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One-pot chemo/regio/stereoselective generation of library of functionalized spiro-oxindoles/pyrrolizines/pyrrolidines from *α*–aroylidineketene dithioacetals

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Abstract: An efficient chemo/regio/stereoselective synthesis of novel and functionalized spiro-oxindole/pyrrolizine/pyrrolidine scaffolds has been achieved. The *in situ* generated azomethine ylide from isatin & L-proline/phenyl alanine underwent 1,3-dipolar cycloaddition with *α*-aroylidineketene dithioacetals under simple reaction conditions affording spiro-oxindole derivatives. This protocol exhibits an interesting double bond selectivity of *α*-aroylidineketene dithioacetals. Furthermore, utilizing these spiro-oxindoles scaffold, biologically important benzimidazole and pyrimidine based polyheterocycles were also synthesized.

Introduction

Assembly of polycyclic frameworks is a fascinating topic of interest to many researchers in modern organic chemistry.[1] The framework present in spiro-oxindole core is part of large number of bioactive, naturally occurring alkaloids and medicinally relevant compounds.[2-4] For example, the naturally occurring (-)-horsfiline,[5] spirotryptostatin A&B,[6] (+)-elacomine,[7] alstonisine[8] and MI-129[9] comprise spiro-oxindole skeleton (Figure. 1). These compounds were reported to show antibacterial, antitumor, antibiotic,[10-11] antitubercular[12] and anti-infective properties.[13] At the same time, the highly substituted pyrrolidine system is constituted as core skeleton of many natural products.[14]

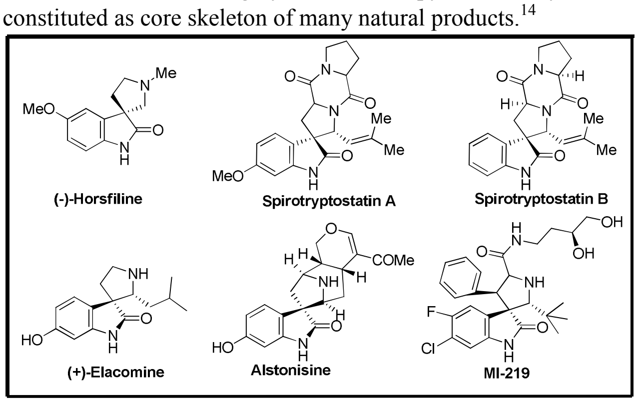


Figure 1: Biologically important Spiro-oxindoles/pyrrolidine scaffold

The 1,3-dipoar cycloaddition is one of the most prominent protocol to construct spiro-oxindoles[15] starting from simple substrates.[16] This is exemplified by the increased number of publications depicting the synthesis of novel spiro heterocycles *via* 1,3-dipolar cycloaddition with different dipolarophiles in recent time.[17-19] In particular, the multicomponent 1,3-dipolar cycloaddition of azomethine ylides generated *in situ* from the decarboxylative condensation of 1,2-dicarbonyl compounds and *α*-amino acids to exocyclic olefinic dipolarophiles have attracted a great deal of attention.[20]

In addition, cycloaddition on various dipolarophiles such as di and tribenzylidine acetone has been extensively studied.[21] Recently, we have reported a chemo/regioselective synthesis of 6-pyrrolylpyrimidine by 1,3-dipolar cycloaddition of *α*-aroylidineketene dithioacetals, (*p*-tolylsulfonyl)methyl isocyanide (TosMIC) and guanidine nitrate *via* a multicomponent reaction.[22]

Multicomponent reactions[23] (MCRs) are eco-friendly reactions wherein three or more components react to yield complex molecules with high atom economy by incorporating all the starting materials. MCRs are cost and time effective and afford the desired products in good yield under simple and mild reaction conditions[24] in synthetic organic chemistry and drug discovery programs.[25] These synthetic methods provide quick access to offer more powerful platform to assemble libraries of structurally complex molecules.[26]

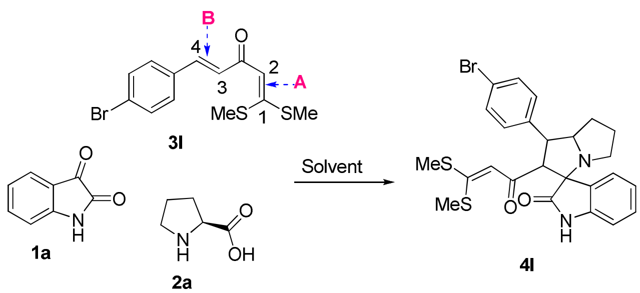
Over the decades, *α*-aroylidineketene dithioacetals **3** have emerged as versatile intermediates in organic synthesis to synthesize substituted and fused aromatic heterocyclic frameworks.[22,27] In the present work, we report the multicomponent reaction involving a 1,3-dipolar cycloaddition of **3**, isatin and *α*-amino acid to afford spiro-oxindole derivatives. To the best of our knowledge, this is the first report on the synthesis of spiro-oxindole derivatives from *α*-aroyilidineketene dithioacetals **3**.

Results and Discussion

Following our reported procedure[22] variety of *α*-aroylidineketene dithioacetals **3** were synthesized by condensing

4,4-bis(methylthio)but-3-en-2-one with various aryl/heteroaryl aldehydes under basic conditions in excellent yields. For the preliminary investigation, the cycloaddition of isatin **1a**, L-proline **2a** and **3l** was performed in acetonitrile (ACN) at 70 ºC for 90 min (Table 1, entry 1). This condition results only one product which was characterised as 2'-(3,3-bis(methylthio)acryloyl)-1'-(4-bromophenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one **4l** which reveals that the *in situ* generated azomethine ylide undergoes a 1,3-dipolar cycloaddition only on the double bond **B** of **3** rather than **A**. The more polar nature of push-pull alkene (**A**) of **3**, prevents the double cycloaddition even though isatin and L-proline were taken as excess.

Table 1: Optimization of the reaction conditions for three component synthesis of **4l**[a]



Entry	Solvent[e]	temp (ºC)	time (min)	Yield[b] (%)
1	ACN	70	90	90
2	EtOH	90	90	89
3	**MeOH**	**65**	**60**	**99**
4	MeOH	rt	120	65
5	MeOH/H_2O	65	90	65[c]
6	EtOH/H_2O	80	90	70[c]
7	IPA	80	4[d]	50
8	THF	69	90	50[c]
9	1,4-dioxan	90	60	78[c]
10	DMF	100	60	92[c]
11	DCM	40	90	96[c]
12	Benzene	65	60	88[c]
13	Toluene	100	60	85[c]

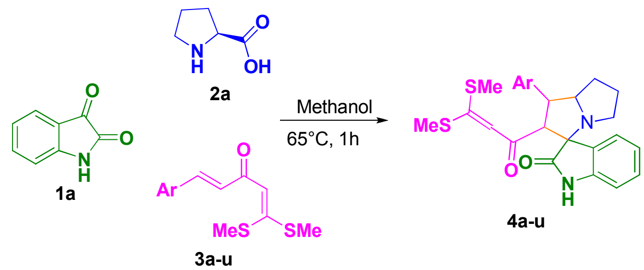
[a] *α*-aroylidineketene dithioacetals **3l** (1mol), Isatin **1a** (1mol) and L-proline **2a** (1mol), Solvent (10Vol), temp, time. [b] Isolated yields. [c] Yields after column chromatography. [d] reaction time in hour, [e] reactions performed at the boiling points of the respective solvents.

This selective cycloaddition is significant to build a library of polyheterocycles for screening. An efficient way to generate **4l** was encouraged us to further optimize the reaction conditions by varying the reaction temperature and solvent (Table 1).

Solvent plays a crucial role in the effective formation of **4l** in high yield. Compound **4l** was isolated in 89% yield, when isatin **1a** and L-proline **2a** was heated with dipolarophile **3l** for 90 min at 90 ºC in ethanol (Table 1, entry 2). Almost quantitative yield 99% was obtained when the cycloaddition was performed in methanol (Table 1 entry 3), while other alcoholic solvents such as ethanol, isopropyl alcohol (IPA) gave only moderate yields (Table 1 entries 1&7). Notably, cycloaddition using methanol at room temperature suppressed the product yield (Table 1, entry 4).

Meanwhile, diluting the reaction could dramatically reduce the yield of **4l** (Table 1, entries 5&6). Aprotic solvents like THF (Table 1, entry 8) and 1,4-dioxane (Table 1, entry 9) provided reduced yields, while polar aprotic solvent like DMF (Table 1, entry 10) gave **4l** in 92% yield. Quite impressively, the corresponding product **4l** was obtained in 96% yield in dichloromethane (Table 1, entry 11). The product yield was drastically reduced, when the reaction was conducted in nonpolar solvents such as benzene and toluene (Table 1, entries 12&13).

Table 2: One-pot multicomponent synthesis of 2'-(3,3-bis(methylthio)acryloyl)-1'-(aryl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one **4**[a]



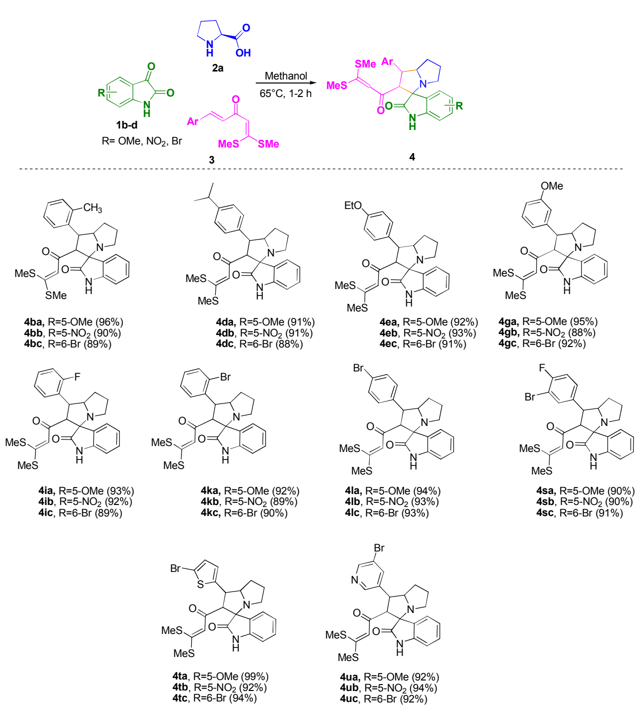
Entry	Ar **3**	Product	Yield[b] (%)
1	C_6H_5	**4a**	91
2	2-CH_3-C_6H_4-	**4b**	94
3	4-CH_3-C_6H_4-	**4c**	92
4	4-$CH(CH_3)_2$-C_6H_4	**4d**	95
5	4-OEt-C_6H_4	**4e**	96
6	2-OMe-C_6H_4	**4f**	92
7	3-OMe-C_6H_4	**4g**	90
8	4-OMe-C_6H_4	**4h**	96
9	2-F-C_6H_4	**4i**	93
10	4-F-C_6H_4	**4j**	98
11	2-Br-C_6H_4	**4k**	94
12	4-Br-C_6H_4	**4l**	99
13	4-CN-C_6H_4	**4m**	88
14	2,4-Cl_2-C_6H_3	**4n**	90
15	2,4-F_2-C_6H_3	**4o**	91
16	3,4-OMe.C_6H_3	**4p**	90
17	2-OMe,5-Br-C_6H_3	**4q**	86
18	2-Cl,5-NO_2-C_6H_3	**4r**	88
19	3-Br,4-F-C_6H_3	**4s**	90
20	5-Br-C_4H_2S	**4t**	93
21	5-Br-C_5H_3N	**4u**	92

[a] Reaction conditions: **1a** (1mol), **2a** (1mol), **3a-u** (1mol), Methanol (10Vol), Reflux at 60 ºC for 1 h. [b] Isolated yield after recrystallization from ethanol/DCM mixture.

Polar solvents afforded **4l** as a solid after the initial work up without need of additional purification. The 1,3-dipolar cycloaddition of **3l** (1mol), isatin **1a** (1mol), and L-proline **2a** (1mol) in methanol at 65 ºC for 60 min *via* MCR was found to be the best optimized reaction condition to afford **4l** in excellent yield (Table 1, entry 3). We then examined the substrate scope and functional group tolerance of this new transformation under optimized condition, in order to find out the generality of the reaction (Table 2). A broad range of dipoles and dipolarophiles provided an access to diverse array of functionalized spiroindoline-pyrrolizine intermediates in excellent yield. Varying the substituents of dipolarophile, the reaction was compatible with all halogenated derivatives such as **4i, 4j, 4k, 4l, 4n, 4o** and **4s** in excellent yield (Table 2). Interestingly, dipolarophiles containing heterocyclic moieties such as **4t&4u** also provided the desired spiro scaffold without any difficulties (Table 2, entries 20&21).

We explored the possibility of generating azomethine ylide from substituted isatin and L-proline. Derivatives of isatins **1b-d** such as 5-methoxy, 5-nitro and 6-bromo were reacted with L-proline with various dipolarophiles underwent multicomponent cycloaddition to afford spiro-oxindoles **4** in excellent yields (Table 3). In all the cases, the product was isolated without the need of any additional purification (Table 3). The products **4** were well characterized by ^{1}H, ^{13}C, and mass spectral data.

Table 3: Scope of the isatin[a]



[a] All the reactions were carried out with **1b-d** (1mol), **2a** (1mol) and **3** (1mol) in 5mL of MeOH. [b] Isolated yield after recrystallization from ethanol/DCM mixture.

In order to determine the stereoselectivity, the structure of **4l** (Figure. 2)**, 4db** (Figure. 3) and **4kb** (Figure. 4) was confirmed by single crystal X-ray analysis.[28] This cycloaddition is stereoselective affording only one diastereomer of **4** exclusively, even though four stereocenters are present in these cycloadducts.

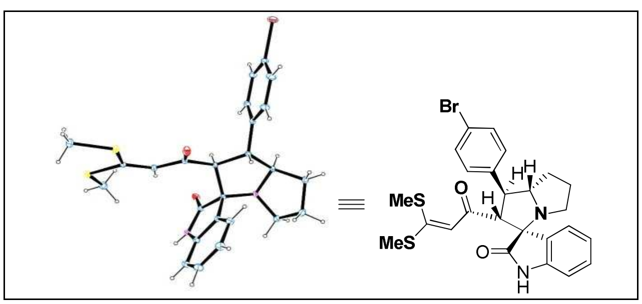


Figure 2: X-ray crystal structures of **4l**

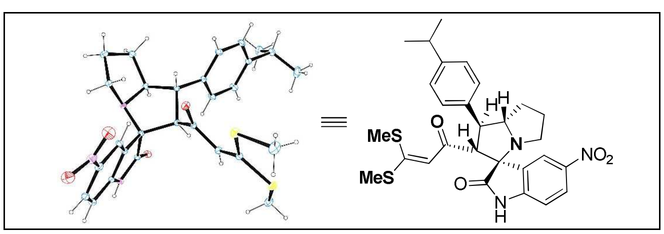


Figure 3: X-ray crystal structures of **4db**

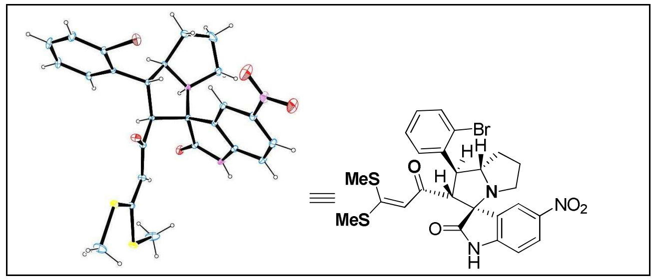
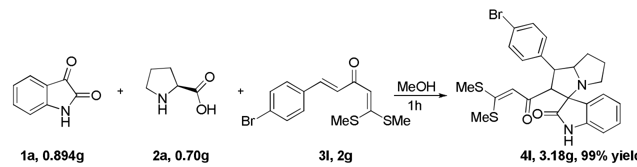


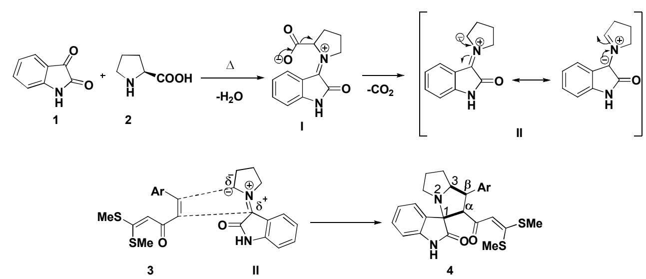
Figure 4: X-ray crystal structures of **4kb**

The present protocol was examined with **3l** by performed on a larger scale to give **4l** in excellent yield which reflects the generality and ease of performing on milligram scale (Scheme 1). It is worth mentioned that this could be highly important in the synthetic application.



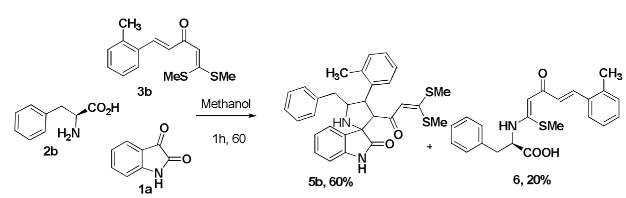
Scheme 1: Reaction of **1a**, **2a** and **3l** in gram scale

As shown in scheme-2, we postulated the plausible mechanism for the regio and stereoselective formation of spiro-oxindoles. Initially, the reaction proceeds *via* condensation of **1** and **2** to furnish intermediate imine **I** followed by loss of CO_2 to generate azomethine ylide **II**. Finally, electron rich carbon of azomethine ylide **II** undergoes 1,3-dipolar cycloaddition selectively with *β*-carbon of double bond **B** of **3** to afford spiro-cycloadducts **4** with four stereogenic center.



Scheme 2: Plausible mechanism for **4**

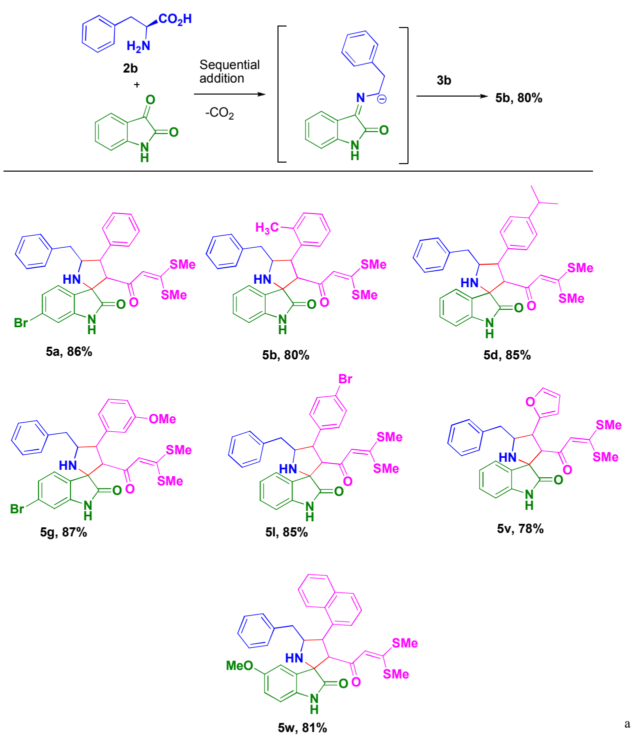
To elaborate the scope of this present protocol, L-proline was replaced with primary amino acid such as L-phenyl alanine **2b** (Scheme 3). The cycloaddition of **3b**, **1a** and L-phenylalanine **2b** were performed under the optimized reaction conditions to furnish 60% yield of expected product **5b** along with 2-((1*Z*,4*E*)-5-(4-methoxyphenyl)-1-(methylthio)-3-oxopenta-1,4-dienylamino)-2-phenylacetic acid **6** in 20% yield (Scheme 3, confirmed by LC-MS).



Scheme 3: Three component synthesis of **5b** using primary amino acid[a]

To avoid the formation of *S,N*-acetal **6**, the sequential addition was performed by mixing phenylalanine **2b**, isatin **1a** together for 15 min, once the formation of azomethine ylide was confirmed the compound **3b** was added to the mixture to reflux for 1h. The sequential cycloaddition was successful to afford **5b** in 80% yield. Using this technique several novel spiro-pyrrolidine **5** were synthesized in good yield (Table 4). The structure of **5g** was confirmed on the basis of single crystal x-ray analysis[28] (Figure. 5).

Table 4: Synthesis of functionalized spiro-pyrrolidine derivatives **5** *via* sequential addition



Reaction conditions: (i) **1** (1mol), **2b** (1mol), Methanol (10Vol), RT, 15 min. (ii) **3** (1mol) reflux at 60 ºC for 1h. [b]Yields after column chromatography.

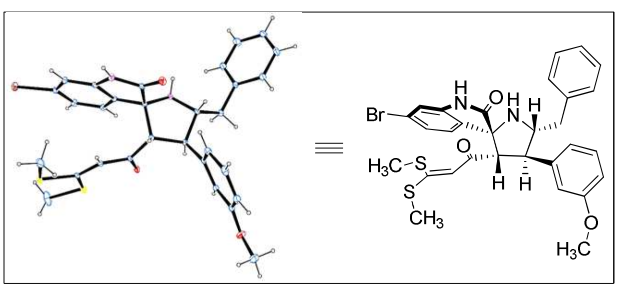
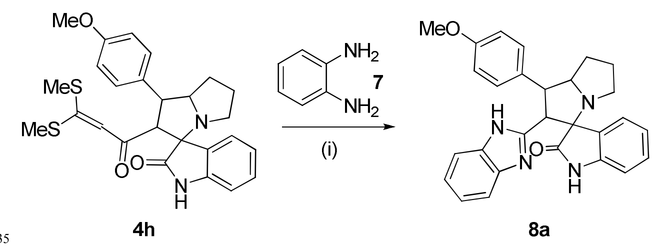


Figure 5: X-ray crystal structures of **5g**

Recently, aryl substituted ketene dithioacetals **3** has been reported to aid the synthesis of molecules which demonstrates antileishmanial activity.[29] With the ready accessibility of spiro based diverse ketene dithioacetal scaffold established, next, the synthetic potential of **4** has been illustrated through the synthesis of new compounds with additional heterocycles such as benzimidazole and pyrimidine.

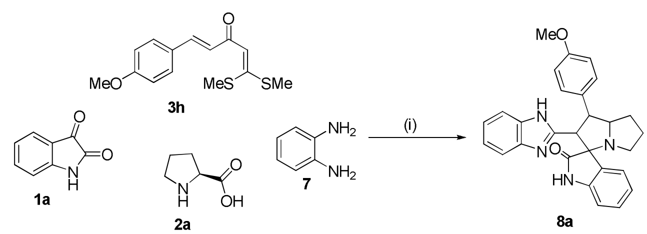
Poly heterocylces **8a** was achieved from the cyclocondensation reaction[30] of the **4h** with OPD **7** in AcOH (cat.)/H_2O media (scheme 4). Inspired by the successful results, few spiro compounds **4** was investigated with OPD **7** under acidic condition. To optimize the best reaction condition, three different methods were executed to obtain **8**. In method **A**, compound **4h** and **7** was allowed to undergo cyclocondensation in dilute acid condition at 100 ºC for 1h to afford **8** in 78% yield. Water being a greened solvent was the preferred choice though similar results were observed with methanol and ethanol (scheme 4, Method A).



Reaction conditions: (i) **4h** (1mol), **7** (1mol), AcOH/Water, reflux, 1h.

Scheme 4: Utility of **4h** towards the Synthesis of spiro-benzimidazole **8a** (Method A)

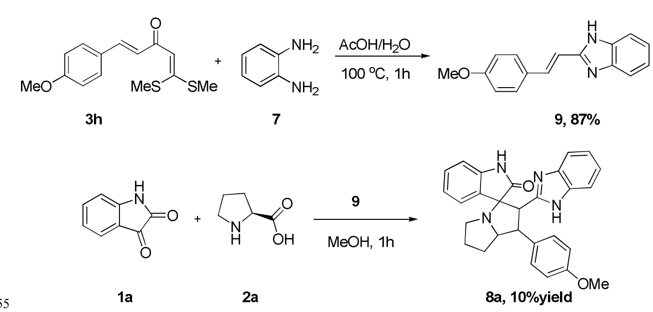
The cyclocondensation product **8a** was confirmed by ^1H & ^{13}C NMR spectroscopy. Next, the cycloaddition was proceeding *via* MCR by involving **3h**, **1a**, **2a** and OPD **7** in the presence of catalytic amount of AcOH in water at reflux for 1h to afford **8a** in 30% yield (Scheme 5 method B).



Reaction conditions: (i) **3h** (1mol), **1a** (1mol), **2a** (1mol), and **7** (1mol), AcOH (Cat.)/H_2O, reflux, 1h.

Scheme 5: Synthesis of **8a** *via* MCR (Method B)

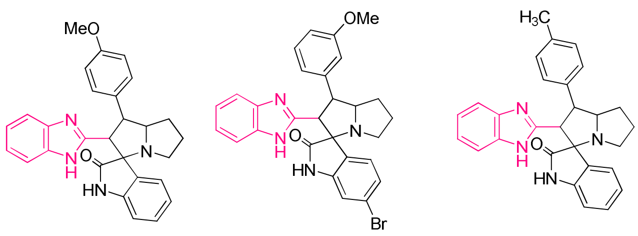
We have acquired a new method to synthesize **8a** even though MCR reaction gives 30% yield, as it involves additional purifications steps. Alternatively, in step-I, styryl benzimidazole **9** was synthesized in 87% yield by condensing **3h** and **7** under AcOH/H_2O media. In the step-II, styryl benzimidazole **9** was reacted with azomethine ylide (adduct of **1a** and **2a)** to give **8a** in very poor yield (10%, Scheme 6).



Scheme 6: Synthesis of spiro benzimidazole **8a** *via* 2-styryl benzimidazole **9**

Among three different methods, method **A** (cyclization reaction of **4h** with OPD **7**) was the best on the basis of yields and isolation procedure. Following method **A**, biologically active poly heterocycles **8a-c** were synthesised from corresponding substituted reagent **4** (Table 5). However, biologically important benzimidazole with spiro-oxindole skeleton is rare combinations in organic synthesis.

Table 5: Synthesis of polyheterocycles **8** containing benzimidazole moiety[a]

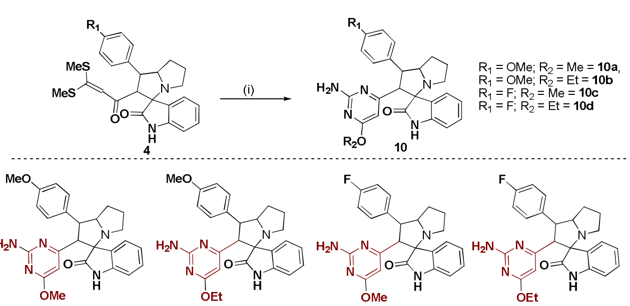


8a, 78% 8b, 80% 8c, 88%

[a] Reaction conditions: (i) **4h** (1mol), **7** (1mol), AcOH/Water, reflux, 1h, Yields given after column chromatography.

The curiosity towards the synthesis of polyheterocycles which contains biologically active pyrimidine moiety **10** was intensified by exploring our reported procedure.[22] However, compound **4** was allowed to react with guanidine nitrate in the presence of NaH base under reflux condition for 10 h to afford **10a-d** in good yields (Table 6).

Table 6: Synthesis of spiro-pyrimidines **10a-d**[a]



10a, 85% 10b, 80% 10c, 80% 10d, 78%

[a] Reaction conditions: (i) **4** (1mol), Guanidine nitrate (1.5mol), NaH (1.5mol), MeOH or EtOH, 65-70 ºC, 10 h. Isolated yield after column chromatography.

The current work depicts the potential of α-aroylidineketene dithioacetal as key synthetic intermediates. The methodology described in this paper provides environmentally attractive synthetic approach with very high yields and atom efficiency. Moreover, this synthetic protocol provided a practical access to various biologically important *N*-based polyheterocycles with minimum number of synthetic steps.

Conclusions

In summary, we have demonstrated the straight forward chemo/regio/stereo selective synthesis of spiro-oxindole/pyrrolidine/derivatives in excellent yields with four chiral centers. The current method discloses many advantages such as high atom economy, ready accessibility of the starting materials, simple reaction conditions under greener medium. This protocol involves in broad substrate scope, excellent functional group tolerance and leaves active site for further synthetic transformation. Furthermore, the utility of cycloadduct was demonstrated through the synthesis of *N*-based poly heterocycles such as benzimidazole/pyrimidine moieties with spiro platform.

Experimental Section

I General Remarks

Melting points were determined in open capillary tubes and were uncorrected. IR spectra were taken on a Jasco FT-IR instrument in KBr pellets and reported in cm^{-1}. Mass spectra were performed with Agilent mass spectrometer and recorded in positive & negative mode with an ESI source. The ^{1}H and ^{13}C NMR spectra of the new compounds were measured at 300 and 400 MHz in DMSO-d_6 with TMS as the internal standard. Chemical shifts are expressed in ppm, coupling constant (*J* values) are given in Hertz (Hz) and spin multiplicities are indicated by the following symbols: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), dd (doublet of doublets), td (triplet of doublets). Elemental analyses were carried out with Perkin Elmer 2400 Series II analyzer. Silica gel-G plates (Merck) were used for TLC analysis with a mixture of petroleum ether (60-80 ºC) and ethyl acetate as eluent. All chemicals were purchased and used without further purification.

General procedure for the synthesis of 4

A mixture of isatin **1** (1mol), L-proline **2** (1mol) and 1,1-bis(methylthio)-5-arylpenta-1,4-dien-3-one **3** (1mol) was heated to reflux in methanol (3 ml) at 65 ºC for indicated time (Table 2). After completion of the reaction (TLC), the mixture was cooled to room temperature and poured in to ice cold water. Then the resulting solid was filtered and recrystallized from Ethanol/DCM to give analytically pure product **4.**

2'-(3,3-bis(methylthio)acryloyl)-1'-phenyl-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4a

Off white solid; Isolated yield 0.328g (91%); M. Pt. 160-162 ºC; ^{1}H NMR (400 MHz, DMSO-d_6) δ_H: 1.65 - 1.69 (m, 2H), 1.78 - 1.83 (m, 2H), 2.15 (s, 3H), 2.23 (s, 3H), 2.33 - 2.37 (m, 1H), 2.40 - 2.49 (m, 1H), 3.68 - 3.77 (m, 2H), 4.00 (d, *J* = 11.9 Hz, 1H), 6.77 (d, *J* = 7.6 Hz, 1H), 6.92 (td, *J* = 0.4 Hz, 7.6 Hz, 1H), 7.14 - 7.26 (m, 3H), 7.33 (t, *J* = 7.6 Hz, 2H), 7.39 (d, *J* = 6.8 Hz, 2H), 10.46 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ_C: 15.5, 16.6, 27.4, 30.5, 47.6, 51.5, 67.9, 72.9, 73.5, 110.0, 112.1, 121.5, 126.1, 127.0, 127.2, 128.2, 129.0, 129.5, 141.2, 142.6, 163.4, 180.1, 189.0; IR (ATR KBr, cm^{-1}) 702, 748, 1134, 1489, 1502, 1616, 1708, 2850, 3082, 3188; LC-MS calcd m/z: 450 found 451 $[(M+1)]^+$. Anal. Calcd for $C_{25}H_{26}N_2O_2S_2$: C, 66.63; H, 5.82; N, 6.22; Found: C, 66.60; H, 5.77; N, 6.20.

2'-(3,3-bis(methylthio)acryloyl)-1'-*o*-tolyl-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4b

Off white solid; Isolated yield 0.33g (94%); M. Pt. 158-160 ºC; ^{1}H NMR (400 MHz, DMSO-d_6) δ_H: 1.59 - 1.68 (m, 2H), 1.77 - 1.83 (m, 2H), 2.14 (s, 3H), 2.22 (s, 3H), 2.35 - 2.48 (m, 2H), 2.49 (s, 3H), 3.74 - 3.78 (m, 1H), 3.92 - 3.94 (m, 1H), 3.96 (d, *J* = 9.24 Hz, 1H), 5.52 (s, 1H), 6.77 - 6.79 (m, 1H), 6.92 - 6.96 (m, 1H), 6.98 - 7.09 (m, 1H), 7.14 - 7.25 (m, 4H), 7.38 (d, J = 7.32 Hz, 1H), 10.50 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.8, 17.2, 19.0, 19.8, 20.3, 27.6, 30.7, 46.3, 69.7, 73.5, 110.1, 111.8, 121.7, 126.1, 126.4, 126.5, 126.6, 126.7, 126.8, 127.0, 129.4, 129.5, 130.6, 131.2, 137.1, 137.6, 139.6, 142.5, 163.3, 180.1, 188.9; IR (ATR KBr cell, cm^{-1}) 726, 1030, 1480, 1587, 1602, 1740, 2984, 3178; LC-MS calcd m/z: 464 found 465 [(M+1)]$^+$. Anal. Calcd for $C_{26}H_{28}N_2O_2S_2$: C, 67.21; H, 6.07; N, 6.03; Found: C, 67.15; H, 6.03; N, 6.01.

2'-(3,3-bis(methylthio)acryloyl)-1'-*p*-tolyl-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4c

Off white solid; Isolated yield 0.323g (92%); M. Pt. 158-160 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.62 - 1.70 (m, 2H), 1.75 - 1.82 (m, 2H), 2.15 (s, 3H), 2.25 (s, 3H), 2.31 (s, 3H), 2.32 - 2.38 (m, 1H), 2.40 - 2.44 (m, 1H), 3.63 - 3.74 (m, 2H), 3.96 (d, J = 11.6 Hz, 1H), 5.62 (s, 1H), 6.77 (d, J = 7.6 Hz, 1H), 6.91 (t, J = 7.2 Hz, 1H), 7.11 - 7.17 (m, 3H), 7.27 (t, J = 8Hz, 3H), 10.45 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.7, 19.0, 21.0, 27.5, 30.5, 47.6, 51.2, 56.5, 67.9, 72.9, 73.4, 110.0, 112.1, 121.5, 126.1, 127.2, 128.0, 129.4, 129.5, 136.0, 138.1, 142.5, 163.3, 180.2, 189.0; IR (ATR KBr cell, cm^{-1}) 730, 1148, 1430, 1500, 1616, 1726, 2800, 3298; LC-MS calcd m/z: 464 found 465 [(M+1)]$^+$. Anal. Calcd for $C_{26}H_{28}N_2O_2S_2$: C, 67.21; H, 6.07; N, 6.03: Found; C, 67.18; H, 6.05; N, 6.00.

2'-(3,3-bis(methylthio)acryloyl)-1'-(4-isopropylphenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4d

Off white solid; Isolated yield 0.32 (95%); M. Pt. 134-136 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.17 (s, 3H), 1.19 (s, 3H), 1.62 - 1.68 (m, 2H), 1.76 - 1.81 (m, 2H), 2.14 (s, 3H), 2.32 (s, 3H), 2.33 - 2.38 (m, 1H), 2.40 - 2.44 (m, 1H), 2.80 - 2.87 (m, 1H), 3.43 - 3.47 (m, 1H), 3.63 - 3.76 (m, 2H), 3.98 (d, J = 11.6 Hz, 1H), 5.61 (s, 1H), 6.77 (d, J = 7.6 Hz, 1H), 6.91 (t, J = 7.6 Hz, 1H), 7.13 - 7.20 (m, 3H), 7.24 (t, J = 7.2 Hz, 1H), 7.31 (d, J = 8 Hz, 2H), 10.46 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.6, 19.0, 24.4, 27.5, 30.5, 47.6, 51.2, 56.5, 67.9, 72.9, 73.5, 110.0, 112.1, 121.5, 126.2, 127.2, 128.1, 129.4, 138.5, 142.6, 147.0, 163.3, 180.2, 189.0; IR (ATR KBr cell, cm^{-1}) 750, 1136, 1483, 1616, 1728, 2980, 3217; LC-MS calcd m/z: 492 found 493 [(M+1)]$^+$. Anal. Calcd for $C_{28}H_{32}N_2O_2S_2$: C, 68.26; H, 6.55; N, 5.69; Found: C, 68.22; H, 6.51; N, 5.65.

2'-(3,3-bis(methylthio)acryloyl)-1'-(4-ethoxyphenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4e

Off white solid; Isolated yield 0.309g (96%); M. Pt. 166-168 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.30 (t, J = 6.8 Hz, 1H), 1.62 - 1.68 (m, 2H), 1.75 - 1.82 (m, 2H), 2.15 (s, 3H), 2.24 (s, 3H), 2.31 - 2.36 (m, 1H), 2.38 - 2.44 (m, 1H), 3.61 - 3.72 (m, 2H), 3.92 (d, J = 11.6 Hz, 1H), 3.99 (q, J = 6.8 Hz, 2H), 5.62 (s, 1H), 6.76 (d, J = 7.6 Hz, 2H), 6.85 - 6.95 (m, 3H), 7.16 (d, J = 7.6 Hz, 1H), 7.24 (d, J = 7.6 Hz, 1H), 7.28 (d, J = 8.4 Hz, 2H), 10.44 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 15.2, 16.7, 27.4, 30.5, 47.6, 50.7, 63.4, 68.0, 72.9, 73.4, 110.0, 112.2, 114.9, 121.5, 126.2, 127.2, 129.1, 129.4, 132.8, 142.5, 157.7, 163.2, 180.2, 189.9.; IR (ATR KBr cell, cm^{-1}) 713, 1192, 1571, 1640, 1716, 2870, 3280; LC-MS calcd m/z: 494 found 495 [(M+1)]$^+$. Anal. Calcd for $C_{27}H_{30}N_2O_3S_2$: C, 65.56; H, 6.11; N, 5.66; Found: C, 65.53; H, 6.08; N, 5.64.

2'-(3,3-bis(methylthio)acryloyl)-1'-(2-methoxyphenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4f

Off white solid; Isolated yield 0.315g (92%); M. Pt. 138-140 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.64 - 1.70 (m, 2H), 1.76 - 1.81 (m, 3H), 2.14 (s, 3H), 2.22 (s, 3H), 2.31 - 2.40 (m, 2H), 3.64 - 3.69 (m, 1H), 3.82 (s, 3H), 4.03 - 4.08 (m, 1H), 4.24 (d, J = 12.4 Hz, 1H), 5.66 (s, 1H), 6.77 (d, J = 7.6 Hz, 1H), 6.94 (q, J = 7.2 Hz, 2H), 6.99 (d, J = 8 Hz, 1H), 7.14 - 7.21 (m, 3H), 7.32 (d, J = 6.4 Hz, 1H), 10.44 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.6, 27.6, 31.1, 45.3, 47.3, 56.1, 66.0, 72.1, 73.4, 110.1, 111.7, 111.8, 121.1, 121.5, 126.4, 126.8, 128.0, 128.6, 129.4, 142.7, 158.0, 163.3, 180.0, 189.3; IR (ATR KBr cell, cm^{-1}) 748, 1024, 1240, 1492, 1618, 1716, 2872, 2960, 3134; LC-MS calcd m/z: 480 found 481 [(M+1)]$^+$. Anal. Calcd for $C_{26}H_{28}N_2O_3S_2$: C, 64.97; H, 5.87; N, 5.83; Found: C, 64.92; H, 5.83; N, 5.80.

2'-(3,3-bis(methylthio)acryloyl)-1'-(3-methoxyphenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4g

Off white solid; Isolated yield 0.309g (90%); M. Pt. 146-148 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.65 - 1.69 (m, 2H), 1.77 - 1.82 (m, 3H), 2.15 (s, 3H), 2.23 (s, 3H), 2.32 - 2.34 (m, 1H), 2.40 - 2.48 (m, 1H), 3.65 - 3.95 (m, 5H), 3.97 (d, J = 11.5 Hz, 1H), 5.63 (s, 1H), 6.75 - 6.79 (m, 2H), 6.91 (td, J = 0.76 Hz, 7.56 Hz, 1H), 6.95 - 6.97 (m, 2H), 7.17 (td, J = 0.96 Hz, 8 Hz, 1H), 7.21 - 7.26 (m, 2H), 10.48 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.7, 19.0, 27.4, 30.4, 47.6, 51.5, 55.4, 56.5, 67.7, 72.8, 73.5, 110.0, 112.1, 112.2, 114.2, 120.2, 121.5, 126.1, 127.2, 129.5, 130.0, 142.6, 142.9, 159.8, 163.4, 180.1, 189.0; IR (ATR KBr cell, cm^{-1}) 715, 781, 1051, 1268, 1379, 1480, 1649, 1729, 2873, 1046, 3189; LC-MS calcd m/z: 480 found 481 [(M+1)]$^+$. Anal. Calcd for $C_{26}H_{28}N_2O_3S_2$: C, 64.97; H, 5.87; N, 5.83; Found: C, 64.93; H, 5.80; N, 5.78.

2'-(3,3-bis(methylthio)acryloyl)-1'-(4-methoxyphenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4h

Off white solid; Isolated yield 0.329g (96%); M. Pt. 154-156 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.66 - 1.68 (m, 2H), 1.75 - 1.81 (m, 2H), 2.15 (s, 3H), 2.24 (s, 3H), 2.30 - 2.34 (m, 1H), 2.35 - 2.41 (m,1H), 3.60 - 3.72 (m, 5H), 3.91 (d, J = 11.56 Hz, 1H), 3H), 5.61 (s, 1H), 6.76 (d, J = 7.64 Hz, 1H), 6.87 - 6.92 (m, 3H), 7.16 (dd, J = 0.68 Hz, 7.64 Hz, 1H), 7.24 (d, J = 7.36 Hz, 1H), 7.30 (d, J = 7.36 Hz, 1H), 10.50 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.7, 27.4, 30.5, 47.6, 50.7, 55.5, 68.0, 72.9, 73.4, 110.0, 112.1, 114.4, 121.5, 126.1, 127.2, 129.1, 129.4, 132.9, 142.5, 158.4, 163.2, 180.1, 189.0; IR (ATR KBr cell, cm^{-1}) 750, 1041, 1234, 1479, 1604, 1728, 2892, 3064, 3199; LC-MS calcd m/z: 480 found 481 [(M+1)]$^+$. Anal. Calcd for $C_{26}H_{28}N_2O_3S_2$: C, 64.97; H, 5.87; N, 5.83; Found: C, 64.93; H, 5.83; N, 5.79.

2'-(3,3-bis(methylthio)acryloyl)-1'-(2-fluorophenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4i

Off white solid; Isolated yield 0.325g (93%); M. Pt. 160-162 ºC;

^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.65 - 1.68 (m, 2H), 1.79 - 1.84 (m, 2H), 2.15 (s, 3H), 2.26 (s, 3H), 2.32 - 2.48 (m, 2H), 3.73 - 3.78 (m, 1H), 3.90 - 3.95 (m, 1H), 4.17 (d, J = 12 Hz, 1H), 5.61 (s, 1H), 6.78 (d, J = 7.5 Hz, 1H), 6.94 (dd, J = 0.8 Hz, 7.2 Hz, 1H), 7.14 - 7.19 (m, 4H), 7.23 - 7.29 (m, 5H), 7.47 - 7.51 (m, 1H), 10.56 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.6, 27.5, 30.7, 45.0, 47.4, 66.6, 71.7, 73.3, 110.1, 111.6, 115.8, 116.0, 121.6, 125.1, 125.9, 127.0, 127.6, 128.7, 128.8, 129.6, 129.7, 142.5, 159.9, 162.4, 163.7, 179.9, 188.5; IR (ATR KBr cell, cm^{-1}) 729, 1390, 1488, 1640, 1720, 2850, 3184; LC-MS calcd m/z: 468 found 469 [(M+1)]$^+$. Anal. Calcd for $C_{25}H_{25}FN_2O_2S_2$: C, 64.08; H, 5.38; N, 5.98; Found: C, 64.04; H, 5.33; N, 5.93.

2'-(3,3-bis(methylthio)acryloyl)-1'-(4-fluorophenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4j

Off white solid; Isolated yield 0.342g (98%); M. Pt. 146-148 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.64 - 1.70 (m, 2H), 1.78 - 1.82 (m, 2H), 2.15 (s, 3H), 2.24 (s, 3H), 2.31 - 2.36 (m, 1H), 2.38 - 2.43 (m, 1H), 3.71 - 3.73 (m, 2H), 3.94 - 3.96 (m, 1H), 5.60 (s, 1H), 6.77 (d, J = 7.6 Hz, 1H), 6.91 (td, J = 0.68 Hz, 7.52 Hz, 1H), 7.12 - 7.18 (m, 3H), 7.24 (d, J = 7.4 Hz, 1H), 7.41 - 7.44 (m, 2H), 10.56 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.6, 27.4, 30.3, 47.6, 50.6, 68.0, 72.7, 73.4, 110.0, 112.0, 115.5, 115.8, 121.5, 126.0, 127.2, 129.5, 129.9, 130.0, 137.3, 142.5, 160.2, 162.6, 163.5, 180.1, 188.8; IR (ATR KBr cell, cm^{-1}) 721, 1197, 1440, 1620, 1728, 2890, 3188; LC-MS calcd m/z: 468 found 469 [(M+1)]$^+$. Anal. Calcd for $C_{25}H_{25}FN_2O_2S_2$: C, 64.08; H, 5.38; N, 5.98; Found: C, 64.03; H, 5.36; N, 5.95.

2'-(3,3-bis(methylthio)acryloyl)-1'-(2-bromophenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4k

Off white solid; Isolated yield 0.303g (94%); M. Pt. 154-156 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.64 - 1.78 (m, 4H), 2.14 (s, 3H), 2.22 (s, 3H), 2.33 - 2.48 (m, 2H), 3.65 - 3.70 (m, 1H), 4.11 (d, J = 12 Hz, 1H), 4.28 (t, J = 11.6 Hz, 1H), 5.56 (s, 1H), 6.78 (d, J = 7.2 Hz, 1H), 6.94 (t, J = 7.2 Hz, 1H), 7.12 - 7.19 (m, 3H), 7.37 (d, J = 7.6 Hz, 1H), 7.51 (d, J = 8 Hz, 1H), 7.61 (d, J = 8 Hz, 1H), 10.49 (s, 1H); ^{13}C NMR (100 MH z, DMSO-d$_6$) δ_C: 14.5, 16.6, 27.3, 30.1, 47.5, 49.4, 67.9, 73.3, 73.5, 110.3, 111.6, 121.7, 125.5, 126.0, 128.6, 128.7, 128.8, 129.7, 133.2, 140.0, 142.7, 163.8, 179.8, 188.5; IR (ATR KBr cell, cm^{-1}) 713, 1197, 1425, 1602, 1716, 2918, 3200; LC-MS calcd m/z: 529 found 530 [(M+1)]$^+$. Anal. Calcd for $C_{25}H_{25}BrN_2O_2S_2$: C, 56.71; H, 4.76; N, 5.29; Found: C, 56.68; H, 4.70; N, 5.24.

2'-(3,3-bis(methylthio)acryloyl)-1'-(4-bromophenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4l

Off white solid; Isolated yield 0.319g (99%); M. Pt. 158-160 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.64 - 1.70 (m, 4H), 1.78-1.82 (m, 2H), 2.15 (s, 3H), 2.25 (s, 3H), 2.31 - 2.36 (m, 1H), 2.39 - 2.45 (m, 1H), 3.70 (m, 2H), 3.95 - 3.98 (m, 1H), 5.60 (s, 1H), 6.77 (d, J = 7.6 Hz, 1H), 6.91 (td, J = 0.8 Hz, 7.6 Hz, 1H), 7.17 (td, J = 1.2 Hz, 7.6 Hz, 1H), 7.24 (d, J = 7.6 Hz, 1H), 7.36 (d, J = 8.4 Hz, 2H), 7.51 (d, J = 8.4 Hz, 2H), 10.49 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.1, 16.3, 27.0, 29.9, 47.2, 50.4, 67.4, 72.2, 73.0, 109.6, 111.6, 119.6, 121.1, 125.5, 126.8, 129.1, 130.1, 131.4, 140.3, 142.1, 163.2, 179.6, 188.3; IR (ATR KBr cell, cm^{-1}) 749, 1128, 1428, 1614, 1720, 2829, 3153; LC-MS calcd m/z: 529 found 530 [(M+1)]$^+$. Anal. Calcd for $C_{25}H_{25}BrN_2O_2S_2$: C, 56.71; H, 4.76; N, 5.29; Found: C, 56.65; H, 4.73; N, 5.26.

4-(2'-(3,3-bis(methylthio)acryloyl)-2-oxo-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizine]-1'-yl)benzonitrile 4m

Off white solid; Isolated yield 0.304g (88%); M. Pt. 168 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.68 - 1.80 (m, 4H), 2.15 (s, 3H), 2.24 (s, 3H), 2.32 - 2.36 (m, 1H), 3.75 - 3.84 (m, 2H), 4.02 (d, J = 11.6 Hz, 1H), 5.58 (s, 1H), 6.77 (d, J = 7.2 Hz, 1H), 6.91 (t, J = 7.6 Hz, 1H), 7.17 (d, J = 7.6 Hz, 1H), 7.25 (d, J = 7.6 Hz, 1H), 7.61 (d, J = 8 Hz, 2H), 7.78 (d, J = 8 Hz, 1H), 10.50 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.2, 16.3, 27.0, 29.8, 47.3, 51.0, 67.3, 72.1, 73.0, 109.4, 109.7, 111.4, 119.0, 121.2, 125.4, 126.9, 129.0, 129.3, 132.5, 142.1, 146.9, 163.5, 179.6, 188.1; IR (ATR KBr cell, cm^{-1}) 709, 1018, 1322, 1490, 1608, 1704, 2230, 2860, 3110; LC-MS calcd m/z: 475 found 476 [(M+1)]$^+$. Anal. Calcd for $C_{26}H_{25}N_3O_2S_2$: C, 65.66; H, 5.30; N, 8.83; Found: C, 65.61; H, 5.27; N, 8.78.

2'-(3,3-bis(methylthio)acryloyl)-1'-(2,4-dichlorophenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4n

Off white solid; Isolated yield 0.293g (90%); M. Pt. 126-128 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.66 - 1.71 (m, 2H), 1.77 - 1.84 (m, 2H), 2.16 (s, 3H), 2.25 (s, 3H), 2.34 - 2.45 (m, 2H), 3.65 - 3.71 (m, 1H), 4.13 (d, J = 11.8 Hz, 1H), 4.20 - 4.25 (m, 1H), 5.57 (s, 1H), 6.79 (d, J = 7.6 Hz, 1H), 6.92 - 6.96 (m, 1H), 7.12 - 7.23 (m, 2H), 7.41 (dd, J = 2.16 Hz, 8.44 Hz, 1H), 7.57 - 7.65 (m, 1H), 7.69 - 7.71 (m, 1H), 10.50 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.6, 27.3, 30.3, 46.6, 47.4, 67.6, 72.8, 73.2, 110.2, 111.6, 114.2, 121.8, 125.8, 126.7, 128.3, 129.3, 129.9, 130.1, 131.8, 132.1, 133.9, 135.0, 137.6, 142.6, 164.0, 166.3, 179.8, 182.6, 188.3; IR (ATR KBr cell, cm^{-1}) 758, 860, 1498, 1616, 1723, 2878, 2930, 3101; LC-MS calcd m/z: 519 found 520 [(M+1)]$^+$. Anal. Calcd for $C_{25}H_{24}ClN_2O_2S_2$: C, 57.80; H, 4.66; N, 5.39; Found: C, 57.78; H, 4.63; N, 5.35.

2'-(3,3-bis(methylthio)acryloyl)-1'-(2,4-difluorophenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4o

Off white solid; Isolated yield 0.309g (91%); M. Pt. 140-142 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.59 - 1.70 (m, 2H), 1.79 - 1.85 (m, 2H), 2.16 (s, 3H), 2.27 (s, 3H), 2.32 - 2.45 (m, 2H), 3.74 - 3.78 (m, 1H), 3.77 - 3.92 (m, 1H), 4.14 (d, J = 12 Hz, 1H), 5.60 (s, 1H), 6.78 (dd, J = 4.4 Hz, 7.6 Hz, 1H), 6.93 (t, J = 7.2 Hz, 1H), 7.07 (td, J = 2 Hz, 8.4 Hz, 1H), 7.15 - 7.22 (m, 3H), 7.57 (q, J = 8.4 Hz, 1H), 10.53 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.6, 19.0, 27.4, 30.6, 44.6, 47.5, 56.5, 66.5, 71.4, 73.3, 104.1, 104.4, 104.6, 110.1, 112.0, 121.7, 123.9, 124.0, 125.8, 127.0, 129.6, 130.8, 130.9, 142.5, 159.8, 160.2, 163.8, 179.9, 188.5; IR (ATR KBr cell, cm^{-1}) 748, 846, 1132, 1425, 1502, 1616, 1708, 2870, 3080, 3190; LC-MS calcd m/z: 486 found 487 [(M+1)]$^+$. Anal. Calcd for $C_{25}H_{24}F_2N_2O_2S_2$: C, 61.71; H, 4.97; N, 5.76; Found: C, 61.71; H, 4.95; N, 5.70.

2'-(3,3-bis(methylthio)acryloyl)-1'-(3,4-dimethoxyphenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4p

Off white solid; Isolated yield 0.296g (90%); M. Pt. 148 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.65 - 1.69 (m, 2H), 1.76 - 1.81 (m, 2H), 2.14 (s, 3H), 2.22 (s, 3H), 2.31 - 2.40 (m, 2H), 3.59 - 3.67 (m, 1H), 3.70 (s, 3H), 3.78 (s, 3H), 3.91 (d, *J* = 12 Hz, 1H), 5.64 (s, 1H), 6.75 (d, *J* = 7.6 Hz, 1H), 6.87 - 6.92 (m, 3H), 7.15 (d, *J* = 7.6 Hz, 1H), 7.25 (d, *J* = 7.6 Hz, 1H), 10.39 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.7, 27.4, 30.4, 47.6, 51.2, 56.0, 56.4, 67.8, 72.8, 73.5, 110.0, 112.1, 112.3, 112.5, 119.9, 121.4, 126.2, 127.2, 129.4, 133.5, 142.6, 148.0, 149.2, 163.2, 180.1, 189.2; IR (ATR KBr cell, cm^{-1}) 720, 1081, 1420, 1606, 1750, 2158, 2300, 2950, 3112; LC-MS calcd m/z: 510 found 511 [(M+1)]$^+$. Anal. Calcd for $C_{27}H_{30}N_2O_4S_2$: C, 63.50; H, 5.92; N, 5.49; Found: C, 63.46; H, 5.89; N, 5.46.

2'-(3,3-bis(methylthio)acryloyl)-1'-(5-bromo-2-methoxyphenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4q

Off white solid; Isolated yield 0.268g (86%); M. Pt. 178 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.64 - 1.76 (m, 4H), 2.14 (s, 4H), 2.25 (s, 4H), 3.80 - 3.84 (m, 2H), 3.84 (s, 3H), 3.96 - 4.02 (m, 1H), 4.22 (d, *J* = 12 Hz, 1H), 5.64 (s, 1H), 6.76 (d, *J* = 7.2 Hz, 1H), 6.91 (t, *J* = 7.6 Hz, 1H), 6.97 (d, *J* = 8.8 Hz, 1H), 7.14 - 7.18 (m, 2H), 7.36 (d, *J* = 8.4 Hz, 1H), 7.50 (s, 1H), 10.44 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 13.5, 15.1, 25.8, 29.0, 44.4, 55.5, 64.6, 70.2, 71.8, 109.0, 111.1, 111.6, 113.2, 120.4, 125.8, 128.4, 129.5, 130.0, 130.6, 141.6, 156.4, 162.2, 178.9, 188.2; IR (ATR KBr cell, cm^{-1}) 760, 890, 1101, 1435, 1607, 1744, 2188, 2998, 3014; LC-MS calcd m/z: 559 found 560 [(M+1)]$^+$. Anal. Calcd for $C_{26}H_{28}N_2O_3S_2$: C, 55.81; H, 4.86; N, 5.01; Found: C, 55.76; H, 4.83; N, 4.99.

2'-(3,3-bis(methylthio)acryloyl)-1'-(2-chloro-5-nitrophenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4r

Off white solid; Isolated yield 0.283g (88%); M. Pt. 152-154 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.65 - 1.71 (m, 2H), 1.81 - 1.85 (m, 1H), 2.17 (s, 3H), 2.23 (s, 3H), 2.38 - 2.43 (m, 1H), 2.49 - 2.53 (m, 1H), 3.81 - 3.86 (m, 1H), 4.19 (d, *J* = 11.6 Hz, 1H), 4.33 - 4.40 (m, 1H), 5.58 (s, 1H), 6.81 (d, *J* = 7.6 Hz, 1H), 6.95 (t, *J* = 7.6 Hz, 1H), 7.14 (d, *J* = 7.2 Hz, 1H), 7.21 (t, *J* = 7.6 Hz, 1H), 7.78 (d, *J* = 8.8 Hz, 1H), 8.08 (dd, *J* = 2.4 Hz, 8.8 Hz, 1H), 8.40 (d, *J* = 2.4 Hz, 1H), 10.63 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.6, 27.1, 30.0, 47.3, 47.6, 67.8, 72.7, 73.3, 110.2, 111.9, 121.8, 123.3, 123.8, 125.7, 126.9, 129.8, 131.4, 140.7, 141.0, 142.6, 147.3, 163.9, 179.8, 188.4; IR (ATR KBr cell, cm^{-1}) 740, 1120, 1498, 1520, 1640, 1733, 2198, 2940, 3184; LC-MS calcd m/z: 530 found 431 [(M+1)]$^+$. Anal. Calcd for $C_{25}H_{24}ClN_3O_4S_2$: C, 56.65; H, 4.56; N, 7.93; Found: C, 56.61; H, 4.53; N, 7.88.

2'-(3,3-bis(methylthio)acryloyl)-1'-(3-bromo-4-fluorophenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4s

Off white solid; Isolated yield 0.284g (90%); M. Pt. 116-118 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.65 - 1.68 (m, 2H), 1.76 - 1.81 (m, 2H), 2.15 (s, 3H), 2.24 (s, 3H), 2.33 - 2.35 (m, 1H), 2.38 - 2.45 (m, 1H), 3.72 - 3.76 (m, 2H), 3.91 - 3.94 (m, 1H), 5.59 (s, 1H), 6.76 (d, *J* = 7.6 Hz, 1H), 6.89 (t, *J* = 7.6 Hz, 1H), 7.16 (t, *J* = 7.6 Hz, 1H), 7.24 (d, *J* = 7.6 Hz, 1H), 7.32 (t, *J* = 8.8 Hz, 1H), 7.42 - 7.45 (m, 1H), 7.73 - 7.75 (m, 1H), 10.46 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.6, 27.3, 30.0, 47.7, 50.3, 67.8, 72.5, 73.4, 108.2, 110.0, 112.1, 117.1, 121.5, 125.9, 127.2, 129.2, 129.3, 129.6, 133.3, 139.6, 142.5, 156.3, 158.7, 163.6, 180.0, 188.7; IR (ATR KBr cell, cm^{-1}) 750, 1047, 1136, 1246, 1475, 1490, 1618, 1716, 2882, 3253; LC-MS calcd m/z: 547 found 548 [(M+1)]$^+$. Anal. Calcd for $C_{25}H_{24}BrFN_2O_2S_2$: C, 54.84; H, 4.42; N, 5.12; Found: C, 54.80; H, 4.39; N, 5.09.

2'-(3,3-bis(methylthio)acryloyl)-1'-(5-bromothiophen-2-yl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4t

Off white solid; Isolated yield 0.297g (93%); M. Pt. 128-130 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.66 - 1.75 (m, 2H), 1.78 - 1.82 (m, 1H), 1.88 - 1.93 (m, 1H), 2.19 (s, 3H), 2.28 (s, 3H), 2.32 - 2.44 (m, 2H), 3.76 - 3.82 (m, 2H), 3.91 - 3.94 (m, 1H), 5.61 (s, 1H), 6.76 (d, *J* = 7.6 Hz, 1H), 6.85 - 6.91 (m, 2H), 7.05 (d, *J* = 3.72 Hz, 1H), 7.13 - 7.19 (m, 2H), 10.48 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.6, 16.7, 27.3, 30.3, 46.8, 47.6, 68.7, 72.1, 73.5, 109.3, 110.1, 111.7, 121.5, 125.5, 126.0, 127.3, 129.6, 130.5, 142.4, 146.4, 164.8, 176.8; IR (ATR KBr cell, cm^{-1}) 723, 983, 1421, 1614, 1720, 2900, 3148; LC-MS calcd m/z: 535 found 536 [(M+1)]$^+$. Anal. Calcd for $C_{23}H_{23}BrN_2O_2S_3$: C, 51.58; H, 4.33; N, 5.23; Found: C, 51.53; H, 4.30; N, 5.16.

2'-(3,3-bis(methylthio)acryloyl)-1'-(5-bromopyridin-3-yl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4u

Off white solid; Isolated yield 0.296g (92%); M. Pt. 156-158 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.66 - 1.72 (m, 2H), 1.78 - 1.84 (m, 2H), 2.16 (s, 3H), 2.25 (s, 3H), 2.33 - 2.38 (m, 1H), 2.41 - 2.49 (m, 1H), 3.75 - 3.82 (m, 2H), 4.01 - 4.06 (m, 1H), 5.61 (s, 1H), 6.78 (d, *J* = 7.56 Hz, 1H), 6.92 (dd, *J* = 0.72 Hz, 7.52 Hz, 1H), 7.18 (dd, *J* = 1 Hz, 7.68 Hz, 1H), 7.26 (t, *J* = 7.44 Hz, 1H), 8.11 (t, *J* = 2.4 Hz, 1H), 8.56 (d, *J* = 2.2 Hz, 1H), 8.62 (d, *J* = 1.8 Hz, 1H), 10.50 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.6, 27.2, 29.8, 47.7, 48.5, 67.4, 72.1, 73.4, 110.1, 112.0, 120.8, 121.6, 125.8, 129.7, 138.1, 139.2, 142.5, 148.6, 149.0, 163.7, 179.8, 188.6; IR (ATR KBr cell, cm^{-1}) 712, 1066, 1188, 1386, 1421, 1612, 1713, 2945, 3259; LC-MS calcd m/z: 530 found 531 [(M+1)]$^+$. Anal. Calcd for $C_{24}H_{24}BrN_3O_2S_2$: C, 54.34; H, 4.56; N, 7.92; Found: C, 54.29; H, 4.51; N, 7.90.

2'-(3,3-bis(methylthio)acryloyl)-5-methoxy-1'-*o*-tolyl-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4ba

Off white solid; Isolated yield 0.360g (96%); M. Pt. 200-202 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.71 - 1.82 (m, 2H), 1.83 - 1.87 (m, 2H), 2.18 (s, 3H), 2.22 (s, 3H), 2.37 - 2.42 (m, 1H), 2.55 (s, 3H), 3.71 (s, 3H), 3.76 - 3.81 (m, 1H), 3.94 (t, *J* = 9.6 Hz, 1H), 4.04 (d, *J* = 11.2 Hz, 1H), 5.54 (s, 1H), 6.70 - 6.72 (m, 2H), 6.78 (dd, *J* = 2.4 Hz, 8.4 Hz, 1H), 7.09 (t, *J* = 7.2 Hz, 1H), 7.15 - 7.21 (m, 2H), 7.40 (d, *J* = 8 Hz, 1H), 10.38 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.5, 20.2, 27.5, 30.6, 46.3, 47.4, 55.8, 69.7, 73.5, 73.8, 110.3, 112.2, 113.8, 114.3, 126.4, 126.6, 126.8, 127.5, 130.6, 135.9, 137.0, 139.6, 154.6, 163.3, 180.0, 189.1; IR

(ATR KBr cell, cm^{-1}) 731, 1197, 1489, 1728, 2684, 3416; LC-MS calcd m/z: 494 found 495 $[(M+1)]^+$. Anal. Calcd for $C_{27}H_{30}N_2O_3S_2$: C, 65.56; H, 6.11; N, 5.66; Found: C, 65.51; H, 6.08; N, 5.64.

2'-(3,3-bis(methylthio)acryloyl)-1'-(4-isopropylphenyl)-5-methoxy-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4da

Off white solid; Isolated yield 0.325g (91%); M. Pt. 134-136 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.18 (d, J = 6.8 Hz, 6H), 1.66 - 1.67 (m, 2H), 1.76 - 1.82 (m, 2H), 2.36 (s, 1H), 2.43 - 2.45 (m, 1H), 2.80 - 2.87 (m, 1H), 3.59 - 3.76 (m, 5H), 3.95 (d, J = 12 Hz, 1H), 5.61 (s, 1H), 6.68 (d, J = 8.4 Hz, 1H), 6.74 - 6.78 (m, 2H), 7.18 (d, J = 8 Hz, 2H), 7.31 (d, J = 7.6 Hz, 2H), 10.26 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 13.5, 23.3, 26.3, 29.3, 32.4, 46.5, 50.0, 55.0, 66.9, 71.7, 72.6, 109.1, 112.9, 113.6, 125.8, 127.0, 135.0, 135.2, 137.4, 145.9, 153.6, 178.9, 188.1; IR (ATR KBr cell, cm^{-1}) 750, 1136, 1480, 1720, 2980, 3500; LC-MS calcd m/z: 522 found 523 $[(M+1)]^+$. Anal. Calcd for $C_{29}H_{34}N_2O_3S_2$: C, 66.63; H, 6.56; N, 5.36; Found: C, 66.58; H, 6.53; N, 5.30.

2'-(3,3-bis(methylthio)acryloyl)-1'-(4-ethoxyphenyl)-5-methoxy-1',2',5',6',7',7a'hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4ea

Off white solid; Isolated yield 0.32g (92%); M. Pt. 150 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.32 (t, J = 6.8 Hz, 1H), 1.66 - 1.70 (m, 2H), 1.76 - 1.86 (m, 2H), 2.18 (s, 3H), 2.20 (s, 3H), 2.33 - 2.37 (m, 1H), 2.43 - 2.47 (m, 1H), 3.60 - 3.65 (m, 1H), 3.71 (s, 4H), 3.91 (d, J = 11.6 Hz, 1H), 4.00 (q, J = 6.8 Hz, 1H), 5.63 (s, 1H), 6.69 (d, J = 8.4 Hz, 1H), 6.75 - 6.77 (m, 1H), 6.80 - 6.81 (m, 1H), 6.87 (d, J = 8.8 Hz, 2H), 7.30 (d, J = 8.4 Hz, 2H), 10.29 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 15.2, 16.7, 27.4, 30.3, 47.6, 50.7, 56.0, 63.4, 68.0, 72.8, 73.7, 79.6, 110.1, 112.4, 113.8, 114.7, 114.9, 127.5, 129.1, 132.8, 136.0, 154.6, 157.7, 163.1, 180.0, 189.2; IR (ATR KBr cell, cm^{-1}) 780, 1190, 1429, 1700, 2888, 3200, 3540; LC-MS calcd m/z: 524 found 525 $[(M+1)]^+$. Anal. Calcd for $C_{28}H_{32}N_2O_4S_2$: C, 64.09; H, 6.15; N, 5.34; Found: C, 64.07; H, 6.11; N, 5.29.

2'-(3,3-bis(methylthio)acryloyl)-5-methoxy-1'-(3-methoxyphenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4ga

Off white solid; Isolated yield 0.346g (95%); M. Pt. 196 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.06 - 1.85 (m, 4H), 2.18 (s, 3H), 2.24 (s, 3H), 3.67 - 3.70 (m, 4H), 3.73 - 3.76 (m, 4H), 3.95 - 3.96 (m, 1H), 5.66 (s, 1H), 6.69 (d, J = 8.4 Hz, 1H), 6.75 - 6.83 (m, 3H), 6.97 - 6.99 (m, 2H), 7.25 (t, J = 8 Hz, 1H), 10.31 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.7, 27.3, 30.3, 47.6, 51.4, 55.4, 56.0, 56.5, 67.8, 72.7, 73.7, 110.2, 112.2, 112.4, 113.8, 114.3, 114.8, 120.2, 127.5, 130.0, 136.0, 142.9, 154.7, 159.8, 163.3, 180.0, 189.2; IR (ATR KBr cell, cm^{-1}) 738, 1303, 1489, 1712, 3431; LC-MS calcd m/z: 510 found 511 $[(M+1)]^+$. Anal. Calcd for $C_{27}H_{30}N_2O_4S_2$: C, 63.50; H, 5.92; N, 5.49; Found: C, 63.44; H, 5.88; N, 5.43.

2'-(3,3-bis(methylthio)acryloyl)-1'-(2-fluorophenyl)-5-methoxy-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4ia

Off white solid; Isolated yield 0.346g (93%); M. Pt. 206-208 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.61 - 1.81 (m, 4H), 2.15 (s, 3H), 2.23 (s, 3H), 2.35 - 2.48 (m, 1H), 3.77 (m, 3H), 3.89 (t, J = 10 Hz, 1H), 4.13 (d, J = 12 Hz, 1H), 5.59 (s, 1H), 6.67 - 6.76 (m, 3H), 7.12 - 7.25 (m, 3H), 7.51 (t, J = 6.8 Hz, 1H), 10.31 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 13.6, 15.4, 26.5, 29.6, 43.9, 46.5, 55.0, 65.6, 70.6, 72.8, 109.4, 110.9, 112.8, 113.5, 114.9, 115.2, 124.2, 126.4, 126.7, 127.9, 128.8, 135.0, 153.7, 155.7, 158.1, 162.7, 178.9, 187.7; IR (ATR KBr cell, cm^{-1}) 732, 1450, 1730, 2918, 3024, 3450; LC-MS calcd m/z: 498 found 499 $[(M+1)]^+$. Anal. Calcd for $C_{26}H_{27}FN_2O_3S_2$: C, 62.63; H, 5.46; N, 5.62; Found: C, 62.60; H, 5.41; N, 5.58.

2'-(3,3-bis(methylthio)acryloyl)-1'-(2-bromophenyl)-5-methoxy-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4ka

Off white solid; Isolated yield 0.313g (92%); M. Pt. 212-214 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.65 - 1.68 (m, 2H), 1.78 - 1.84 (m, 2H), 2.18 (s, 3H), 2.24 (s, 3H), 2.34 - 2.37 (m, 1H), 2.43 - 2.48 (m, 1H), 3.60 - 3.65 (m, 1H), 3.69 - 3.73 (m, 4H), 3.91 (d, J = 12 Hz, 1H), 5.64 (s, 1H), 6.69 (d, J = 8.4 Hz, 1H), 6.75 - 6.81 (m, 2H), 6.89 (d, J = 2.8 Hz, 2H), 7.30 (d, J = 8.8 Hz, 2H), 10.29 (s, 1H); ^{13}C NMR (100 MH z, DMSO-d$_6$) δ_C: 14.5, 16.6, 27.3, 30.0, 47.4, 49.3, 55.8, 67.9, 73.4, 73.7, 110.5, 111.9, 113.9, 114.0, 125.5, 127.3, 128.7, 128.8, 133.2, 136.0, 140.0, 154.6, 163.7, 179.6, 188.6; IR (ATR KBr cell, cm^{-1}) 742, 1199, 1489, 1693, 1726, 2860, 3263; LC-MS calcd m/z: 559 found 560 $[(M+1)]^+$. Anal. Calcd for $C_{26}H_{27}BrN_2O_3S_2$: C, 55.81; H, 4.86; N, 5.01; Found: C, 55.78; H, 4.81; N, 4.98.

2'-(3,3-bis(methylthio)acryloyl)-1'-(4-bromophenyl)-5-methoxy-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4la

Off white solid; Isolated yield 0.319g (94%); M. Pt. 186-188 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.64 - 1.69 (m, 2H), 1.77 - 1.84 (m, 2H), 2.17 (s, 3H), 2.23 (s, 3H), 2.32 - 2.51 (m, 2H), 3.67 - 3.71 (m, 5H), 3.92 (d, J = 11.5 Hz, 1H), 5.60 (s, 1H), 6.68 (d, J = 8.36 Hz, 1H), 6.74 - 6.76 (m, 1H), 6.80 (d, J = 2.44 Hz, 1H), 7.37 (dd, J = 1.76 Hz, 6.88 Hz, 2H), 7.49 - 7.51 (m, 2H), 10.31 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.6, 16.6, 27.3, 30.1, 47.6, 50.7, 56.0, 56.5, 67.8, 72.5, 73.6, 110.2, 112.3, 114.0, 120.0, 127.3, 130.5, 131.8, 136.0, 140.7, 154.7, 163.4, 179.9, 188.9; IR (ATR KBr cell, cm^{-1}) 745, 1145, 1428, 1690, 1718, 2875, 2928, 3198, 3435; LC-MS calcd m/z: 559 found 560 $[(M+1)]^+$. Anal. Calcd for $C_{26}H_{27}BrN_2O_3S_2$: C, 55.81; H, 4.86; N, 5.01; Found: C, 55.75; H, 4.80; N, 4.95.

2'-(3,3-bis(methylthio)acryloyl)-1'-(3-bromo-4-fluorophenyl)-5-methoxy-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4sa

Off white solid; Isolated yield 0.299g (90%); M. Pt. 120-122 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.68 - 1.84 (m, 4H), 2.19 (s, 3H), 2.26 (s, 3H), 2.37 - 2.51 (m, 2H), 3.71 - 3.75 (m, 5H), 3.92 - 3.95 (m, 1H), 5.63 (s, 1H), 6.70 (d, J = 8.08 Hz, 1H), 6.77 (d, J = 8.28 Hz, 1H), 6.84 (s, 1H), 7.34 (d, J = 8.48 Hz, 1H), 7.46 (s,1H), 7.80 (d, J = 6.36 Hz, 1H), 10.34 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.6, 16.7, 27.2, 29.9, 47.7, 50.1, 67.8, 72.6, 73.7, 79.7, 108.2, 110.2, 112.3, 114.0, 114.7, 117.3, 127.3, 129.2, 133.4, 139.6, 139.6, 154.3, 156.3, 158.7, 163.5, 179.8, 188.9; IR (ATR KBr cell, cm^{-1}) 755, 1480, 1720, 2918, 3270, 3578; LC-MS calcd m/z: 577 found 578 $[(M+1)]^+$. Anal. Calcd for

$C_{26}H_{26}BrN_2O_3S_2$: C, 54.07; H, 4.54; N, 4.85; Found: C, 54.03; H, 4.51; N, 4.79.

2'-(3,3-bis(methylthio)acryloyl)-1'-(5-bromothiophen-2-yl)-5-methoxy-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4ta

Off white solid; Isolated yield 0.334g (99%); M. Pt. 154 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.68 - 1.77 (m, 2H), 1.81 - 1.93 (m, 2H), 2.18 (s, 3H), 2.25 (s, 3H), 2.32 - 2.47 (m, 2H), 3.44 (s, 3H), 3.74 - 3.87 (m, 2H), 3.93 - 3.98 (m, 1H), 5.64 (s, 1H), 6.67 - 6.70 (m, 1H), 6.75 - 6.77 (m, 2H), 6.87 - 6.93 (m, 1H), 7.07 (d, J = 3.6 Hz, 1H), 10.34 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.6, 16.7, 27.3, 30.1, 46.7, 47.6, 56.1, 68.6, 72.1, 73.7, 109.3, 110.3, 112.0, 114.1, 114.7, 126.1, 126.9, 130.5, 135.9, 146.5, 154.7, 164.1, 179.6, 188.4; IR (ATR KBr cell, cm^{-1}) 748, 1078, 1343, 1470, 1628, 1709, 2918, 3440; LC-MS calcd m/z: 565 found 566 [(M+1)]$^+$. Anal. Calcd for $C_{24}H_{25}BrN_2O_3S_3$: C, 50.97; H, 4.46; N, 4.95; Found: C, 50.91; H, 4.43; N, 4.90.

2'-(3,3-bis(methylthio)acryloyl)-1'-(5-bromopyridin-3-yl)-5-methoxy-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4ua

Off white solid; Isolated yield 0.312g (92%); M. Pt. 208-210 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.67 - 1.81 (m, 2H), 1.83 - 1.87 (m, 2H), 2.18 (s, 3H), 2.24 (s, 3H), 2.35 - 2.39 (m, 1H), 2.45 - 2.51 (m, 1H), 3.69 (s, 3H), 3.73 - 3.79 (m, 2H), 4.02 (d, J = 11.3 Hz, 1H), 5.62 (s, 1H), 6.69 (d, J = 8.4 Hz, 1H), 6.75 - 6.78 (m, 1H), 6.83 (d, J = 2.4 Hz, 1H), 8.13 (t, J = 2 Hz, 1H), 8.55 (d, J = 2.2 Hz, 1H), 8.63 (d, J = 1.76 Hz, 1H), 10.36 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.6, 16.6, 27.2, 29.7, 47.7, 48.4, 56.1, 67.4, 72.1, 73.6, 110.2, 112.3, 114.1, 120.7, 127.1, 135.9, 138.2, 139.2, 148.6, 148.9, 154.8, 163.9, 179.7, 188.7; IR (ATR KBr cell, cm^{-1}) 704, 823, 1016, 1203, 1489, 1645, 1716, 2868, 3024, 3417, 3514; LC-MS calcd m/z: 560 found 561 [(M+1)]$^+$. Anal. Calcd for $C_{25}H_{26}BrN_3O_3S_2$: C, 53.57; H, 5.68; N, 7.50; Found: C, 53.52; H, 5.64; N, 7.48.

2'-(3,3-bis(methylthio)acryloyl)-5-nitro-1'-*o*-tolyl-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4bb

Off white solid; Isolated yield 0.347g (90%); M. Pt. 200-204 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.64 - 1.79 (m, 2H), 1.82 - 1.91 (m, 2H), 2.14 (s, 3H), 2.21 (s, 3H), 2.49 - 2.59 (m , 4H), 3.85 - 3.90 (m, 1H), 4.00 (t, J = 9.2 Hz, 1H), 4.09 (d, J = 11.2 Hz, 1H), 5.56 (s, 1H), 7.00 (d, J = 8.4 Hz, 1H), 7.01 - 7.11 (m, 1H), 7.16 - 7.23 (m, 2H), 7.45 (d, J = 7.2 Hz, 1H), 7.92 (d, J = 7.2 Hz, 1H), 8.19 (dd, J = 2 Hz, 8.4 Hz, 1H), 11.28 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.6, 20.1, 27.4, 30.3, 46.5, 47.6, 69.9, 73.0, 73.5, 110.3, 112.0, 122.3, 126.7, 126.8, 126.9, 127.0, 127.2, 130.7, 137.0, 138.8, 142.1, 149.2, 164.9, 180.5, 189.0; IR (ATR KBr cell, cm^{-1}) 749, 1140, 1480, 1600, 1728, 2970, 3300; LC-MS calcd m/z: 508 found 509 [(M+1)]$^+$. Anal. Calcd for $C_{26}H_{27}N_3O_4S_2$: C, 61.27; H, 5.34; N, 8.25; Found; C, 61.23; H, 5.29; N, 8.20.

2'-(3,3-bis(methylthio)acryloyl)-1'-(4-isopropylphenyl)-5-nitro-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4db

Off white solid; Isolated yield 0.335g (91%); M. Pt. 196-198 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.18 (d, J = 6.88 Hz, 6H), 1.70 - 1.73 (m, 2H), 1.81 - 1.87 (m, 2H), 2.14 (s, 3H), 2.21 (s, 3H), 2.39 - 2.43 (m ,1H), 2.47 - 2.52 (m, 2H), 2.80 - 2.87 (m, 1H), 3.67 - 3.73 (m, 1H), 3.78 - 3.83 (m, 1H), 4. 00 (d, J = 11.8 Hz, 1H), 5.66 (s, 1H), 6.98 (d, J = 8.64 Hz, 1H), 7.20 (d, J = 8.16 Hz, 2H), 7.35 (d, J = 8.16 Hz, 2H), 7.99 (d, J = 2.28 Hz, 1H), 8.17 (dd, J = 2.32 Hz, 8.64 Hz, 1H), 11.28 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.7, 24.3, 24.4, 27.4, 30.1, 33.5, 47.8, 51.2, 68.3, 72.9, 73.1, 110.3, 112.0, 122.3, 126.9, 127.0, 127.2, 128.2, 137.8, 142.1, 149.2, 164.9, 180.6, 189.0; IR (ATR KBr cell, cm^{-1}) 748, 1368, 1445, 1630, 1700, 2970, 3320; LC-MS calcd m/z: 537 found 538 [(M+1)]$^+$. Anal. Calcd for $C_{28}H_{31}N_3O_4S_2$: C, 62.54; H, 5.81; N, 7.81; Found: C, 62.48; H, 5.78; N, 7.80.

2'-(3,3-bis(methylthio)acryloyl)-1'-(4-ethoxyphenyl)-5-nitro-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4eb

Off white solid; Isolated yield 0.341g (93%); M. Pt. 190-192 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.31 (t, J = 6.8 Hz, 3H), 1.68 - 1.76 (m, 2H), 1.78 - 1.88 (m, 2H), 2.14 (s, 3H), 2.24 (s, 3H), 2.38 - 2.43 (m ,1H), 2.49 - 2.54 (m, 1H), 3.65 - 3.71 (m, 1H), 3.76 - 3.81 (m, 1H), 3.94 - 4.01 (m, 3H), 5.68 (s, 1H), 6.88 (d, J = 8.8 Hz, 2H), 6.98 (d, J = 8.4 Hz, 1H), 7.33 (d, J = 8.8 Hz, 2H), 7.99 (d, J = 2 Hz, 1H), 8.17 (dd, J = 2 Hz, 8.4 Hz, 1H), 11.20 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 15.2, 16.7, 27.4, 30.0, 47.8, 50.7, 63.4, 68.4, 72.9, 73.0, 110.3, 112.1, 115.0, 122.4, 126.9, 127.2, 129.2, 132.1, 142.1, 149.2, 157.8, 164.8, 180.6, 189.1; IR (ATR KBr cell, cm^{-1}) 746, 910, 1049, 1332, 1483, 1739, 2972, 3354; LC-MS calcd m/z: 538 found 539 [(M+1)]$^+$. Anal. Calcd for $C_{27}H_{29}N_3O_5S_2$: C, 60.09; H, 5.42; N, 7.79; Found: C, 60.05; H, 5.39; N, 7.72.

2'-(3,3-bis(methylthio)acryloyl)-1'-(3-methoxyphenyl)-5-nitro-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4gb

Off white solid; Isolated yield 0.33g (88%); M. Pt. 162 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.69 - 1.77 (m, 2H), 1.79 - 1.86 (m, 2H), 2.14 (s, 3H), 2.24 (s, 3H), 2.40 - 2.50 (m, 1H), 2.55 (s, 1H), 3.71 - 3.85 (m, 5H), 4.01 (t, J = 12 Hz, 1H), 5.70 (s, 1H), 6.80 (d, J = 8 Hz, 2H), 6.97 - 7.01 (m, 3H), 7.26 (t, J = 7.6 Hz, 1H), 8.01 (s, 1H), 8.17 (dd, J = 1.2 Hz, 8.8 Hz, 1H), 11.21 (s, 1H). ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.6, 16.7, 27.3, 30.0, 47.8, 51.4, 55.5, 68.1, 72.9, 73.1, 110.3, 112.1, 112.5, 114.2, 120.2, 122.4, 127.0, 130.1, 142.1, 142.2, 149.3, 159.9, 165.0, 180.6, 189.1; IR (ATR KBr cell, cm^{-1}) 720, 840, 1130, 1480, 1740, 2800, 3260; LC-MS calcd m/z: 525 found 526 [(M+1)]$^+$. Anal. Calcd for $C_{26}H_{27}N_3O_5S_2$: C, 59.41; H, 5.18; N, 7.99; C, 59.38; H, 5.11; N, 7.94.

2'-(3,3-bis(methylthio)acryloyl)-1'-(2-fluorophenyl)-5-nitro-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4ib

Off white solid; Isolated yield 0.352g (92%); M. Pt. 206-208 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.84 - 1.90 (m, 4H), 2.14 (s, 3H), 2.26 (s, 3H), 2.42 - 2.45 (m, 1H), 2.49 - 2.52 (m, 1H), 3.85 - 3.89 (m, 1H), 3.93 - 3.98 (m, 1H), 4.21 (d, J = 11.68 Hz, 1H), 5.66 (s, 1H), 6.99 (d, J = 8.64 Hz, 1H), 7.00 - 7.21 (m, 2H), 7.26 - 7.31 (m, 1H), 7.58, (q, J = 7.8 Hz, 1H), 7.94 (d, J = 2.24 Hz, 1H), 8.18 (dd, J = 2.28 Hz, 8.64 Hz, 1H), 11.30, (s, 1H); ^{13}C NMR

(100 MHz, DMSO-d_6) δ_C: 14.6, 16.6, 27.4, 30.3, 45.2, 47.7, 56.5, 68.8, 71.6, 73.0, 110.4, 111.6, 116.2, 122.2, 125.2, 126.7, 126.9, 127.1, 129.0, 127.1, 129.0, 129.9, 1421, 149.2, 159.9, 162.4, 165.3, 180.4, 188.5; IR (ATR KBr cell, cm^{-1}) 710, 1170, 1300, 1490, 1748, 2800, 3400; LC-MS calcd m/z: 513 found 514 $[(M+1)]^+$. Anal. Calcd for $C_{25}H_{24}FN_3O_4S_2$: C, 58.46; H, 4.71; N, 8.18; Found: C, 58.42; H, 4.66; N, 8.15.

2'-(3,3-bis(methylthio)acryloyl)-1'-(2-bromophenyl)-5-nitro-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4kb

Off white solid; Isolated yield 0.311g (89%); M. Pt. 226-228 ºC; ^{1}H NMR (400 MHz, DMSO-d_6) δ_H: 1.83 - 1.88 (m, 4H), 2.15 (s, 3H), 2.21 (s, 3H), 2.44 - 2.55 (m, 1H), 3.67 - 3.82 (m, 1H), 4.17 (d, J = 11.6 Hz, 1H), 4.29 - 4.35 (m, 1H), 5.62 (s, 1H), 7.01 (d, J = 8.68 Hz, 1H), 7.19 (td, J = 1.56 Hz, 8 Hz, 1H), 7.42 (td, J = 1.04 Hz, 7.56 Hz, 1H), 7.61 - 7.66 (m, 2H), 7.97 (d, J = 2.28 Hz, 1H), 8.20 (d, J = 2.24 Hz, 8.6 Hz, 1H), 11.35 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ_C: 14.6, 16.7, 27.2, 29.8, 47.7, 49.5, 55.4, 68.1, 73.0, 73.5, 110.5, 111.6, 122.0, 125.4, 127.0, 127.1, 128.9, 129.0, 129.1, 133.3, 139.3, 142.0, 149.3, 165.4, 180.1, 188.5; IR (ATR KBr cell, cm^{-1}) 752, 1130, 1494, 1710, 2879, 3387; LC-MS calcd m/z: 574 found 575 $[(M+1)]^+$. Anal. Calcd for $C_{25}H_{24}BrN_3O_4S_2$: C, 52.26; H, 4.21; N, 7.31; Found: C, 52.22; H, 4.16; N, 7.29.

2'-(3,3-bis(methylthio)acryloyl)-1'-(4-bromophenyl)-5-nitro-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4lb

Off white solid; Isolated yield 0.325g (93%); M. Pt. 196-198 ºC; ^{1}H NMR (400 MHz, DMSO-d_6) δ_H: 1.73 - 1.78 (m, 2H), 1.80 - 1.78 (m, 2H), 2.14 (s, 3H), 2.25 (s, 3H), 2.39 - 2.44 (m, 1H), 2.48 - 2.55 (m, 1H), 3.73 - 3.81 (m, 2H), 3.99 (d, J = 11.28 Hz, 1H), 5.66 (s, 1H), 6.98 (d, J = 8.68 Hz, 1H), 7.42 (d, J = 8.48 Hz, 2H), 7.52 (d, J = 8.44 Hz, 2H), 8.00 (d, J = 2.28 Hz, 1H), 8.17 (dd, J = 2.24 Hz, 8.6 Hz, 1H), 11.27 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ_C: 14.6, 16.7, 27.3, 29.8, 47.8, 50.8, 68.1, 72.6, 73.0, 110.3, 111.9, 120.3, 122.5, 126.9, 127.0, 130.6, 131.9, 140.0, 142.2, 149.2, 165.1, 180.5, 188.8; IR (ATR KBr cell, cm^{-1}) 760, 1400, 1498, 1760, 2800, 3117, 3289; LC-MS calcd m/z: 574 found 575 $[(M+1)]^+$. Anal. Calcd for $C_{25}H_{24}BrN_3O_4S_2$: C, 52.26; H, 4.21; N, 7.31; Found: C, 52.20; H, 4.18; N, 7.29.

2'-(3,3-bis(methylthio)acryloyl)-1'-(3-bromo-4-fluorophenyl)-5-nitro-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4sb

Off white solid; Isolated yield 0.307g (90%); M. Pt. 210-212 ºC; ^{1}H NMR (400 MHz, DMSO-d_6) δ_H: 1.66 - 1.85 (m, 4H), 2.14 (s, 3H), 2.24 (s, 3H), 2.42 - 2 48 (m, 1H), 2.51 - 2.53 (m, 1H), 3.80 (d, J = 7.2 Hz, 2H), 3.97 (s, 1H), 5.67 (s, 1H), 6.97 (d, J = 8.4 Hz, 1H), 7.33 (t, J = 8.8 Hz, 1H) 7.47 - 7.50 (m, 1H), 7.82 - 7.84 (m, 1H), 8.00 (s, 1H), 8.16 (dd, J = 1.6 Hz, 8.8 Hz, 1H), 11.20 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ_C: 14.6, 16.7, 27.1, 29.5, 47.9, 50.1, 68.1, 72.7, 73.0, 108.3, 108.5, 110.3, 112.1, 117.4, 122.5, 127.0, 129.4, 133.4, 138.9, 142.2, 149.2, 156.4, 158.8, 165.1, 180.5, 188.8; IR (ATR KBr cell, cm^{-1}) 740, 1280, 1640, 1718, 2300, 3088, 3421; LC-MS calcd m/z: 592 found 593 $[(M+1)]^+$. Anal. Calcd for $C_{25}H_{23}BrFN_3O_4S_2$: C, 50.68; H, 3.91; N, 7.09; Found: C, 50.62; H, 3.88; N, 7.07.

2'-(3,3-bis(methylthio)acryloyl)-1'-(5-bromothiophen-2-yl)-5-nitro-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4tb

Off white solid; Isolated yield 0.319g (92%); M. Pt. 196-198 ºC; ^{1}H NMR (400 MHz, DMSO-d_6) δ_H: 1.83 - 1.96 (m, 4H), 2.17 (s, 3H), 2.29 (s, 3H), 2.37 - 2.42 (m, 1H), 2.49 - 2.54 (m, 1H), 3.81 - 3.88 (m, 2H), 4.02 - 4.07 (m, 1H), 5.70 (s, 1H), 6.92 (d, J = 3.6 Hz, 1H), 6.97 (d, J = 8.4 Hz, 1H), 7.07 (d, J = 4 Hz, 1H), 7.97 (d, J = 2.4 Hz, 1H), 8.17 (dd, J = 2 Hz, 8.4 Hz, 1H), 11.24 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ_C: 14.6, 16.8, 27.2, 29.7, 46.8, 47.9, 68.8, 72.2, 73.0, 109.6, 110.4, 111.8, 122.6, 126.4, 126.5, 127.1, 130.7, 142.2, 145.7, 149.1, 165.7, 180.3, 188.3; IR (ATR KBr cell, cm^{-1}) 694, 732, 1093, 1336, 1481, 1624, 1716, 2854, 3227, 3042; LC-MS calcd m/z: 580 found 581 $[(M+1)]^+$. Anal. Calcd for $C_{23}H_{22}BrN_3O_4S_3$: C, 47.58; H, 3.82; N, 7.24; Found: C, 47.51; H, 3.80; N, 7.19.

2'-(3,3-bis(methylthio)acryloyl)-1'-(5-bromopyridin-3-yl)-5-nitro-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4ub

Off white solid; Isolated yield 0.328g (94%); M. Pt. 216-218 ºC; ^{1}H NMR (400 MHz, DMSO-d_6) δ_H: 1.70 - 1.91 (m, 4H), 2.15 (s, 3H), 2.25 (s, 3H), 2.40 - 2.49 (m, 1H), 2.50 - 2.59 (m, 1H), 3.82 - 3.89 (m, 2H), 4.12 (d, J = 11.2 Hz, 1H), 6.99 (d, J = 8.64 Hz, 1H), 8.01 (d, J = 2.24 Hz, 1H), 8.16 - 8.19 (m, 2H), 8.57 (d, J = 2.2 Hz, 1H), 8.67 (d, J = 1.8 Hz, 1H), 11.30 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ_C: 14.6, 16.7, 27.1, 29.3, 48.0, 48.4, 67.5, 72.3, 73.0, 110.3, 112.2, 120.8, 122.5, 126.7, 127.1, 133.3, 138.5, 142.3, 148.5, 149.1, 165.0, 180.3, 188.6; IR (ATR KBr cell, cm^{-1}) 724, 906, 1480, 1708, 2800, 3058, 3423; LC-MS calcd m/z: 575 found 576 $[(M+1)]^+$. Anal. Calcd for $C_{24}H_{23}BrN_4O_4S_2$: C, 50.09; H, 4.03; N, 9.74; Found: C, 50.02; H, 4.00; N, 9.70.

2'-(3,3-bis(methylthio)acryloyl)-6-bromo-1'-*o*-tolyl-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4bc

Off white solid; Isolated yield 0.366g (89%); M. Pt. 160-162 ºC; ^{1}H NMR (400 MHz, DMSO-d_6) δ_H: 1.64 - 1.77 (m, 2H), 1.79 - 1.85 (m, 2H), 2.19 (s, 3H), 2.25 (s, 3H), 2.39 - 2.51 (m, 2H), 2.54 (s, 3H), 3.73 - 3.78 (m, 1H), 3.93 (t, J = 9.52 Hz, 1H), 4.07 (d, J = 11.62 Hz, 1H), 5.55 (s, 1H), 6.94 (s, 1H), 7.07 - 7.10 (m, 1H), 7.14 - 7.21 (m, 4H), 7.38 (d, J = 7.72 Hz, 1H), 10.67 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ_C: 14.5, 16.5, 20.4, 27.7, 30.8, 46.4, 47.4, 69.6, 73.3, 73.7, 111.8, 112.9, 122.2, 124.4, 125.5, 126.5, 126.8, 130.7, 137.1, 139.3, 144.3, 163.9, 180.0, 188.8; IR (ATR KBr cell, cm^{-1}) 727, 1134, 1325, 1494, 1602, 1710, 2854, 3159, 3320; LC-MS calcd m/z: 541 found 542 $[(M+1)]^+$. Anal. Calcd for $C_{26}H_{27}BrN_2O_2S_2$: C, 57.45; H, 5.01; N, 5.15; Found: C, 57.40; H, 4.97; N, 5.13.

2'-(3,3-bis(methylthio)acryloyl)-6-bromo-1'-(4-isopropylphenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4dc

Off white solid; Isolated yield 0.344g (88%); M. Pt. 170-172 ºC; ^{1}H NMR (400 MHz, DMSO-d_6) δ_H: 1.18 (d, J = 6.8 Hz, 6H), 1.62 - 1.71 (m, 2H), 1.78 - 1.80 (m, 2H), 2.19 (s, 3H), 2.23 (s, 3H), 2.36 - 2.37 (m, 2H), 2.81 - 2.88 (m, 1H), 3.62 - 3.73 (m, 2H), 3.99 (d, J = 12 Hz, 1H), 5.63 (s, 1H), 6.93 (s, 1H), 7.11 (d, J = 7.6 Hz, 1H), 7.19 - 7.24 (m, 3H), 7.31 (d, J = 8 Hz, 2H), 10.62 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.7, 20.4, 27.5, 30.5, 33.5, 47.6, 51.1, 67.8, 73.1, 73.3, 112.0, 112.8, 122.1, 124.1, 125.7, 127.0, 128.1, 129.0, 138.0, 144.3, 147.1, 164.0, 180.0, 188.9; IR (ATR KBr cell, cm^{-1}) 734, 812, 1165, 1329, 1446, 1620, 1732, 3219, 3384; LC-MS calcd m/z: 569 found 570 [(M+1)]$^+$. Anal. Calcd for $C_{28}H_{31}BrN_2O_2S_2$: C, 58.84; H, 5.47; N, 4.90; Found: C, 58.80; H, 5.41; N, 4.88.

2'-(3,3-bis(methylthio)acryloyl)-6-bromo-1'-(4-ethoxyphenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4ec

Off white solid; Isolated yield 0.355g (91%); M. Pt. 200-202 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.32 (t, J = 6.88 Hz, 3H), 1.63 - 1.70 (m, 2H), 1.72 - 1.80 (m, 2H), 2.18 (s, 3H), 2.26 (s, 3H), 2.36 - 2.39 (m, 2H), 3.60 - 3.72 (m, 2H), 3.93 (d, J = 11.8 Hz, 1H), 4.00 (q, J = 6.92 Hz, 2H), 5.65 (s, 1H), 6.88 (d, J = 8.56 Hz, 2H), 6.92 (s, 1H), 7.11 (dd, J = 1.48 Hz, 7.92 Hz, 1H), 7.23 (d, J = 8.04 Hz, 1H), 7.29 (d, J = 8.56 Hz, 2H), 10.59 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 15.2, 16.7, 27.5, 30.4, 47.6, 50.6, 63.4, 67.9, 73.0, 73.2, 112.1, 112.8, 114.9, 122.1, 124.1, 125.6, 129.0, 132.5, 144.3, 157.8, 163.9, 180.0, 189.0; IR (ATR KBr cell, cm^{-1}) 779, 1103, 1498, 1711, 2253, 3299; LC-MS calcd m/z: 573 found 574 [(M+1)]$^+$. Anal. Calcd for $C_{27}H_{29}BrN_2O_3S_2$: C, 56.54; H, 5.10; N, 4.88; Found: C, 56.50; H, 5.08; N, 4.83.

2'-(3,3-bis(methylthio)acryloyl)-6-bromo-1'-(3-methoxyphenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4gc

Off white solid; Isolated yield 0.367g (92%); M. Pt. 150 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.66 - 1.70 (m, 2H), 1.76 - 1.82 (m, 2H), 2.19 (s, 3H), 2.24 (s, 3H), 2.35 - 2.36 (m, 2H), 3.64 - 3.75 (m, 5H), 3.98 (d, J = 11.6 Hz, 1H), 5.65 (s, 1H), 6.78 - 6 .80 (m, 1H), 6.91 - 6.97 (m, 3H), 7.09 - 7.11 (m, 1H), 7.22 - 7.25 (m, 2H), 10.60 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.7, 27.5, 30.4, 47.6, 51.4, 55.4, 67.6, 72.9, 73.3, 110.0, 112.0, 112.3, 112.8, 114.2, 120.1, 122.2, 124.1, 125.6, 129.0, 130.1, 142.6, 144.3, 159.8, 164.0, 179.9, 188.9; IR (ATR KBr cell, cm^{-1}) 734, 1360, 1684, 1704, 3060, 3168, 3320; LC-MS calcd m/z: 559 found 560 [(M+1)]$^+$. Anal. Calcd for $C_{26}H_{27}BrN_2O_3S_2$: C, 55.81; H, 4.86; N, 5.01; Found: C, 55.75; H, 4.83; N, 4.94.

2'-(3,3-bis(methylthio)acryloyl)-6-bromo-1'-(2-fluorophenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4ic

Off white solid; Isolated yield 0.363g (89%); M. Pt. 134 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.60 - 1.71 (m, 2H), 1.78 - 1.83 (m, 2H), 2.18 (s, 3H), 2.27 (s, 3H), 2.32 - 2.38 (m, 2H), 3.72 - 3.77 (m, 1H), 3.85 - 3.90 (m, 1H), 4.17 (d, J = 12 Hz, 1H), 5.62 (s, 1H), 6.91 (s, 1H), 7.11 - 7.19 (m, 4H), 7.24 - 7.29 (m, 1H), 7.50 (d, J = 7.48 Hz, 1H), 10.75 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.6, 27.6, 30.7, 45.1, 47.4, 66.4, 71.7, 73.2, 111.5, 112.9, 116.1, 122.2, 124.3, 125.2, 125.3, 127.2, 127.3, 128.8, 128.9, 129.8, 144.3, 159.9, 162.4, 164.3, 179.8, 188.4; IR (ATR KBr cell, cm^{-1}) 760, 1128, 1444, 1620, 1700, 1780, 2980, 3420; LC-MS calcd.m/z: 547 found 548 [(M+1)]$^+$. Anal. Calcd for $C_{25}H_{24}BrFN_2O_2S_2$: C, 54.84; H, 4.42; N, 5.12; C, 54.81; H, 4.38; N, 5.08.

2'-(3,3-bis(methylthio)acryloyl)-6-bromo-1'-(2-bromophenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4kc

Off white solid; Isolated yield 0.333g (90%); M. Pt. 204-206 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.66 - 1.83 (m, 4H), 2.19 (s, 3H), 2.24 (s, 3H), 2.36 - 2.39 (m, 2H), 3.65 - 3.70 (m, 1H), 4.13 (d, J = 11.9 Hz, 2H), 4.19 - 4.25 (m, 1H), 5.58 (s, 1H), 6.93 (d, J = 1.8 Hz, 1H), 7.07 (d, J = 8.04 Hz, 1H), 7.14 - 7.18 (m, 2H), 7.39 (td, J = 1.08 Hz, 1.6 Hz, 1H), 7.53 (dd, J = 1.44 Hz, 7.92 Hz, 1H), 7.63 (dd, J = 1.2 Hz, 8 Hz, 1H), 10.65 (s, 1H); ^{13}C NMR (100 MH z, DMSO-d$_6$) δ_C: 14.5, 16.6, 27.4, 30.1, 47.5, 49.4, 67.8, 73.1, 73.5, 111.5, 113.0, 122.3, 124.4, 125.4, 128.3, 128.7, 128.8, 128.9, 133.3, 139.7, 144.4, 164.4, 179.6, 188.4; IR (ATR KBr cell, cm^{-1}) 732, 1491, 1614, 1722, 2829, 1241, 3284, 3425; LC-MS calcd m/z: 608 found 609 [(M+1)]$^+$. Anal. Calcd for $C_{25}H_{24}Br_2N_2O_2S_2$: C, 49.35; H, 3.98; N, 4.60; C, 49.30; H, 3.96; N, 4.54.

2'-(3,3-bis(methylthio)acryloyl)-6-bromo-1'-(4-bromophenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4lc

Off white solid; Isolated yield 0.344g (93%); M. Pt. 190-192 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.65 - 1.71 (m, 2H), 1.74 - 1.84 (m, 2H), 2.19 (s, 3H), 2.26 (s, 3H), 2.35 - 2.36 (m, 2H), 3.65 - 3.72 (m, 1H), 3.92 - 3.98 (m, 1H), 5.61 (s, 1H), 6.90 (d, J = 1.8 Hz, 1H), 7.10 (dd, J = 1.8 Hz, 7.96 Hz, 1H), 7.23 (d, J = 8.04 Hz, 1H), 7.35 (d, J = 8.48 Hz, 2H), 7.51 (d, J = 1.6 Hz, 2H), 10.65 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.5, 16.7, 27.5, 30.2, 47.6, 50.7, 67.6, 72.7, 73.2, 111.8, 112.9, 120.1, 122.2, 124.1, 125.3, 129.0, 130.5, 131.8, 140.4, 144.3, 164.2, 179.8, 188.6; IR (ATR KBr cell, cm^{-1}) 760, 1126, 1348, 1490, 1708, 2878, 3380; LC-MS calcd m/z: 608 found 609 [(M+1)]$^+$. Anal. Calcd for $C_{25}H_{24}Br_2N_2O_2S_2$: C, 49.35; H, 3.98; N, 4.60; Found: C, 49.30; H, 3.94; N, 4.58.

2'-(3,3-bis(methylthio)acryloyl)-6-bromo-1'-(3-bromo-4-fluorophenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4sc

Off white solid; Isolated yield 0.328g (91%); M. Pt. 150-152 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.68 - 1.72 (m, 2H), 1.76 - 1.81 (m, 2H), 2.19 (s, 3H), 2.27 (s, 3H), 2.32 - 2.38 (m, 2H), 3.69 - 3.76 (m, 2H), 3.95 (d, J = 11.6 Hz, 1H), 5.63 (s, 3H), 6.91 (d, J = 1.76 Hz, 1H), 7.09 (dd, J = 1.76 Hz, 7.96 Hz, 1H), 7.23 (t, J = 7.89 Hz, 1H), 7.33 (t, J = 8.68 Hz, 1H), 7.42 - 7.46 (m, 1H), 7.76 (dd, J = 2.08 Hz, 6.8 Hz, 1H), 10.70 (s, 1H). ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.6, 16.6, 27.3, 29.9, 47.6, 50.1, 67.6, 72.6, 73.2, 112.0, 112.9, 117.1, 117.3, 122.3, 124.1, 125.3, 129.0, 133.3, 144.3, 164.1, 179.8, 185.6; IR (ATR KBr cell, cm^{-1}) 748, 1128, 1348, 1494, 1608, 1710, 3328; LC-MS calcd m/z: 626 found 627 [(M+1)]$^+$. Anal. Calcd for $C_{25}H_{23}Br_2FN_2O_2S_2$: C, 47.94; H, 3.70; N, 4.47: Found: C, 47.90; H, 3.68; N, 4.43.

2'-(3,3-bis(methylthio)acryloyl)-6-bromo-1'-(5-bromothiophen-2-yl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4tc

Off white solid; Isolated yield 0.345g (94%); M. Pt. 130-132 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.67 - 1.78 (m, 2H), 1.79 - 1.95 (m, 1H), 2.24 (s, 3H), 2.32 (s, 3H), 2.35 - 2.46 (m, 2H), 3.78 - 3.83 (m, 2H), 3.91 - 3.97 (m, 1H), 5.66 (s, 1H), 6.87 (d, J = 3.64

Hz, 1H), 6.92 (s, 1H), 7.06 - 7.10 (m, 2H), 7.19 (d, $J = 8$ Hz, 1H), 10.65 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.6, 16.7, 27.4, 30.2, 46.7, 47.6, 68.5, 72.2, 73.3, 109.4, 111.7, 112.9, 122.4, 124.2, 124.9, 126.1, 129.2, 130.6, 144.2, 146.1, 164.8, 179.6, 188.1; IR (ATR KBr cell, cm^{-1}) 761, 1384, 1606, 1700, 2456, 3071, 3309; LC-MS calcd m/z: 614 found 615 [(M+1)]$^+$. Anal. Calcd for $C_{23}H_{22}Br_2N_2O_2S_3$: C, 44.96; H, 3.61; N, 4.56; Found: C, 44.93; H, 3.56; N, 4.52.

2'-(3,3-bis(methylthio)acryloyl)-6-bromo-1'-(5-bromopyridin-3-yl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 4uc

Off white solid; Isolated yield 0.34g (92%); M. Pt. 194-196 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.79 - 1.80 (m, 2H), 1.81 - 1.84 (m, 2H), 2.21 (s, 3H), 2.29 (s, 3H), 2.38 - 2.45 (m, 2H), 3.74 - 3.79 (m, 2H), 4.08 (d, J = 11.36 Hz, 1H), 5.65 (s, 1H), 6.94 (s, 1H), 7.12 (dd, $J = 1.36$ Hz, 7.88 Hz, 1H), 7.25 (d, $J = 8$ Hz, 1H), 8.12 (s, 1H), 8.58 (s, 1H), 8.64 (s, 1H), 10.69 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ_C: 14.6, 16.7, 27.4, 29.8, 47.7, 48.4, 67.2, 72.2, 73.2, 112.0, 112.9, 120.8, 122.4, 125.2, 129.0, 138.1, 138.9, 144.3, 148.6, 149.1, 164.1, 179.7, 188.4; IR (ATR KBr cell, cm^{-1}) 709, 1480, 1722, 2827, 3248, 3423; LC-MS calcd m/z: 609 found 610 [(M+1)]$^+$. Anal. Calcd for $C_{24}H_{23}Br_2N_3O_2S_2$: C, 47.30; H, 3.80; N, 6.90; Found: C, 47.28; H, 3.76; N, 6.85.

General procedure for the synthesis of 5

A mixture of Isatin **1** (1mol), L-phenylalanine **2** (1mol) was taken in methanol and heated for 15 min. This led to the formation of azomethine ylide which was treated with 1,1-bis(methylthio)-5-arylpenta-1,4-dien-3-one **3** and continued heating for further indicated time in table-2. After completion of the reaction checked by TLC, the mixture was concentrated in vacuo. Column chromatography of the residue gave the pure product **5.**

5'-benzyl-3'-(3,3-bis(methylthio)acryloyl)-6-bromo-4'-phenylspiro[indoline-3,2'-pyrrolidin]-2-one 5a

Pale yellow solid; Isolated yield 0.398g (86%); M. Pt. 130 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 2.13 - 2.22 (m, 6H), 2.68 - 2.73 (m, 2H), 3.58 - 3.67 (m, 3H), 3.92 (s, 1H), 5.48 (s, 1H), 6.86 - 6.92 (m, 2H), 6.99 - 7.07 (m, 3H), 7.11 - 7.39 (m, 9H), 10.60 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 14.4, 14.6, 16.5, 22.2, 52.5, 66.2, 67.6, 69.0, 112.1, 113.1, 121.7, 126.3, 127.1, 127.7, 128.5, 128.8, 129.0, 129.5, 139.6, 140.8, 143.8, 162.9, 189.5; IR (ATR KBr cell, cm^{-1}) 740, 1520, 1600, 1726, 2967, 3140, 3240; LC-MS calcd m/z: 579 found 580 [(M+1)]$^+$. Anal. Calcd for $C_{29}H_{27}BrN_2O_2S_2$: C, 60.10; H, 4.70; N, 4.83; Found: C, 60.05; H, 4.67; N, 4.76.

5'-benzyl-3'-(3,3-bis(methylthio)acryloyl)-4'-*o*-tolylspiro[indoline-3,2'-pyrrolidin]-2-one 5b

Pale yellow solid; Isolated yield 0.311g (80%); M. Pt. 122 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 2.11 (s, 3H), 2.19 (s, 3H), 2.54 (s, 3H), 2.58 - 2.64 (m, 1H), 2.70 - 2.76 (m, 2H), 3.08 - 3.10 (m, 1H), 3.69 (d, $J = 10$ Hz, 1H), 3.88 - 3.96 (m, 2H), 5.36 (s, 1H), 6.74 (d, $J = 7.6$ Hz, 1H), 6.85 (td, $J = 0.8$ Hz, 7.6 Hz, 1H), 7.06 - 7.24 (m, 10H), 7.49 (d, $J = 7.6$ Hz, 1H), 10.47 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 14.5, 14.8, 16.4, 19.8, 20.3, 48.5, 68.1, 69.0, 69.5, 109.2, 113.2, 121.8, 125.9, 126.2, 126.5, 126.7, 127.1, 128.4, 129.1, 129.2, 130.5, 137.4, 137.6, 139.8, 140.3, 142.1, 162.0, 182.3, 190.2; IR (ATR KBr cell, cm^{-1}) 748, 1619, 1750, 2948, 3300; LC-MS calcd m/z: 514 found 515 [(M+1)]$^+$. Anal. Calcd for $C_{30}H_{30}N_2O_2S_2$: C, 70.01; H, 5.87; N, 5.44; Found: C, 69.07; H, 5.80; N, 5.41.

5'-benzyl-3'-(3,3-bis(methylthio)acryloyl)-4'-(4-isopropylphenyl)spiro[indoline-3,2'-pyrrolidin]-2-one 5d

Pale yellow solid; Isolated yield 0.315g (85%); M. Pt. 172 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.09 - 1.21 (m, 6H), 2.11 - 2.22 (m, 6H), 2.63 - 2.74 (m, 2H), 2.83 - 2.94 (m, 2H), 3.51 - 3.56 (m, 1H), 3.62 (d, $J = 10.8$ Hz, 1H), 3.87 - 3.88 (m, 1H), 5.40 (s, 1H), 6.71 (d, $J = 7.6$ Hz, 1H), 6.82 (t, $J = 7.2$ Hz, 1H), 6.89 (d, $J = 7.6$ Hz, 1H), 7.08 - 7.22 (m, 9H), 7.31 (d, $J = 8$ Hz, 2H), 10.44 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 14.5, 16.4, 24.3, 24.4, 33.5, 52.4, 66.0, 69.3, 109.2, 113.1, 121.8, 125.8, 126.3, 127.0, 128.4, 128.6, 129.6, 142.1, 147.0, 142.1, 147.0, 189.3; IR (ATR KBr cell, cm^{-1}) 780, 1168, 1600, 1720, 2897, 3300; LC-MS calcd m/z: 542 found 543 [(M+1)]$^+$. Anal. Calcd for $C_{32}H_{34}N_2O_2S_2$: C, 70.81; H, 6.31; N, 5.16; Found: C, 70.79; H, 6.27; N, 5.13.

5'-benzyl-3'-(3,3-bis(methylthio)acryloyl)-6-bromo-4'-(3-methoxyphenyl)spiro[indoline-3,2'-pyrrolidin]-2-one 5g

Pale yellow solid; Isolated yield 0.377g (87%); M. Pt. 196 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 2.19 (s, 3H), 2.22 (s, 3H), 2.59 - 2.68 (m, 1H), 2.75 (dd, $J = 3.2$ Hz, 14 Hz, 1H), 3.54 (t, $J = 10.4$ Hz, 1H), 3.63 (d, $J = 10.8$ Hz, 1H), 3.76 (s, 3H), 3.86 - 3.87 (m, 1H), 5.49 (s, 1H), 6.80 - 6.87 (m, 3H), 6.93 (s, 1H), 6.97 (d, $J = 7.6$ Hz, 1H), 7.01 (dd, $J = 1.6$ Hz, 7.6 Hz, 1H), 7.09 - 7.16 (m, 3H), 7.21- 7.30 (m, 3H), 10.59 (s, 1H). ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 14.6, 16.5, 52.6, 55.4, 66.1, 67.6, 69.1, 112.0, 112.1, 113.1, 114.9, 120.8, 121.6, 124.4, 126.3, 127.6, 128.4, 128.8, 129.5, 129.8, 130.0, 130.3, 130.4, 139.8, 142.6, 143.8, 159.8, 162.7, 182.0, 189.6; IR (ATR KBr cell, cm^{-1}) 765, 1299, 1610, 1740, 2696, 3280; LC-MS calcd m/z: 609 found 610 [(M+1)]$^+$. Anal. Calcd for $C_{30}H_{29}BrN_2O_3S_2$: C, 59.11; H, 4.80; N, 4.60; Found: C, 59.05; H, 4.73; N, 4.57.

5'-benzyl-3'-(3,3-bis(methylthio)acryloyl)-4'-(4-bromophenyl)spiro[indoline-3,2'-pyrrolidin]-2-one 5l

Pale yellow solid; Isolated yield 0.299g (85%); M. Pt. 118 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 2.14 (s, 3H), 2.18 (s, 3H), 2.70 (d, $J = 6$ Hz, 2H), 3.54 - 3.62 (m, 2H), 3.85 - 3.88 (m, 1H), 5.39 (s, 1H), 6.72 (d, $J = 7.6$ Hz, 1H), 6.81 (td, $J = 3.2$ Hz, 6.8 Hz, 1H), 6.91 (d, $J = 8$ Hz, 1H), 7.09 - 7.23 (m, 6H), 7.34 ($J = 8.4$ Hz, 2H), 7.53 (d, $J = 8.4$ Hz, 2H), 10.46 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 14.6, 16.4, 52.3, 66.1, 67.8, 69.3, 109.3, 113.0, 120.0, 121.8, 125.8, 126.3, 128.4, 129.1, 129.6, 130.4, 130.6, 131.0, 131.8, 139.6, 140.7, 142.0, 162.4, 182.0, 189.5: IR (ATR KBr cell, cm^{-1}) 720, 1019, 1336, 1490, 1640, 1748, 3220, 3380; LC-MS calcd m/z: 579 found 580 [(M+1)]$^+$. Anal. Calcd for $C_{29}H_{27}BrN_2O_2S_2$: C, 60.10; H, 4.70; N, 4.83; Found: C, 60.05; H, 4.67; N, 4.80.

5'-benzyl-3'-(3,3-bis(methylthio)acryloyl)-4'-(furan-2-yl)spiro[indoline-3,2'-pyrrolidin]-2-one 5v

Pale yellow solid; Isolated yield 0.318g (78%); M. Pt. 118 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 2.19 (s, 3H), 2.21 (s, 3H), 2.74 - 2.79 (m, 1H), 2.89 - 2.97 (m, 2H), 3.65 - 3.82 (m, 1H), 5.49 (s, 1H), 6.25 - 6.26 (m, 1H), 6.38 - 6.39 (m, 1H), 6.70 (d, $J = 7.6$ Hz, 1H), 6.78 (d, J = 4 Hz, 2H), 7.07 - 7.27 (m, 6H), 7.58 (s, 1H), 10.43 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 14.6, 16.5, 45.7, 63.7, 64.3, 69.0, 106.8, 109.2, 110.9, 112.7, 121.8, 122.0, 125.7, 126.4, 128.5, 129.1, 129.6, 129.8, 139.4, 142.0, 154.3, 162.7, 181.7, 189.2; IR (ATR KBr cell, cm^{-1}) 704, 1081, 1280, 1490, 1649, 1720, 2916, 3100; LC-MS calcd m/z: 490 found 491 [(M+1)]$^+$. Anal. Calcd for $C_{27}H_{26}N_2O_3S_2$: C, 66.10; H, 5.34; N, 5.71; Found: C, 66.04; H, 5.30; N, 5.68.

5'-benzyl-3'-(3,3-bis(methylthio)acryloyl)-5-methoxy-4'-(naphthalen-1-yl)spiro[indoline-3,2'-pyrrolidin]-2-one 5w

Pale yellow solid; Isolated yield 0.313g (81%); M. Pt. 118 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 2.07 (s, 3H), 2.17 (s, 3H), 2.77 - 2.82 (m, 1H), 3.12 (s, 1H), 3.68 - 3.74 (m, 4H), 3.83 - 3.88 (m, 1H), 4.06 (s, 1H), 5.42 (s, 1H), 6.68 - 6.79 (m, 4H), 7.01 - 7.17 (m, 6H), 7.48 - 8.21 (m, 6H), 10.32 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 13.0, 15.1, 54.9, 66.4, 67.7, 69.4, 105.2, 109.6, 110.9, 112.0, 124.8, 125.0, 125.2, 126.1, 127.0, 127.9, 128.1 148.8, 154.2, 157.6, 163.0, 180.2, 188.3; IR (ATR KBr cell, cm^{-1}) 738, 1136, 1430, 1646, 1749, 2860, 3320; LC-MS calcd m/z: 580 found 581 [(M+1)]$^+$. Anal. Calcd for $C_{34}H_{32}N_2O_3S_2$: C, 70.32; H, 5.55; N, 4.82; Found: C, 70.28; H, 5.50; N, 4.80.

2'-(1*H*-benzo[*d*]imidazol-2-yl)-1'-(4-methoxyphenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 8a

Off white solid; Isolated yield 0.073g (78%); M. Pt. 138 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.81 - 1.96 (m, 2H), 2.42 - 2.45 (m, 1H), 2.70 - 2.75 (m, 1H), 3.67 (s, 3H), 3.89 - 3.95 (m, 1H), 4.01 - 4.09 (m, 1H), 4.38 (d, J = 12.4 Hz, 1H), 6.59 (d, J = 7.6 Hz, 1H), 6.77 (td, J = 0.8 Hz, 7.6 Hz, 1H), 6.85 (d, J = 8.8 Hz, 2H), 6.95 - 7.01 (m, 3H), 7.15 - 7.17 (m, 1H), 7.29 (d, J = 7.2 Hz, 1H), 7.36 - 7.39 (m, 3H), 10.29 (s, 1H), 11.84 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 27.3, 30.4, 48.0, 53.0, 55.4, 57.3, 72.4, 74.4, 109.9, 111.2, 114.5, 118.7, 120.9, 121.2, 121.9, 126.2, 127.3, 129.0, 129.3, 132.3, 134.3, 142.6, 143.2, 151.5, 158.5, 169.0, 179.8; IR (ATR KBr cell, cm^{-1}) 831, 1125, 1428, 1404, 1625, 2981, 3481; LC-MS calcd m/z: 450 found 451 [(M+1)]$^+$. Anal. Calcd for $C_{28}H_{26}N_4O_2$: C, 74.65; H, 5.82; N, 12.44; Found: C, 74.59; H, 5.78; N, 12.40.

2'-(1*H*-benzo[*d*]imidazol-2-yl)-6-bromo-1'-(3-methoxyphenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 8b

Off white solid; Isolated yield 0.076g (80%); M. Pt. 144 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.74 - 1.81 (m, 2H), 1.92 - 1.96 (m, 2H), 2.20 - 2.26 (m, 1H), 2.68 - 2.71 (m, 1H), 3.48 - 3.55 (m, 1H), 3.69 (m, 1H), 3.94 - 3.97 (m, 1H), 4.11 (t, J = 9.6 Hz, 1H), 4.43 (d, J = 12 Hz, 1H), 6.73 - 6.76 (m, 1H), 6.92 - 7.03 (m, 5H), 7.18 - 7.29 (m, 3H), 7.39 - 7.42 (m, 1H), 10.48 (s, 1H), 11.94 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 27.3, 30.3, 48.0, 53.8, 55.4, 56.9, 72.2, 74.2, 111.3, 112.3, 112.8, 114.2, 120.1, 121.4, 122.0, 122.1, 123.6, 125.5, 130.1, 134.3, 142.0, 143.2, 144.4, 151.3, 159.8, 179.6; IR (ATR KBr cell, cm^{-1}) 752, 1134, 1332, 1625, 2883, 3441; LC-MS calcd m/z: 528 found 529 [(M+1)]$^+$. Anal. Calcd for $C_{28}H_{25}BrN_4O_2$: C, 63.52; H, 4.76; N, 10.58; Found: C, 63.48; H, 4.73; N, 10.53.

2'-(1*H*-benzo[*d*]imidazol-2-yl)-1'-*p*-tolyl-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 8c

Off white solid; Isolated yield 0.082g (88%); M. Pt. 148 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.72 - 1.80 (m, 2H), 1.92 - 1.97 (m, 2H), 2.20 (s, 3H), 2.25 - 2.27 (m, 1H), 2.41 - 2.45 (m, 1H), 2.72 - 2.74 (m, 1H), 3.92 - 3.95 (m, 1H), 4.06 - 4.11 (m, 1H), 4.42 (d, J = 12.4 Hz, 1H), 6.60 (d, J = 7.2 Hz, 1H), 6.77 (t, J = 7.6 Hz, 1H), 6.95 - 7.01 (m, 3H), 7.08 (d, J = 8 Hz, 2H), 7.12 - 7.17 (m, 1H), 7.27 - 7.35 (m, 4H), 10.30 (s, 1H), 11.85 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 21.0, 27.3, 30.4, 48.0, 53.4, 57.2, 72.4, 74.4, 109.9, 120.9, 121.9, 126.2, 127.4, 129.3, 129.6, 136.3, 137.5, 142.6, 151.5, 179.8; IR (ATR KBr cell, cm^{-1}) 752, 1134, 1332, 1625, 2883, 3441; LC-MS calcd m/z: 434 found 435 [(M+1)]$^+$. Anal. Calcd for $C_{28}H_{26}N_4O$: C, 77.39; H, 6.03; N, 12.89; Found: C, 77.33; H, 6.00; N, 12.85.

2'-(2-amino-6-methoxypyrimidin-4-yl)-1'-(4-methoxyphenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 10a

Off white solid; Isolated yield 0.081g (85%); M. Pt. 118 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.43 - 1.74 (m, 2H), 1.80 - 1.92 (m, 2H), 2.33 - 2.53 (m, 2H), 3.55 (s, 3H), 3.68 - 3.81 (m, 5H), 4.00 (d, J = 12 Hz, 1H), 5.59 (s, 1H), 6.12 (s, 1H), 6.66 (d, J = 7.6 Hz, 1H), 6.86 (d, J = 8.4 Hz, 3H), 7.08 (td, J = 0.8 Hz, 7.6 Hz, 1H), 7.31 (d, J = 8.8 Hz, 2H), 7.38 (d, J = 7.6 Hz, 1H), 10.10 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 27.8, 30.7, 47.6, 51.4, 53.0, 55.4, 62.7, 73.1, 74.9, 95.1, 109.8, 114.4, 120.7, 126.2, 127.5, 129.0, 132.6, 142.8, 158.4, 162.8, 167.1, 170.0, 180.0; IR (ATR KBr cell, cm^{-1}) 1140, 1750, 2380, 3328; LC-MS calcd m/z: 457 found 458 [(M+1)]$^+$. Anal. Calcd for $C_{26}H_{27}N_5O_3$: C, 68.25; H, 5.95; N, 15.31; Found: C, 68.21; H, 5.90; N, 15.29.

2'-(2-amino-6-ethoxypyrimidin-4-yl)-1'-(4-methoxyphenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 10b

Off white solid; Isolated yield 0.078g (80%); M. Pt. 108 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.09 - 1.28 (m, 3H), 1.69 - 1.98 (m, 4H), 2.19 - 2.36 (m, 2H), 3.66 - 3.79 (m, 6H), 3.97 - 4.00 (m, 2H), 5.98 (s, 1H), 6.00 (s, 1H), 6.70 - 6.86 (m, 4H), 7.03 - 7.07 (m, 1H), 7.29 - 7.34 (m, 3H), 10.05 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 14.7, 27.7, 30.6, 47.6, 51.2, 55.4, 61.2, 62.4, 73.2, 74.9, 95.1, 109.8, 114.4, 120.6, 127.6, 129.0, 132.7, 143.0, 158.4, 162.8, 167.1, 170.0, 180.9; IR (ATR KBr cell, cm^{-1}) 1125, 1748, 2520, 3152, 3420; LC-MS calcd m/z: 471 found 472 [(M+1)]$^+$. Anal. Calcd for $C_{27}H_{27}N_5O_3$: C, 68.77; H, 6.20; N, 14.85; Found: C, 68.73; H, 6.15; N, 14.83.

2'-(2-amino-6-methoxypyrimidin-4yl)-1'-(4-fluorophenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 10c

Off white solid; Isolated yield 0.076g (80%); M. Pt. 128 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.70 - 1.73 (m, 2H), 1.83 - 1.89 (m, 2H), 2.36 - 2.40 (m, 1H), 2.48 - 2.53 (m, 1H), 3.56 (s, 3H), 3.74 - 3.78 (m, 1H), 3.85 - 3.91 (m, 1H), 4.01 (d, J = 12.4 Hz, 1H), 5.60 (s, 1H), 6.15 (s, 2H), 6.67 (d, J = 7.6 Hz, 1H), 6.87 (td, J = 1.2 Hz, 7.6 Hz, 1H), 7.06 - 7.15 (m, 3H), 7.38 (d, J = 7.6 Hz, 1H), 7.42 - 7.46 (m, 2H), 10.14 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 27.7, 30.6, 47.6, 51.3, 53.0, 62.8, 73.0, 74.8, 95.0, 109.8, 115.6, 115.8, 120.7, 126.1, 127.6, 129.1, 129.8, 129.9, 137.0, 142.8, 162.8, 166.8, 170.1, 179.9; IR (ATR KBr cell, cm^{-1}) 1176, 1740, 2360, 3340; LC-MS calcd m/z: 445 found 446

[(M+1)]$^+$. Anal. Calcd for $C_{25}H_{24}FN_5O_2$: C, 67.40; H, 5.43; N, 15.72; Found: C, 67.33; H, 5.40; N, 15.68.

2'-(2-amino-6-ethoxypyrimidin-4-yl)-1'-(4-fluorophenyl)-1',2',5',6',7',7a'-hexahydrospiro[indoline-3,3'-pyrrolizin]-2-one 10d

Off white solid; Isolated yield 0.076g (78%); M. Pt. 116 ºC; ^{1}H NMR (400 MHz, DMSO-d$_6$) δ_H: 1.15 (t, J = 6.8 Hz, 3H), 1.67 - 1.75 (m, 2H), 1.80 - 1.91 (m, 2H), 2.35 - 2.40 (m, 1H), 2.46 - 2.52 (m, 1H), 3.72 - 3.80 (m, 1H), 3.86 - 3.91 (m, 1H), 3.96 - 4.04 (m, 1H), 5.59 (s, 1H), 6.10 (s, 1H), 6.67 (d, J = 7.6 Hz, 1H), 6.87 (td, J = 0.8 Hz, 7.6 Hz, 1H), 7.06 - 7.15 (m, 3H), 7.38 (d, J = 7.2 Hz, 1H), 7.43 - 7.46 (m, 2H), 10.13 (s, 1H); ^{13}C NMR (75 MHz, DMSO-d$_6$) δ_C: 14.7, 27.7, 30.6, 47.6, 51.2, 61.2, 62.7, 73.1, 74.8, 95.1, 109.8, 115.6, 115.8, 120.7, 126.1, 127.6, 129.0, 129.8, 129.9, 137.1, 142.8, 159.8, 162.8, 163.0, 166.8, 169.7, 179.9; IR (ATR KBr cell, cm^{-1}) 856, 1180, 1700, 2490, 3390; LC-MS calcd m/z: 459 found 460 [(M+1)]$^+$. Anal. Calcd for $C_{26}H_{26}FN_5O_2$: C, 67.96; H, 5.70; N, 15.24; Found: C, 67.93; H, 5.65; N, 15.18.

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Notes and references

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† Electronic Supplementary Information (ESI) available: [Crystallographic data and refinement for compound **4,5,8&10** and crystal structure of **4l**, **4db**, **4kb** and **5g** in CIF format, See DOI: 10.1039/b000000x/

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One-pot chemo/regio/stereoselective generation of library of functionalized spiro-oxindoles/pyrrolizines/pyrrolidines from *α*–aroylidineketene dithioacetals

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Graphical abstract