COUPLING REACTION OF 3-CHLOROOXINDOLE AND 9-XANTHYL FLUORENE FOR THE SYNTHESIS OF 3-ARYLIDENE-2-OXINDOLE

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Title	COUPLING REACTION OF 3-CHLOROOXINDOLE AND 9-XANTHYL FLUORENE FOR THE SYNTHESIS OF 3-ARYLIDENE-2-OXINDOLE
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ABSTRACT

This present work describes 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU)-mediated coupling reaction of 3-chlorooxindole and *O*-ethyl *S*-(9*H*-fluoren-9-yl) carbonodithioate for the synthesis of 3-(9*H*-fluoren-9-ylidene)indolin-2-one derivatives in moderate to good yields. Scale-up synthesis of selected 3-arylidene-2-oxindole derivatives works well to form products in decent yields. The methodology has the advantages of a metal-free conditions, short reaction time (15 minutes), and a broad functional group tolerance.

Keywords: 3-Alkenyl-oxindole, 3-Chloroindolin-2-one, Cross-coupling, DBU, *O*-ethyl *S*-(9*H*-fluoren-9-yl) carbonodithioate

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LIST OF ABBREVIATIONS

aq.	aqueous
Ar	aryl
Å	angstrom
Ac	acetyl
Bn	benzyl
n-Bu	*n*-butyl
tert-Bu	*tert*-butyl
cat.	catalyst
$CDCl_3$	deuterochloroform
°C	degree Celcius
DCE	dichloromethane
DMF	*N*,*N*-dimethylformamide
DMSO	dimethyl sulfoxide
dd	doublet of doublets
ddd	doublet of doublet of doublets
dt	doublet of triplets
Et	ethyl
EtOAc	ethyl acetate
EWG	electron withdrawing group
g	gram
h	hour (s)
Hz	hertz
HRMS	high resolution mass spectrometry
J	coupling constant
m	multipet
M	Molar
min	minute (s)
mg	milligram
mL	milliliter
mm	millimeter
mmol	millimole
m/z	a value of mass divided by charge
M^+	molecular ion
MHz	megahertz
m.p.	melting point
MeOH	methanol
Me	methyl
MS	mass spectrometry
NMR	nuclear magnetic resonance
ppm	part per million
%	percent
Ph	phenyl
q	quartet

ref.	reference
rt	room temperature
s	singlet
t	triplet
td	triplet of doublets
Temp.	temperature
THF	tetrahydrofuran
TLC	thin layer chromatography
TMS	tetramethylsilane

CHAPTER 1
INTRODUCTION

1.1 Research Motivation

3-Arylidene-2-oxindoles core structures are of significant interest in medicinal chemistry due to their pharmacological properties and widely used in the design of new antiangiogenic and anticancer drugs (Figure 1.1). Many 3-arylidene-2-oxindole derivative analogues have been extensively evaluated for antimicrobial, α-glucosidase inhibitory, antiviral, anti-leishmanial, antitubercular, tyrosinase inhibitory, and kinase inhibitory activities. [1-3] Due to the significant biological activities of these compounds, the development for the synthesis of 3-arylidene-2-oxindoles remains an interesting issue in organic synthesis.

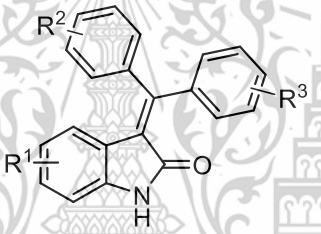
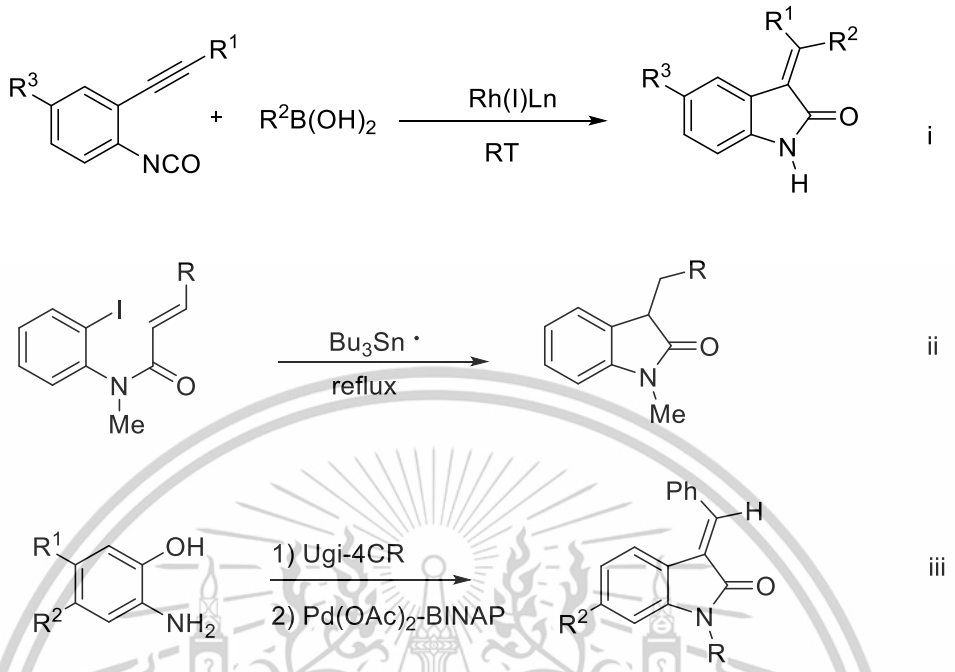


Figure 1.1 Chemical structure of 3-arylidene-2-oxindole

There are many synthetic protocols having been developed to synthesize 3-arylidene-2-oxindoles over decades. The classical methods reported for the synthesis of 3-arylidene-2-oxindoles include Rh-catalyzed cyclization of 2-alkynyl aryl isocyanates (Figure 1.2 i).[4-5] radical cyclization (Figure1.2 ii),[6] and Ugi and Heck-carbocyclization reaction (Figure1.2 iii).[7]



Scheme 1.1 The classical methods for the synthesis of 3-arylidene-2-oxindole derivatives

However, most of these reactions require the use of transition metal catalysts, complex ligands, high reaction temperature and multi-step synthesis. Therefore, it is of great significance to explore a metal-free, mild and efficient reaction for the preparation of 3-arylidene-2-oxindoles framework. Herein, we report an alternative route towards the synthesis of 3-arylidene-2-oxindoles and their derivatives, which enables the reduction of the number of synthetic steps. Moreover, our approach avoids the use of expensive substrates and longing reaction time while obtaining good yields.

1.2 Objectives of the study

1. To explore a new synthetic method to prepare 3-arylidene-2-oxindoles.
2. To publish a new method in an international journal.

1.3 Scopes of the study

1. A study of a new method for the synthesis of 3-arylidene-2-oxindoles.
2. An investigation of the reaction mechanism and evaluation of substrate scope.

1.4 Benefits of the study

This new approach to synthesizing 3-arylidene-2-oxindoles is expected to advance organic synthesis and pharmaceutical research.

CHAPTER 2
THEORY AND LITERATURE REVIEWS

2.1 Oxindole

Oxindole is an aromatic heterocyclic organic compound with the molecular formula of C_8H_7NO. It has a bicyclic structure, consisting of a six-membered benzene ring fused to 2-pyrrolidone as illustrated in Figure 2.1. It has been found in the tissues and bodily fluids of mammals and natural products.[8] Oxindole has been manifested to be a pharmacologically advantageous scaffold having many biological properties such as anti-cancer, anti-HIV, anti-diabetic, antibacterial, antioxidant, kinase inhibitory that are relevant to medicinal chemistry.[9-10]

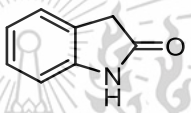


Figure 2.1 Chemical structure of oxindole

2.1.1 2-Alkenyloxindoles in natural products

An emergence of oxindole as a valuable scaffold has further been increased by its natural occurrence. For example, 1,3-dihydroindol-2-ones exhibit a wide variety of biodynamic activities such as antituberculer, anti-HIV, fungicidal, antibacterial, anticonvulsant (Figure 2.2a). Other naturally occurring oxindoles such as isatinone A and B are new oxindole alkaloids isolated from *Isatis costata*. Both exhibited significant antifungal activity (Figures 2.2b and 2.2c).[11]

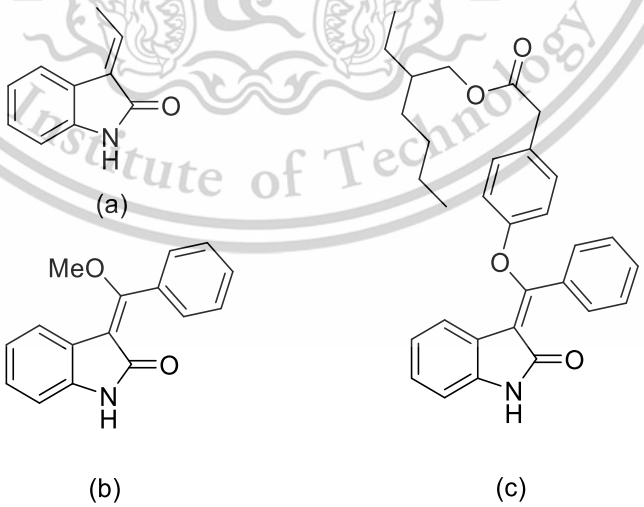


Figure 2.2 Natural products containing 2-alkenyloxindole core

2.1.2 Commercially marketed drugs containing oxindoles

Oxindole derivatives with distinct pharmacological profiles are of great interest in many sectors of the pharmaceutical industry and academia. In medicinal chemistry, oxindole is a valuable scaffold. For example, Nintedanib, also known as BIBF 1120, an indolinone derivative, is an intracellular tyrosine kinase inhibitor (Figure2.3(a)). It inhibits multiple kinases. It was developed by Boehringer Ingelheim for treatment of idiopathic pulmonary fibrosis (IPF) and cancer.[12] Nintedanib received its first global approval in the US in October 2014 for the treatment of IPF. Commercially, Nintedanib is marketed under the brand names 'Ofev' and 'Vargatef'. Sunitinib, the multitarget tyrosine kinase inhibitor (TKI). It has been approved for the treatment of advanced renal cell cancer (RCC) and for imatinib-resistant gastrointestinal and pancreatic neuroendocrine tumors.[13] It has clinically approved by the United States Food and Drug Administration (USFDA) since 2006, becoming the first anticancer drug to be sanctioned the use on two discrete type of cancer cell lines simultaneously (Figure 2.3(b)). Other notable oxindole derivatives include semaxanib, also known as semaxinib or SU-5416. It is a tyrosine kinase inhibitor based on vascular endothelial growth factor (VEGF) pathway targeted for angiogenesis and for colon-rectal cancer (Figure 2.3(c)). It is a drug initially intended for the treatment of cancer.[14]

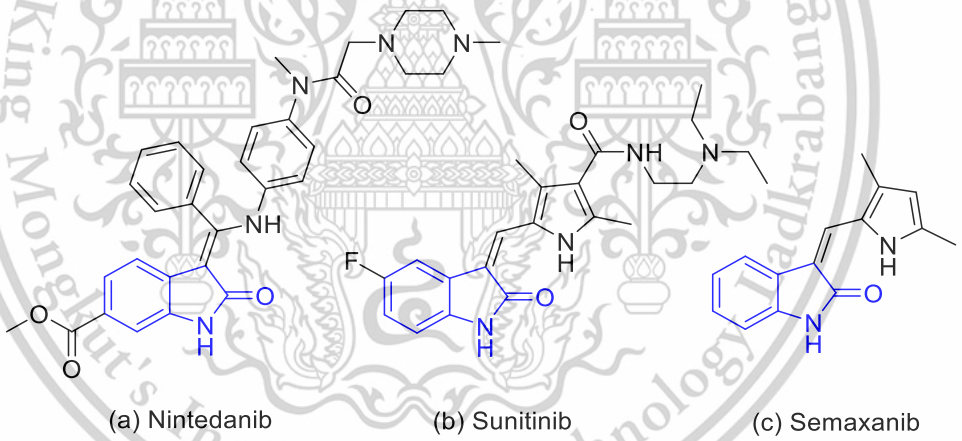
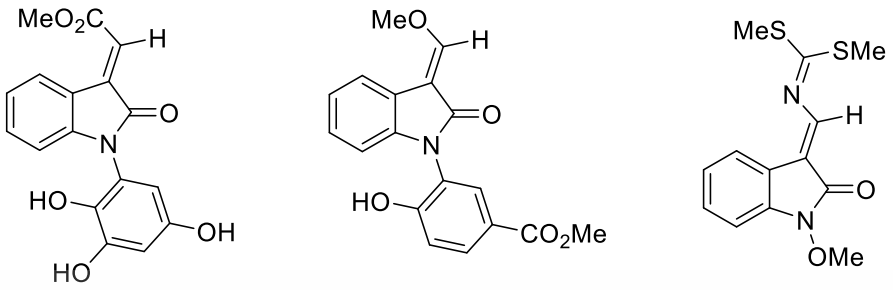


Figure 2.3 Commercially marketed drugs containing oxindoles

2.2 3-Alkylidene-2-oxindole scaffold

3-Alkylidene-2-oxindole refers to a class of organic compounds that contain both an oxindole moiety and an alkylidene group. The alkylidene group typically refers to a carbon-carbon double bond attached to an alkyl group. The 3-alkylidene-2-oxindole structure holds significant and has garnered considerable attention in recent times due to its presence in numerous pharmaceutical compounds. Additionally, this scaffold is found in various natural products, such as costinone A, costinone B and wasalexin A, which are known for their anticancer and antifungal properties, respectively (Figure 2.4).[15]

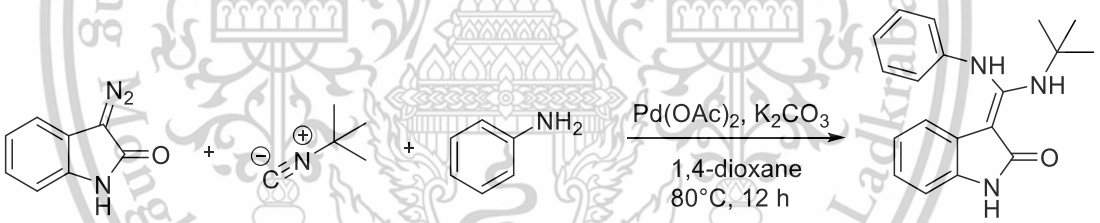


costinone A costinone B wasalexin A

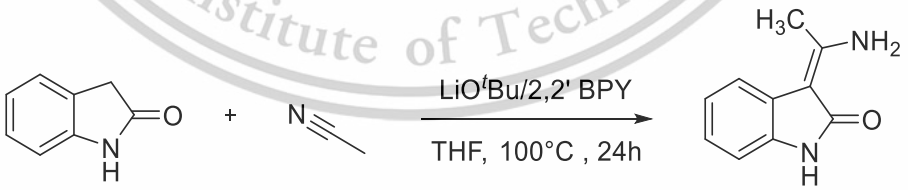
Figure 2.4 Natural products containing 3-alkylidene-2-oxindole scaffold

2.3 Literature Review

In the previous decade, there were many approaches that had been developed to synthesize a 3-alkylidene-2-oxindole scaffold. For example, Vikas Tyagi et al.[16] reported a method for the synthesis of 3-alkylidene oxindoles using a Pd-catalyzed multicomponent reaction of 3-diazo oxindole, isocyanide, and aniline as shown in Scheme 2.1. Additionally, Boopathy Gnanaprakasam et al.[17] reported a new approach for the synthesis of 3-(aminomethylidene)indolin-2-one using 2-oxindole, acetonitrile, LiO^{t}Bu/2,2′-bipyridine base ligand system, and THF at 100 °C for 24 h as illustrated in Scheme 2.2.

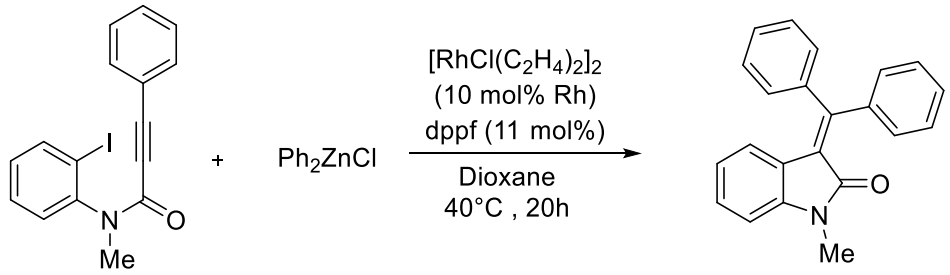


Scheme 2.1 Synthesis of 3-alkylidene oxindoles



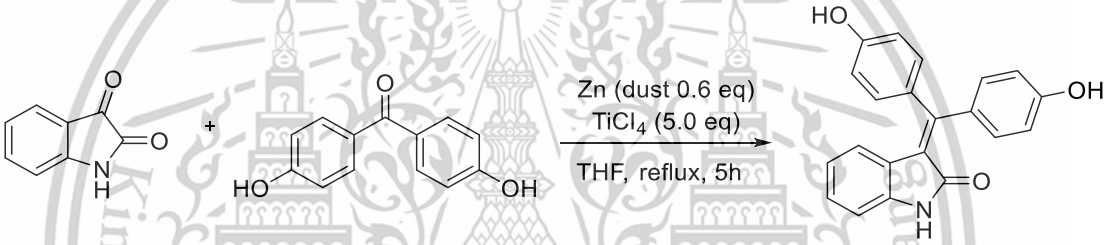
Scheme 2.2 Synthesis of 3-(aminomethylidene)indolin-2-one

Tamio Hayashi et al.[18] prepared 3-(diphenylmethylidene)-1-methyl-1,3-dihydro-2*H*-indol-2-one by cross-coupling reaction with organohalide from alkyne - tethered iodoarene with phenylzinc chloride in the presence of a rhodium-catalyst at 40 °C as shown in Scheme 2.3.



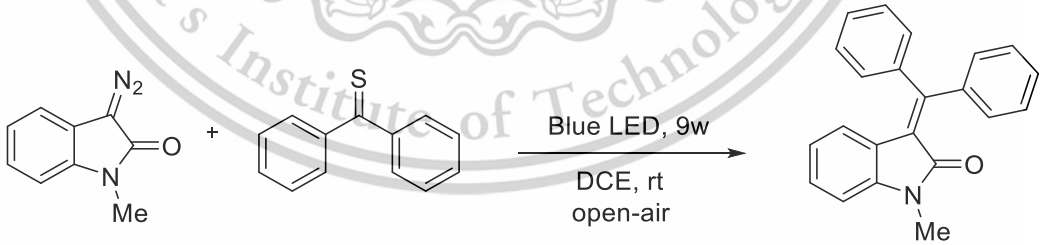
Scheme 2.3 Synthesis of 3-(diphenylmethylidene)-1-methyl-1,3-dihydro-2*H*-indol-2-one via arylation cross-coupling reaction

A procedure developed by Antal Csámpai et al.[19] serves for the preparation of 3-[bis(4-hydroxyphenyl)methylidene]-1,3-dihydro-2*H*-indol-2-one. They applied the McMurry reaction, during which 4,4'-dihydroxybenzophenone was coupled with isatin using a $TiCl_4$/Zn reagent system, as illustrated in Scheme 2.4.



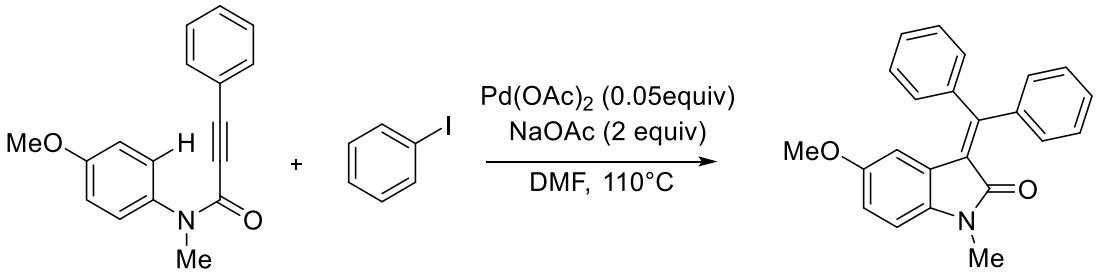
Scheme 2.4 Synthesis of 3-[bis(4-hydroxyphenyl)methylidene]-1,3-dihydro-2*H*-indol-2-one via McMurry reactions

The syntheses of symmetrical and unsymmetrical 3-arylidene oxindoles were reported by Sengodagounder Muthusamy et al.[20] via blue LED-light mediated cross-coupling olefination reactions of diazoindolones and diphenylmethanethiones as shown in Scheme 2.5.



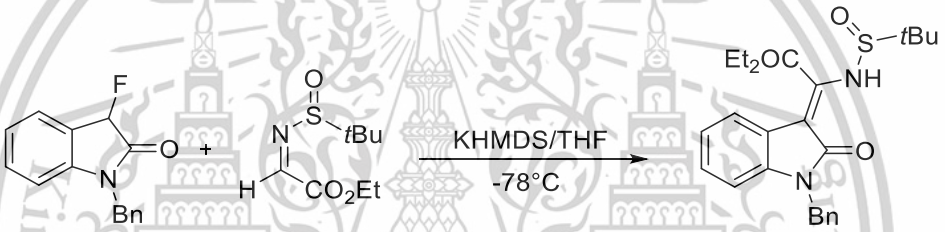
Scheme 2.5 Synthesis of 3-arylidene oxindoles via cross-coupling olefination reaction

Synthesis of 3-(diarylmethylenyl) oxindoles was also disclosed by Jieping Zhu et al.[21] through the domino intermolecular carbopalladation C-H activation from N-(4-methoxyphenyl)-N-methyl-3-phenylpropiolamide and 1-iodobenzene using 5 mol% of $Pd(OAc)_2$ as a catalyst and sodium acetate as a base in DMF at 110 °C as shown in Scheme 2.6



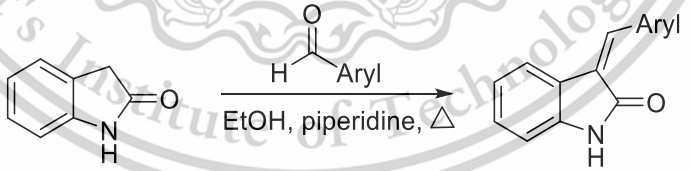
Scheme 2.6 Synthesis of 3-(diarylmethylenyl) oxindole via domino intermolecular reaction

Shuai Song et al.[22] reported a tandem reaction involving condensation followed by elimination to synthesize amidoacrylates containing a 3-ylideneoxindole from 3-fluorooxindole and iminoacetate using KHMDS as a base in THF at -78 °C under N_2 atmosphere as shown in Scheme 2.7.



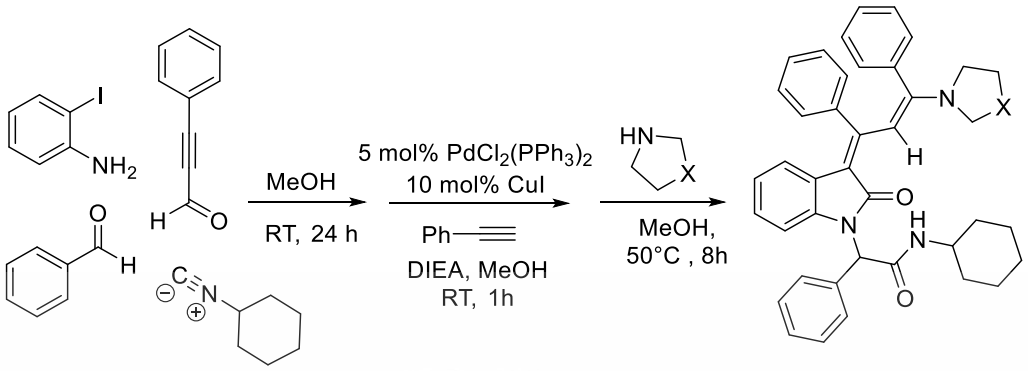
Scheme 2.7 Synthesis of amidoacrylates containing a 3-ylideneoxindole via tandem reaction

Natalia A. Lozinskaya et al.[23] reported the condensation of oxindoles with aromatic aldehydes in presence of piperidine in ethanol under refluxing conditions leading to 3-arylideneindolinones as illustrated in Scheme 2.8.



Scheme 2.8 Synthesis of 3-arylideneindolinones via condensation

Morteza Bararjanian et al.[24] developed a new approach for the synthesis of 3-arylidene-2-oxindoles through six-component reactions. This method involves sequential one-pot Ugi, Heck carbocyclization, Sonogashira and nucleophilic addition of benzaldehyde in one-pot reaction conditions. The reactions were carried out in the presence of 5% $PdCl_2(PPh_3)_2$, 10% CuI, and DIEA as the base in MeOH as shown in Scheme 2.9



Scheme 2.9 Synthesis of 3-arylidene-2-oxindoles through one-pot six-component reaction

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Chemicals and materials

3.1.1 Chemicals

The details of chemicals used in the experiment have been summarized in Table 3.1

Table 3.1 chemicals

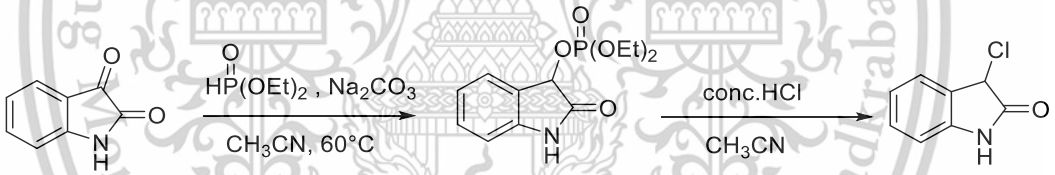
No.	Chemicals	Grade	Supplier
1	Acetone	AR	Honeywell
2	Acetonitrile	AR	Honeywell
3	Dichloromethane	AR	Sigma-Aldrich
4	Diethyl ether	AR	LOBA Chemie
5	Diethyl phosphite	-	-
6	Dimethyl formamide	AR	Sigma-Aldrich
7	Ethyl acetate	AR	Sigma-Aldrich
8	9-Fluorenone	AR	TOKYO CHEMICAL INDUSTRY
9	Hydrochloric acid	AR	Sigma-Aldrich
10	Isatin	AR	TOKYO CHEMICAL INDUSTRY
11	Methanol	AR	Sigma-Aldrich
12	Potassium ethylxanthate	AR	TOKYO CHEMICAL INDUSTRY
13	Sodium borohydride	AR	TOKYO CHEMICAL INDUSTRY
14	Sodium carbonate	AR	KEMAUS
15	Sodium hydrogen carbonate	AR	KEMAUS
16	Sodium sulphate	AR	KEMAUS
17	Thionyl chloride	-	-

3.1.2 Materials

^{1}H NMR spectra were recorded with a JEOL, Model JNM-ECZ-500R/S1, spectrometer (Solution-state NMR; 500 MHz) in $CDCl_3$ by using tetramethylsilane (δ = 0 ppm) as an internal standard and dimethylsulfoxide-d_6 as a solvent. ^{13}C NMR spectra were recorded with a JEOL, Model JNM-ECZ- 500R/S1, spectrometer (Solution-state NMR; 126 MHz). High-resolution mass spectra (HRMS) were recorded with a Bruker micro TOF spectrometer in the ESI mode. Melting points were recorded with a Sanyo Gallenkamp apparatus. Reactions were monitored by thin-layer chromatography and visualized by UV. All reagents and solvents were obtained from commercial sources and were used without further purification. Column chromatography was performed by using Merck silica gel 60 (Art 7734). All single crystal X-ray diffraction data were collected at 100 K on a Bruker APEX II diffractometer with Mo Kα radiation (λ = 0.71073 Å). The structures were solved by direct methods using SHELXS-97 and refined full-matrix least squares on all F 2 data using SHELXL97 to final *R* values. All hydrogen atoms were added at calculated positions and refined using a rigid model. Crystallographic data for compound 3e have been deposited with the Cambridge Crystallographic Data Centre, (Cambridge, UK). The deposition number is CCDC2380192.

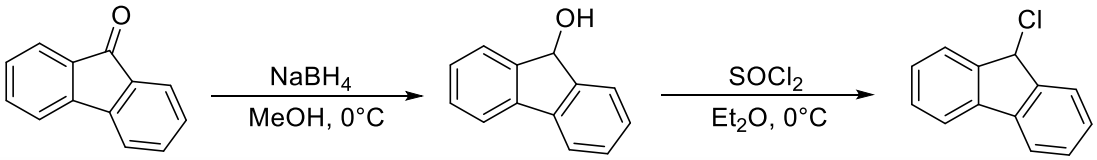
3.2 Methods

3.2.1 General procedure for preparation of 3-chlorooxindole

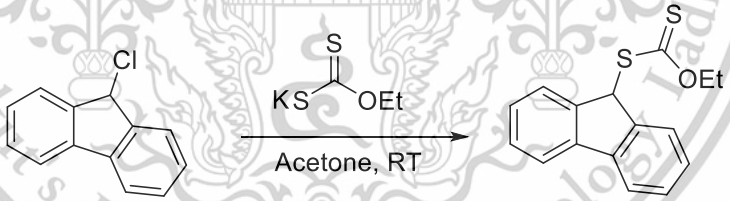


3-Chlorooxindole was obtained from isatin (10 mmol) in acetonitrile (20 mL), followed by the addition of sodium carbonate (1 mmol, 0.1 equiv) and diethyl phosphite (11 mmol, 11 equiv). The solution was stirred at 60 °C. Once the reaction was completed, the mixture was extracted with EtOAc (20 mL) and water (20 mL) 3 times. The combined EtOAc extracts were washed with brine (20 mL) and dried over anhydrous Na_2SO_4 and filtered. The solvent was evaporated under reduced pressure to afford the corresponding phosphate product. Next, conc. HCl (150 mmol, 15 equiv) was added to a solution of phosphate product in acetonitrile (30 mL) and stirring on continued for about 2 h or until the reaction was completed (monitored by TLC). The reaction mixture was diluted with water and extracted with EtOAc (3 x 20 mL). The combined organic layers were dried over anhydrous Na_2SO_4, and filtered. The volatiles were removed under reduced pressure. The residue was purified by column chromatography on silica gel to yield the 3-chlorooxindole product.

3.2.2 General procedure for preparation of 9-xanthyl fluorene

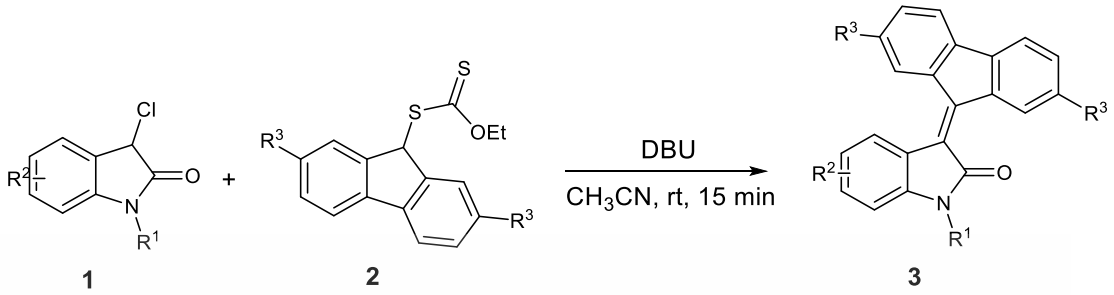


For the preparation of 9-chlorofluorene, the fluorenone (10 mmol) and methanol (30 mL) were added into round bottom flask. The solution was cooled to 0 °C, and to this solution was added sodium borohydride (11 mmol, 1.1 equiv). Then the reaction was allowed to warm to room temperature and stirred for 1 h. The solvent was removed under reduced pressure and diluted with water (20 mL). The reaction mixture was extracted with EtOAc (2 x 20 mL). The combined organic layers were washed with brine (20 mL) and then dried over anhydrous Na_2SO_4 and filtered. Then, the solvent was removed to afford the alcohol which was used to the next step without further purification. The crude alcohol was diluted with diethyl ether (10 mL). After cooling to 0 °C, one drop of DMF was added to the mixture, followed by dropwise addition of thionyl chloride (15 mmol, 1.5 equiv). The reaction mixture was stirred at room temperature for 2 h or overnight until the reaction was completed. The resulting mixture was poured into ice and washed with saturated aqueous $NaHCO_3$ (20 mL). The reaction was extracted with Et_2O (2 x 30 mL) and dried over anhydrous Na_2SO_4 and filtered. The solvent was removed, and the crude mixture was purified by silica gel column chromatography.



For the preparation of *O*-ethyl *S*-9*H*-fluoren-9-yl carbonodithioate, potassium ethyl xanthate (11 mmol, 1.1 equiv) was added to 9-chlorofluorene (10 mmol) in acetone (10 mL). The reaction mixture was stirred at room temperature for 2 h. Then, the solvent was evaporated, and the reaction mixture was diluted with water (20 mL) and extracted with EtOAc (3 x 10 mL). The combined organic layers were dried over anhydrous Na_2SO_4, and the volatiles were removed under reduced pressure. The residue was purified by column chromatography on silica gel to yield the product.

3.2.3 General procedure for the synthesis of compounds 3



1 2 3

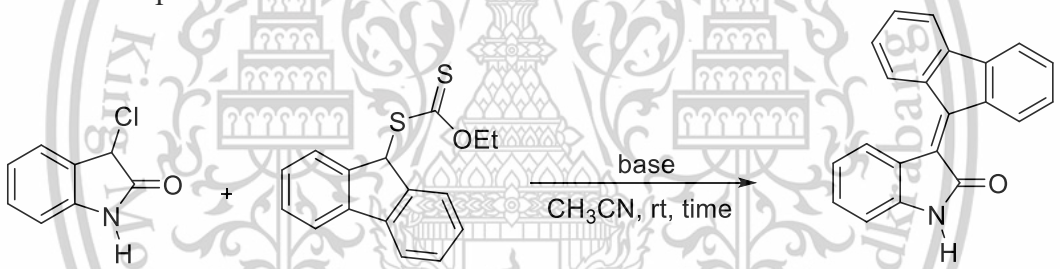
To a solution of 3-chlorooxindole (0.5 mmol) and *O*-ethyl S-(9*H*-fluoren-9-yl) carbonodithioate (1 mmol, 2 equiv) in acetonitrile (2 mL), DBU (0.15 mL, 1.0 mmol) was added. The reaction was stirred at room temperature for 15 min. After completion, the reaction was quenched by 1M HCl (1 mL) and diluted with water (20 mL). The aqueous mixture was extracted with EtOAc (2 x 20 mL). Then the combined organic layers were washed with brine (20 mL), dried over anhydrous Na_2SO_4 and filtered. The solvent was evaporated under reduced pressure. The crude product was purified by column chromatography using silica gel and 5% DCM:EtOAc as the eluent.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Reaction of 3-chlorooxindole and *O*-ethyl *S*-(9*H*-fluoren-9-yl) carbonodithioate for the synthesis of 3-arylidene-2-oxindole

To begin our study, we initially investigated the optimized reaction conditions. 3-Chlorooxindole (**1a**) and *O*-ethyl S-(9*H*-fluoren-9-yl) carbonodithioate (**2a**) were selected as representative substrates to evaluate various reaction parameters. The reaction of **1a** and **2a** (2 equiv) was performed in the presence of DBU (2 equiv) in CH_3CN (2 mL) and the resulting mixture was stirred at room temperature for 15 minutes. 3-Arylidene-2-oxindole **3a** was isolated in 54% yield (Table 4.1, entry 1). Various bases were screened, including DABCO, Na_2CO_3, and K_2CO_3, with DBU provided to be the most efficient in facilitating the reaction. (Table 4.1, entries 2-4). Furthermore, the reaction performed in the absence of base failed to give the desired product (Table 4.1, entry 5). These results highlight the crucial role of the base in this transformation.

Table 4.1 Optimization of bases[a]



1a **2a** **3a**

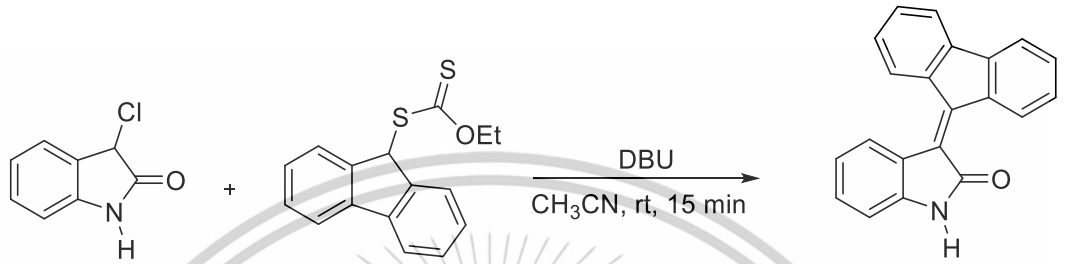
Entry	Base	Time	**3a** (%yield)[b]
1	DBU	15 min	54
2	DABCO	15 min	38
3	Na_2CO_3	4 h	7
4	K_2CO3	3 h	11
5	-	2 h	n.d.[c]

[a]Conditions: **1a** (0.5 mmol), **2a** (1 mmol, 2equiv), and base (1 mmol, 2 equiv) in acetonitrile (2 mL) at room temperature. [b]Isolated yield. [C]Not detected.

Next, stoichiometry of *O*-ethyl *S*-(9*H*-fluoren-9-yl) carbonodithioate (**2a**) and DBU required for the present transformation was evaluated. When **2a** (1 equiv) and DBU (1 equiv) were employed, the desired product **3a** was obtained in 40% yield (Table 4.2, entry 1). Increasing the amount of DBU (from 1 equiv to 2 equiv) resulted in lower yield 31% yield (Table 4.2, entry 2). When the reaction of **2a** (2 equiv) and DBU (2 equiv) was conducted, the desired product was obtained in 40% yield (Table 4.2, entry 3). Subsequently, increasing amount of DBU to 2 equiv afforded **3a** in 54% yield. Furthermore, increasing the amount of DBU to 3 equiv furnished **3a** in 44% yield (Table 4.2, entry 5). This result implies that the increasing amount of DBU did not improve yield of product. According to these results, the reaction of 3-

chlorooxindole (**1a**) with *O*-ethyl *S*-(9*H*-fluoren-9-yl) carbonodithioate (**2a**, 2 equiv) and DBU (2 equiv) gave the highest yield (54%) of the desired product **3a** (Table 4.2, entry 1).

Table 4.2 Optimization of stoichiometry of *O*-ethyl *S*-(9*H*-fluoren-9-yl) carbonodithioate (**2a**) and DBU[a]



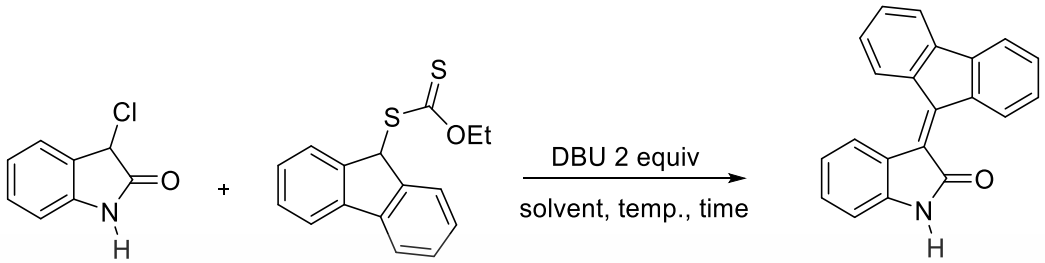
1a **2a** **3a**

Entry	**2a** (equiv)	DBU (equiv)	**3a** (%yield)[b]
1	1	1	40
2	1	2	31
3	2	1	40
4	2	2	54
5	2	3	44

[a]Conditions: **1a** (0.5 mmol), **2a** and DBU in acetonitrile (2 mL) at room temperature for 15 min. [b]Isolated yield.

We next explored the effects of solvents and reaction temperature, and the results are summarized in Table 4.3. Various solvents were screened including acetonitrile (CH_3CN), dimethyl sulfoxide (DMSO), *N,N*-dimethylformamide (DMF), tetrahydrofuran (THF), ethanol (EtOH) and toluene (Table 4.3, entries 1-6). Almost all the solvents screened provided comparable results, leading to product **3a** in slightly different yields. Notably, CH_3CN and THF provided compound **3a** in 50-54% yields. In contrast, DMSO, EtOH, toluene gave the desired product **3a** in lower yields (34-36% yields). However, When DMF was used to conduct the reaction, the yield of **3a** dramatically dropped to 15% yield (Table 4.3, entry 3). The reaction temperature was then evaluated (Table 4.3, entries 7-8). The optimal result was obtained when the reaction was performed at room temperature. Conducting the reaction at elevated temperatures (60 °C and 80 °C) did not improve the outcome and led to lower product formation. With the optimized reaction conditions in hand, the highest yield was obtained using the following conditions: **1a** (0.5 equiv), **2a** (2 equiv) in the presence of DBU (2 equiv) in CH_3CN at room temperature for 15 minutes (Table 4.3, entry 1).

Table 4.3 Optimization of solvents and temperature[a]



1a **2a** **3a**

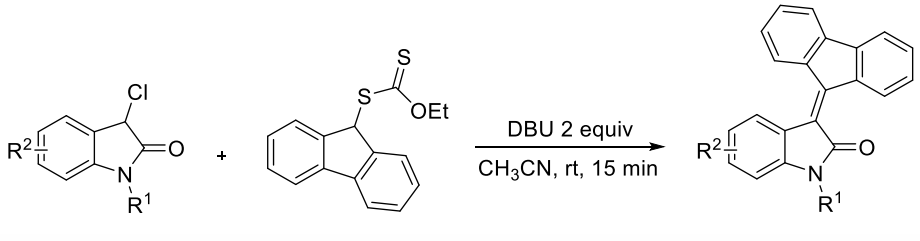
Entry	Solvent	Temperature (°C)	Time	**3a** (%yield)[b]
1	CH_3CN	rt	15 min	54
2	DMSO	rt	15 min	36
3	DMF	rt	15 min	15
4	THF	rt	15 min	50
5	EtOH	rt	15 min	34
6	Toluene	rt	15 min	35
7	CH_3CN	60	6 h	41
8	CH_3CN	80	8 h	40

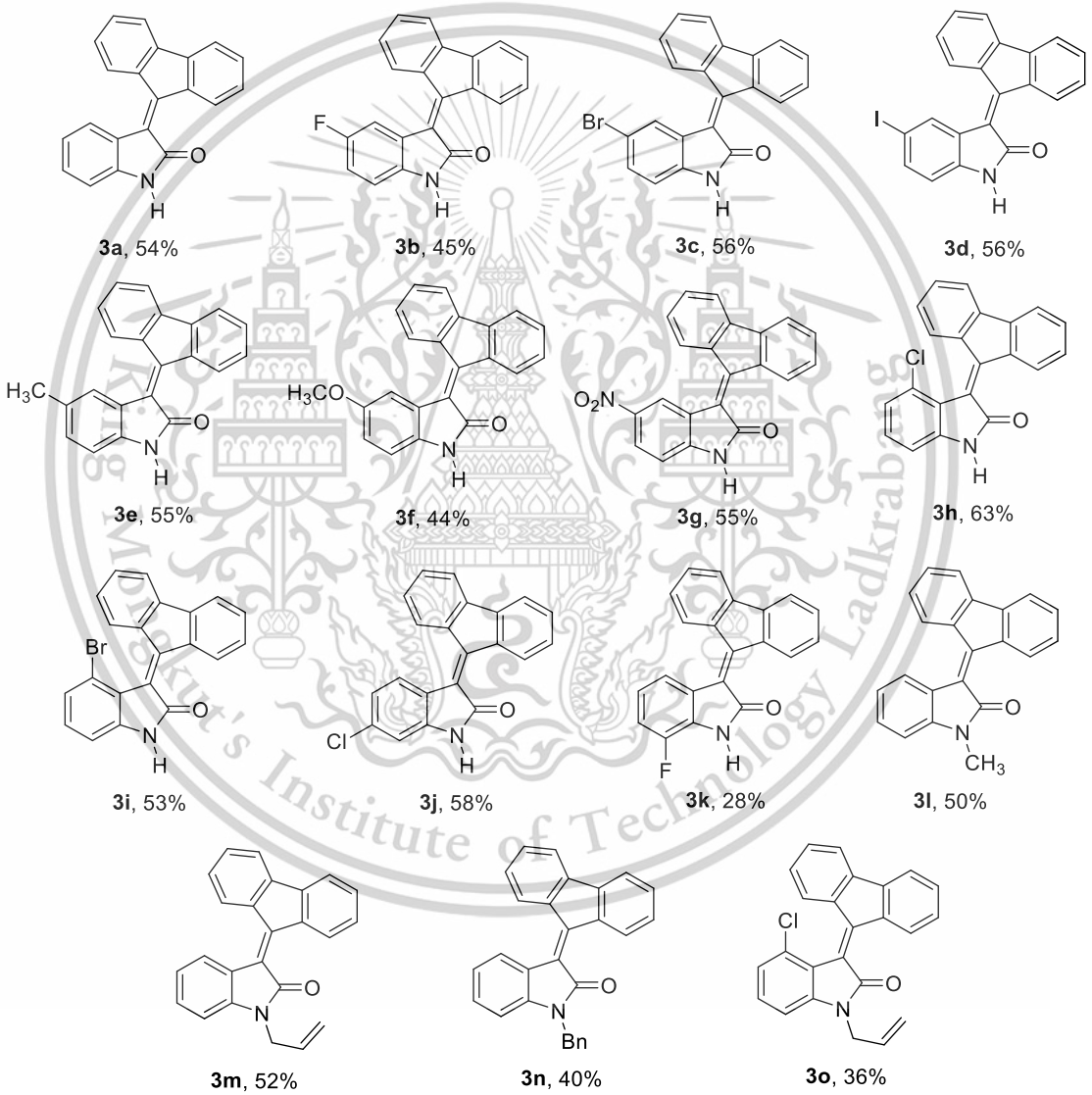
[a]Conditions: **1a** (0.5 mmol), **2a** (1 mmol, 2 equiv), and DBU (1 mmol, 2 equiv) in solvent (2 mL). [b]Isolated yield.

4.2 Scope of the synthesis of 3-arylidene-2-oxindoles

After a comprehensive investigation, we explored the functional group compatibility of this transformation under established reaction conditions and the results were illustrated in Table 4.4. The reaction of *O*-ethyl *S*-(9*H*-fluoren-9-yl) carbonodithioate (**2a**) with 3-chlorooxindole (**1**) bearing halogen substituents (-F, -Cl, -Br) on C-5 position provided products **3a**-**3d** in 45-56% yields. Electron-donating substituents (-CH_3, -OCH_3) on C-5 position of 3-chlorooxindole were also well tolerated giving products **3e** and **3f** in 55% and 44% yields, respectively. Similarly, 3-chlorooxindole bearing a nitro (-NO_2) group on C-5 position smoothly reacted with **2a** to produce **3g** in 55% yield. Furthermore, 4-chloro and 4-bromo-3-chlorooxindole reacted efficiently with **2a** leading to **3h** and **3i** products in 63% and 53% yields. Moreover, 3-chlorooxindole containing chlorine and fluorene on C-6 and C-7 position gave the corresponding products **3j** and **3k** in 58% and 28% yields, respectively. The reaction of *N*-substituents 3-chlorooxindole including *N*-Me, *N*-allyl, *N*-Bn exhibited as effective substrates leading to products **3l-3n** in moderate yields (40-52% yields). Additionally, 3,4-dichloro-1-(prop-2-en-1-yl)-1,3-dihydro-2*H*-indol-2-one successfully converted to product **3o** in 36% yield.

Table 4.4 Scope of 3-chlorooxindole (**1**)[a]



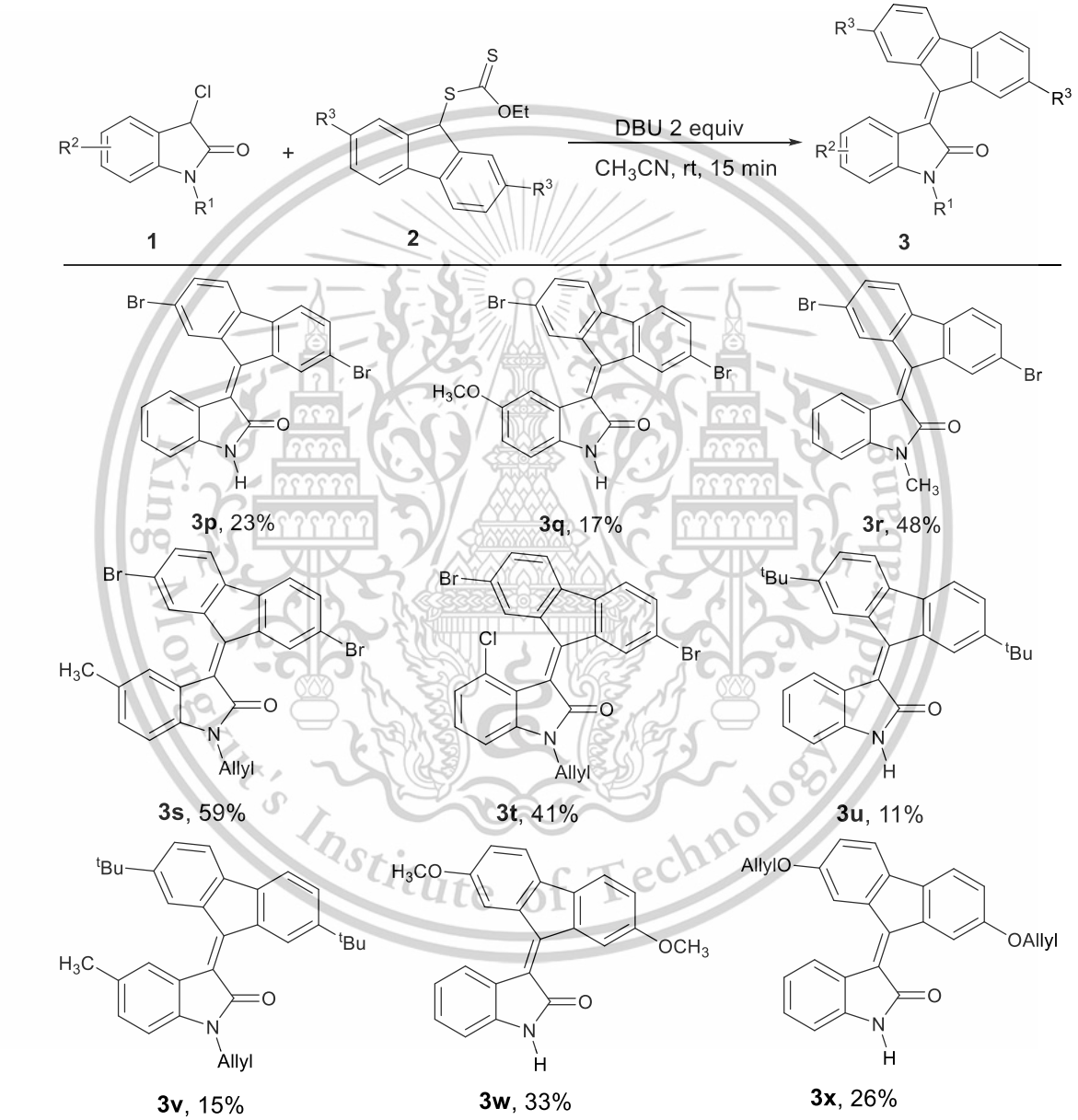


[a]Conditions: **1a** (0.5 mmol), **2a** (1 mmol, 2equiv), and DBU (1 mmol, 2 equiv) in acetonitrile (2 mL) at room temperature. Isolated yield.

Apart from the variation of 3-chloroindolin-2-one (**1**), we further explored the influence of different groups on *O*-ethyl *S*-(9*H*-fluoren-9-yl) carbonodithioate (**2**) (Table 4.5). The reaction of xanthate (**2**) containing dibromo-substituent reacted with several 3-chlorooxindoles (**1**) to produce product **3p-3t** in 17-59% yields. The reaction

of xanthate bearing di-tertbutyl substituted on the aromatic ring is an untoward substrate providing product **3u** and **3v** in low yields (11-15% yields). Compound **2** containing di-methoxy substituted reacted with 3-chlorooxindole **1** producing **3w** product in 33% yield. Additionally, di-allyloxy substituted xanthate was also good substrates for this transformation giving product **3x** in 26% yield.

Table 4.5 Scope of *O*-ethyl *S*-(9*H*-fluoren-9-yl)carbonodithioate (**2**)[a]

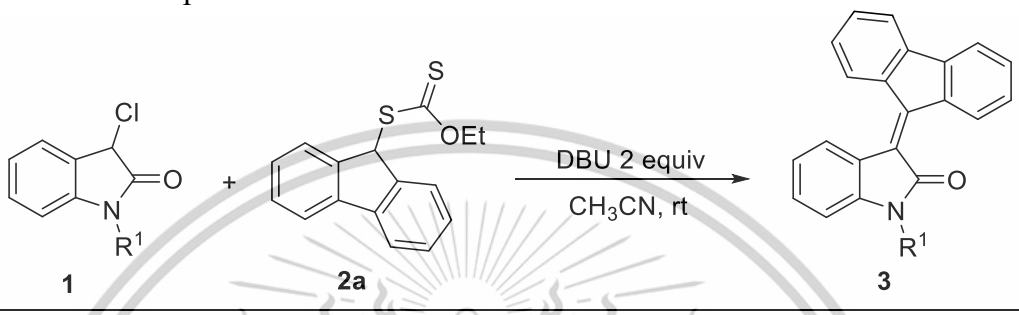


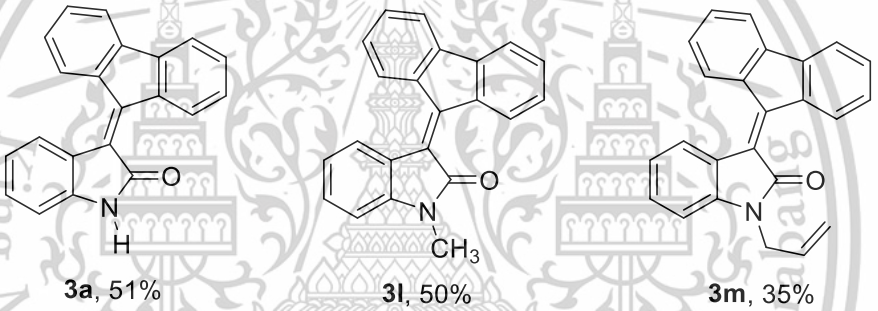
[a]Conditions: **1a** (0.5 mmol), **2a** (1 mmol, 2 equiv), and DBU (1 mmol, 2 equiv) in acetonitrile (2 mL) at room temperature. Isolated yield.

4.3 Scale-up synthesis of 3-arylidene-2-oxindole

To extend the efficiency and utility of this transformation, a large-scale reaction of some selected 3-chlorooxindole (**1**) was performed as shown in Scheme 4.3. The results show good performance leading to corresponding product **3a**, **3l** and **3m** in decent yields (Table 4.6).

Table 4.6 Scale-up reactions



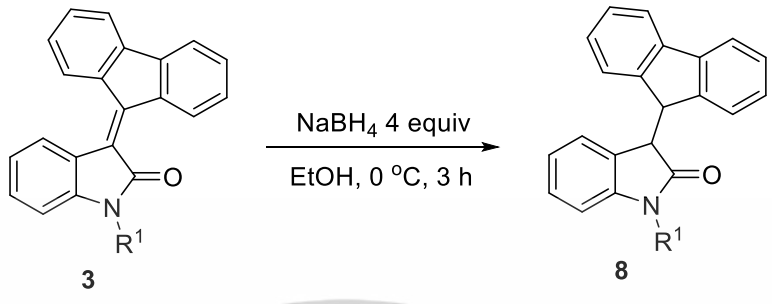


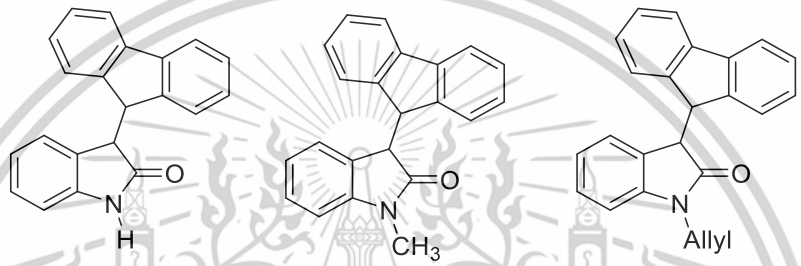
[a]Reaction conditions: **1a** (3 mmol), **2a** (6 mmol, 2 equiv), and DBU (6 mmol, 2 equiv) in acetonitrile (12 mL) at room temperature. Isolated yield.

4.4 Functionalization of 3-arylidene-2-oxindole

To highlight the benefits of our synthetic approach, some selected 3-arylidene-2-oxindole derivatives were further functionalized. As illustrated in Table 4.7, sodium borohydride was employed as a reducing agent to functionalize 3-arylidene-2-oxyndole derivatives (**3a**, **3l**, and **3m**) producing the corresponding products **8a**, **8l** and **8m** in high yields.

Table 4.7 Conjugate reduction of compound **3**[a]

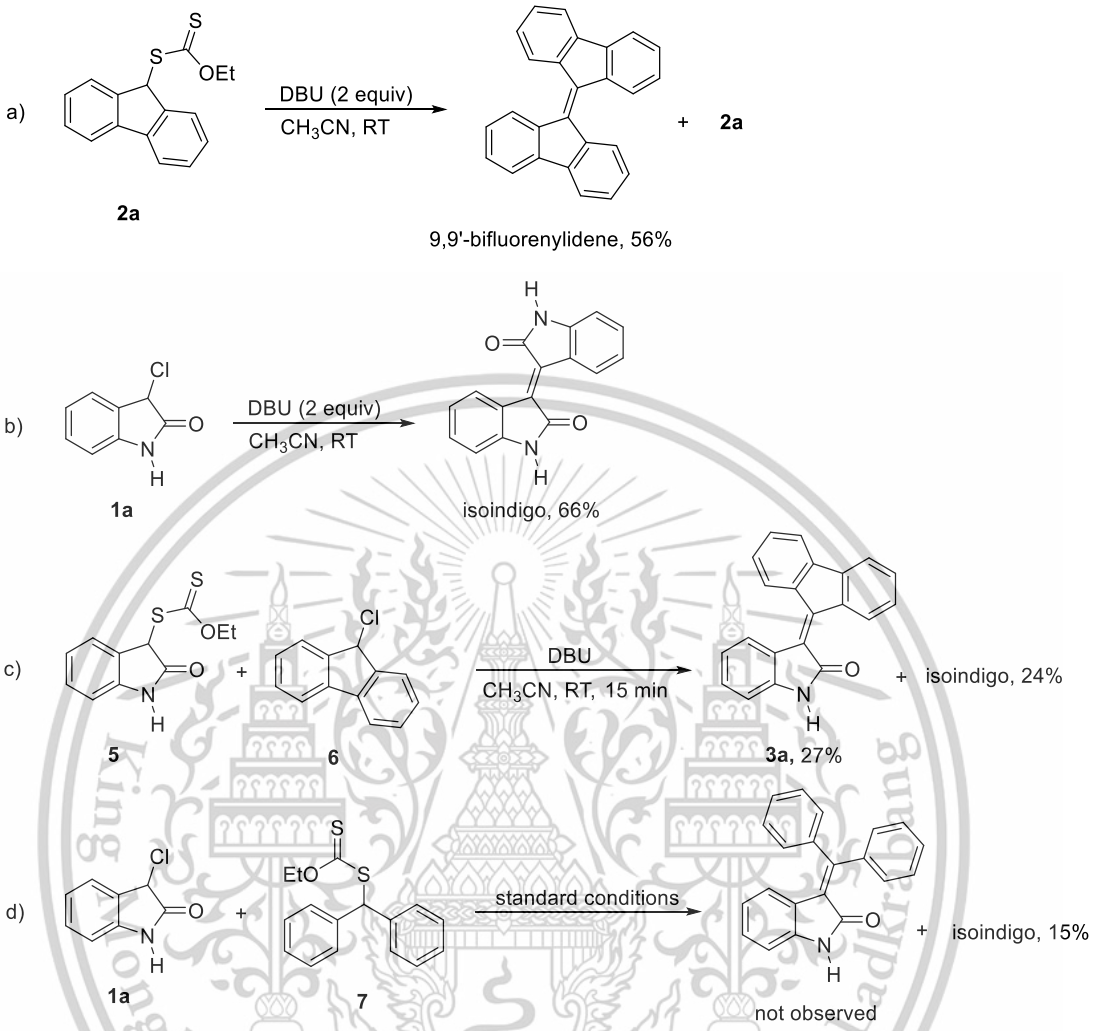




[a]Reaction conditions: **3** (1 mmol) , $NaBH_4$ (4 mmol, 4 equiv) in EtOH (10 mL) at 0 °C to room temperature (28 °C) for 3 h.

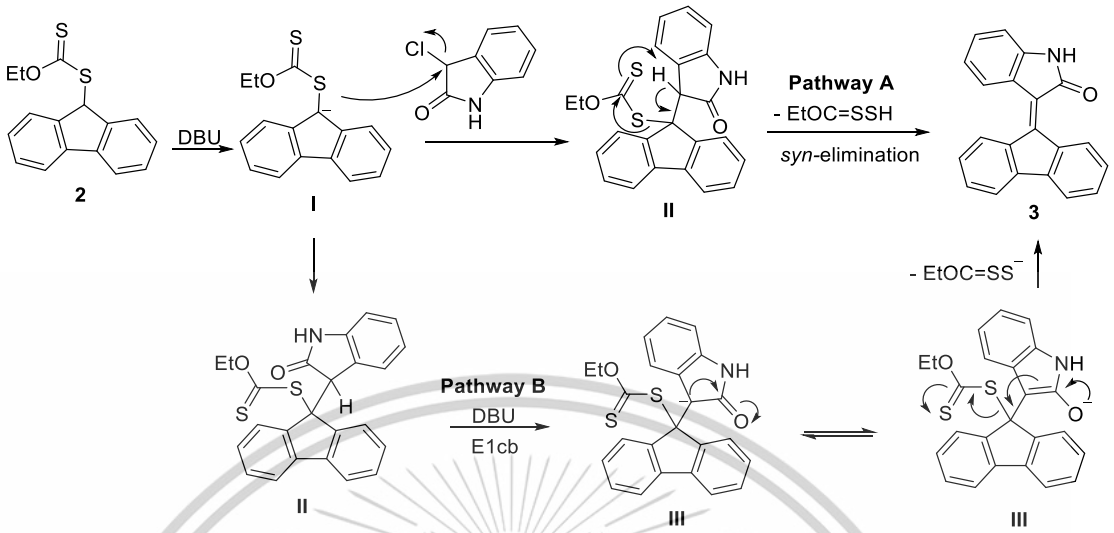
4.5 Control experiments and proposed reaction mechanism

To better understand mechanistic pathway, several control experiments were performed (Scheme 4.1). First, the reaction of **2a** was conducted under standard conditions in the absence of **1a** resulting in the formation of 9,9'-bifluorenylidene in 56% yield and recover of **2a** (Scheme 4.1a). Furthermore, the reaction of compound **1a** was carried out under standard conditions without the addition of **2a**. This reaction provided isoindigo in 66% yield (Scheme 4.1b). Both observations suggested that the dimerization of **1a** and **2a** are competitive reactions in this transformation. The desired coupling product **3** was obtained in only 27% yield, when *O*-ethyl *S*-(2-oxoindolin-3-yl) carbonodithioate (**5**) reacted with 9-chlorofluorene (**6**) (Scheme 4.1c). The desired product **3a** was not obtained when *S*-benzhydryl *O*-ethyl carbonodithioate (**7**) was employed in place of **2a** to react with **1a**; isoindigo was isolated in 15% yield (Scheme 4.1d). From this result, It could be possible that the acidity of the hydrogen atom at *C*9 of *O*-ethyl *S*-(9*H*-fluoren-9-yl)carbonodithioate is crucial for the reaction.



Scheme 4.1 Control experiments

Based on the above control experiments, a possible mechanism for the formation of 3-arylidene-2-oxindole (**3**) was proposed, as depicted in Scheme 4.2. Firstly, DBU serves as a base to abstract a proton of *O*-ethyl *S*-(9*H*-fluoren-9-yl) carbonodithioate **2a** providing carbanion intermediate **I**. Next, the resulting carbanion **I** attacks *C*3 of 3-chlorooxindole **1a** giving an intermediate **II**. Subsequent elimination of *O*-ethyl *S*-hydrogen carbonodithioate leads to the formation of product **3** (Scheme 4.2, Pathway A). Alternatively, in pathway B, deprotonation of intermediate **II** affords intermediate **III**, followed by elimination of *O*-ethyl carbonate from intermediate **III** to produce the product **3** (Scheme 4.2, Pathway B).

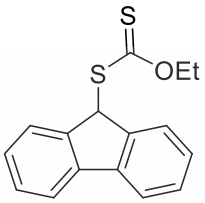


Scheme 4.2 Plausible mechanism for the formation of 3-arylidene-2-oxindole

4.6 Characterization of 3-arylidene-2-oxoidole derivatives

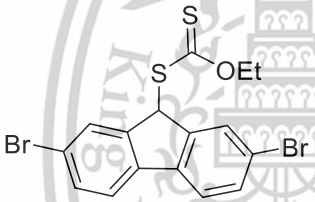
NMR spectroscopy and HRMS spectroscopy were used to characterize the structure of the synthesized 3-arylidene-2-oxindole. The results are summarized below.

_O_-Ethyl _S_-9_H_-fluoren-9-yl carbonodithioate (2a)



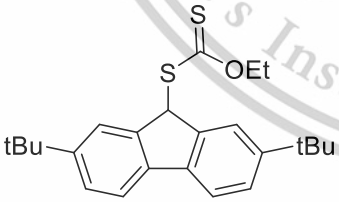
Pale yellow solid, mp = 62-64 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.74 (d, J = 6.1 Hz, 2H), 7.69 (d, J = 6.0 Hz, 2H), 7.41 (t, J = 5.9 Hz, 2H), 7.33 (t, J = 6.0 Hz, 2H), 6.13 (s, 1H), 4.76 (q, J = 5.7 Hz, 2H), 1.45 (t, J = 5.7 Hz, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 214.4, 143.0, 140.6, 128.4, 127.6, 125.3, 120.0,70.7, 53.2, 13.7. HRMS (ESI): m/z $[M\text{-}SC(S)OEt]^+$ calcd for $C_{13}H_9$: 165.0704; found: 165.0701

_S_-(2,7-Dibromo-9_H_-fluoren-9-yl) _O_-ethyl carbonodithioate (2b)



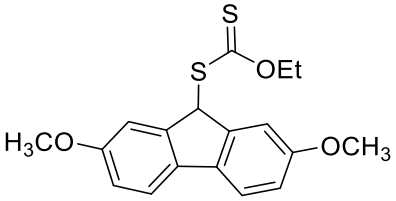
Pale yellow solid, mp = 92-93 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.78 (s, 2H), 7.55 – 7.53 (m, 4H), 6.11 (s, 1H), 4.76 (q, J = 5.7 Hz, 2H), 1.45 (t, J = 5.7 Hz, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 213.4, 144.8, 138.6, 131.8, 128.6, 121.7, 121.3, 71.3, 52.8, 13.7. HRMS (ESI): m/z $[M\text{-}SC(S)OEt]^+$ calcd for $C_{13}H_7Br_2$: 320.8915; not found

_S_-(2,7-Di-tert-butyl-9_H_-fluoren-9-yl) _O_-ethyl carbonodithioate (2c)



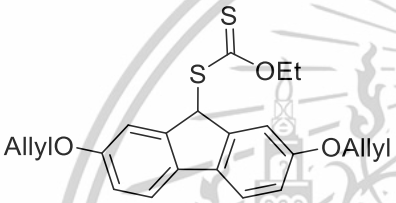
Pale yellow solid, mp = 92-94 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.68 (d, J = 0.6 Hz, 2H), 7.60 (d, J = 6.4 Hz, 2H), 7.42 (dd, J = 6.4, 1.4 Hz, 2H), 6.08 (s, 1H), 4.81 (q, J = 5.7 Hz, 2H), 1.50 (t, J = 5.7 Hz, 3H), 1.35 (s, 18H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 214.9, 150.6, 142.9, 138.0, 125.6, 122.1, 119.2, 70.6, 53.3, 34.9, 31.5, 13.8. HRMS (ESI): m/z $[M\text{-}SC(S)OEt]^+$ calcd for $C_{21}H_{25}$: 277.1956; found: 277.1956

_S_-(2,7-Dimethoxy-9_H_-fluoren-9-yl) _O_-ethyl carbonodithioate (2d)



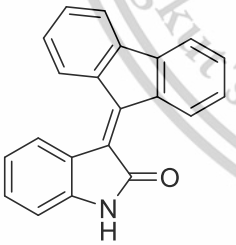
Pale orange solid, mp = 59-60 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.51 (d, J = 6.7 Hz, 2H), 7.19 (d, J = 1.6 Hz, 2H), 6.92 (dd, J = 6.7, 1.8 Hz, 2H), 6.00 (s, 1H), 4.75 (q, J = 5.7 Hz, 2H), 3.84 (s, 6H), 1.45 (t, J = 5.7 Hz, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 158.9, 144.3, 133.6, 119.8, 114.6, 110.8, 70.8, 55.6, 53.2, 29.6, 13.8. HRMS (ESI): m/z [M-SC(S)OEt]$^+$ calcd for $C_{15}H_{13}O_2$: 225.0916; found: 225.0918

_S_-[2,7-Bis(prop-2-en-1-yloxy)-9_H_-fluoren-9-yl] _O_-ethyl carbonodithioate (2e)



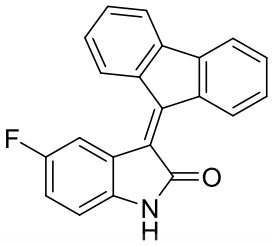
Pale yellow solid, mp = 68-69 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.50 (d, J = 6.7 Hz, 2H), 7.21 (d, J = 1.6 Hz, 2H), 6.93 (dd, J = 6.7, 1.9 Hz, 2H), 6.07 (ddt, J = 13.7, 8.5, 4.3 Hz, 2H), 6.00 (s, 1H), 5.44 (dd, J = 13.8, 1.2 Hz, 2H), 5.30 (dd, J = 8.4, 1.1 Hz, 2H), 4.75 (q, J = 5.7 Hz, 2H), 4.56 (dd, J = 4.3, 1.2 Hz, 4H), 1.45 (t, J = 5.7 Hz, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 214.6, 158.1, 144.5, 133.9, 133.3, 120.0, 117.9, 115.5, 111.9, 70.9, 69.3, 53.36, 13.9. HRMS (ESI): m/z [M-SC(S)OEt]$^+$ calcd for $C_{19}H_{17}O_2$: 277.1229; found: 277.1225

3-(9_H_-fluoren-9-ylidene)-1,3-dihydro-2_H_-indol-2-one (3a)



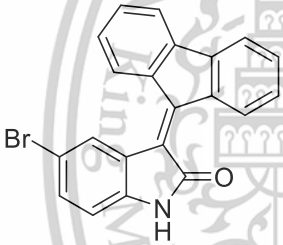
Red solid, 80.9 mg, yield 54%; mp = 196-197 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.81 (s, 1H), 8.98 (d, J = 6.4 Hz, 1H), 8.34 (d, J = 6.3 Hz, 1H), 8.00 (d, J = 6.3 Hz, 1H), 7.82 (d, J = 6.0 Hz, 1H), 7.79 (d, J = 6.0 Hz, 1H), 7.43 (q, J = 6.2 Hz, 2H), 7.29 –7.24 (m,. 3H), 6.94 (t, J = 6.1 Hz, 1H), 6.89 (d, J = 6.2 Hz, 1H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 168.9, 147.1, 143.5, 142.6, 141.3, 137.5, 137.1, 132.1, 131.9, 131.6, 129.3, 129.1, 128.4, 128.1, 126.5, 125.4, 123.1, 121.4, 121.1, 120.4, 110.8. HRMS (ESI): m/z [M+H]$^+$ calcd for $C_{21}H_{14}NO$: 296.1075; found: 296.1042

3-(9*H*-Fluoren-9-ylidene)-5-fluoro-1,3-dihydro-2*H*-indol-2-one (3b)



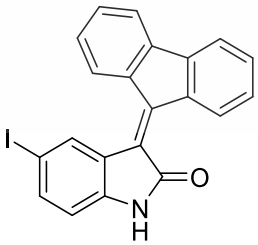
Red solid, 72.1 mg, yield 45%; mp = 221-222 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.82 (s, 1H), 8.98 (d, *J* = 6.4 Hz, 1H), 8.31 (d, *J* = 6.3 Hz, 1H), 7.80 (dd, *J* = 13.7, 6.0 Hz, 2H), 7.74 (dd, *J* = 7.8, 2.0 Hz, 1H), 7.45 (dt, *J* = 9.3, 6.0 Hz, 2H), 7.28 (dt, *J* = 13.2, 6.2 Hz, 2H), 7.13 (td, *J* = 7.1, 2.0 Hz, 1H), 6.88 (dd, *J* = 6.9, 3.8 Hz, 1H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 168.8, 158.3, 156.4, 148.7, 142.8, 141.5, 139.8, 137.4, 136.7, 132.4, 129.3 (d, *J* = 94.1 Hz), 128.7 (d, *J* = 10.1 Hz), 128.3 (d, *J* = 120.3 Hz), 126.6, 123.9 (*J* = 28.1 Hz), , 121.7, 121.2, 120.5, 118.0 (d, *J* = 76.6 Hz), 111.7 (d, *J* = 82.9 Hz), 111.4 (d, *J* = 26.0 Hz). HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{21}H_{13}FNO$: 314.0981; found: 314.0978

5-Bromo-3-(9*H*-fluoren-9-ylidene)-1,3-dihydro-2*H*-indol-2-one (3c)



Red solid, 110.3 mg, yield 56%; mp = 285-286 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.98 (s, 1H), 8.97 (d, *J* = 6.4 Hz, 1H), 8.28 (d, *J* = 6.2 Hz, 1H), 8.10 (d, *J* = 1.4 Hz, 1H), 7.83 (d, *J* = 6.0 Hz, 1H), 7.80 (d, *J* = 5.9 Hz, 1H), 7.49 – 7.42 (m, 3H), 7.28 (ddd, *J* = 12.4, 6.5, 0.7 Hz, 2H), 6.86 (d, *J* = 6.7 Hz, 1H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 168.4, 148.9, 142.9, 142.4, 141.5, 137.4, 136.7, 133.5, 132.6, 132.3, 129.3, 128.5, 128.1, 127.8, 127.1, 126.5, 125.1, 121.3, 120.5, 112.7, 112.6. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{21}H_{13}BrNO$: 374.0181; found: 374.0157

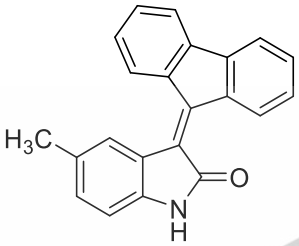
3-(9*H*-Fluoren-9-ylidene)-5-iodo-1,3-dihydro-2*H*-indol-2-one (3d)



Red solid, 121.1 mg, yield 56%; mp = 288-289 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.95 (s, 1H), 8.95 (d, *J* = 6.3 Hz, 1H), 8.28 – 8.26 (m, 2H), 7.83 (d, *J* = 6.0 Hz, 1H), 7.79 (d, *J* = 5.9 Hz, 1H), 7.58 (dd, *J* = 6.5, 1.2 Hz, 1H), 7.44 (ddd, *J* = 8.0, 6.5, 3.3 Hz, 2H), 7.27 (ddd, *J* = 12.3, 6.5, 0.7 Hz, 2H), 6.74 (d, *J* = 6.5 Hz, 1H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 168.3, 148.7, 142.8, 141.5, 139.2, 136.8, 136.2, 132.9, 132.7,

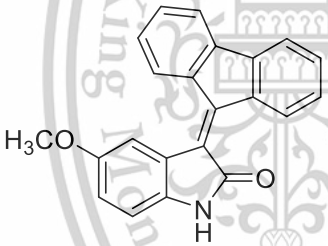
132.4, 130.4, 129.3, 128.6, 128.3, 128.0, 127.1, 126.5, 121.4, 120.6, 113.1, 83.7. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{21}H_{13}INO$: 422.0042; found: 422.0032

3-(9*H*-Fluoren-9-ylidene)-5-methyl-1,3-dihydro-2*H*-indol-2-one (3e)



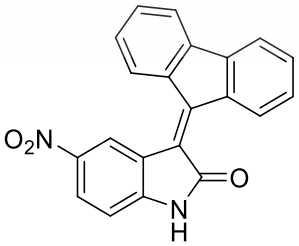
Red solid, 87.3 mg, yield 55%; mp = 230-231 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.68 (s, 1H), 8.97 (d, *J* = 6.3 Hz, 1H), 8.37 (d, *J* = 6.3 Hz, 1H), 7.83 (s, 2H), 7.82 – 7.78 (m, 2H), 7.43 (dt, *J* = 9.0, 6.0 Hz, 2H), 7.26 (dt, *J* = 8.2, 6.2 Hz, 2H), 7.09 (d, *J* = 6.4 Hz, 1H), 6.78 (d, *J* = 6.3 Hz, 1H), 2.24 (s, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 169.0, 146.8, 142.5, 141.4, 141.2, 137.5, 137.1, 132.2, 132.0, 131.7, 130.0, 129.6, 129.1, 128.3, 128.0, 126.4, 125.6, 123.2, 121.0, 120.4, 110.5, 21.3. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{22}H_{16}NO$: 310.1232; found: 310.1228

3-(9*H*-Fluoren-9-ylidene)-5-methoxy-1,3-dihydro-2*H*-indol-2-one (3f)



Black solid, 71.2 mg, yield 44%; mp = 179-180 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.61 (s, 1H), 9.00 (d, *J* = 6.4 Hz, 1H), 8.40 (d, *J* = 6.3 Hz, 1H), 7.81 (dd, *J* = 13.5, 6.0 Hz, 2H), 7.56 (d, *J* = 1.9 Hz, 1H), 7.43 (dt, *J* = 7.9, 5.9 Hz, 2H), 7.32 – 7.23 (m, 2H), 6.89 (dd, *J* = 6.8, 1.9 Hz, 1H), 6.80 (d, *J* = 6.8 Hz, 1H), 3.67 (s, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 169.0, 154.1, 147.2, 142.6, 141.31, 137.6, 137.5, 136.9, 132.2, 131.8, 129.8, 129.1, 128.4, 127.9, 126.5, 123.7, 121.1, 120.4, 118.0, 111.3, 110.6, 55.9. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{22}H_{16}NO$: 326.1181; found: 326.1175

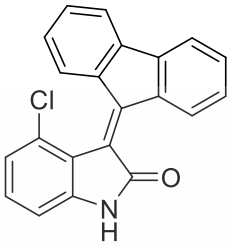
3-(9*H*-Fluoren-9-ylidene)-5-nitro-1,3-dihydro-2*H*-indol-2-one (3g)



Orange solid, 93.2 mg, yield 55%; mp >300 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.55 (s, 1H), 8.97 (dd, *J* = 6.3, 1.8 Hz, 1H), 8.84 (s, 1H), 8.31 (dd, *J* = 5.8, 3.3 Hz, 1H), 8.20 (dd, *J* = 6.9, 1.8 Hz, 1H), 7.87 – 7.78 (m, 2H), 7.48 (dtd, *J* = 7.8, 6.0, 1.8 Hz, 2H), 7.28 (t, *J* = 6.0 Hz, 2H), 7.07 (dd, *J* = 7.0, 2.3 Hz, 1H). ^{13}C NMR (126 MHz,

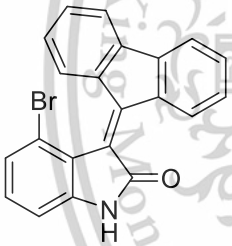
DMSO-d_6) δ 168.7, 147.8, 144.6, 142.7, 141.4, 137.4, 136.9, 135.1, 132.3, 132.1, 129.2, 128.4, 128.2, 127.9, 126.6, 122.0, 121.2, 121.1, 120.5, 120.5, 110.4. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{21}H_{13}N_2O_3$: 341.0926; not found

4-Chloro-3-(9*H*-fluoren-9-ylidene)-1,3-dihydro-2*H*-indol-2-one (3h)



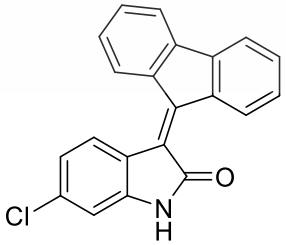
Red solid, 104.6 mg, yield 63%; mp = 248-249 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.98 (s, 1H), 8.75 (d, *J* = 6.2 Hz, 1H), 7.79 (dd, *J* = 5.9, 3.0 Hz, 2H), 7.43 (ddd, *J* = 7.0, 6.0, 3.2 Hz, 2H), 7.36 (t, *J* = 6.4 Hz, 1H), 7.31 – 7.27 (m, 1H), 7.24 (ddd, *J* = 10.9, 8.2, 3.2 Hz, 2H), 7.08 (d, *J* = 6.3 Hz, 1H), 6.90 (d, *J* = 6.1 Hz, 1H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 168.6, 147.9, 145.3, 141.9, 141.9, 138.1, 137.2, 132.3, 132.1, 131.9, 130.8, 130.7, 128.3, 128.1, 127.9, 125.5, 123.5, 121.9, 120.6, 120.5, 108.8. HRMS (ESI): m/z [M+H]+ calcd for $C_{21}H_{13}ClNO$: 330.0686; found: 330.0688

4-Bromo-3-(9*H*-fluoren-9-ylidene)-1,3-dihydro-2*H*-indol-2-one (3i)



Red solid, 102.1 mg, yield 53%; mp = 228-229 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.95 (s, 1H), 8.73 (d, *J* = 6.2 Hz, 1H), 7.78 (t, *J* = 5.4 Hz, 2H), 7.46 – 7.39 (m, 2H), 7.30 – 7.21 (m, 5H), 6.93 (dd, *J* = 5.5, 1.3 Hz, 1H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 168.5, 158.0, 147.5, 145.6, 142.0, 141.9, 138.1, 137.1, 132.3, 132.1, 131.9, 130.9, 128.4, 128.1, 127.9, 126.9, 126.8, 123.8, 120.7, 120.5, 109.2. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{21}H_{13}BrNO$: 374.0181; found: 374.0165

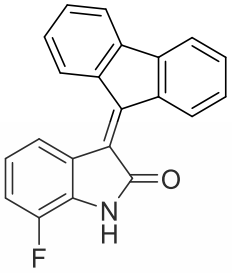
6-Chloro-3-(9*H*-fluoren-9-ylidene)-1,3-dihydro-2*H*-indol-2-one (3j)



Red solid, 96.7 mg, yield 58%; mp = 249-250 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.98 (s, 1H), 8.95 (d, *J* = 6.4 Hz, 1H), 8.27 (d, *J* = 6.3 Hz, 1H), 7.99 (d, *J* = 6.7 Hz, 1H), 7.81 (dd, *J* = 11.9, 5.9 Hz, 2H), 7.47 – 7.42 (m, 2H), 7.26 (t, *J* = 6.2 Hz, 2H), 7.00 (dd, *J* = 6.7, 1.6 Hz, 1H), 6.90 (d, *J* = 1.6 Hz, 1H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 168.7, 147.8, 144.6, 141.4, 136.9, 135.1, 132.3, 132.1, 129.2, 128.4, 128.2,

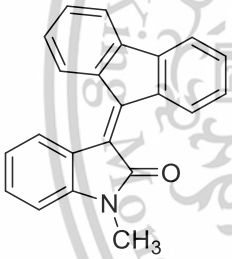
127.9, 126.6, 121.2, 120.5, 110.4. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{21}H_{13}ClNO$: 330.0686; found: 330.0674

3-(9*H*-Fluoren-9-ylidene)-7-fluoro-1,3-dihydro-2*H*-indol-2-one (3k)



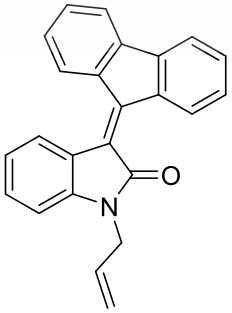
Red solid, 44.7 mg, yield 28%; mp = 254-255 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.34 (s, 1H), 8.95 (d, *J* = 6.3 Hz, 1H), 8.31 (d, *J* = 6.3 Hz, 1H), 7.94 – 7.67 (m, 3H), 7.45 (q, *J* = 5.9 Hz, 2H), 7.30 – 7.24 (m, 2H), 7.24 – 7.17 (m, 1H), 6.96 (td, *J* = 6.5, 4.1 Hz, 1H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 168.5, 148.8, 142.8, 141.5, 137.3, 136.8, 132.5, 132.3, 129.3, 128.5, 128.3, 128.3, 128.1, 126.7, 121.9, 121.9, 121.4, 121.2, 120.5, 117.7, 117.5. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{21}H_{13}FNO$: 314.0981; found: 314.0970

3-(9*H*-Fluoren-9-ylidene)-1-methyl-1,3-dihydro-2*H*-indol-2-one (3l)



Brown solid, 95.9 mg, yield 50%; mp = 136-137 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.99 (d, *J* = 6.4 Hz, 1H), 8.32 (d, *J* = 6.3 Hz, 1H), 8.04 (d, *J* = 6.2 Hz, 1H), 7.81 (dd, *J* = 11.5, 5.9 Hz, 2H), 7.43 (dt, *J* = 5.9, 3.1 Hz, 2H), 7.39 – 7.34 (m, 1H), 7.29 – 7.24 (m, 2H), 7.07 (d, *J* = 6.2 Hz, 1H), 7.04 – 7.00 (m, 1H), 3.26 (s, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 167.1, 147.5, 144.5, 142.7, 141.4, 137.5, 137.0, 132.2, 132.0, 131.5, 129.2, 128.4, 128.1, 128.1, 126.6, 125.1, 122.2, 121.9, 121.1, 120.4, 109.6, 26.5. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{22}H_{16}NO$: 310.1232; found: 310.1217

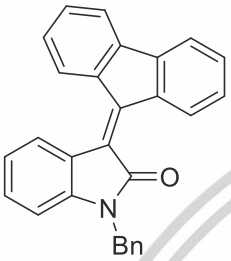
3-(9*H*-Fluoren-9-ylidene)-1-(prop-2-en-1-yl)-1,3-dihydro-2*H*-indol-2-one (3m)



Red solid, 90.6 mg, yield 52%; amorphous solid; ^{1}H NMR (500 MHz, DMSO-d_6) δ 9.01 (d, *J* = 6.4 Hz, 1H), 8.35 (d, *J* = 6.3 Hz, 1H), 8.08 (d, *J* = 6.2 Hz, 1H), 7.82 (dd, *J*

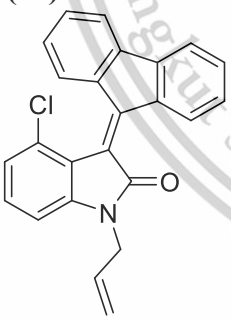
= 9.9, 5.9 Hz, 2H), 7.48 – 7.43 (m, 2H), 7.40 (d, *J* = 5.8 Hz, 2H), 7.35 (t, *J* = 6.1 Hz, 2H), 7.31 – 7.26 (m, 4H), 7.01 (d, *J* = 6.2 Hz, 2H), 5.04 (s, 2H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 167.1, 148.1, 143.5, 142.8, 141.5, 137.4, 137.1, 132.4, 132.2, 131.4, 129.3, 129.2, 128.4, 128.1, 127.9, 127.8, 127.8, 126.7, 125.3, 122.1, 121.2, 120.5, 110.1, 43.2. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{24}H_{18}NO$: 336.1388; found: 336.1355

1-Benzyl-3-(9*H*-fluoren-9-ylidene)-1,3-dihydro-2*H*-indol-2-one (3n)



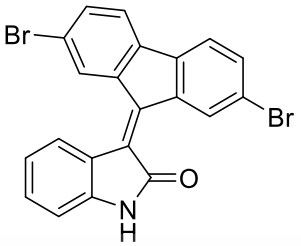
Red solid, 69.5 mg, yield 40%; amorphous solid; ^{1}H NMR (500 MHz, DMSO-d_6) δ 9.01 (d, *J* = 6.4 Hz, 1H), 8.35 (d, *J* = 6.3 Hz, 1H), 8.07 (d, *J* = 6.2 Hz, 1H), 7.82 (dd, *J* = 10.0, 6.0 Hz, 2H), 7.45 (td, *J* = 5.9, 3.1 Hz, 2H), 7.41 – 7.32 (m, 4H), 7.27 (dt, *J* = 6.7, 4.7 Hz, 4H), 7.00 (t, *J* = 6.0 Hz, 2H), 5.03 (s, 2H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 167.1, 148.1, 143.5, 142.7, 141.5, 137.4, 137.1, 136.9, 132.4, 132.2, 131.4, 130.0, 129.3, 129.2, 128.4, 128.1, 127.9, 127.8, 127.7, 126.7, 125.3, 124.4, 122.3, 122.1, 121.1, 120.5, 110.1, 43.2. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{28}H_{20}NO$: 386.1545; found: 386.1529

4-Chloro-3-(9*H*-fluoren-9-ylidene)-1-(prop-2-en-1-yl)-1,3-dihydro-2*H*-indol-2-one (3o)



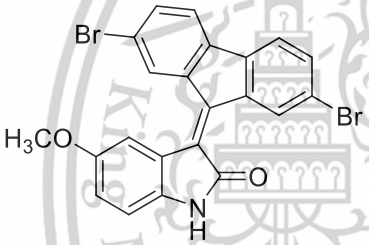
Orange solid, 66.4 mg, yield 36%; mp = 160-161 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.85 (d, *J* = 6.5 Hz, 1H), 7.57 (dd, *J* = 5.4, 4.9 Hz, 2H), 7.39 – 7.31 (m, 2H), 7.29 (dd, *J* = 7.8, 3.7 Hz, 3H), 7.15 (t, *J* = 6.1 Hz, 1H), 7.05 (d, *J* = 6.6 Hz, 1H), 6.79 (d, *J* = 6.3 Hz, 1H), 5.90 (dtd, *J* = 12.6, 8.4, 4.3 Hz, 1H), 5.33 – 5.23 (m, 2H), 4.54 (dd, *J* = 13.1, 4.2 Hz, 1H), 4.38 (dd, *J* = 13.1, 4.4 Hz, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 167.1, 150.1, 144.9, 142.4, 142.3, 138.4, 137.5, 131.6, 131.5, 131.5, 131.2, 130.8, 130.3, 128.7, 127.8, 127.0, 123.9, 123.4, 121.9, 119.5, 119.5, 117.7, 106.8, 42.6. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{24}H_{17}ClNO$: 370.0999; found: 370.0964

3-(2,7-Dibromo-9*H*-fluoren-9-ylidene)-1,3-dihydro-2*H*-indol-2-one (3p)



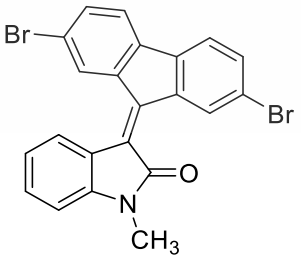
Red solid, 55.1 mg, yield 23%; mp >300 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.90 (s, 1H), 9.21 (d, *J* = 1.2 Hz, 1H), 8.43 (d, *J* = 1.1 Hz, 1H), 7.95 (d, *J* = 6.3 Hz, 1H), 7.82 (dd, *J* = 10.0, 6.5 Hz, 2H), 7.67 – 7.63 (m, 2H), 7.31 (d, *J* = 6.2 Hz, 1H), 6.98 (t, *J* = 6.1 Hz, 1H), 6.91 (d, *J* = 6.3 Hz, 1H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 168.8, 144.4, 143.6, 140.4, 139.2, 138.9, 138.8, 134.4, 134.2, 132.8, 131.8, 131.4, 128.6, 125.7, 123.1, 122.5, 122.5, 121.6, 121.6, 121.0, 111.2. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{21}H_{12}Br_2NO$: 451.9286; not found

3-(2,7-Dibromo-9*H*-fluoren-9-ylidene)-5-methoxy-1,3-dihydro-2*H*-indol-2-one (3q)



Black solid, 41.9 mg, yield 17%; amorphous solid; ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.70 (s, 1H), 9.26 (d, *J* = 1.2 Hz, 1H), 8.54 (d, *J* = 1.3 Hz, 1H), 7.88 (d, *J* = 6.5 Hz, 1H), 7.82 (dd, *J* = 11.1, 6.6 Hz, 3H), 7.66 (dd, *J* = 5.3, 1.3 Hz, 3H), 7.54 (d, *J* = 2.0 Hz, 1H), 6.94 (dd, *J* = 6.8, 1.9 Hz, 1H), 6.82 (d, *J* = 6.9 Hz, 1H), 6.61 (dd, *J* = 15.7, 7.0 Hz, 1H), 3.71 (s, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 168.9, 154.2, 143.7, 140.5, 139.2, 138.9, 138.7, 138.6, 134.4, 134.2, 132.3, 131.4, 128.7, 123.1, 122.9, 122.7, 122.5, 120.8, 120.1, 111.9, 110.1, 56.0. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{22}H_{14}Br_2NO_2$: 481.9391; found: 481.9376

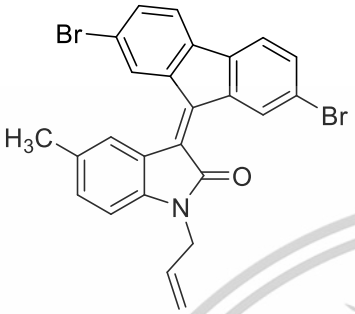
3-(2,7-Dibromo-9*H*-fluoren-9-ylidene)-1-methyl-1,3-dihydro-2*H*-indol-2-one (3r)



Brown solid, 112.6 mg, yield 48%; mp = 184-185 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 9.19 (s, 1H), 8.37 (s, 1H), 7.94 (d, *J* = 6.2 Hz, 1H), 7.77 (dd, *J* = 10.3, 6.5 Hz, 2H), 7.62 (t, *J* = 5.1 Hz, 2H), 7.39 (t, *J* = 6.1 Hz, 1H), 7.06 (d, *J* = 6.3 Hz, 1H), 7.02 (t, *J* = 6.1 Hz, 1H), 3.22 (s, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 167.0, 145.2, 144.0, 140.5, 139.2, 138.8, 138.6, 134.4, 134.2, 132.6, 131.4, 130.6, 128.7, 125.3, 123.0,

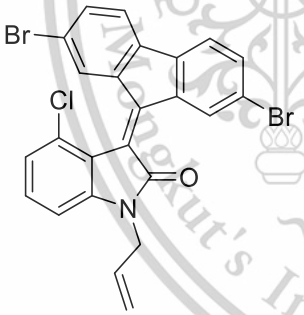
122.4, 122.0, 121.6, 121.6, 120.9, 110.0, 26.6. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{22}H_{14}Br_2NO$: 467.9442; found: 467.9374

3-(2,7-Dibromo-9*H*-fluoren-9-ylidene)-5-methyl-1-(prop-2-en-1-yl)-1,3-dihydro-2*H*-indol-2-one (3s)



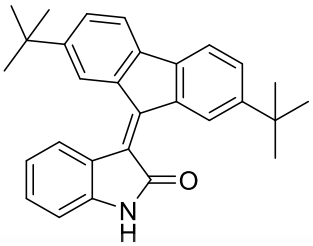
Black solid, 148.8 mg, yield 59%; mp = 174-175 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.34 (d, *J* = 1.3 Hz, 1H), 8.58 (d, *J* = 1.1 Hz, 1H), 7.92 (s, 1H), 7.53 – 7.40 (m, 4H), 7.11 (d, *J* = 6.4 Hz, 1H), 6.74 (d, *J* = 6.4 Hz 1H), 5.98 – 5.84 (m, 1H), 5.35 – 5.20 (m, 2H), 4.47 – 4.40 (m, 2H), 2.33 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 145.0, 141.6, 140.4, 138.8, 138.7, 136.2, 133.5, 133.3, 131.8, 131.6, 131.2, 130.8, 129.6, 128.9, 125.8, 121.9, 121.8, 120.8, 120.5, 120.2, 117.3, 108.9, 42.1, 29.4, 20.8. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{25}H_{18}Br_2NO$: 507.9735; found: 507.9733

4-Chloro-3-(2,7-dibromo-9*H*-fluoren-9-ylidene)-1-(prop-2-en-1-yl)-1,3-dihydro-2*H*-indol-2-one (3t)



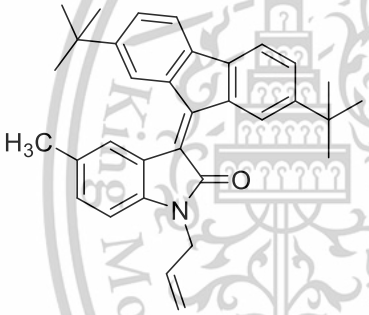
Black solid, 66.5 mg, yield 41%; mp = 202-203 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.08 (s, 1H), 7.53 – 7.46 (m, 2H), 7.42 (dd, *J* = 6.4, 2.7 Hz, 2H), 7.37 (s, 1H), 7.31 (t, *J* = 6.4 Hz, 1H), 7.10 (d, *J* = 6.6 Hz, 1H), 6.81 (d, *J* = 6.3 Hz, 1H), 5.90 (ddd, *J* = 17.8, 8.4, 4.3 Hz, 1H), 5.29 (t, *J* = 11.0 Hz, 2H), 4.56 (dd, *J* = 13.2, 4.2 Hz, 1H), 4.36 (dd, *J* = 13.1, 4.4 Hz, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.9, 146.5, 145.5, 140.0, 139.9, 139.6, 138.8, 134.1, 133.7, 133.4, 131.9, 131.5, 131.5, 131.2, 124.3, 121.9, 120.9, 120.7, 120.6, 117.9, 107.2, 42.7, 31.5, 22.6. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{24}H_{15}Br_2ClNO$: 527.9188; found: 527.9175

3-(2,7-Di-tert-butyl-9H-fluoren-9-ylidene)indolin-2-one (3u)



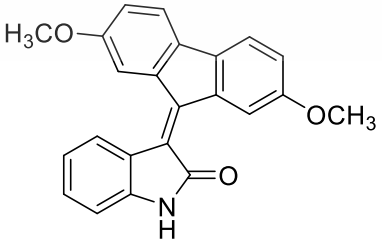
Red solid, 22.8 mg, yield 11%; mp = 232-233 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.75 (s, 1H), 9.19 (d, *J* = 1.3 Hz, 1H), 8.39 (d, *J* = 1.1 Hz, 1H), 8.02 (d, *J* = 6.3 Hz, 1H), 7.66 (d, *J* = 6.4 Hz, 1H), 7.63 (d, *J* = 6.3 Hz, 1H), 7.46 (dd, *J* = 6.4, 1.3 Hz, 1H), 7.43 (dd, *J* = 6.3, 1.4 Hz, 1H), 7.27 (t, *J* = 6.1 Hz, 1H), 6.92 (dd, *J* = 11.7, 6.2 Hz, 2H), 1.31 (s, 9H), 1.27 (s, 9H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 169.0, 152.5, 150.6, 149.9, 148.3, 143.3, 140.3, 138.8, 137.8, 137.2, 134.2, 132.6, 131.3, 129.2, 128.8, 128.4, 126.5, 125.1, 123.7, 123.2, 121.1, 120.9, 120.4, 119.6, 110.7, 35.3, 35.2, 31.6, 31.4. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{29}H_{30}NO$: 408.2327; found: 408.2293

1-Allyl-3-(2,7-di-tert-butyl-9H-fluoren-9-ylidene)-5-methylindolin-2-one (3v)



Red solid, 34.3 mg, yield 15%; mp = 80-82 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.27 (s, 1H), 8.48 (s, 1H), 8.00 (s, 1H), 7.47 – 7.43 (m, 2H), 7.36 (t, *J* = 7.4 Hz, 2H), 7.04 (d, *J* = 6.3 Hz, 1H), 6.73 (d, *J* = 6.3 Hz, 1H), 5.97 – 5.89 (m, 1H), 5.31 (d, *J* = 13.9 Hz, 1H), 5.25 (d, *J* = 8.0 Hz, 1H), 4.47 (d, *J* = 4.2 Hz, 2H), 2.27 (s, 3H), 1.38 (s, 9H), 1.31 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 167.4, 150.8, 149.9, 149.4, 141.0, 140.7, 139.0, 138.2, 137.7, 132.0, 130.4, 130.1, 128.1, 128.1, 126.7, 126.6, 125.5, 124.4, 123.1, 119.1, 118.5, 117.2, 108.6, 42.3, 35.1, 34.8, 31.4, 31.1, 21.0. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{33}H_{36}NO$: 462.2797; found: 462.2791

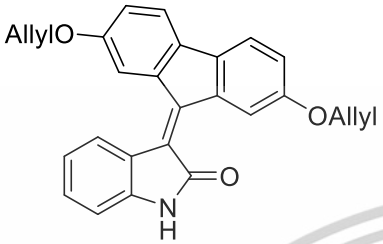
3-(2,7-dimethoxy-9H-fluoren-9-ylidene)-1,3-dihydro-2H-indol-2-one (3w)



Red solid, 35.6 mg, yield 33%; mp = 210-211 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.72 (d, *J* = 1.8 Hz, 1H), 8.21 (d, *J* = 6.4 Hz, 1H), 7.94 (d, *J* = 1.7 Hz, 1H), 7.69 (s, 1H), 7.34 – 7.28 (m, 2H), 7.24 – 7.19 (m, 1H), 6.95 (dd, *J* = 9.7, 3.5 Hz, 1H), 6.88 – 6.82 (m, 3H), 3.86 (s, 3H), 3.76 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 168.9, 159.2,

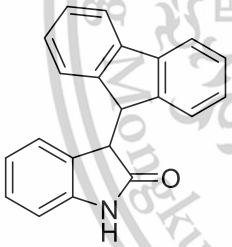
158.4, 141.1, 139.2, 138.6, 136.7, 135.1, 130.4, 127.4, 125.1, 123.6, 121.2, 119.8, 119.2, 118.0, 117.3, 114.0, 112.4, 109.9, 55.6, 55.5, 29.7. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{23}H_{18}NO_3$: 356.1287; found: 356.1284

3-(2,7-Bis(allyloxy)-9H-fluoren-9-ylidene)indolin-2-one (3x)



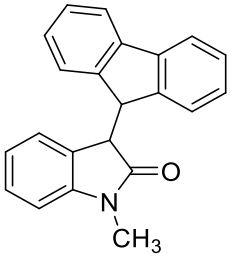
Black solid, 55.9 mg, yield 26%; mp = 185-186 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.75 (d, *J* = 1.9 Hz, 1H), 8.57 (s, 1H), 8.17 (d, *J* = 6.3 Hz, 1H), 7.93 (d, *J* = 1.8 Hz, 1H), 7.31 (dd, *J* = 6.4, 5.8 Hz, 2H), 7.21 (td, *J* = 6.2, 0.6 Hz, 1H), 6.97 – 6.85 (m, 4H), 6.16 – 5.96 (m, 2H), 5.41 (ddd, *J* = 31.2, 13.8, 1.2 Hz, 2H), 5.29 (ddd, *J* = 8.4, 6.3, 1.0 Hz, 2H), 4.60 (d, *J* = 4.3 Hz, 2H), 4.48 (dt, *J* = 4.2, 1.0 Hz, 2H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 169.5, 158.2, 157.4, 149.9, 141.3, 139.1, 138.6, 136.8, 135.3, 133.3, 133.1, 130.4, 127.6, 125.1, 123.5, 121.2, 119.8, 119.2, 118.8, 118.4, 117.7, 117.7, 114.9, 113.1, 110.0, 69.1, 69.0. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{27}H_{22}NO_3$: 408.1600; found: 408.1603

3-(9*H*-Fluoren-9-yl)-1,3-dihydro-2*H*-indol-2-one (8a)



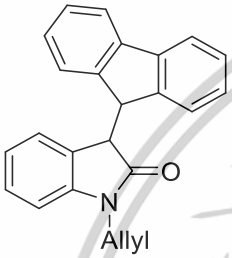
Purple solid, 569.3 mg, yield 76%; mp = 172-174 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.67 (s), 7.77 (d, *J* = 5.9 Hz), 7.65 (d, *J* = 5.9 Hz), 7.61 (d, *J* = 6.1 Hz), 7.48 (t, *J* = 5.9 Hz), 7.41 (t, *J* = 6.2 Hz), 7.21 (t, *J* = 6.0 Hz), 7.07 (t, *J* = 6.0 Hz), 6.95 (t, *J* = 6.1 Hz), 6.71 (d, *J* = 6.2 Hz), 6.52 (t, *J* = 6.1 Hz), 5.86 (d, *J* = 6.0 Hz), 4.84 (d, *J* = 2.9 Hz), 4.33 (d, *J* = 2.9 Hz). ^{13}C NMR (126 MHz, $CDCl_3$) δ 178.9, 144.6, 142.7, 141.9, 141.2, 141.0, 127.9, 127.8, 127.5, 127.3, 127.0, 126.1, 124.1, 123.9, 123.6, 121.9, 120.0, 119.7, 109.3, 48.9, 47.4. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{21}H_{16}NO$: 298.1232; found: 298.1201

3-(9*H*-Fluoren-9-yl)-1-methyl-1,3-dihydro-2*H*-indol-2-one (8l)



Pale orange solid, 224.0 mg, yield 78%; mp = 136-137 °C; ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.88 (d, *J* = 6.0 Hz, 1H), 7.80 (d, *J* = 5.9 Hz, 1H), 7.73 (d, *J* = 6.0 Hz, 1H), 7.48 (t, *J* = 5.9 Hz, 1H), 7.42 (t, *J* = 5.9 Hz, 1H), 7.21 (t, *J* = 5.9 Hz, 1H), 7.14 (d, *J* = 5.9 Hz, 1H), 7.09 (t, *J* = 5.9 Hz, 1H), 7.01 (t, *J* = 6.1 Hz, 1H), 6.82 (d, *J* = 6.2 Hz, 1H), 6.52 (t, *J* = 6.0 Hz, 1H), 5.78 (d, *J* = 5.8 Hz, 1H), 4.70 (d, *J* = 3.1 Hz, 1H), 4.58 (d, *J* = 3.1 Hz, 1H), 3.19 (s, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 176.2, 145.0, 144.5, 143.3, 141.5, 141.4, 128.3, 127.9, 127.8, 127.4, 126.1, 125.0, 123.9, 122.9, 121.9, 120.6, 120.5, 108.6, 47.6, 47.5, 26.4. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{22}H_{18}INO$: 312.1388; found: 312.1385

3-(9*H*-fluoren-9-yl)-1-(prop-2-en-1-yl)-1,3-dihydro-2*H*-indol-2-one (8m)



White solid, 94.0 mg, yield 54%; mp = 224-225 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.76 (d, *J* = 6.0 Hz, 1H), 7.61 (dd, *J* = 10.8, 6.0 Hz, 2H), 7.47 (t, *J* = 5.9 Hz, 1H), 7.40 (t, *J* = 5.9 Hz, 1H), 7.27 (d, *J* = 5.5 Hz, 1H), 7.20 (t, *J* = 6.0 Hz, 1H), 7.06 (t, *J* = 5.9 Hz, 1H), 6.98 (t, *J* = 6.2 Hz, 1H), 6.63 (d, *J* = 6.3 Hz, 1H), 6.53 (t, *J* = 6.0 Hz, 1H), 5.89 – 5.79 (m, 2H), 5.25 (s, 1H), 5.22 (d, *J* = 5.6 Hz, 1H), 4.86 (d, *J* = 3.0 Hz, 1H), 4.52 (dd, *J* = 12.9, 4.3 Hz, 1H), 4.32 (dd, *J* = 14.6, 3.5 Hz, 2H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 176.1, 144.6, 143.1, 142.7, 141.9, 141.2, 131.2, 127.8, 127.8, 127.5, 127.2, 126.7, 125.4, 124.1, 124.1, 123.3, 121.9, 120.0, 119.6, 117.8, 108.5, 48.4, 47.6, 42.4. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{24}H_{20}NO$: 338.1545; found: 338.1549

ORTEP diagram of compound 3e

Datablock mo_mah02_tle_0m - ellipsoid plot

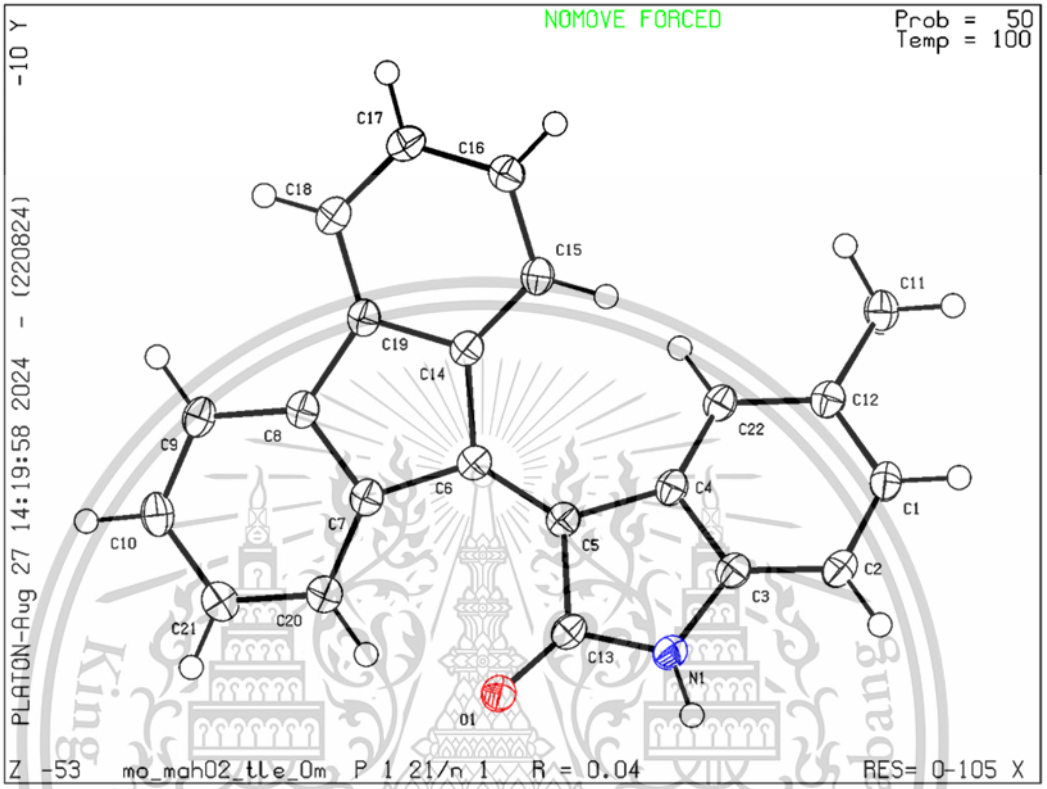


Figure 4.1 ORTEP drawing of compound 3e

checkCIF/PLATON report

Datablock: mo_mah02_tle_0m

Bond precision: C-C = 0.0020 A Wavelength=0.71073

Cell: a=18.0576(10) b=4.0863(2) c=21.8951(10)
alpha=90 beta=113.353(2) gamma=90

Temperature: 100 K

	Calculated	Reported
Volume	1483.26(13)	1483.26(13)
Space group	P 21/n	P 1 21/n 1
Hall group	-P 2yn	-P 2yn
Moiety formula	C22 H15 N O	C22 H15 N O
Sum formula	C22 H15 N O	C22 H15 N O
Mr	309.35	309.35
Dx,g cm-3	1.385	1.385
Z	4	4
Mu (mm-1)	0.085	0.085
F000	648.0	648.0
F000'	648.26	
h,k,lmax	23,5,28	23,5,28
Nref	3427	3422
Tmin,Tmax	0.989,0.996	0.698,0.746
Tmin'	0.970	

Correction method= # Reported T Limits: Tmin=0.698 Tmax=0.746
AbsCorr = MULTI-SCAN

Data completeness= 0.999 Theta(max)= 27.538

R(reflections)= 0.0421(2795) wR2(reflections)= 0.1143(3422)

S = 1.092 Npar= 223

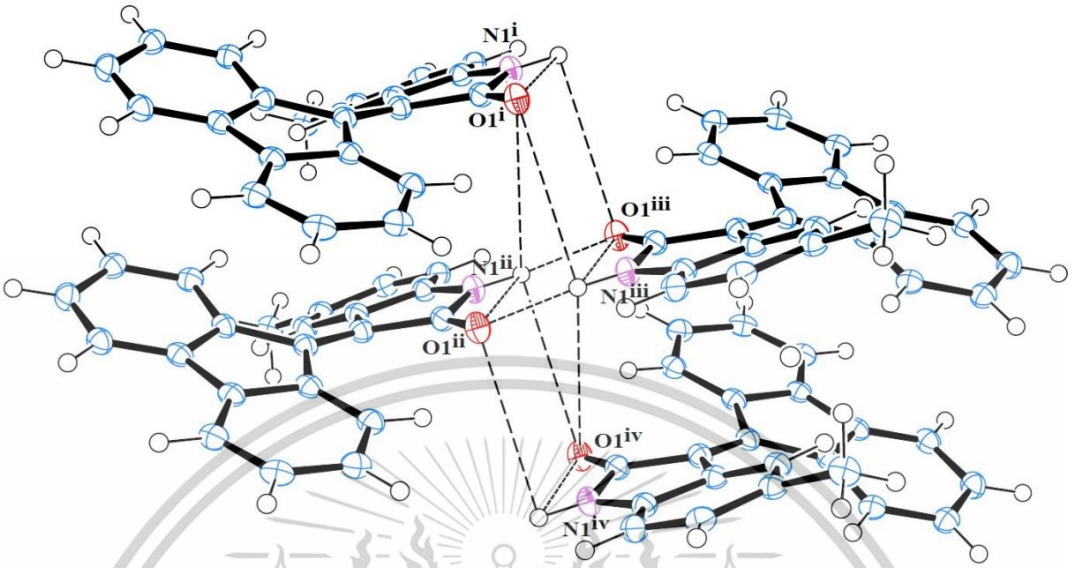
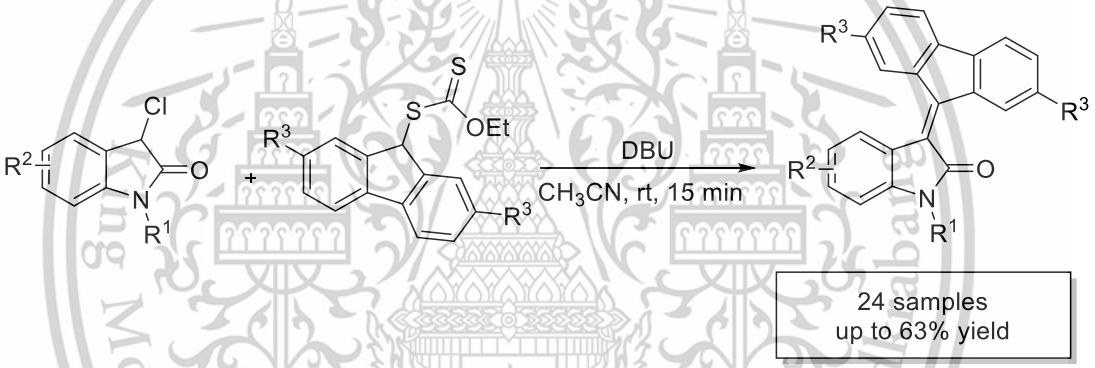


Figure 4.2 Intramolecular hydrogen bond in compound 3e

Oxygen and nitrogen atoms in amide oxindole can bind intramolecular hydrogen bond N1-H1...O1 with 2.8167 Å (Figure 2). The intermolecular hydrogen bond N1- H1...O1 as shown in Figure S66 and π-π interactions of oxindole rings and fluorene rings play an important role in stabilizing the intermolecular networks within crystal.

CHAPTER 5
CONCLUSION

In conclusion, we have described a facile and environmentally benign synthetic route for the construction of 3-arylidene-2-oxindole via DBU-mediated cross-coupling reaction of 3-chloroindolin-2-one with *O*-ethyl *S*-(9*H*-fluoren-9-yl) carbonodithioate under mild and metal-free reaction conditions. The reaction is effective in producing 3-arylidene-2-oxindole bearing electron-donating and electron-withdrawing groups in acceptable yields. Furthermore, a scale up of some synthesized 3-arylidene-2-oxindole was performed demonstrating promising results. Additionally, the functionalization of synthesized 3-arylidene-2-oxindole using $NaBH_4$ reduction accomplished to provide 3-(9*H*-fluoren-9-yl)indolin-2-ones.



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