Hitachi F-7000 fluoresence spectrometer was used to record the emission intensities. All the solutions were excited at 360 nm and the emission spectra were recorded between 400 and 700 nm. The samples were prepared by mixing Mes-AcrClO$_4$ (0.05 mM) and different amounts of quenchers (**1a**, **4a** and DABSO) in DCE (total volume = 2.0 mL) in a light path quartz fluorescence cuvette. Then the emission intensity was collected and the results were presented in Figure S7-S10. I_0 and I represent the intensities of the emission in the absence and presence of the quencher at 500 nm. The observations indicate that the fluorescence intensity of Mes-AcrClO$_4$ significantly decreases along with the increasing of concentration of **4a**

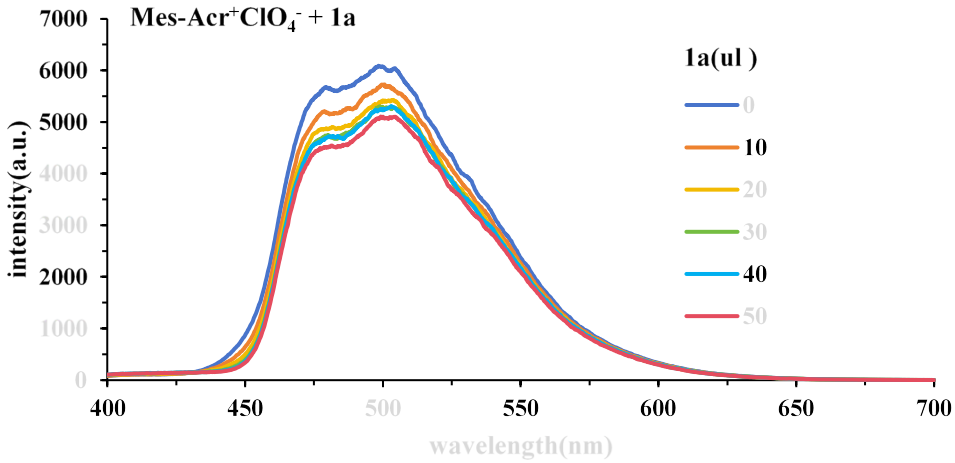


Figure S7 Quenching of Mes-AcrClO$_4$ fluorescence emission in the presence of **1a**

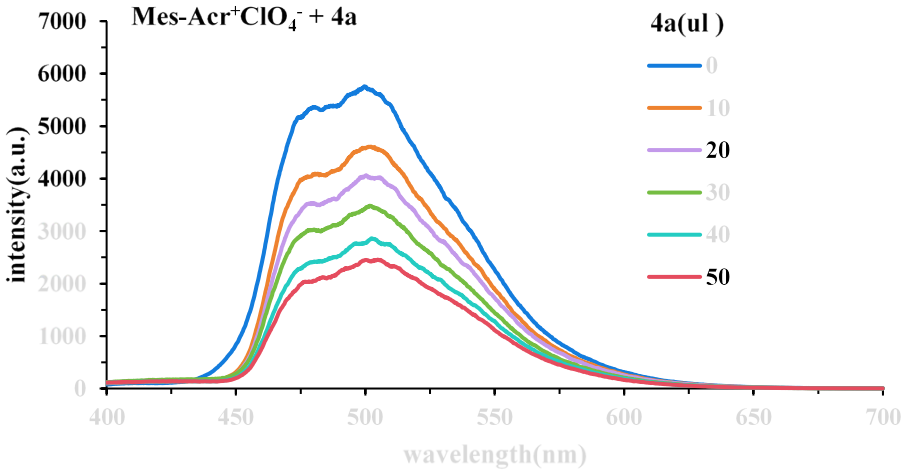


Figure S8 Quenching of Mes-AcrClO$_4$ fluorescence emission in the presence of **4a**

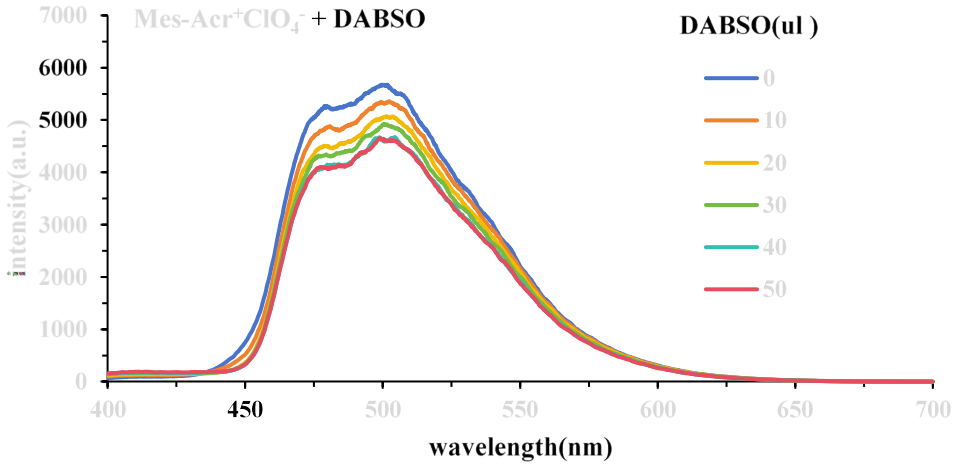


Figure S9 Quenching of Mes-AcrClO$_4$ fluorescence emission in the presence of DABSO

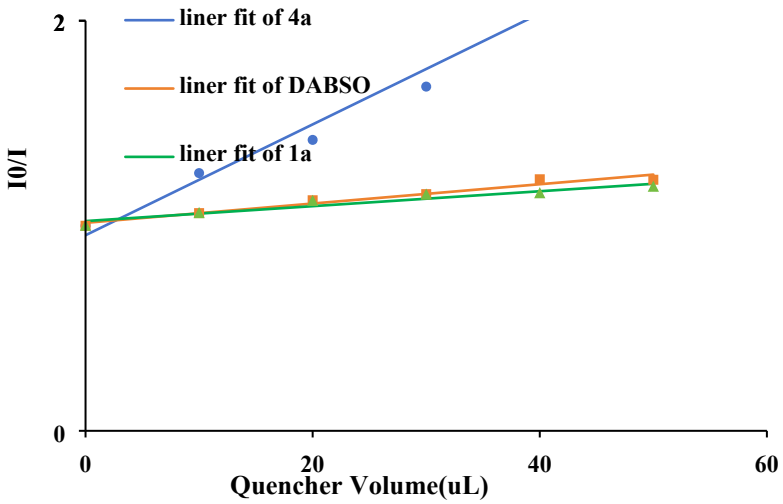


Figure S10. Stern-Volmer analysis for Mes-AcrClO$_4$ with **1a**, **4a** and DABSO

(3) UV-vis absorption spectra.

UV/vis absorption spectra between **1a** (5 mM), **6a** (5 mM) and DABSO (5 mM) in 20 mL DMA were recorded in 1 cm path quartz cuvettes using a Shimadzu UV-2550 UV-vis spectrophotometer.

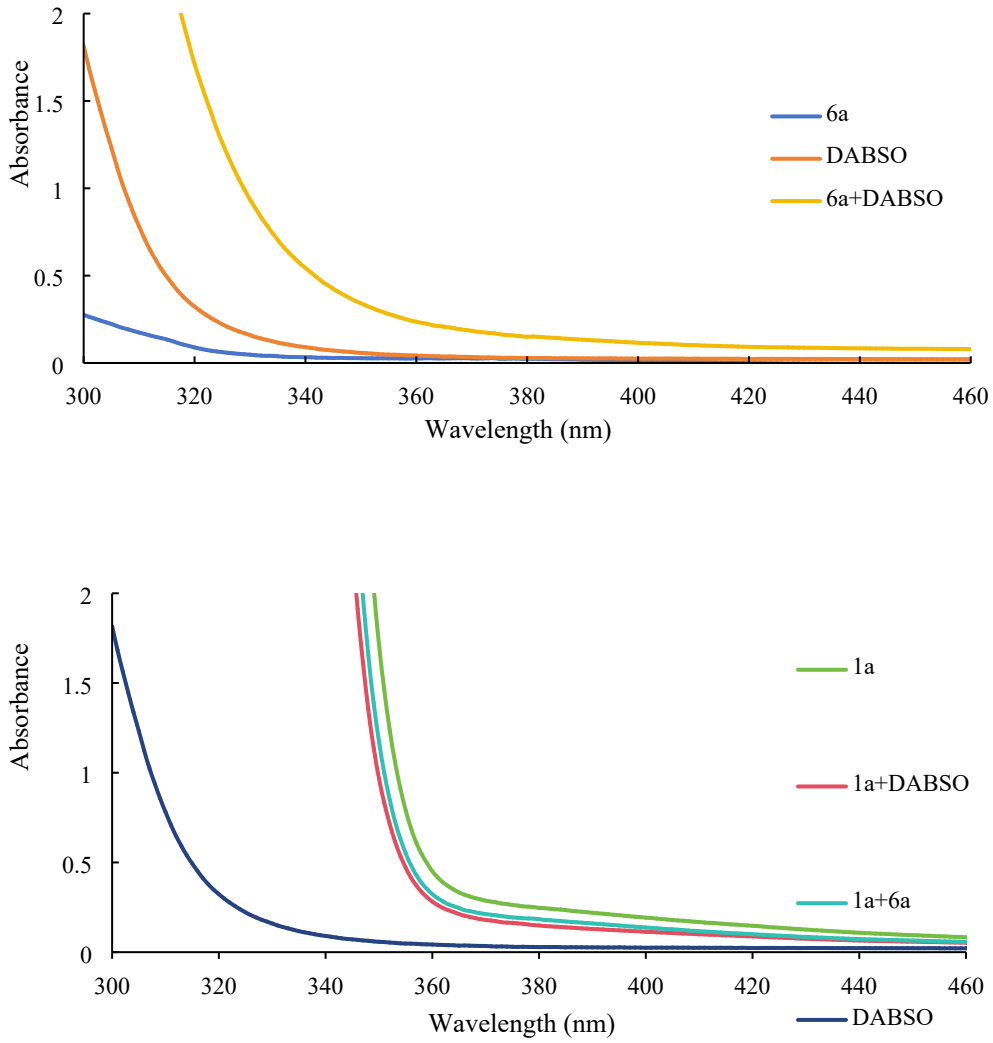


Figure S11. UV-vis absorption spectra.

(4) Light on-off experiments.

On/off experiments of model reaction

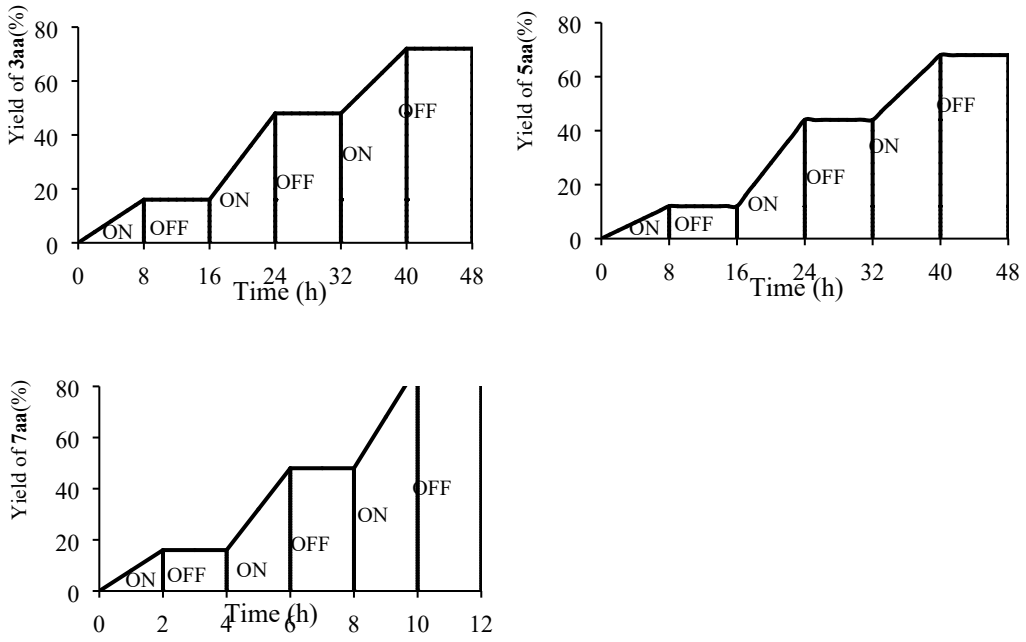


Figure S12. Light on-off experiments

(5) Measurement of quantum yield

(a) Determination of the light intensity at 458 nm:

The photon flux of the spectrophotometer was determined by standard ferrioxalate actinometry[3]. A 0.15 M solution of ferrioxalate was prepared by dissolving 0.737 g of potassium ferrioxalate hydrate in 10.0 mL of 0.05 M H_2SO_4. A buffered solution of phenanthroline was prepared by dissolving 5.0 mg of phenanthroline and 1.13 g of sodium acetate in 5.0 mL of 0.5 M H_2SO_4. Both solutions were stored in the dark. To determine the photon flux of the LED, the ferrioxalate solution (3.0 mL) was placed in a cuvette and irradiated for 90 seconds at λ = 460 nm. After irradiation, the phenanthroline solution (0.525 mL) was added to the cuvette and the mixture was allowed to stir in the dark for 1 h to allow the ferrous ions to completely coordinate to the phenanthroline. The absorbance of the solution was measured at 510 nm. A nonirradiated sample was also prepared and the absorbance at 510 nm was measured. Conversion was calculated using eq 1

$$mol\,Fe^{2+} = \frac{V * \Delta A}{L * \varepsilon} \quad (1)$$

V is the total volume (3.525×10^{-3} L) of the solution after addition of phenanthroline; **ΔA** is the difference in absorbance at 510 nm between the irradiated and non-irradiated solutions; **l** is the path length (1.00 cm), and **ε** is the molar absorptivity of the ferrioxalate actinometer at 510 nm (11100 L $mol^{-1}cm^{-1}$). The photon flux can be calculated using eq 2.

$$photon\ flux = \frac{mol\ Fe^{2+}}{\varphi * t * f} \quad (2)$$

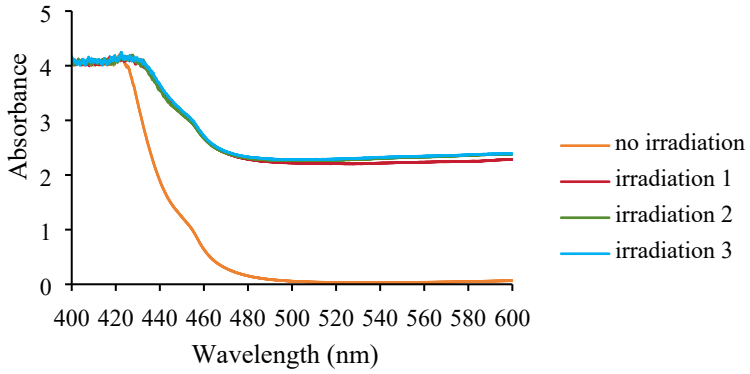


Figure S13. Absorption spectra of three irradiation experiments and non-irradiation experiment

Where **Φ** is the quantum yield for the ferrioxalate actinometer (0.92 for 0.15 M solution at λ = 468 nm), **t** is the time (90.0 s), and **f** is the fraction of light absorbed at λ = 468 nm (0.850, vide infra). The photon flux was calculated to be 9.98×10^{-9} einstein s^{-1}.

Sample calculation:

$$mol\ Fe^{2+} = \frac{0.003525\ L * (2.2536 - 0.0402)}{1.0000\ cm * 11100\ L\ mol^{-1} cm^{-1}} = 7.03 \times 10^{-7} mol$$

$$photon\ flux = \frac{7.03 * 10^{-7} mol}{0.92 * 90 * 0.850} = 9.98 \times 10^{-9}$$

(b) Determination of the quantum yield

3ab: 1a (0.3 mmol), **2b** (0.6 mmol, 2 equiv.), DABSO (0.6 mmol, 2 equiv.), 4CzIPN (2 mol%), and 2 mL DMSO were added in a 10 mL schlenk-tube. Then the mixture was stirred at rt for 1 h in the photochemical reactor with 25 W blue LED as light source under air atmosphere. After irradiation, the yield of product was determined by ^{1}H NMR analysis using CH_2Br_2 as an internal standard. The quantum yield was determined using eq 3

$$\varphi = \frac{mol\ product}{flux * t * f} \quad (3)$$

$$f = 1 - 10^{-A} \quad (4)$$

Sample calculation:

$$\varphi(3ab) = \frac{1.5 * 10^{-5}}{9.98 * 10^{-9} einstein\ s^{-1} * 3600s * 0.994} = 0.42$$

Thus, 0.45 equivalent of product was formed for every photon absorbed by the photocatalyst, ruling out the possibility of chain propagation process.

5aa: 1a (0.3 mmol), **4a** (0.6 mmol, 2 equiv.), DABSO (0.6 mmol, 2 equiv.), Mes-AcrClO$_4$ (2 mol%), and 2 mL DCE were added in a 10 mL schlenk-tube. Then the mixture was stirred at rt for 1 h in the photochemical reactor with 25 W blue LED as light source under air atmosphere. After irradiation, the yield of product was determined by ^{1}H NMR analysis using CH_2Br_2 as an internal standard. The quantum yield was determined using eq 3

Sample calculation:

$$\varphi(5aa) = \frac{1.2 * 10^{-5}}{9.98 * 10^{-9} einstein\ s^{-1} * 3600s * 0.994} = 0.34$$

Thus, ruling out the possibility of chain propagation process.

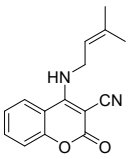
7aa: 1a (0.3 mmol), **6a** (0.45 mmol, 1.5 equiv.), DABSO (0.45 mmol, 1.5 equiv.) and 2 mL DMA were added in a 10 mL schlenk-tube. Then the mixture was stirred at rt for 1 h in the photochemical reactor with 25 W blue LED as light source under Ar atmosphere. After irradiation, the yield of product was determined by ^{1}H NMR analysis using CH_2Br_2 as an internal standard. The quantum yield was determined using eq 3

Sample calculation:

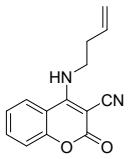
$$\varphi(7aa) = \frac{2.4 * 10^{-5}}{9.98 * 10^{-9} einstein\ s^{-1} * 3600s * 0.994} = 0.67$$

Thus, ruling out the possibility of chain propagation process.

6. Unsuccessful substrates



1f



1g

7. References

1. Z. Li, S. Li, G. Qian, Z. Ke and Z. Chen, Copper-Catalyzed Synthesis of Difluoromethylated/C-4- and C-5-Functionalized Polycyclic Coumarin Derivatives, *J. Org. Chem.*, 2024, **89**, 8084-8098.
2. A. Sharma and P. Gogoi, Transition-metal free C(sp^2)-C(sp^2) bond formation: arylation of 4-aminocoumarins using arynes as an aryl source, *Org. Biomol. Chem.*, 2019, **17**, 9014-9025.
3. M. A. Cismesia and T. P. Yoon, Characterizing chain processes in visible light photoredox catalysis, *Chem. Sci*., 2015, **6**, 5426

8. X-ray data of 3ac (DMSO):

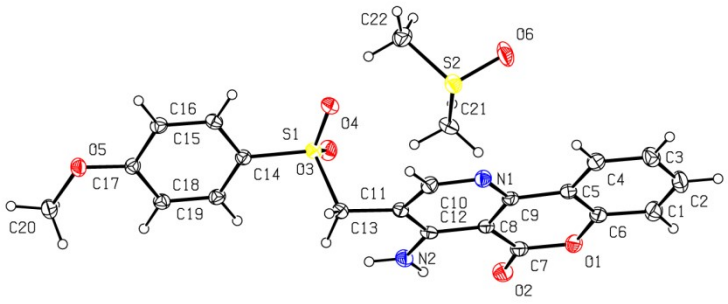
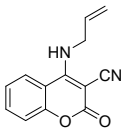


Table 2 Crystal data and structure refinement for3ac (DMSO).

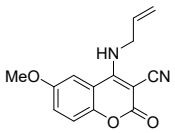
Identification code	**3ac (DMSO)**
Empirical formula	$C_{22}H_{22}N_2O_6S_2$
Formula weight	474.53
Temperature/K	170.00
Crystal system	monoclinic
Space group	$P2_1/n$
a/Å	13.8810(5)
b/Å	11.8967(4)
c/Å	14.0748(5)
α/°	90
β/°	110.8250(10)
γ/°	90
Volume/Å^3	2172.44(13)
Z	4
ρ_{calc}g/cm^3	1.451
μ/mm^{-1}	0.288
F(000)	992.0
Crystal size/mm^3	0.39 × 0.32 × 0.18
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	4.616 to 56.612
Index ranges	$-18 \le h \le 18$, $-15 \le k \le 15$, $-18 \le l \le 18$
Reflections collected	24965
Independent reflections	5350 [R_{int} = 0.0392, R_{sigma} = 0.0342]
Data/restraints/parameters	5350/0/292
Goodness-of-fit on F^2	1.121
Final R indexes [I>=2σ (I)]	R_1 = 0.0498, wR_2 = 0.0951
Final R indexes [all data]	R_1 = 0.0702, wR_2 = 0.1055
Largest diff. peak/hole / e Å^{-3}	0.26/-0.39

9.Characterization data for the products.



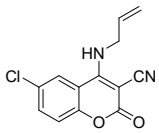
4-(allylamino)-2-oxo-2*H*-chromene-3-carbonitrile (1a):

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (2:1). white solid (1.582g, 70% yield); mp: 254-255 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.02 (s, 1H), 8.22 (d, J = 8.2 Hz, 1H), 7.72 (t, J = 7.8 Hz, 1H), 7.52 – 7.30 (m, 2H), 6.12 – 5.93 (m, 1H), 5.23 (dd, J = 19.0, 13.9 Hz, 2H), 4.56 – 4.37 (m, 2H). ^{13}C NMR (101 MHz, DMSO) δ 160.8, 156.2, 152.3, 134.8, 134.1, 124.9, 123.6, 118.1, 117.6, 116.6, 113.7, 70.3, 45.6. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{13}H_{11}N_2O_2^+$ 227.0816; Found 227.0819



4-(allylamino)-6-methoxy-2-oxo-2*H*-chromene-3-carbonitrile (1b):

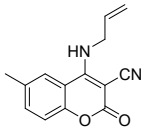
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (2:1). white solid (2.074g, 81% yield); mp: 242-243 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.92 (s, 1H), 7.69 (t, J = 1.6 Hz, 1H), 7.30 (d, J = 1.5 Hz, 2H), 6.08 – 5.95 (m, 1H), 5.31 – 5.16 (m, 2H), 4.44 (dd, J = 4.4, 2.2 Hz, 2H), 3.84 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 160.9, 156.2, 156.0, 146.6, 134.2, 122.4, 119.2, 117.6, 116.7, 113.9, 106.0, 70.4, 56.6, 45.6. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{14}H_{13}N_2O_3^+$ 257.0921; Found 257.0927



4-(allylamino)-6-chloro-2-oxo-2*H*-chromene-3-carbonitrile(1c):

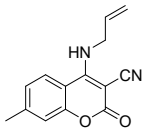
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (2:1). white solid (1.768g, 68% yield); mp: 238-239 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.03 (s, 1H), 8.50

(d, J = 2.2 Hz, 1H), 7.88 (dd, J = 8.8, 2.2 Hz, 1H), 7.36 (d, J = 8.8 Hz, 1H), 6.10 – 5.91 (m, 1H), 5.34 – 5.16 (m, 2H), 4.43 (dt, J = 4.9, 1.8 Hz, 2H). ^{13}C NMR (101 MHz, DMSO) δ 160.4, 155.2, 151.5, 137.1, 133.9, 126.2, 120.3, 117.3, 117.0, 116.9, 115.7, 70.7, 45.8. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{13}H_{10}ClN_2O_2^+$ 261.0426; Found 261.0421



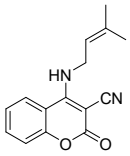
4-(allylamino)-6-methyl-2-oxo-2*H*-chromene-3-carbonitrile (1d):

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (2:1). white solid (1.872g, 78% yield); mp: 237-238 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.91 (t, J = 6.2 Hz, 1H), 8.07 (d, J = 8.4 Hz, 1H), 7.24 (dd, J = 8.4, 1.7 Hz, 1H), 7.20 – 7.11 (m, 1H), 6.00 (ddt, J = 17.2, 10.4, 4.7 Hz, 1H), 5.31 – 5.14 (m, 2H), 4.42 (h, J = 2.2 Hz, 2H), 2.40 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 161.0, 156.2, 152.3, 145.9, 134.2, 126.0, 123.3, 117.9, 117.7, 116.6, 111.1, 69.7, 45.5, 21.4. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{14}H_{13}N_2O_2^+$ 241.0972; Found 241.0976



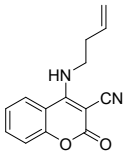
4-(allylamino)-7-methyl-2-oxo-2*H*-chromene-3-carbonitrile (1e):

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (2:1). white solid (1.944g, 81% yield); mp: 265-267 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.92 (s, 1H), 8.03 (d, J = 2.0 Hz, 1H), 7.52 (dd, J = 8.5, 1.8 Hz, 1H), 7.25 (d, J = 8.4 Hz, 1H), 6.18 – 5.86 (m, 1H), 5.39 – 5.11 (m, 2H), 4.54 – 4.36 (m, 2H), 2.38 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 160.9, 156.1, 150.4, 135.5, 134.3, 134.1, 123.2, 117.8, 117.6, 116.7, 113.3, 70.2, 45.6, 20.9. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{14}H_{13}N_2O_2^+$ 241.0972; Found 241.0975



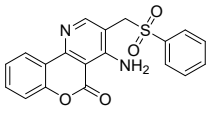
4-((3-methylbut-2-en-1-yl)amino)-2-oxo-2*H*-chromene-3-carbonitrile (1f):

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (2:1). white solid (1.728 g, 68% yield); mp: 267-268 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.88 (s, 1H), 8.23 (d, J = 8.2 Hz, 1H), 7.70 (t, J = 7.8 Hz, 1H), 7.53 – 7.29 (m, 2H), 5.37 (d, J = 6.5 Hz, 1H), 4.42 (d, J = 6.4 Hz, 2H), 1.73 (d, J = 9.3 Hz, 6H). ^{13}C NMR (101 MHz, DMSO) δ 160.9, 155.9, 152.2, 136.3, 134.7, 124.8, 123.7, 120.4, 118.0, 117.8, 113.9, 69.8, 42.3, 26.0, 18.6. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{15}H_{15}N_2O_2^+$ 255.1129; Found 255.1125



4-(but-3-en-1-ylamino)-2-oxo-2*H*-chromene-3-carbonitrile (1g):

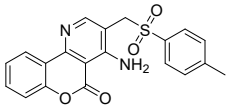
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (2:1). white solid (1.800 g, 75% yield); mp: 254-256 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.79 (t, J = 6.3 Hz, 1H), 8.17 (dd, J = 8.2, 1.3 Hz, 1H), 7.79 – 7.61 (m, 1H), 7.49 – 7.29 (m, 2H), 5.87 (ddt, J = 17.0, 10.2, 6.7 Hz, 1H), 5.23 – 5.02 (m, 2H), 3.88 (q, J = 6.7 Hz, 2H), 2.51 – 2.39 (m, 2H). ^{13}C NMR (101 MHz, DMSO) δ 160.9, 156.1, 152.3, 134.9, 134.8, 124.9, 123.5, 118.1, 118.0, 117.8, 113.8, 69.8, 43.2, 34.1. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{14}H_{13}N_2O_2^+$ 241.0972; Found 241.0976



4-amino-3-((phenylsulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3aa):

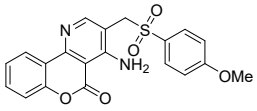
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (86 mg, 78% yield); mp: 280-282 °C;^{1}H NMR (400 MHz, DMSO-d_6) δ 8.38 (dd, J = 8.3, 1.7 Hz, 1H), 8.02 (s, 1H), 7.88 – 7.82 (m, 2H), 7.79 – 7.73 (m, 1H), 7.64 (td, J = 7.8, 1.6 Hz, 3H), 7.43 –

7.36 (m, 2H), 4.88 (s, 2H).^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.9, 155.8, 153.2, 152.3, 138.7, 134.6, 132.8, 129.7, 128.8, 125.3, 125.1, 119.7, 117.0, 108.4, 100.6, 54.2. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{19}H_{15}N_2O_4S^+$ 367.0748; Found 367.0754



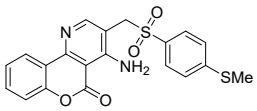
4-amino-3-(tosylmethyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3ab)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (104mg, 91% yield); mp 258-259 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.39 (dd, J = 8.4, 1.6 Hz, 1H), 8.02 (s, 1H), 7.79 – 7.70 (m, 2H), 7.64 (td, J = 7.5, 1.7 Hz, 1H), 7.51 – 7.36 (m, 4H), 4.84 (s, 2H), 2.42 (s, 3H).^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.9, 155.8, 153.2, 152.3, 145.0, 136.0, 132.8, 130.1, 128.8, 125.3, 125.1, 119.7, 117.0, 108.6, 100.6, 54.3, 21.6. ; HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{20}H_{17}N_2O_4S^+$ 381.0904; Found 381.0906.



4-amino-3-(((4-methoxyphenyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3ac)

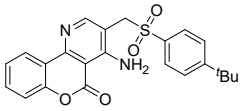
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (102 mg, 86% yield); mp 228-229 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.37 (dd, J = 8.3, 1.7 Hz, 1H), 8.01 (s, 1H), 7.77 – 7.71 (m, 2H), 7.62 (td, J = 7.7, 1.7 Hz, 1H), 7.41 – 7.35 (m, 2H), 7.15 – 7.09 (m, 2H), 4.80 (s, 2H), 3.84 (s, 3H).^{13}C NMR (101 MHz, DMSO) δ 163.9, 162.7, 156.8, 155.7, 153.1, 152.3, 132.7, 131.1, 130.3, 125.3, 125.1, 119.7, 116.9, 114.8, 108.8, 100.5, 56.3, 54.5. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{20}H_{17}N_2O_5S^+$ 397.0853; Found 397.0855.



4-amino-3-(((4-(methylthio)phenyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3ad)

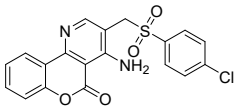
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (110 mg, 89% yield); mp 289-291 °C. ^{1}H NMR (600 MHz, DMSO-d_6) δ 8.39 – 8.36 (m, 1H), 8.04 (s, 1H), 7.72 (d, J = 8.2 Hz, 2H), 7.66 – 7.60 (m, 1H), 7.45 (d, J = 8.2 Hz, 2H), 7.39 (dt, J = 7.5, 3.3 Hz, 2H), 4.83 (s, 2H), 2.54 (s, 3H).^{13}C NMR (151 MHz, DMSO) δ 162.7, 156.9, 155.8, 153.2, 152.3,

147.3, 134.4, 132.8, 129.1, 125.6, 125.3, 125.1, 119.7, 117.0, 108.6, 100.6, 54.4, 14.4. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{20}H_{17}N_2O_4S_2^+$ 413.0625; Found 413.0627.



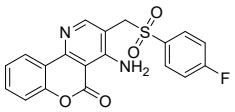
4-amino-3-(((4-(tert-butyl)phenyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3ae)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (107 mg, 85% yield); mp 225-227 °C. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.45 (dd, *J* = 8.4, 1.5 Hz, 1H), 7.95 (s, 1H), 7.82 – 7.76 (m, 2H), 7.61 – 7.54 (m, 3H), 7.40 – 7.33 (m, 2H), 4.41 (s, 2H), 1.35 (s, 9H).^{13}C NMR (101 MHz, $CDCl_3$) δ 163.0, 158.7, 156.5, 156.3, 153.9, 152.4, 134.1, 132.4, 128.3, 126.5, 125.3, 124.8, 119.2, 116.8, 108.6, 101.8, 58.1, 35.4, 31.0. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{23}H_{23}N_2O_4S^+$ 423.1374; Found 423.1375.



4-amino-3-(((4-chlorophenyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3af)

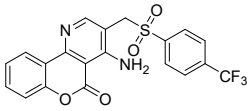
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (85 mg, 71% yield); mp 278-280 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.41 – 8.38 (m, 1H), 8.16 – 8.11 (m, 2H), 8.10 (s, 1H), 8.04 – 7.99 (m, 2H), 7.64 (td, *J* = 8.0, 1.7 Hz, 1H), 7.40 (t, *J* = 7.3 Hz, 2H), 4.97 (s, 2H).^{13}C NMR (101 MHz, DMSO) δ 162.6, 156.9, 155.8, 153.4, 152.4, 142.8, 133.7, 132.9, 129.7, 125.4, 125.2, 119.6, 118.1, 117.0, 107.7, 100.7, 53.9. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{19}H_{14}ClN_2O_4S^+$ 401.0358; Found 401.0357.



4-amino-3-(((4-fluorophenyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3ag)

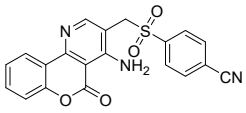
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (78 mg, 68% yield); mp 271-272 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.40 (dd, *J* = 8.2, 1.7 Hz, 1H), 8.07 (s, 1H), 7.93 – 7.86 (m, 2H), 7.65 (ddd, *J* = 9.5, 6.3, 1.7 Hz, 1H), 7.52 – 7.38 (m, 4H), 4.89 (s, 2H).^{13}C NMR (101 MHz, DMSO-d_6) δ 165.7 (d, *J* = 253.5 Hz), 162.7, 157.0, 155.7, 153.3, 152.4,

135.1 (d, J = 3.0 Hz), 132.8, 132.1 (d, J = 10.1 Hz), 125.4, 125.2, 119.7, 117.0, 116.9 (d, J = 19.2 Hz), 108.4, 100.6, 54.3.^{19}F NMR (376 MHz, DMSO-d_6) δ -104.43.; HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{19}H_{14}F_1N_2O_4S^+$ 385.0653; Found 385.0654



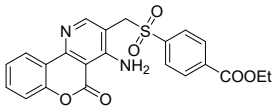
4-amino-3-(((4-(trifluoromethyl)phenyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3ah)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (85 mg, 65% yield); mp 288-290 °C. ^{1}H NMR (600 MHz, DMSO-d_6) δ 8.43 (d, J = 7.9 Hz, 1H), 8.14 (s, 1H), 8.10 (d, J = 8.1 Hz, 2H), 8.04 (d, J = 8.2 Hz, 2H), 7.69 – 7.62 (m, 1H), 7.41 (dt, J = 7.5, 3.3 Hz, 2H), 5.00 (s, 2H).^{13}C NMR (101 MHz, DMSO-d_6) δ 162.6, 157.0, 155.8, 153.4, 152.4, 142.8, 134.1 (q, J = 32.3 Hz), 132.8, 130.0, 126.8(q, J = 4.0 Hz), 125.3, 125.1,123.4(q, J = 273.7 Hz), 119.6, 117.0, 107.8, 100.7, 54.0.^{19}F NMR (376 MHz, DMSO-d_6) δ -61.69. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{20}H_{14}F_3N_2O_4S^+$ 435.0621; Found 435.0626



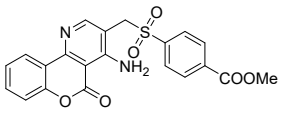
4-(((4-amino-5-oxo-5*H*-chromeno[4,3-*b*]pyridin-3-yl)methyl)sulfonyl)benzonitrile(3ai)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (89 mg, 76% yield); mp 297-298 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.34 (dd, J = 7.8, 1.6 Hz, 1H), 7.92 – 7.86 (m, 2H), 7.82 – 7.73 (m, 2H), 7.63 (ddd, J = 8.6, 7.3, 1.7 Hz, 1H), 7.56 (ddd, J = 8.3, 7.0, 1.7 Hz, 1H), 7.42 – 7.34 (m, 2H), 5.03 (s, 2H). ^{13}C NMR (101 MHz, None) δ 162.6, 156.5, 155.9, 153.3, 152.4, 136.4, 135.9, 132.9, 132.6, 132.3, 128.5, 125.3, 125.2, 119.6, 117.0, 108.0, 100.7, 53.4. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{20}H_{14}N_3O_4S^+$ 392.0700; Found 392.0706



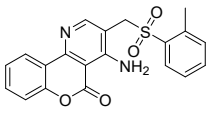
ethyl 4-(((4-amino-5-oxo-5*H*-chromeno[4,3-*b*]pyridin-3-yl)methyl)sulfonyl)benzoate(3aj)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (104 mg, 79% yield); mp 251-252 °C. ^{1}H NMR (600 MHz, DMSO-d_6) δ 8.38 (d, J = 7.8 Hz, 1H), 8.15 (d, J = 8.1 Hz, 2H), 8.05 (s, 1H), 7.99 (d, J = 8.1 Hz, 2H), 7.63 (t, J = 7.7 Hz, 1H), 7.40 (d, J = 7.8 Hz, 2H), 4.95 (s, 2H), 4.37 (q, J = 7.1 Hz, 2H), 1.35 (t, J = 7.0 Hz, 3H).^{13}C NMR (151 MHz, DMSO) δ 165.1, 162.6, 157.0, 155.8, 153.3, 152.4, 142.7, 135.0, 132.8, 130.3, 129.4, 125.3, 125.1, 119.7, 117.0, 108.0, 100.7, 62.0, 54.1, 14.5. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{22}H_{19}N_2O_6S^+$ 439.0959; Found 439.0954



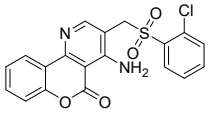
methyl 4-(((4-amino-5-oxo-5*H*-chromeno[4,3-*b*]pyridin-3-yl)methyl)sulfonyl)benzoate(3ak)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (102 mg, 80% yield); mp 279-280 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.39 (dd, J = 8.4, 1.6 Hz, 1H), 8.20 – 8.13 (m, 2H), 8.07 (s, 1H), 8.04 – 7.97 (m, 2H), 7.70 – 7.58 (m, 1H), 7.46 – 7.34 (m, 2H), 4.96 (s, 2H), 3.91 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 165.6, 162.6, 157.0, 155.8, 153.3, 152.4, 142.8, 134.7, 132.8, 130.3, 129.4, 125.4, 125.1, 119.7, 117.0, 108.0, 100.7, 54.1, 53.2. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{21}H_{17}N_2O_6S^+$ 425.0802; Found 425.0807



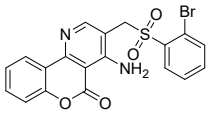
4-amino-3-((o-tolylsulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3al)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (84 mg, 74% yield); mp 237-239 °C. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.42 (dd, J = 8.4, 1.6 Hz, 1H), 7.90 (d, J = 6.7 Hz, 2H), 7.60 – 7.51 (m, 2H), 7.40 – 7.30 (m, 4H), 4.44 (s, 2H), 2.74 (s, 3H).^{13}C NMR (101 MHz, $CDCl_3$) δ 163.0, 156.3, 156.3, 154.0, 152.4, 138.3, 135.2, 134.5, 133.0, 132.4, 130.6, 127.0, 125.3, 124.8, 119.3, 116.8, 108.3, 101.8, 57.3, 20.6. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{20}H_{17}N_2O_4S^+$ 381.0904; Found 381.0906.



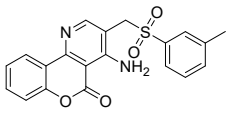
4-amino-3-(((2-chlorophenyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3am)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (76 mg, 63% yield); mp 264-265 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.36 (dd, J = 8.0, 1.6 Hz, 1H), 7.99 (s, 1H), 7.88 – 7.79 (m, 1H), 7.74 (td, J = 7.5, 1.8 Hz, 1H), 7.63 (ddd, J = 8.6, 7.2, 1.7 Hz, 1H), 7.53 (ddd, J = 10.5, 8.3, 1.0 Hz, 1H), 7.47 – 7.35 (m, 3H), 4.98 (s, 2H).^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.5, 156.0, 153.4, 152.4, 136.3, 135.9, 132.9, 132.6, 132.5, 132.3, 128.5, 125.3, 125.2, 119.6, 117.0, 108.0, 100.7, 53.5. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{19}H_{14}ClN_2O_4S^+$ 401.0358; Found 401.0354



4-amino-3-(((2-bromophenyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3an)

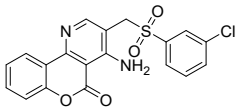
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (81 mg, 61% yield); mp 259-261 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.33 (dd, J = 7.9, 1.7 Hz, 1H), 7.98 (dd, J = 7.8, 1.3 Hz, 1H), 7.92 (dd, J = 7.8, 1.8 Hz, 1H), 7.87 (s, 1H), 7.69 – 7.58 (m, 3H), 7.42 – 7.35 (m, 2H), 5.03 (s, 2H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.5, 156.0, 153.3, 152.3, 137.5, 136.3, 136.1, 132.9, 132.8, 129.0, 125.3, 125.2, 121.0, 119.6, 117.0, 108.0, 100.7, 53.0. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{19}H_{14}BrN_2O_4S^+$ 444.9853; Found 444.9857



4-amino-3-((m-tolylsulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3ao)

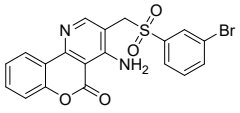
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (87 mg, 76% yield); mp 266-267 °C. ^{1}H NMR (400 MHz,) δ 8.41 – 8.36 (m, 1H), 8.04 (s, 1H), 7.70 – 7.61 (m, 3H), 7.57 (d, J = 7.6 Hz, 1H), 7.50 (t, J = 7.6 Hz, 1H), 7.40 (t, J = 7.4 Hz, 2H), 4.84

(s, 2H), 2.37 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.9, 155.8, 153.1, 152.3, 139.4, 138.7, 135.1, 132.8, 129.5, 128.9, 125.9, 125.3, 125.1, 119.7, 117.0, 108.4, 100.6, 54.2, 21.2. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{20}H_{17}N_2O_4S^+$ 381.0904; Found 381.0908



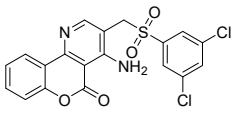
4-amino-3-(((3-chlorophenyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3ap)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (85 mg, 71% yield); mp 252-253 °C. ^{1}H NMR (400 MHz,) δ 8.40 (dd, *J* = 8.1, 1.7 Hz, 1H), 8.13 (s, 1H), 7.94 (t, *J* = 1.9 Hz, 1H), 7.89 – 7.85 (m, 1H), 7.79 (dt, *J* = 7.9, 1.3 Hz, 1H), 7.72 – 7.61 (m, 2H), 7.43 – 7.37 (m, 2H), 4.94 (s, 2H). ^{13}C NMR (101 MHz, DMSO) δ 162.1, 156.4, 155.4, 152.8, 151.9, 140.2, 134.1, 133.9, 132.4, 131.2, 128.0, 127.1, 124.9, 124.7, 119.1, 116.5, 107.5, 100.2, 53.6. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{19}H_{14}ClN_2O_4S^+$ 401.0358 ; Found 401.0364



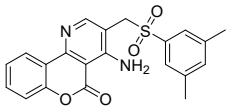
4-amino-3-(((3-bromophenyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3aq)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (94 mg, 71% yield); mp 258-260 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.41 (dd, *J* = 8.2, 1.7 Hz, 1H), 8.14 (s, 1H), 8.04 – 7.96 (m, 2H), 7.82 (dt, *J* = 7.9, 1.2 Hz, 1H), 7.68 – 7.62 (m, 1H), 7.59 (t, *J* = 7.9 Hz, 1H), 7.45 – 7.37 (m, 2H), 4.93 (s, 2H). ^{13}C NMR (101 MHz, DMSO) δ 162.6, 157.1, 155.8, 153.4, 152.4, 140.8, 137.4, 132.8, 131.9, 131.3, 127.9, 125.4, 125.2, 122.6, 119.7, 117.0, 108.0, 100.6, 54.1. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{19}H_{14}BrN_2O_4S^+$ 444.9853; Found 444.9857



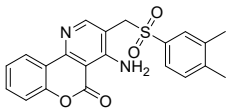
4-amino-3-(((3,5-dichlorophenyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3ar)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (75 mg, 58% yield); mp 253-255 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.42 (dd, J = 8.1, 1.7 Hz, 1H), 8.21 (s, 1H), 8.10 (t, J = 1.9 Hz, 1H), 7.87 (d, J = 1.8 Hz, 2H), 7.69 – 7.62 (m, 1H), 7.45 – 7.38 (m, 2H), 4.97 (s, 2H). ^{13}C NMR (101 MHz, DMSO) δ 162.6, 157.1, 155.9, 153.5, 152.4, 141.9, 135.5, 134.2, 132.9, 127.5, 125.4, 125.2, 119.6, 117.0, 107.5, 100.7, 54.1. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{19}H_{13}Cl_2N_2O_4S^+$ 434.9968 ; Found 434.9963



4-amino-3-(((3,5-dimethylphenyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3as)

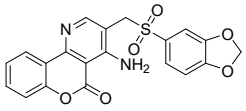
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (98 mg, 83% yield); mp 287-289 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.80 (d, J = 8.1 Hz, 1H), 8.13 (s, 1H), 7.81 (td, J = 7.7, 1.5 Hz, 1H), 7.58 – 7.50 (m, 3H), 7.42 (s, 1H), 5.00 (s, 2H), 2.36 (s, 5H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.9, 155.8, 153.1, 152.4, 139.2, 138.7, 135.7, 132.8, 126.1, 125.3, 125.2, 119.6, 117.0, 108.5, 100.6, 54.2, 21.1. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{21}H_{19}N_2O_4S^+$ 395.1061 ; Found 395.1064



4-amino-3-(((3,4-dimethylphenyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3at)

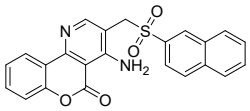
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (99 mg, 83% yield); mp 291-292 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.37 (dd, J = 8.1, 1.7 Hz, 1H), 8.03 (s, 1H), 7.67 – 7.59 (m, 2H), 7.56 (dd, J = 7.9, 2.0 Hz, 1H), 7.42 – 7.33 (m, 3H), 4.80 (s, 2H), 2.32 (s, 3H), 2.28 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.9, 155.8, 153.1, 152.3, 143.8,

138.1, 136.2, 132.7, 130.4, 129.2, 126.2, 125.3, 125.1, 119.7, 116.9, 108.6, 100.6, 54.3, 20.0, 19.7.; HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{21}H_{19}N_2O_4S^+$ 395.1061 ; Found 395.1065



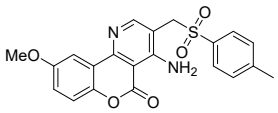
4-amino-3-((benzo[*d*][1,3]dioxol-5-ylsulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3au)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (93 mg, 76% yield); mp 273-274 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.40 (dd, J = 8.2, 1.7 Hz, 1H), 8.07 (s, 1H), 7.68 – 7.61 (m, 1H), 7.43 – 7.37 (m, 3H), 7.33 (dd, J = 8.2, 1.9 Hz, 1H), 7.11 (d, J = 8.2 Hz, 1H), 6.21 (s, 2H), 4.82 (s, 2H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.9, 155.8, 153.2, 152.5, 152.3, 148.3, 132.8, 131.9, 125.3, 125.1, 124.9, 119.7, 117.0, 108.8, 108.6, 108.5, 103.2, 100.6, 54.3. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{20}H_{15}N_2O_6S^+$ 411.0646 ; Found 411.0641



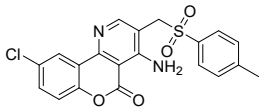
4-amino-3-((naphthalen-2-ylsulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3av)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (106 mg, 85% yield); mp 262-263 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.53 (d, J = 1.8 Hz, 1H), 8.33 (dd, J = 7.9, 1.7 Hz, 1H), 8.19 – 8.12 (m, 2H), 8.10 – 8.07 (m, 1H), 8.04 (s, 1H), 7.90 (dd, J = 8.7, 1.9 Hz, 1H), 7.75 (ddd, J = 8.2, 6.8, 1.3 Hz, 1H), 7.68 (ddd, J = 8.1, 6.8, 1.3 Hz, 1H), 7.61 (ddd, J = 8.6, 7.2, 1.7 Hz, 1H), 7.39 – 7.33 (m, 2H), 4.96 (s, 2H). ^{13}C NMR (101 MHz, DMSO) δ 162.6, 156.9, 155.8, 153.2, 152.3, 136.0, 135.3, 132.7, 132.0, 130.4, 129.9, 129.9, 129.6, 128.4, 128.2, 125.3, 125.1, 123.6, 119.7, 116.9, 108.4, 100.6, 54.3. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{23}H_{17}N_2O_4S^+$ 417.0904 ; Found 417.0907



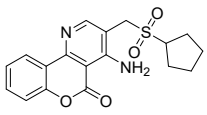
4-amino-9-methoxy-3-(tosylmethyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3aw)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (108 mg, 88% yield); mp 263-264 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.03 (s, 1H), 7.87 – 7.66 (m, 3H), 7.38 (dd, *J* = 41.2, 8.4 Hz, 3H), 7.20 (d, *J* = 9.0 Hz, 1H), 4.83 (s, 2H), 3.84 (s, 3H), 2.41 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.6, 156.4, 155.8, 152.9, 146.6, 145.0, 136.0, 130.2, 128.8, 120.6, 120.1, 118.3, 108.6, 106.9, 100.5, 56.1, 54.3, 21.6. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{21}H_{19}N_2O_5S^+$ 411.1010 ; Found 411.1016



4-amino-9-chloro-3-(tosylmethyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(3ax)

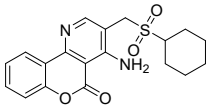
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (101 mg, 81% yield); mp 297-298 °C. ^{1}H NMR (600 MHz, DMSO-d_6) δ 8.31 (s, 1H), 8.02 (s, 1H), 7.73 (d, *J* = 7.8 Hz, 2H), 7.68 (d, *J* = 8.9 Hz, 1H), 7.46 (dd, *J* = 18.0, 8.3 Hz, 3H), 4.85 (s, 2H), 2.43 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 164.6, 162.0, 161.9, 155.9, 151.0, 145.1, 135.9, 132.6, 129.3, 128.8, 128.5, 126.0, 124.3, 119.3, 109.4, 100.8, 54.1, 21.6. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_2H_{16}ClN_2O_4S^+$ 415.0514 ; Found 415.0518



4-amino-3-((cyclopentylsulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(5aa)

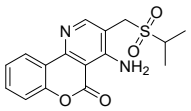
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (76 mg, 71% yield); mp 268-269 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.43 (d, *J* = 8.4 Hz, 1H), 8.38 (s, 1H), 7.64 (t, *J* = 7.8 Hz, 1H), 7.41 (dt, *J* = 7.4, 3.3 Hz, 2H), 4.64 (s, 2H), 3.74 – 3.63 (m, 1H), 1.99 (q, *J* = 6.3 Hz, 4H), 1.73 – 1.54 (m, 4H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.9, 155.9,

153.2, 152.3, 132.7, 125.3, 125.1, 119.8, 117.0, 108.5, 100.8, 60.6, 50.5, 26.8, 26.1. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{18}H_{19}N_2O_4S^+$ 359.1061 ; Found 359.1066



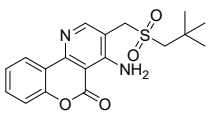
4-amino-3-((cyclohexylsulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(5ab)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (80 mg, 72% yield); mp 273-274 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.42 (dd, J = 8.1, 1.7 Hz, 1H), 8.34 (s, 1H), 7.64 (ddd, J = 8.6, 7.2, 1.7 Hz, 1H), 7.45 – 7.36 (m, 2H), 4.62 (s, 2H), 3.26 – 3.16 (m, 1H), 2.18 (dd, J = 12.8, 3.5 Hz, 2H), 1.86 (dt, J = 12.4, 3.4 Hz, 2H), 1.67 (dt, J = 12.5, 3.3 Hz, 1H), 1.46 (qd, J = 12.4, 3.3 Hz, 2H), 1.39 – 1.16 (m, 3H).^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.9, 156.0, 153.1, 152.3, 132.7, 125.3, 125.1, 119.8, 117.0, 108.2, 100.8, 60.3, 48.9, 25.3, 25.1, 25.0.; HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{19}H_{21}N_2O_4S^+$ 373.1217 ; Found 373.1221



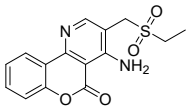
4-amino-3-((isopropylsulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(5ac)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (67 mg, 67% yield); mp 278-279 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.42 (dd, J = 8.1, 1.7 Hz, 1H), 8.36 (s, 1H), 7.64 (ddd, J = 8.7, 7.3, 1.7 Hz, 1H), 7.43 – 7.37 (m, 2H), 4.65 (s, 2H), 3.42 (hept, J = 6.9 Hz, 1H), 1.35 (d, J = 6.8 Hz, 6H).^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.9, 156.0, 153.2, 152.3, 132.7, 125.2, 125.1, 119.7, 117.0, 108.3, 100.8, 52.6, 48.7, 15.5. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{16}H_{17}N_2O_4S^+$ 333.0904 ; Found 333.0900



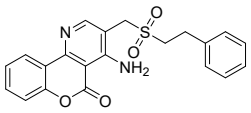
4-amino-3-((neopentylsulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(5ad)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (69 mg, 64% yield); mp 302-304 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.41 (dd, J = 8.2, 1.7 Hz, 1H), 8.35 (s, 1H), 7.63 (ddd, J = 8.7, 7.3, 1.7 Hz, 1H), 7.40 (ddd, J = 8.2, 6.7, 1.2 Hz, 2H), 4.59 (s, 2H), 3.20 (s, 2H), 1.14 (s, 9H).^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.9, 155.8, 153.1, 152.3, 132.7, 125.2, 125.1, 119.7, 116.9, 108.6, 100.8, 62.4, 54.2, 32.2, 30.1. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{18}H_{21}N_2O_4S^+$ 361.1217 ; Found 361.1219



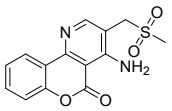
4-amino-3-((ethylsulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(5ae)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (65 mg, 68% yield); mp 279-281 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.41 (dd, J = 8.2, 1.7 Hz, 1H), 8.37 (s, 1H), 7.63 (ddd, J = 8.6, 7.3, 1.7 Hz, 1H), 7.42 – 7.36 (m, 2H), 4.66 (s, 2H), 3.18 (q, J = 7.5 Hz, 2H), 1.28 (t, J = 7.5 Hz, 3H).^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.9, 155.8, 153.2, 152.3, 132.7, 125.2, 125.1, 119.7, 116.9, 108.6, 100.8, 51.1, 46.5, 6.1. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{15}H_{15}N_2O_4S^+$ 319.0748; Found319.0751



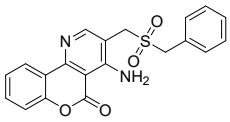
4-amino-3-((phenethylsulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(5af)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (98 mg, 83% yield); mp 278-280 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.42 (dd, J = 8.1, 1.7 Hz, 1H), 8.39 (s, 1H), 7.63 (ddd, J = 8.7, 7.3, 1.7 Hz, 1H), 7.44 – 7.37 (m, 2H), 7.36 – 7.28 (m, 4H), 7.24 (ddd, J = 8.6, 5.5, 2.2 Hz, 1H), 4.72 (s, 2H), 3.54 – 3.46 (m, 2H), 3.11 – 3.03 (m, 2H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.9, 155.8, 153.3, 152.3, 138.8, 132.7, 129.1, 129.0, 127.1, 125.3, 125.1, 119.7, 117.0, 108.4, 100.9, 53.2, 51.8, 27.3. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{21}H_{19}N_2O_4S^+$ 395.1061 ; Found 395.1065



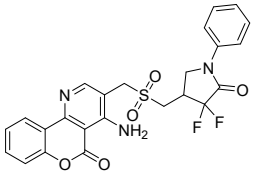
4-amino-3-((methylsulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(5ag)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (64 mg, 70% yield); mp 212-214 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.43 (dd, J = 8.1, 1.7 Hz, 1H), 8.39 (s, 1H), 7.65 (ddd, J = 8.6, 7.3, 1.7 Hz, 1H), 7.45 – 7.39 (m, 2H), 4.67 (s, 2H), 3.02 (s, 3H).^{13}C NMR (101 MHz, DMSO-d_6) δ 162.70, 156.75, 155.71, 153.13, 152.35, 132.80, 125.26, 125.17, 119.64, 117.01, 108.96, 100.88, 55.37, 52.93. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{14}H_{13}N_2O_4S^+$ 305.0591; Found305.0595



4-amino-3-((benzylsulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(5ah)

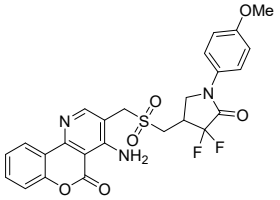
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (58 mg, 51% yield); mp 209-211 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.45 (dd, J = 8.3, 1.7 Hz, 1H), 8.37 (s, 1H), 7.68 – 7.62 (m, 1H), 7.42 (d, J = 14.7 Hz, 7H), 4.72 (s, 2H), 4.58 (s, 2H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 156.9, 155.9, 153.3, 152.4, 132.8, 131.7, 129.0, 128.9, 128.0, 125.3, 125.2, 119.8, 117.0, 108.3, 100.9, 58.0, 51.9. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{21}H_{19}N_2O_4S^+$ 381.0904 ; Found 381.0907



4-amino-3-((((4,4-difluoro-5-oxo-1-phenylpyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7aa)

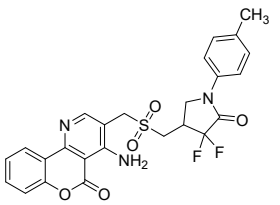
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (139 mg, 93% yield); mp 296-298 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.43 (dd, J = 8.1,

1.7 Hz, 1H), 8.41 (s, 1H), 7.70 – 7.61 (m, 3H), 7.50 – 7.44 (m, 2H), 7.44 – 7.37 (m, 2H), 7.32 – 7.25 (m, 1H), 4.85 (s, 2H), 4.15 (ddd, *J* = 9.8, 7.7, 1.7 Hz, 1H), 3.97 (ddd, *J* = 9.5, 6.9, 2.2 Hz, 1H), 3.92 – 3.81 (m, 1H), 3.74 – 3.57 (m, 2H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 162.7, 161.1(dd, *J* = 31.8 Hz, 29.8 Hz), 157.0, 155.9, 153.4, 152.4, 138.0, 132.8, 129.6, 126.6, 125.3, 125.2, 120.7, 119.7, 117.8(dd, *J* = 256.0 Hz, 249.0 Hz), 117.0, 107.8, 100.9, 52.3, 48.3 (d, *J* = 5.1 Hz), 48.2(d, *J* = 7.1 Hz), 33.4(dd, *J* = 21.7 Hz, 19.7 Hz). ^{19}F NMR (376 MHz, DMSO-d_6) δ -108.01 (d, *J* = 263.2 Hz), -112.81 (d, *J* = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{24}H_{20}F_2N_3O_5S^+$ 500.1087; Found 500.1092



4-amino-3-((((4,4-difluoro-1-(4-methoxyphenyl)-5-oxopyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7ab)

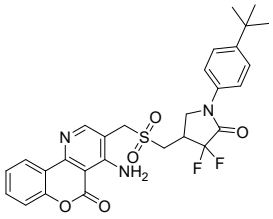
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (119 mg, 75% yield); mp 285-286 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.44 (dd, *J* = 8.1, 1.7 Hz, 1H), 8.41 (s, 1H), 7.70 – 7.60 (m, 1H), 7.61 – 7.52 (m, 2H), 7.47 – 7.37 (m, 2H), 7.06 – 6.96 (m, 2H), 4.85 (s, 2H), 4.09 (ddd, *J* = 9.8, 7.7, 1.8 Hz, 1H), 3.92 (ddd, *J* = 10.0, 7.2, 2.3 Hz, 1H), 3.89 – 3.81 (m, 1H), 3.77 (s, 3H), 3.68 – 3.57 (m, 2H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 162.7, 160.7(dd, *J* = 31.8 Hz, 29.8 Hz), 157.7, 157.0, 155.9, 153.4, 152.4, 132.8, 131.0, 125.3, 125.2, 122.6, 119.7, 117.9(dd, *J* = 255.5 Hz, 249.5 Hz), 117.0, 114.7, 107.8, 100.9, 55.8, 52.3, 48.7(d, *J* = 6.1 Hz), 48.3(d, *J* = 6.1 Hz), 33.5, 33.5(dd, *J* = 21.7 Hz, 19.7 Hz). ^{19}F NMR (376 MHz, DMSO) δ -107.82 (d, *J* = 259.4 Hz), -112.62.(d, *J* = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{25}H_{22}F_2N_3O_6S^+$ 530.1192; Found 530.1192



4-amino-3-((((4,4-difluoro-5-oxo-1-(*p*-tolyl)pyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-

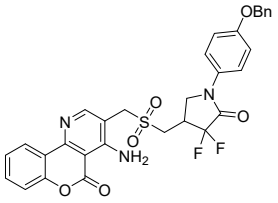
chromeno[4,3-*b*]pyridin-5-one(7ac)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (170 mg, 76% yield); mp 282-283 °C.^{1}H NMR (400 MHz, DMSO-d_6) δ 8.42 (dd, J = 8.2, 1.7 Hz, 1H), 8.40 (s, 1H), 7.64 (ddd, J = 8.6, 7.3, 1.7 Hz, 1H), 7.57 – 7.51 (m, 2H), 7.43 – 7.37 (m, 2H), 7.29 – 7.23 (m, 2H), 4.85 (s, 2H), 4.12 (ddd, J = 9.9, 7.9, 1.8 Hz, 1H), 3.93 (ddd, J = 9.9, 6.9, 2.1 Hz, 1H), 3.90 – 3.81 (m, 1H), 3.70 – 3.54 (m, 2H), 2.30 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 160.9(dd, J = 31.3 Hz, 30.3 Hz), 157.0, 155.9, 153.4, 152.3, 136.0, 135.6, 132.8, 129.9, 125.3, 125.1, 120.7, 119.7, 117.8(dd, J = 255.5 Hz, 249.5 Hz), 117.0, 107.8, 100.9, 52.3, 48.3 (d, J = 6.1 Hz), 48.3(d, J = 7.1 Hz), 33.4(dd, J = 21.7 Hz, 19.7 Hz), 21.0. ^{19}F NMR (376 MHz, DMSO) δ -107.92 (d, J = 259.4 Hz), -112.68(d, J = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{25}H_{22}F_2N_3O_5S^+$ 514.1243; Found 514.1247



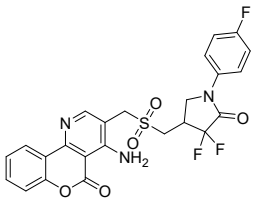
4-amino-3-((((1-(4-(*tert*-butyl)phenyl)-4,4-difluoro-5-oxopyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7ad)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (122 mg, 73% yield); mp 284-285 °C.^{1}H NMR (400 MHz, DMSO-d_6) δ 8.43 (dd, J = 8.2, 1.7 Hz, 1H), 8.41 (s, 1H), 7.64 (ddd, J = 8.7, 7.3, 1.7 Hz, 1H), 7.59 – 7.53 (m, 2H), 7.49 – 7.44 (m, 2H), 7.44 – 7.38 (m, 2H), 4.85 (s, 2H), 4.12 (td, J = 8.3, 7.9, 4.1 Hz, 1H), 3.93 (td, J = 7.6, 6.9, 3.9 Hz, 1H), 3.90 – 3.82 (m, 1H), 3.72 – 3.56 (m, 2H), 1.27 (s, 9H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 162.7, 160.9(dd, J = 31.3 Hz, 30.3 Hz), 157.0, 155.9, 153.4, 152.3, 149.1, 135.5, 132.8, 126.2, 125.3, 125.1, 120.5, 119.7, 117.8(dd, J = 256.0 Hz, 250.0 Hz), 117.0, 107.8, 100.9, 52.3, 48.3 (d, J = 6.1 Hz), 48.2(d, J = 6.1 Hz), 34.7, 33.5(dd, J = 21.7 Hz, 19.7 Hz), 31.5. ^{19}F NMR (376 MHz, DMSO) δ -108.01 (d, J = 263.2 Hz), -112.82(d, J = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{28}H_{28}F_2N_3O_5S^+$ 556.1713; Found 556.1718



4-amino-3-((((1-(4-(benzyloxy)phenyl)-4,4-difluoro-5-oxopyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7ae)

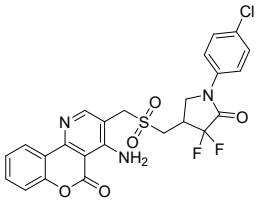
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (129 mg, 71% yield); mp 262-263 °C.^{1}H NMR (400 MHz, DMSO-d_6) δ 8.45 (dd, J = 8.2, 1.7 Hz, 1H), 8.41 (s, 1H), 7.70 – 7.61 (m, 1H), 7.62 – 7.52 (m, 2H), 7.49 – 7.35 (m, 6H), 7.38 – 7.28 (m, 1H), 7.14 – 7.05 (m, 2H), 5.12 (s, 2H), 4.89 – 4.82 (m, 2H), 4.09 (ddd, J = 9.8, 7.7, 1.9 Hz, 1H), 3.92 (ddd, J = 9.8, 6.8, 2.2 Hz, 1H), 3.88 – 3.81 (m, 1H), 3.70 – 3.55 (m, 2H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 162.7, 160.7(t, J = 31.3 Hz), 157.0, 156.8, 155.9, 153.4, 137.3, 132.8, 131.2, 128.9, 128.3, 128.2, 125.3, 125.2, 122.6, 119.7, 117.9(dd, J = 255.5 Hz, 250.5 Hz), 117.0, 115.6, 107.8, 100.9, 69.8, 52.2, 48.6 (d, J = 7.1 Hz), 48.3 (d, J = 7.1 Hz), 33.5(dd, J = 21.7 Hz, 19.7 Hz). ^{19}F NMR (376 MHz, DMSO) δ -107.84 (d, J = 263.2 Hz), -112.63(d, J = 259.4 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{31}H_{26}F_2N_3O_6S^+$ 606.1505; Found 606.1501



4-amino-3-((((4,4-difluoro-1-(4-fluorophenyl)-5-oxopyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7af)

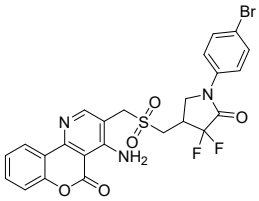
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (119 mg, 77% yield); mp 270-271 °C.^{1}H NMR (400 MHz, DMSO-d_6) δ 8.43 (dd, J = 8.1, 1.7 Hz, 1H), 8.40 (s, 1H), 7.73 – 7.67 (m, 2H), 7.64 (ddd, J = 8.7, 7.3, 1.7 Hz, 1H), 7.45 – 7.36 (m, 2H), 7.36 – 7.25 (m, 2H), 4.85 (s, 2H), 4.13 (ddd, J = 9.7, 7.7, 1.6 Hz, 1H), 3.96 (td, J = 7.2, 3.6 Hz, 1H), 3.91 – 3.81 (m, 1H), 3.64 (ddd, J = 13.3, 6.5, 3.7 Hz, 2H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 161.0(t, J = 29.8 Hz), 160.2(d, J = 244.4 Hz), 157.0, 155.9, 153.4, 152.3, 134.4(d, J = 3.0 Hz), 132.8, 125.2(d, J = 14.1 Hz), 123.2(d, J = 8.1 Hz), 119.7, 117.8(dd, J = 255.5 Hz, 249.5 Hz), 117.0, 116.4, 116.2, 107.8,

100.9, 52.3, 48.6(d, J = 6.1 Hz) 48.2(d, J = 7.1 Hz), 33.4(dd, J = 22.2 Hz, 20.2 Hz). ^{19}F NMR (376 MHz, DMSO) δ -108.01 (d, J = 263.2 Hz), -112.71(d, J = 263.2 Hz), -115.44. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{24}H_{19}F_3N_3O_5S^+$ 518.0993; Found 518.0997



4-amino-3-((((1-(4-chlorophenyl)-4,4-difluoro-5-oxopyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7ag)

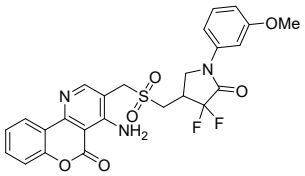
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (123 mg, 77% yield); mp 276-278 °C.^{1}H NMR (400 MHz, DMSO-d_6) δ 8.43 (dd, J = 8.1, 1.7 Hz, 1H), 8.41 (s, 1H), 7.74 – 7.68 (m, 2H), 7.65 (ddd, J = 8.6, 7.3, 1.7 Hz, 1H), 7.55 – 7.49 (m, 2H), 7.45 – 7.37 (m, 2H), 4.85 (s, 2H), 4.21 – 4.09 (m, 1H), 3.96 (ddd, J = 9.5, 7.1, 2.2 Hz, 1H), 3.92 – 3.81 (m, 1H), 3.73 – 3.54 (m, 2H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 161.2(t, J = 31.3 Hz), 157.0, 155.9, 153.4, 152.3, 136.9, 132.8, 130.5, 129.5, 125.3, 125.2, 122.4, 119.7, 117.7(dd, J = 256.0 Hz, 250.0 Hz), 117.0, 107.8, 100.9, 52.3, 48.2(d, J = 6.1 Hz) 48.2(d, J = 8.1 Hz), 33.3(t, J = 21.1 Hz). ^{19}F NMR (376 MHz, DMSO) δ -108.01 (d, J = 263.2 Hz), -112.62(d, J = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{24}H_{19}ClF_2N_3O_5S^+$ 534.0697; Found 534.0692.



4-amino-3-((((1-(4-bromophenyl)-4,4-difluoro-5-oxopyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7ah)

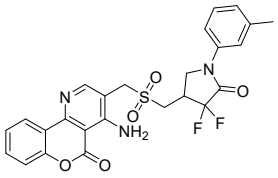
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (137 mg, 79% yield); mp 286-287 °C.^{1}H NMR (400 MHz, DMSO-d_6) δ 8.42 (dd, J = 8.2, 1.7 Hz, 1H), 8.40 (s, 1H), 7.65 (s, 5H), 7.44 – 7.38 (m, 2H), 4.85 (s, 2H), 4.18 – 4.09 (m, 1H), 3.96 (ddd, J

= 9.4, 6.9, 2.2 Hz, 1H), 3.91 – 3.82 (m, 1H), 3.71 – 3.57 (m, 2H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 161.2(t, *J* = 31.3 Hz), 157.0, 155.9, 153.4, 152.3, 137.4, 132.8, 132.4, 125.3, 125.1, 122.6, 119.7, 118.8, 117.7(dd, *J* = 255.5 Hz, 249.5 Hz), 117.0, 107.8, 100.9, 52.3, 48.2, 48.1, 33.2(t, *J* = 20.7 Hz). ^{19}F NMR (376 MHz, DMSO) δ -108.01 (d, *J* = 263.2 Hz), -112.60(d, *J* = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{24}H_{19}BrF_2N_3O_5S^+$ 578.0192; Found 578.0196



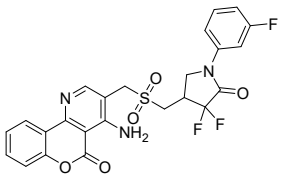
4-amino-3-((((4,4-difluoro-1-(3-methoxyphenyl)-5-oxopyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7ai)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (141 mg, 89% yield); mp 256-257 °C.^{1}H NMR (400 MHz, DMSO-d_6) δ 8.43 (dd, *J* = 8.2, 1.7 Hz, 1H), 8.41 (s, 1H), 7.64 (ddd, *J* = 8.7, 7.3, 1.7 Hz, 1H), 7.45 – 7.33 (m, 3H), 7.31 (t, *J* = 2.3 Hz, 1H), 7.17 (ddd, *J* = 8.2, 2.1, 0.8 Hz, 1H), 6.91 – 6.85 (m, 1H), 4.85 (s, 2H), 4.19 – 4.08 (m, 1H), 4.00 – 3.91 (m, 1H), 3.92 – 3.82 (m, 1H), 3.77 (s, 3H), 3.70 – 3.56 (m, 2H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 161.1(dd, *J* = 31.8 Hz, 29.8 Hz), 160.0, 157.0, 155.9, 153.4, 152.3, 139.1, 132.8, 130.4, 125.3, 125.1, 119.7, 117.8(dd, *J* = 256.5 Hz, 249.5 Hz), 117.0, 112.9, 112.1, 107.8, 106.9, 100.9, 55.8, 52.3, 48.4(d, *J* = 6.1 Hz) 48.2(d, *J* = 7.1 Hz), 33.3(dd, *J* = 21.2 Hz, 20.2 Hz). ^{19}F NMR (376 MHz, DMSO) δ -108.04 (d, *J* = 263.2 Hz), -112.82(d, *J* = 259.4 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{25}H_{22}F_2N_3O_6S^+$ 530.1192; Found 530.1195



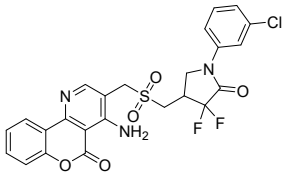
4-amino-3-((((4,4-difluoro-5-oxo-1-(*m*-tolyl)pyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7aj)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (126 mg, 82% yield); mp 273-274 °C.^{1}H NMR (400 MHz, DMSO-d_6) δ 8.43 (dd, J = 8.1, 1.7 Hz, 1H), 8.41 (s, 1H), 7.64 (ddd, J = 8.7, 7.3, 1.7 Hz, 1H), 7.47 (d, J = 7.3 Hz, 2H), 7.44 – 7.38 (m, 2H), 7.33 (td, J = 7.5, 1.4 Hz, 1H), 7.13 – 7.08 (m, 1H), 4.85 (s, 2H), 4.17 – 4.10 (m, 1H), 3.95 (ddd, J = 9.6, 7.0, 2.2 Hz, 1H), 3.91 – 3.83 (m, 1H), 3.73 – 3.54 (m, 2H), 2.33 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 161.0(dd, J = 31.8 Hz, 29.8 Hz), 157.0, 155.9, 153.4, 152.3, 139.0, 138.0, 132.8, 129.4, 127.3, 125.3, 125.1, 121.2, 119.7, 118.0, 117.8(dd, J = 255.5 Hz, 250.5 Hz), 117.0, 107.8, 100.9, 52.3, 48.4(d, J = 6.1 Hz), 48.2(d, J = 7.1 Hz), 33.4(dd, J = 21.7 Hz, 19.7 Hz), 21.5. ^{19}F NMR (376 MHz, DMSO) δ -108.02 (d, J = 259.4 Hz), -112.85(d, J = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{25}H_{22}F_2N_3O_5S^+$ 514.1243; Found 514.1246



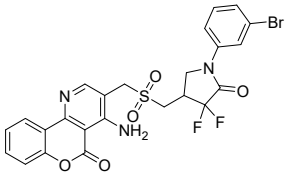
4-amino-3-((((4,4-difluoro-1-(3-fluorophenyl)-5-oxopyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7ak)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (116 mg, 75% yield); mp 281-282 °C.^{1}H NMR (400 MHz, DMSO-d_6) δ 8.43 (dd, J = 8.2, 1.7 Hz, 1H), 8.41 (s, 1H), 7.65 (ddd, J = 8.7, 7.1, 1.8 Hz, 2H), 7.55 – 7.44 (m, 2H), 7.44 – 7.38 (m, 2H), 7.18 – 7.10 (m, 1H), 4.85 (s, 2H), 4.18 (td, J = 8.1, 4.0 Hz, 1H), 3.97 (td, J = 7.3, 3.7 Hz, 1H), 3.91 – 3.80 (m, 1H), 3.64 (td, J = 9.2, 4.7 Hz, 2H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 162.4(d, J = 244.4 Hz), 161.3(dd, J = 33.3 Hz, 30.3 Hz), 157.0, 155.9, 153.4, 152.4, 139.5(d, J = 10.1 Hz), 132.8, 131.4(d, J = 10.1 Hz), 125.3, 125.2, 119.7, 117.6(dd, J = 256.5 Hz, 250.5 Hz), 117.0, 116.4(d, J = 2.0 Hz), 113.3(d, J = 21.2 Hz), 108.0, 107.8(d, J = 3.0 Hz), 100.9, 52.3, 48.3(d, J = 6.1 Hz), 48.1(d, J = 7.1 Hz), 33.2(dd, J = 22.2 Hz, 20.2 Hz). ^{19}F NMR (376 MHz, DMSO) δ -108.12 (d, J = 259.4 Hz), -111.3, -112.71(d, J = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{24}H_{19}F_3N_3O_5S^+$ 518.0993; Found 518.0997



4-amino-3-((((1-(3-chlorophenyl)-4,4-difluoro-5-oxopyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7al)

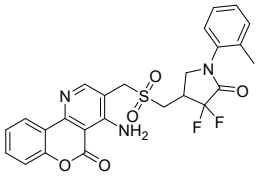
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (125 mg, 78% yield); mp 278-279 °C.^{1}H NMR (400 MHz, DMSO-d_6) δ 8.42 (d, J = 8.0 Hz, 2H), 7.82 (t, J = 2.1 Hz, 1H), 7.69 – 7.56 (m, 2H), 7.49 (t, J = 8.1 Hz, 1H), 7.44 – 7.30 (m, 3H), 4.85 (s, 2H), 4.16 (t, J = 8.5 Hz, 1H), 4.02 – 3.93 (m, 1H), 3.86 (t, J = 9.4 Hz, 1H), 3.70 – 3.56 (m, 3H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 161.3(dd, J = 32.3 Hz, 30.3 Hz), 157.0, 155.8, 153.4, 152.3, 139.3, 133.9, 132.8, 131.3, 126.4, 125.3, 125.1, 120.5, 119.7, 119.2, 117.6(dd, J = 256.5 Hz, 249.5 Hz), 117.0, 107.8, 100.9, 52.4, 48.3(d, J = 6.1 Hz), 48.1(d, J = 7.1 Hz), 33.3(dd, J = 21.7 Hz, 19.7 Hz). ^{19}F NMR (376 MHz, DMSO) δ -108.12 (d, J = 259.4 Hz), -112.75(d, J = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{24}H_{19}ClF_2N_3O_5S^+$ 534.0697; Found 534.0692



4-amino-3-((((1-(3-bromophenyl)-4,4-difluoro-5-oxopyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7am)

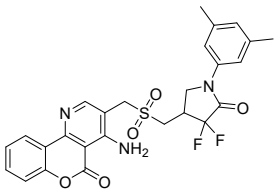
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (139 mg, 80% yield); mp 280-281 °C.^{1}H NMR (400 MHz, DMSO-d_6) δ 8.42 (d, J = 8.4 Hz, 2H), 7.95 (t, J = 2.0 Hz, 1H), 7.68 – 7.59 (m, 2H), 7.49 (dt, J = 8.1, 1.3 Hz, 1H), 7.46 – 7.35 (m, 3H), 4.85 (s, 2H), 4.16 (t, J = 8.6 Hz, 1H), 4.04 – 3.93 (m, 1H), 3.87 (d, J = 10.4 Hz, 1H), 3.72 – 3.50 (m, 2H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 161.3(dd, J = 30.3 Hz, 32.3 Hz), 157.0, 155.8, 153.4, 152.3, 139.4, 132.8, 131.5, 129.3, 125.3, 125.1, 123.4, 122.2, 119.7, 119.6, 117.6(dd, J = 257.0 Hz, 249.0 Hz), 117.0, 107.8, 100.9, 52.4, 48.3(d, J = 6.1 Hz), 48.1(d, J = 7.1 Hz), 33.3(t, J = 21.2 Hz). ^{19}F NMR (376

MHz, DMSO) δ -108.10 (d, *J* = 263.2 Hz), -112.75(d, *J* = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{24}H_{19}BrF_2N_3O_5S^+$ 578.0192; Found 578.0196



4-amino-3-((((4,4-difluoro-5-oxo-1-(*o*-tolyl)pyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-b]pyridin-5-one(7an)

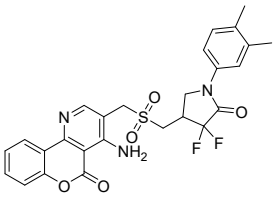
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (83 mg, 54% yield); mp 292-293 °C.^{1}H NMR (400 MHz, DMSO-d_6) δ 8.43 (dd, *J* = 8.1, 1.7 Hz, 1H), 8.41 (s, 1H), 7.68 – 7.61 (m, 1H), 7.45 – 7.36 (m, 3H), 7.32 (ddd, *J* = 9.8, 6.2, 2.9 Hz, 3H), 4.85 (s, 2H), 4.00 – 3.83 (m, 3H), 3.79 – 3.57 (m, 2H), 2.16 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 160.9(t, *J* = 30.8 Hz), 157.0, 155.8, 153.4, 152.3, 136.1, 135.4, 132.8, 131.4, 129.1, 127.4, 126.7, 125.3, 125.2, 119.7, 117.7(dd, *J* = 255.5 Hz, 249.5 Hz), 117.0, 107.8, 100.9, 52.3, 50.4(d, *J* = 5.0 Hz), 48.2(d, *J* = 7.1 Hz), 34.2(t, *J* = 21.2 Hz), 17.7. ^{19}F NMR (376 MHz, DMSO) δ -109.10 (d, *J* = 263.2 Hz), -112.61(d, *J* = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{25}H_{22}F_2N_3O_5S^+$ 514.1243; Found 514.1248



4-amino-3-((((1-(3,5-dimethylphenyl)-4,4-difluoro-5-oxopyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7ao)

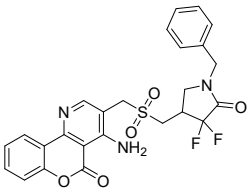
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (136 mg, 86% yield); mp 296-297 °C.^{1}H NMR (400 MHz, DMSO-d_6) δ 8.43 (dd, *J* = 8.2, 1.7 Hz, 1H), 8.40 (s, 1H), 7.64 (ddd, *J* = 8.7, 7.3, 1.7 Hz, 1H), 7.46 – 7.36 (m, 2H), 7.31 – 7.24 (m, 2H), 6.91 (s, 1H), 4.85 (s, 2H), 4.15 – 4.07 (m, 1H), 3.96 – 3.82 (m, 2H), 3.67 – 3.56 (m, 2H), 2.28 (s, 6H). ^{13}C

NMR (101 MHz, DMSO) δ 162.7, 161.0(dd, *J* = 32.3 Hz, 30.3 Hz), 157.0, 155.8, 153.4, 152.3, 138.8, 138.0, 132.8, 128.1, 125.3, 125.1, 119.7, 118.5, 117.8(dd, *J* = 255.5 Hz, 249.5 Hz), 117.0, 107.8, 100.9, 52.2, 48.4(d, *J* = 6.1 Hz), 48.2(d, *J* = 7.1 Hz), 33.4(t, *J* = 21.2 Hz), 21.4. ^{19}F NMR (376 MHz, DMSO) δ -108.01 (d, *J* = 263.2 Hz), -112.89(d, *J* = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{26}H_{24}F_2N_3O_5S^+$ 528.1400; Found 528.1405



4-amino-3-((((1-(3,4-dimethylphenyl)-4,4-difluoro-5-oxopyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7ap)

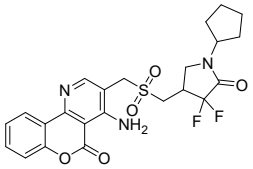
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (139 mg, 88% yield); mp 285-286 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.41 (d, *J* = 7.5 Hz, 2H), 7.63 (td, *J* = 7.8, 1.7 Hz, 1H), 7.44 – 7.33 (m, 4H), 7.18 (d, *J* = 8.2 Hz, 1H), 4.85 (s, 2H), 4.14 – 4.07 (m, 1H), 3.97 – 3.81 (m, 2H), 3.73 – 3.54 (m, 2H), 2.22 (s, 3H), 2.20 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 160.8(dd, *J* = 32.3 Hz, 30.3 Hz), 157.0, 155.8, 153.4, 152.3, 137.5, 135.8, 134.8, 132.8, 130.3, 125.3, 125.1, 121.7, 119.7, 118.3, 117.9(dd, *J* = 256.5 Hz, 249.5 Hz), 116.9, 107.7, 100.9, 52.3, 48.4(d, *J* = 6.1 Hz), 48.3(d, *J* = 7.1 Hz), 33.4(dd, *J* = 22.2 Hz, 20.2 Hz), 20.0, 19.3. ^{19}F NMR (376 MHz, DMSO) δ -107.94 (d, *J* = 263.2 Hz), -112.74(d, *J* = 259.4 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{26}H_{24}F_2N_3O_5S^+$ 528.1400; Found 528.1404



4-amino-3-((((1-benzyl-4,4-difluoro-5-oxopyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7aq)

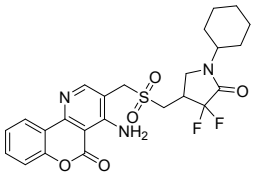
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (120 mg, 78% yield); mp 251-253 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.41 (dd, *J* = 8.2,

1.7 Hz, 1H), 8.35 (s, 1H), 7.64 (ddd, *J* = 8.7, 7.3, 1.7 Hz, 1H), 7.43 – 7.34 (m, 4H), 7.34 – 7.30 (m, 1H), 7.29 – 7.23 (m, 2H), 4.78 (d, *J* = 2.7 Hz, 2H), 4.61 (d, *J* = 14.8 Hz, 1H), 4.43 (d, *J* = 14.8 Hz, 1H), 3.76 (dd, *J* = 13.7, 3.1 Hz, 1H), 3.67 – 3.52 (m, 2H), 3.52 – 3.37 (m, 1H), 3.29 (ddd, *J* = 9.9, 7.3, 2.4 Hz, 1H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 162.0(dd, *J* = 31.3 Hz, 29.3 Hz), 161.7, 156.9, 155.8, 153.4, 152.3, 135.5, 132.8, 129.3, 128.4, 128.3, 125.3, 125.1, 119.7, 118.1(dd, *J* = 256.5 Hz, 249.5 Hz), 117.0, 107.7, 100.9, 52.2, 48.1(d, *J* = 7.1 Hz), 47.0(d, *J* = 7.1 Hz), 46.9, 33.8(dd, *J* = 22.2 Hz, 20.2 Hz). ^{19}F NMR (376 MHz, DMSO) δ -109.85 (d, *J* = 263.2 Hz), -113.08(d, *J* = 259.4 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{25}H_{22}F_2N_3O_5S^+$ 514.1243; Found 514.1246



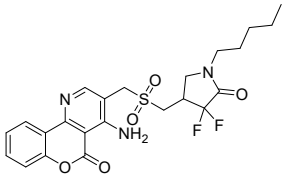
4-amino-3-((((1-cyclopentyl-4,4-difluoro-5-oxopyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7ar)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (116 mg, 79% yield); mp 280-281 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.43 (dd, *J* = 8.1, 1.7 Hz, 1H), 8.39 (s, 1H), 7.65 (ddd, *J* = 8.6, 7.3, 1.7 Hz, 1H), 7.45 – 7.38 (m, 2H), 4.81 (d, *J* = 1.8 Hz, 2H), 4.31 (p, *J* = 7.2 Hz, 1H), 3.76 (dd, *J* = 13.8, 3.0 Hz, 1H), 3.73 – 3.61 (m, 1H), 3.54 (dd, *J* = 13.9, 9.5 Hz, 1H), 3.49 – 3.36 (m, 2H), 1.78 (qd, *J* = 6.5, 3.1 Hz, 2H), 1.67 – 1.52 (m, 6H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 161.5(dd, *J* = 30.3 Hz, 29.3 Hz), 157.0, 155.8, 153.4, 152.3, 132.8, 125.3, 125.2, 119.7, 118.3(dd, *J* = 256.0 Hz, 250.0 Hz), 117.0, 107.8, 100.9, 53.4, 52.2, 48.3(d, *J* = 7.1 Hz), 43.6(d, *J* = 6.1 Hz), 33.8(dd, *J* = 22.2 Hz, 20.2 Hz), 28.8, 28.7, 24.4. ^{19}F NMR (376 MHz, DMSO) δ -109.10 (d, *J* = 259.4 Hz), -113.16(d, *J* = 259.4 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{23}H_{24}F_2N_3O_5S^+$ 492.1400; Found 492.1406



4-amino-3-((((1-cyclohexyl-4,4-difluoro-5-oxopyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7as)

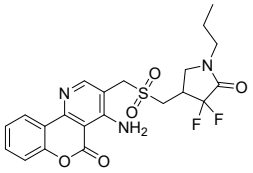
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (109 mg, 72% yield); mp 276-277 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.44 (dd, J = 8.2, 1.7 Hz, 1H), 8.39 (s, 1H), 7.69 – 7.62 (m, 1H), 7.46 – 7.39 (m, 2H), 4.82 (d, J = 2.7 Hz, 2H), 3.80 – 3.65 (m, 3H), 3.53 (dd, J = 13.9, 9.8 Hz, 1H), 3.46 – 3.25 (m, 2H), 1.74 (d, J = 12.1 Hz, 2H), 1.67 – 1.52 (m, 3H), 1.52 – 1.36 (m, 2H), 1.35 – 1.21 (m, 2H), 1.15 – 1.02 (m, 1H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 161.1(t, J = 30.3 Hz), 157.0, 155.8, 153.4, 152.4, 132.8, 125.3, 125.2, 119.7, 118.4(dd, J = 255.5 Hz, 249.5 Hz), 117.0, 107.8, 100.9, 52.2, 52.0, 48.3(d, J = 8.1 Hz), 43.5(d, J = 6.1 Hz), 33.9(dd, J = 22.2 Hz, 20.2 Hz), 29.5, 29.2, 25.3, 25.2, 25.1. ^{19}F NMR (376 MHz, DMSO) δ -109.40 (d, J = 259.4 Hz), -113.26(d, J = 259.4 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{24}H_{26}F_2N_3O_5S^+$ 506.1556; Found 506.1552



4-amino-3-((((4,4-difluoro-5-oxo-1-pentylpyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7at)

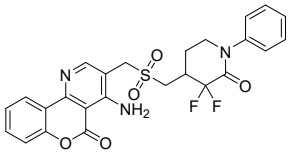
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (120 mg, 81% yield); mp 257-258 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.42 (dd, J = 8.2, 1.7 Hz, 1H), 8.38 (s, 1H), 7.64 (ddd, J = 8.6, 7.3, 1.7 Hz, 1H), 7.44 – 7.37 (m, 2H), 4.81 (d, J = 2.9 Hz, 2H), 3.77 (dd, J = 14.0, 2.9 Hz, 1H), 3.73 – 3.65 (m, 1H), 3.55 (dd, J = 13.8, 9.7 Hz, 1H), 3.40 (td, J = 11.4, 9.7, 4.7 Hz, 2H), 3.32 (d, J = 7.5 Hz, 1H), 3.21 (dt, J = 13.6, 7.0 Hz, 1H), 1.54 – 1.44 (m, 2H), 1.34 – 1.24 (m, 2H), 1.24 – 1.14 (m, 2H), 0.84 (t, J = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 161.8(t, J = 30.3 Hz), 157.0, 155.8, 153.4, 152.3, 132.8, 125.3, 125.1, 119.7, 118.2(dd, J = 255.5 Hz,

249.5 Hz), 117.0, 107.8, 100.9, 52.2, 48.3(d, *J* = 7.1 Hz), 47.0, (d, *J* = 6.1 Hz), 43.1, 33.9(t, *J* = 21.1 Hz), 28.6, 26.2, 22.1, 14.3. ^{19}F NMR (376 MHz, DMSO) δ -109.38 (d, *J* = 259.4 Hz), -113.10(d, *J* = 259.4 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{23}H_{26}F_2N_3O_5S^+$ 494.1556; Found 494.1554



4-amino-3-((((4,4-difluoro-5-oxo-1-propylpyrrolidin-3-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7au)

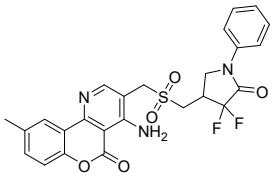
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (109 mg, 78% yield); mp 261-262 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.42 (dd, *J* = 8.1, 1.7 Hz, 1H), 8.38 (s, 1H), 7.64 (ddd, *J* = 8.7, 7.3, 1.7 Hz, 1H), 7.41 (dtd, *J* = 8.2, 3.6, 1.2 Hz, 2H), 4.81 (d, *J* = 2.9 Hz, 2H), 3.77 (dd, *J* = 14.0, 2.8 Hz, 1H), 3.74 – 3.65 (m, 1H), 3.56 (dd, *J* = 13.8, 9.7 Hz, 1H), 3.41 (dt, *J* = 8.7, 5.1 Hz, 2H), 3.34 – 3.28 (m, 1H), 3.19 (dt, *J* = 13.5, 6.9 Hz, 1H), 1.60 – 1.41 (m, 2H), 0.82 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 161.9(dd, *J* = 30.3 Hz, 29.3 Hz), 157.0, 155.8, 153.4, 152.3, 132.8, 125.3, 125.1, 119.7, 118.2(dd, *J* = 256.0 Hz, 250.0 Hz), 117.0, 107.8, 100.9, 52.2, 48.3(d, *J* = 7.1 Hz), 47.0(d, *J* = 6.1 Hz), 44.8, 33.9(dd, *J* = 22.2 Hz, 20.2 Hz), 20.0, 11.4. ^{19}F NMR (376 MHz, DMSO) δ -109.38 (d, *J* = 263.2 Hz), -113.06(d, *J* = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{21}H_{22}F_2N_3O_5S^+$ 466.1243; Found 466.1248



4-amino-3-((((3,3-difluoro-2-oxo-1-phenylpiperidin-4-yl)methyl)sulfonyl)methyl)-5*H*-chromeno[4,3-*b*]pyridin-5-one(7av)

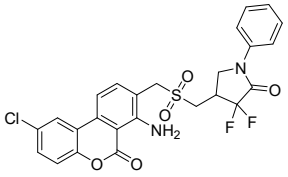
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (102 mg, 66% yield); mp 317-318 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.43 (dd, *J* = 8.2, 1.7 Hz, 1H), 8.40 (s, 1H), 7.64 (ddd, *J* = 8.6, 7.3, 1.7 Hz, 1H), 7.48 – 7.30 (m, 7H), 4.85 (d, *J* = 2.4 Hz,

2H), 4.03 – 3.89 (m, 1H), 3.72 (d, *J* = 12.2 Hz, 1H), 3.57 (ddd, *J* = 12.2, 5.2, 2.6 Hz, 1H), 3.52 – 3.42 (m, 2H), 2.44 (dt, *J* = 14.2, 3.5 Hz, 1H), 2.20 – 2.04 (m, 1H). ^{13}C NMR (101 MHz, DMSO) δ 162.7, 160.3(t, *J* = 29.1 Hz), 156.9, 155.9, 153.4, 152.4, 141.8, 132.8, 129.6, 127.9, 126.5, 125.3, 125.1, 119.7, 117.0, 113.6(dd, *J* = 249.2 Hz, 244.9 Hz), 107.8, 100.9, 52.5, 49.7, 48.9(d, *J* = 4.0 Hz), 35.2(t, *J* = 20.4 Hz), 25.3(d, *J* = 7.1 Hz). ^{19}F NMR (376 MHz, DMSO) δ -106.84 (d, *J* = 274.5 Hz), -108.34(d, *J* = 274.5 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{25}H_{22}F_2N_3O_5S^+$ 514.1243; Found 514.1247



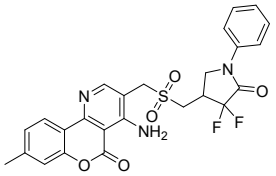
4-amino-3-((((4,4-difluoro-5-oxo-1-phenylpyrrolidin-3-yl)methyl)sulfonyl)methyl)-9-methyl-5*H*-chromeno[4,3-*b*]pyridin-5-one(7aw)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (132 mg, 86% yield); mp 287-288 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.37 (s, 1H), 8.26 (d, *J* = 8.5 Hz, 1H), 7.70 – 7.64 (m, 2H), 7.50 – 7.43 (m, 2H), 7.33 – 7.25 (m, 1H), 7.25 – 7.17 (m, 2H), 4.83 (s, 2H), 4.19 – 4.12 (m, 1H), 3.98 (td, *J* = 7.1, 3.5 Hz, 1H), 3.93 – 3.82 (m, 1H), 3.72 – 3.57 (m, 2H), 2.42 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 162.8, 161.1(dd, *J* = 32.3 Hz, 30.3 Hz), 157.0, 155.8, 153.5, 152.3, 143.4, 138.1, 129.6, 126.6, 126.2, 125.0, 120.7, 117.8(dd, *J* = 255.9 Hz, 249.5 Hz), 117.2, 116.9, 107.3, 100.5, 52.3, 48.3(d, *J* = 6.1 Hz), 48.2(d, *J* = 8.1 Hz), 33.4(t, *J* = 21.2 Hz), 21.6. ^{19}F NMR (376 MHz, DMSO) δ -108.08(d, *J* = 263.2 Hz), -112.81(d, *J* = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{25}H_{22}F_2N_3O_5S^+$ 514.1243; Found 514.1239



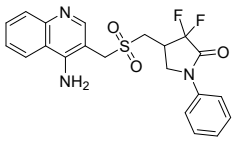
4-((((7-amino-2-chloro-6-oxo-6*H*-benzo[*c*]chromen-8-yl)methyl)sulfonyl)methyl)-3,3-difluoro-1-phenylpyrrolidin-2-one(7ax)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (120 mg, 75% yield); mp 247-248 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.42 (d, J = 2.6 Hz, 1H), 8.38 (s, 1H), 7.76 (dd, J = 8.8, 2.5 Hz, 1H), 7.72 – 7.63 (m, 2H), 7.50 – 7.43 (m, 2H), 7.35 (d, J = 8.7 Hz, 1H), 7.33 – 7.25 (m, 1H), 4.86 (s, 2H), 4.16 (ddd, J = 9.7, 7.7, 1.7 Hz, 1H), 3.97 (ddd, J = 9.7, 6.9, 2.0 Hz, 1H), 3.93 – 3.83 (m, 1H), 3.72 – 3.59 (m, 2H). ^{13}C NMR (101 MHz, DMSO) δ 162.1, 161.1(dd, J = 31.3 Hz, 30.3 Hz), 156.9, 155.8, 152.1, 151.4, 138.0, 135.1, 129.6, 127.3, 126.6, 121.6, 120.7, 119.4, 117.8(dd, J = 256.5 Hz, 249.5 Hz), 117.1, 108.3, 101.0, 52.2, 48.3, 48.2, 33.4(dd, J = 22.2 Hz, 20.2 Hz). ^{19}F NMR (376 MHz, DMSO) δ -108.02(d, J = 259.4 Hz), -112.82(d, J = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{24}H_{19}ClF_2N_3O_5S^+$ 533.0745; Found 533.0749



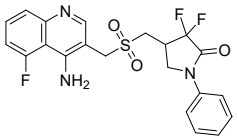
4-amino-3-((((4,4-difluoro-5-oxo-1-phenylpyrrolidin-3-yl)methyl)sulfonyl)methyl)-8-methyl-5*H*-chromeno[4,3-*b*]pyridin-5-one(7ay)

The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate(3:1). white solid (139 mg, 90% yield); mp 271-272 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.38 (s, 1H), 8.19 (d, J = 2.2 Hz, 1H), 7.70 – 7.63 (m, 2H), 7.51 – 7.39 (m, 3H), 7.32 – 7.23 (m, 2H), 4.84 (s, 2H), 4.21 – 4.12 (m, 1H), 3.97 (ddd, J = 9.6, 7.1, 2.2 Hz, 1H), 3.91 – 3.82 (m, 1H), 3.72 – 3.55 (m, 2H), 2.40 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 162.8, 161.1(dd, J = 31.3 Hz, 30.3 Hz), 156.9, 155.9, 153.4, 150.4, 138.0, 134.3, 133.5, 129.6, 126.6, 124.9, 120.7, 119.3, 117.8(dd, J = 255.5 Hz, 249.5 Hz), 116.7, 107.6, 100.8, 52.3, 48.3(d, J = 6.1 Hz), 48.2(d, J = 7.1 Hz), 33.4(dd, J = 21.6 Hz, 19.7Hz), 21.0. ^{19}F NMR (376 MHz, DMSO) δ -108.02(d, J = 263.2 Hz), -112.83(d, J = 263.2 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{25}H_{22}F_2N_3O_5S^+$ 514.1243; Found 514.1249



4-((((4-aminoquinolin-3-yl)methyl)sulfonyl)methyl)-3,3-difluoro-1-phenylpyrrolidin-2-one (9a):

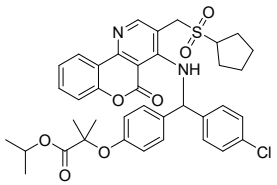
The product was purified by silica gel column chromatography with ethyl acetate/dichloromethane (1:1). white solid (53 mg, 41% yield); mp: 206-207 °C;^{1}H NMR (600 MHz, DMSO-d_6) δ 8.38 (s, 1H), 8.27 (d, J = 8.4 Hz, 1H), 7.81 (d, J = 8.3 Hz, 1H), 7.65 (d, J = 8.4 Hz, 3H), 7.51 – 7.43 (m, 3H), 7.29 (t, J = 7.4 Hz, 1H), 6.98 (s, 2H), 4.84 (s, 2H), 4.12 (t, J = 8.8 Hz, 1H), 3.97 – 3.90 (m, 1H), 3.79 (dd, J = 13.6, 3.2 Hz, 1H), 3.69 – 3.60 (m, 1H), 3.56 (dd, J = 13.6, 10.0 Hz, 1H). ^{13}C NMR (151 MHz, DMSO) δ 161.1(dd, J = 31.7 Hz, 30.2 Hz), 153.8, 150.9, 148.6, 138.1, 129.9, 129.5, 129.3, 126.6, 124.9, 123.0, 120.8, 118.7, 117.8(dd, J = 255.2 Hz, 249.2 Hz), 100.1, 53.4, 48.4(d, J = 6.0 Hz), 48.1(d, J = 7.5 Hz), 33.5(dd, J = 22.6 Hz, 21.1 Hz). ^{19}F NMR (565 MHz, DMSO) δ -108.20 (d, J = 265.6 Hz), -112.98(d, J = 265.6 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{21}H_{20}F_2N_3O_3S^+$ 432.1188; Found 432.1182



4-((((4-amino-5-fluoroquinolin-3-yl)methyl)sulfonyl)methyl)-3,3-difluoro-1-phenylpyrrolidin-2-one(9b):

The product was purified by silica gel column chromatography with ethyl acetate/dichloromethane (1:1). white solid (70 mg, 52% yield); mp: 212-213 °C;^{1}H NMR (400 MHz, DMSO-d_6) δ 8.36 (s, 1H), 7.72 – 7.57 (m, 4H), 7.52 – 7.43 (m, 2H), 7.34 – 7.19 (m, 2H), 6.90 (d, J = 4.1 Hz, 2H), 4.88 (s, 2H), 4.19 – 4.10 (m, 1H), 3.97 (ddd, J = 9.5, 7.0, 2.0 Hz, 1H), 3.90 – 3.80 (m, 1H), 3.69 – 3.56 (m, 2H). ^{13}C NMR (101 MHz, DMSO) δ 161.1(dd, J = 31.3 Hz, 30.3 Hz), 159.6(d, J = 253.5 Hz), 154.6, 150.8, 149.9(d, J = 3.0Hz), 138.1, 130.0(d, J = 12.1 Hz), 129.6, 126.6, 125.7(d, J = 3.0 Hz), 120.8, 117.8(dd, J = 256.0 Hz, 250.0 Hz), 110.1(d, J = 23.2 Hz), 109.0(d, J = 7.1 Hz), 101.2, 52.8, 48.3(d, J = 6.1 Hz), 48.1(d, J = 7.1 Hz), 33.2(dd, J = 22.2 Hz, 20.2 Hz). ^{19}F NMR (376 MHz, DMSO) δ -108.13 (d, J = 263.2 Hz), -

112.35, -112.92(d, J = 259.4 Hz). HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{21}H_{19}F_3N_3O_3S^+$ 450.1094; Found 450.1099

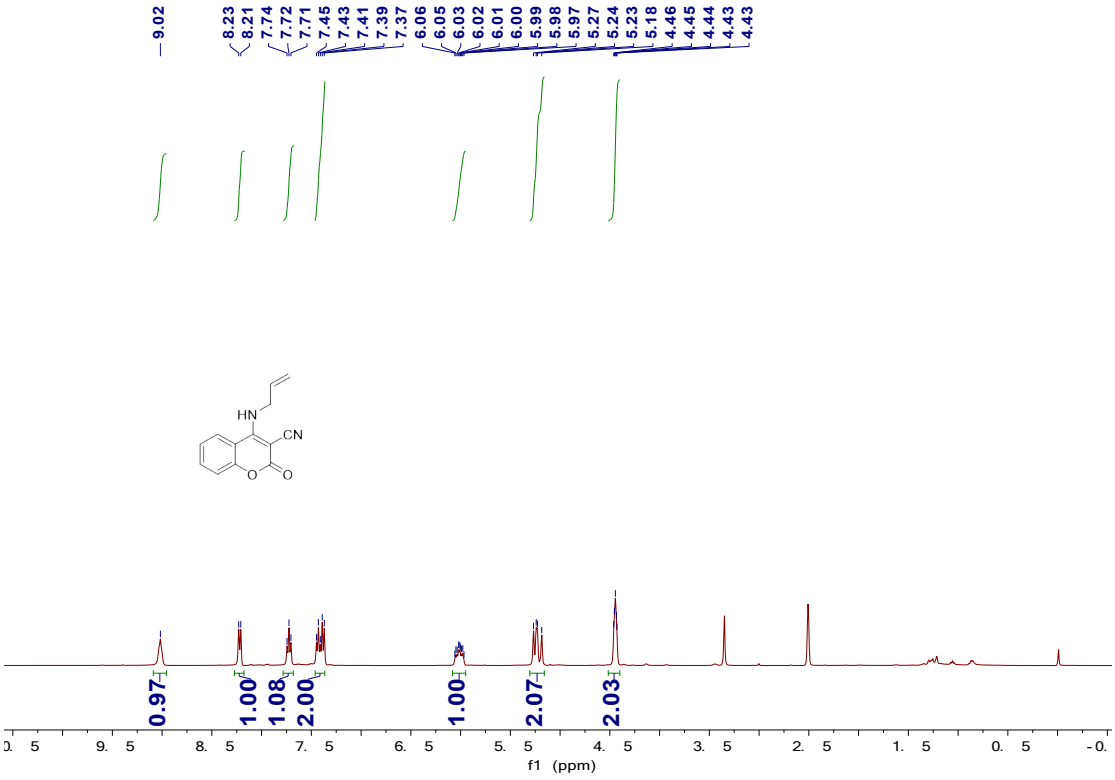


Isopropyl 2-(4-((4-chlorophenyl)((3-((cyclopentylsulfonyl)methyl)-5-oxo-5*H*-chromeno[4,3-*b*] pyridin-4-yl) amino)methyl)phenoxy)-2-methylpropanoate (11):

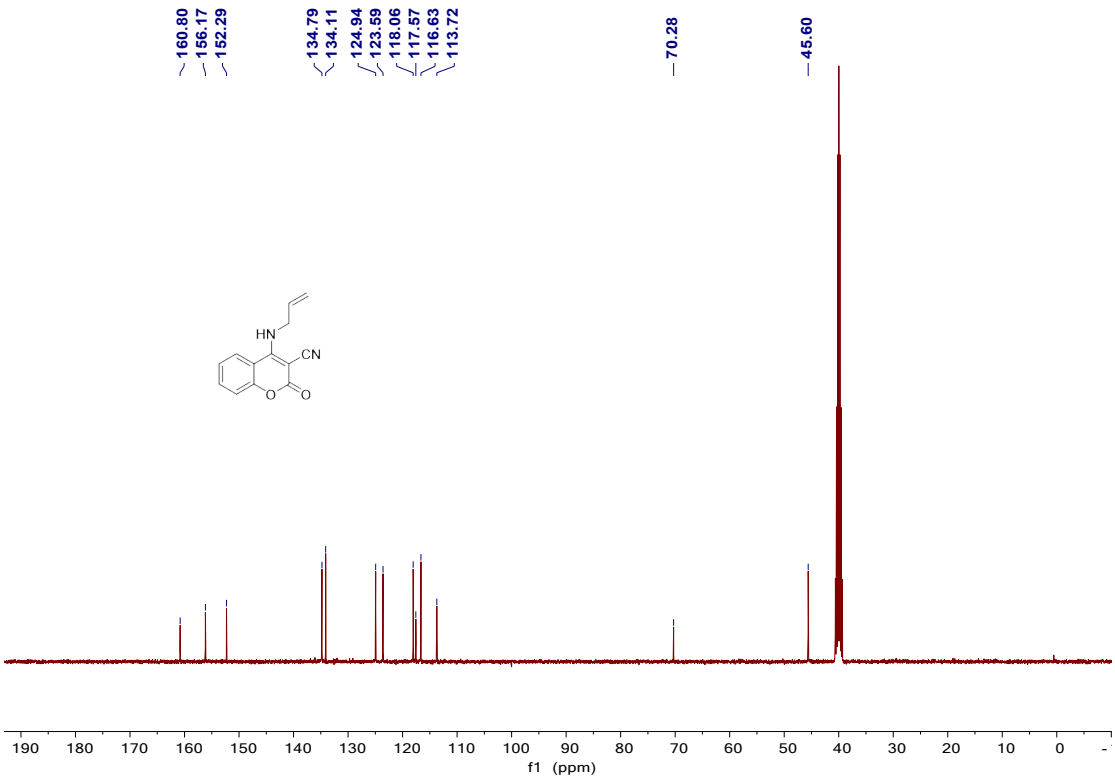
The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (4:1). white solid (120 mg, 57% yield); mp: 327-328 ^oC; ^1H NMR (400 MHz, DMSO-d_6) δ 10.21 (d, J = 7.2 Hz, 1H), 8.47 (dd, J = 8.2, 1.7 Hz, 1H), 8.37 (s, 1H), 7.72 – 7.63 (m, 1H), 7.54 – 7.40 (m, 4H), 7.36 (d, J = 8.2 Hz, 2H), 7.24 (d, J = 8.3 Hz, 2H), 6.83 (d, J = 8.4 Hz, 2H), 6.45 (d, J = 7.2 Hz, 1H), 5.02 – 4.85 (m, 1H), 4.35 (q, J = 14.7 Hz, 2H), 3.83 – 3.64 (m, 1H), 2.05 – 1.86 (m, 4H), 1.78 – 1.58 (m, 4H), 1.52 (s, 6H), 1.12 (dd, J = 6.3, 4.3 Hz, 6H). ^{13}C NMR (101 MHz, DMSO) δ 172.9, 163.9, 160.8, 155.4, 154.6, 153.4, 152.0, 141.5, 135.1, 133.0, 133.0, 129.7, 129.2, 128.4, 125.4, 125.4, 119.6, 119.2, 116.8, 105.8, 103.2, 79.2, 69.1, 61.2, 60.4, 53.1, 26.8, 26.0, 26.0, 25.6, 25.5, 21.7, 21.7. HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{38}H_{40}ClN_2O_7S^+$ 703.2240; Found 703.2245

10.^{1}H, ^{13}C and ^{19}F NMR spectra for products.

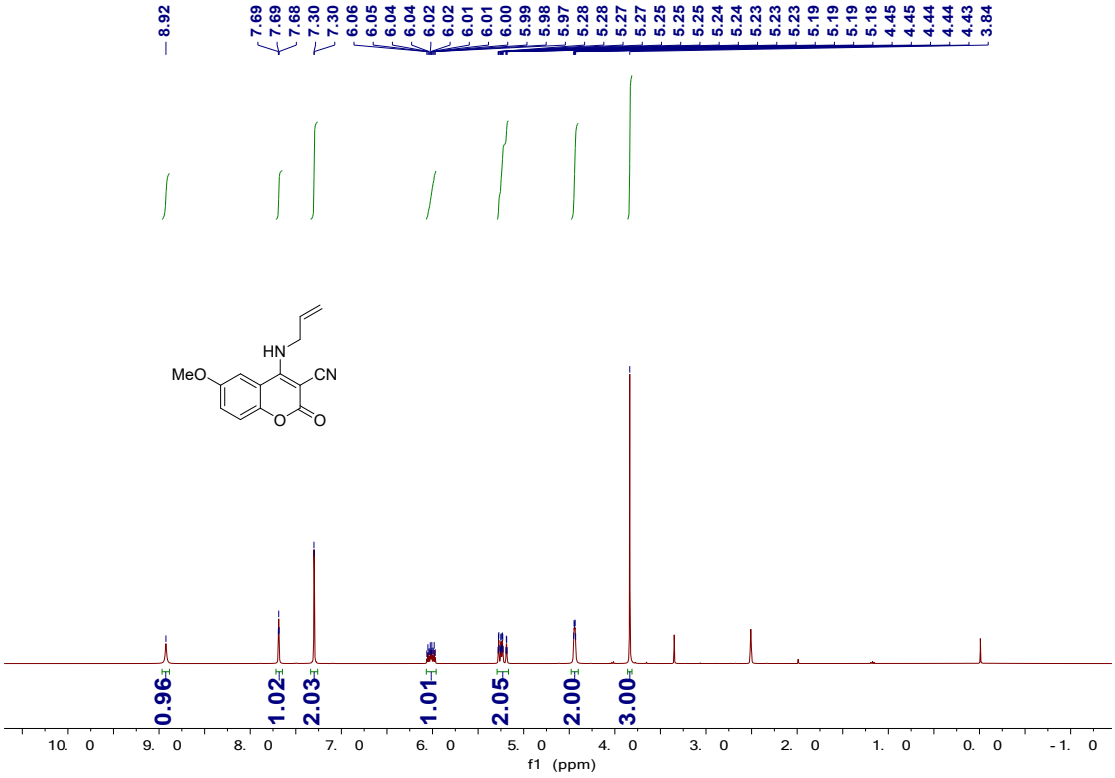
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **1a**



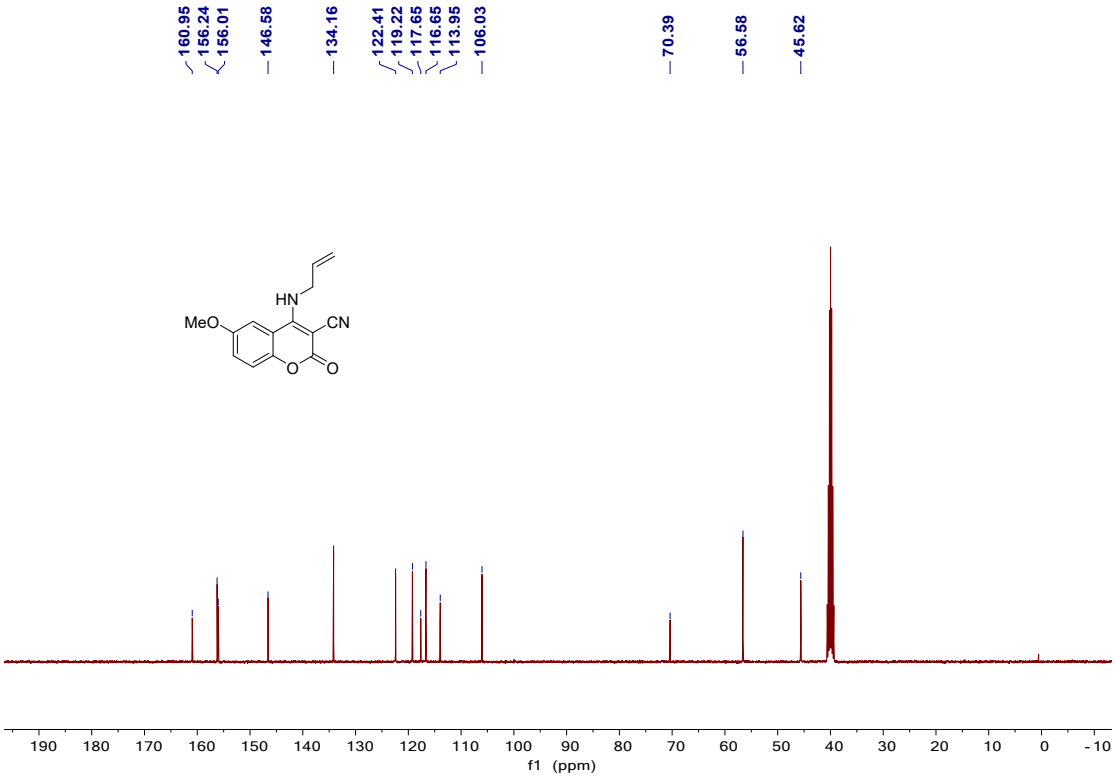
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **1a**



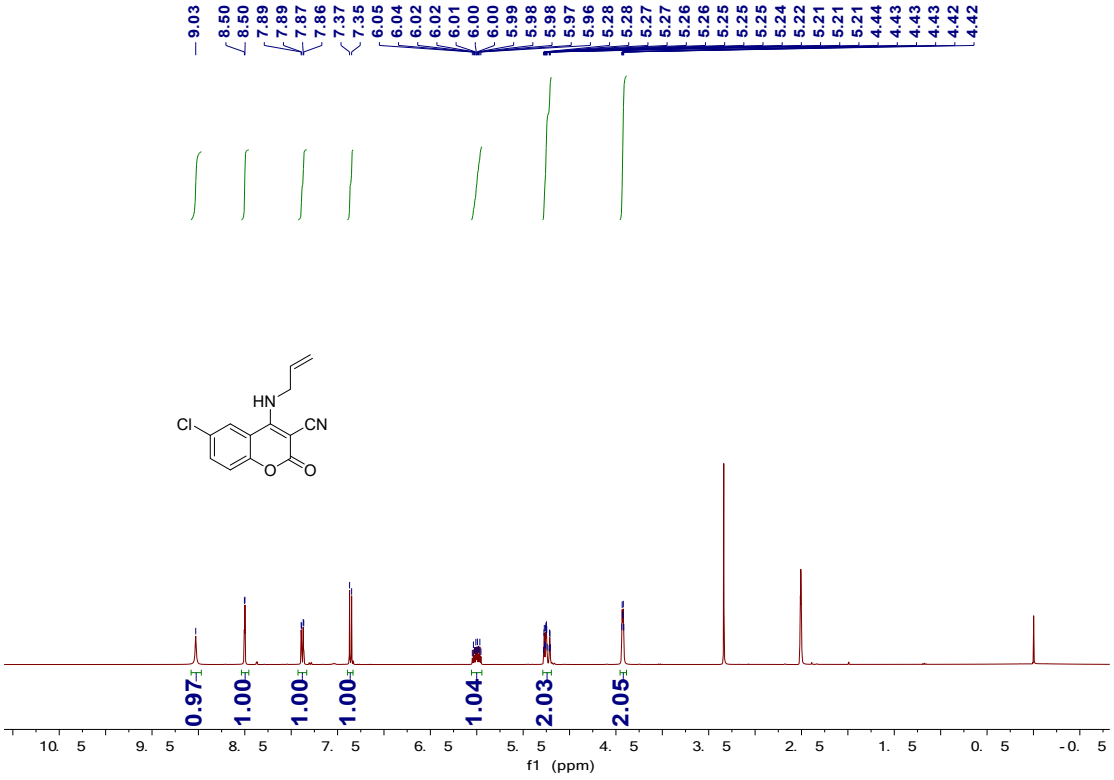
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **1b**



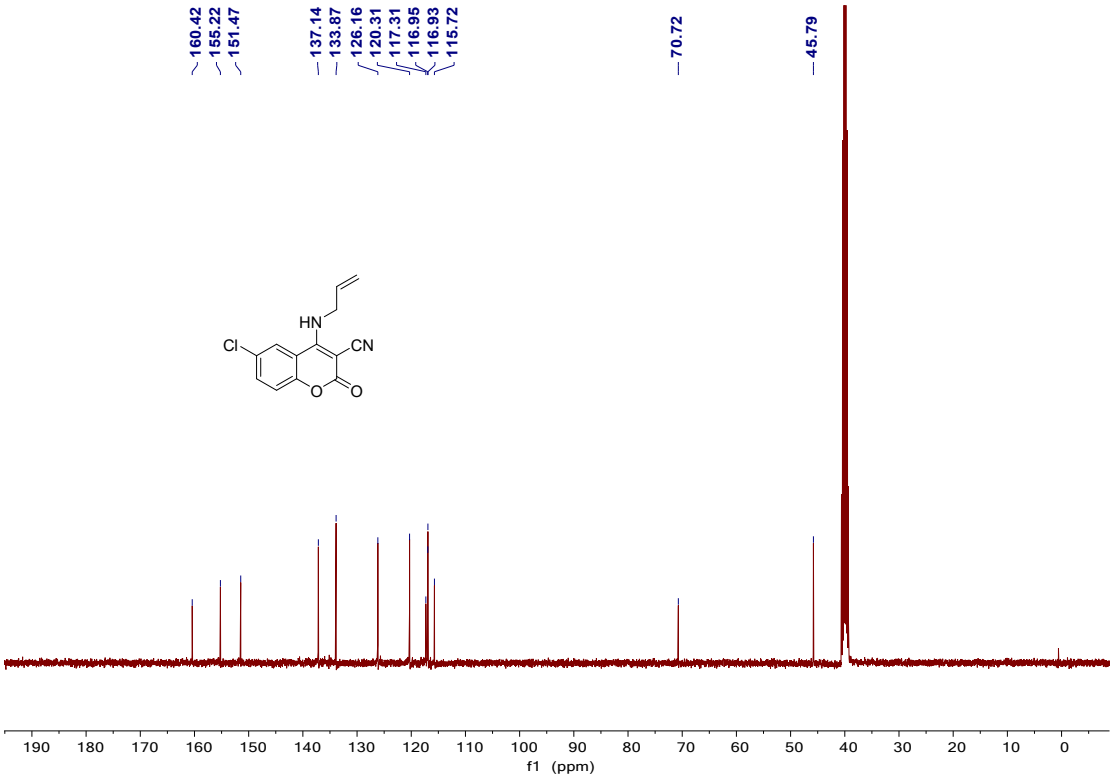
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **1b**



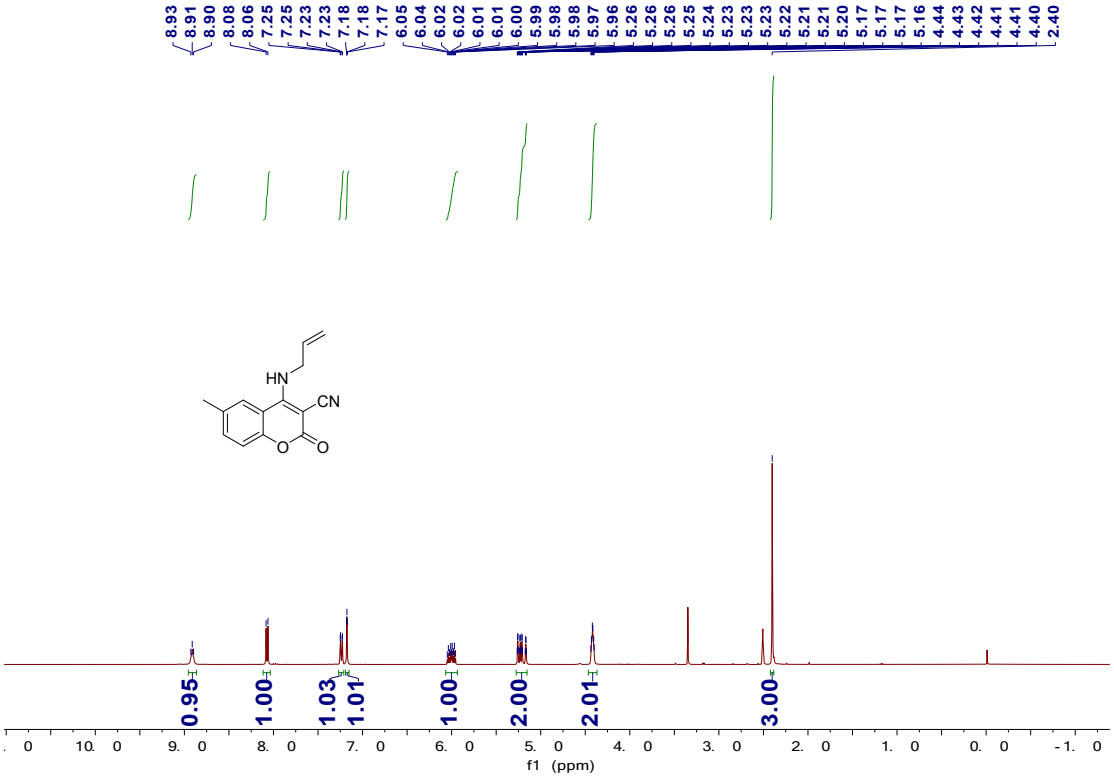
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **1c**



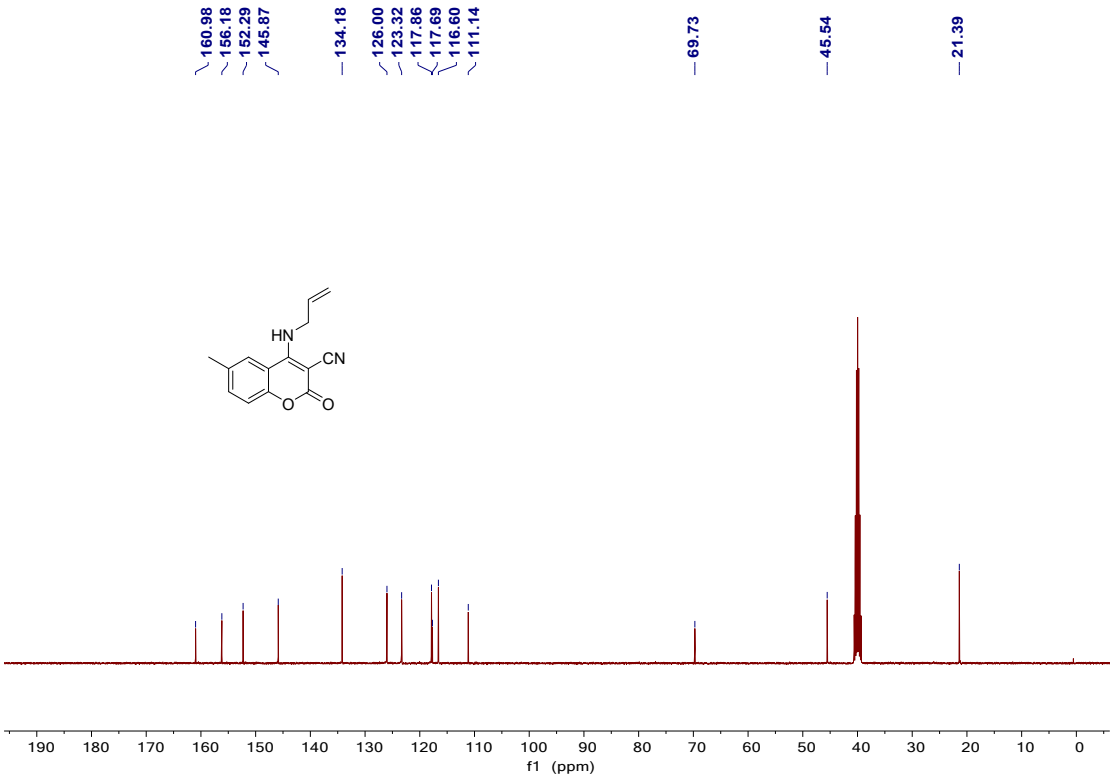
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **1c**



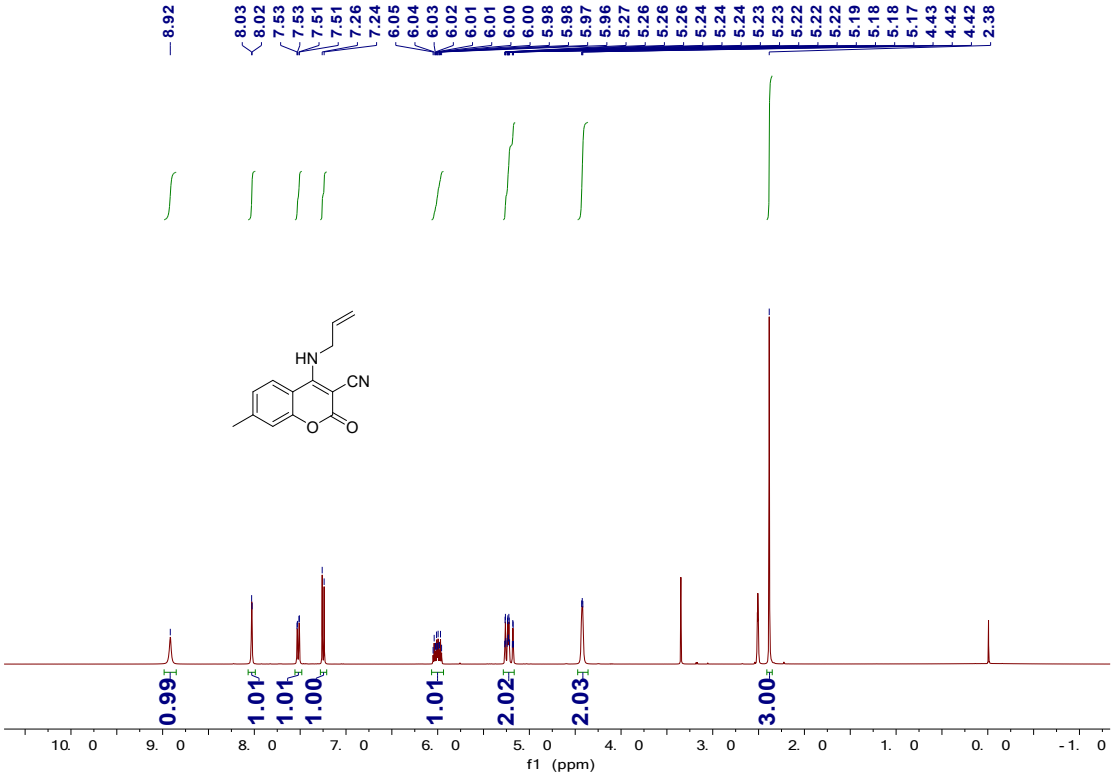
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **1d**



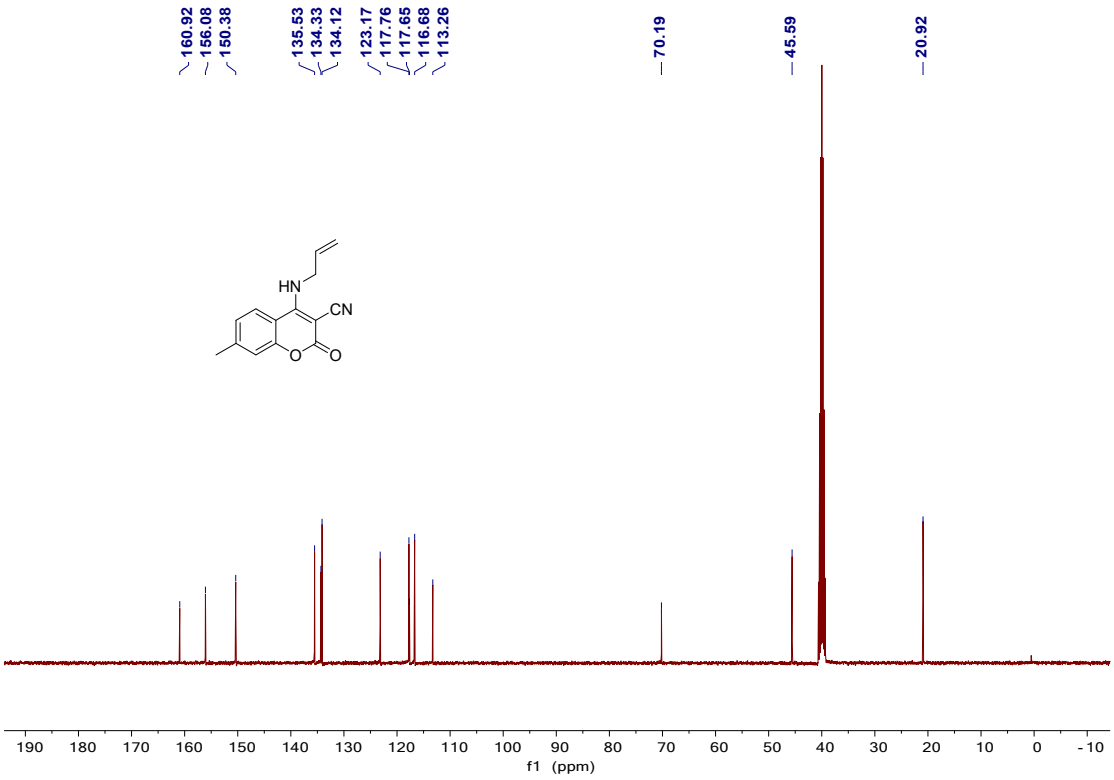
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **1d**



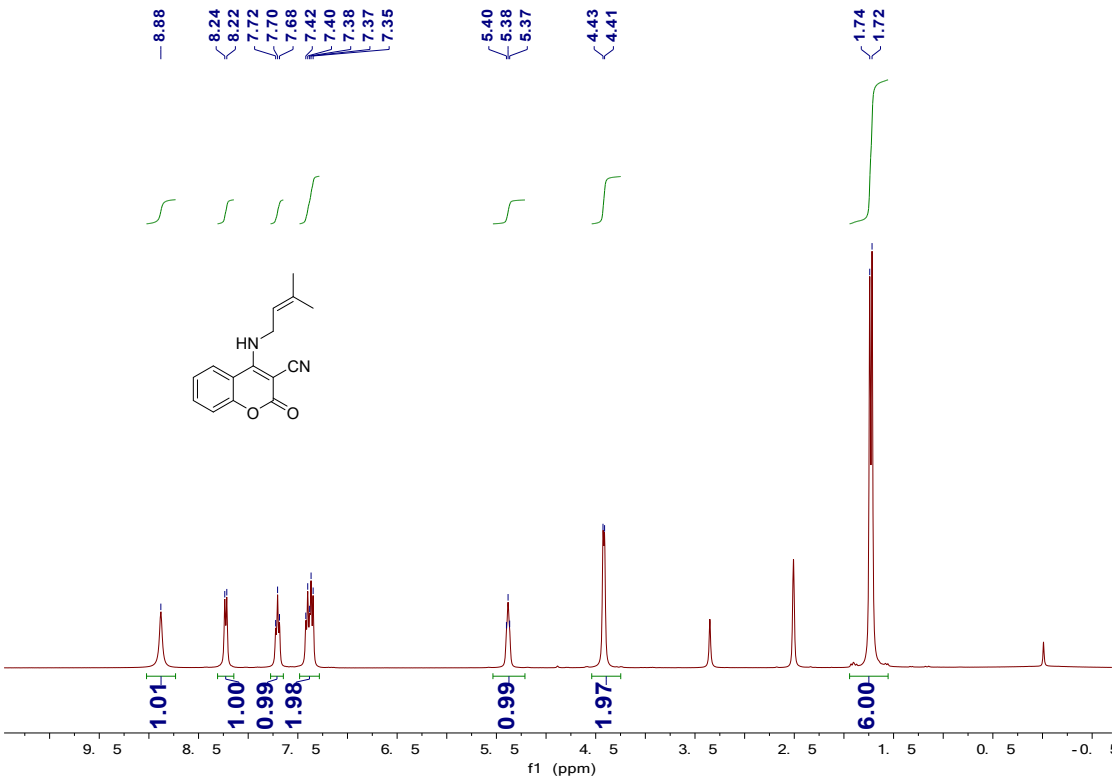
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **1e**



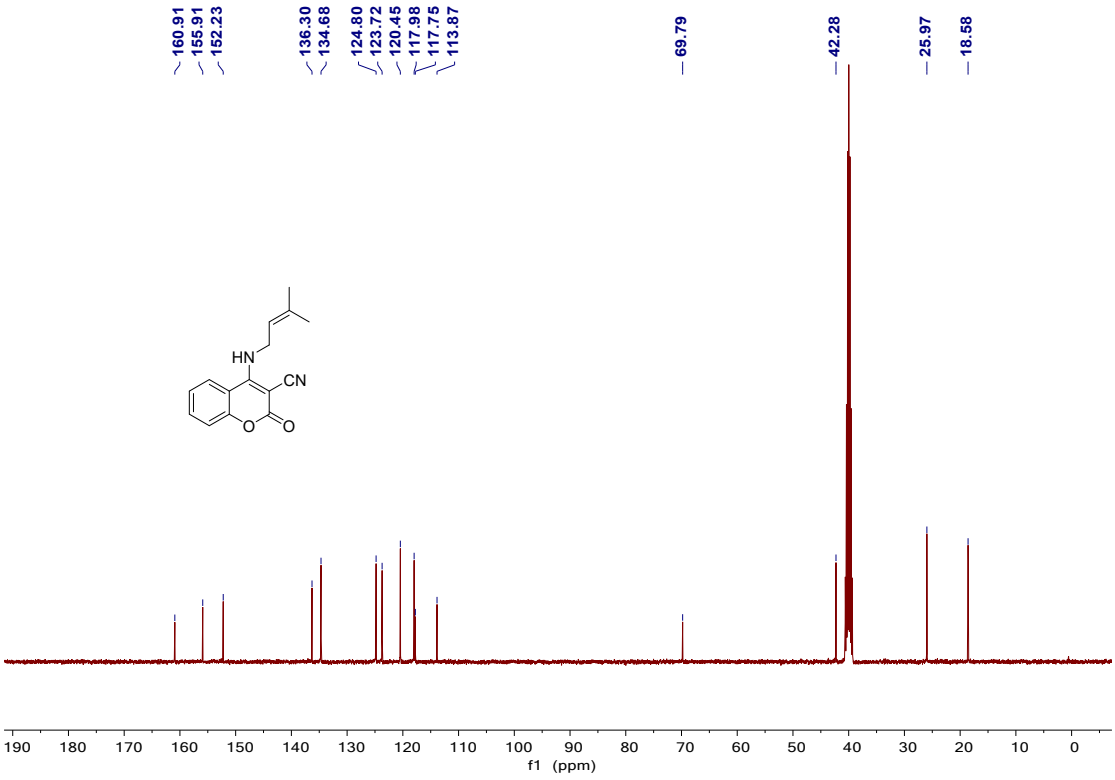
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **1e**



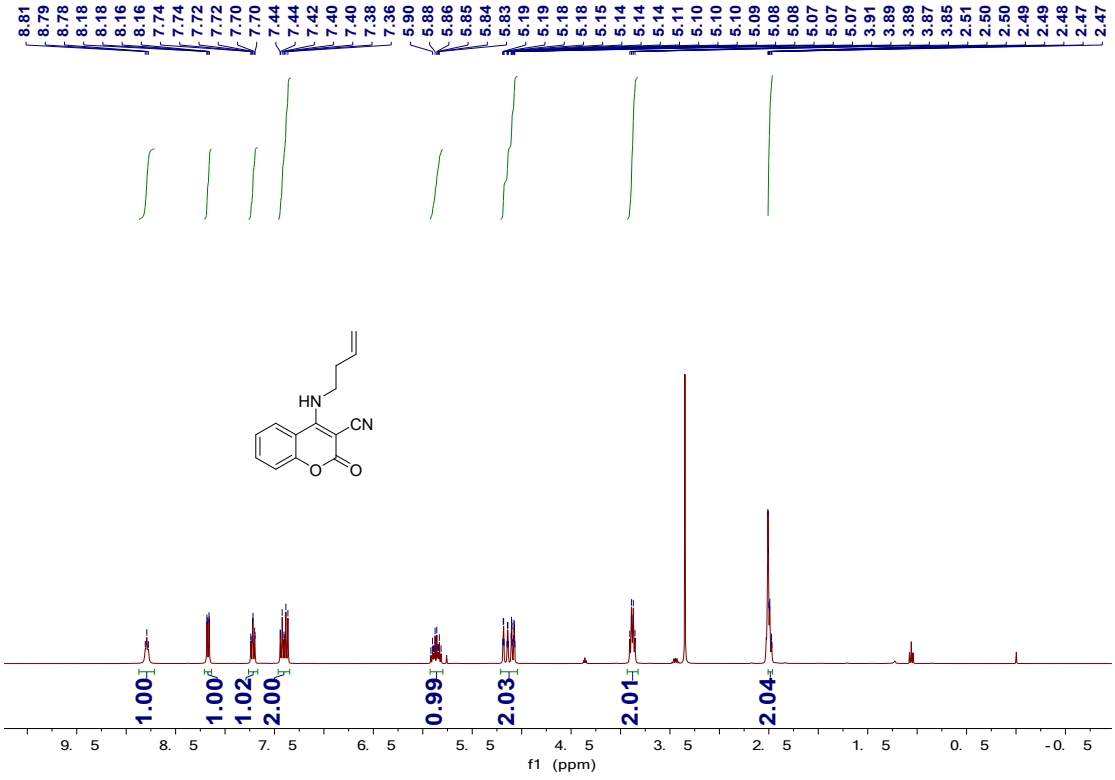
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **1f**



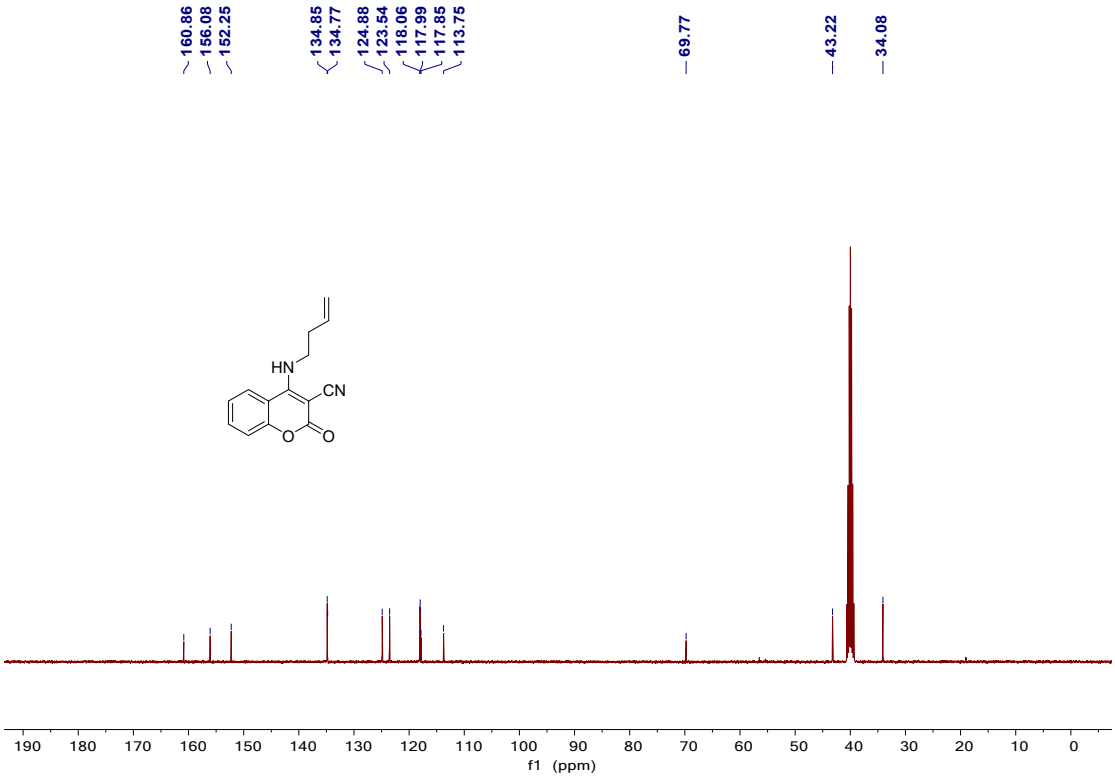
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **1f**



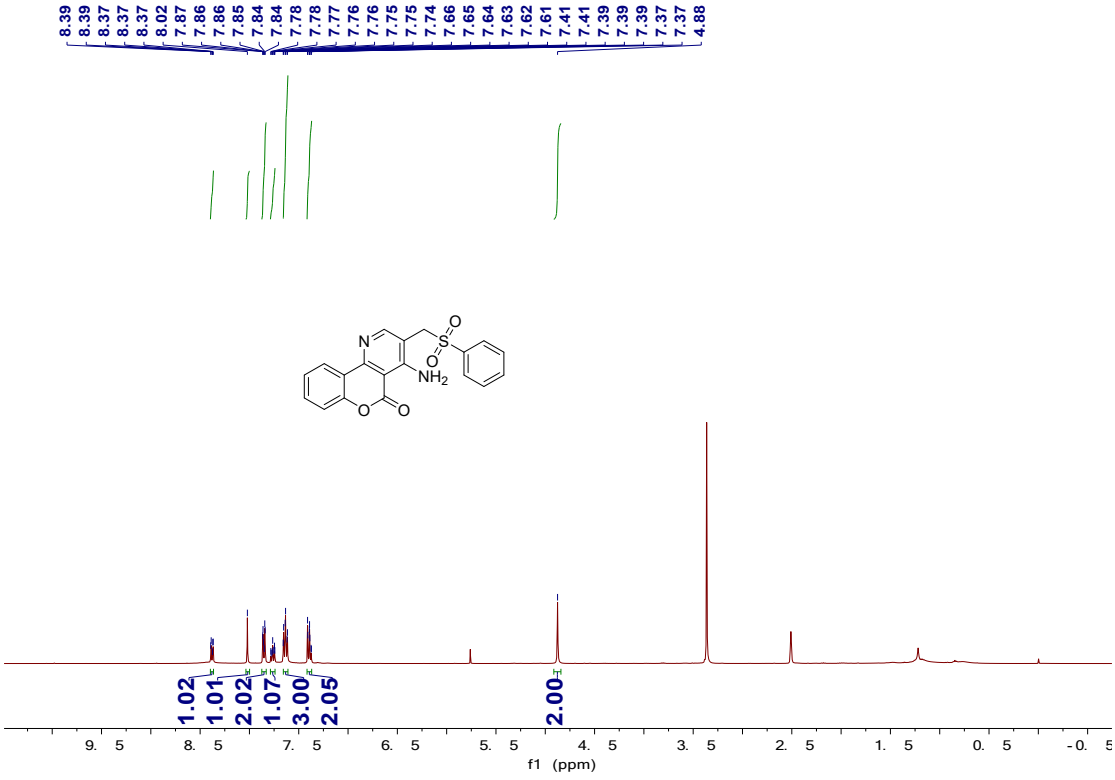
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **1g**



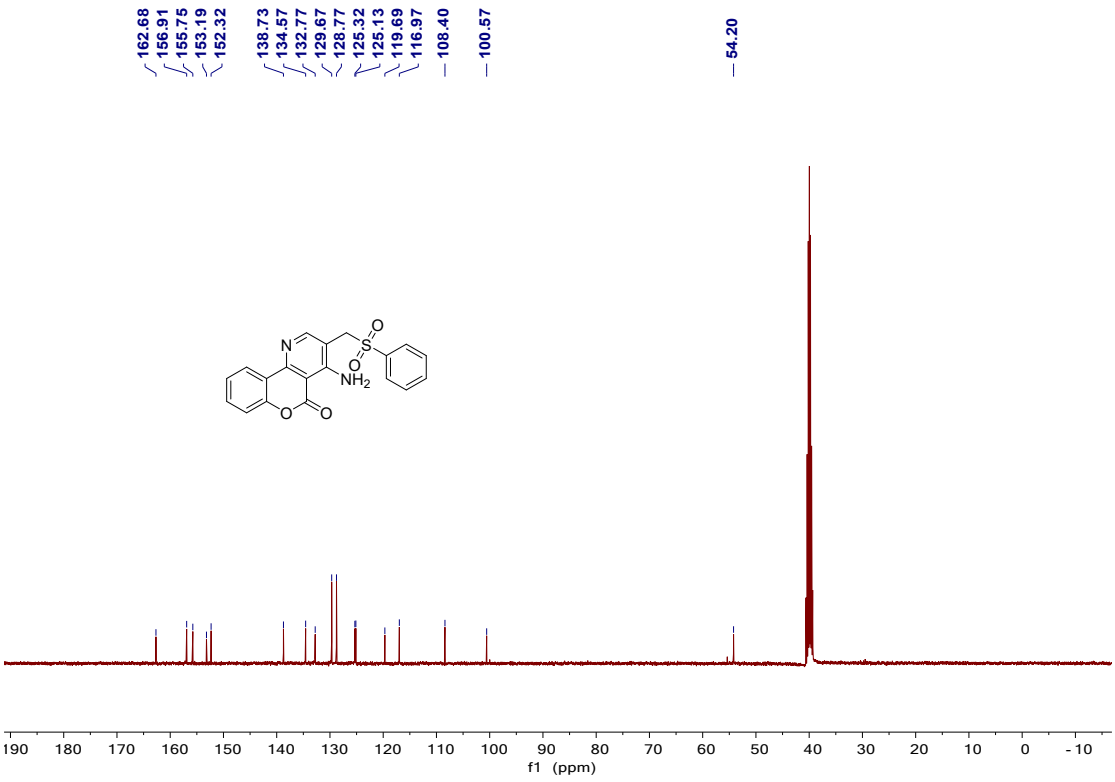
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **1g**



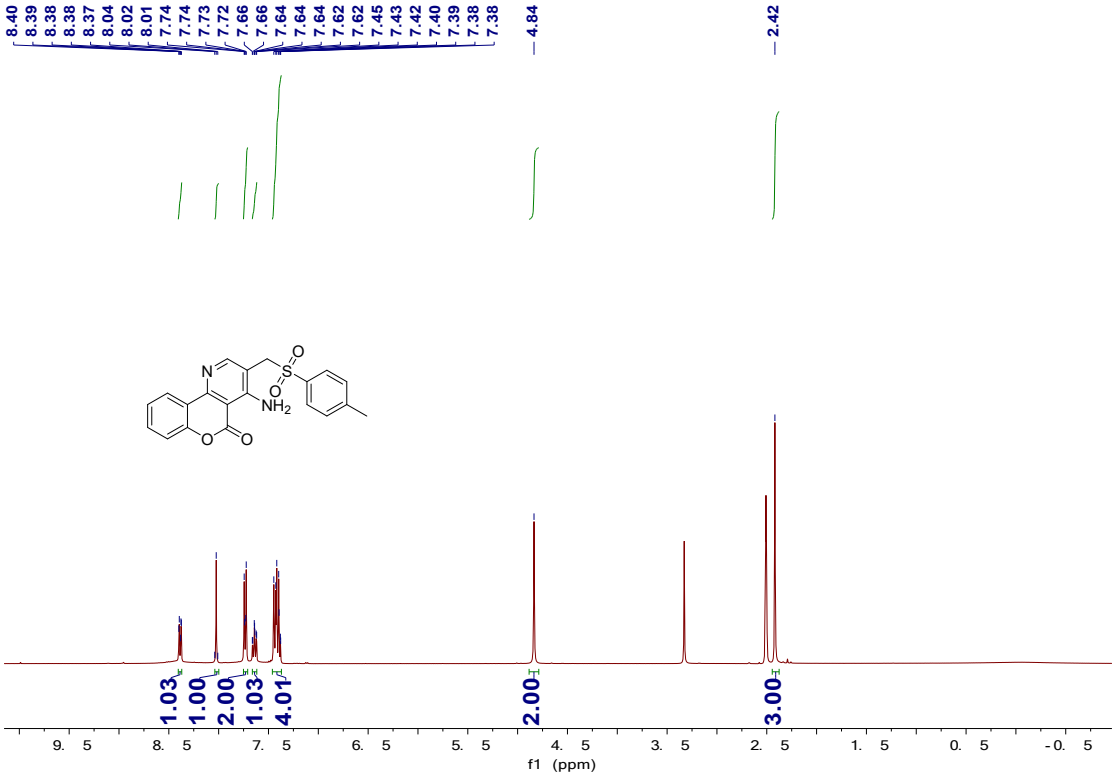
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3aa**



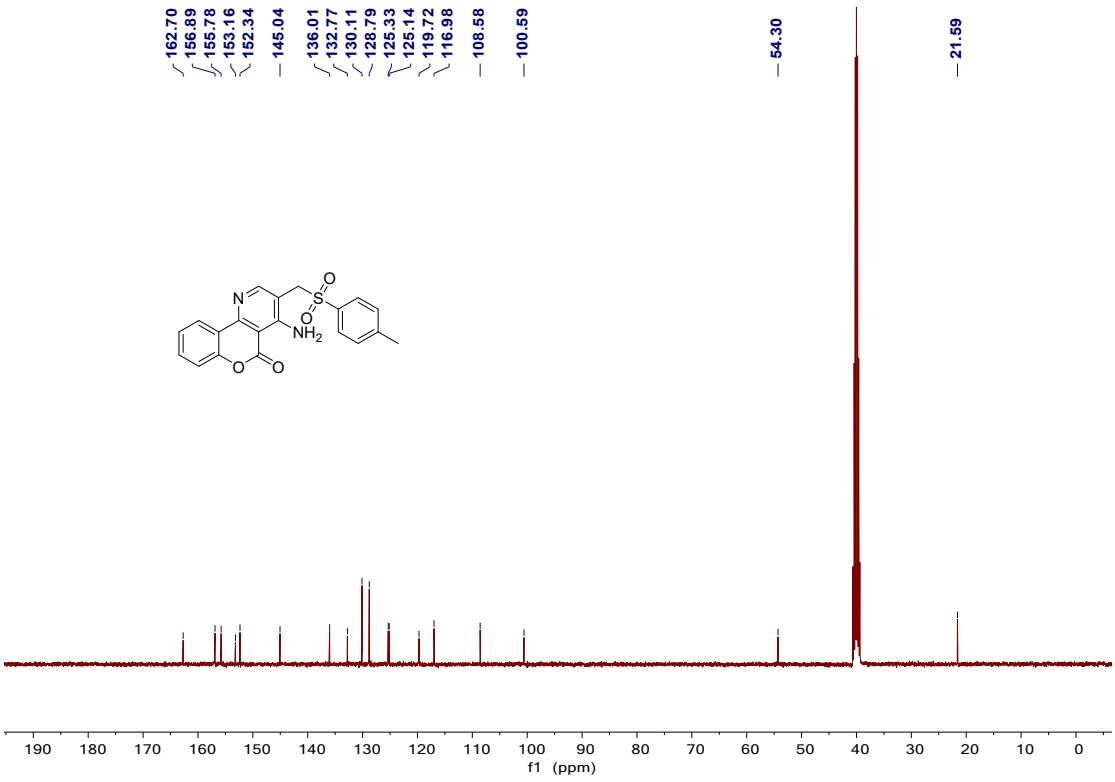
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3aa**



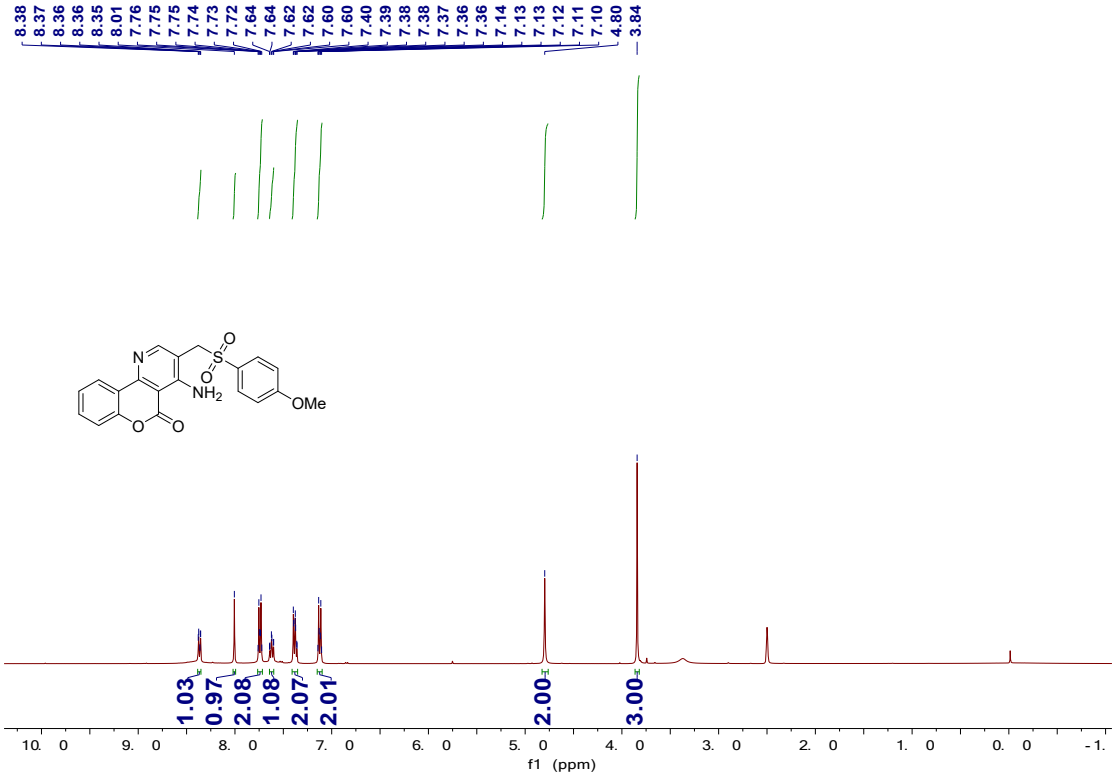
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3ab**



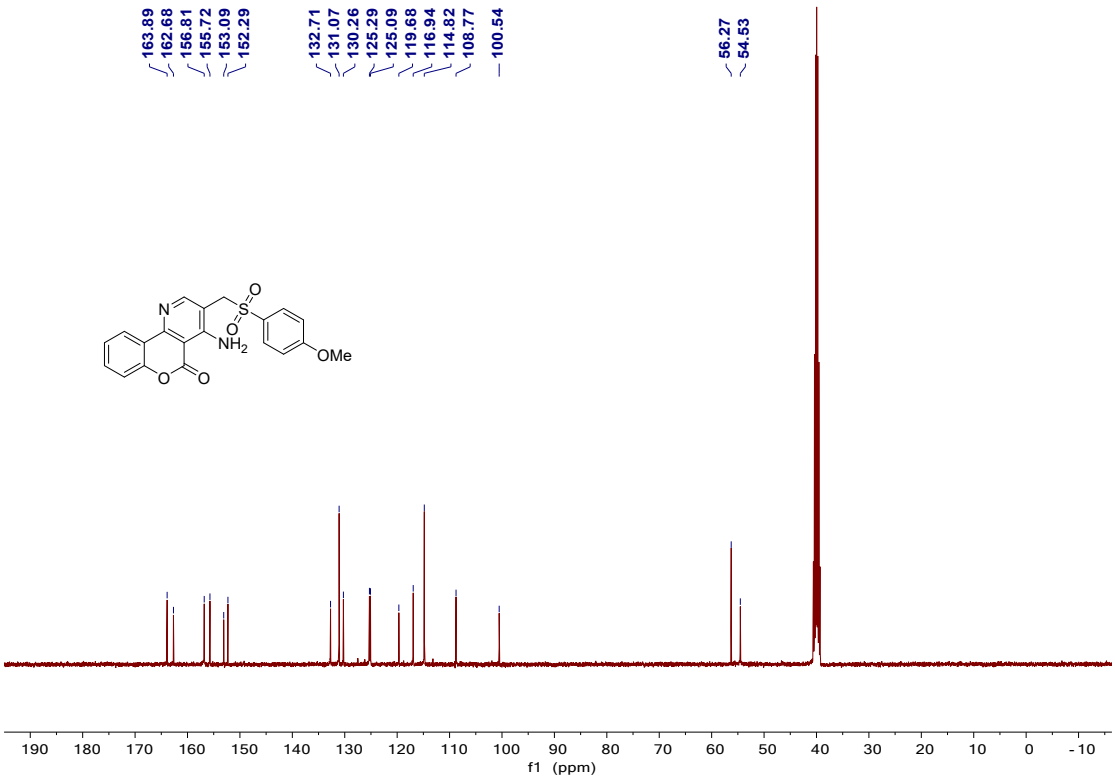
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3ab**



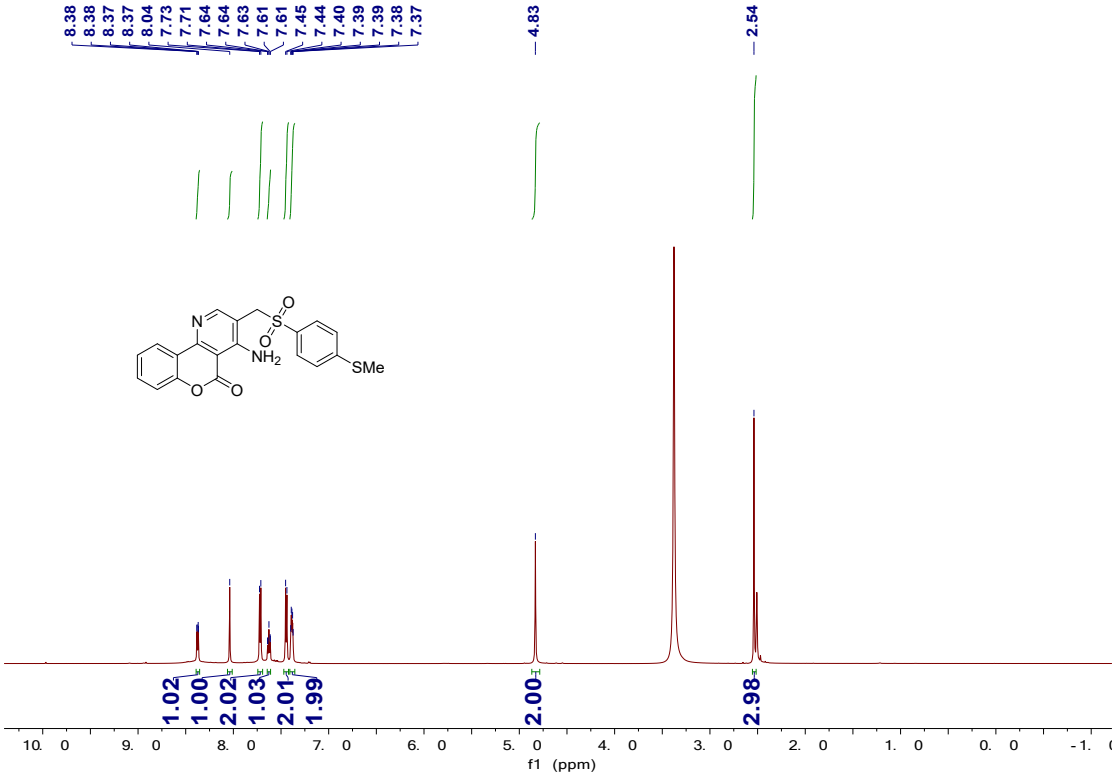
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3ac**



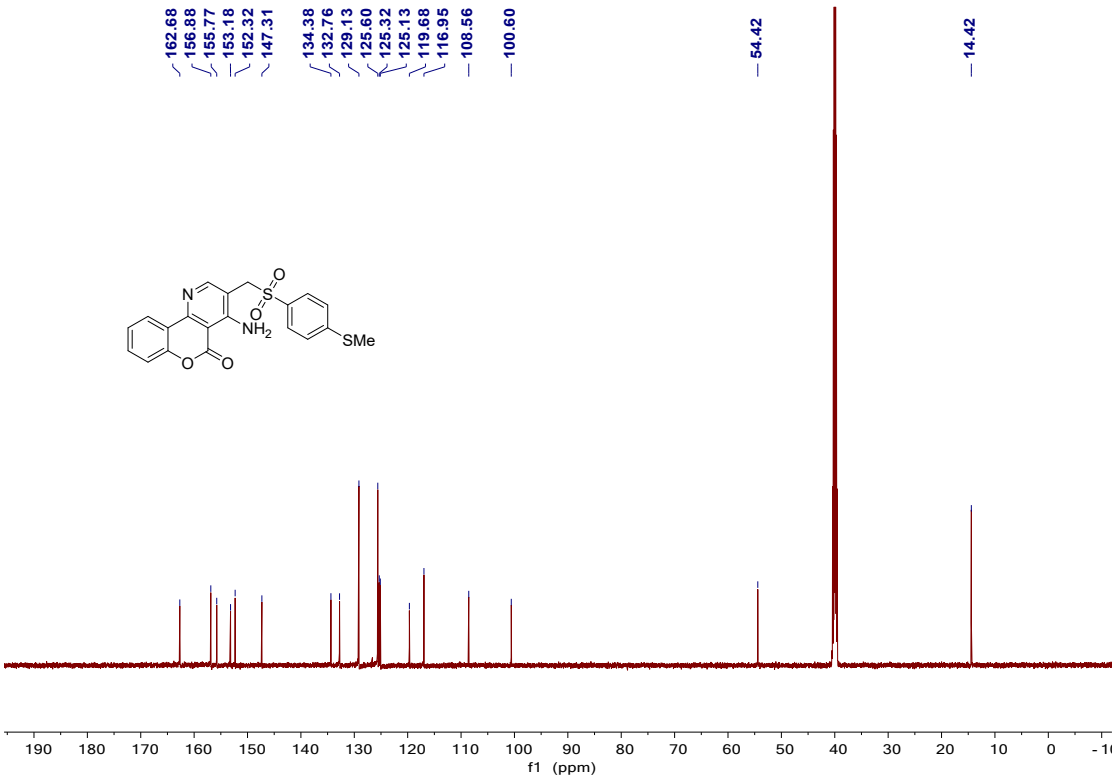
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3ac**



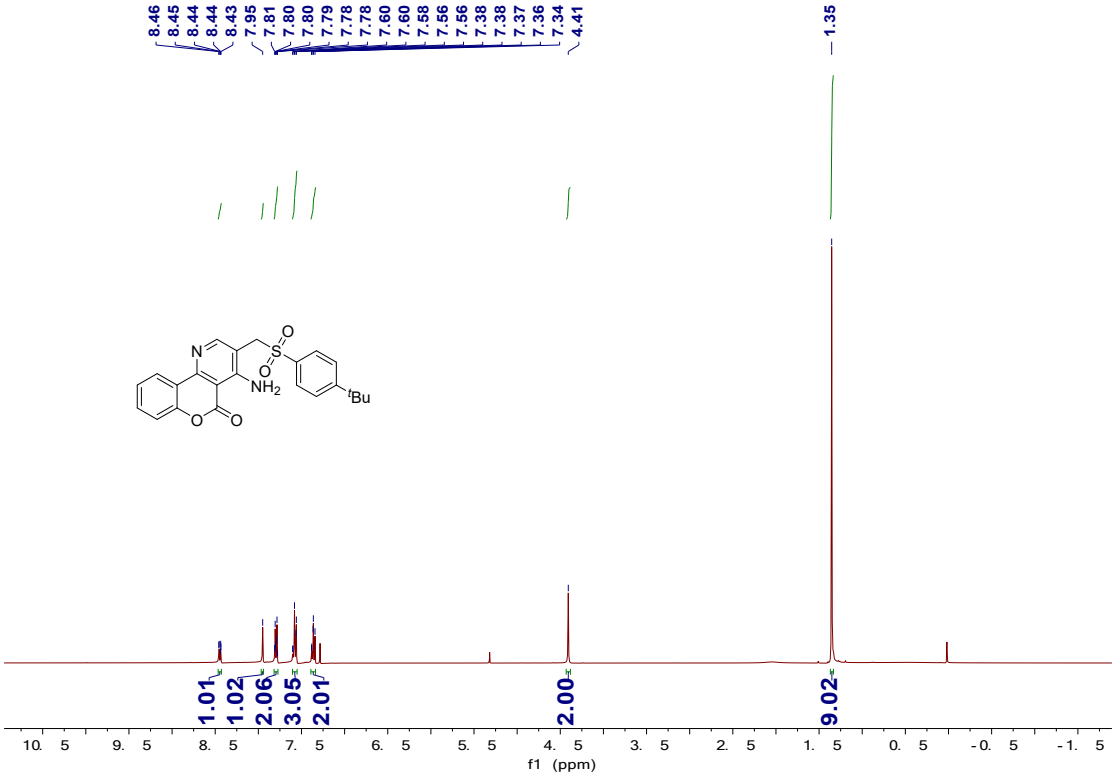
^{1}H NMR-spectrum (600 MHz, DMSO-d_6) of **3ad**



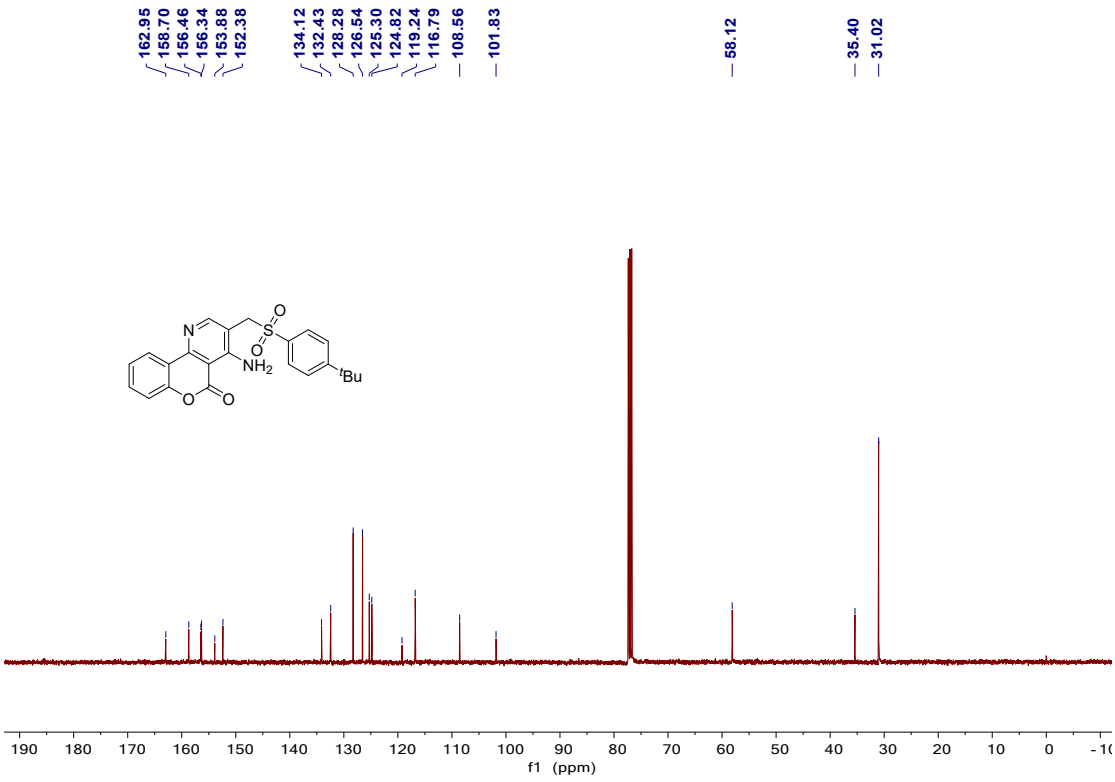
^{13}C NMR-spectrum (151 MHz, DMSO-d_6) of **3ad**



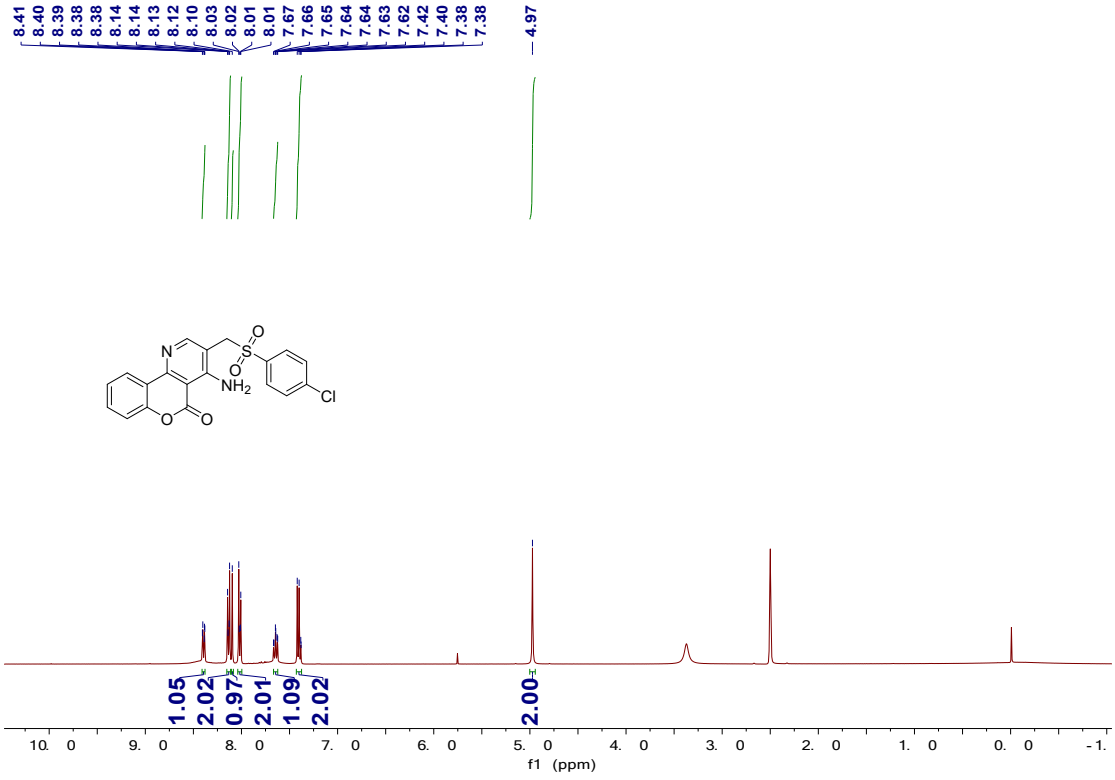
^{1}H NMR-spectrum (400 MHz, $CDCl_3$) of **3ae**



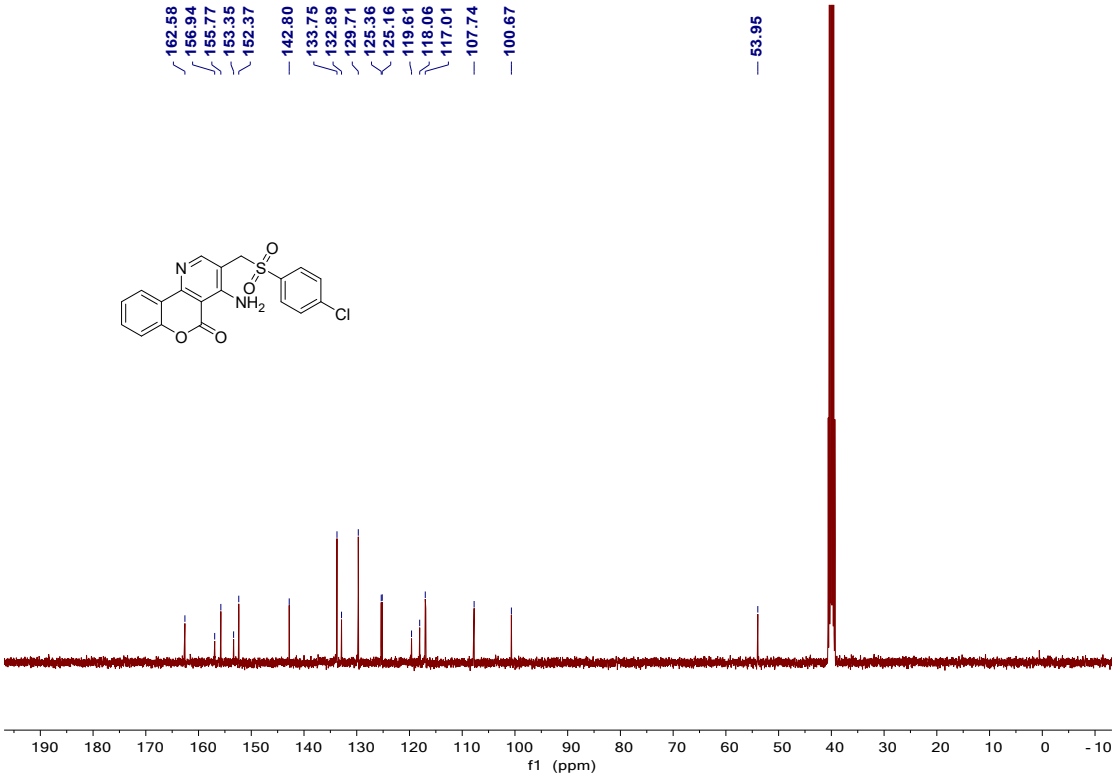
^{13}C NMR-spectrum (101 MHz, $CDCl_3$) of **3ae**



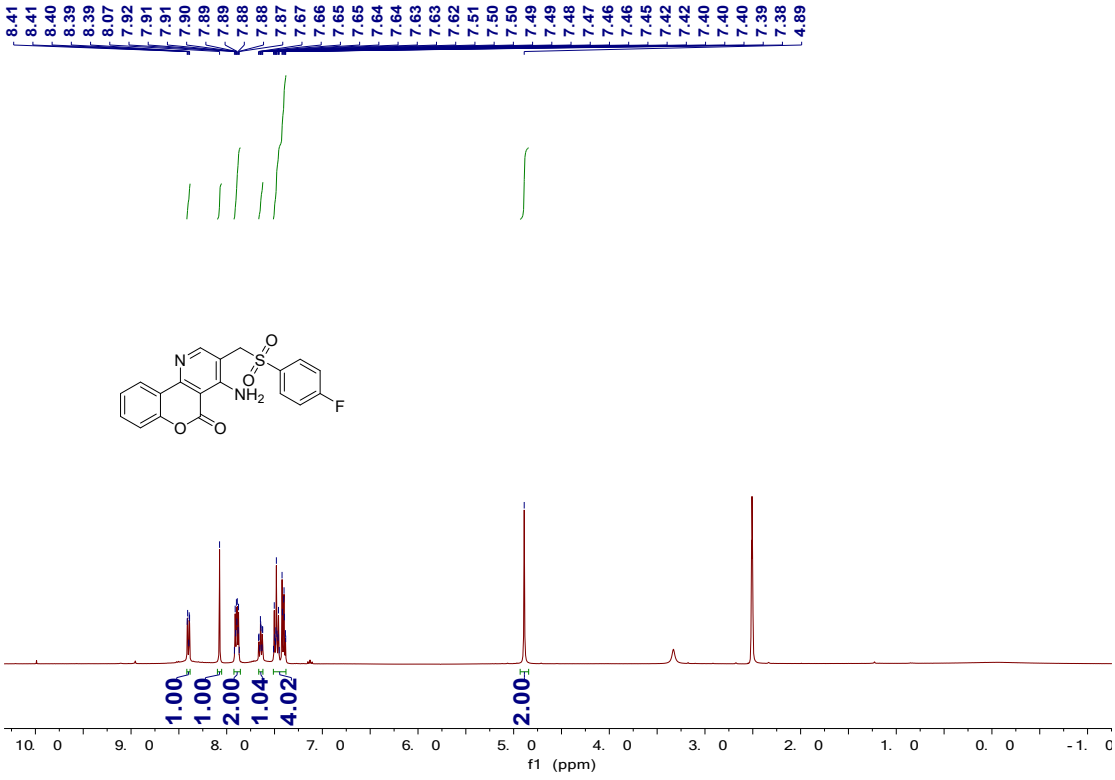
[1]H NMR-spectrum (400 MHz, DMSO-d_6) of **3af**



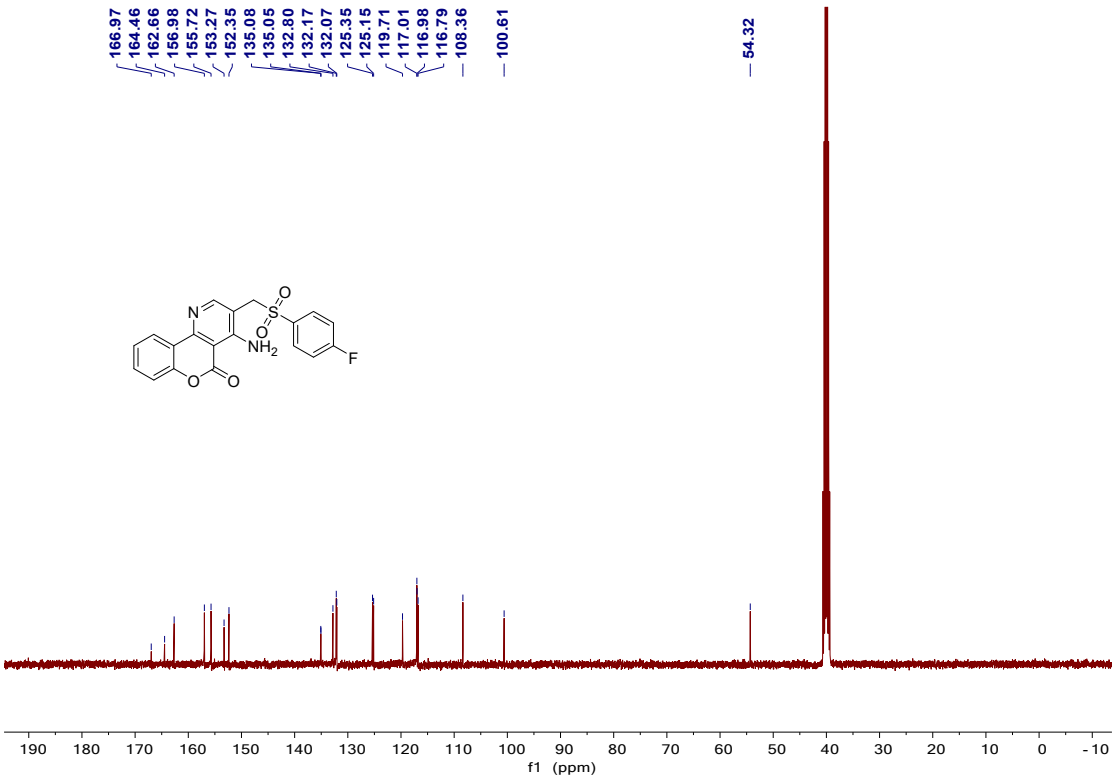
[13]C NMR-spectrum (101 MHz, DMSO-d_6) of **3af**



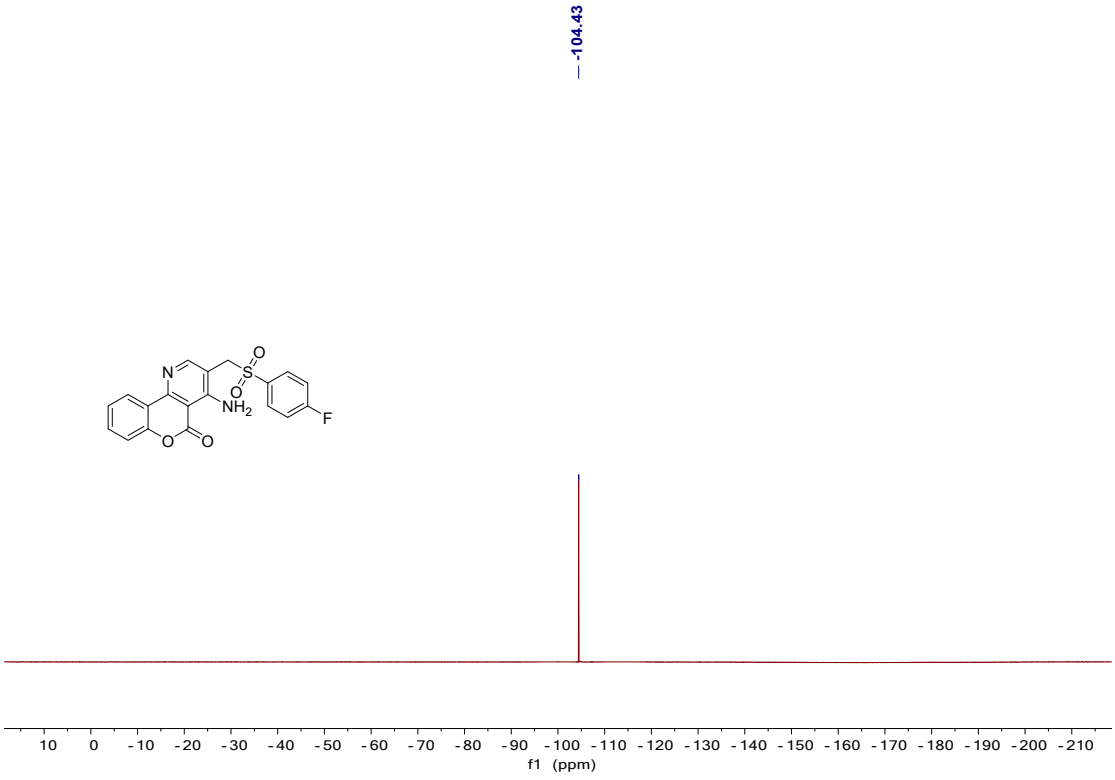
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3ag**



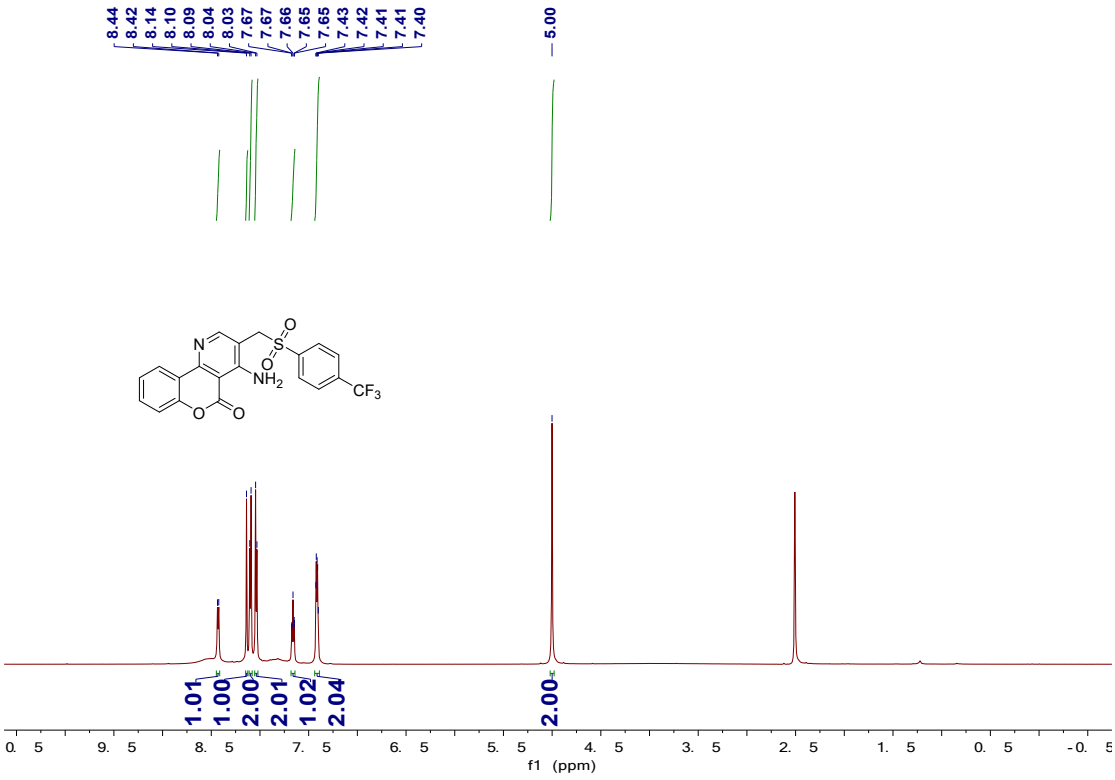
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3ag**



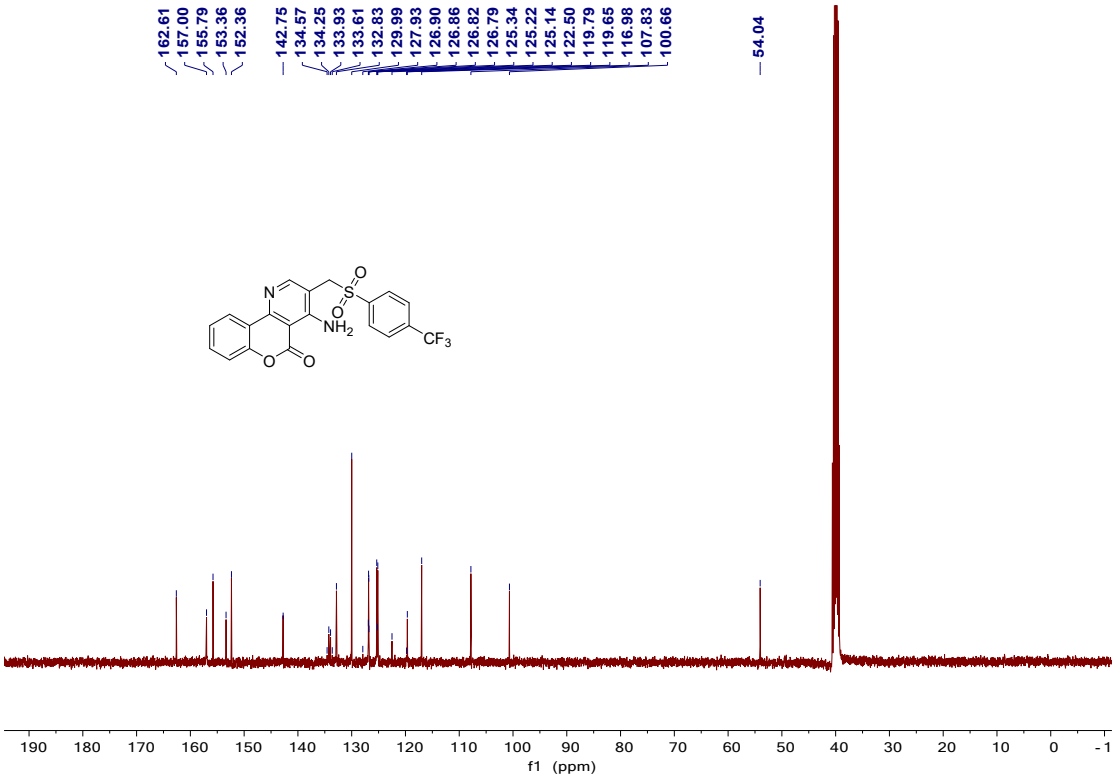
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **3ag**



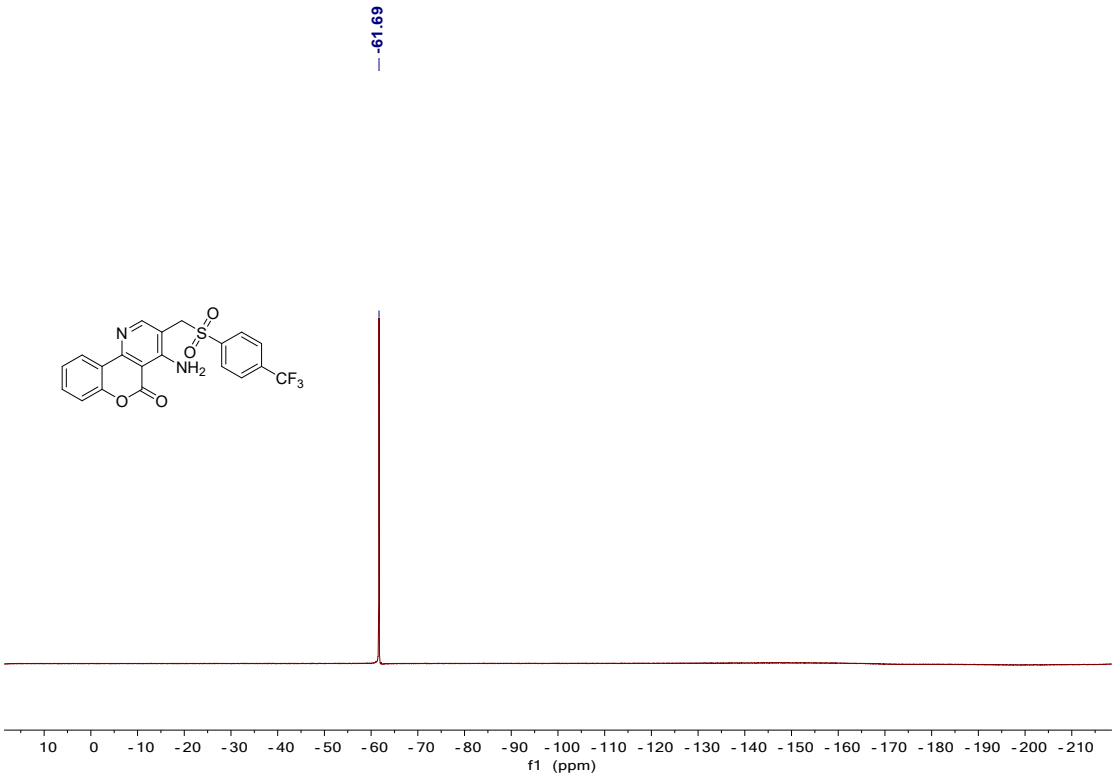
^{1}H NMR-spectrum (600 MHz, DMSO-d_6) of **3ah**



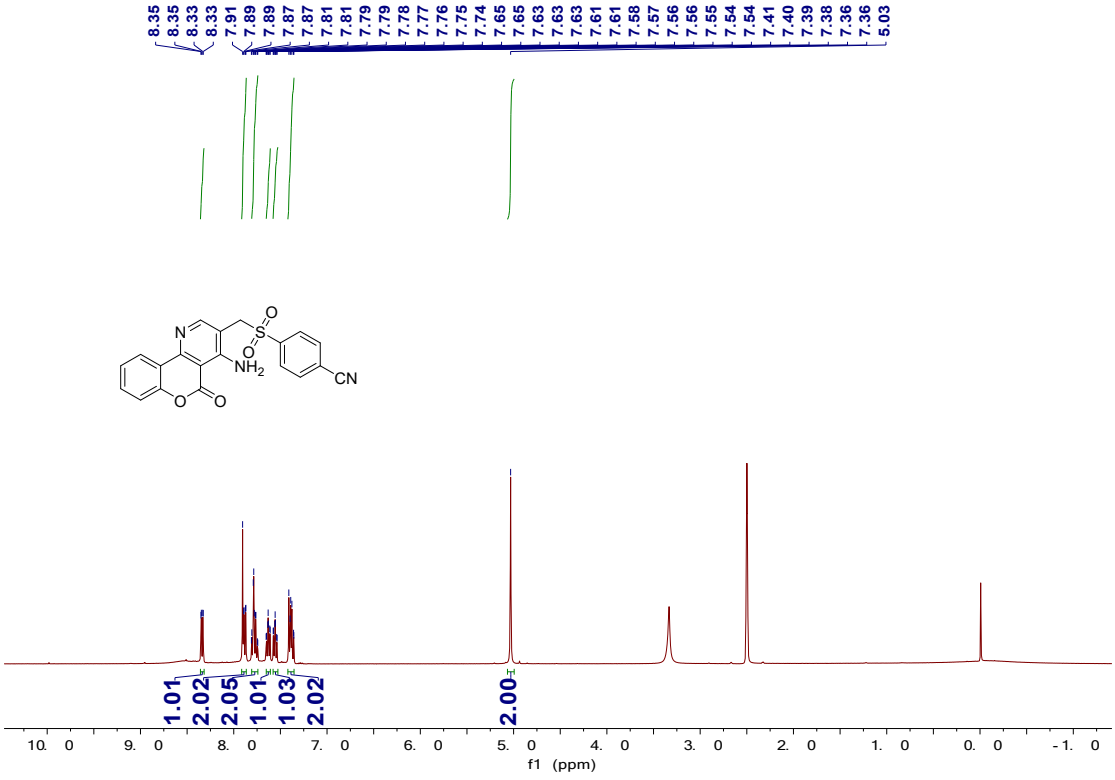
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3ah**



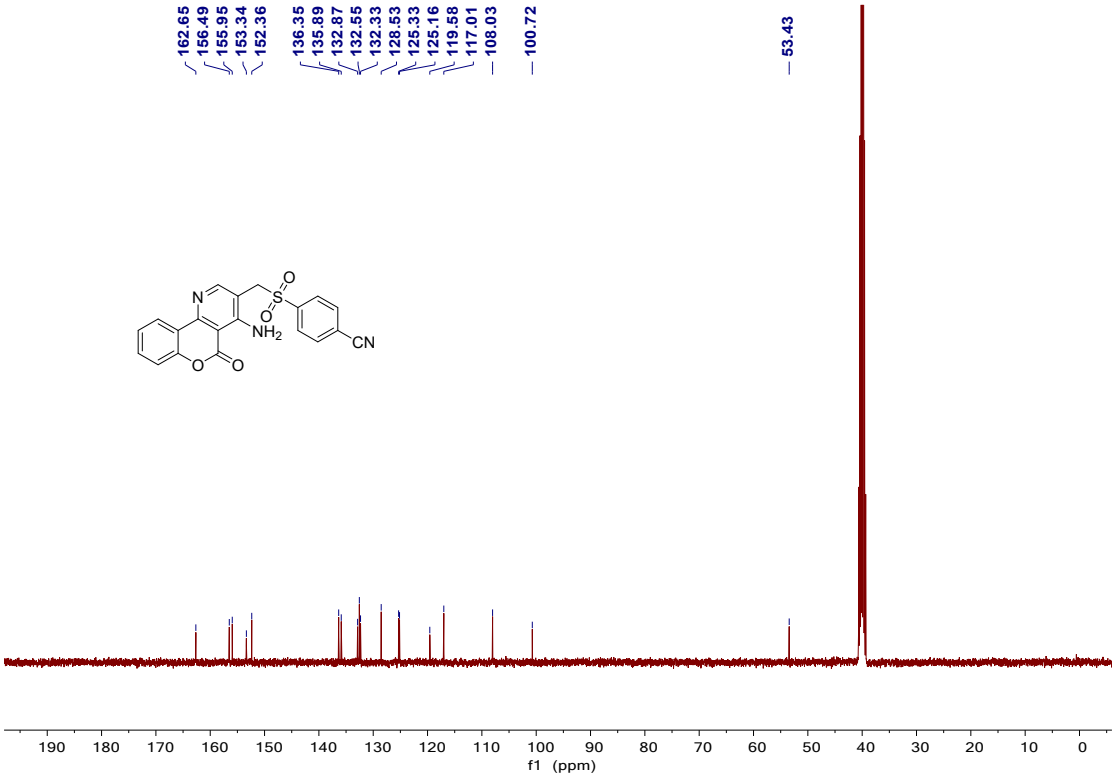
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **3ah**



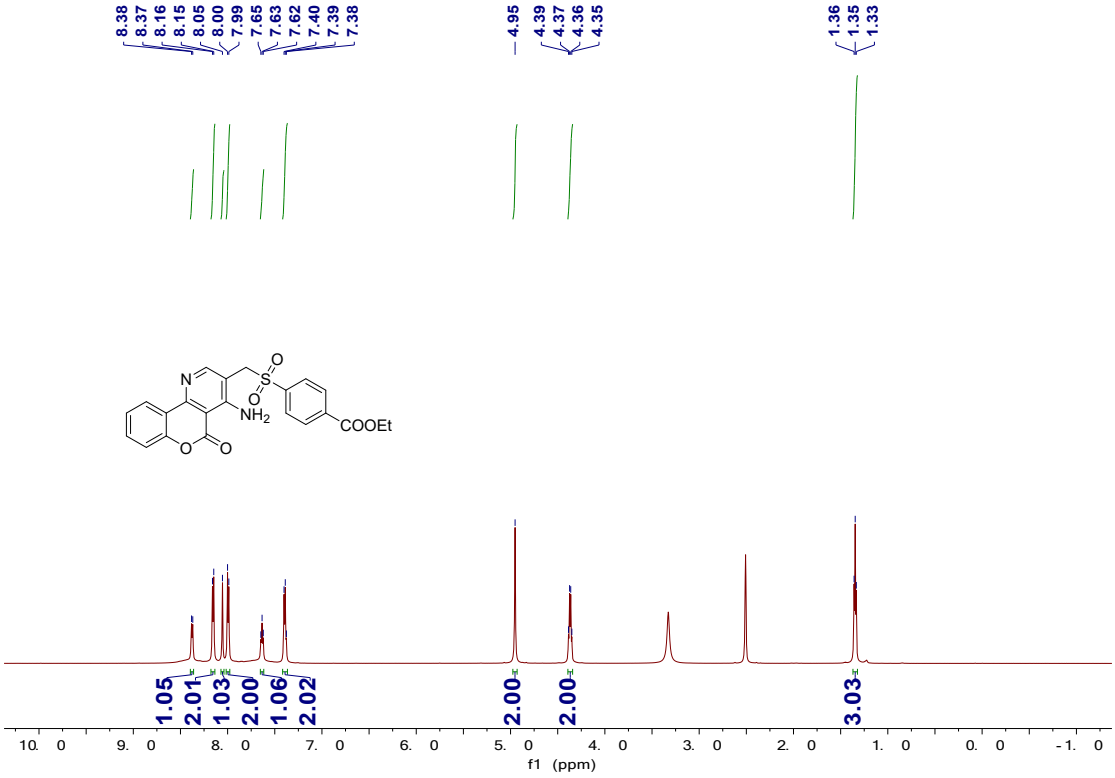
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3ai**



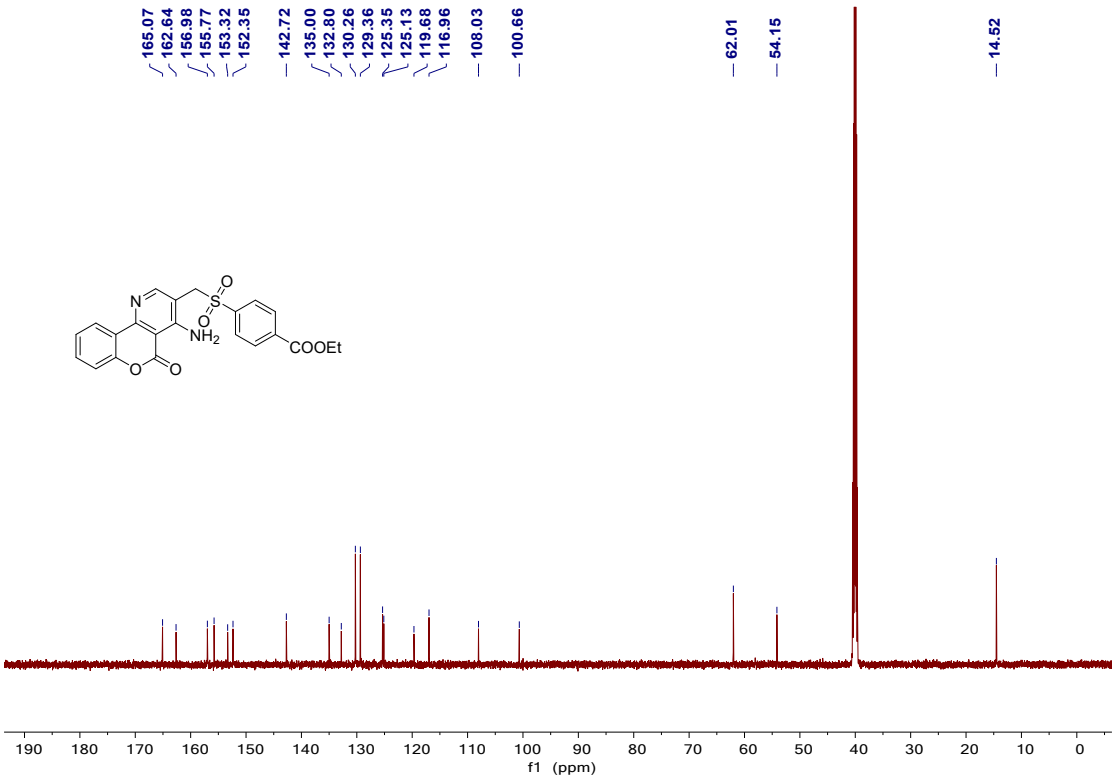
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3ai**



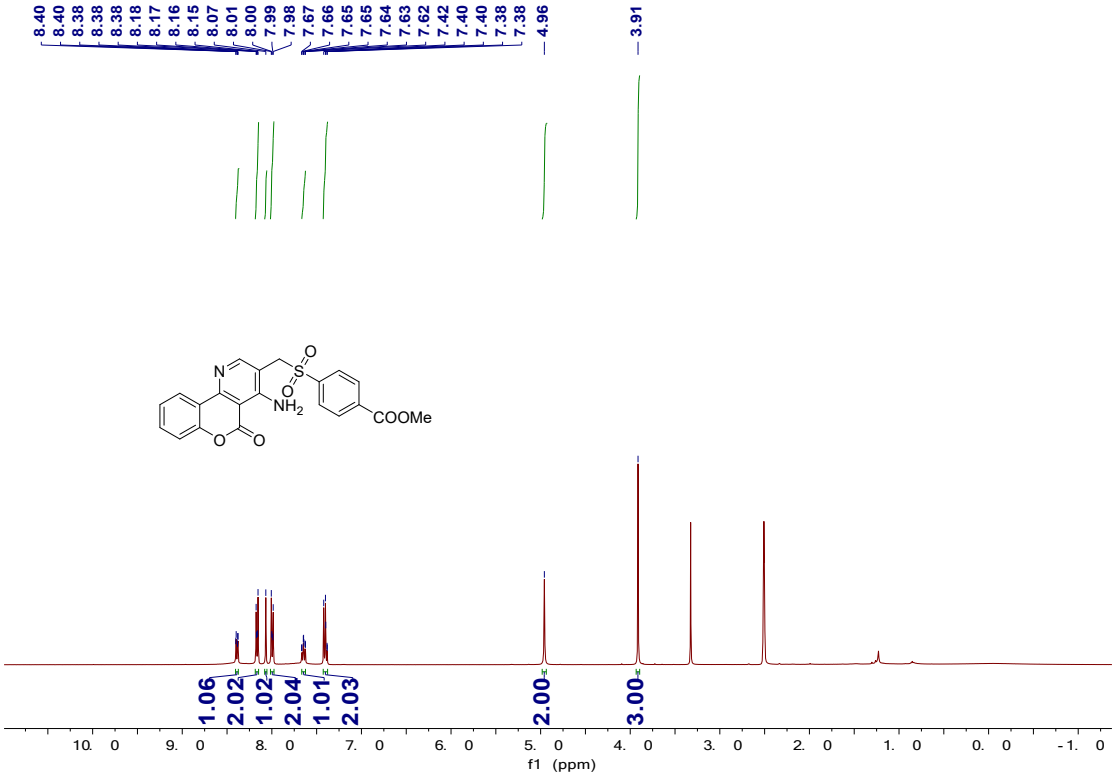
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3aj**



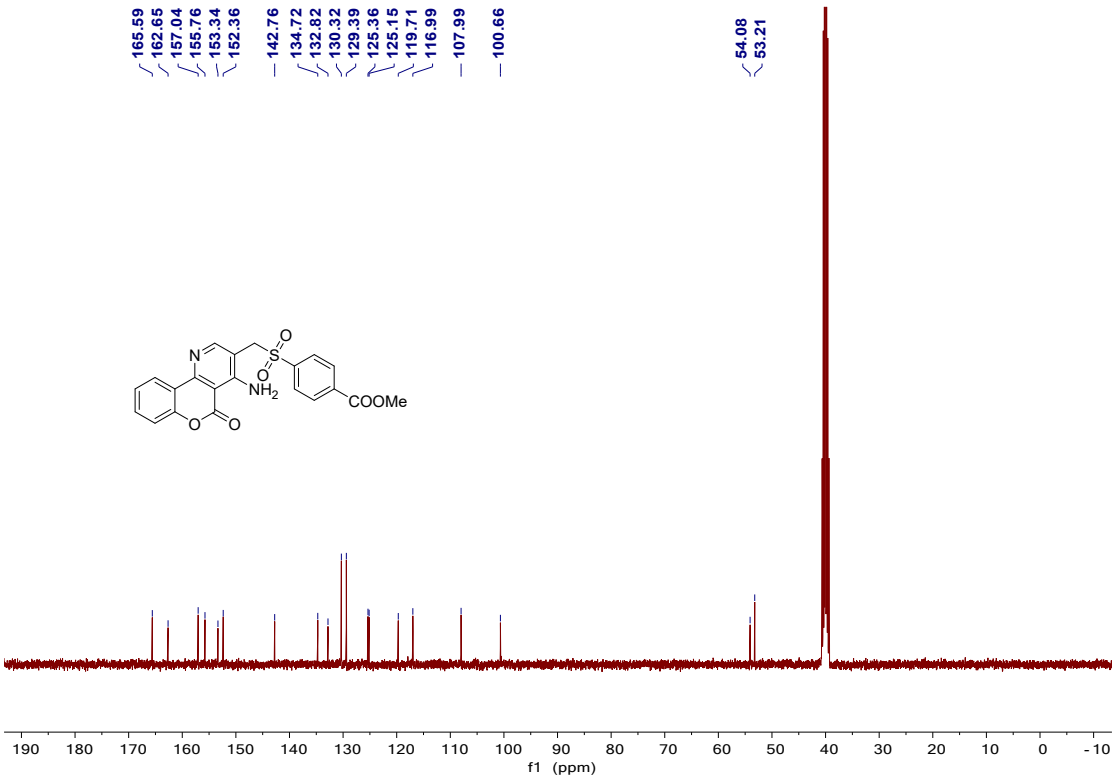
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3aj**



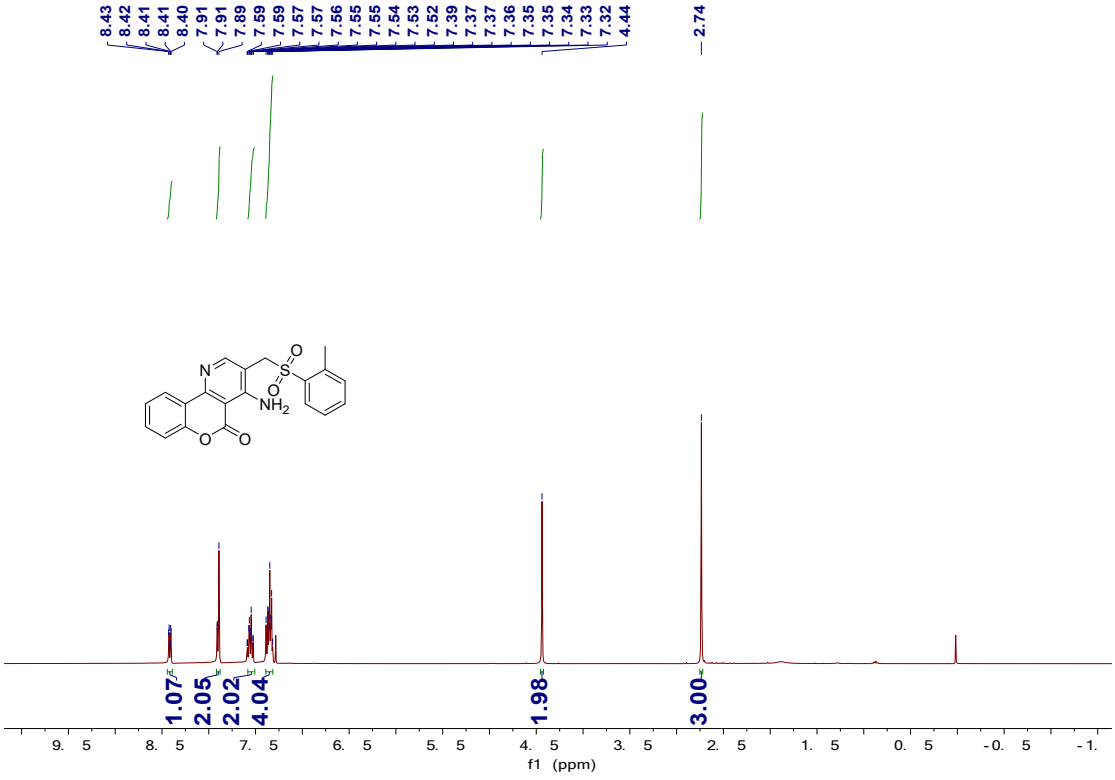
^{1}H NMR-spectrum (600 MHz, DMSO-d_6) of **3ak**



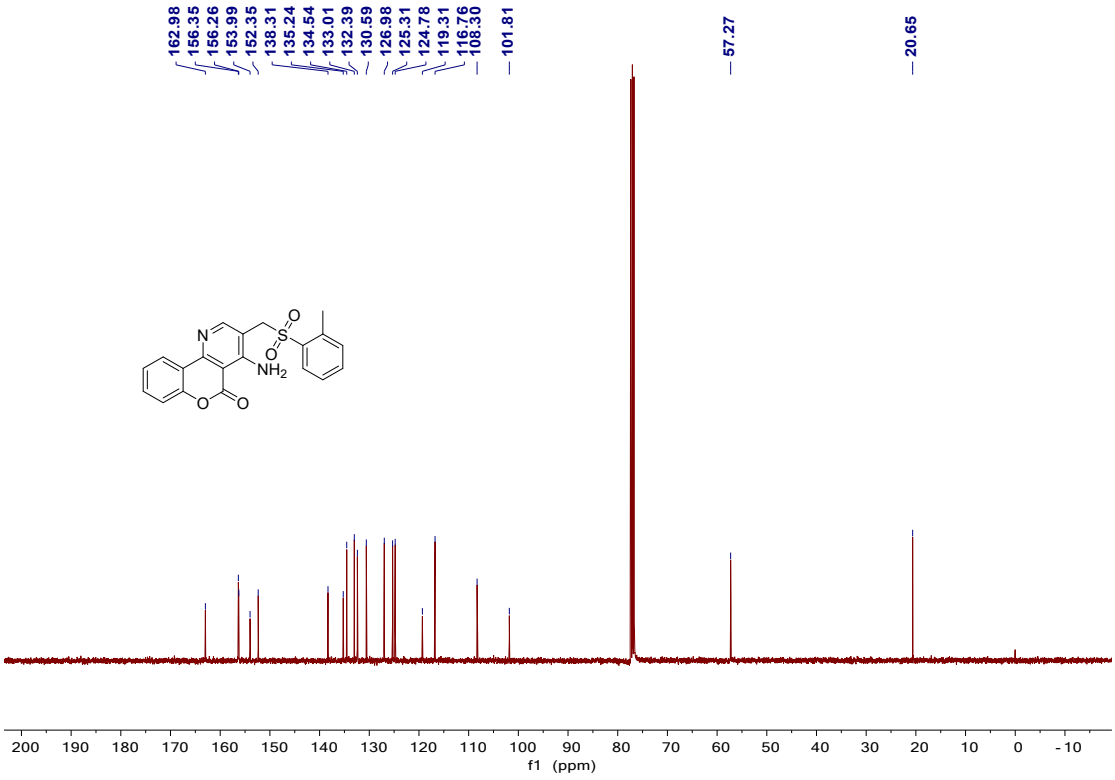
^{13}C NMR-spectrum (151 MHz, DMSO-d_6) of **3ak**



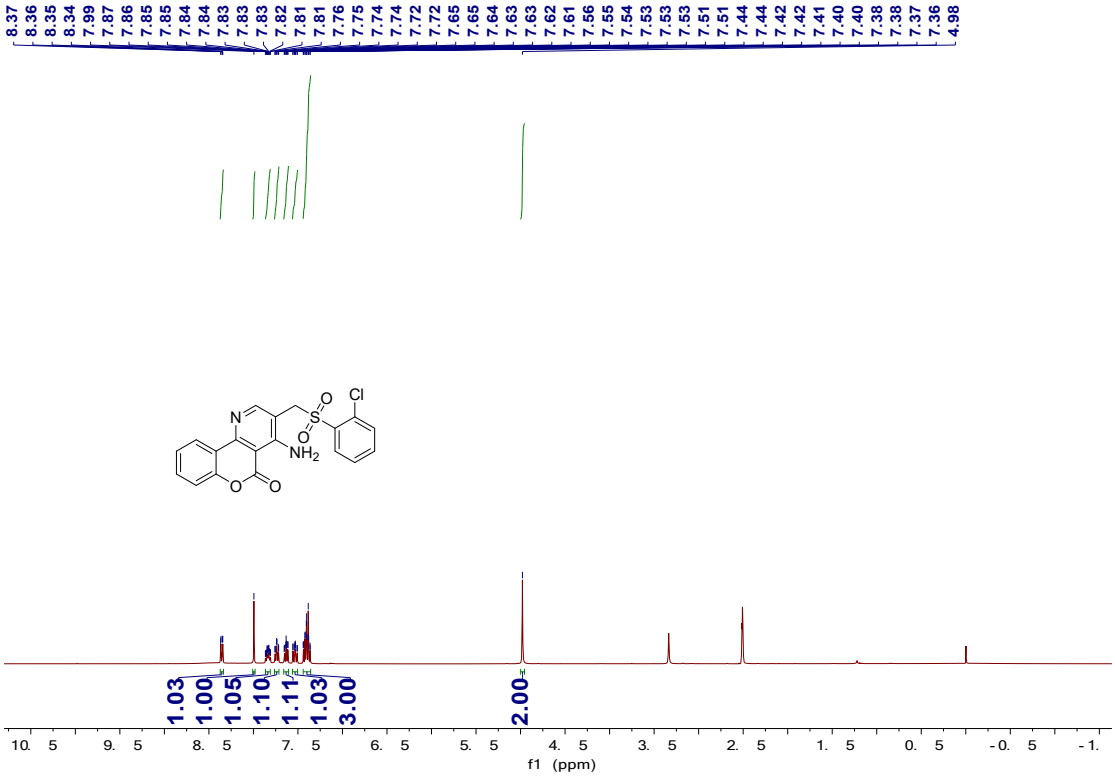
^{1}H NMR-spectrum (400 MHz, $CDCl_3$) of **3al**



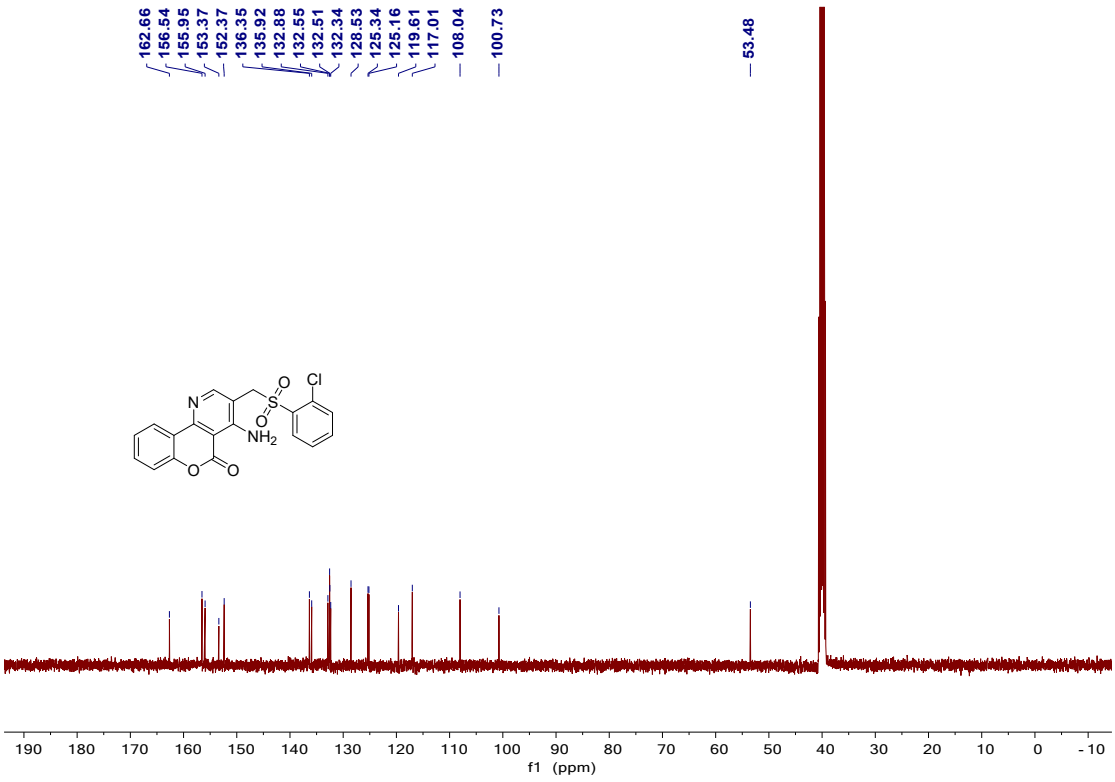
^{13}C NMR-spectrum (101 MHz, $CDCl_3$) of **3al**



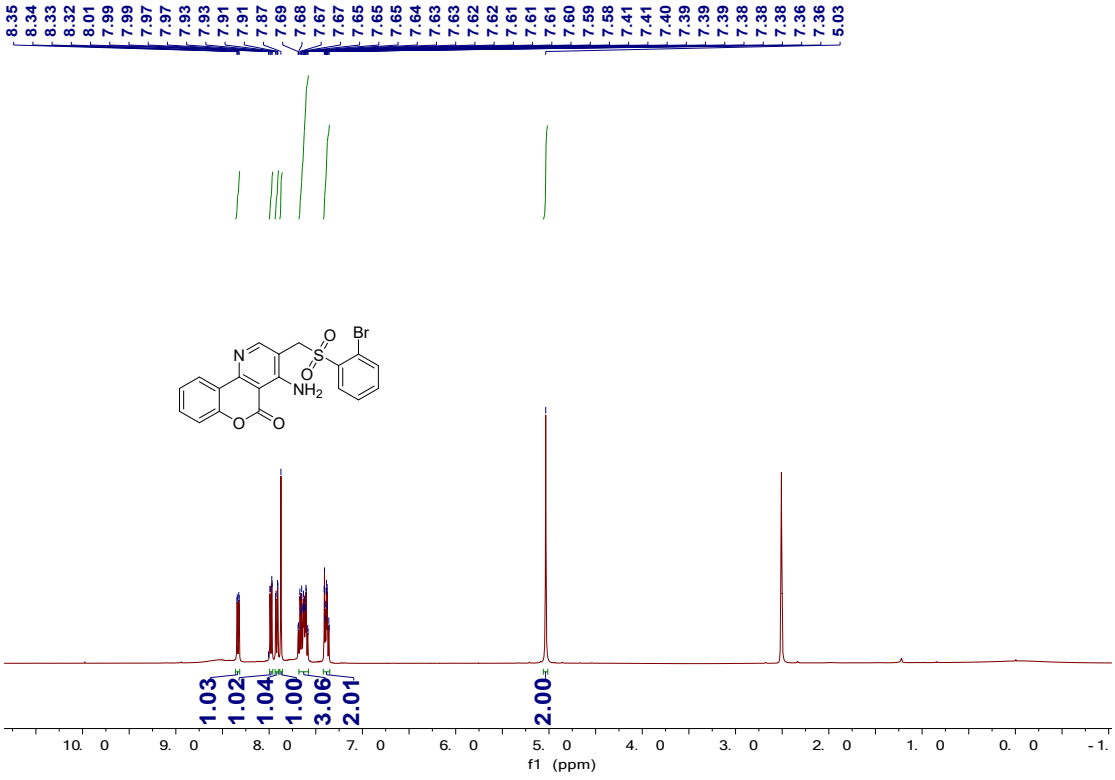
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3am**



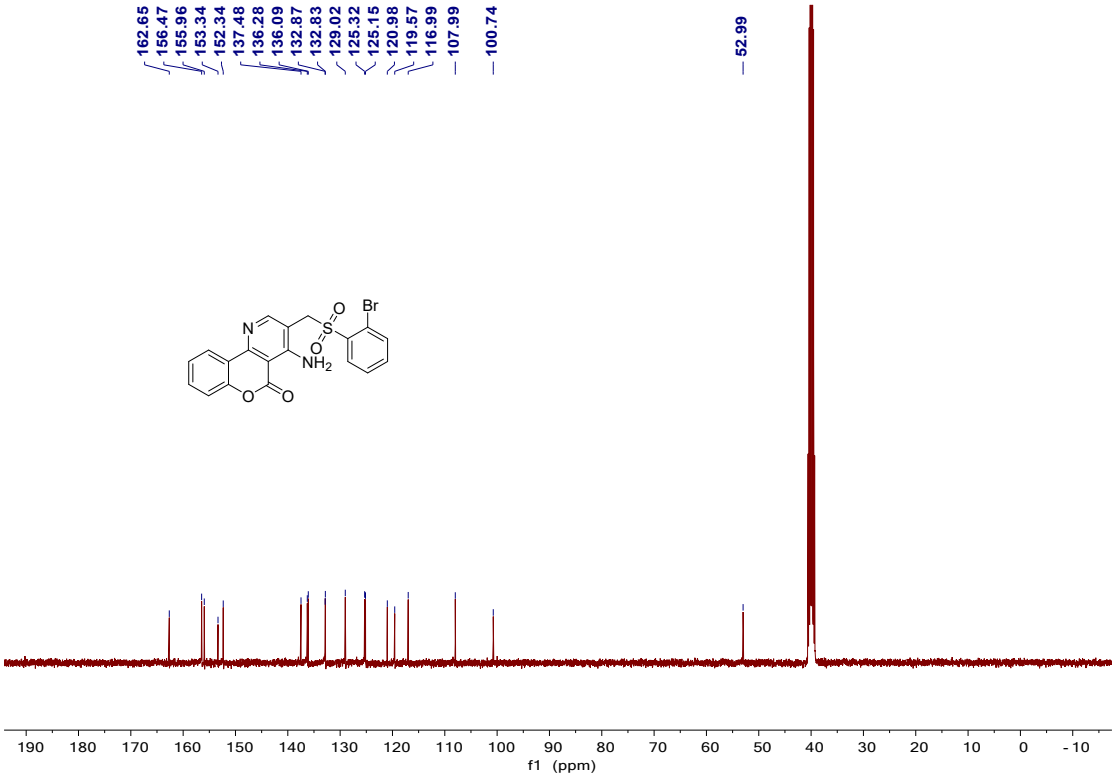
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3am**



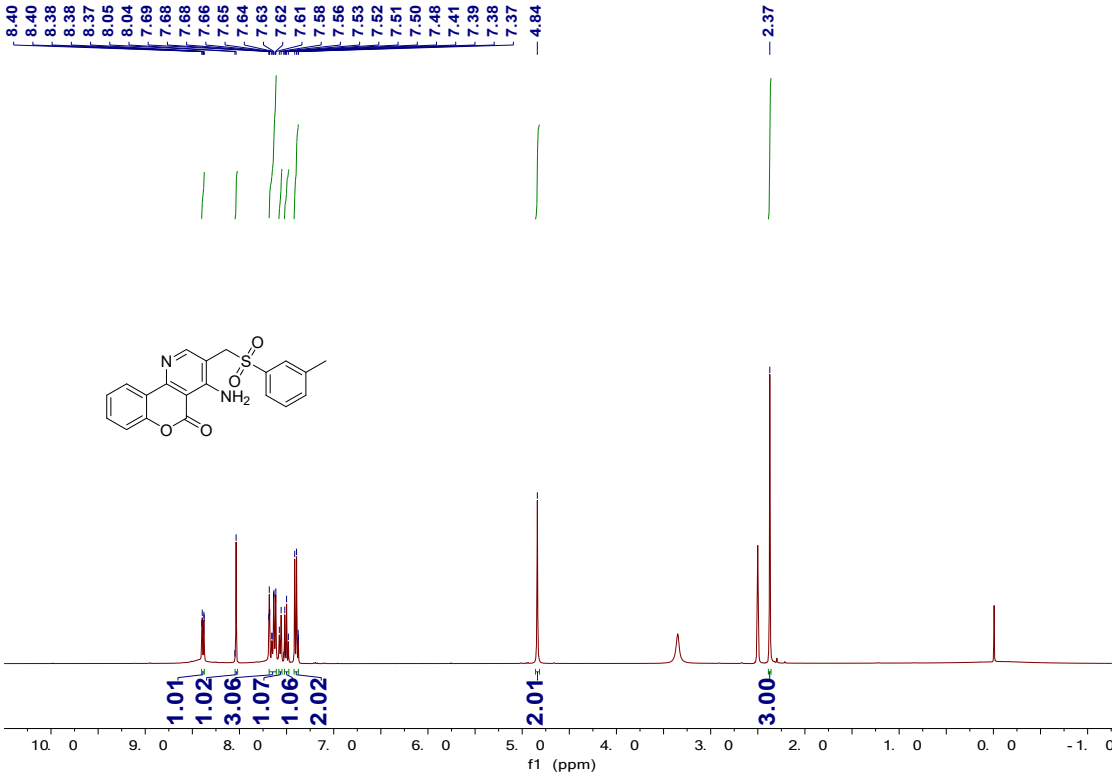
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3an**



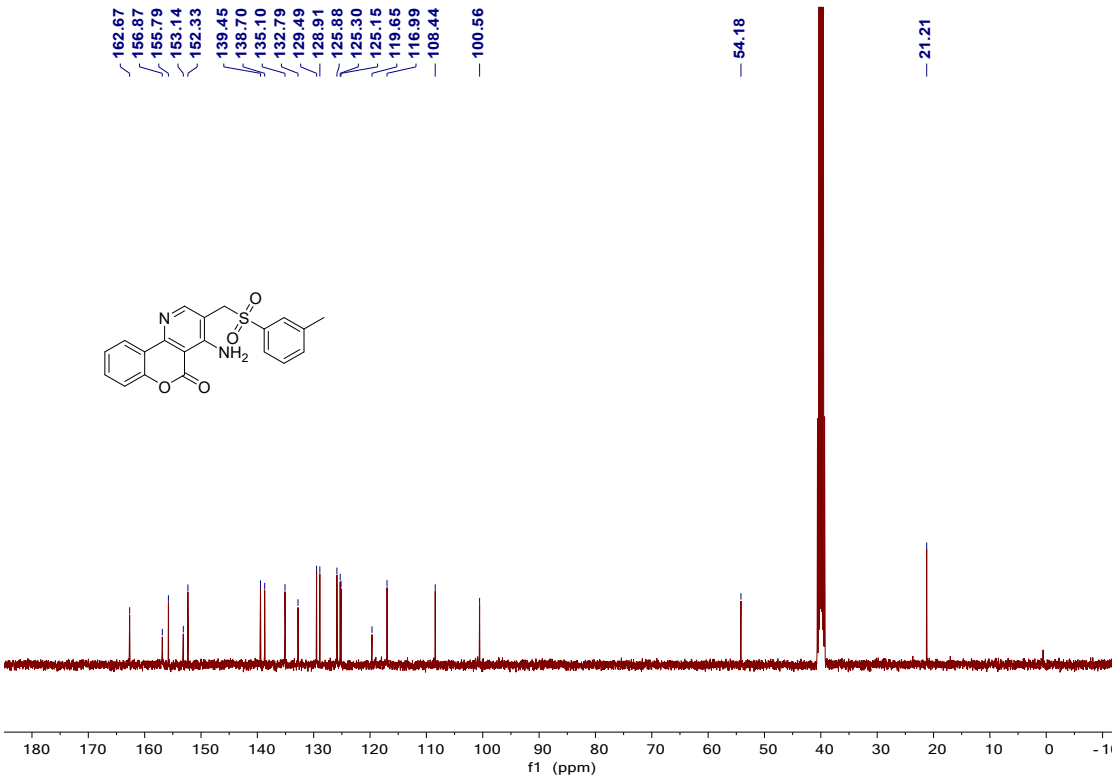
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3an**



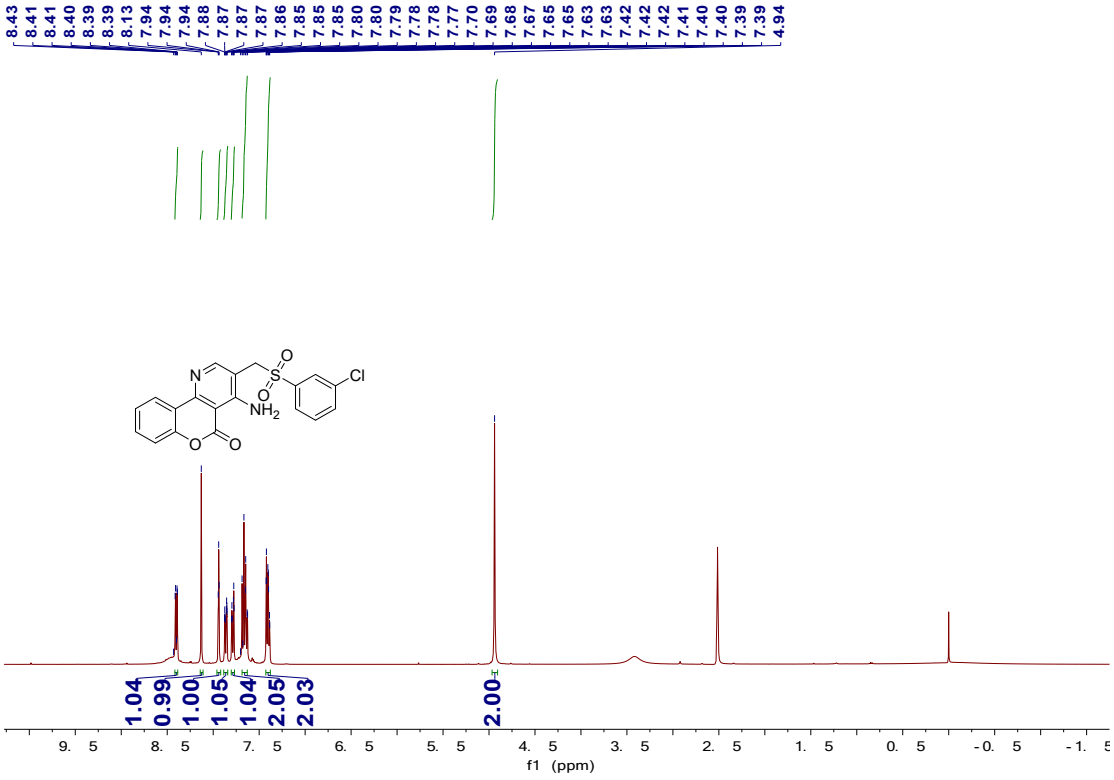
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3ao**



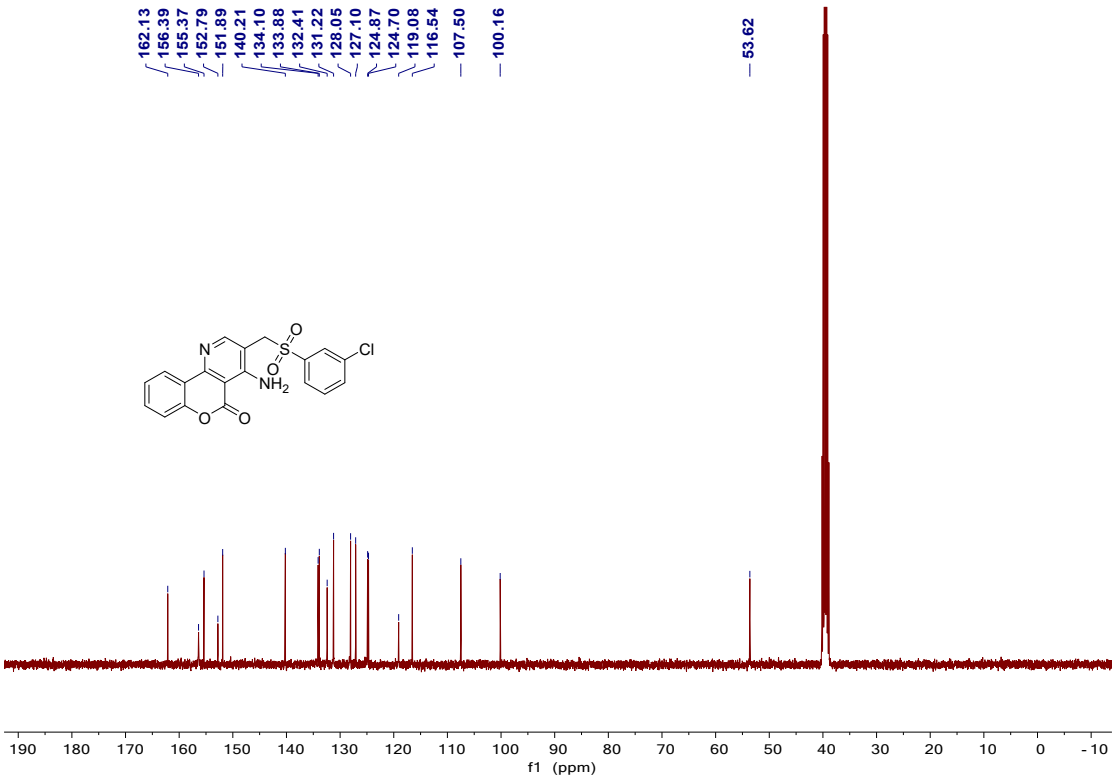
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3ao**



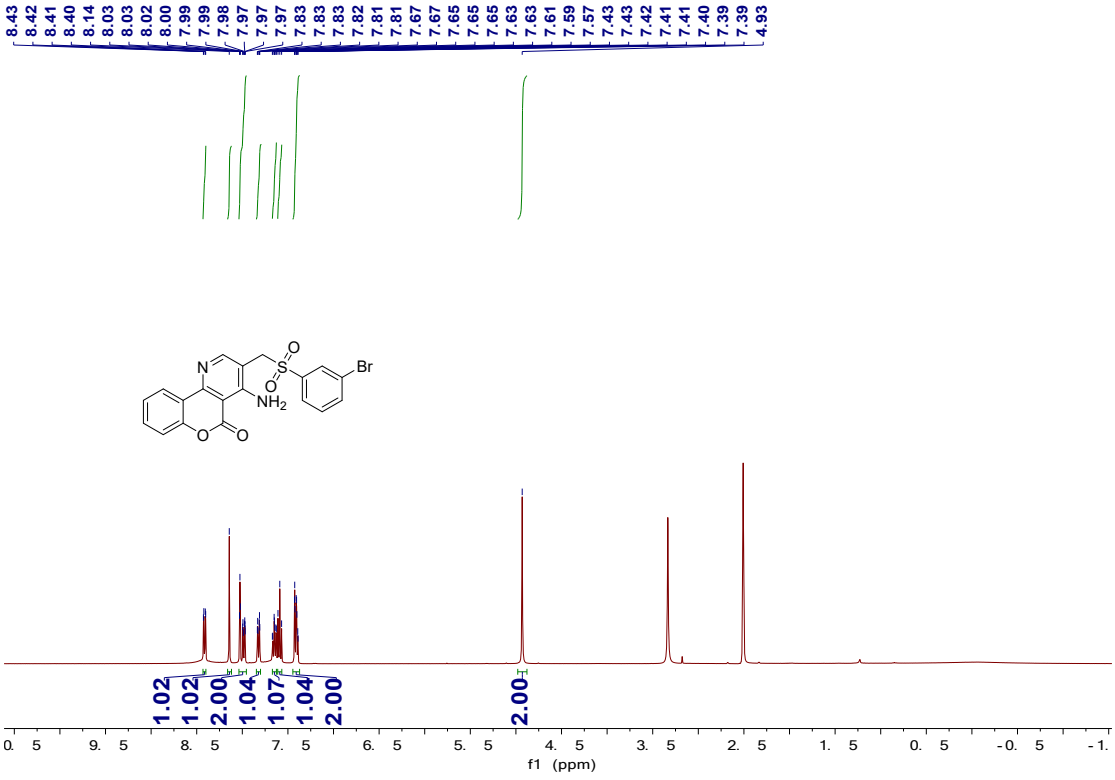
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3ap**



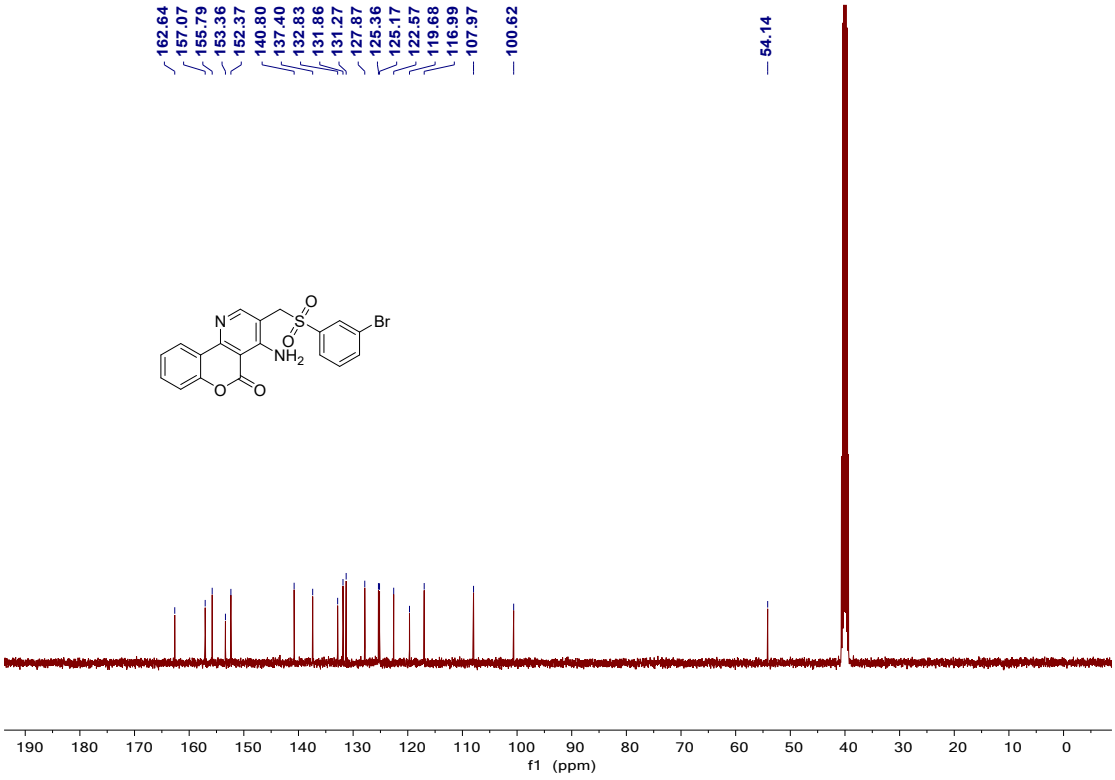
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3ap**



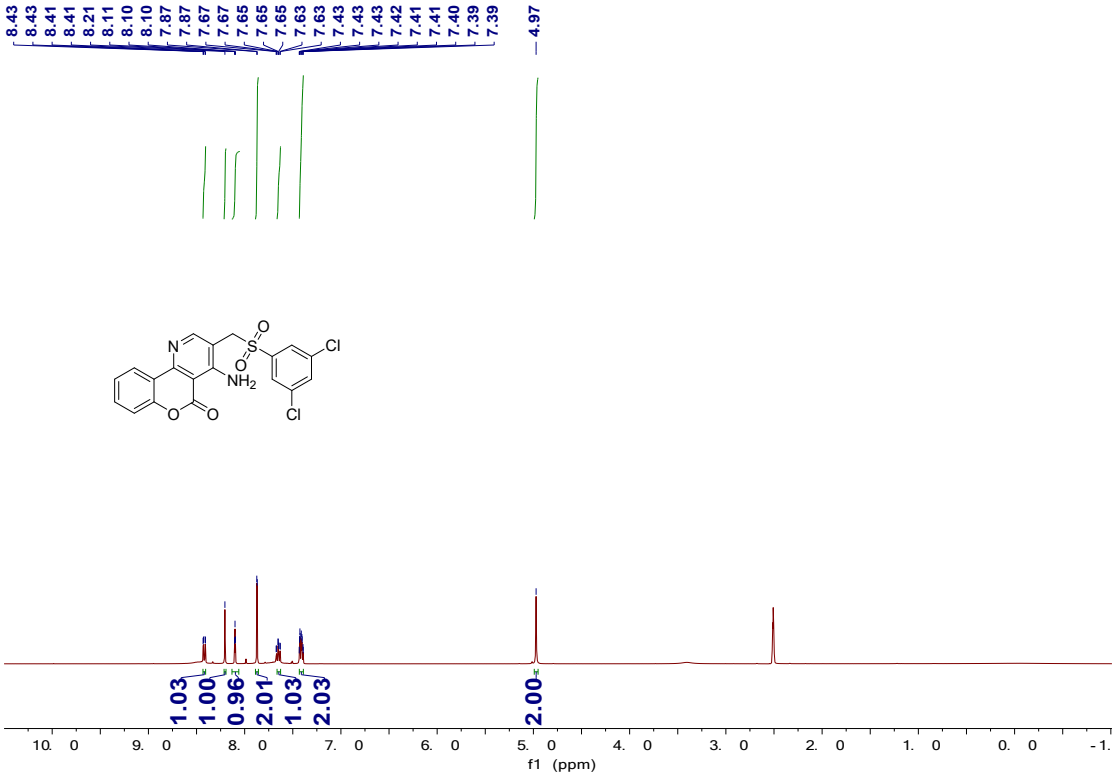
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3aq**



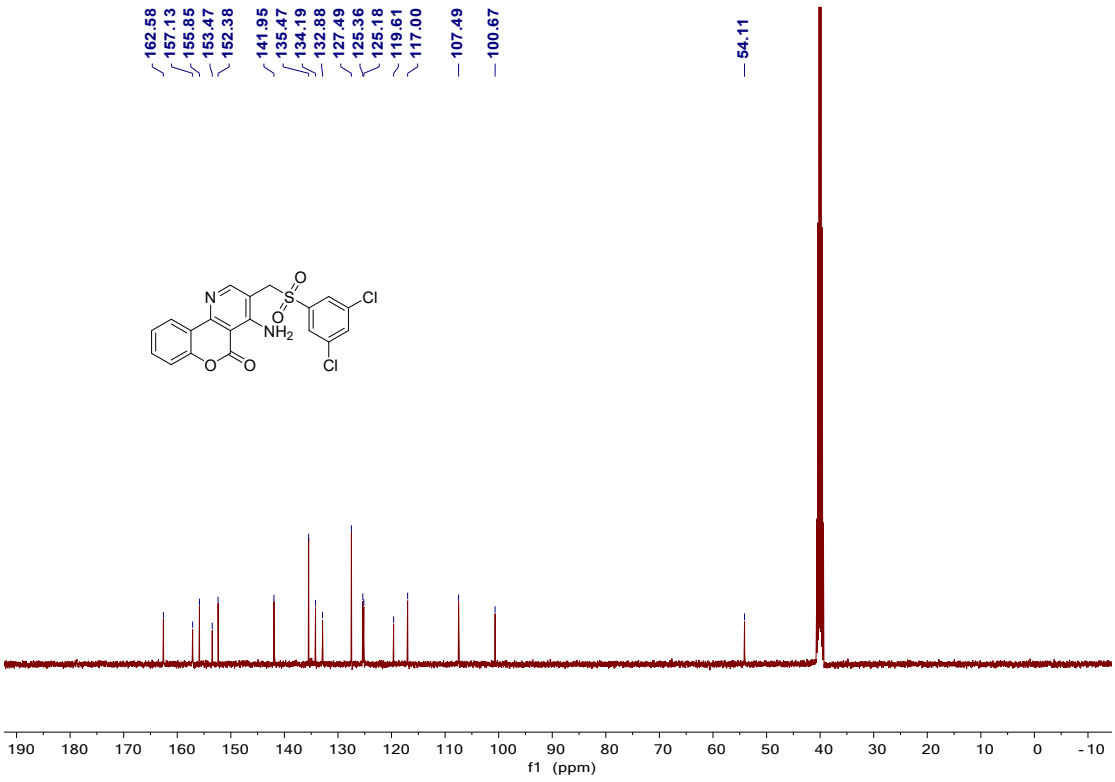
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3aq**



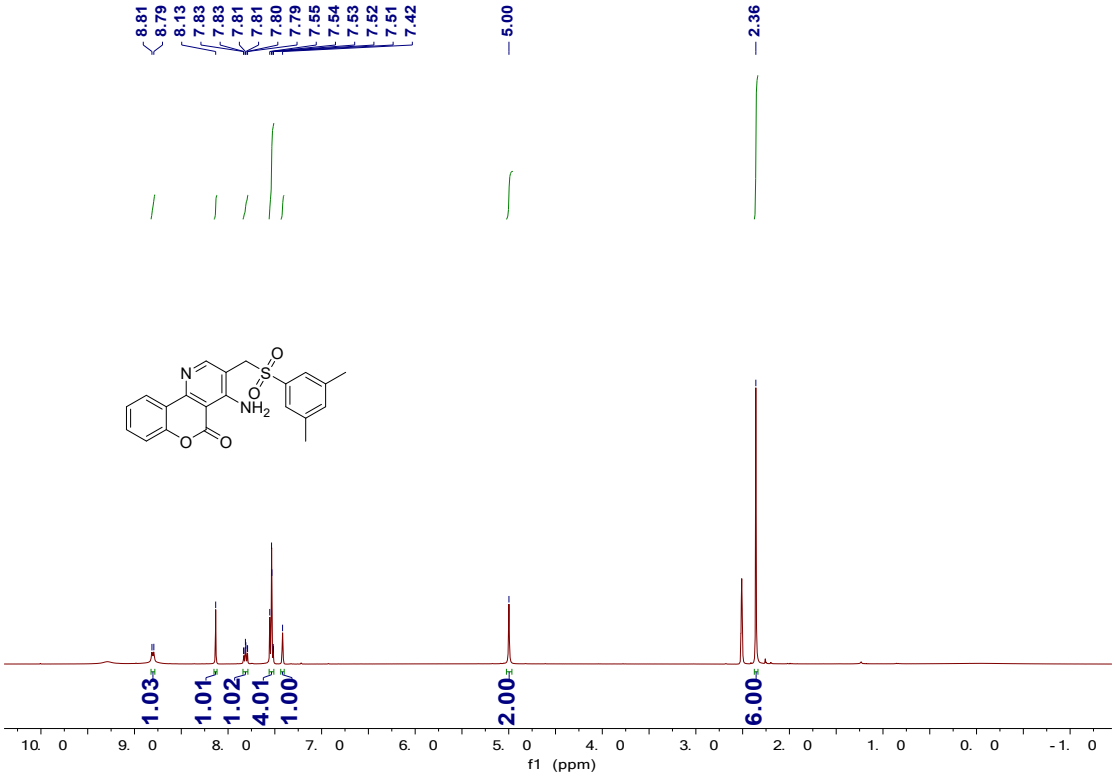
[1]H NMR-spectrum (400 MHz, DMSO-d_6) of **3ar**



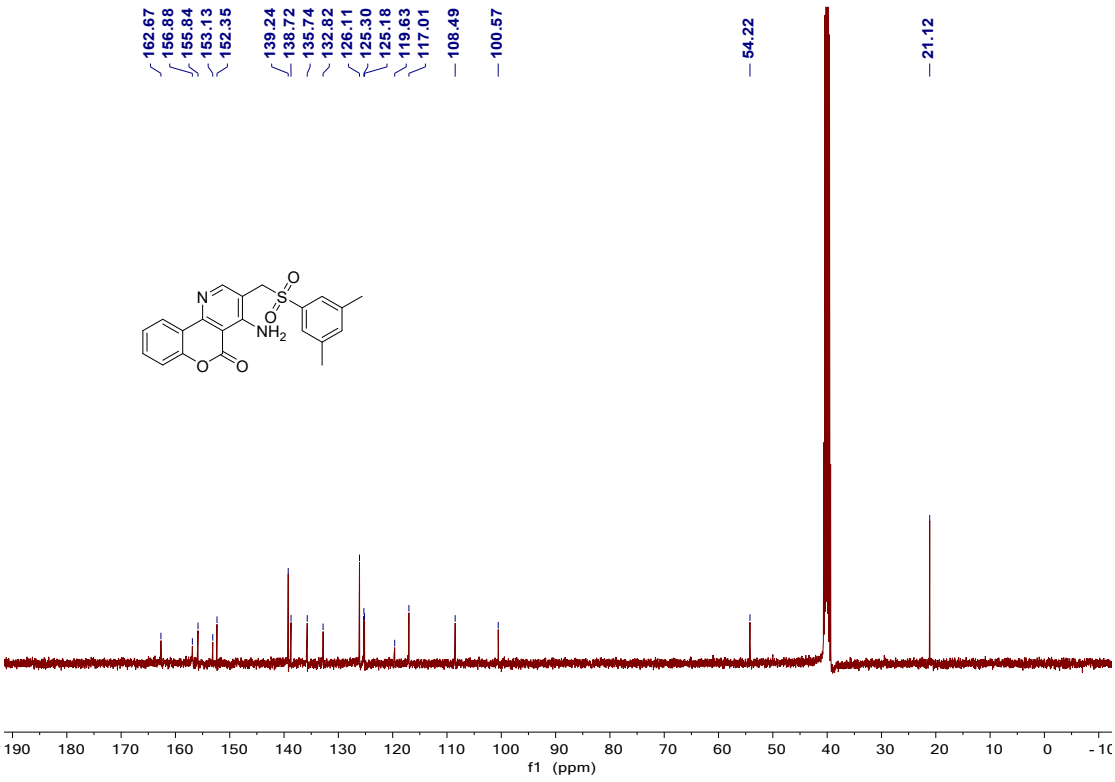
[13]C NMR-spectrum (101 MHz, DMSO-d_6) of **3ar**



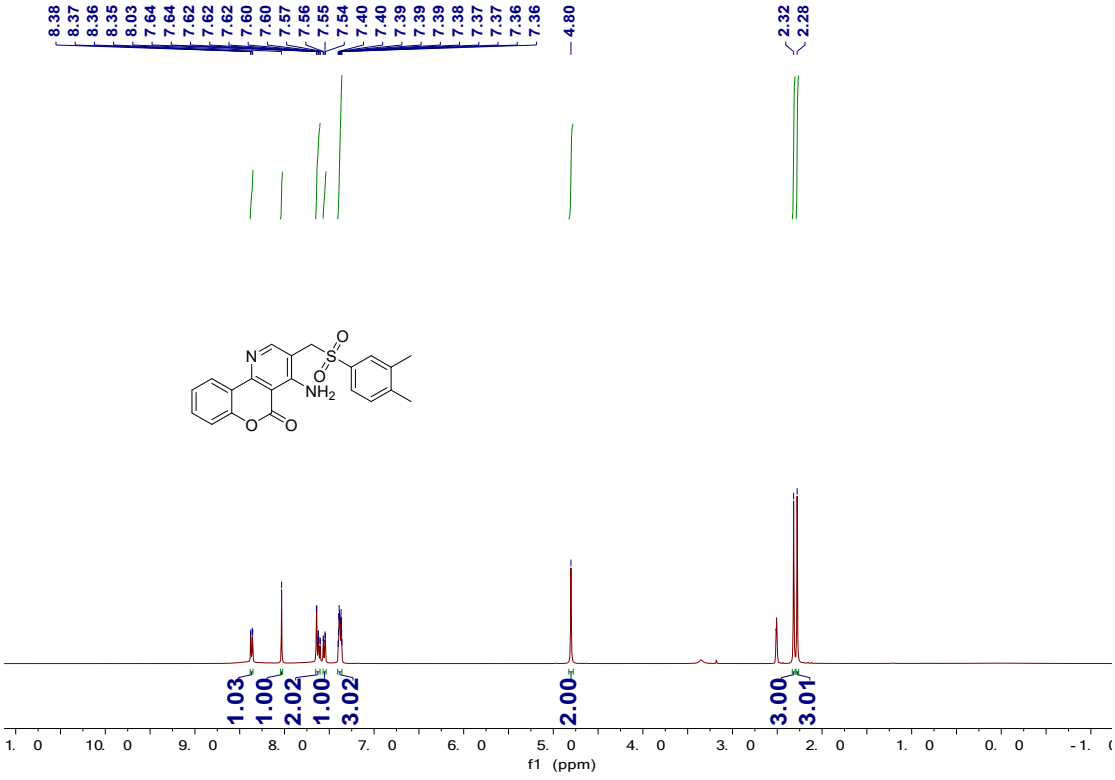
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3as**



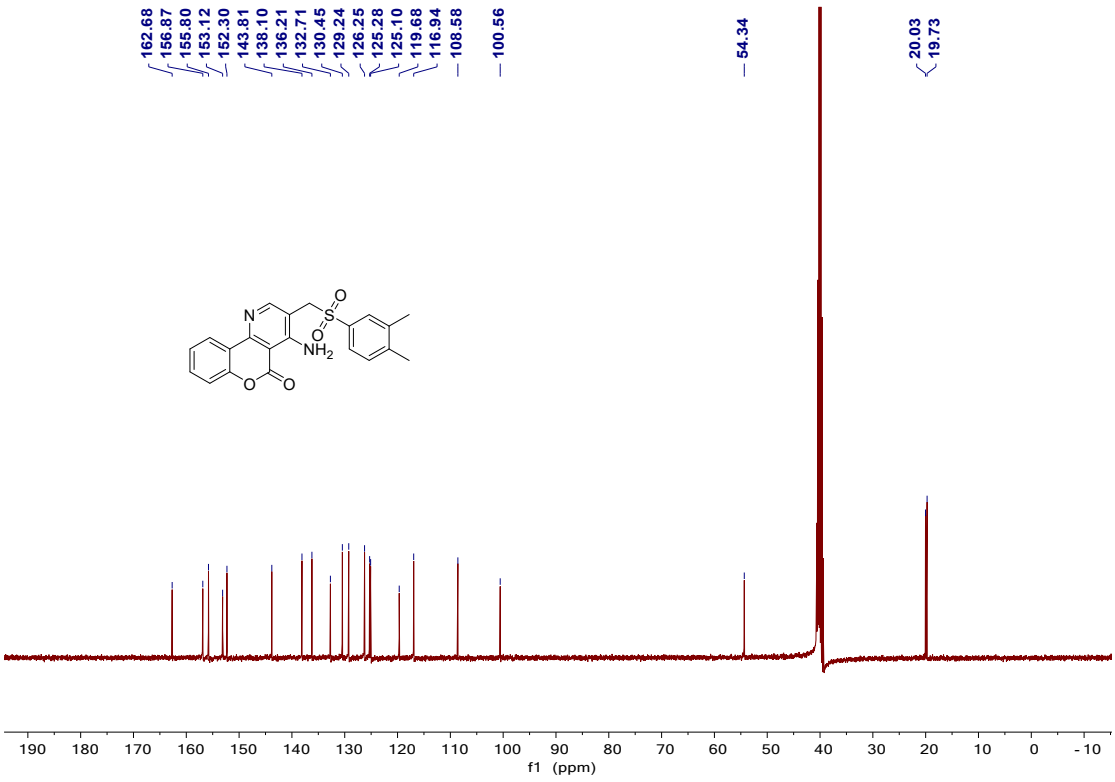
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3as**



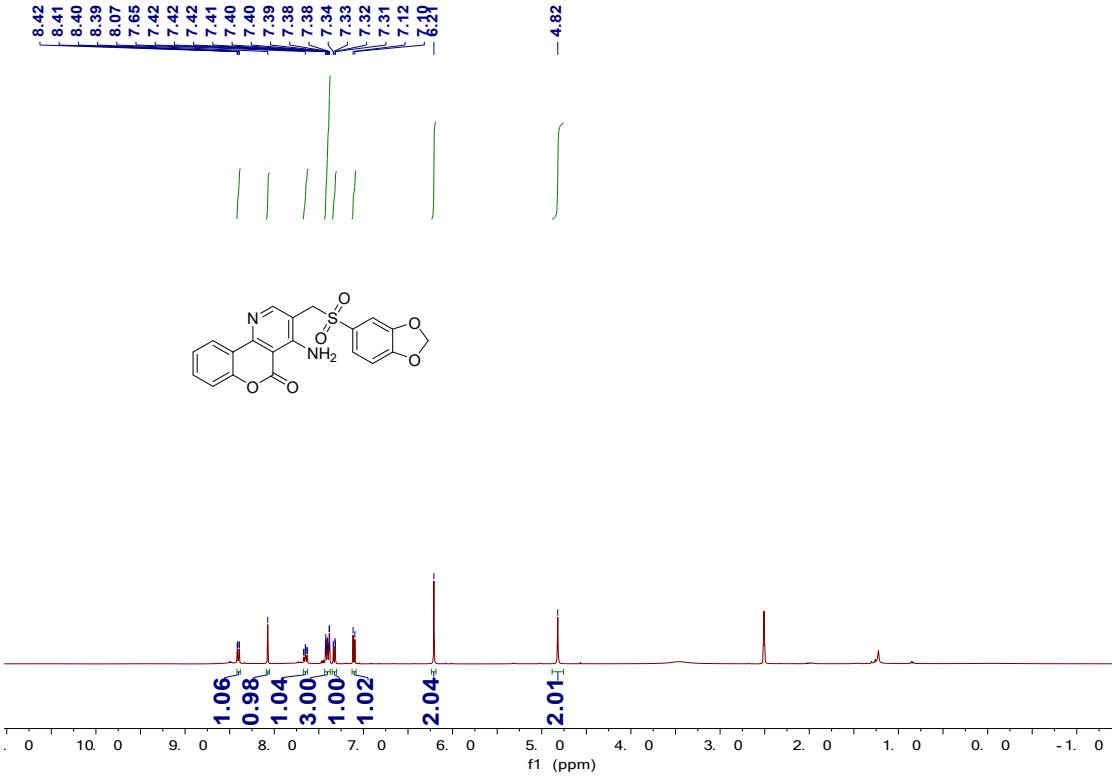
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3at**



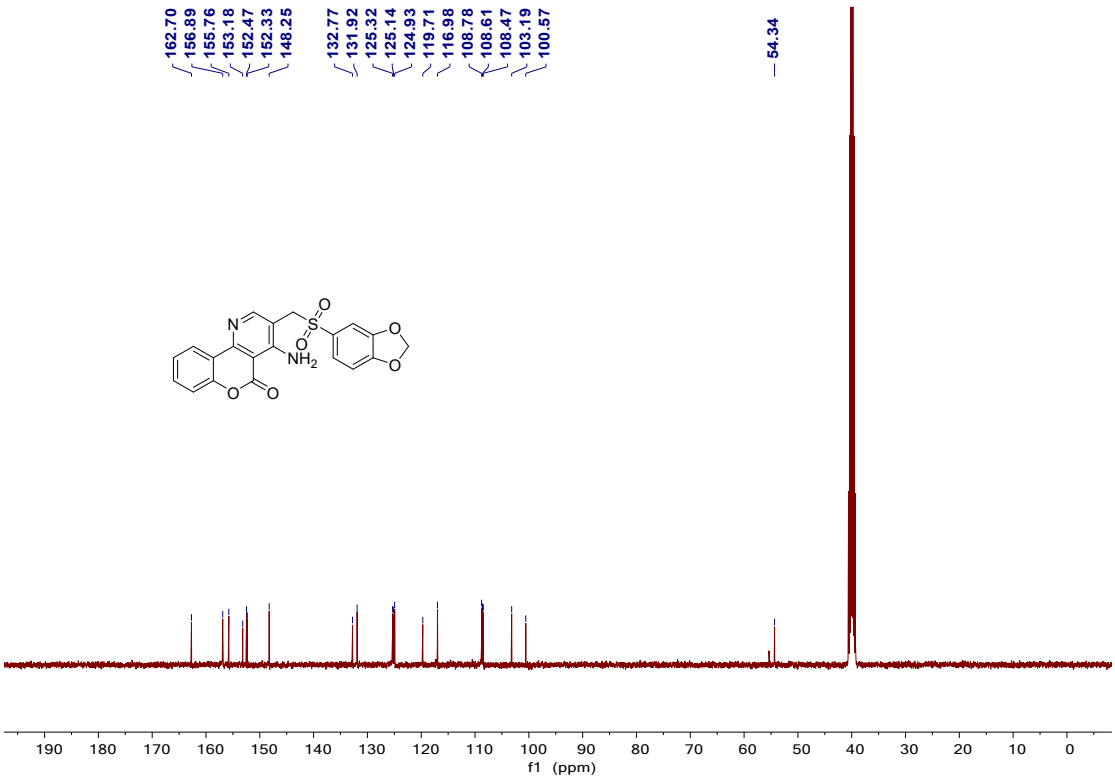
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3at**



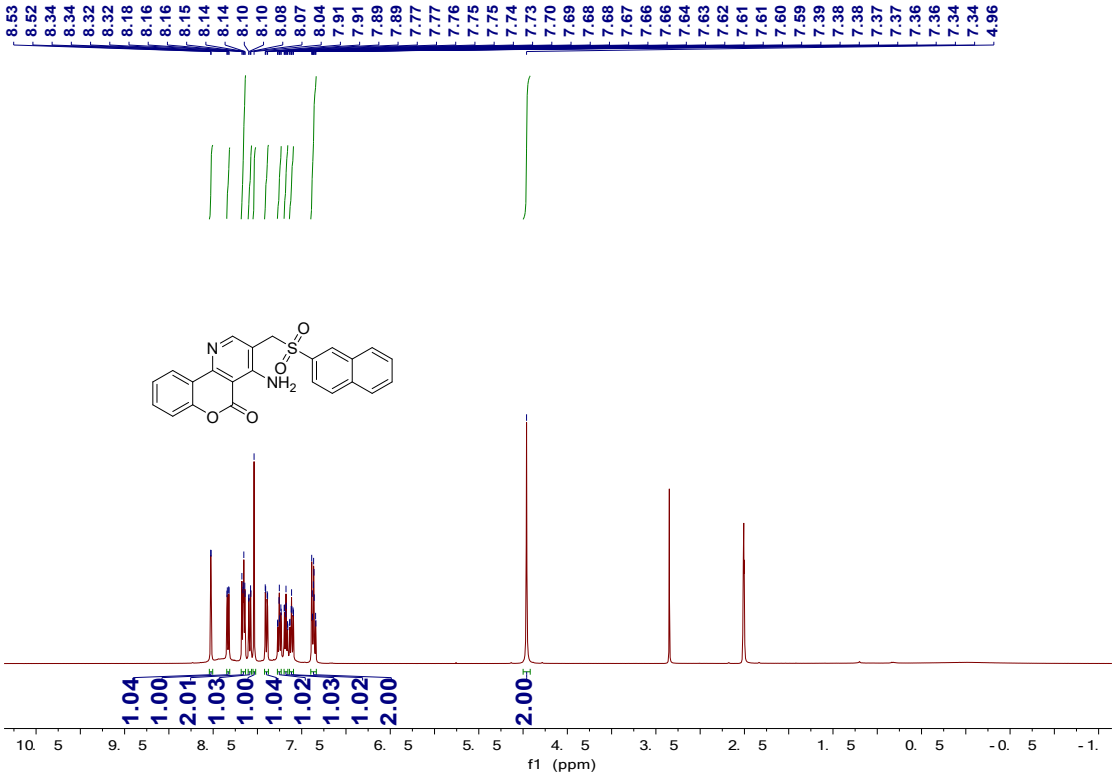
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3au**



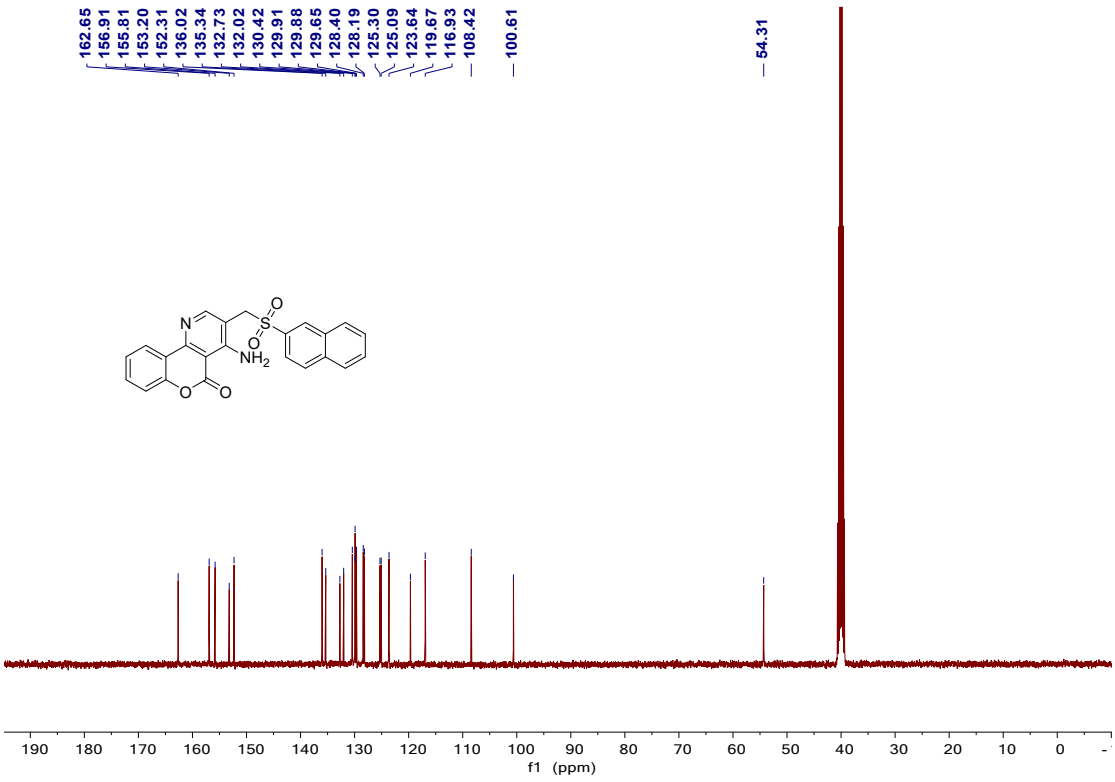
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3au**



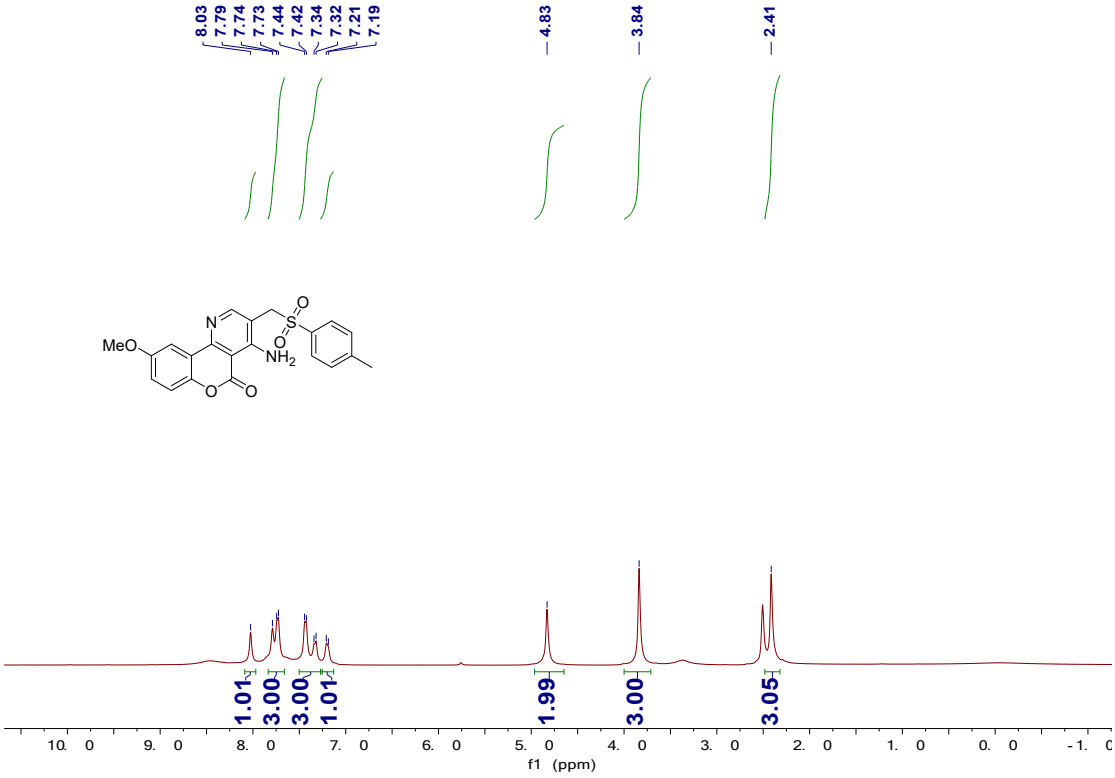
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3av**



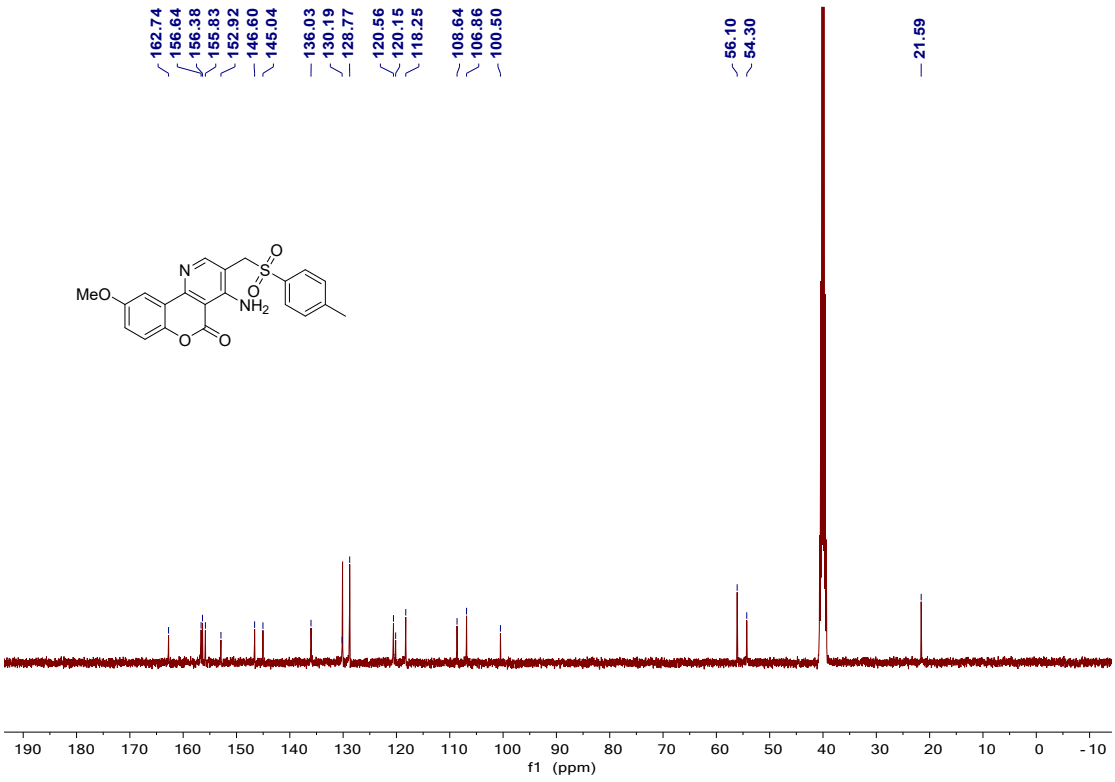
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3av**



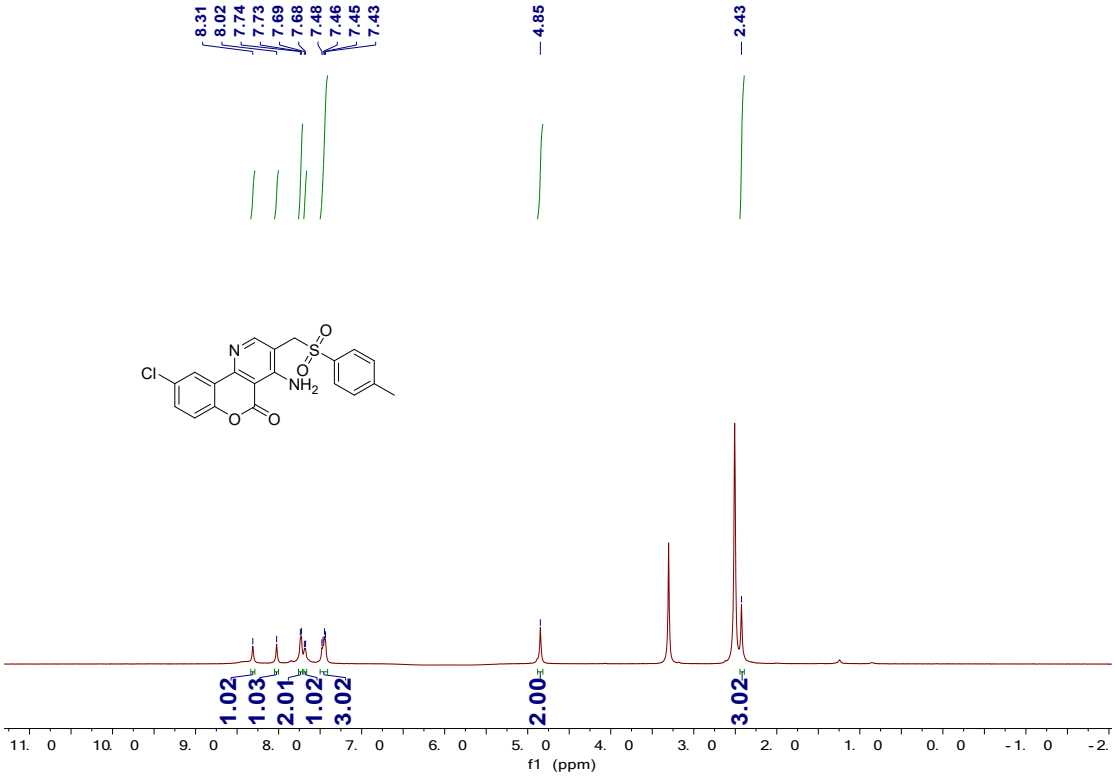
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3aw**



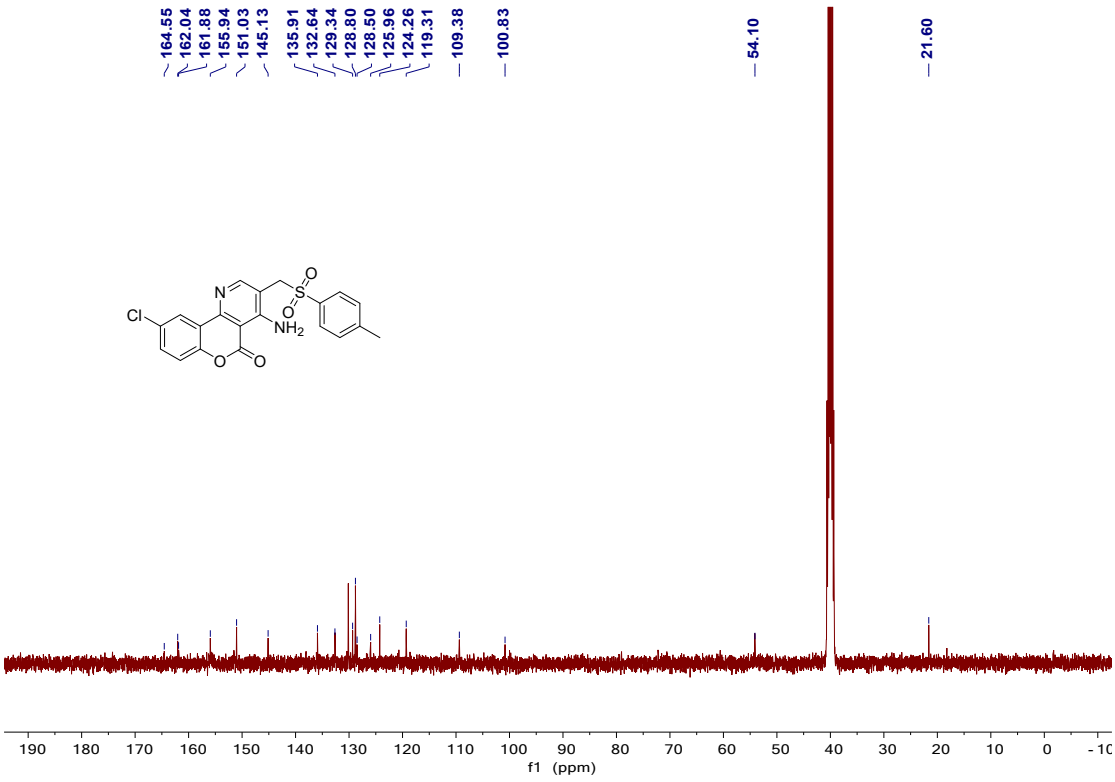
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3aw**



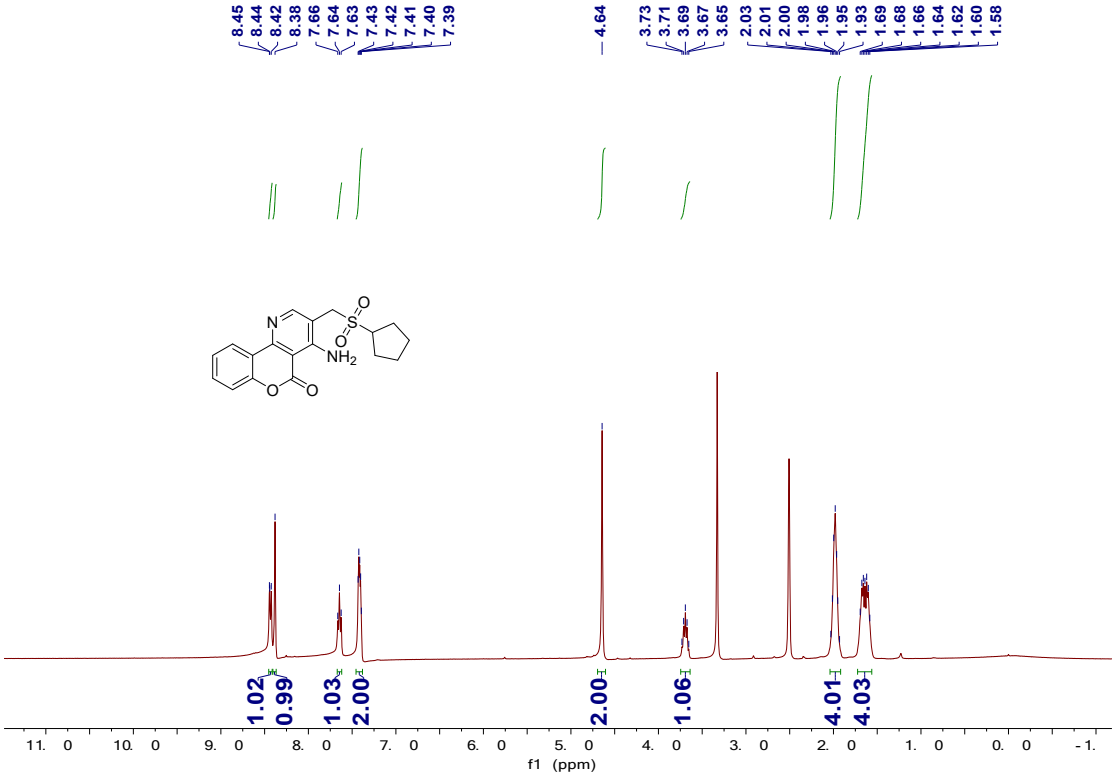
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **3ax**



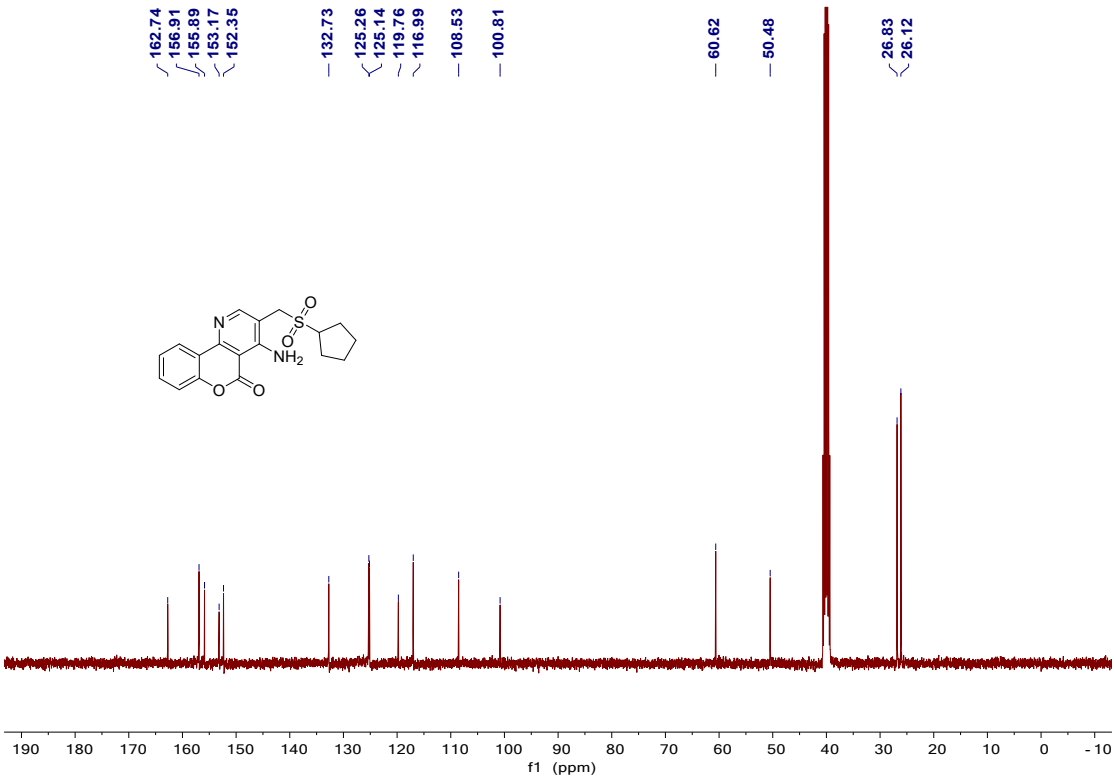
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **3ax**



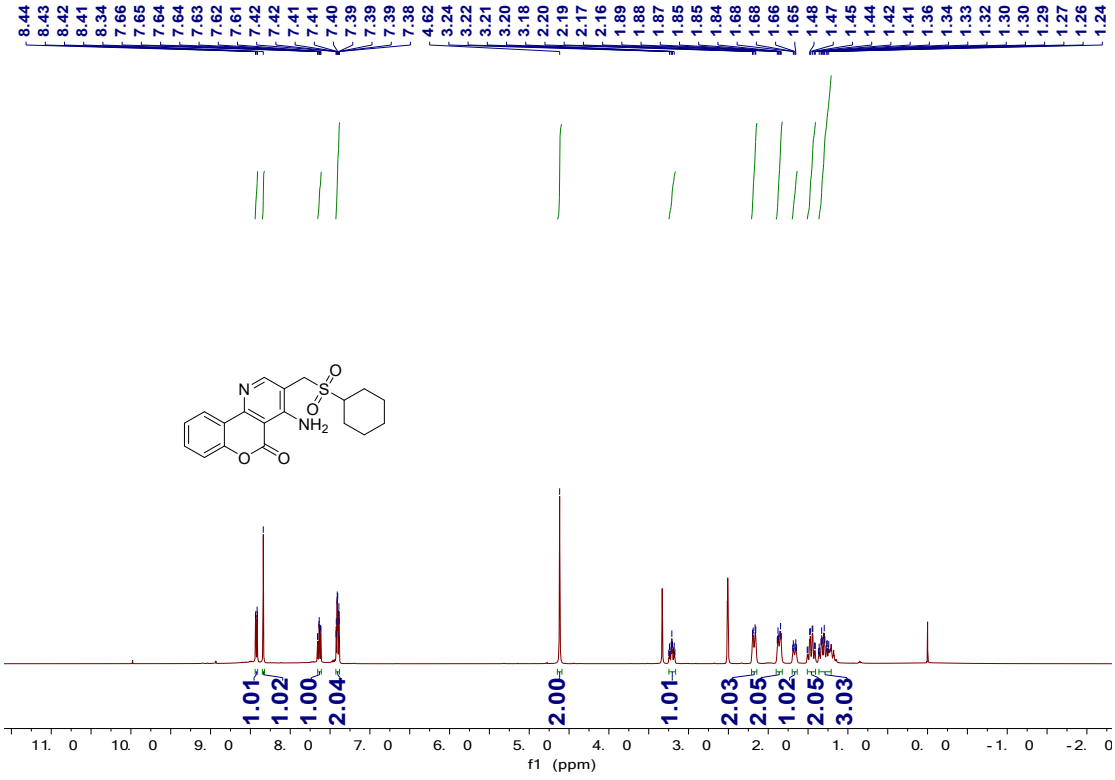
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **5aa**



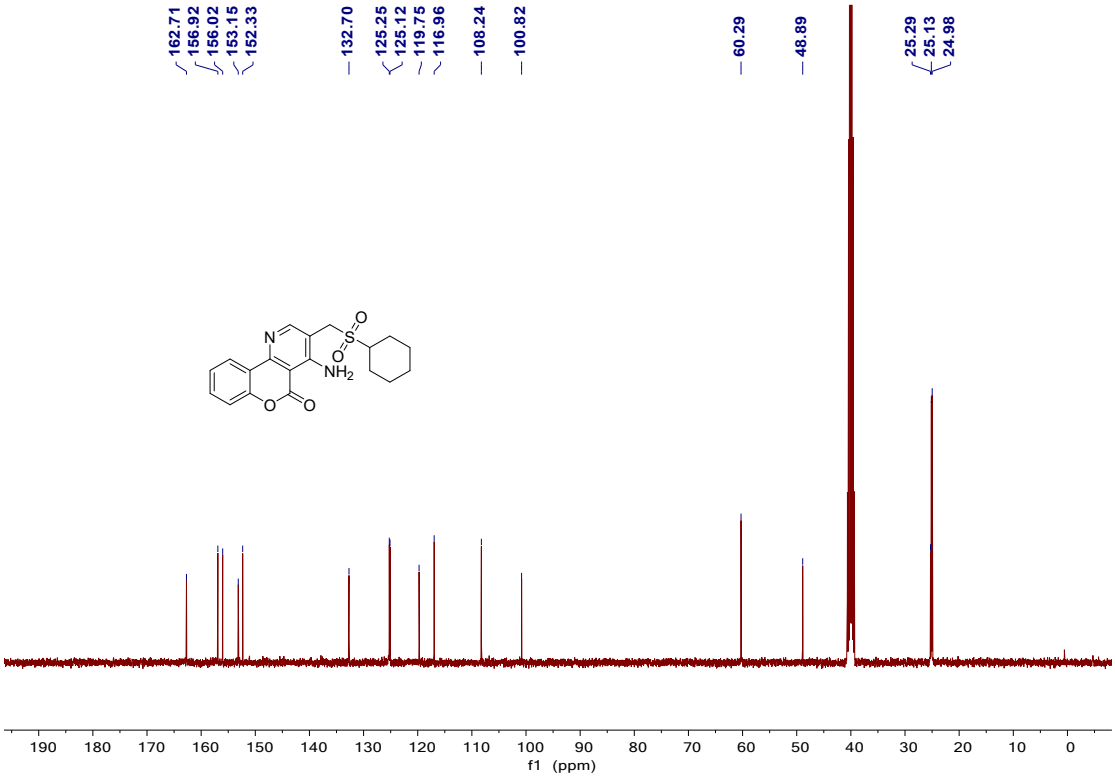
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **5aa**



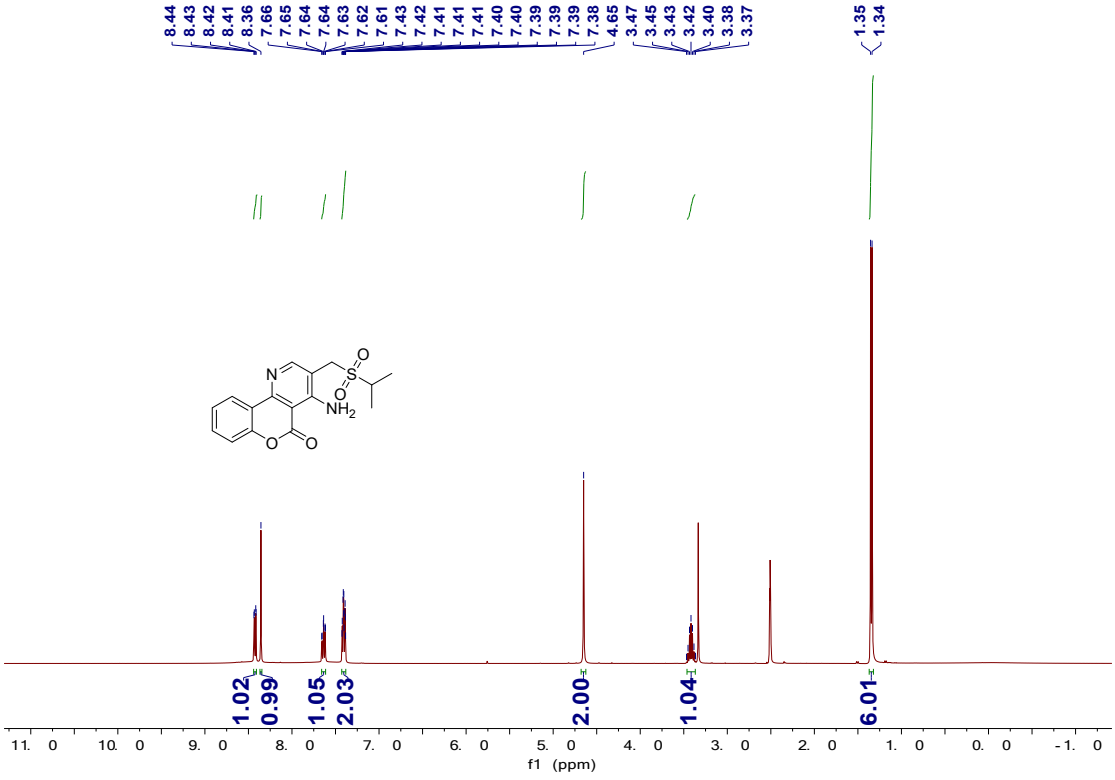
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **5ab**



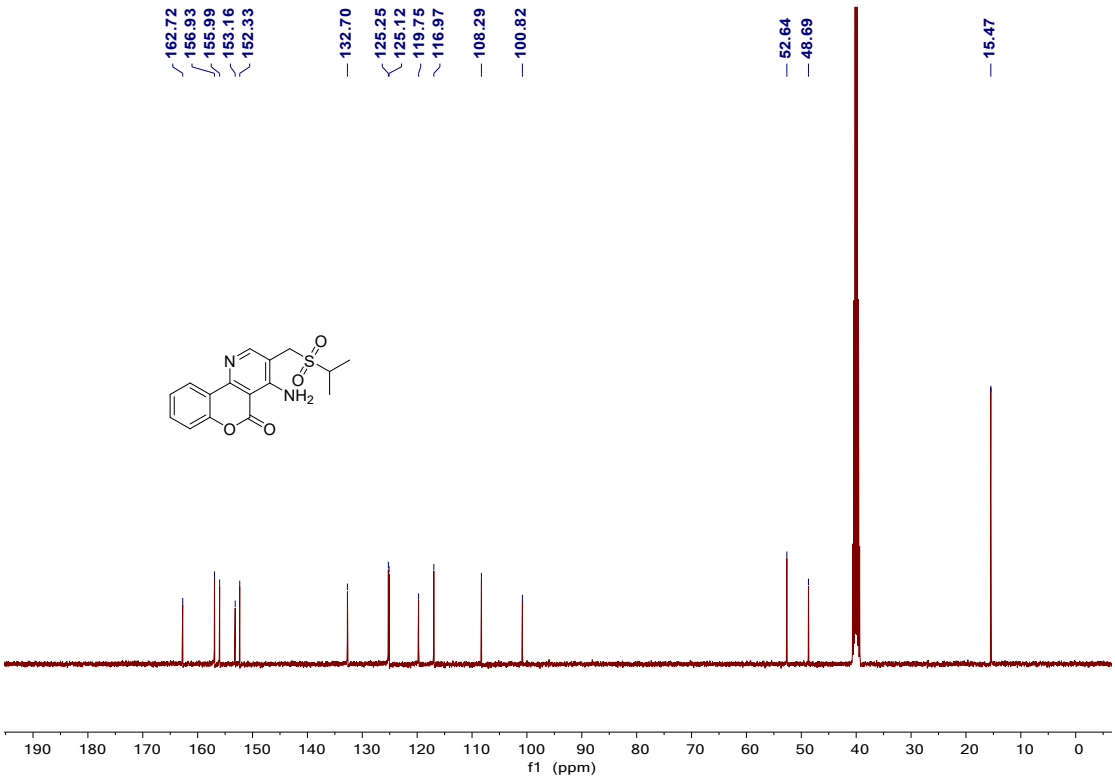
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **5ab**



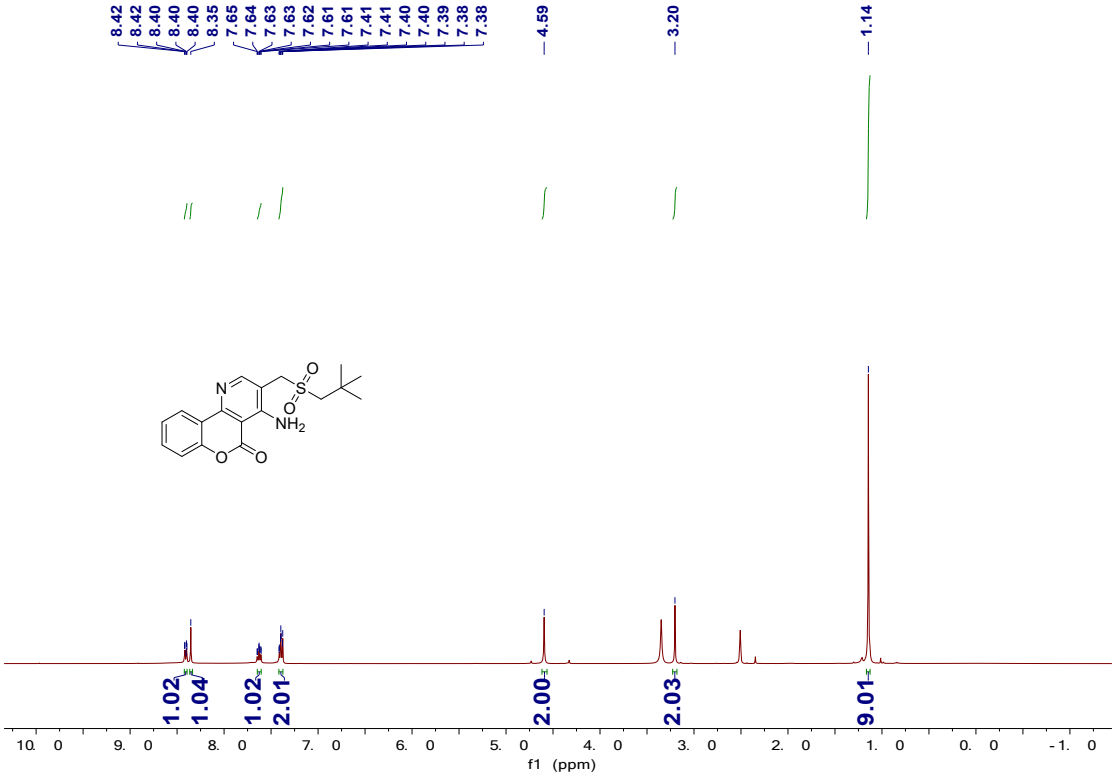
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **5ac**



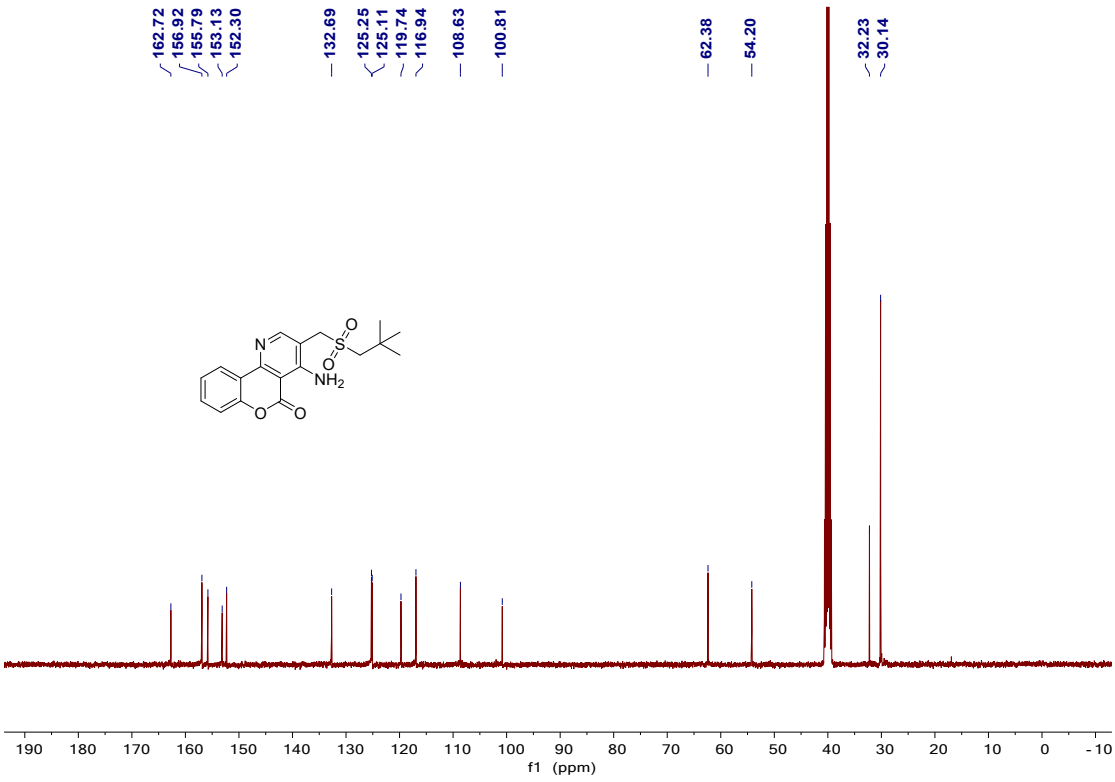
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **5ac**



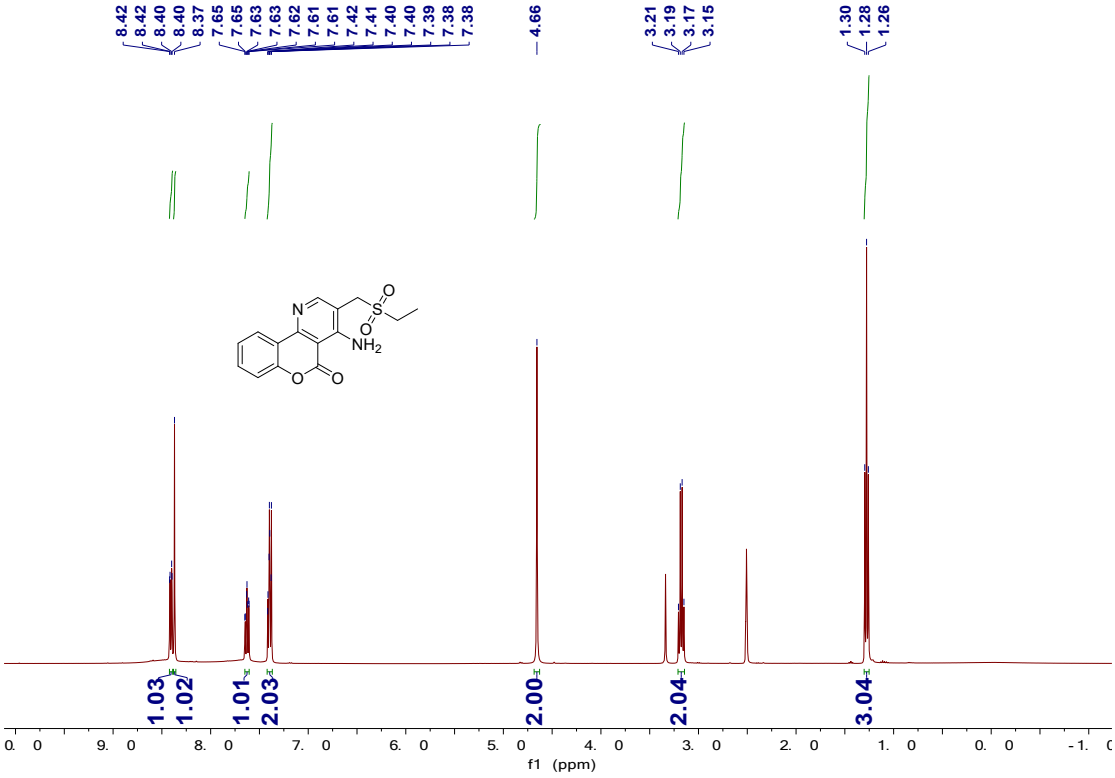
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **5ad**



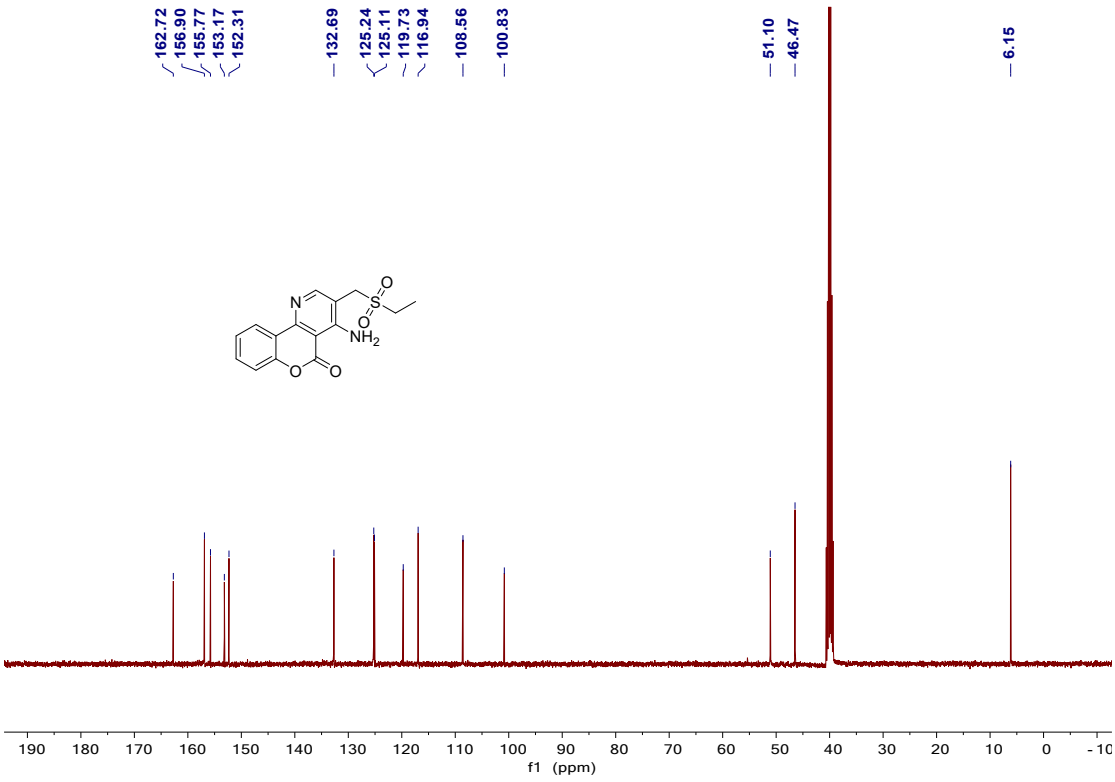
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **5ad**



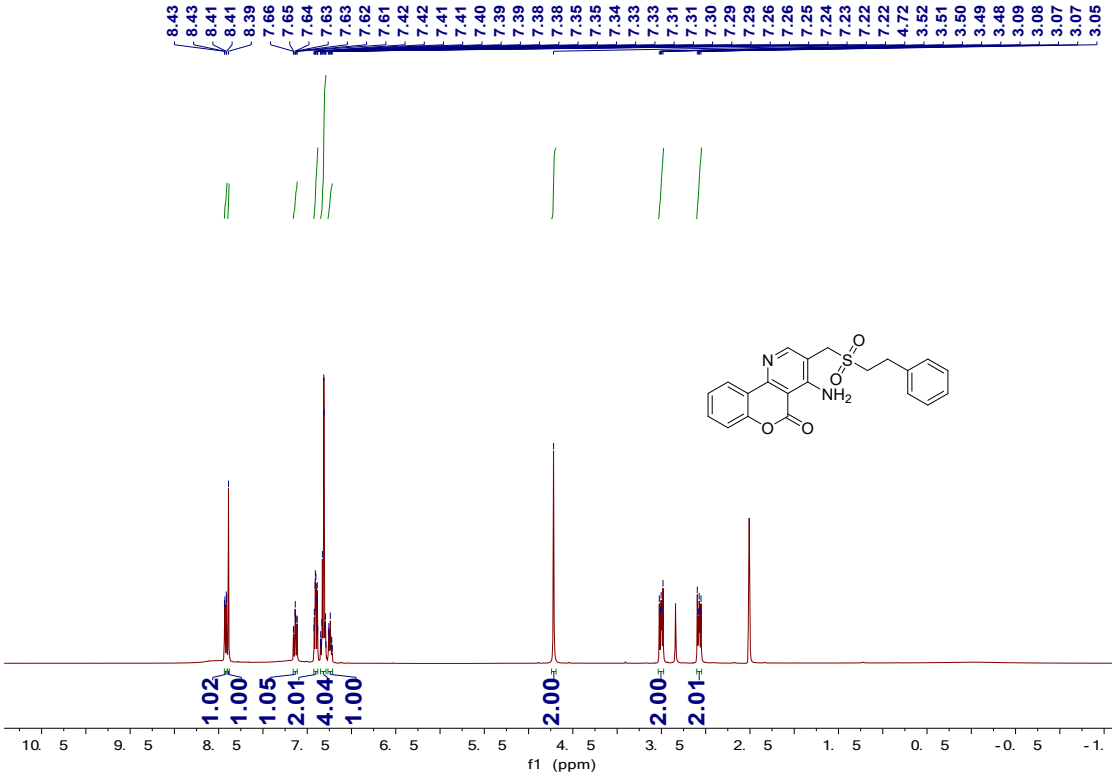
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **5ae**



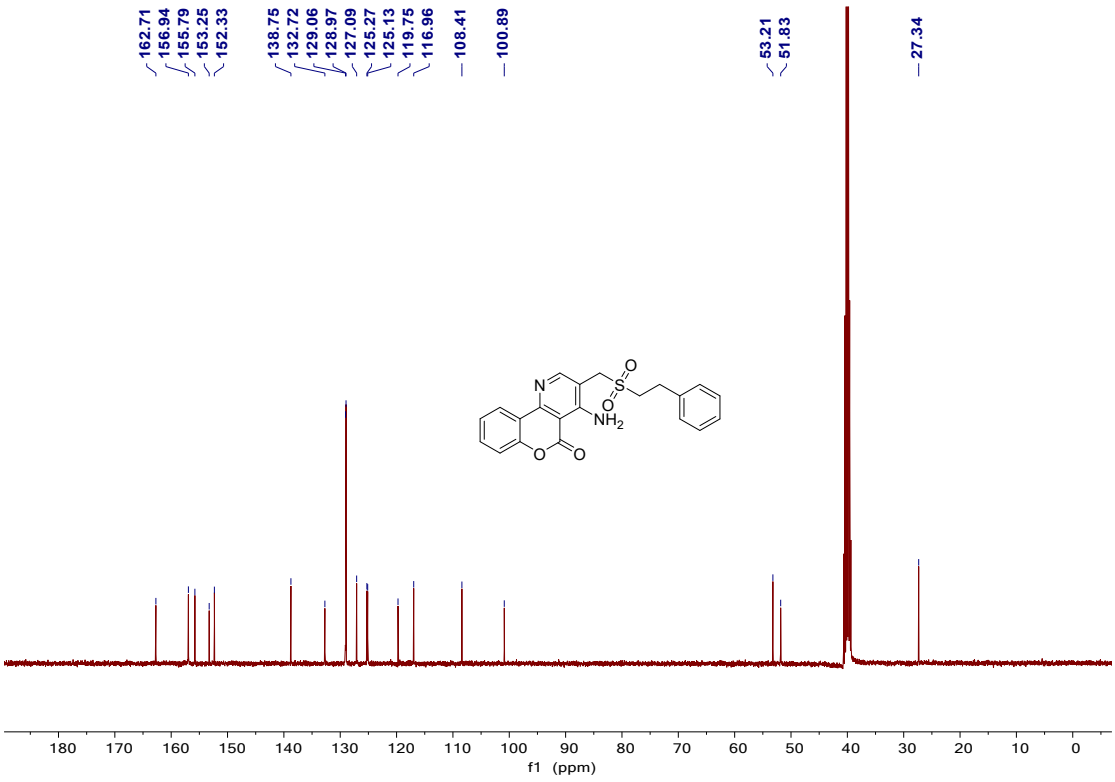
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **5ae**



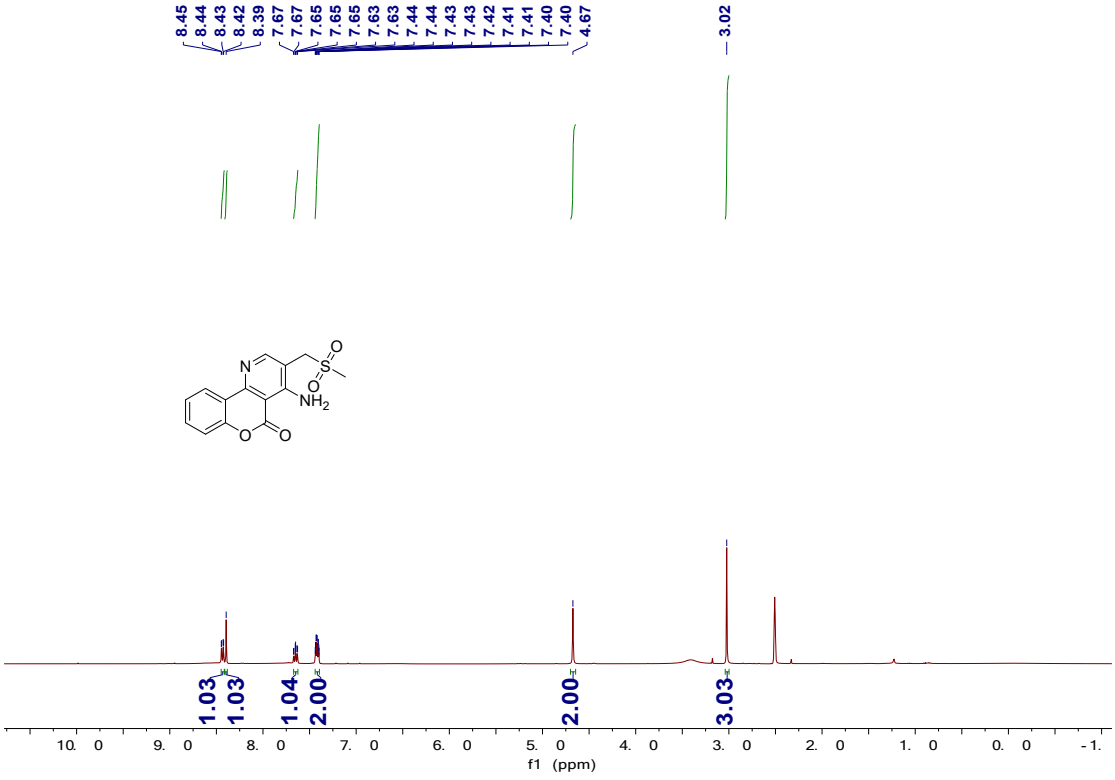
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **5af**



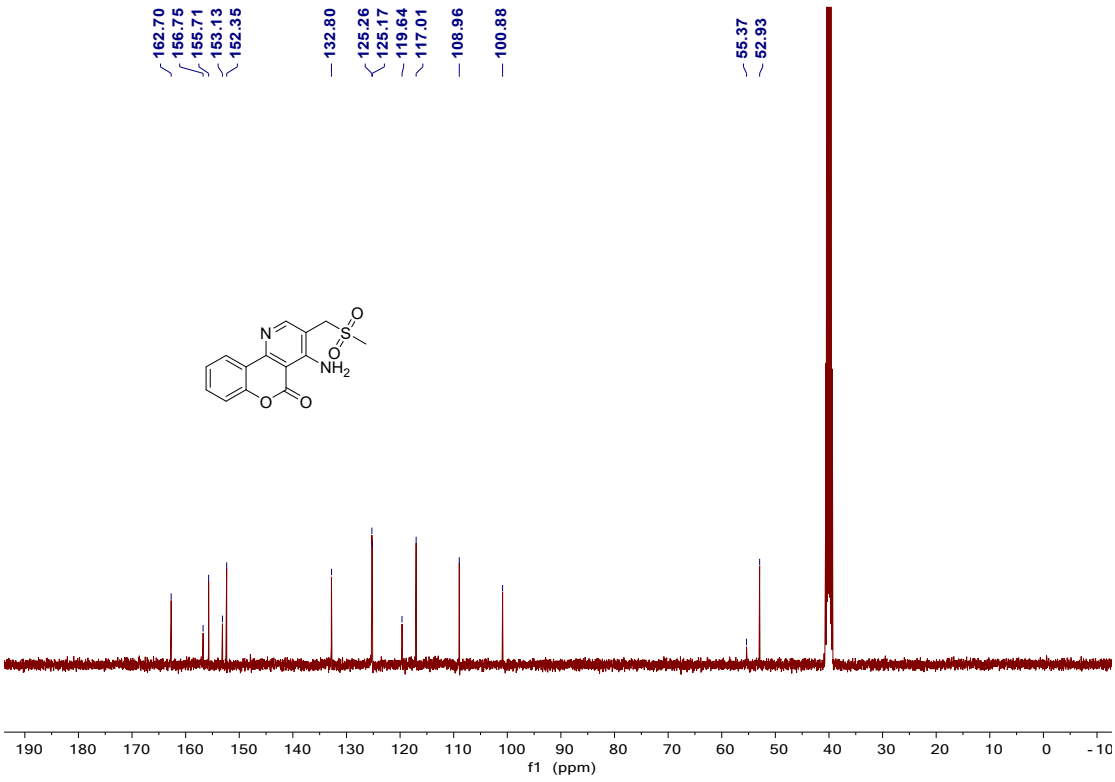
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **5af**



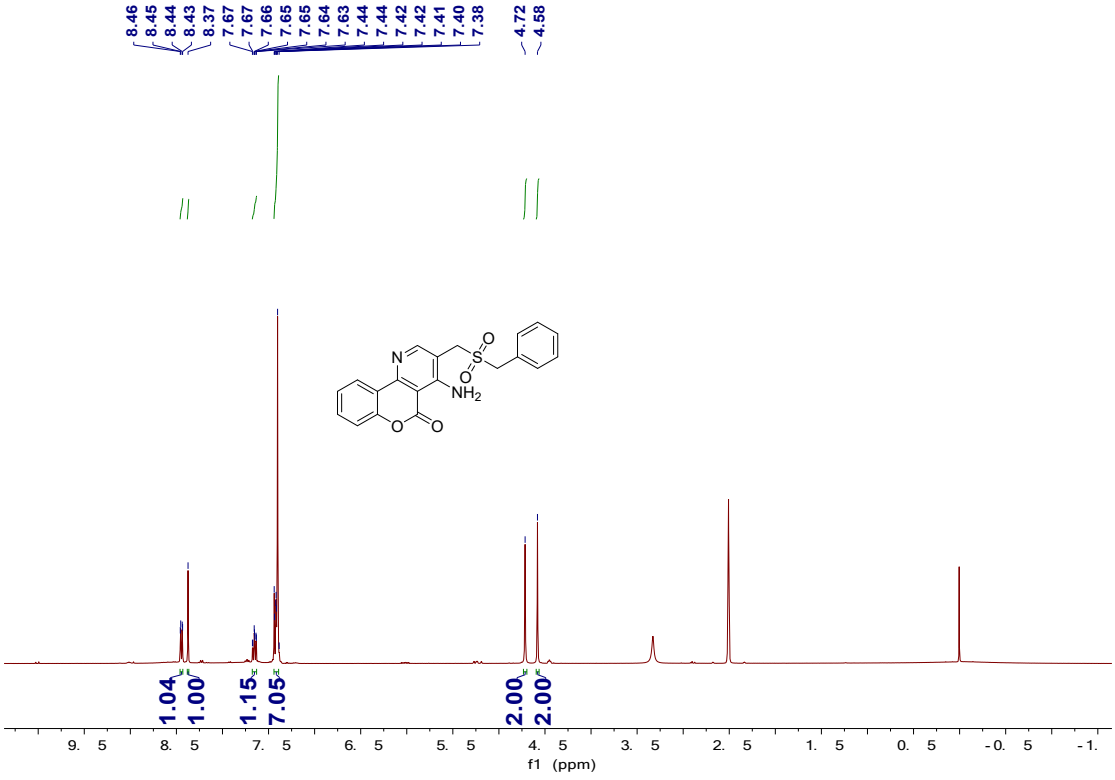
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **5ag**



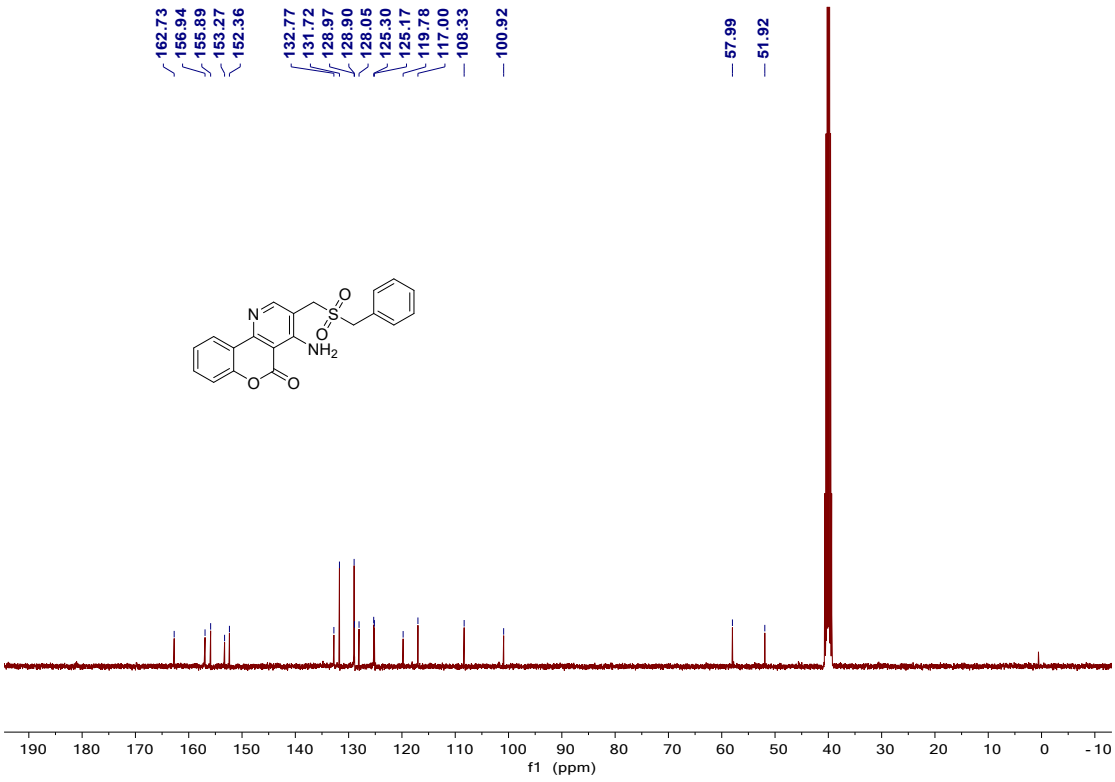
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **5ag**



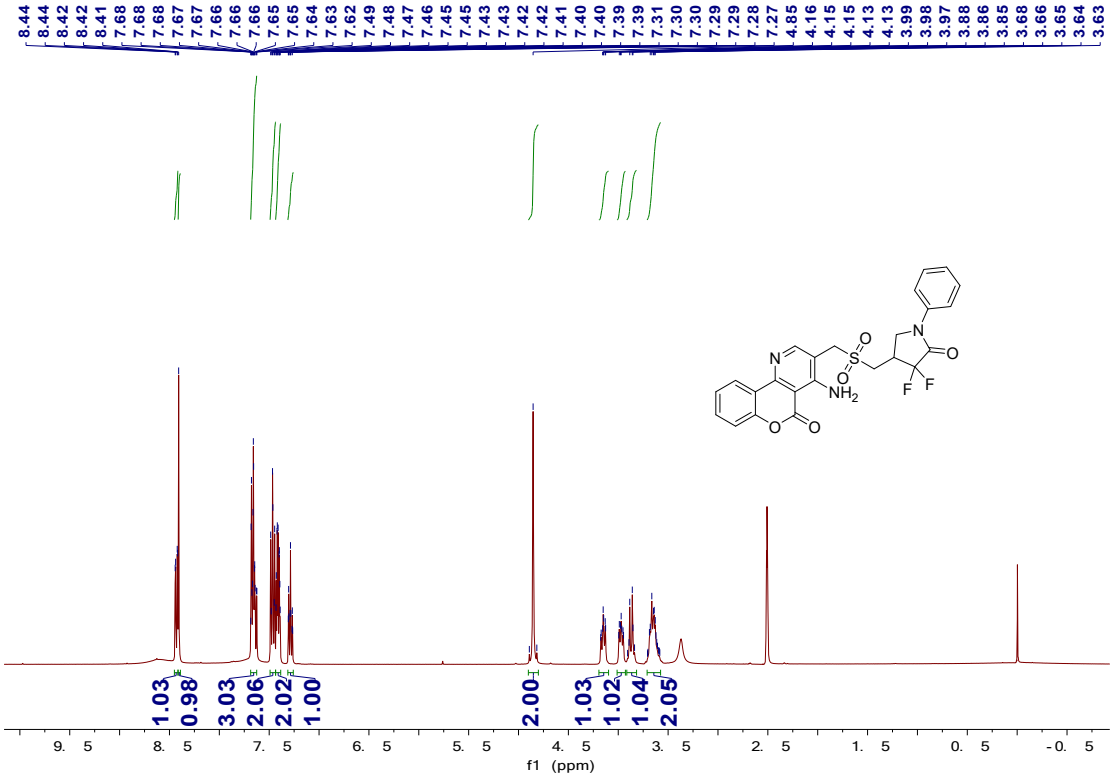
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **5ah**



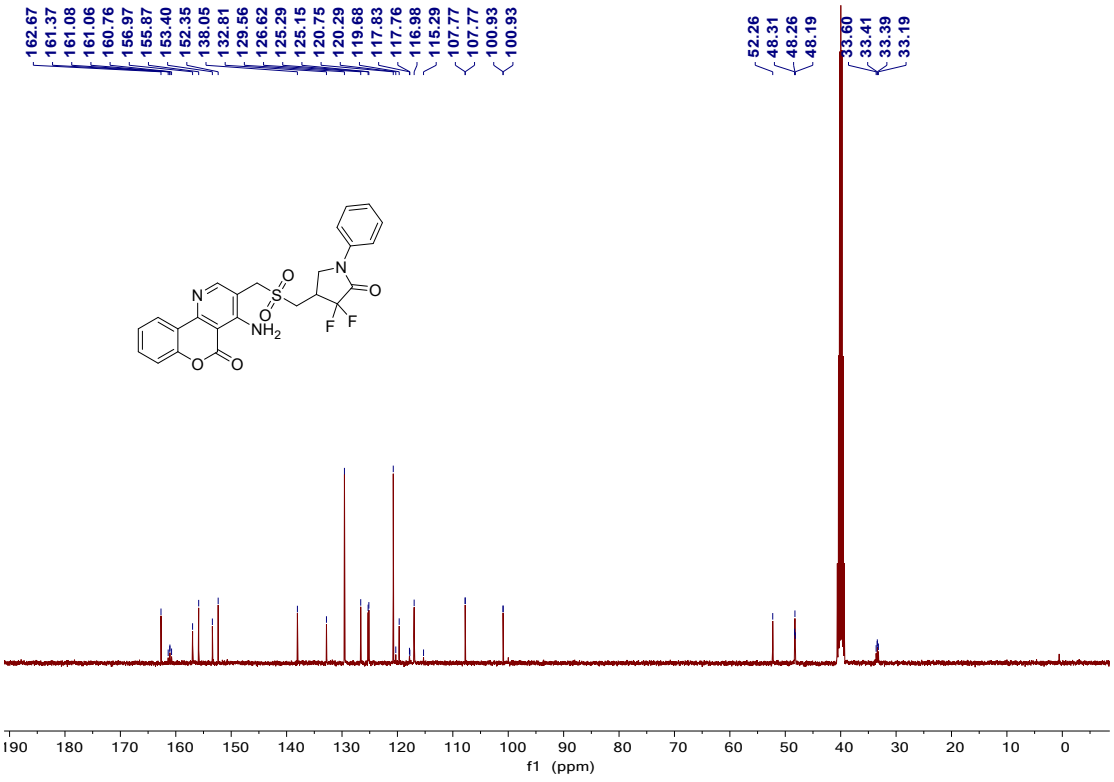
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **5ah**



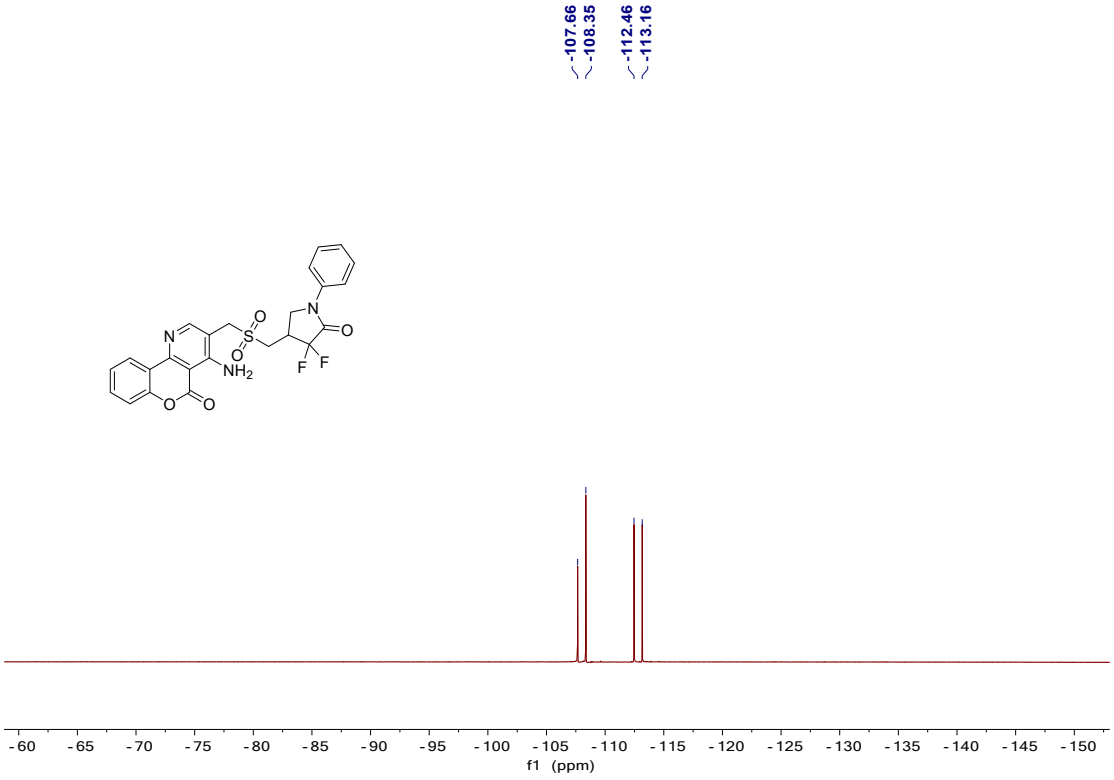
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7aa**



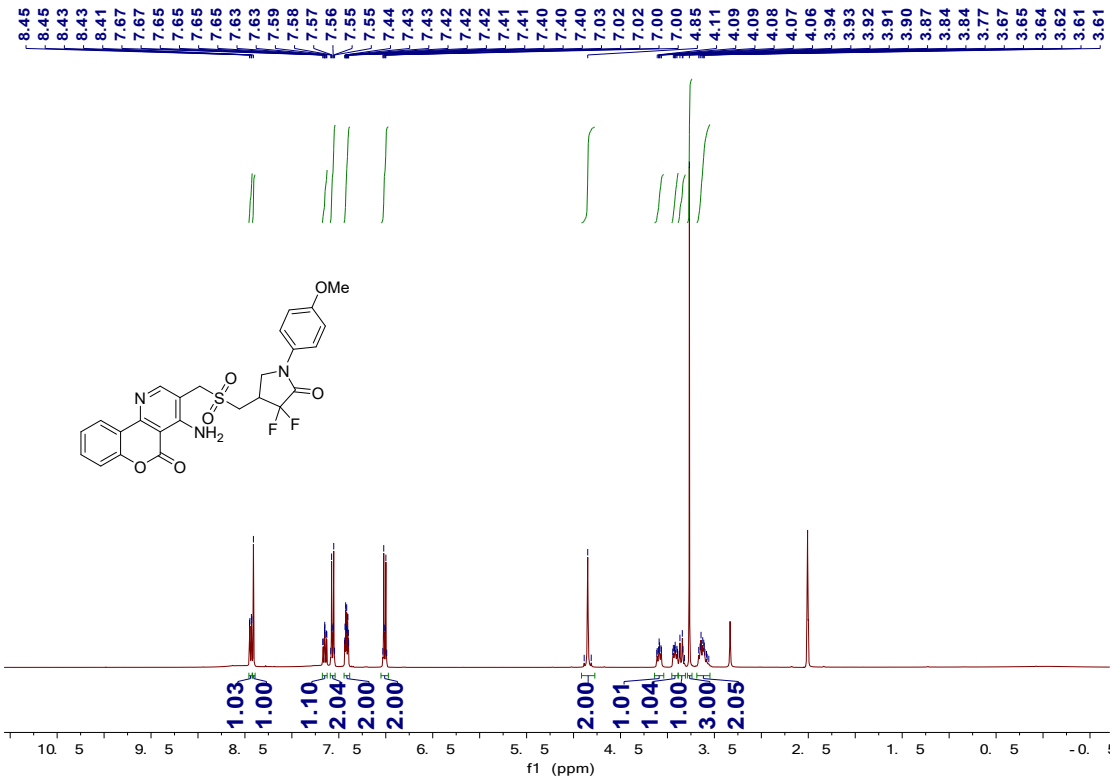
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7aa**



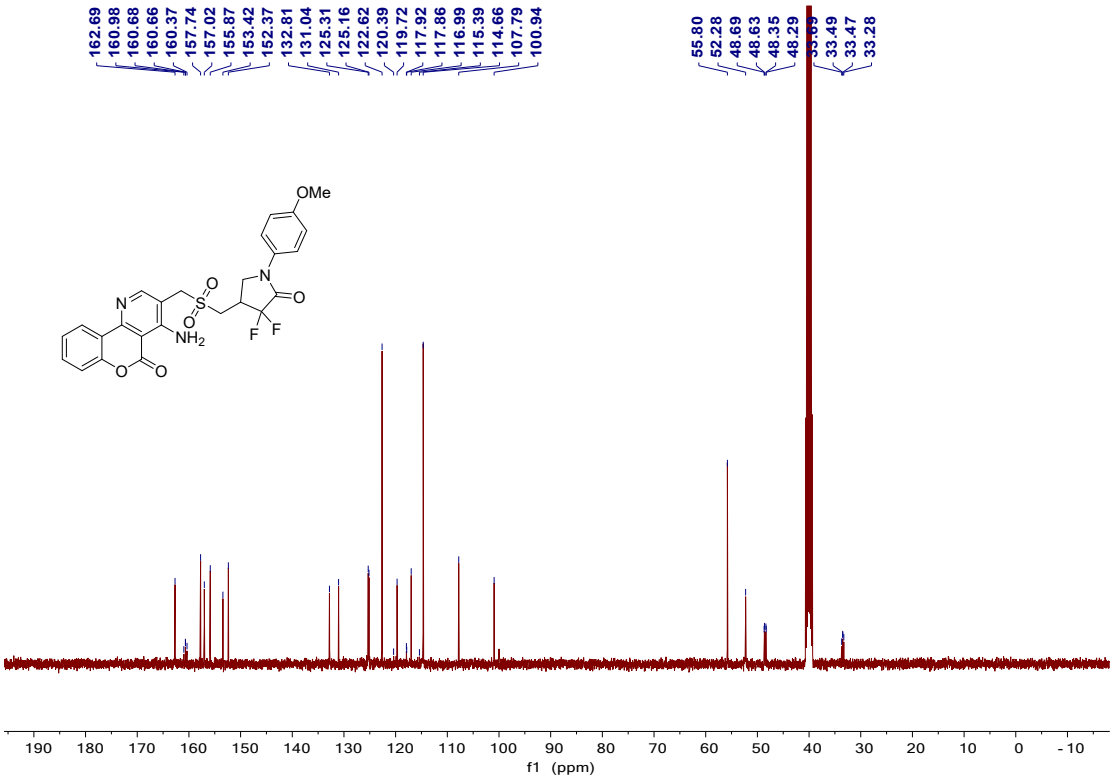
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7aa**



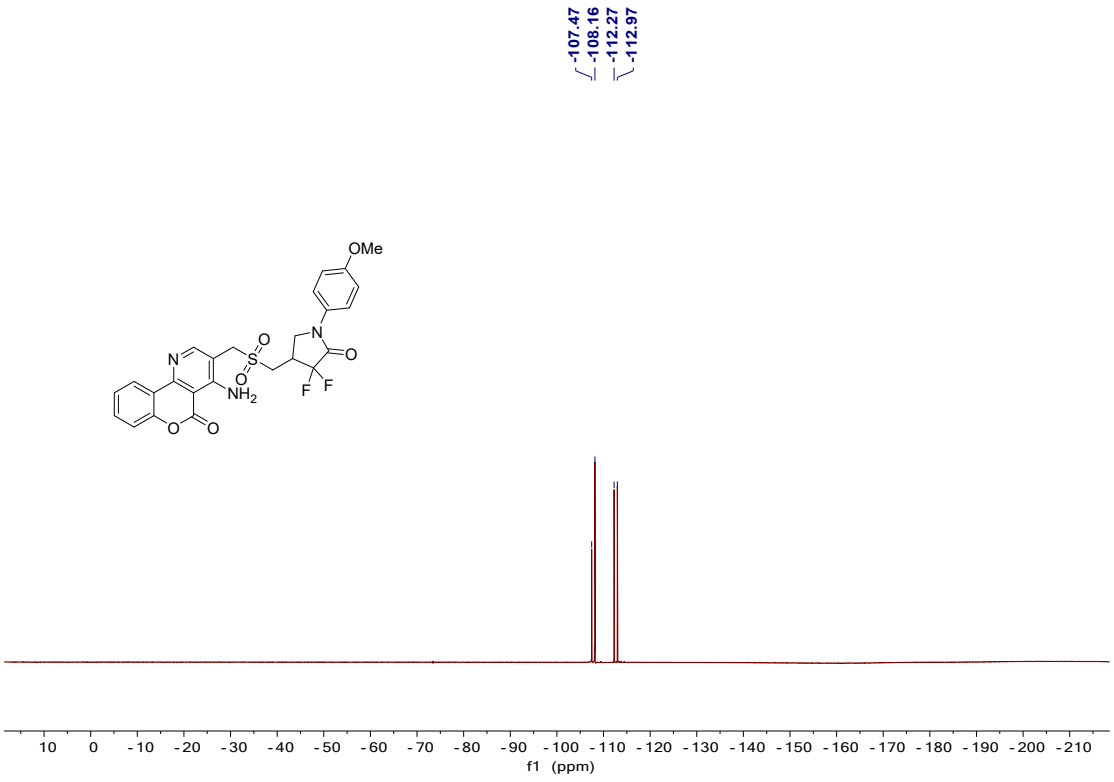
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7ab**



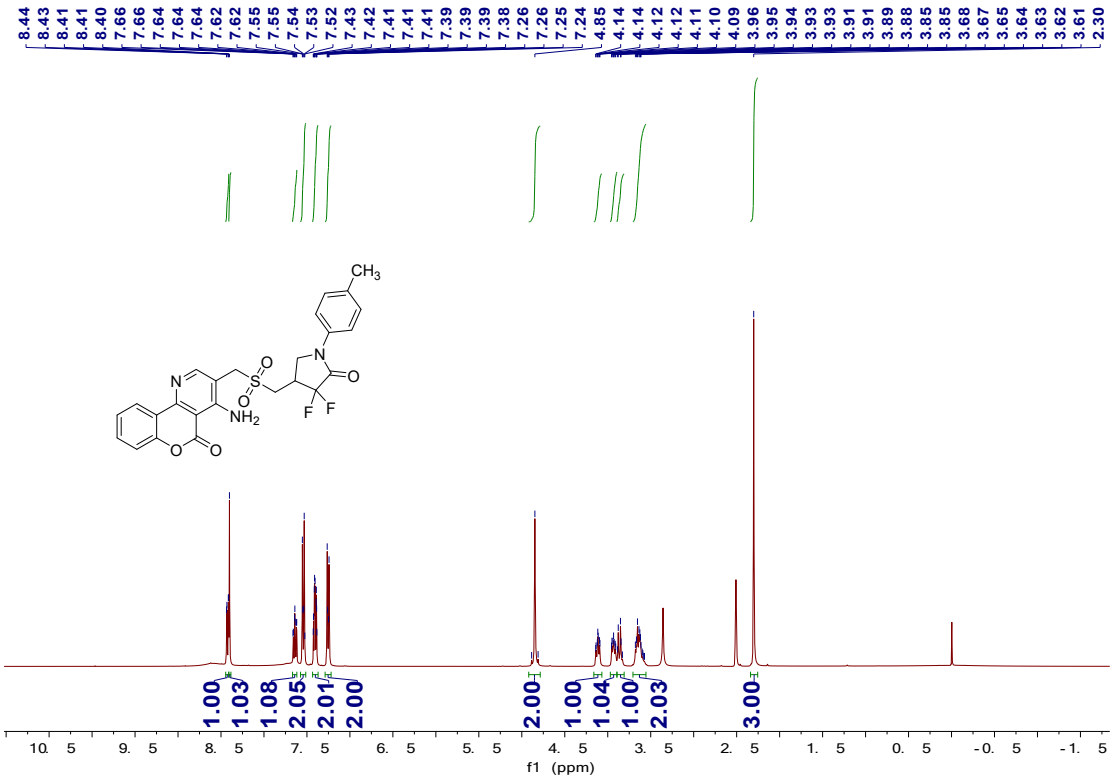
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7ab**



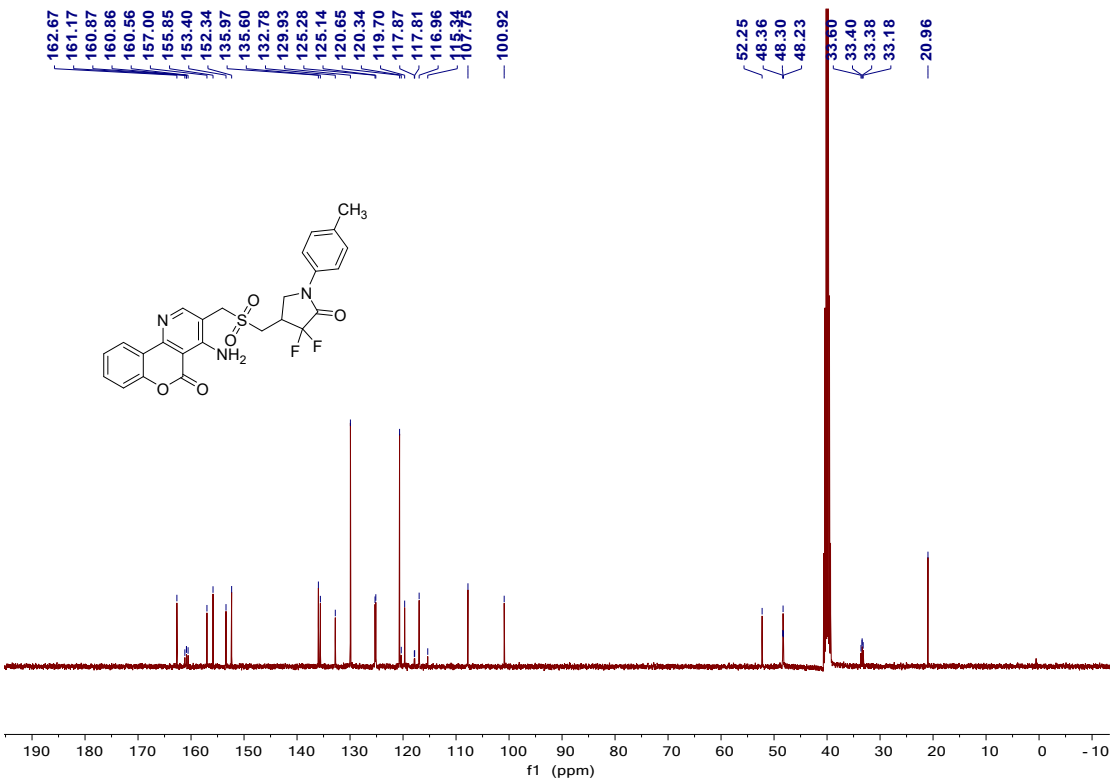
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7ab**



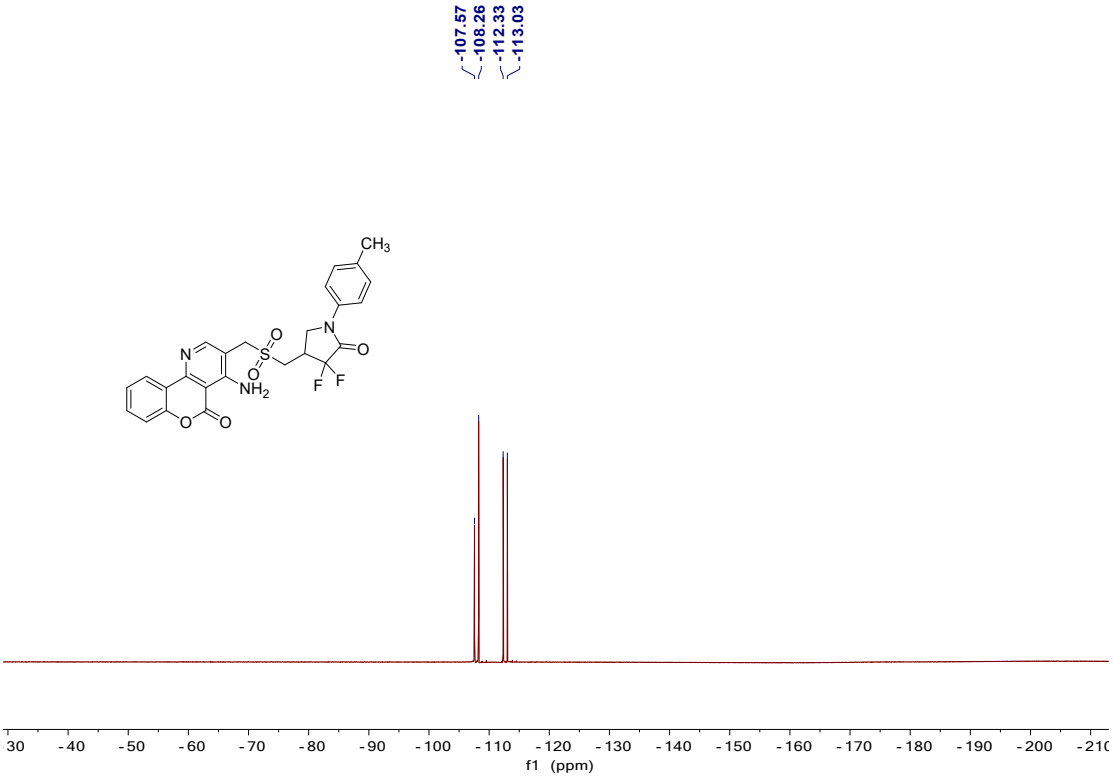
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7ac**



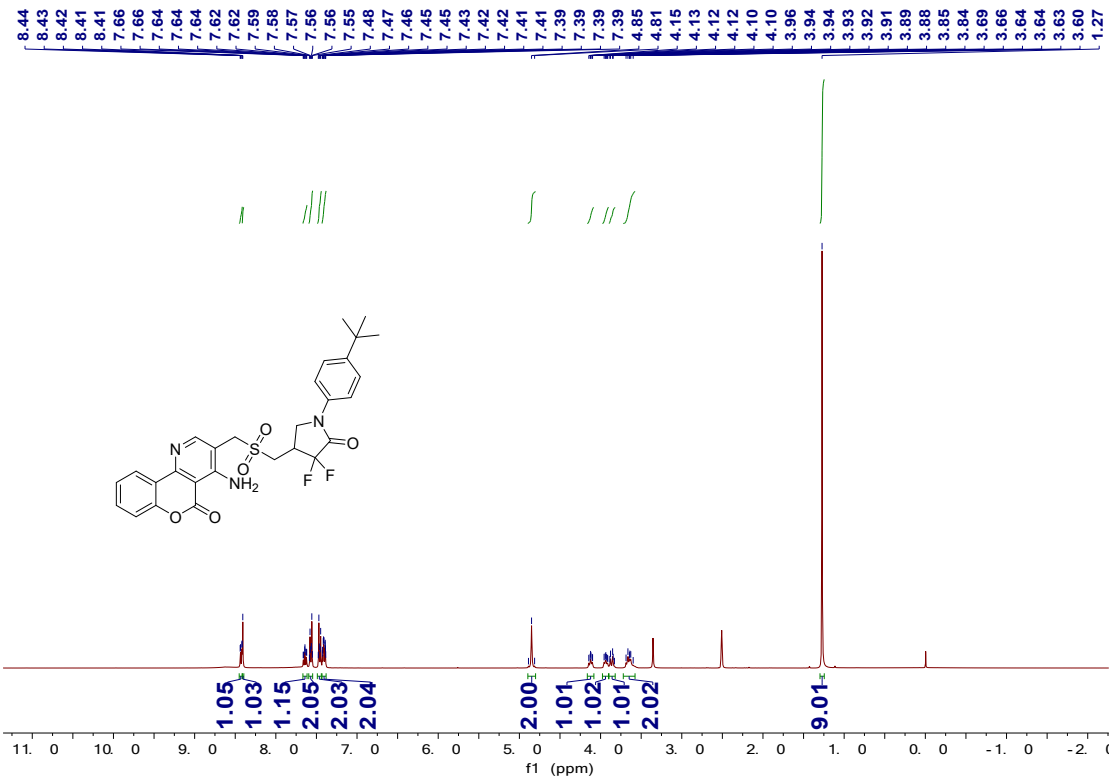
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7ac**



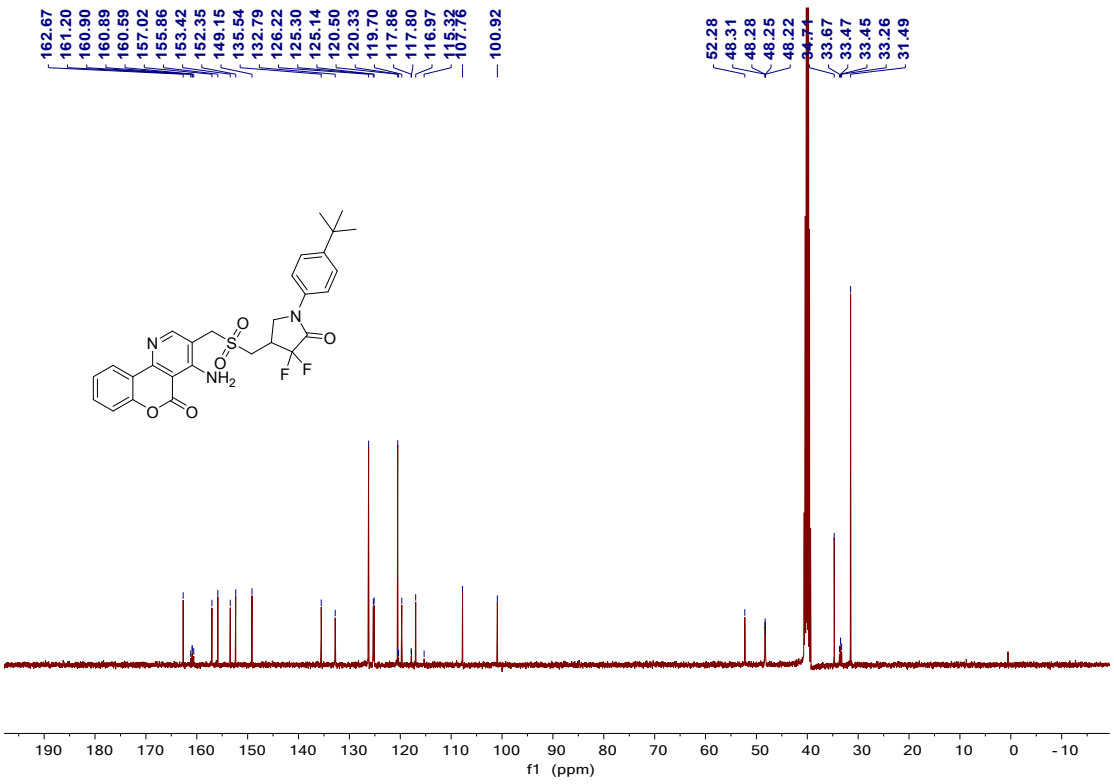
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7ac**



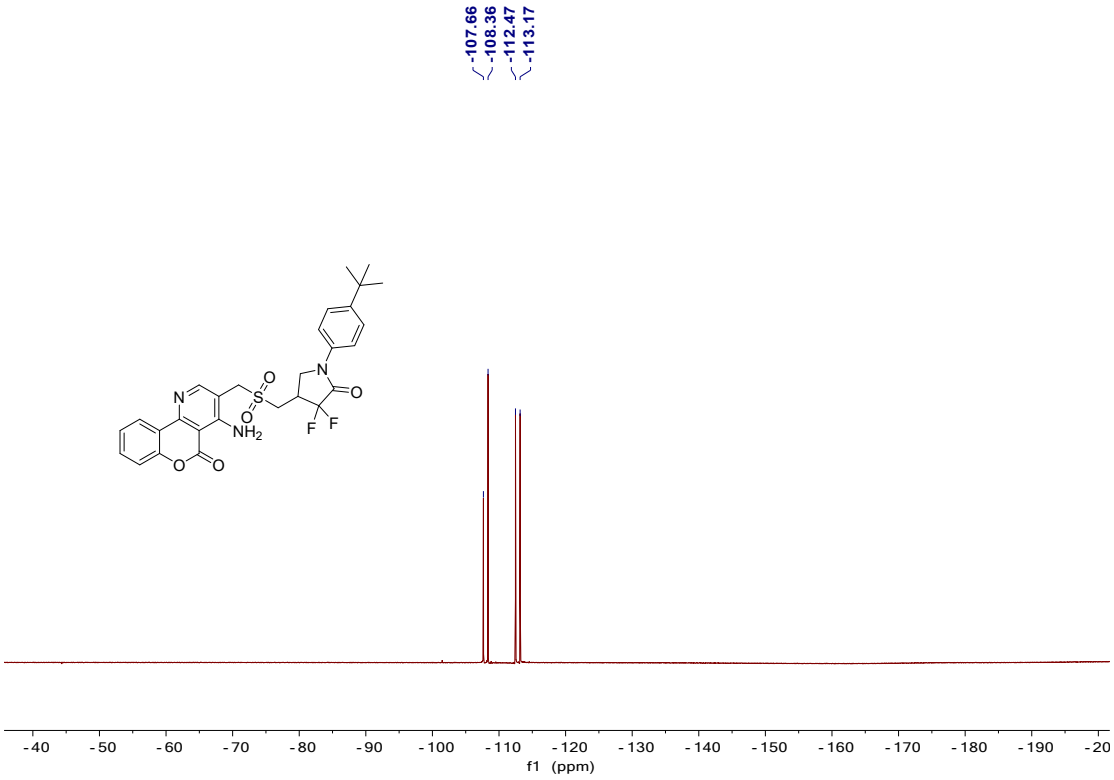
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7ad**



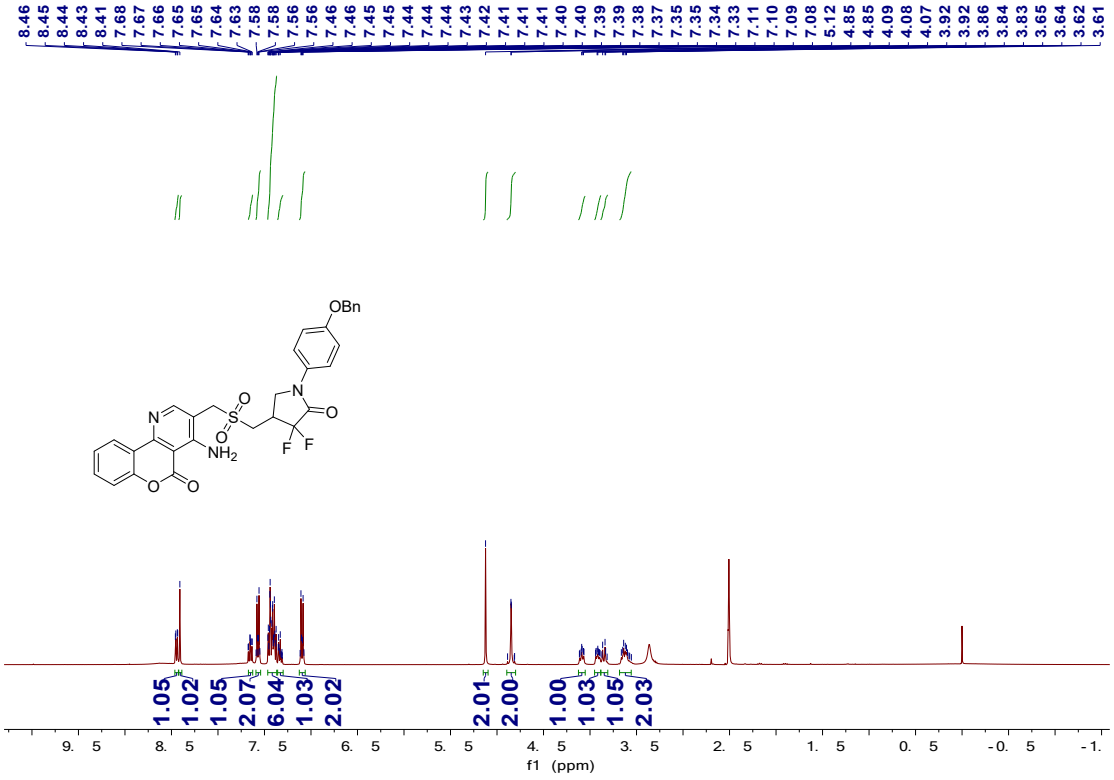
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7ad**



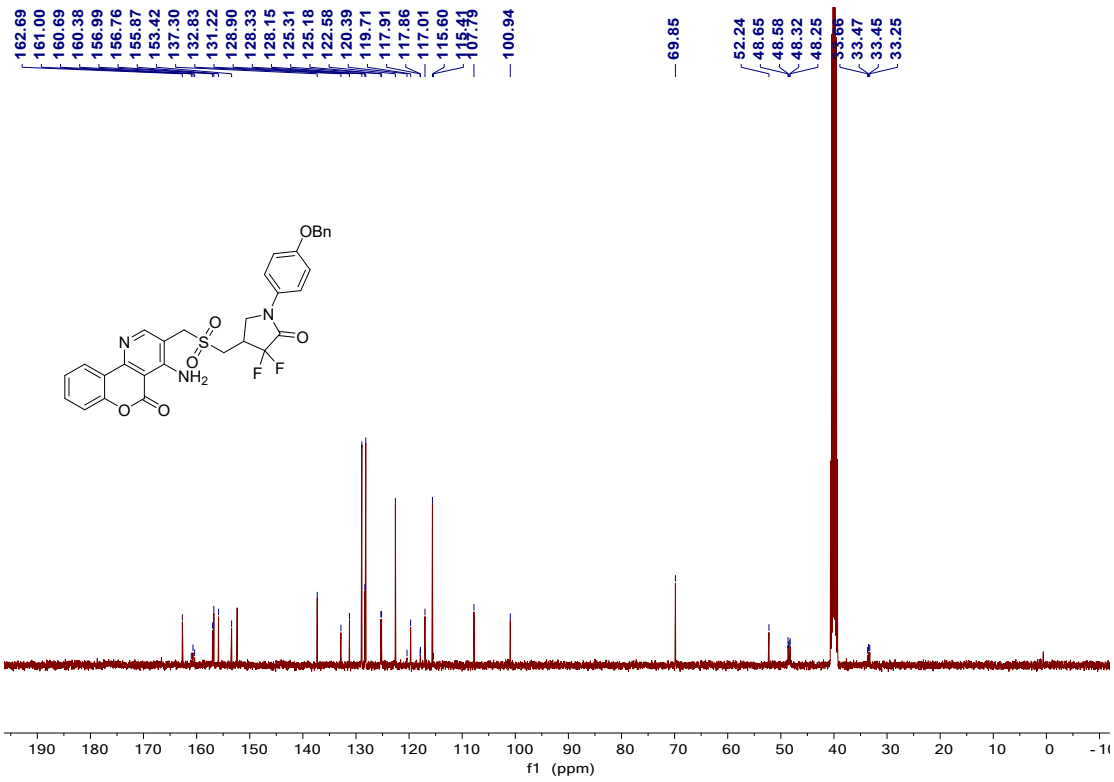
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7ad**



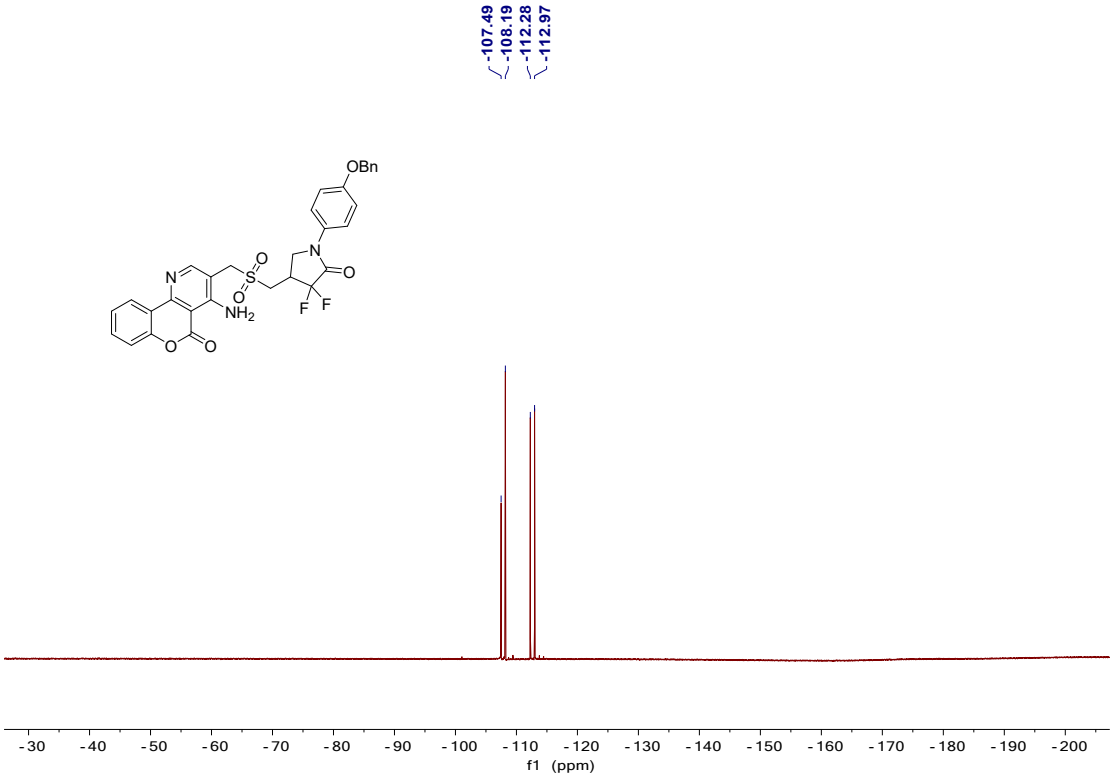
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7ae**



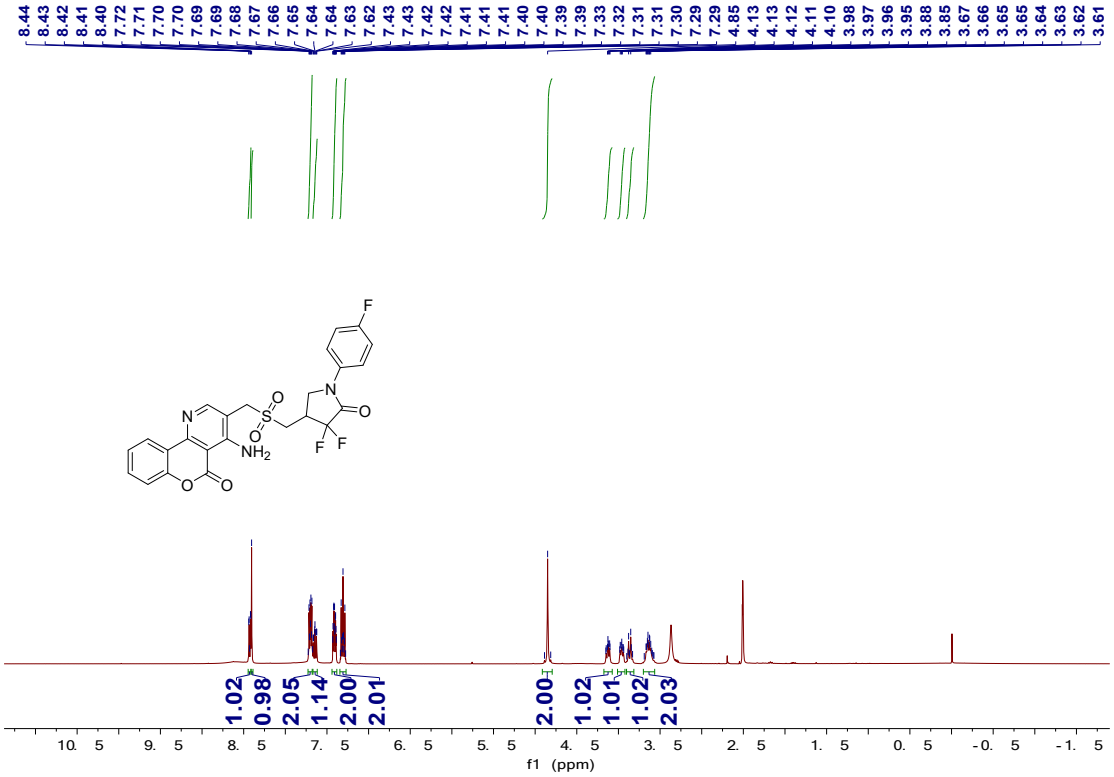
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7ae**



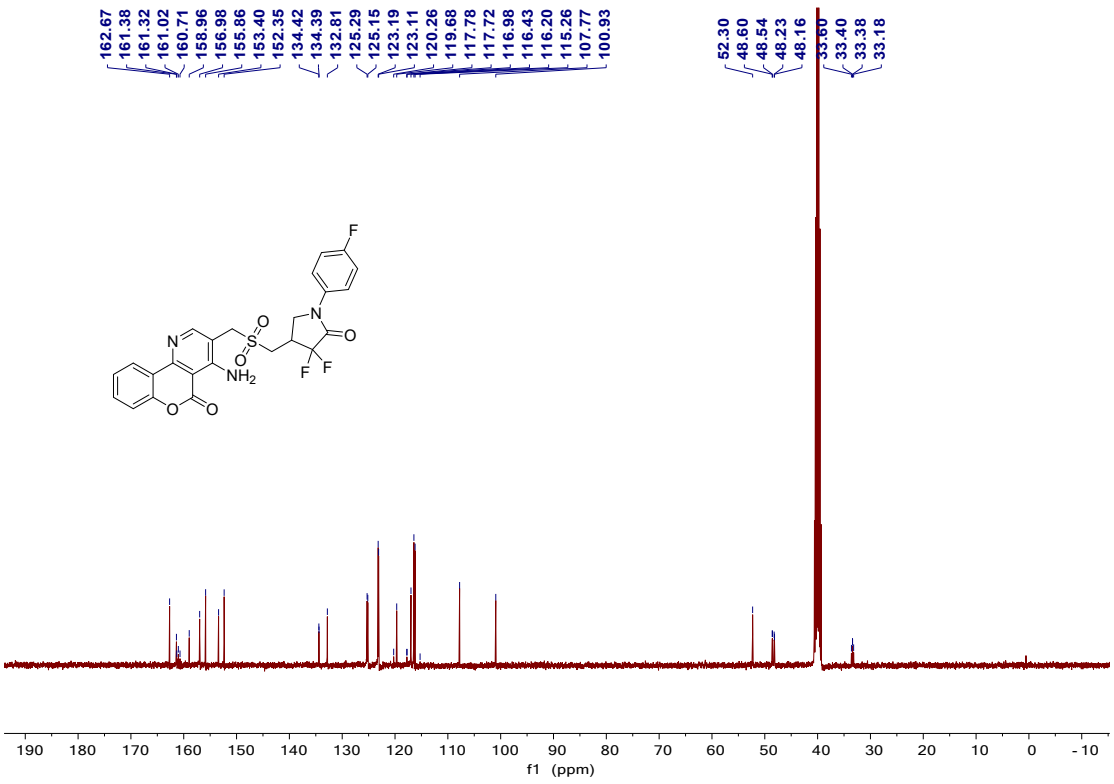
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7ae**



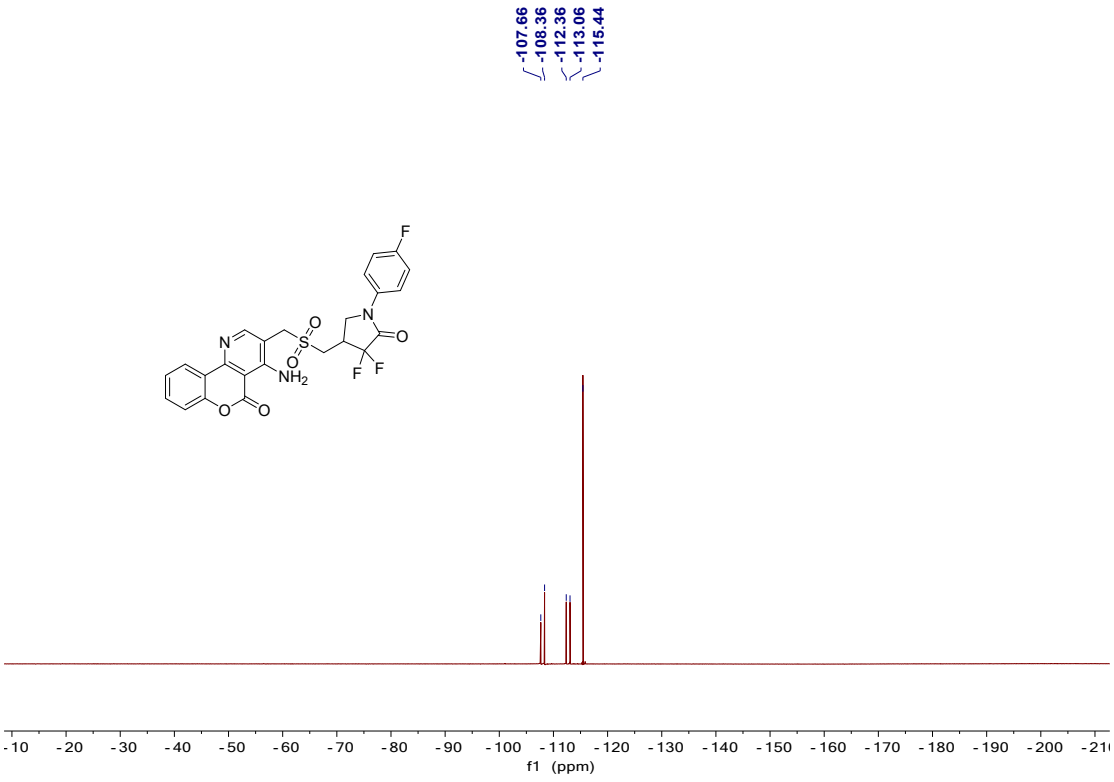
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7af**



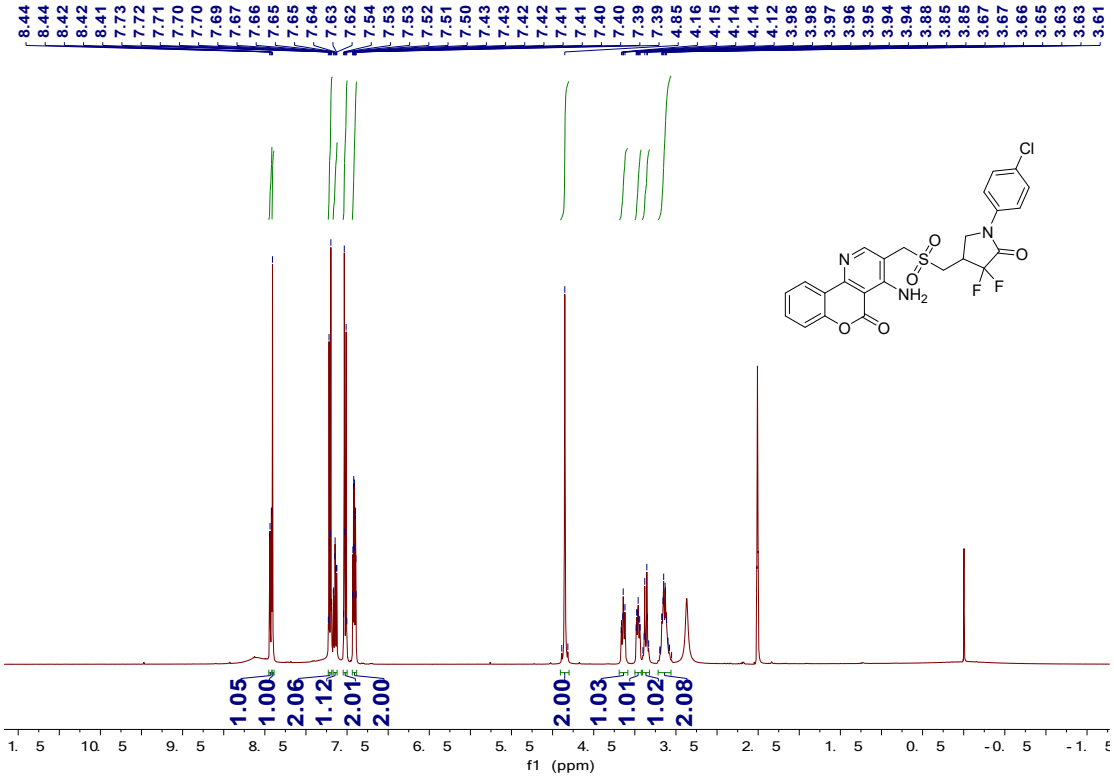
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7af**



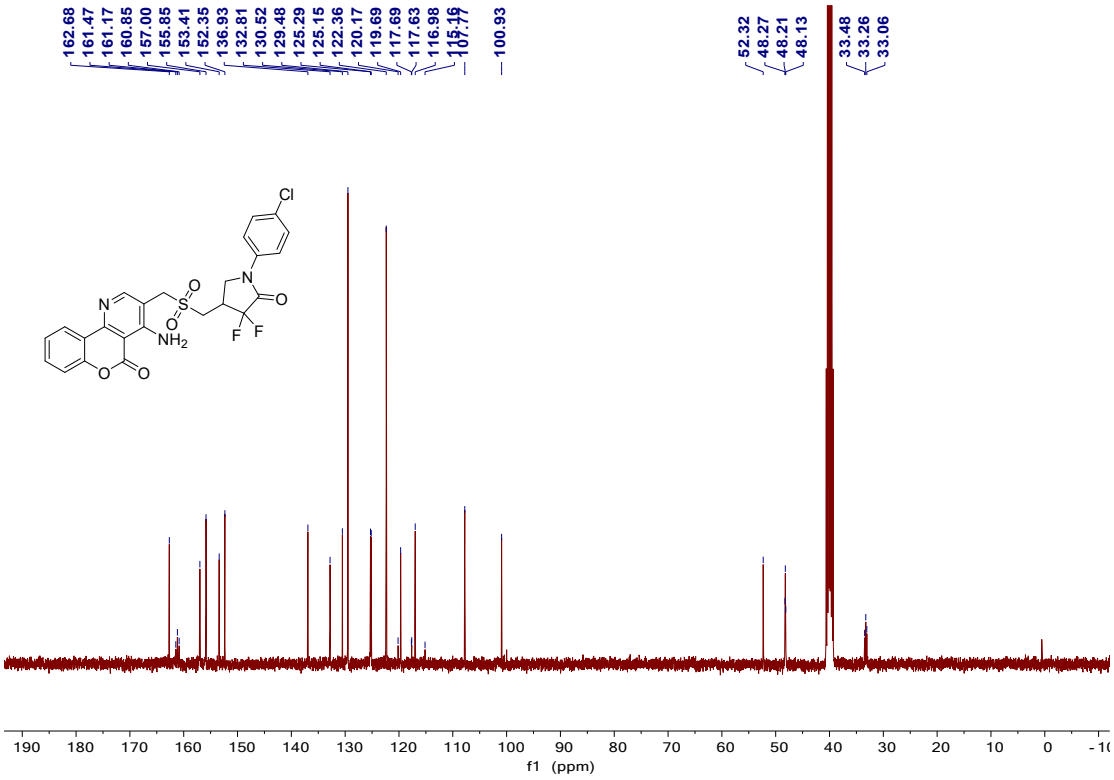
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7af**



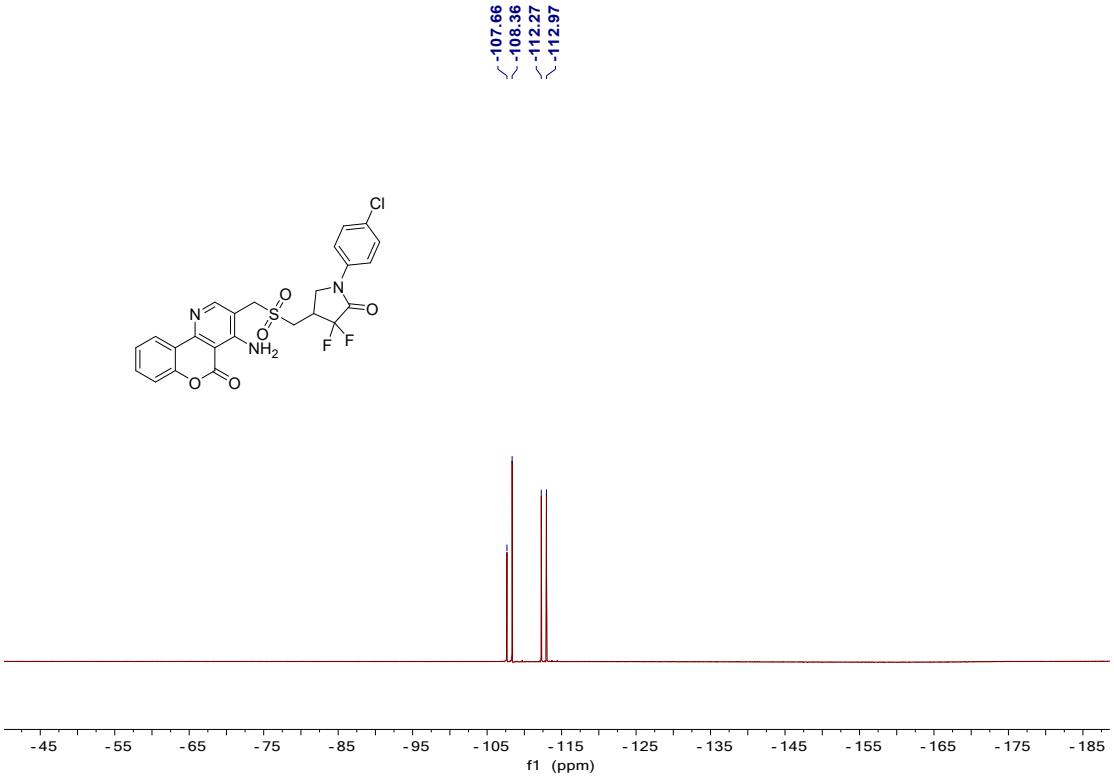
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7ag**



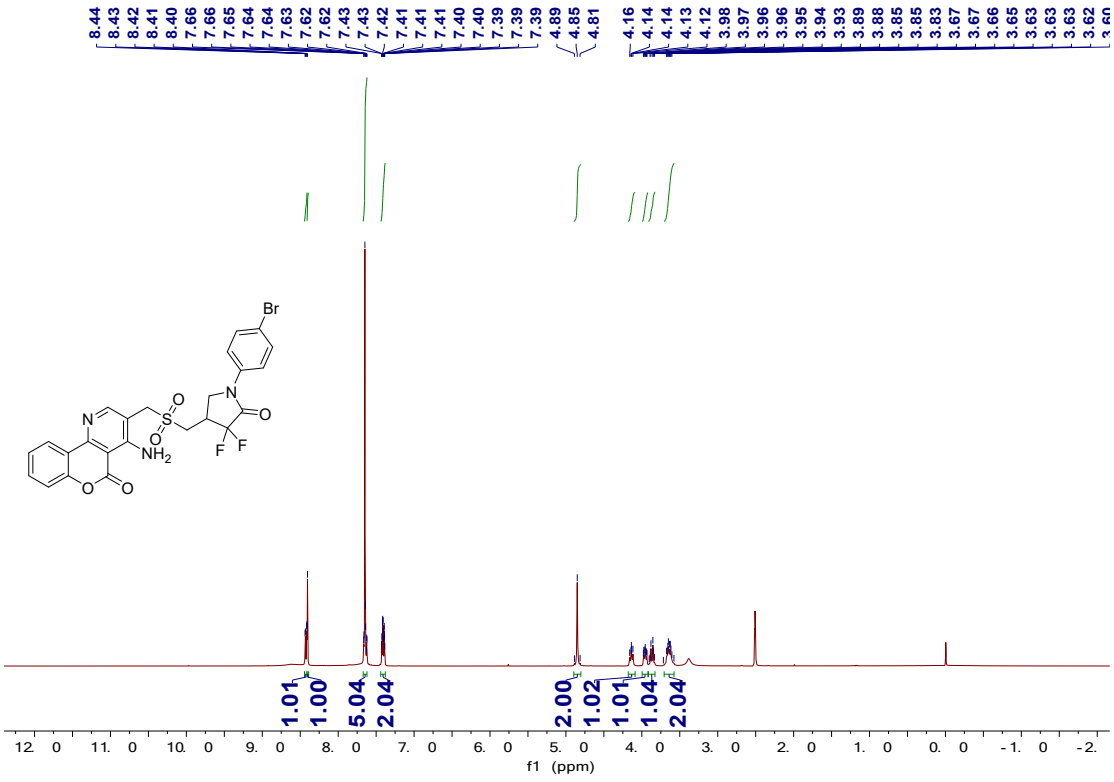
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7ag**



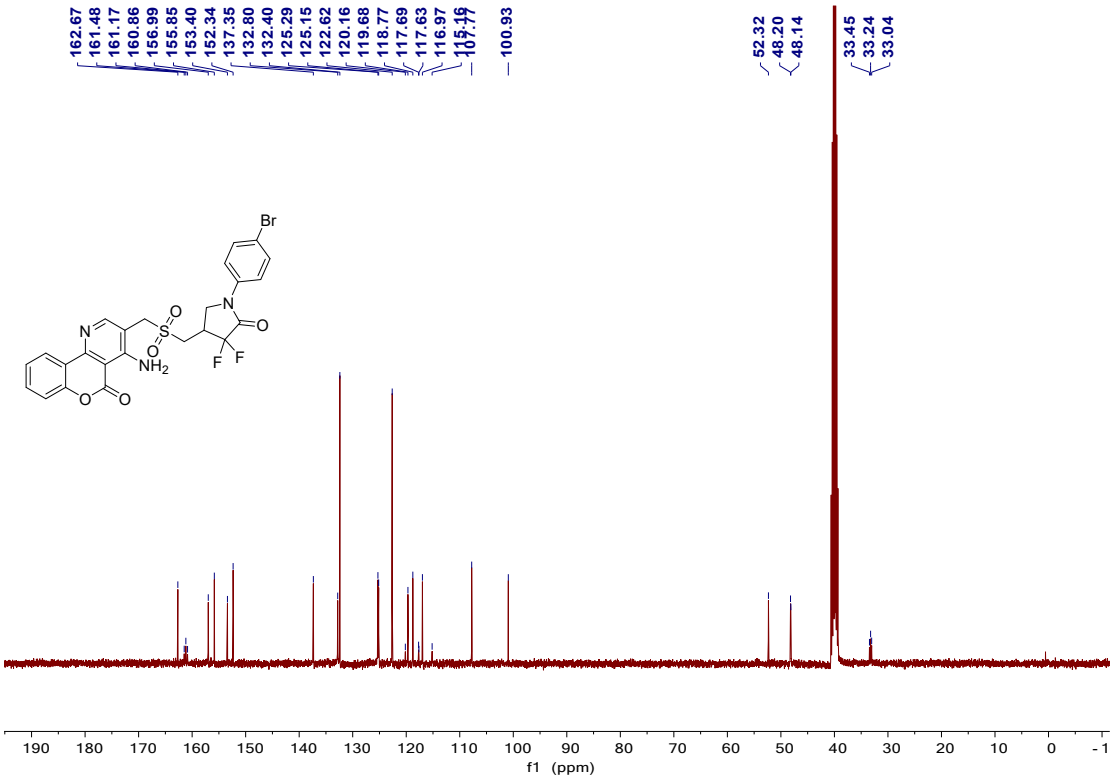
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7ag**



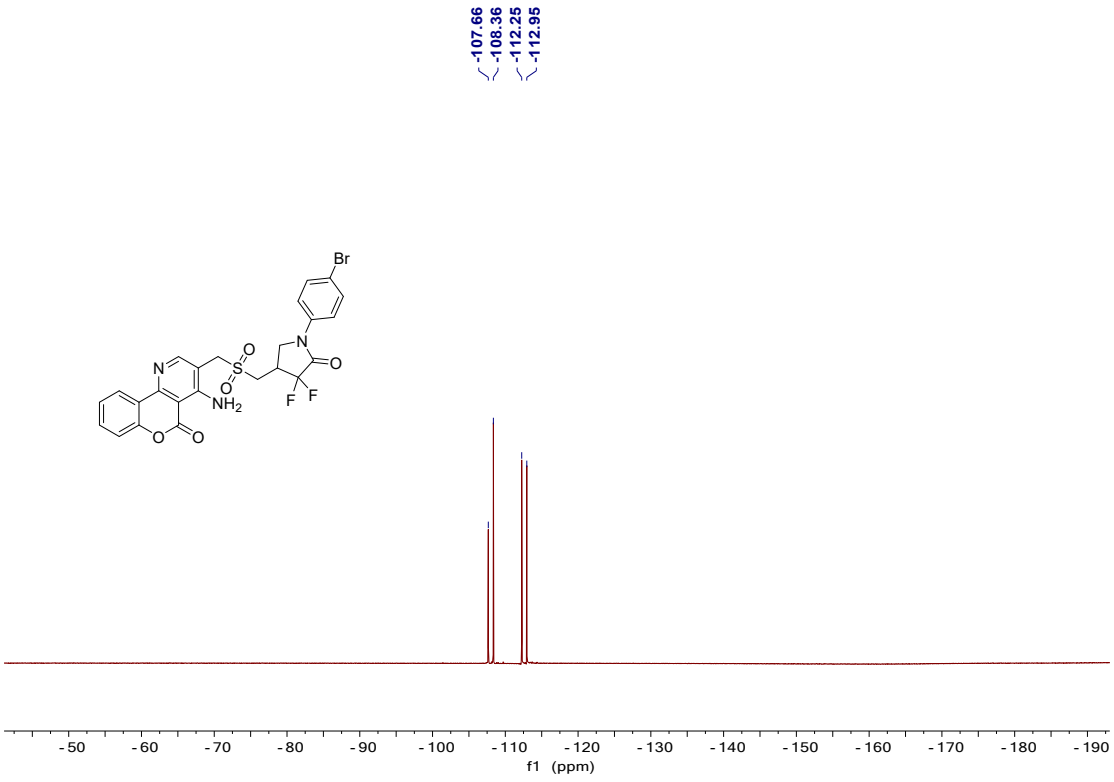
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7ah**



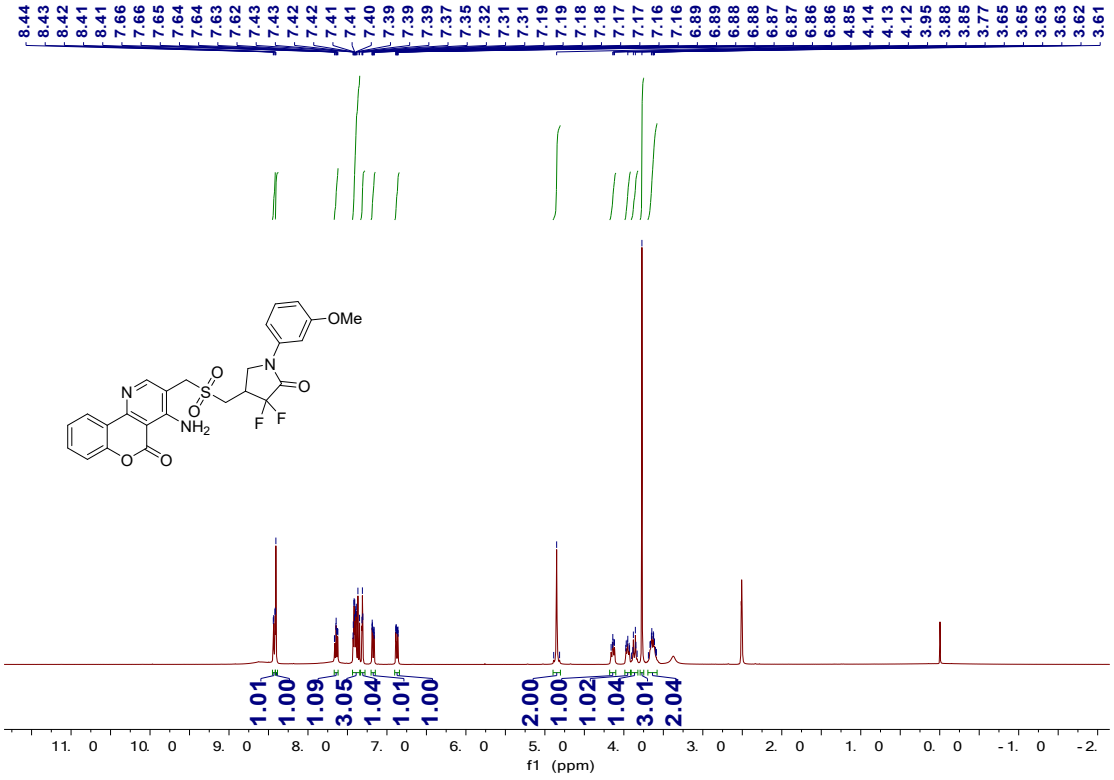
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7ah**



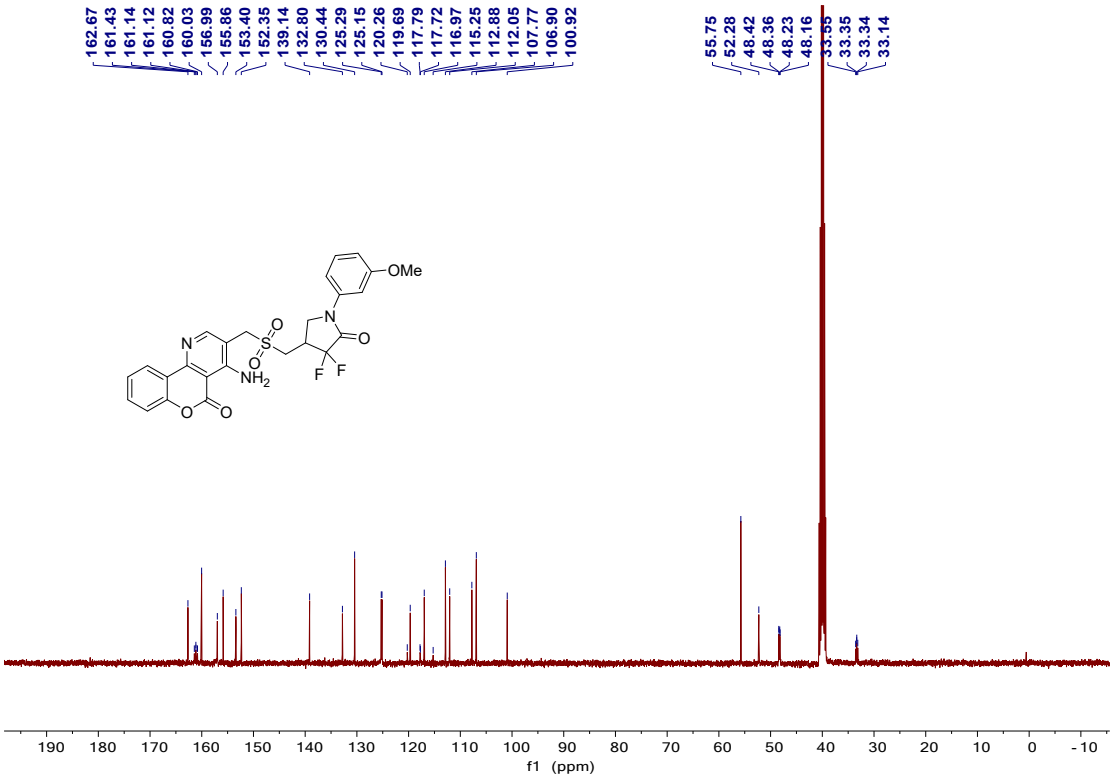
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7ah**



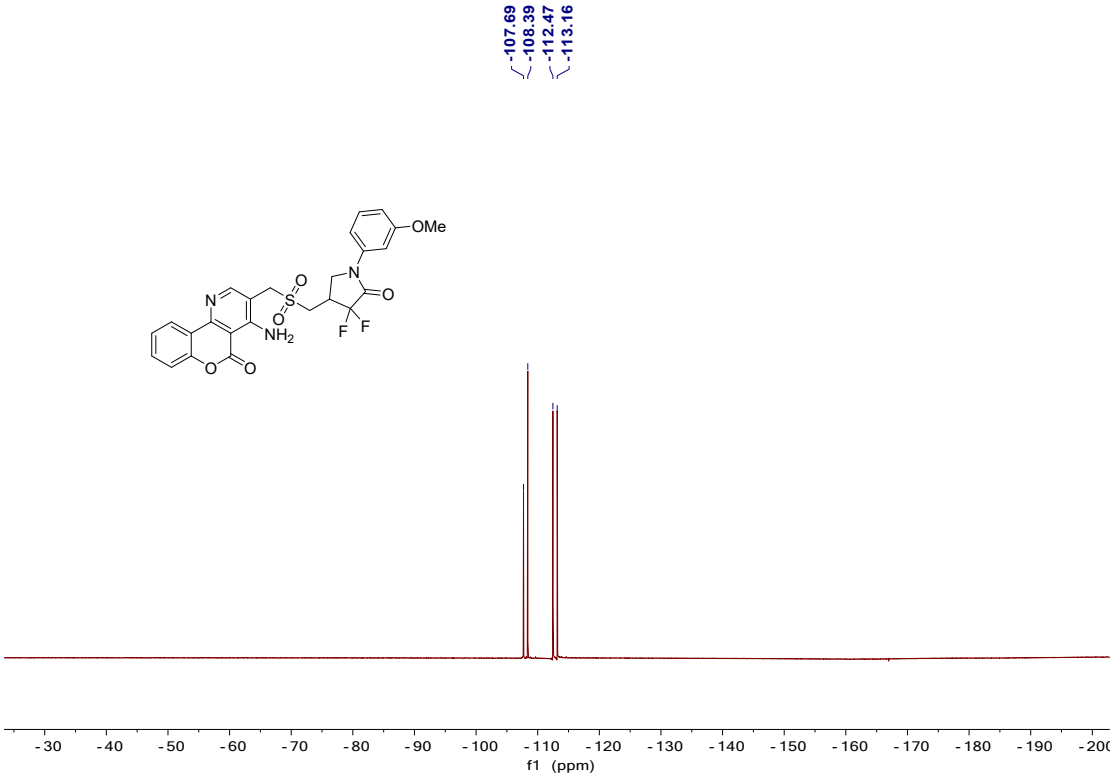
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7ai**



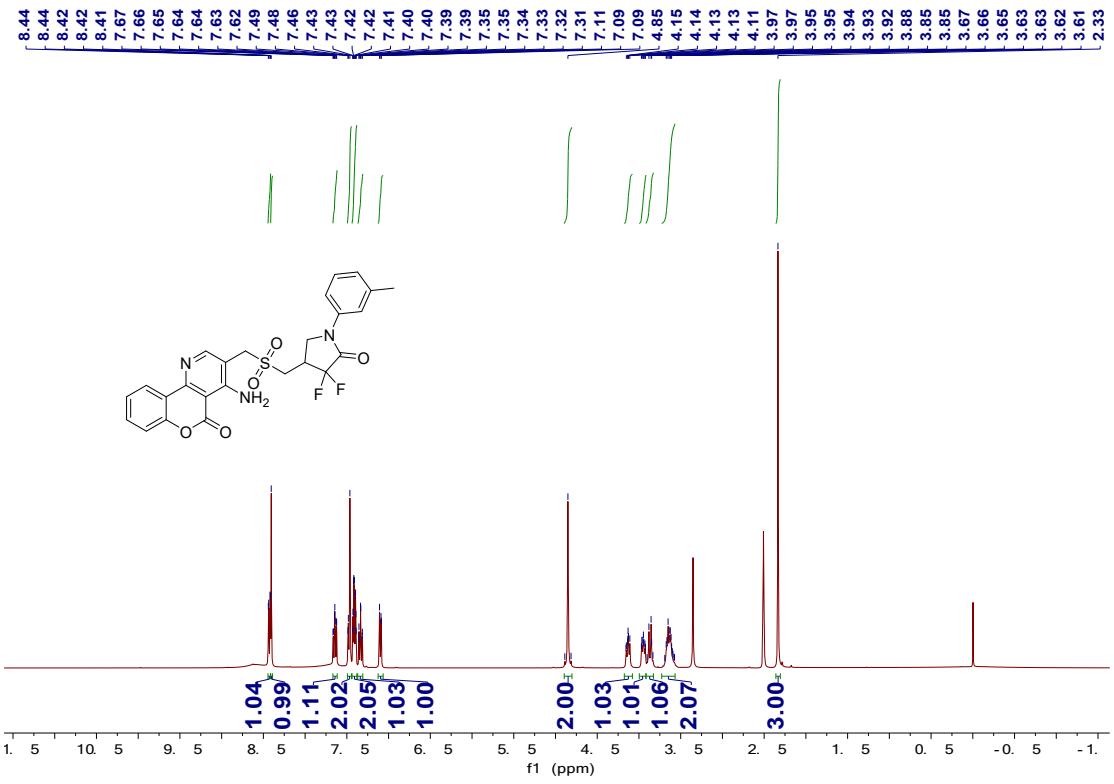
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7ai**



^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7ai**



^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7aj**



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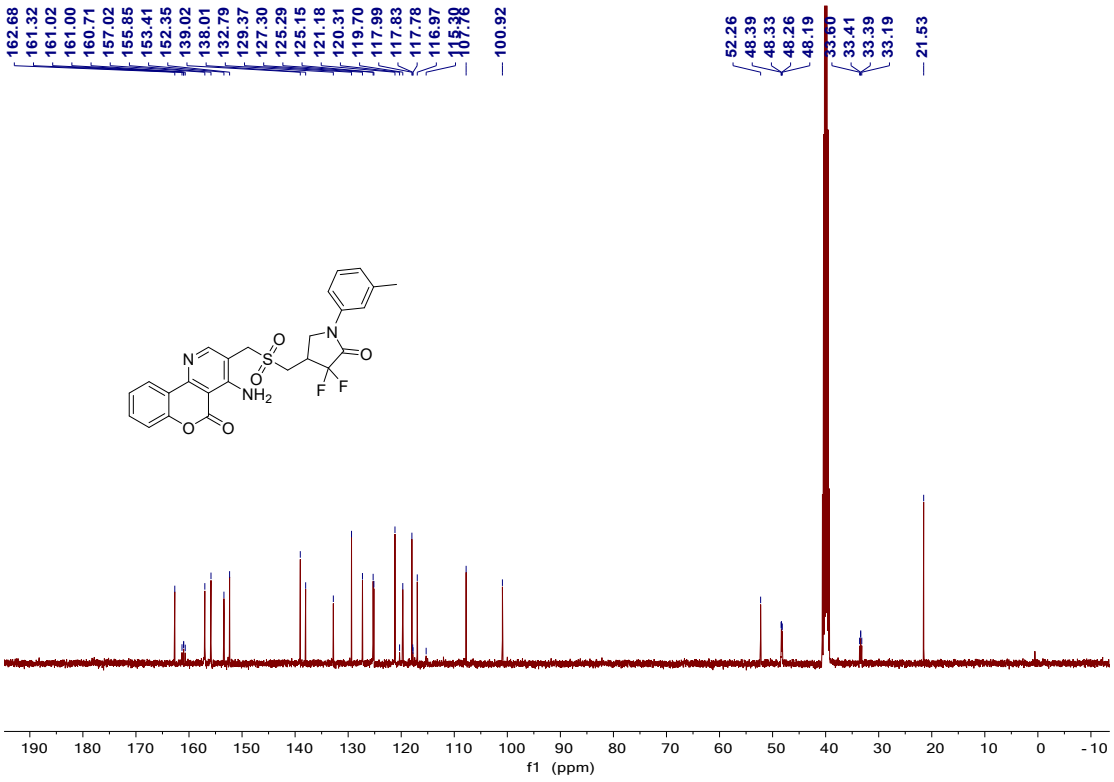
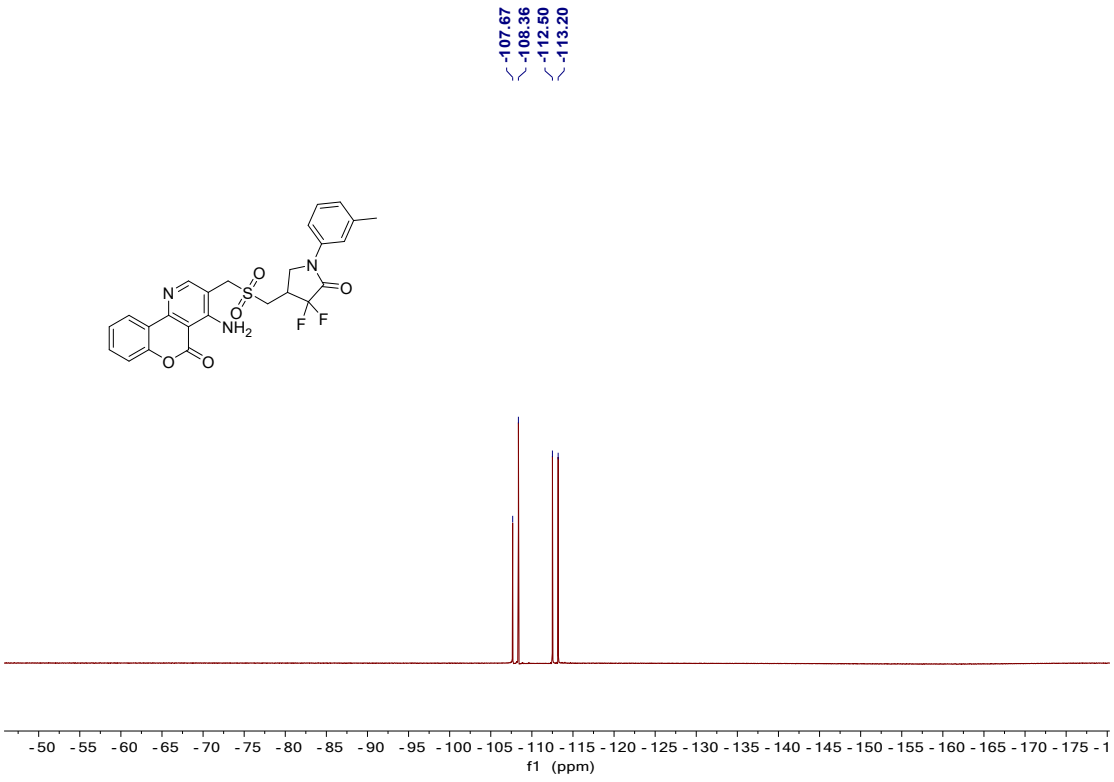
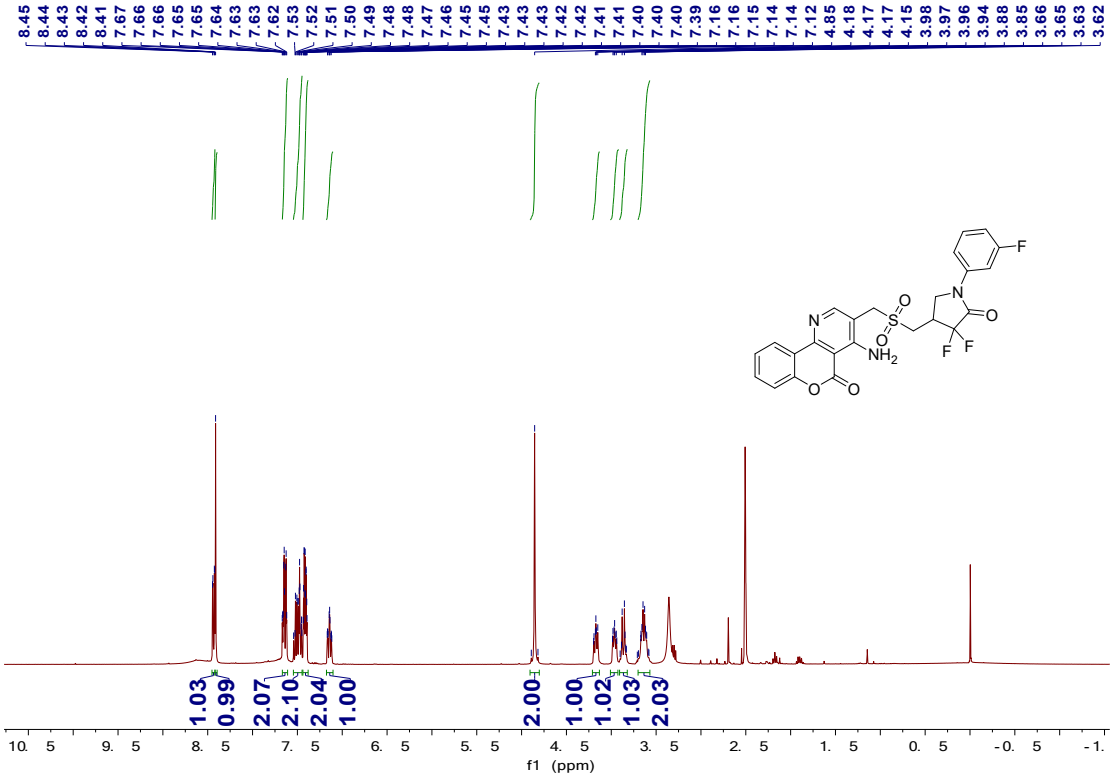


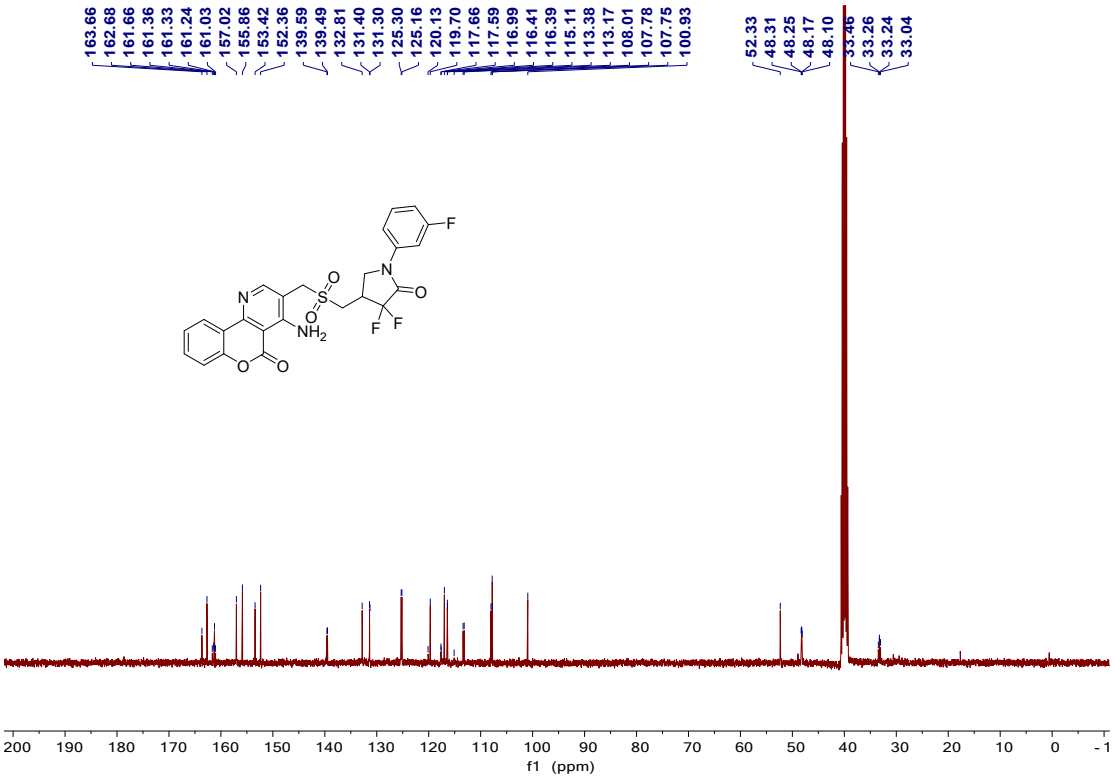
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7aj**



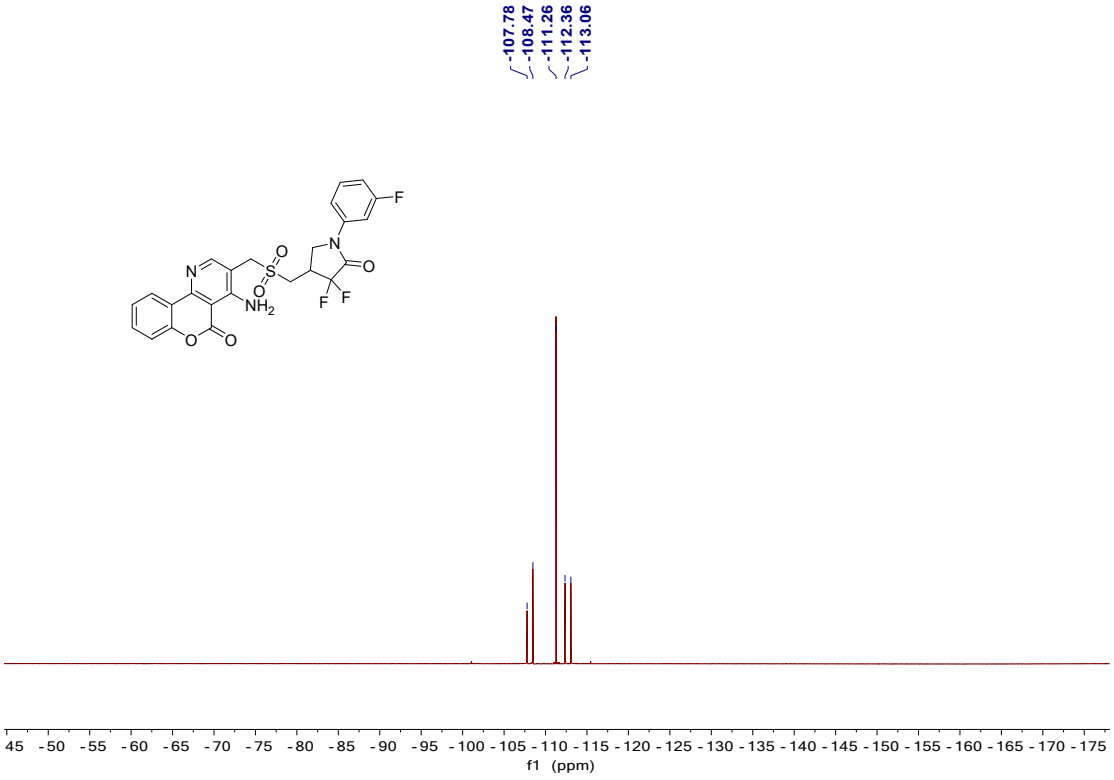
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7ak**



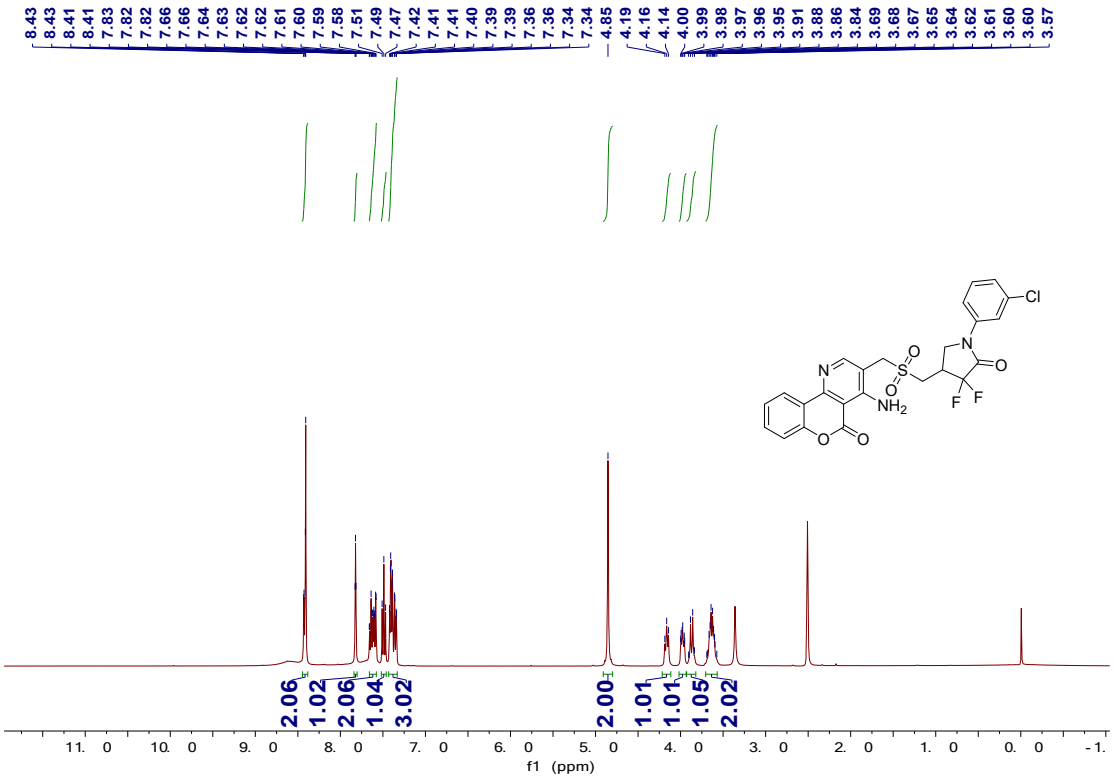
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7ak**



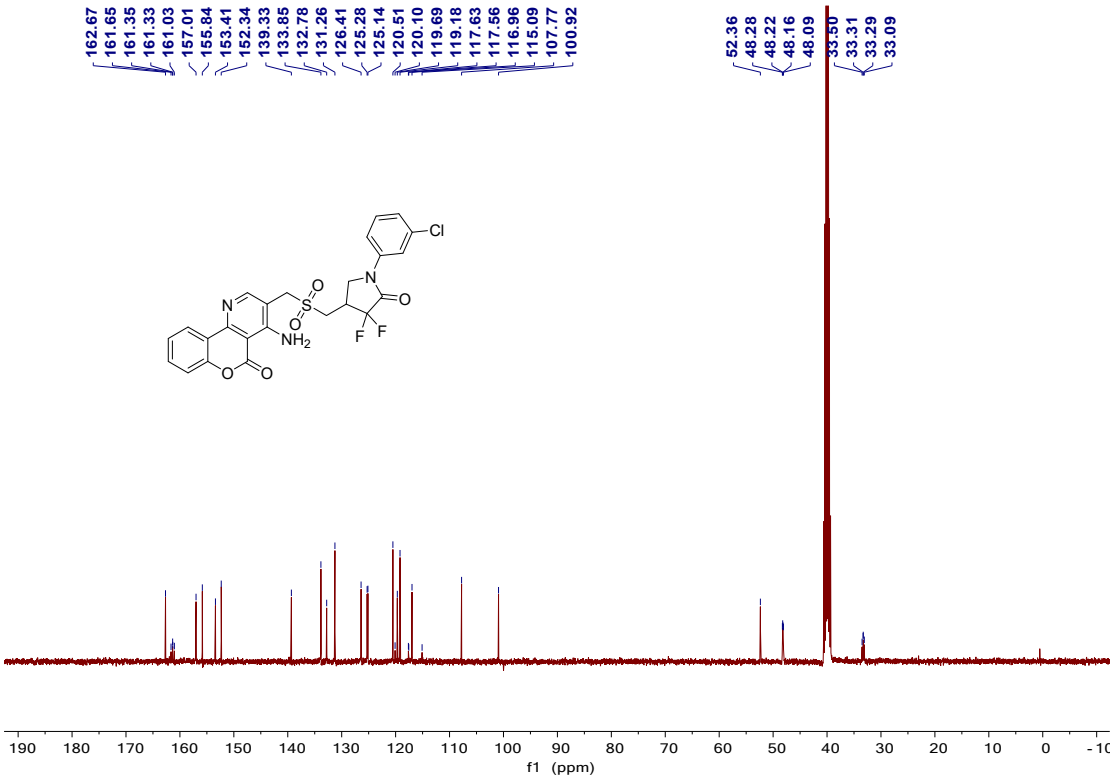
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7ak**



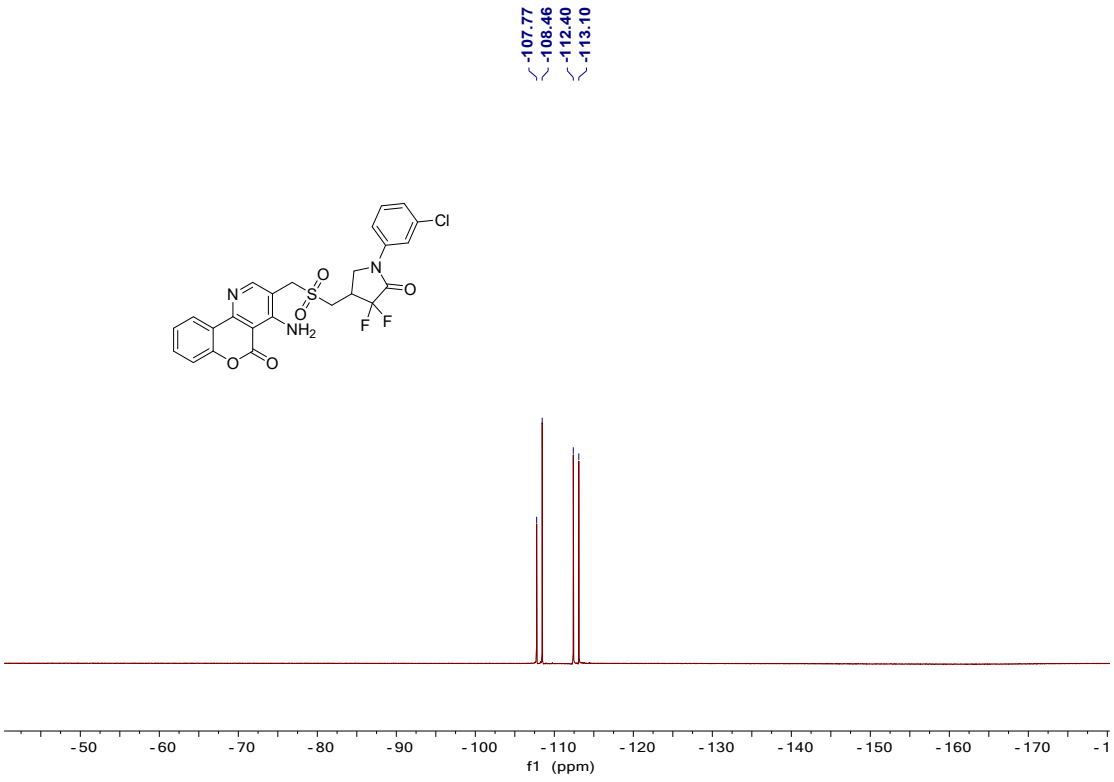
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7al**



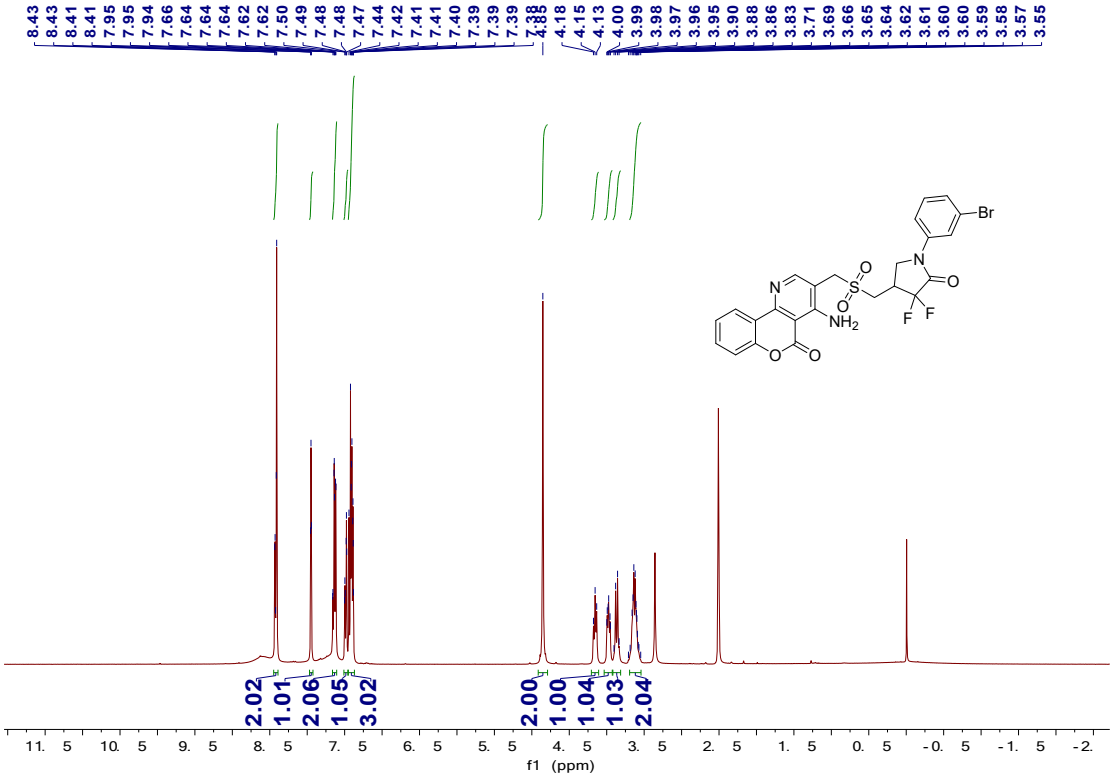
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7al**



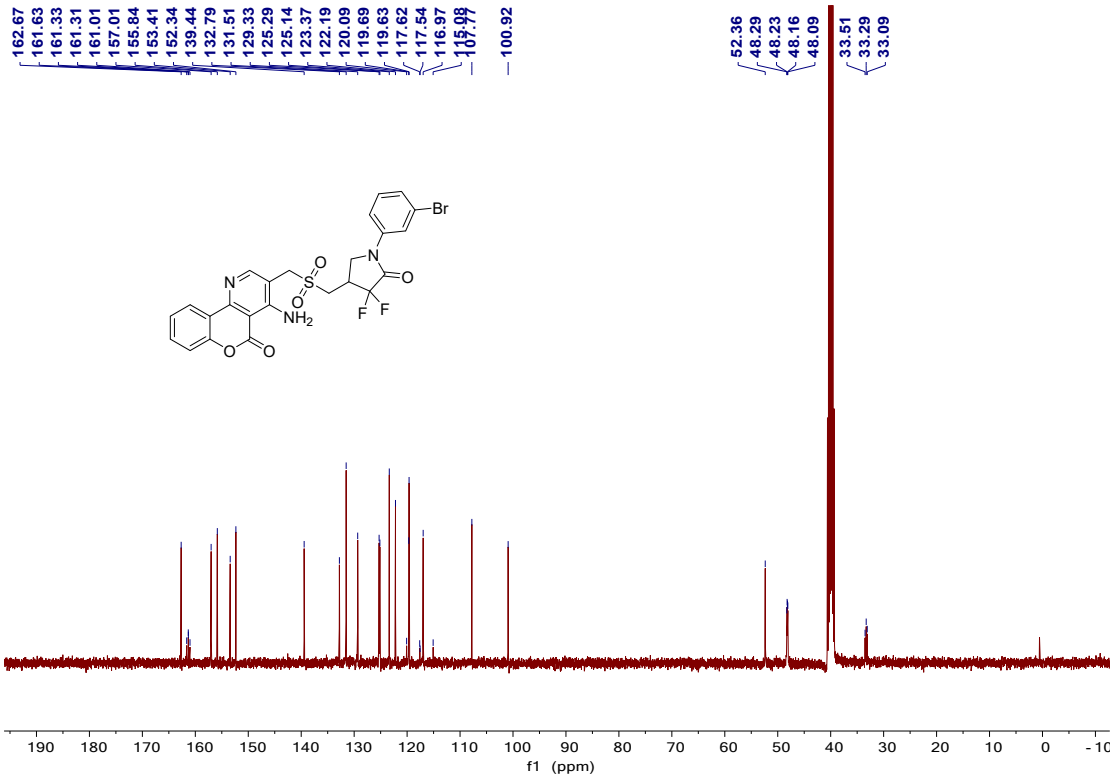
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7al**



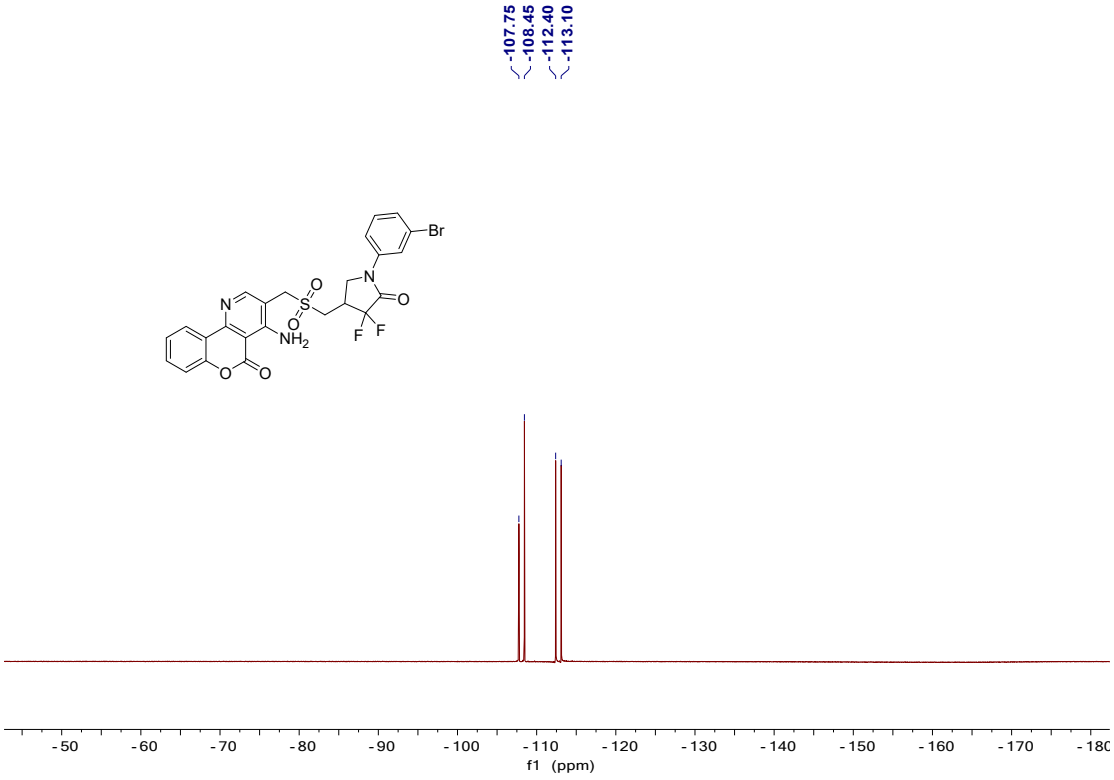
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7am**



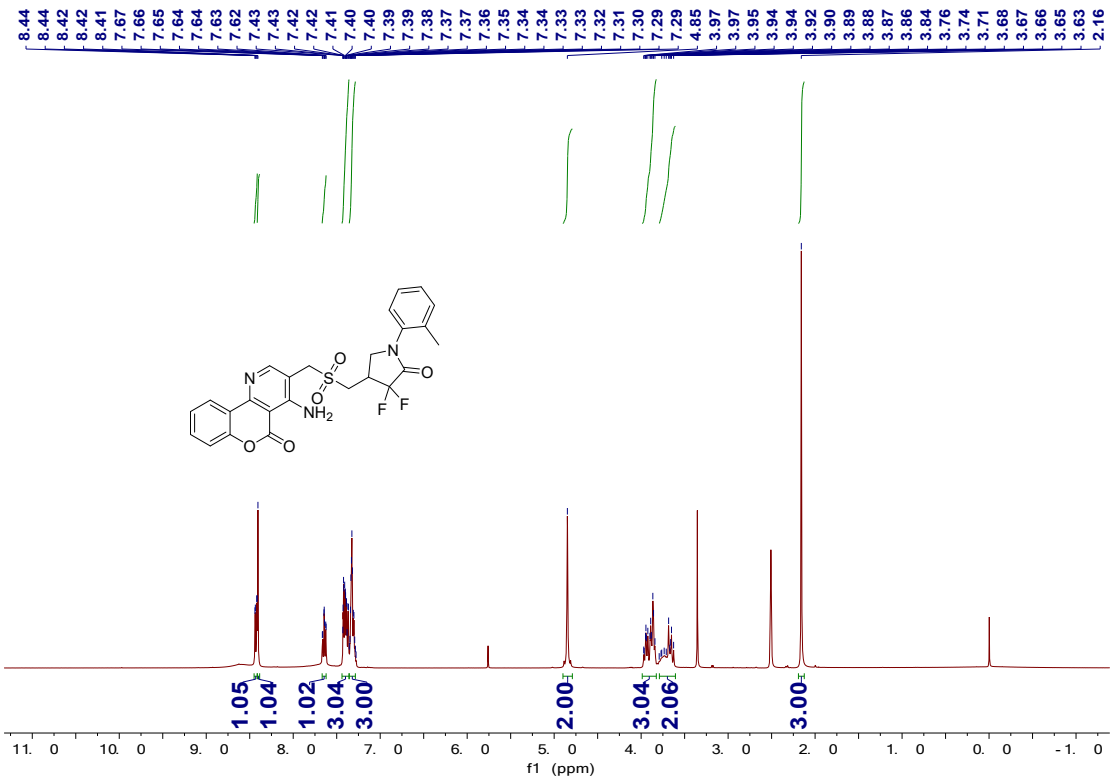
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7am**



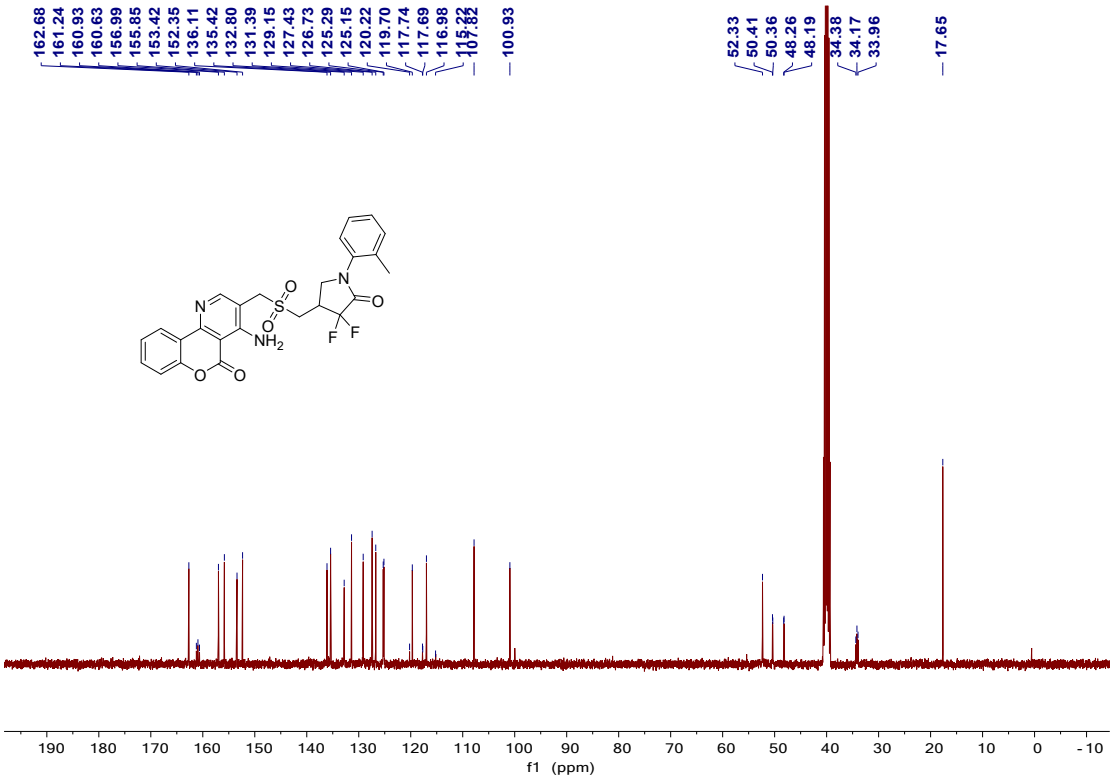
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7am**



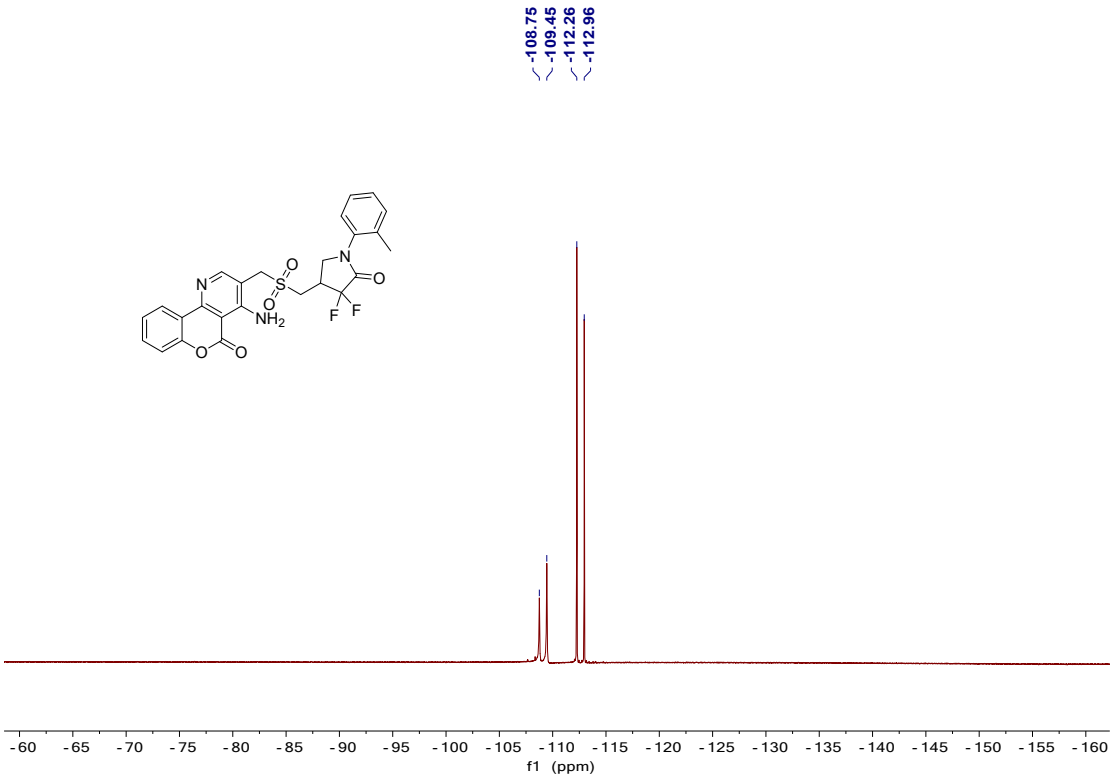
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7an**



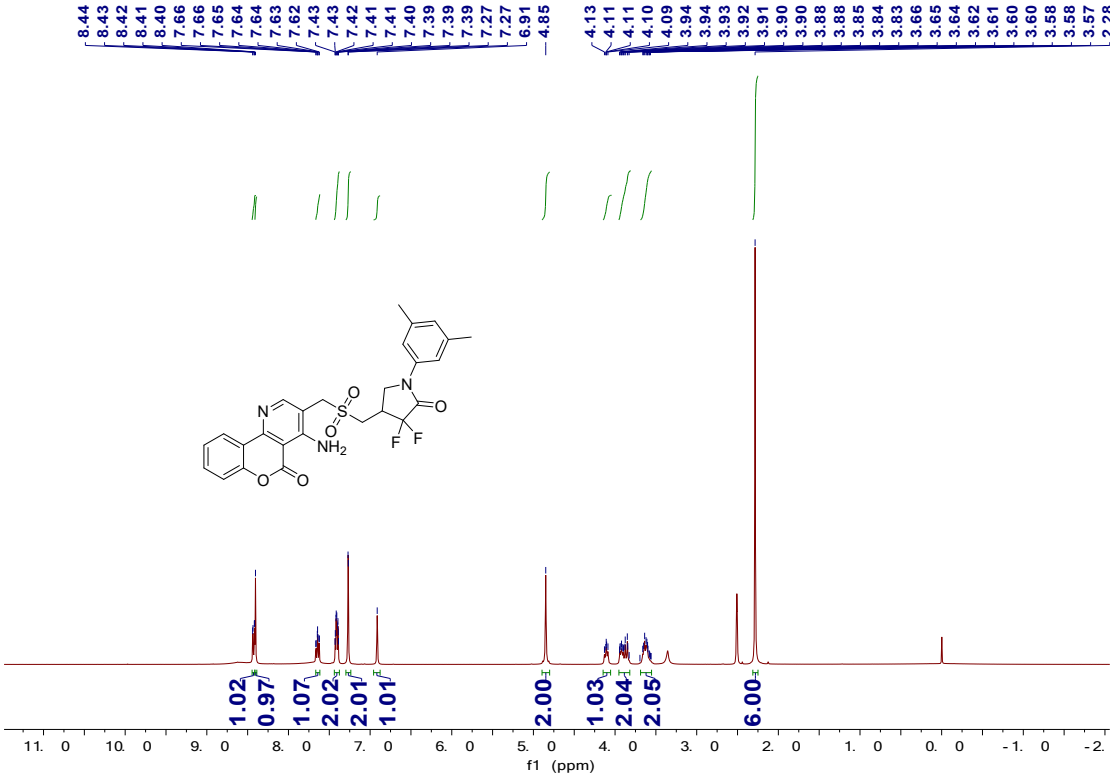
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7an**



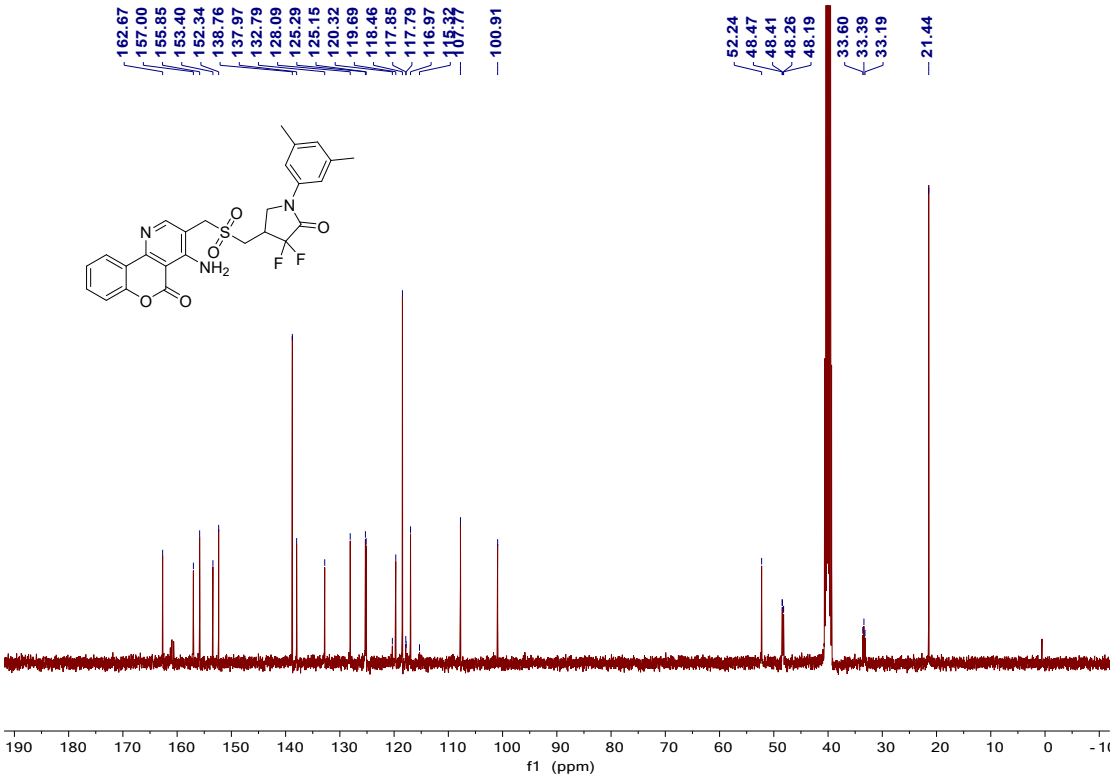
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7an**



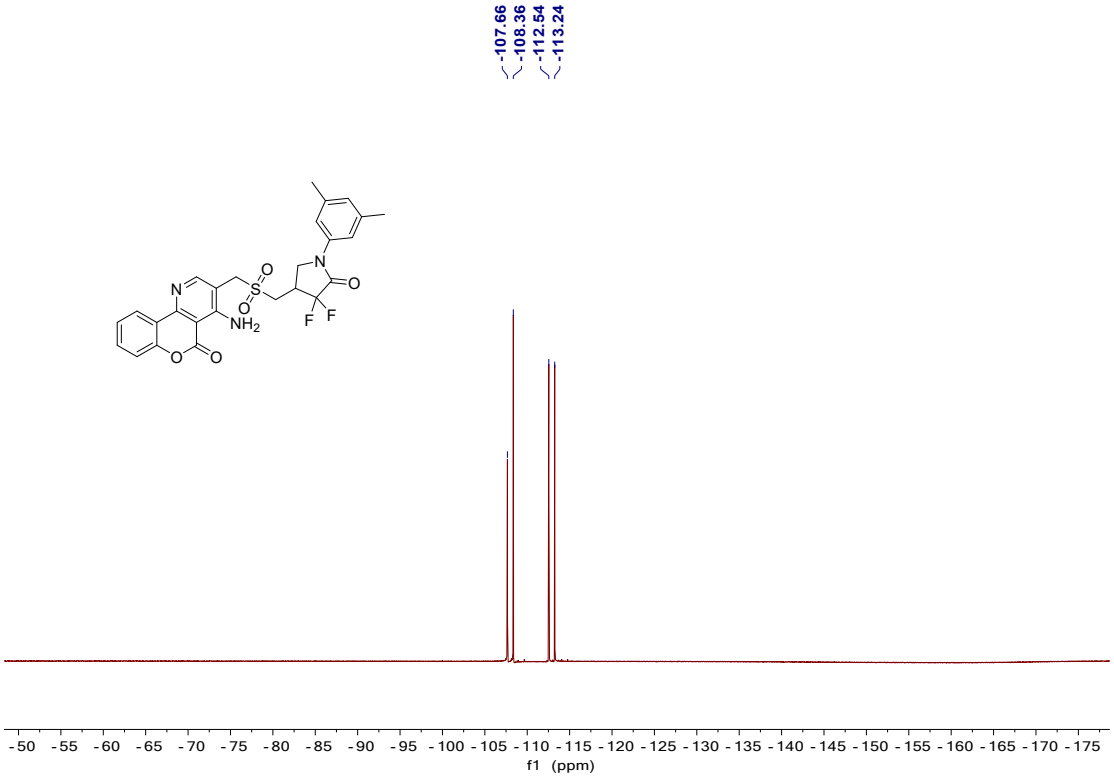
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7ao**



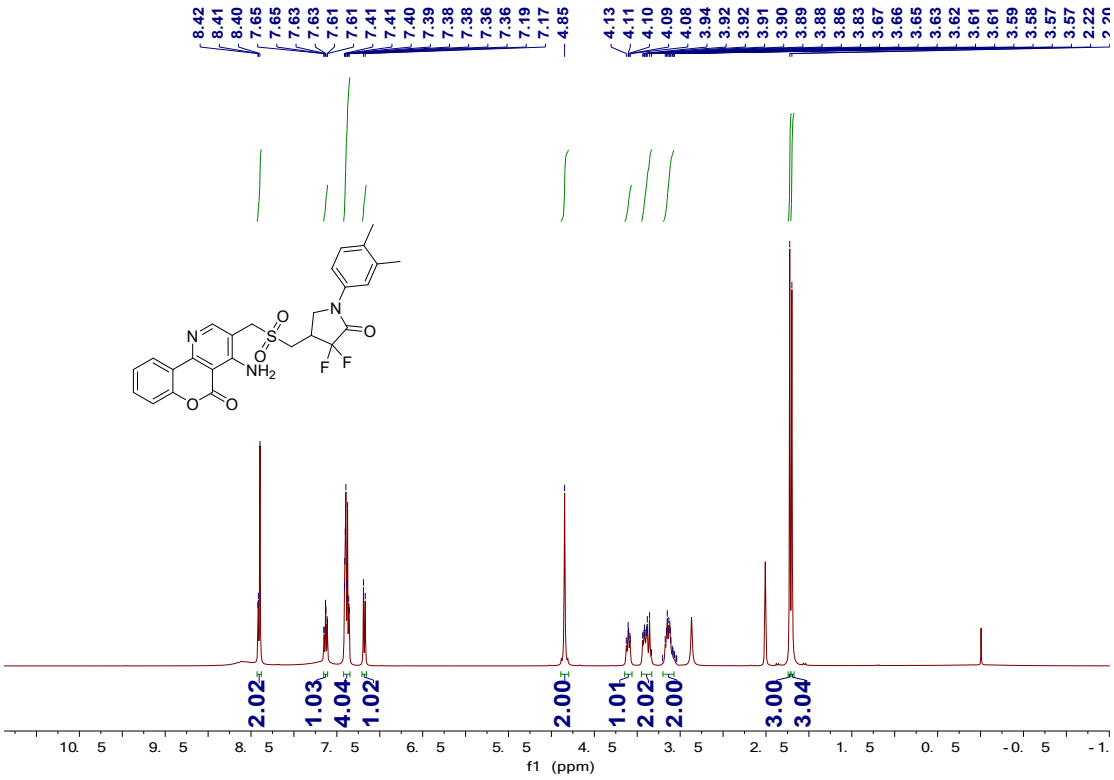
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7ao**



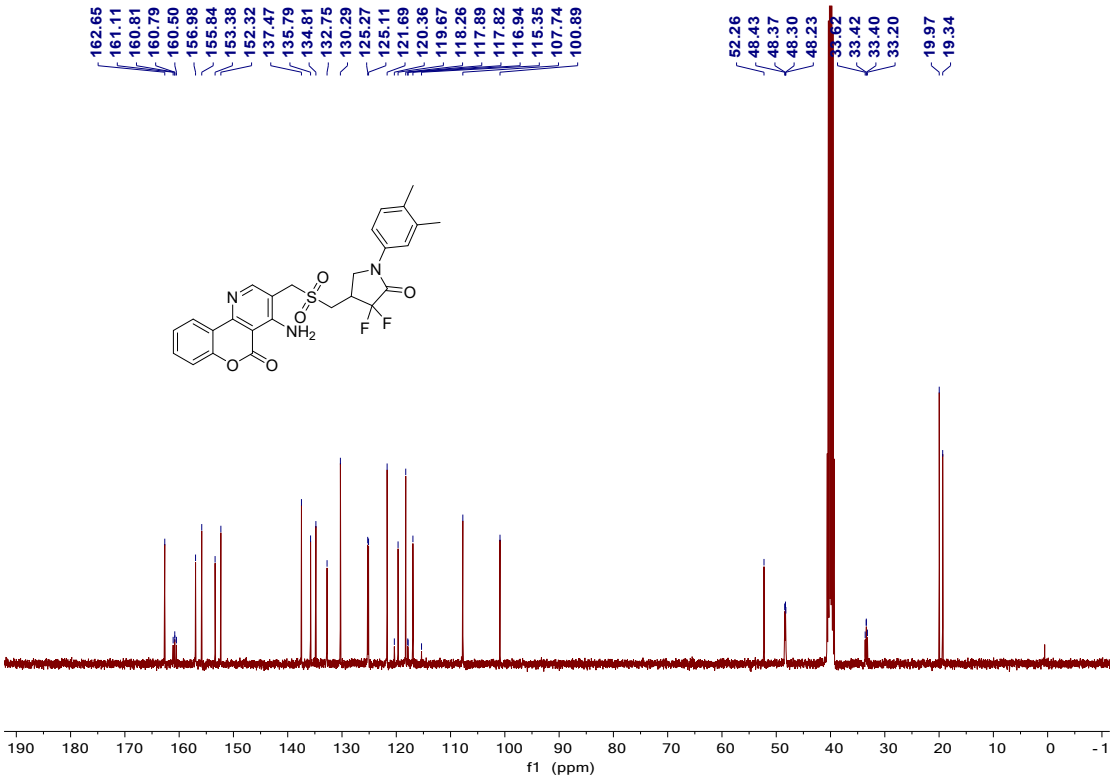
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7ao**



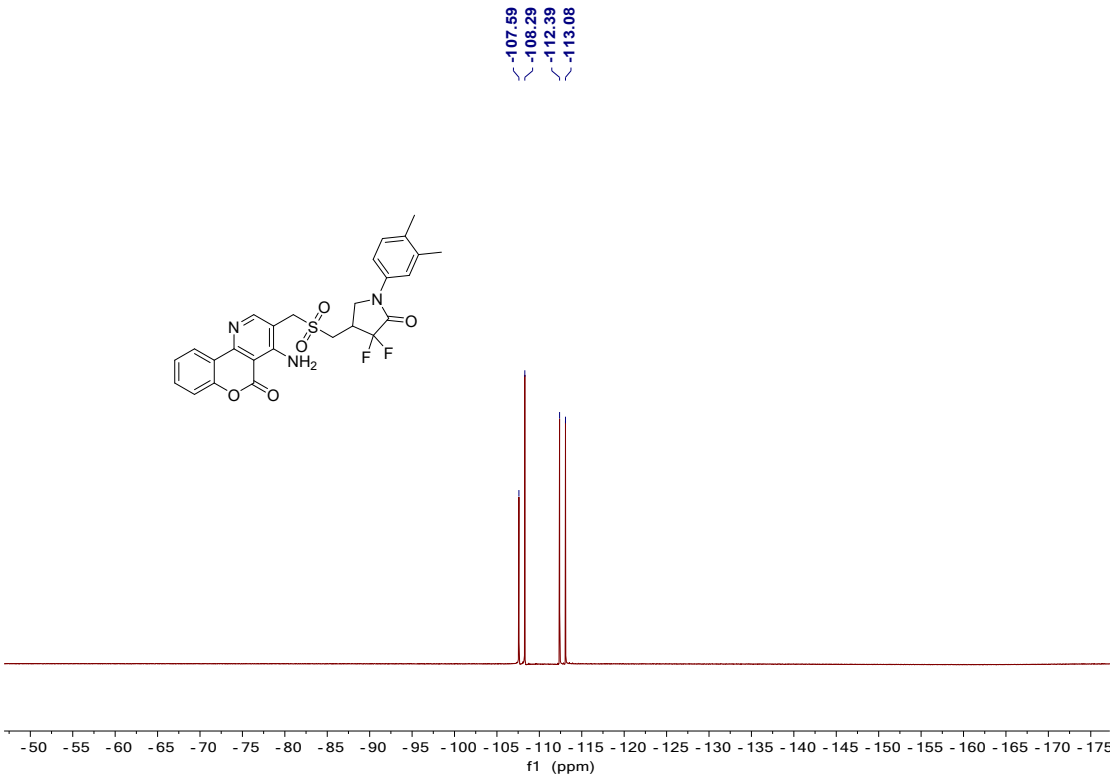
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7ap**



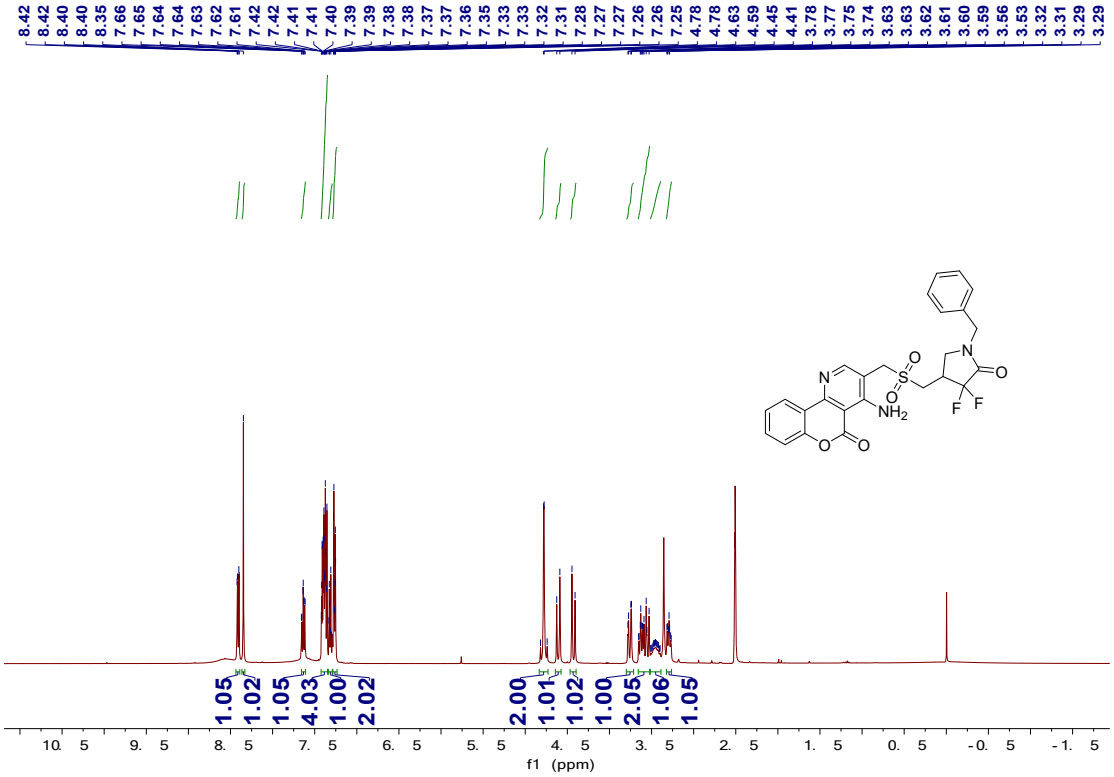
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7ap**



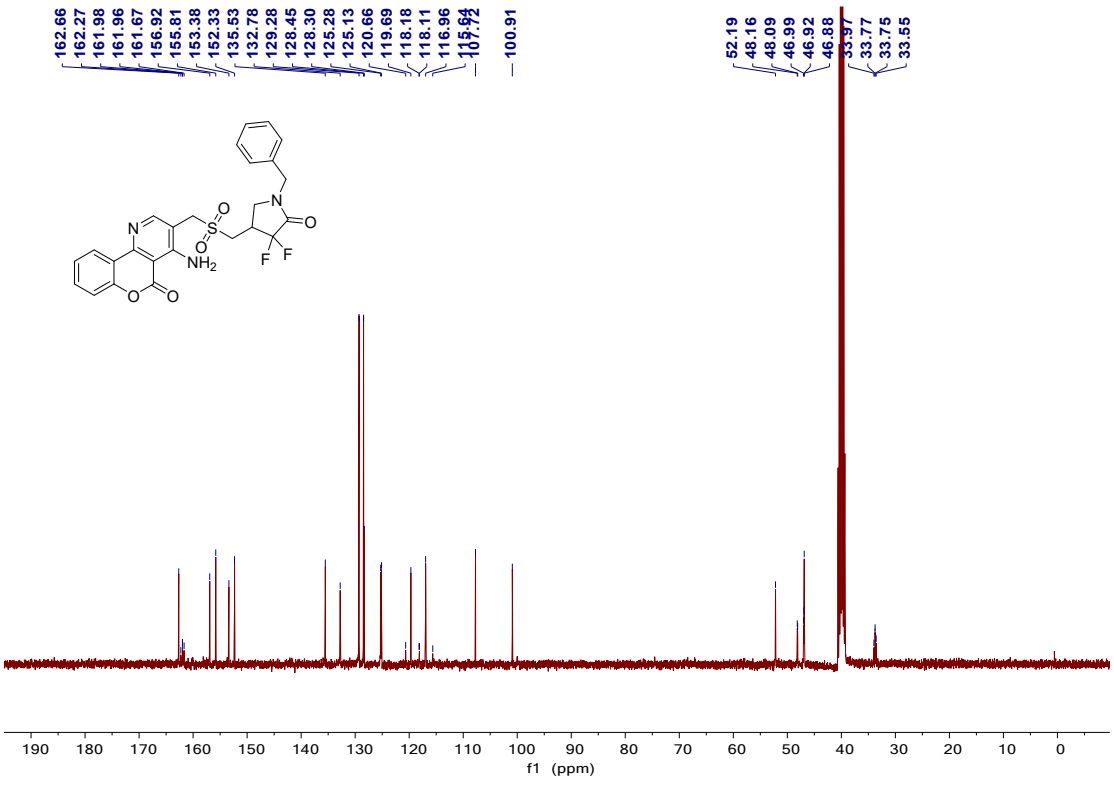
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7ap**



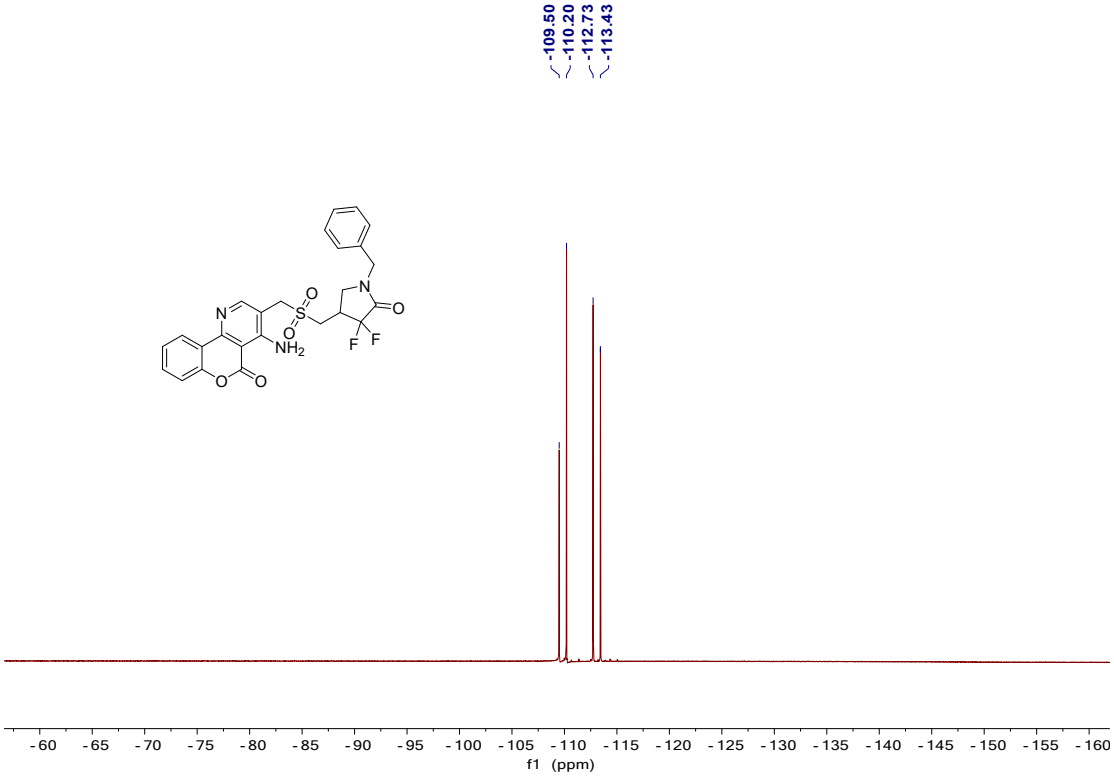
[1]H NMR-spectrum (400 MHz, DMSO-d_6) of**7aq**



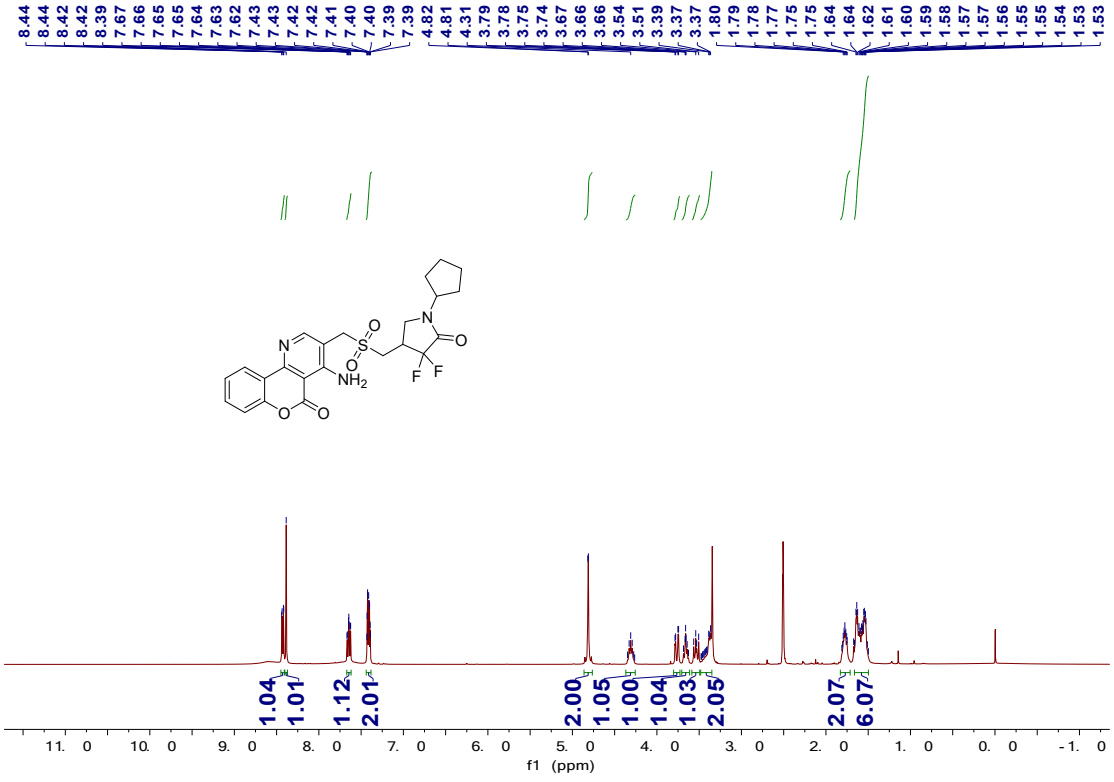
[13]C NMR-spectrum (101 MHz, DMSO-d_6) of **7aq**



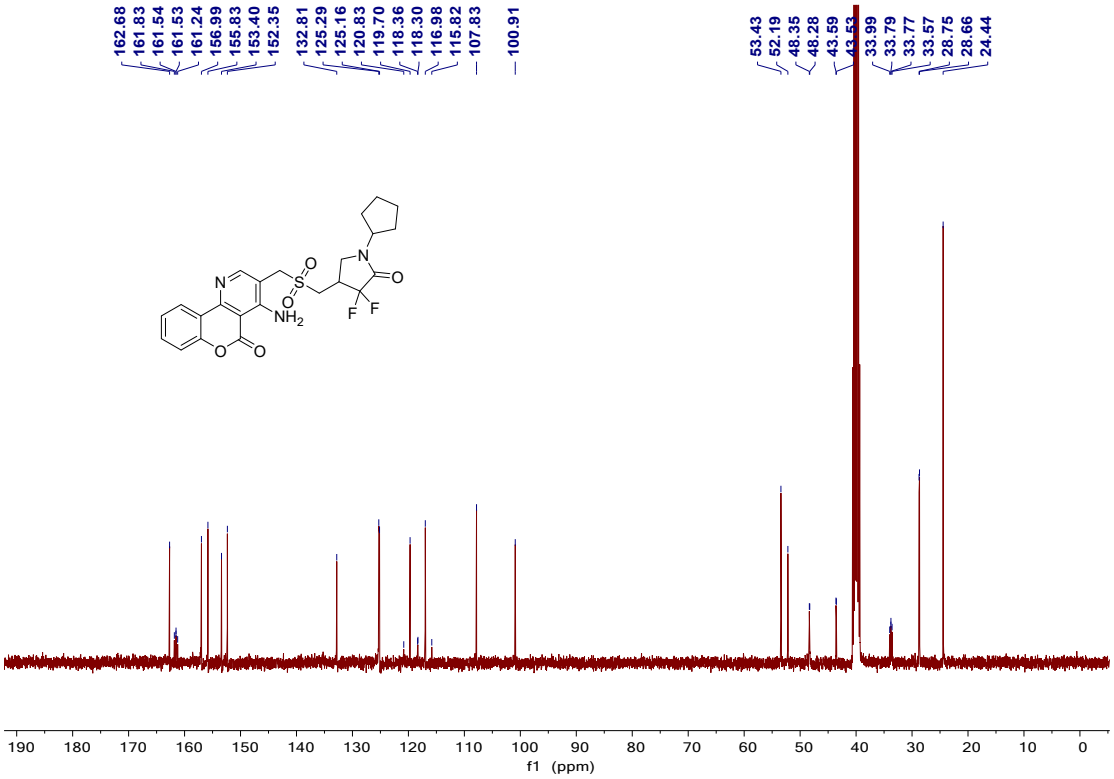
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7aq**



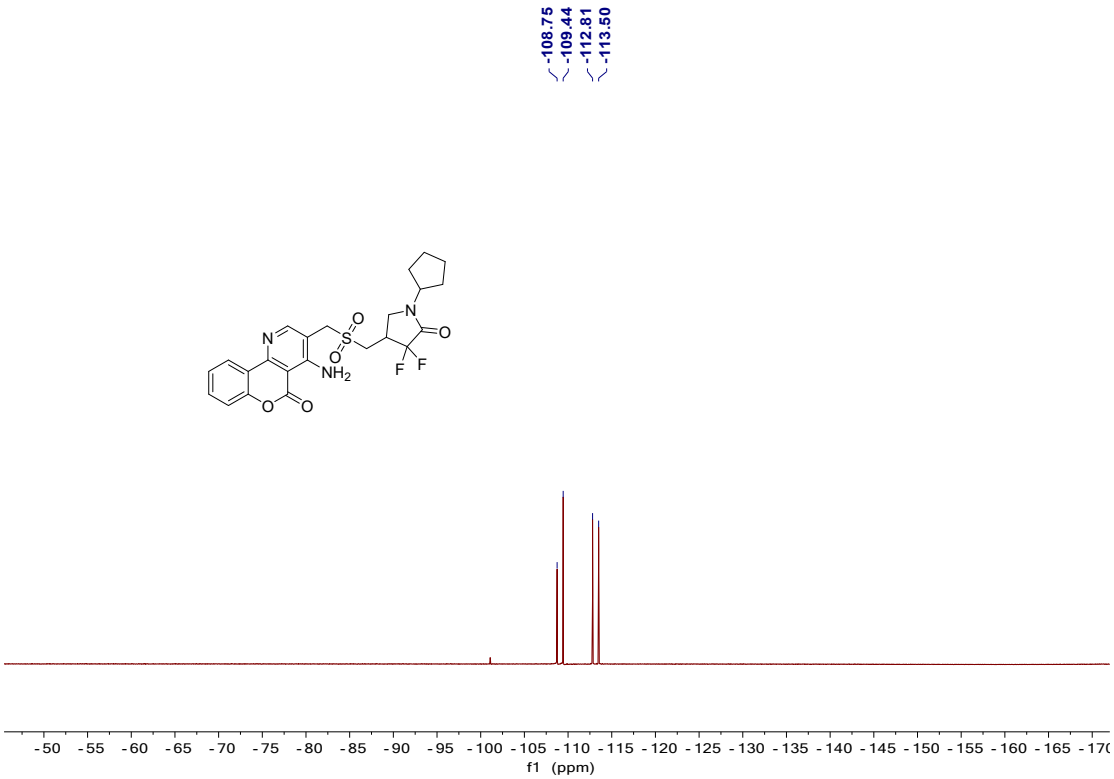
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7ar**



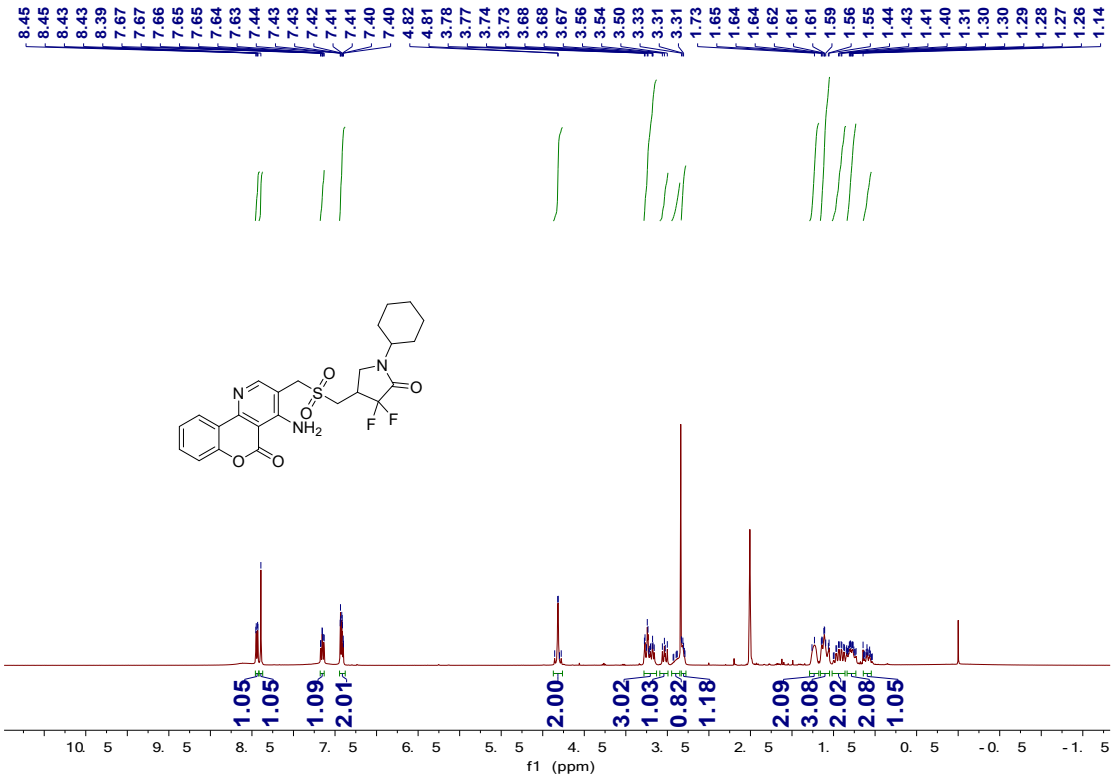
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7ar**



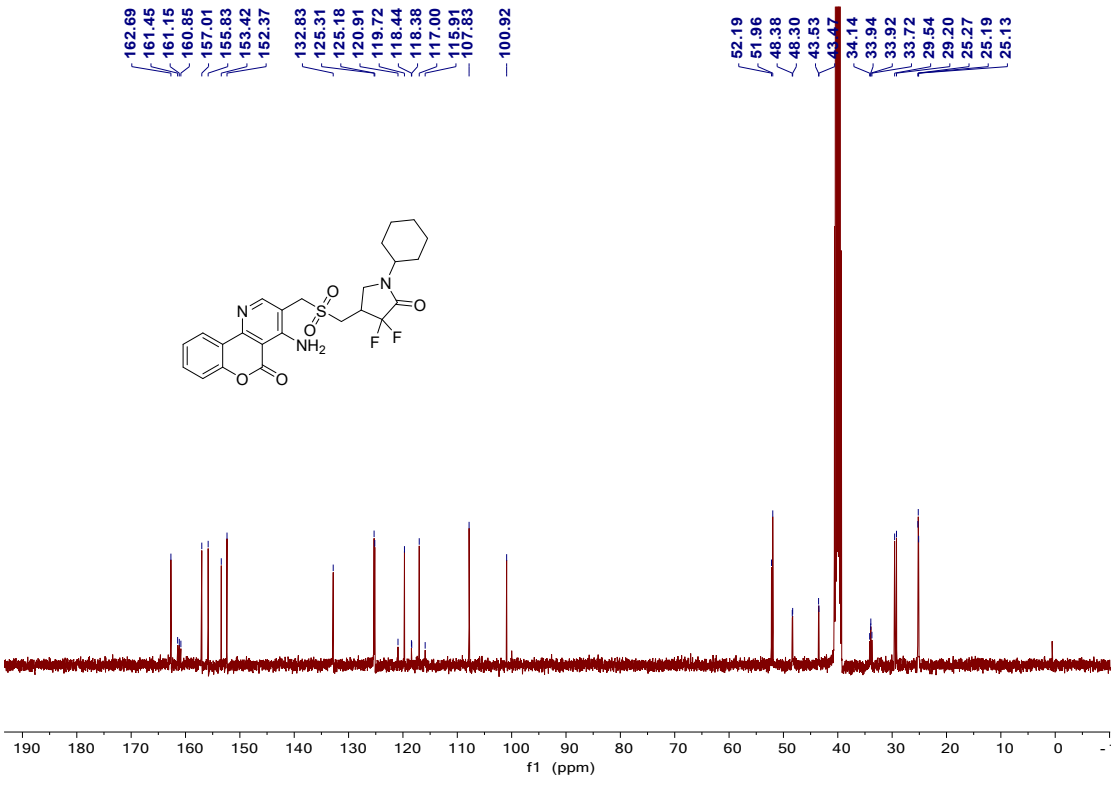
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7ar**



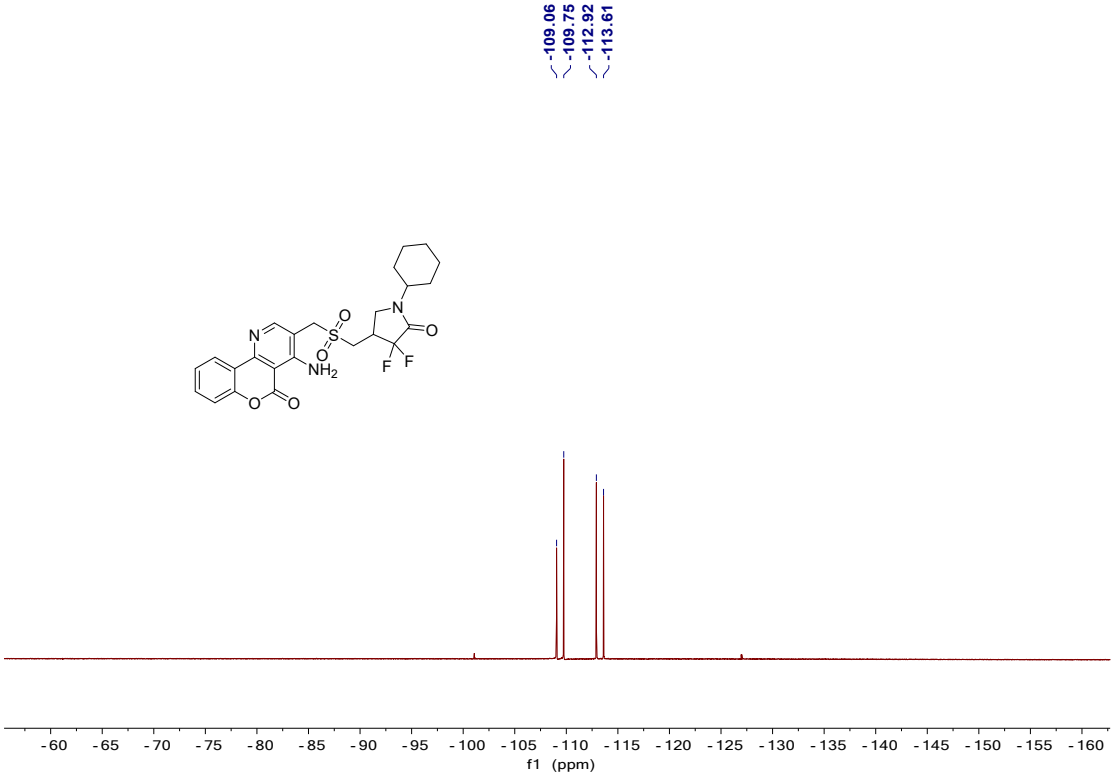
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7as**



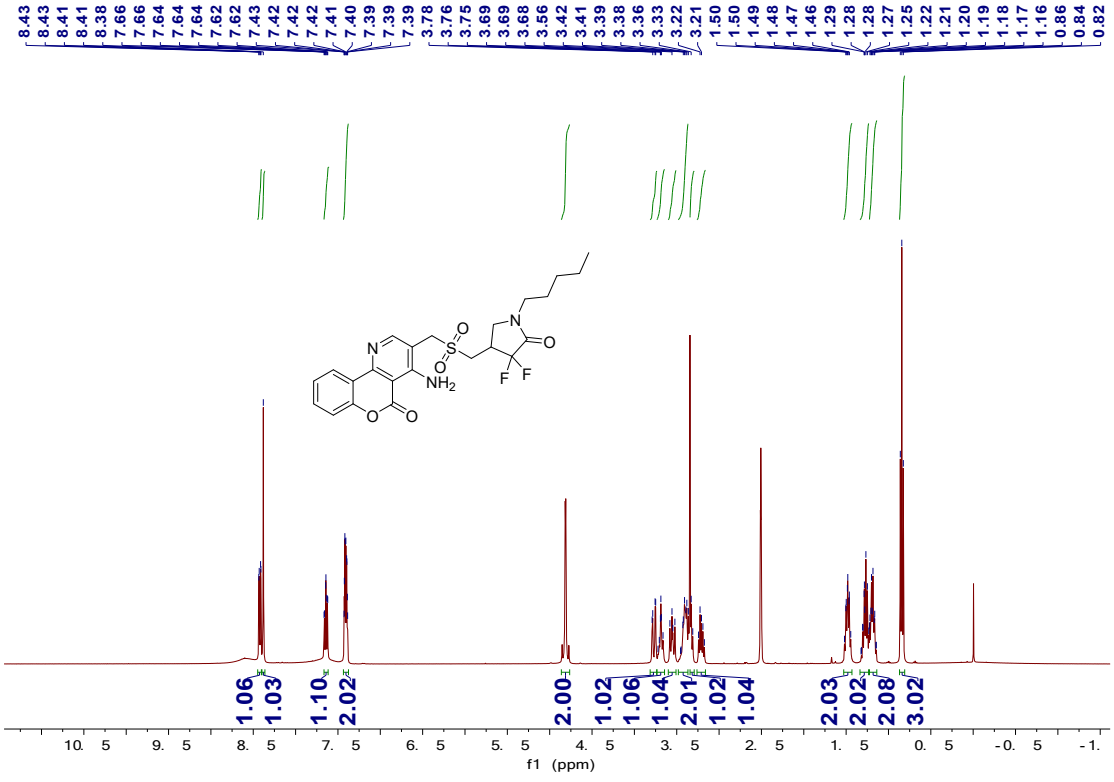
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7as**



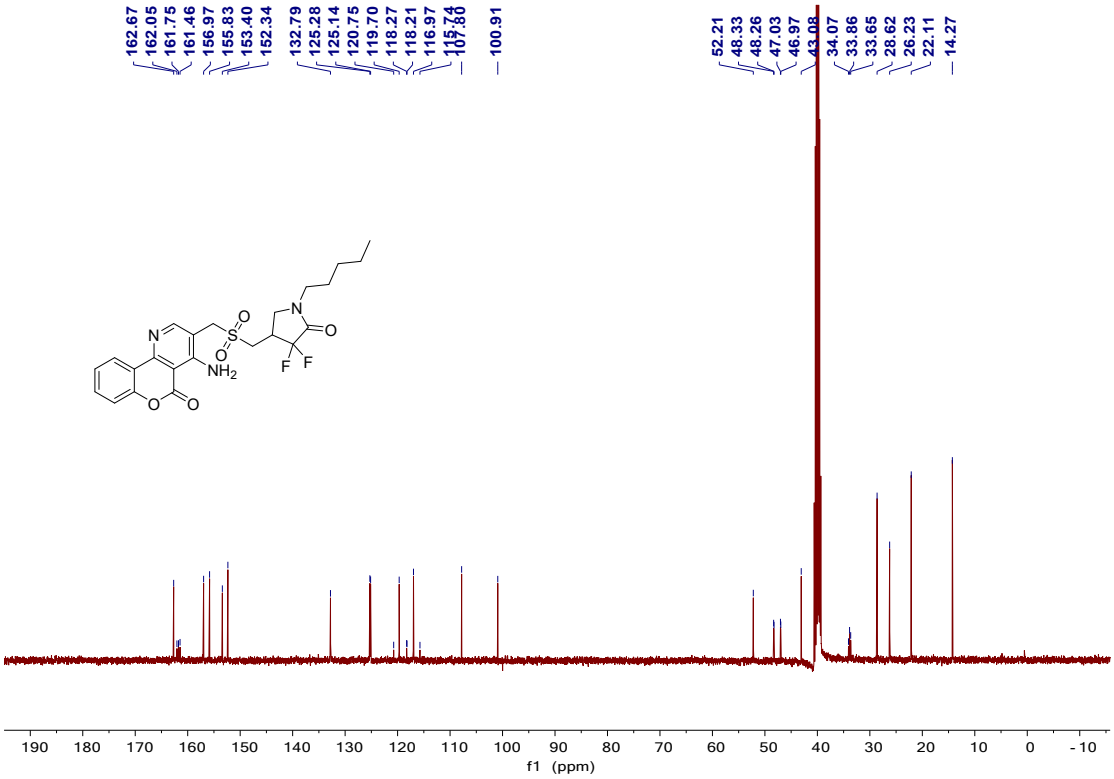
[19]F NMR-spectrum (376 MHz, DMSO-d6) of **7as**



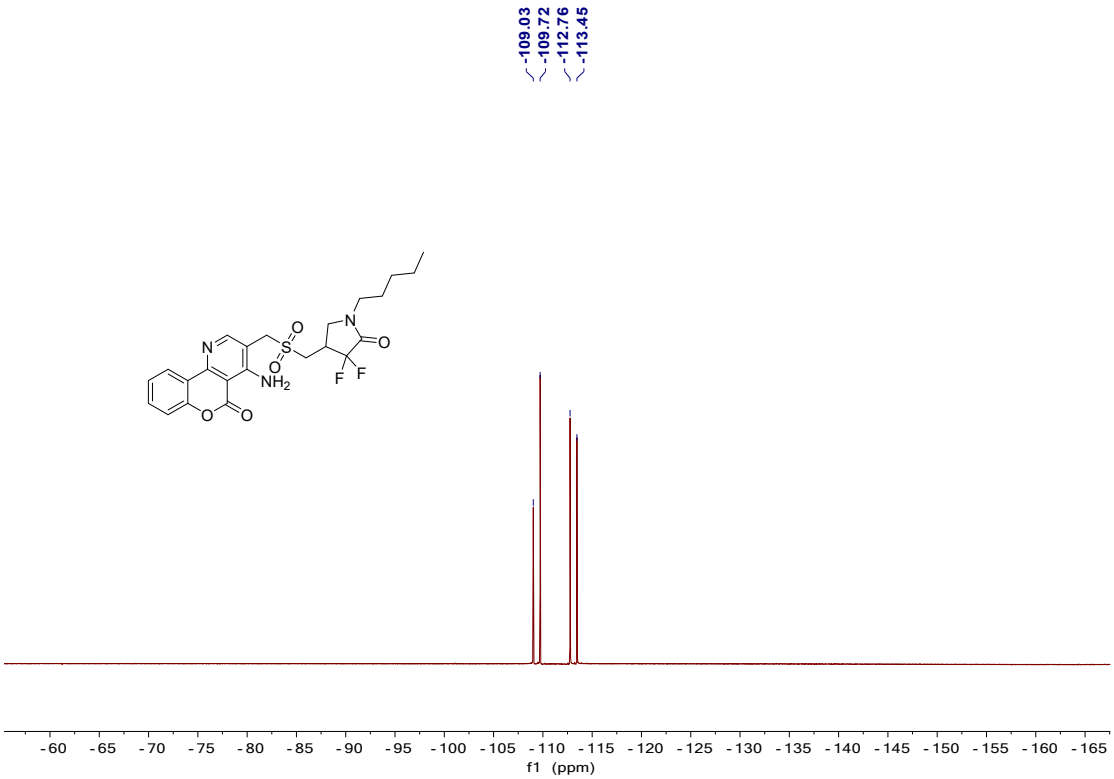
[1]H NMR-spectrum (400 MHz, DMSO-d_6) of **7at**



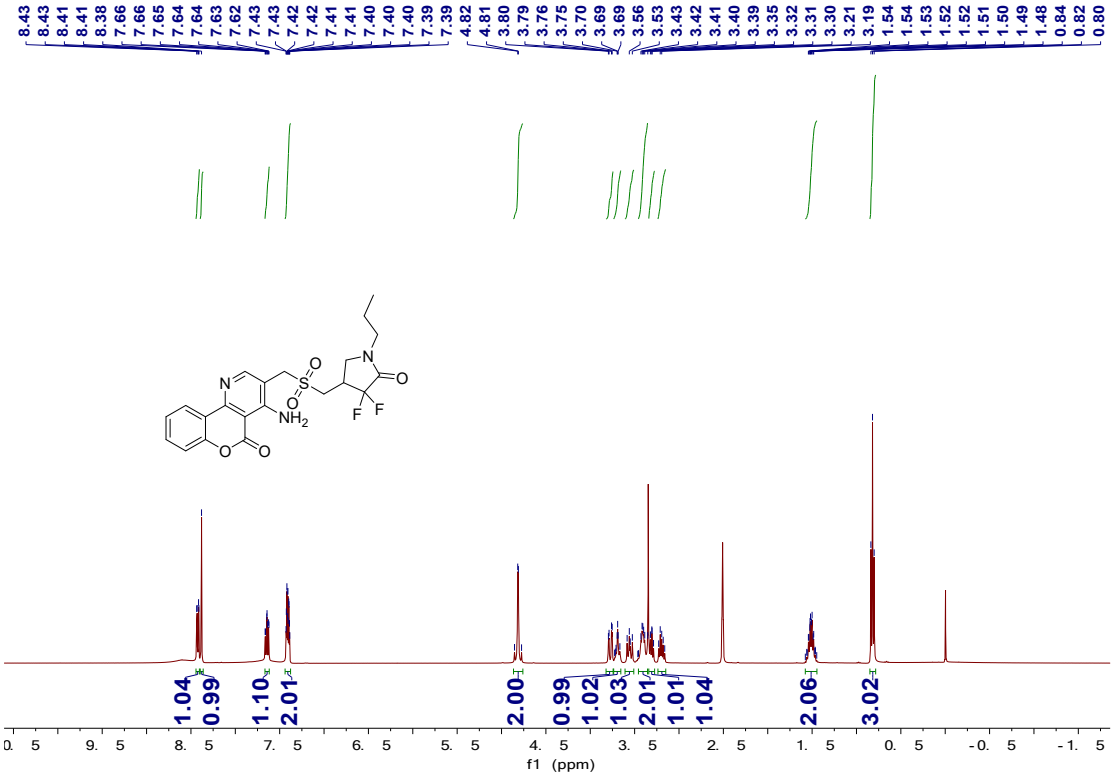
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7at**



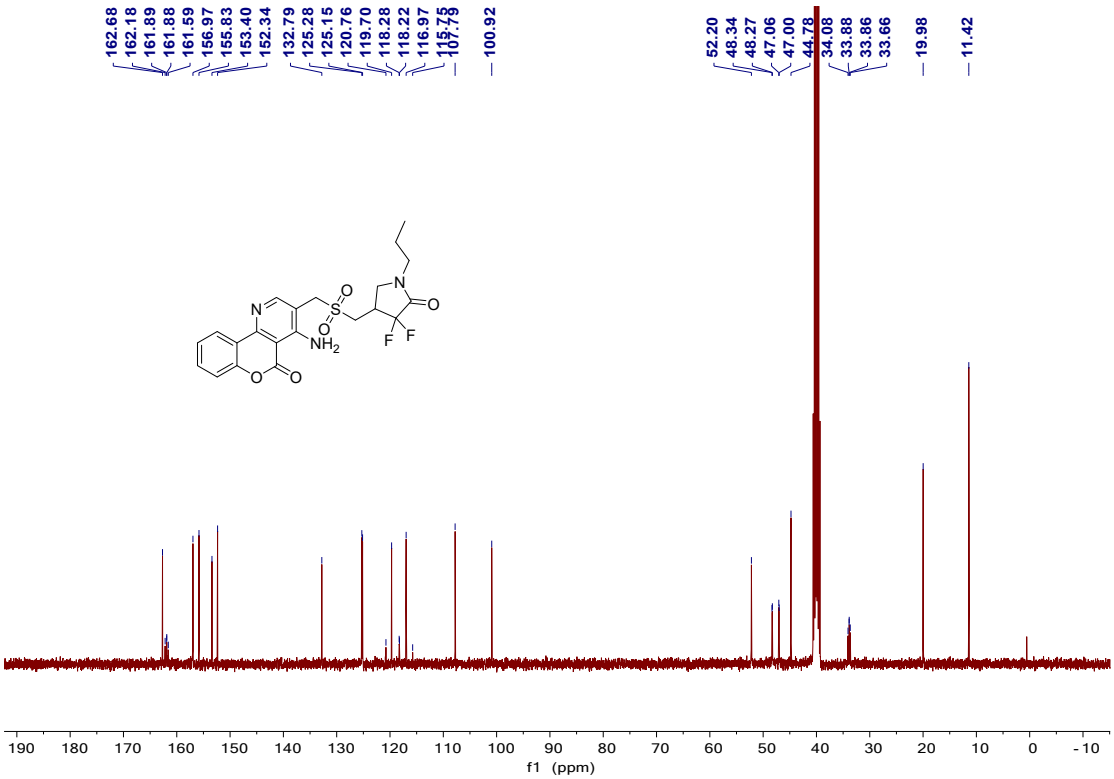
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7at**



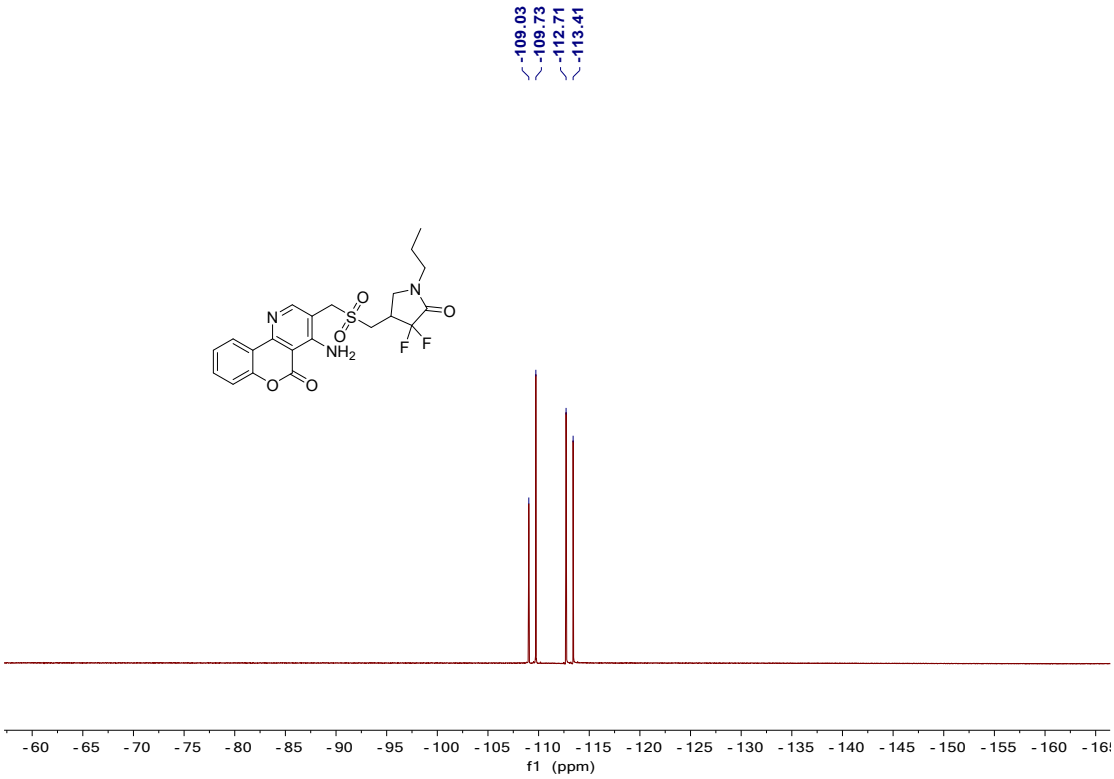
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7au**



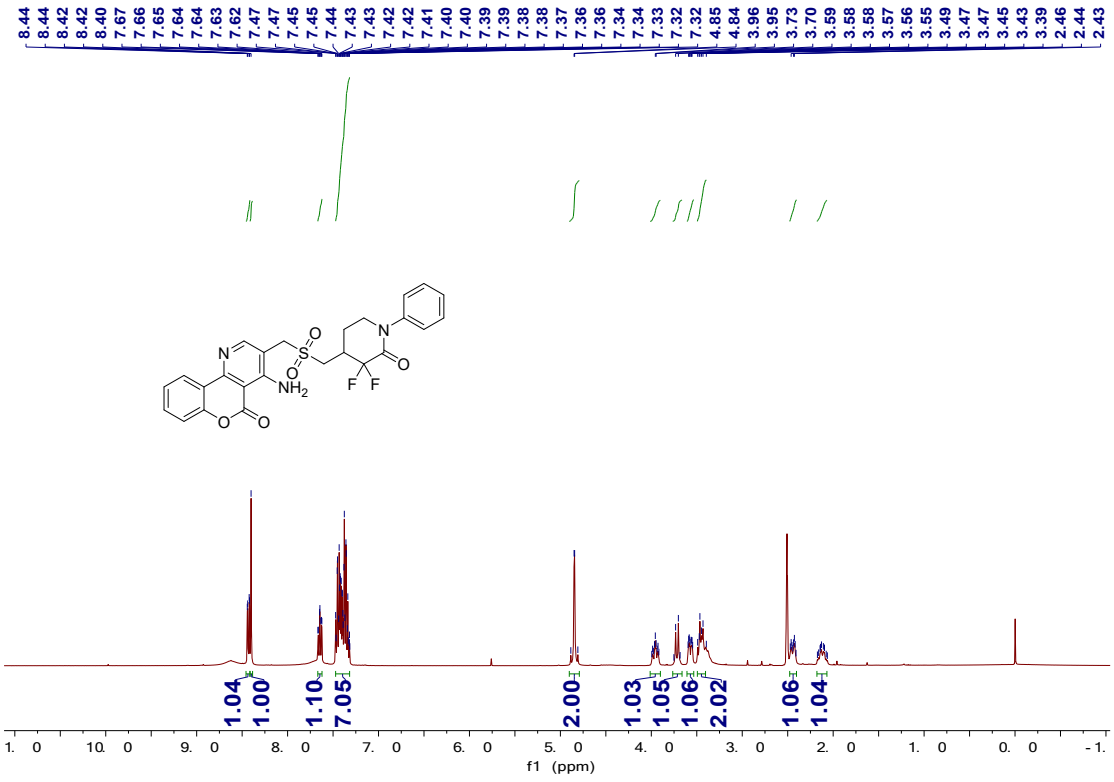
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7au**



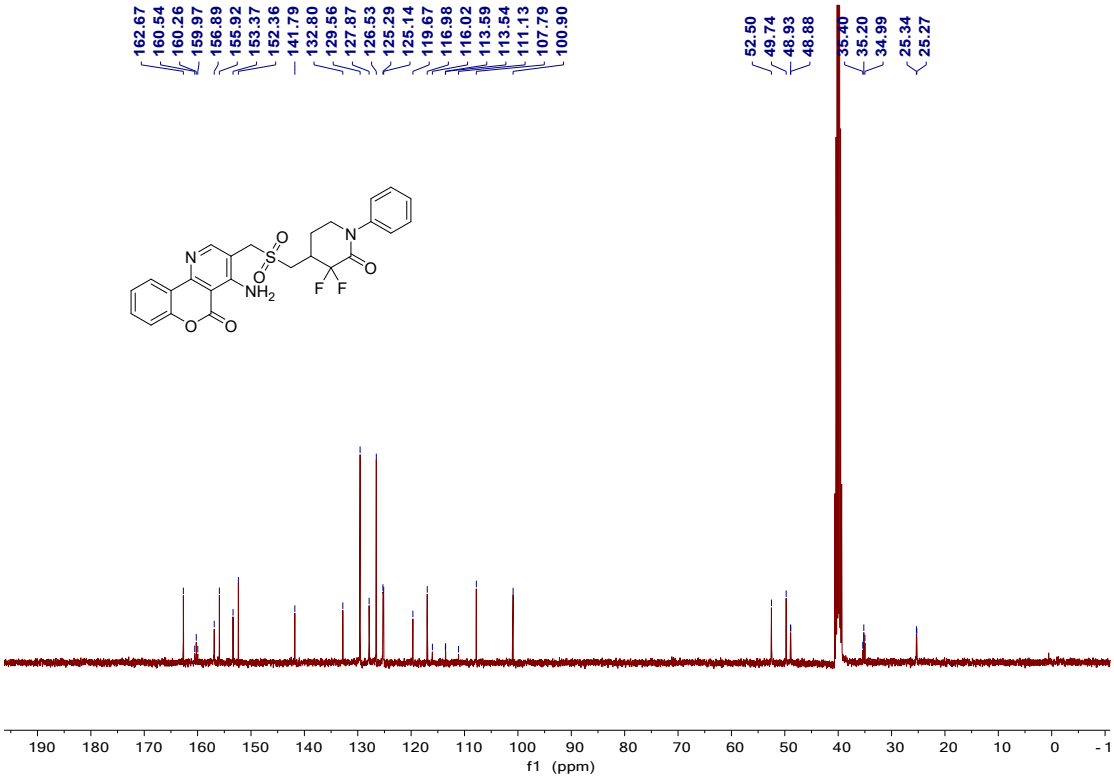
[19]F NMR-spectrum (376 MHz, DMSO-d6) of **7au**



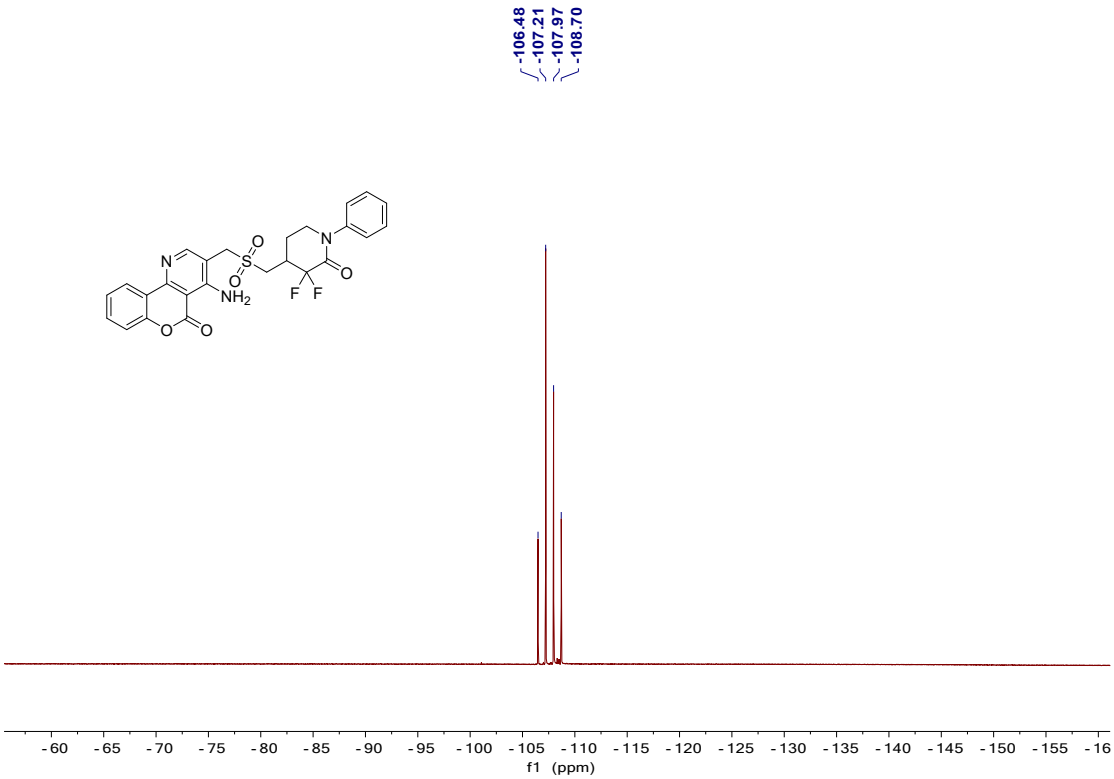
[1]H NMR-spectrum (400 MHz, DMSO-d_6) of **7av**



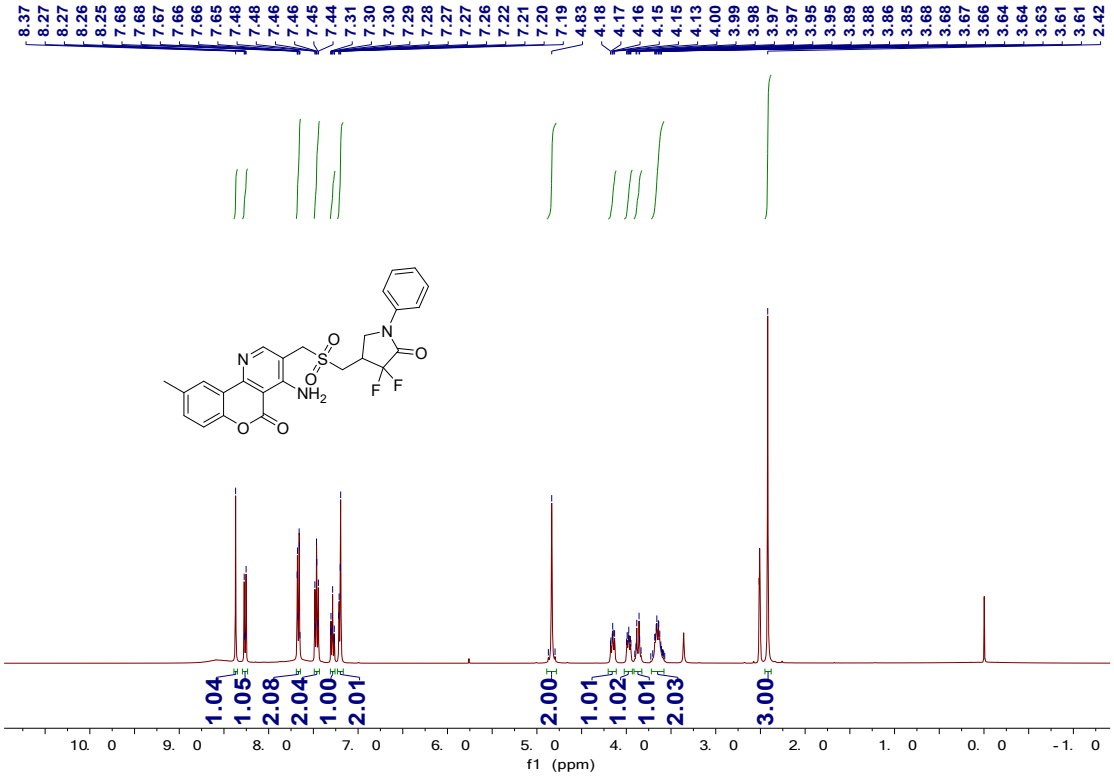
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7av**



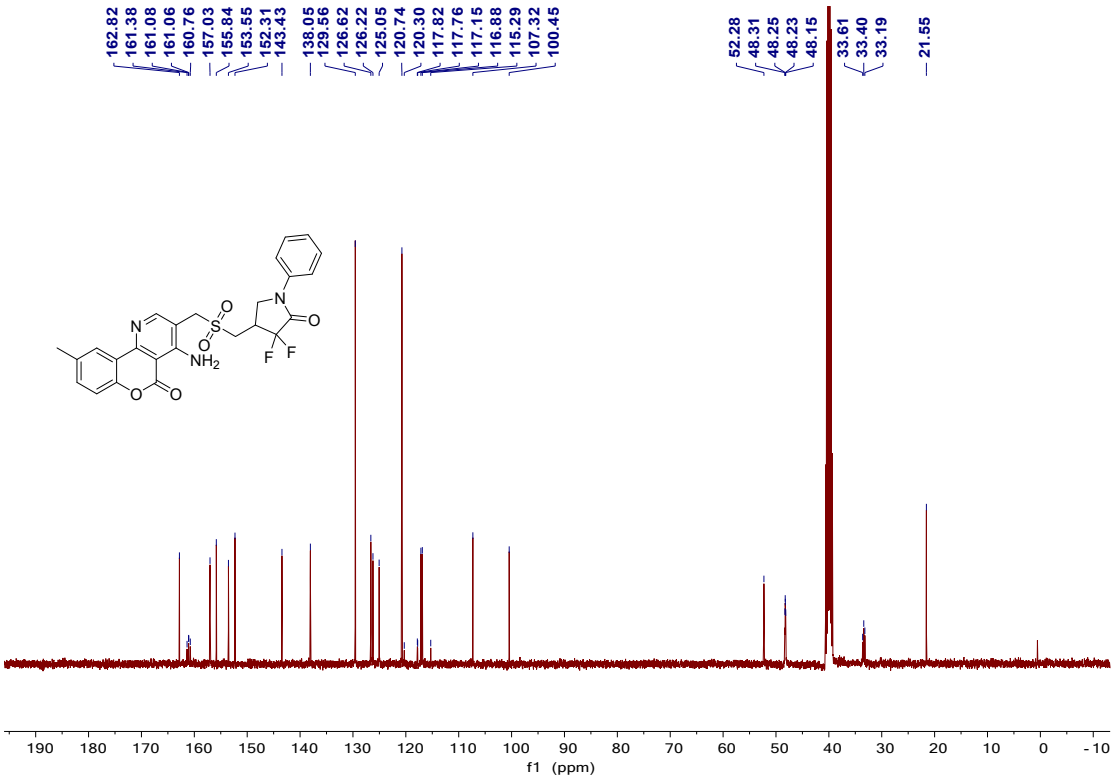
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7av**



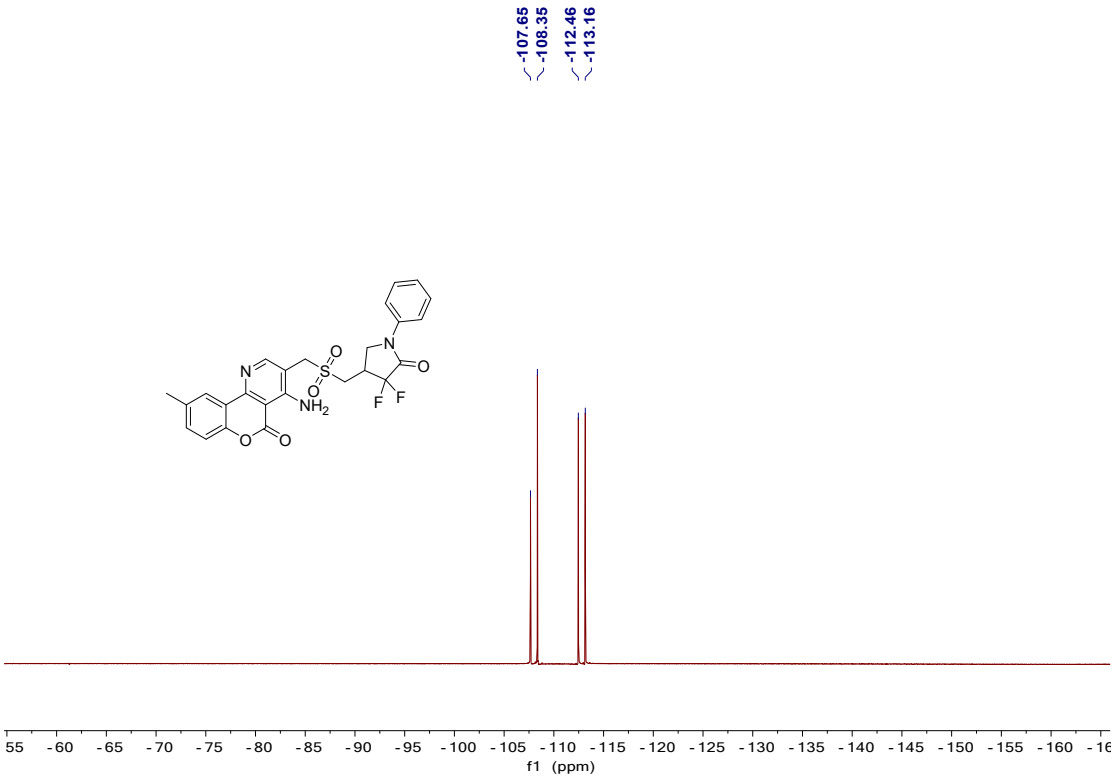
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7aw**



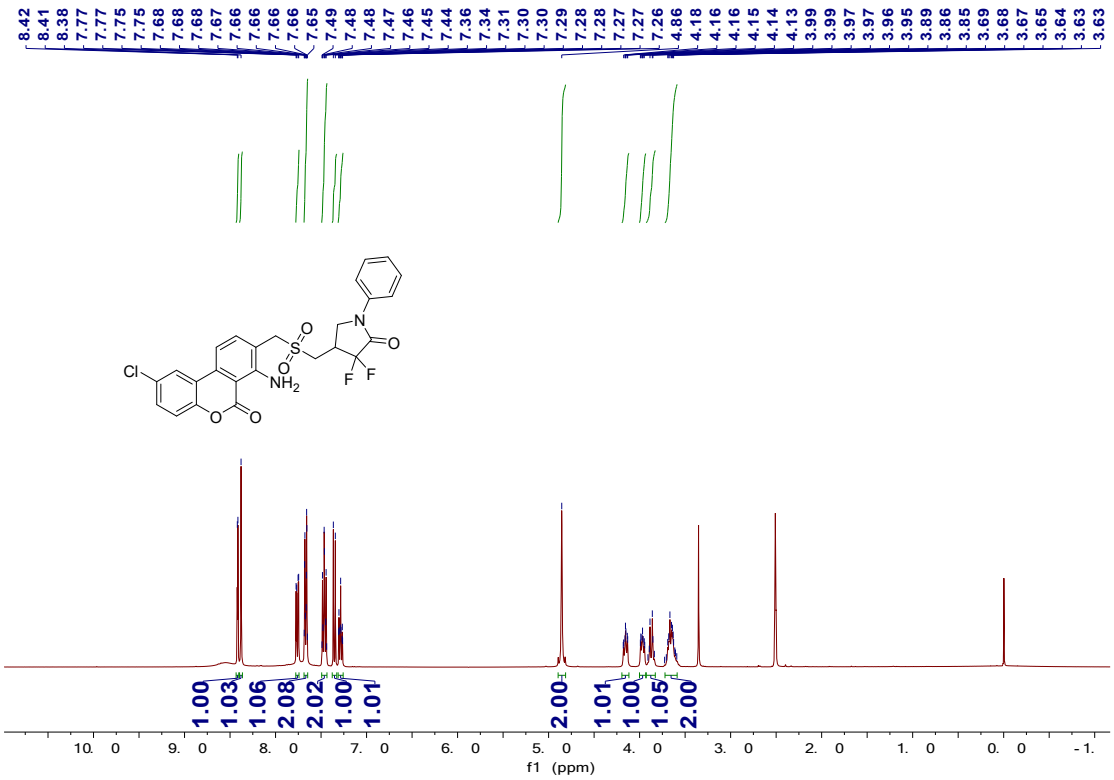
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7aw**



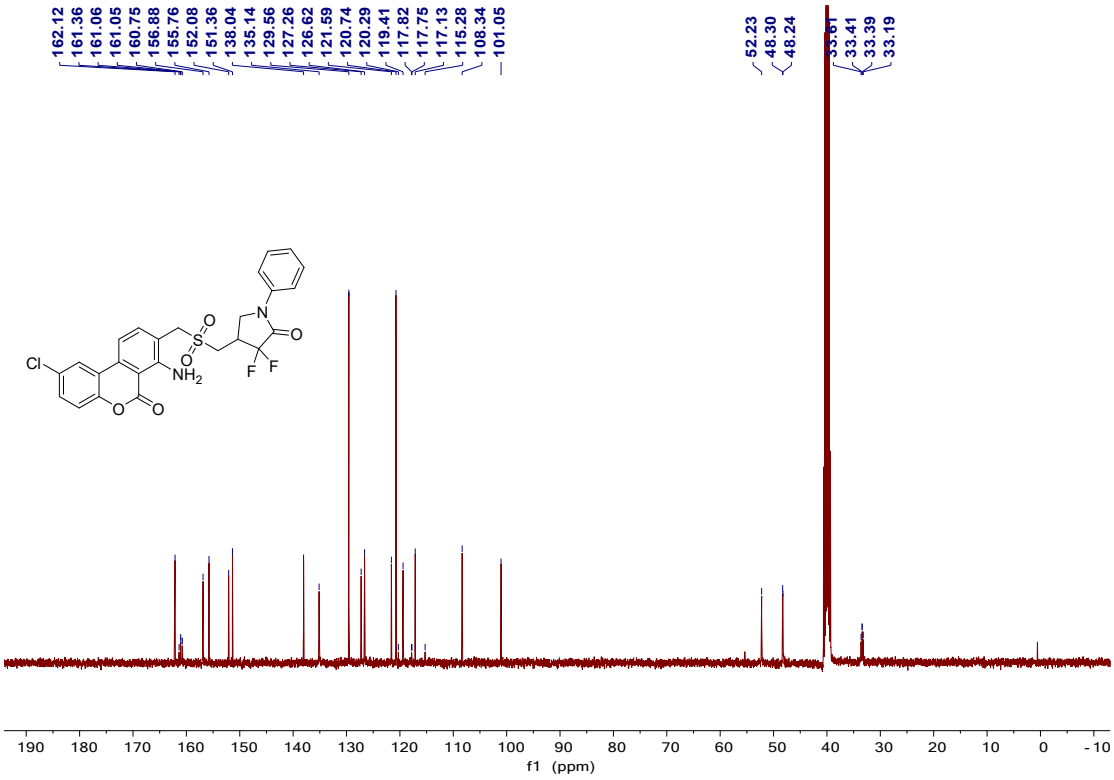
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7aw**



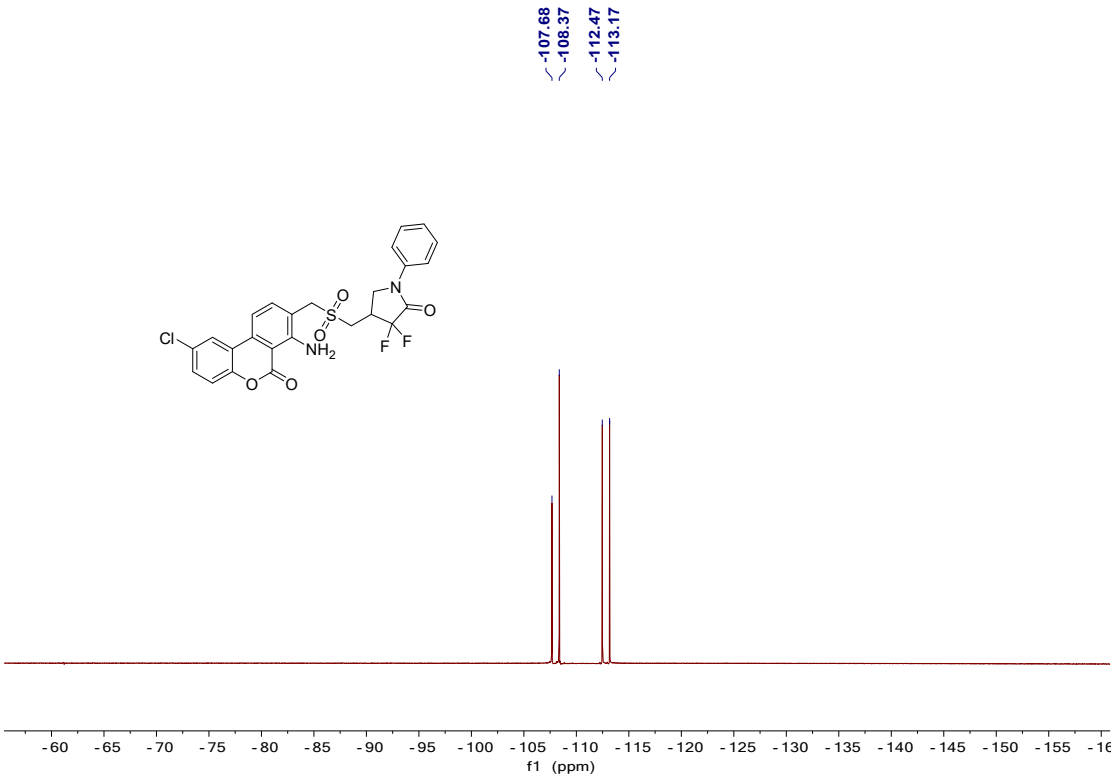
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7ax**



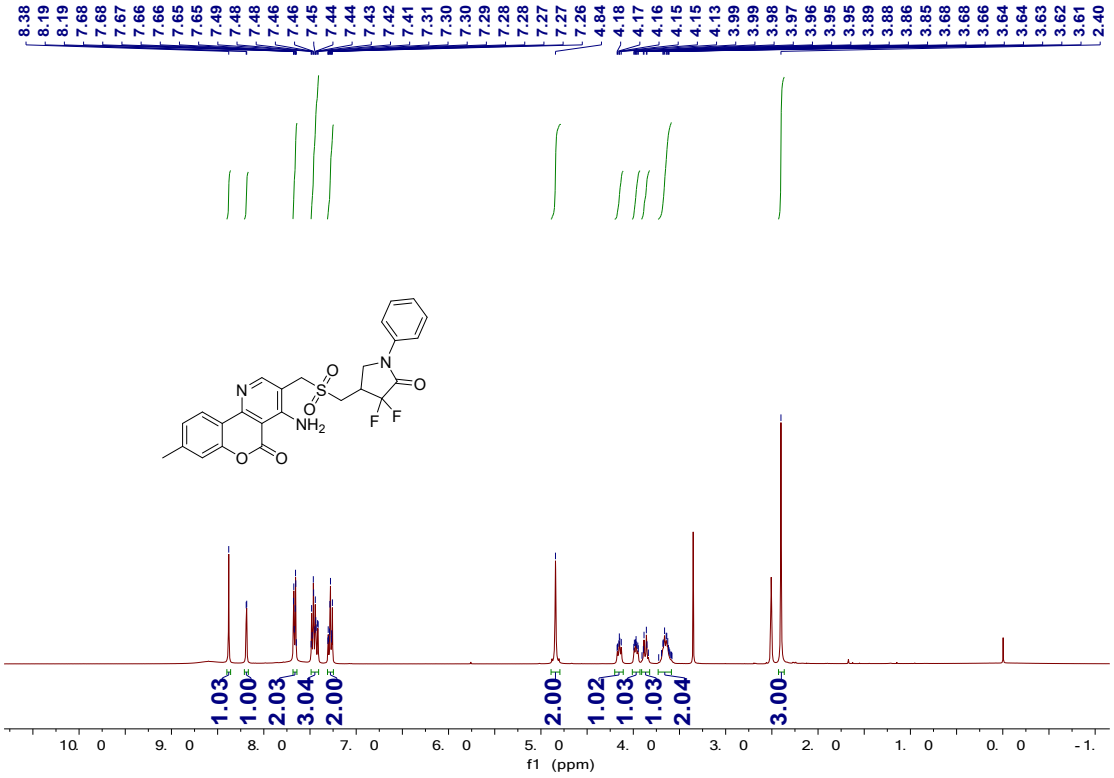
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7ax**



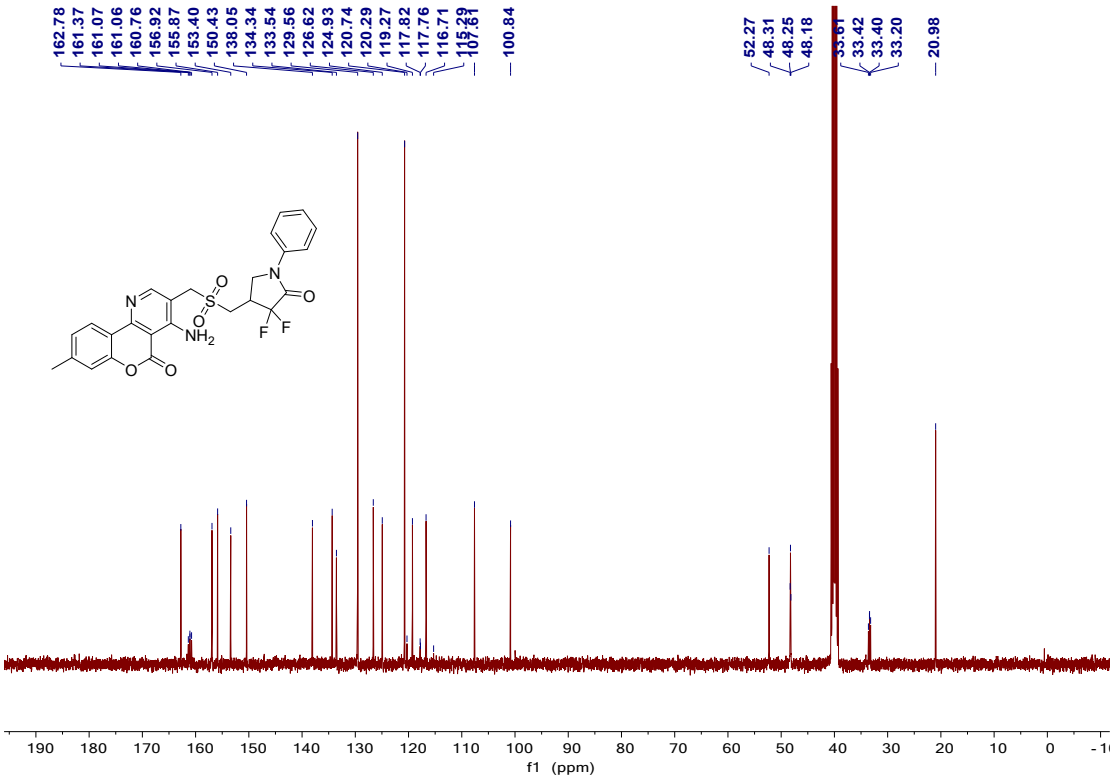
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7ax**



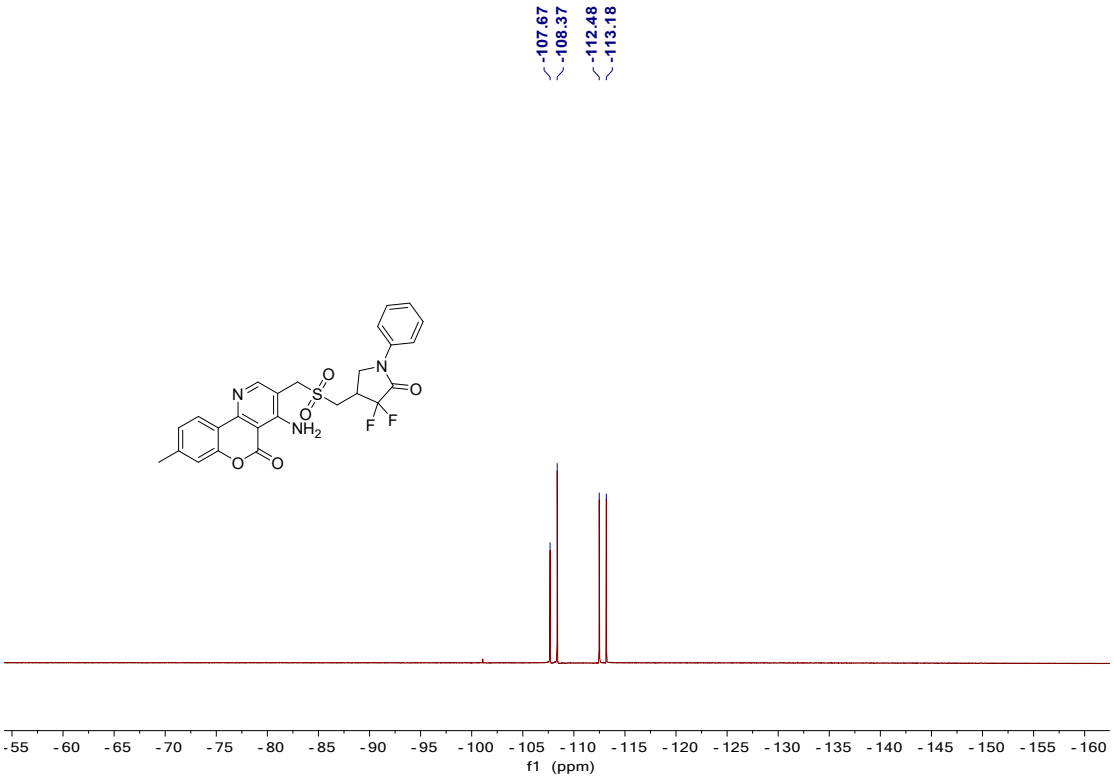
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **7ay**



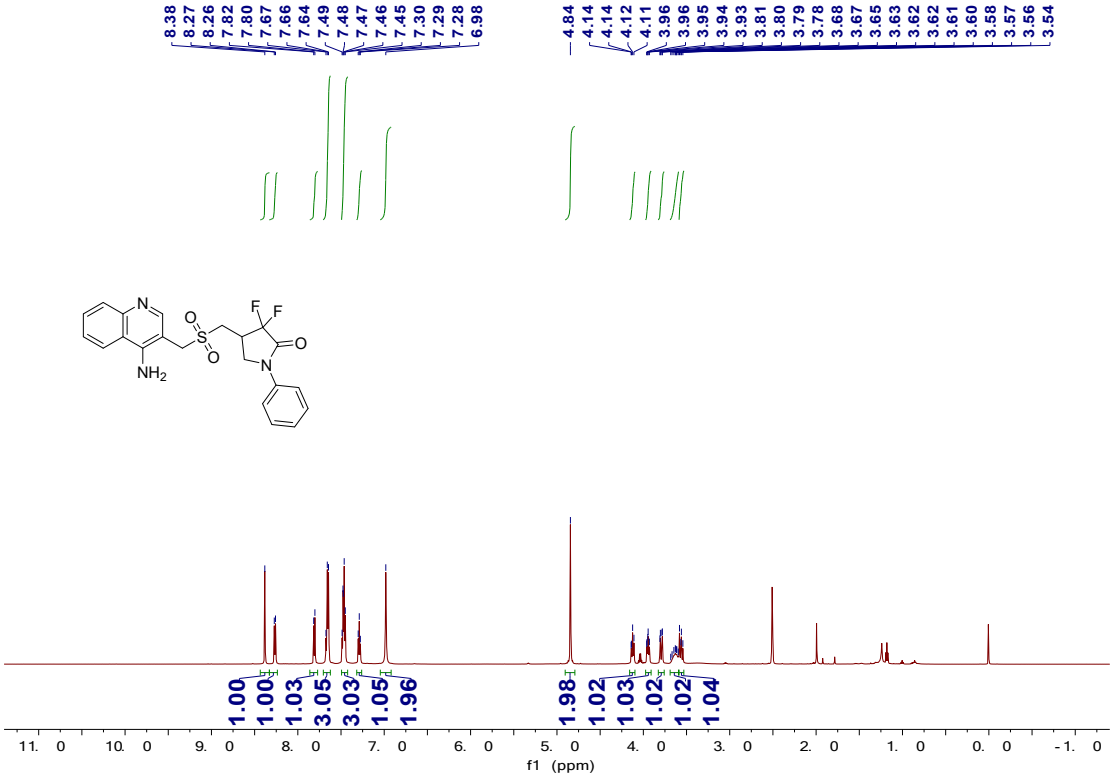
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **7ay**



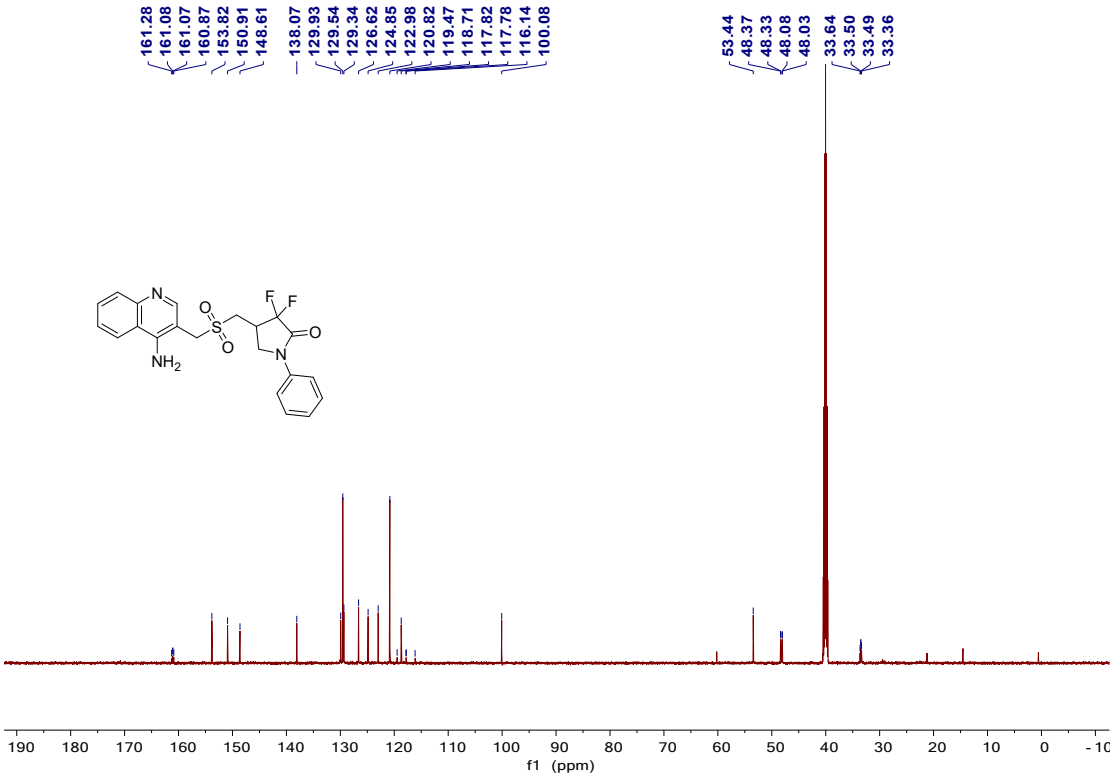
^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **7ay**



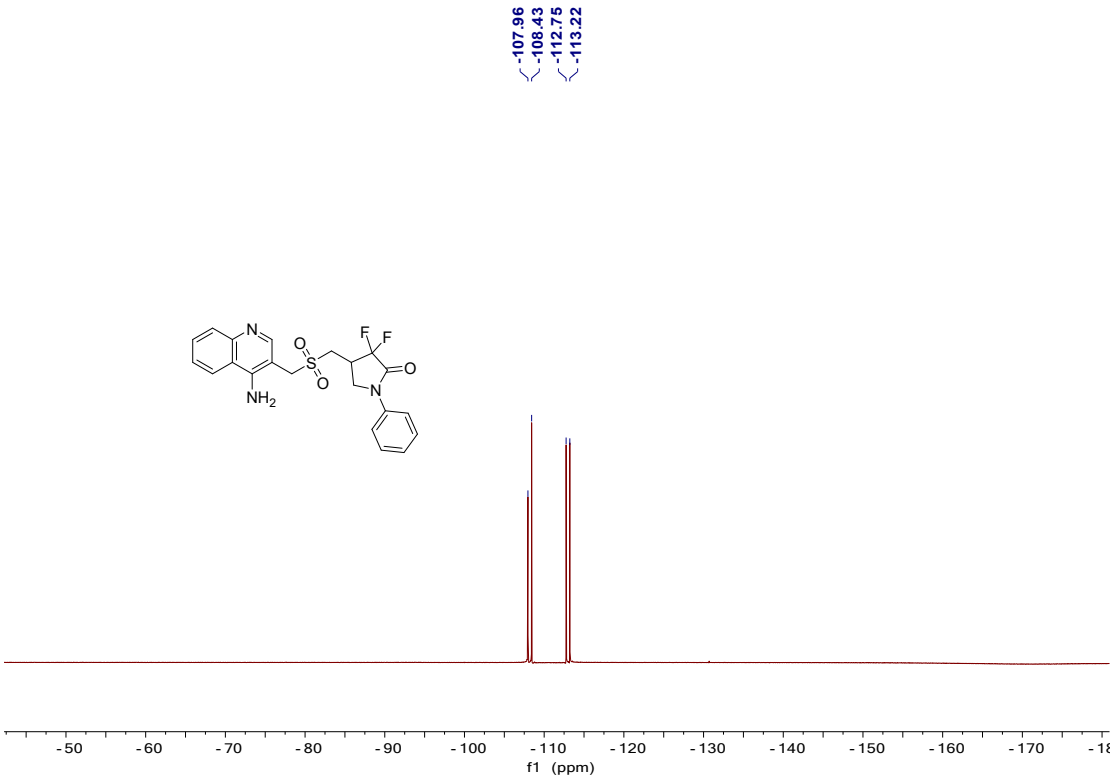
^{1}H NMR-spectrum (600 MHz, DMSO-d_6) of **9a**



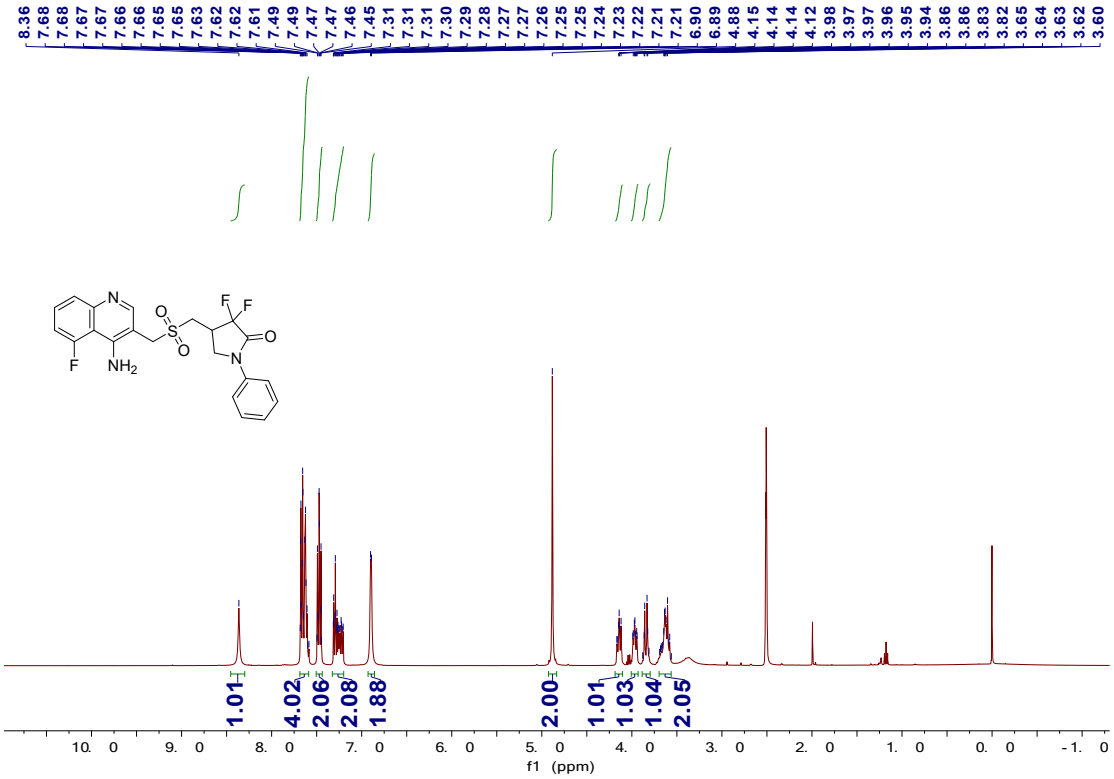
^{13}C NMR-spectrum (151 MHz, DMSO-d_6) of **9a**



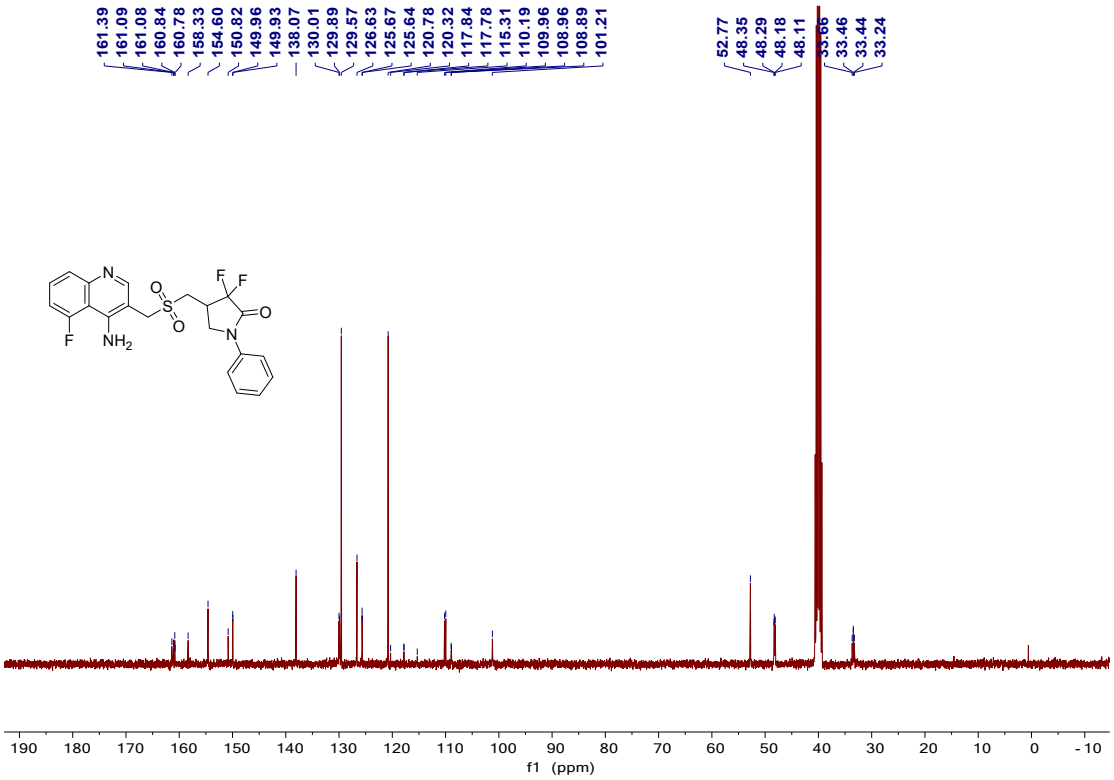
^{19}F NMR-spectrum (565 MHz, DMSO-d6) of **9a**



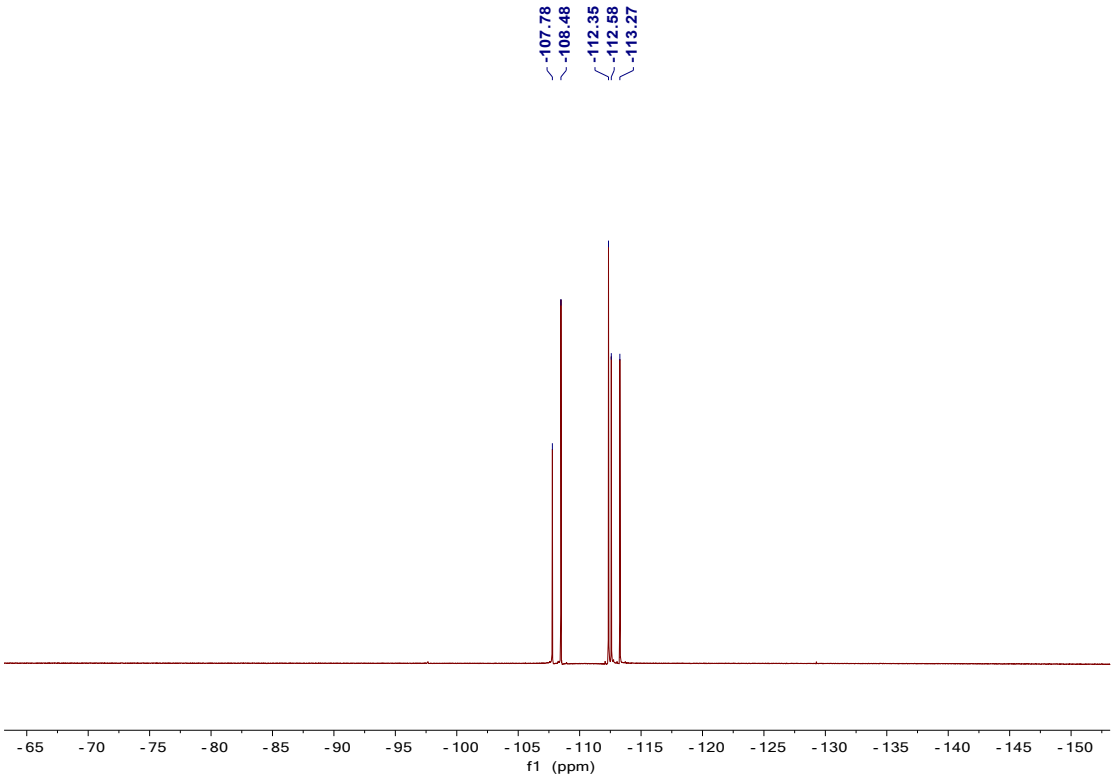
^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **9b**



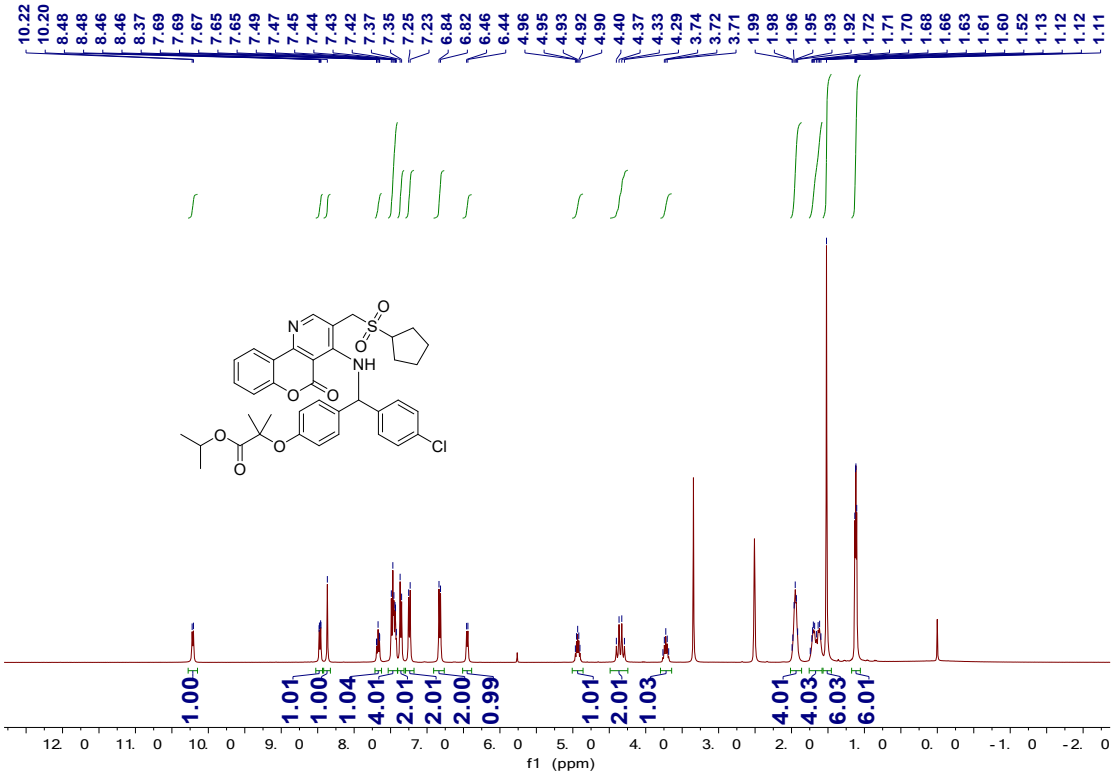
^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **9b**



^{19}F NMR-spectrum (376 MHz, DMSO-d6) of **9b**



^{1}H NMR-spectrum (400 MHz, DMSO-d_6) of **11**



^{13}C NMR-spectrum (101 MHz, DMSO-d_6) of **11**