JOC The Journal of Organic Chemistry

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J. Org. Chem., **Just Accepted Manuscript** • Publication Date (Web): 22 Nov 2018

Just Accepted

ACS Publications

is published by the American Chemical Society. 1155 Sixteenth Street N.W., Washington, DC 20036

Copper-catalyzed Domino Addition, Hydroamination and Cyclization: A Multicomponent Approach to Spiro Oxazolidinone Derivatives

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Abstract

Copper-catalysed one-pot multicomponent protocol has been developed for construction of spiro heterocycles. The domino approach, leads to synthesis of spiro oxazolidinones starting from ketones, arylacetylenes, and isocyanates *via* catalytic addition, hydroamination and cyclization involving consecutive C-C, C-O, and C-N bond formations.

INTRODUCTION

Metal catalysed domino transformations allow construction of complex molecules from readily available starting materials.[1] Additionally, these metal mediated domino transformations involving intramolecular hydroamination as a key step, leading to formation of multiple C-C and C-N bonds, have become reliable and valuable tool for assembling structurally diverse N-heterocycles.[2] A classic metal catalysed three component approach involving assembly of alkyne, carbonyl, and amine has been much adopted for construction

of many N-heterocycles such as oxazolidinones. Oxazolidinones and their derivatives have been widely used not only as chiral synthons or chiral auxiliaries [3] but also pharmaceuticals [4] and agrochemicals [5] due a diverse range of biological activities.[6]

The feasibility of C-C bond formation, through C-H activation of terminal alkynes to carbonyl compound has been a much investigated protocol for construction of propargyl alcohols. These compounds are versatile building blocks for natural products and also oxazolidinones.[7] Direct nucleophilic addition of alkyne to ketones is rather difficult due to its lower reactivity compared with aldehydes and imines.[8] In recent years, metal mediated C-H activation direct alkynylation has been explored for synthesis of propargyl alcohol of carbonyls supported by various catalysts such as copper, [9] zinc-mediated, [10] silver, NHC-silver complexes,[11] copper/guanidine, [12] and Rh-Phosphine [13] etc., has been reported in literature.

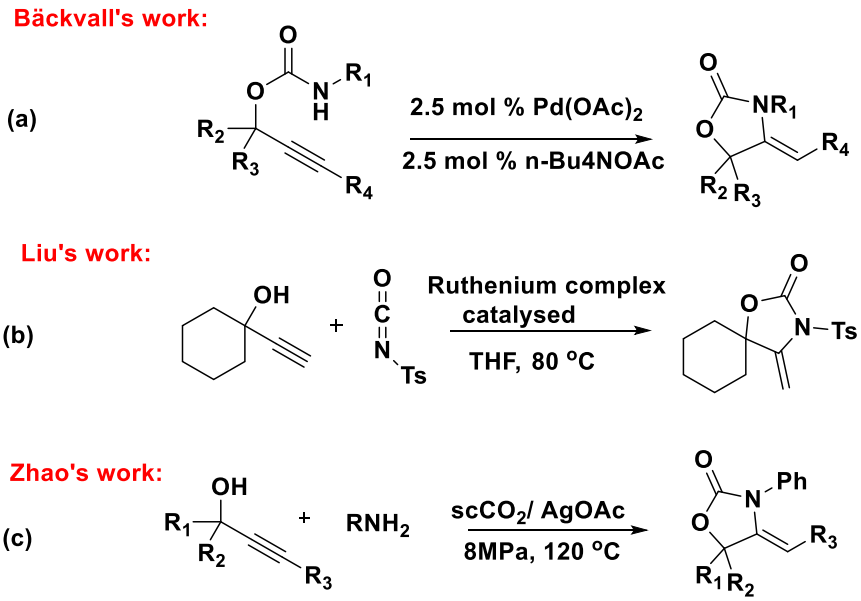
On the other hand catalytic hydroamination *i.e.,* nucleophilic addition of N-H across C-C multiple bonds followed by cyclization has been an important tool in synthesis of many spiro oxazolidinone. Bäckvall *et al* reported palladium catalyzed intramolecular hydroamination of propargylic carbamates (Scheme 1a).[14] Later on, Liu and co-workers reported ruthenium complex catalyzed domino addition/exo cycloisomerization of propargylic alcohols and tosyl isocyanates (Scheme 1b).[15] Looper and co-workers reported rhodium catalyzed hydroamination of propargyl guanidines.[16] Silver catalyzed activation of internal propargylic alcohols in supercritical carbon dioxide has been reported by Zhao's *et al* (Scheme 1c).[17] While numerous synthetic approaches to access spiro oxazolidinones have been investigated many of them involve harsh reaction conditions, and use of expensive catalysts.

As a part of our group's continuous efforts towards development of copper-catalyzed reaction protocols, [18] one of the major objectives was to uncover a synthetic procedure that

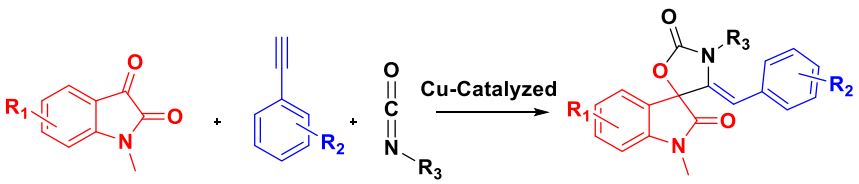
allows multiple carbon-carbon and/or carbon-heteroatom bond formations. Prior reports on such transformations by Sun,[19] Yamada,[20] and Nair [9] served as inspiration behind the proposed one-pot multicomponent copper-mediated protocol (Scheme 1d). Herein, we report copper-catalysed synthesis of spiro oxazolidinone framework as a viable alternative to the existing expensive catalyst based (Ag, Pd, Ru, Au) methods.

Scheme 1: Previous and Present Approaches:

Previous work:



This work: (d) Synthesis of Spiro oxazololidinones from readily available starting materials.

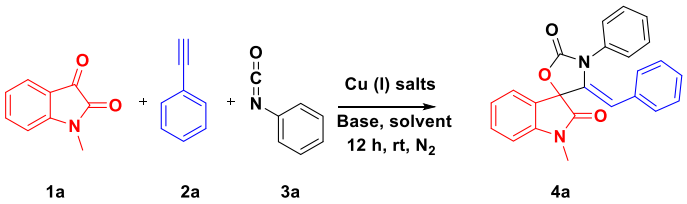


Results and Discussion

An assessment study on suitability of the proposed method has been performed using N-methyl isatin (**1a**), phenylacetylene (**2a**), and phenyl isocyanate (**3a**) as model substrates. The desired product (Z)-4'-benzylidene-1-methyl-3'-phenylspiro[indoline-3,5'-oxazolidine]-2,2'-dione (**4a**) was obtained in 43 % yield using copper iodide (CuI) as the catalyst, triethylamine (Et_3N) as the base, and toluene as the solvent. The reaction proceeds at room

temperature during 12 h under nitrogen atmosphere (Table 1, Entry 1). The optimum reaction parameters

Table 1: Synthesis of spiro oxazolidione-oxindole employing various reaction parameters.[a]



Entry	Catalyst	Base	solvent	Yield (%)[b]
1	CuI	Et_3N	Toluene	43
2	CuI	tBuOK	Toluene	64
3	CuI	DIPEA	Toluene	36
4	**CuI**	**DBU**	**Toluene**	**86**
5	CuI	K_2CO_3	Toluene	NR[c]
6	CuI	DBU	DMSO	59
7	CuI	DBU	DMF	52
8	CuI	DBU	CH_3CN	43
9	CuI	DBU	DCM	25
10	CuI	DBU	EtOH	NR
11	CuI	DBU	-	Trace
12	CuCl	DBU	Toluene	59
13	CuBr	DBU	Toluene	67
14	CuOAc	DBU	Toluene	48
15	$Cu(OAc)_2$	DBU	Toluene	Trace
16	$Cu(OTf)_2$	DBU	Toluene	Trace
17	-	DBU	Toluene	NR

[a]**Reaction Conditions**: Reaction was carried out with **1a** (0.621 mmol, 1equiv), CuI (10 mol %), **2a** (0.745 mmol, 1.2 equiv), DBU (0.31 mmol, 0.5 equiv) and **3a** (0.745 mmol, 1.2 equiv) in anhydrous toluene (3 mL) at room temperature for 12 h under N_2 atmosphere; [b]isolated yields were reported. [c]No Reaction.

were evaluated systematically and results summarized in Table 1. Firstly, a series of bases, such as Et_3N, potassium tert-butoxide, DIPEA DBU and K_2CO_3 were tested (Entries 1- 5). Among them DBU has been found to be the most effective base for this reaction (Entry 4).

It has been observed that reaction proceeds most smoothly in toluene compared to other solvents (DMSO, DMF, CH_3CN, and DCM, Entries 6 -9). The reaction didn't proceed at all with EtOH as a solvent (Entry 10). A non polar solvent which helps in the formation of the copper acetylide, and subsequent formation of the propargyl alcohol on reacting with the electrophilic carbonyl carbon, serves as a better solvent for this reaction. In a polar protic solvent such as ethanol, the formation of the copper acetylide is not possible. Therefore, the reaction doesn't progress. The reaction did not proceed at all in absence of the solvent (Entry 11).

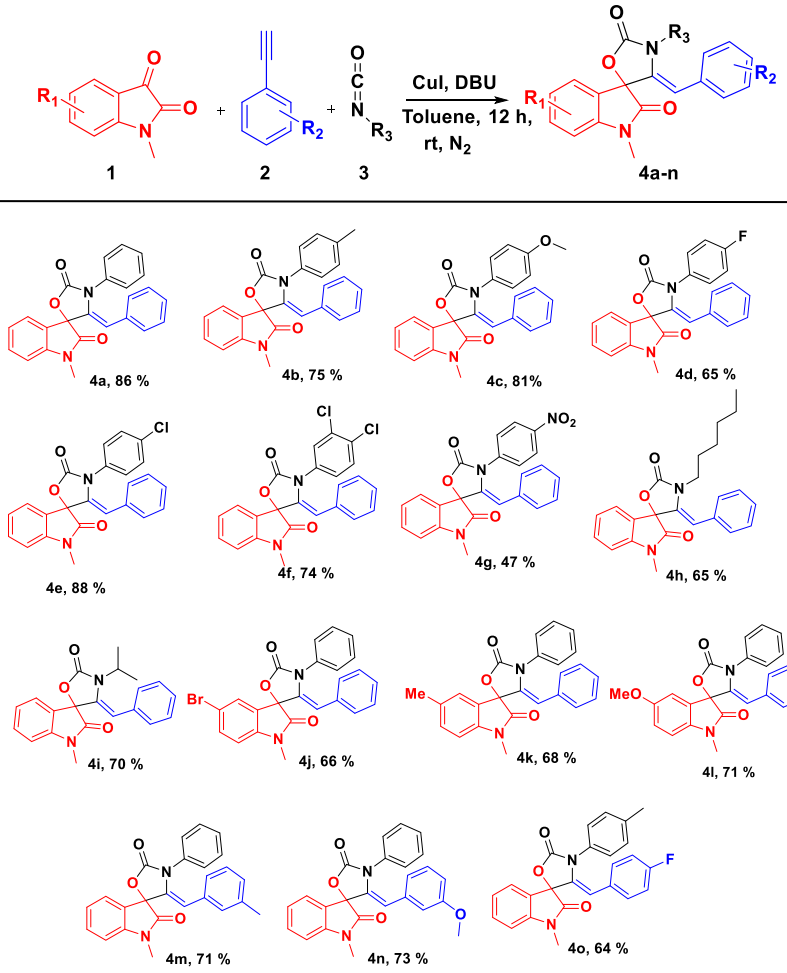
A comparison of catalyst efficiency has been examined at this stage, employing various copper salts such as CuCl, CuBr, CuOAc, $Cu(OAc)_2$ and $Cu(OTf)_2$ (Entries 12 - 16). Among them, CuI has been found to be the most suitable catalyst. As expected, reaction did not proceed in the absence of catalyst (Entry 17).

The successfully optimized reaction conditions were adopted for screening various substrates to evaluate the scope of this reaction. To begin with a range of different isocyanates were tested (Scheme 2). Phenyl isocyanates with neutral or electron donating substituents (4-H, 4-Me, 4-OMe) resulted in excellent yields of corresponding products (**4a-4c,** 75-86%). Halogen containing phenyl isocyantates also led to formation of desired spiro oxazolidione products in good to excellent yields (**4d**-**4f,** 65-88%). The structure of the product **4e** was confirmed by X-ray analysis (Figure-1 & S1).[21] Reaction with phenyl isocyanate having electron withdrawing substituent resulted in lower yield of corresponding product (**4g,** 47 %). Aliphatic isocyanates afforded the expected product with slightly lower yields compared to phenyl isocyanates (**4h**-**4i**, 65-70%**)**.

The substrate scope was investigated with respect to various N-methyl isatins and phenyl acetylenes as well (Scheme 2). In general, benzene ring substitutions on N-methyl isatin, as exemplified by 5-bromo, 5-methyl, 5-methoxy groups, gave moderate yields (**4j-4l,**

66-71%). Substitutions on phenylacetylene such as 3-methyl and 3-methoxy resulted in marginally decreased reaction yields (**4m-4n**, 71-73%**)**. Halogen substituted phenylacetylene gave moderate yield (**4o,** 64 %,). The reaction was unsuccessful with alkyl acetylenes under the established reaction conditions. Isatin with an unprotected N-H group didn't react.

Scheme 2: Scope of spiro oxazolidinone-oxindoles.[a,b]

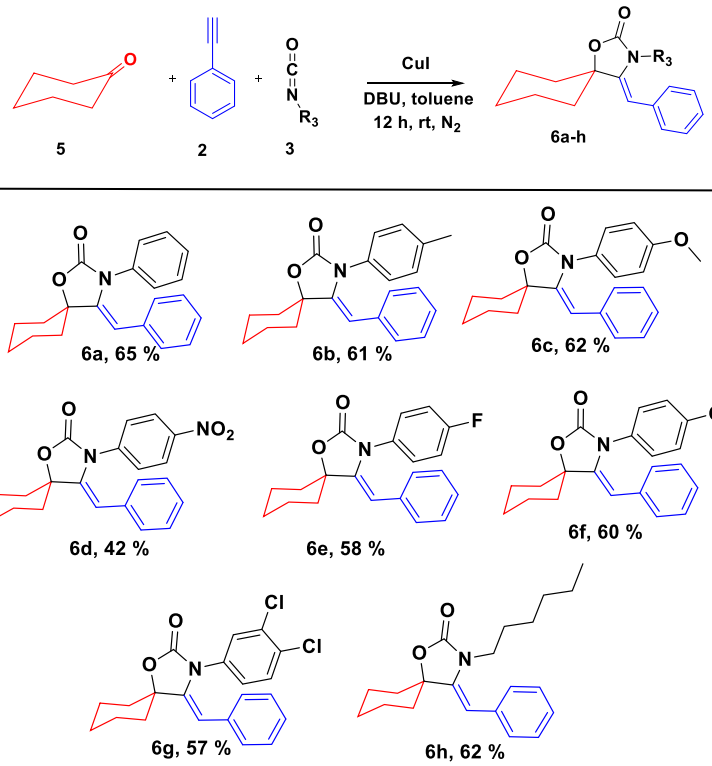


[a]**Reaction Conditions**: Reaction was carried out with **1** (0.621 mmol, 1equiv), CuI (10 mol %), **2** (0.745 mmol, 1.2 equiv), DBU (0.31 mmol, 0.5 equiv) and **3** (0.745 mmol, 1.2 equiv) in anhydrous toluene (3 mL) at room temperature for 12 h under N_2 atmosphere; [b]isolated yields were reported

Further, the scope of this protocol was extended to other carbonyl compounds. Cyclohexanone reacts by the established protocol to give moderate yield the product of **6a** compared with N-methyl isatin product of **4a**. Once again it was noticed that the reaction efficiency depends on electronic properties of phenyl isocyanates. As earlier phenyl

isocyanates with neutral and electron donating (4-H, 4-Me, 4-OMe) groups attached to phenyl ring gave better yields (Scheme 3, **6a-6c**, 61-65%), while substrates with electron withdrawing group attached phenyl isocyanate gave lower yields (**6d**, 42%). Gratifyingly, halo substituted phenyl isocyanates were also successfully converted to the expected products (**6e-6g,** 57-60%). The structure of the product **6f** was confirmed using single-crystal X-ray diffraction (Figure-1 & S2).[21] In addition, aliphatic isocyanate also followed trend and gave product in moderate yields (Scheme 3, **6h,** 62 %).

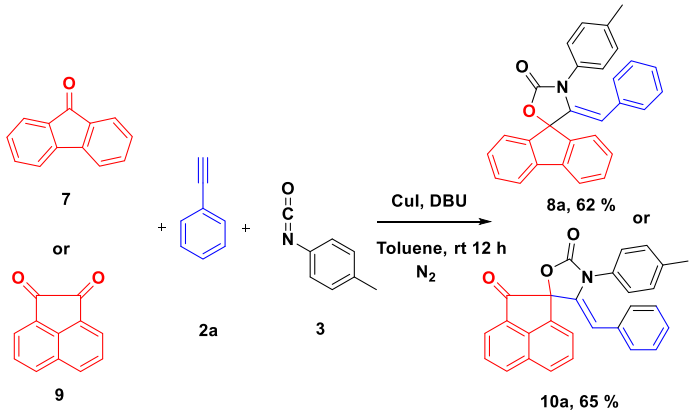
Scheme 3: Scope of cyclohexane containing spiro-oxazolidinones.[a, b]



[a]**Reaction Conditions:** Reaction was carried out with **5** (0.621 mmol, 1equiv), CuI (10 mol %), **2** (0.745 mmol, 1.2 equiv), DBU (0.31 mmol, 0.5 equiv) and **3** (0.745 mmol, 1.2 equiv) in anhydrous toluene (3 mL) at room temperature for 12 h under N_2 atmosphere; [b]isolated yields were reported.

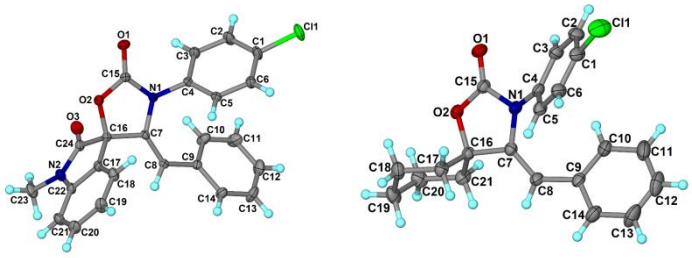
Carbonyls such as 9-fluorenone and acenaphthoquinone (Scheme 4) were successfully utilized for this protocol. However, the yields were moderate (**8a & 10a**, 62 & 65 %). The reaction was unsuccessful with acyclic ketones such as 3-pentanone, isobutyl methyl ketone and t-butyl methyl ketone under the established reaction conditions.

Scheme 4: Scope of Different Carbonyls. [a, b]



[a]**Reaction Conditions**: Reaction was carried out with **7** or **9** (0.621 mmol, 1 equiv), CuI (10 mol %), **2** (0.745 mmol, 1.2 equiv), DBU (0.31 mmol, 0.5 equiv) and **3** (0.745 mmol, 1.2 equiv) in anhydrous toluene (3 mL) at room temperature for 12 h under N_2 atmosphere; [b]isolated yields were reported.

Figure-1: Crystal structure of 4e and 6f.

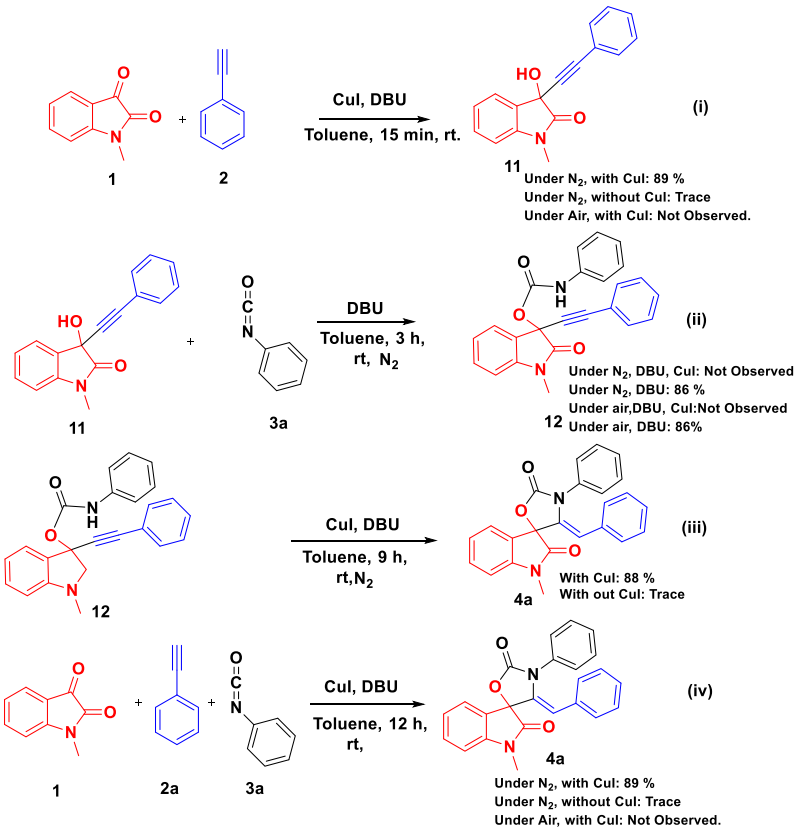


4e **6f**

Once, the scope of the protocol was established, our attention was focused on the possible mechanism of the reaction. A series of control experiments were conducted to obtain insights on the reaction pathway (Scheme 5). Firstly, the reaction was performed in a stepwise manner and reaction intermediates isolated and characterized. N-Methyl isatin on nucleophilic addition of copper acetylide of phenylacetylene yields the corresponding propargyl alcohol in 89% yield (Scheme 5 **i**). The reaction is rapid and proceeds exclusively under nitrogen atmosphere. The propargyl alcohol intermediate (**11**) reacts with phenyl isocyanate in the presence of DBU leading to formation of propargyl carbamate in 86 % yield (**12**, Scheme 5 **ii**). Compound **12** could be isolated in absence of catalyst. While in the presence of base and copper salts compound **4a** was formed exclusively and no carbamate

could be isolated. The hydroamination reaction does proceed even in non-anhydrous conditions without alteration of product yield. Both propargylation and hydroamination steps did not proceed in the absence of catalyst (Scheme 5 **i** & **iii**). However, carbamate does form even in the absence of catalyst. It was also observed that when the one-pot protocol was carried out in aerobic conditions no product formation was observed (Scheme 5 **iv**), which indirectly indicates reaction proceeds *via* propargyl alcohol intermediate (**11**).

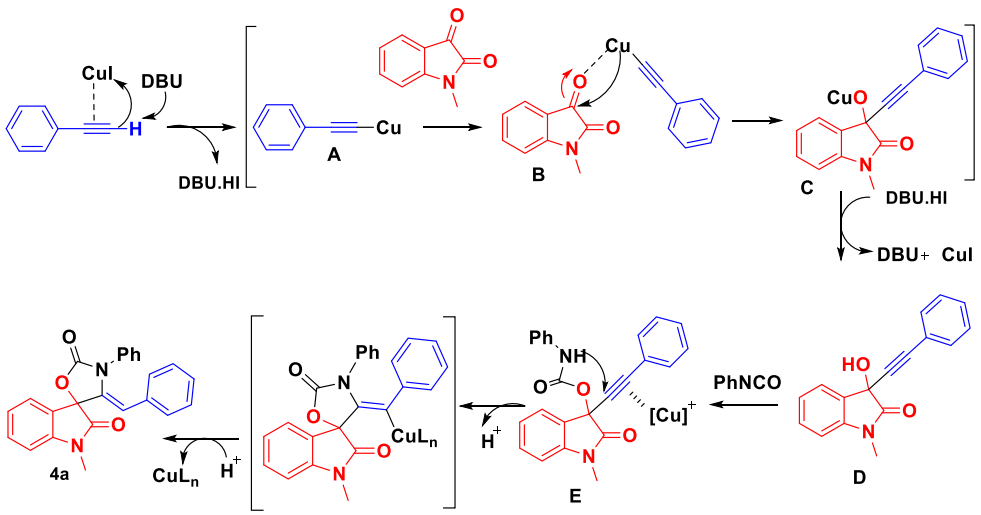
Scheme 5: Control Experiments.



The following reaction mechanism is proposed based on our experimental observations and previous literature reports [22] (Scheme 6). Initially, copper (I) iodide coordinates with the phenylacetylene activating the terminal C-H bond. The abstraction of the terminal proton easily by DBU leads to the formation of copper acetylide nucleophile (**A**), and DBU.HI. Copper acetylide then attacks the electrophilic carbonyl carbon afford the

addition product (**C**).[9-13, 22a] DBU.HI helps in removal of the copper from addition product to give propargyl alcohol (**D**). The hydroxyl of propargylic alcohol participated in the nucleophilic addition to the isocyanate carbon followed by intramolecular *exo* cyclization of carbmate intermediate (**E**). Carbamate undergoes intramolecular hydroamination across the internal C-C multiple bond, activated by copper (I) salts, resulting formation of corresponding oxazolidinone product (**4a**, 88 % Scheme 5 **iii**). the hydroaminaton yields desired oxazolidinone (**4a**). Role of copper is multifaceted in the reaction protocol. It is involved in elecrophilic activation of triple bond for generation of acetylide and carbonyl group as well as subsequent assistance in hydroamination.

Scheme 6: Proposed Mechanism.



Conclusions

To summarize a convenient one-pot MCR approach for construction of spiro heterocycles has be demonstrated successfully *via* a copper-catalyzed domino reaction. The protocol involving simple starting materials such carbonyl compounds, arylacetylene, and isocyanates proceeds through catalytic addition, hydroamination, and cyclization involving, formation of three bonds, a C-C, a C-N, and a C-O. Once the optimized conditions were

established this domino protocol has been successfully applied to a range of isocyanates, substituted phenylacetylenes, substituted N-methyl isatins and other carbonyls compounds, demonstrating its broad scope. This synthetic method with good functional group tolerance coupled with simple substrates and reagents is a valuable tool for construction of important sprio heterocyclic frameworks.

EXPERIMENTAL SECTION

General Information: Commercially available reagents were used without further purification unless otherwise specified. All the reactions were performed under an atmosphere of nitrogen in oven-dried glassware with magnetic stirring. All reactions were monitored by TLC analyses were performed on glass plates coated with silica gel 60 F254. Plates were visualized using UV light (254 nm) and/or iodine. Organic solutions were dried (Na_2SO_4) and concentrated under reduced pressure in a Büchi rotary evaporator. Column chromatography was performed on silica gel (60×120 mesh) on a glass column. Melting points (mp) were determined in capillary tubes and are uncorrected. ^{1}H NMR spectra were recorded at 300, 400 and 500 MHz (using TMS, as a reference), and ^{13}C NMR were recorded at 75, 100, 125 MHz (using the $CDCl_3$ triplet centred at δ 77.0 Hz as reference) in $CDCl_3$ and $CDCl_3$+DMSO as solvent at ambient temperature. Data are reported as follows: chemical shift, integration, multiplicity (s = singlet, d = doublet, dd = doublet of doublet, br = broad, t = triplet, q = quartet, m = multiplet). Chemical shifts were reported as (δ) in parts per million (ppm) and Coupling constants *J* values are given in Hz Mass (ESI) data were recorded on quadruple mass spectrometry. HRMS data were obtained by the ESI ionization sources. IR spectra were recorded on a FTIR spectrometer as KBr pellets or neat.

All chemicals were purchased from Sigma-Aldrich, Spectrochem, and avra chemicals Pvt. Ltd. India and used as received. The Spiro Oxazolidione-oxindole and other derivatives preparation and procedures experiments are given below.

Experimental procedure for the Preparation of (Z)-4'-benzylidene-1-methyl-3'-phenylspiro[indoline-3,5'-oxazolidine]-2,2'-dione (4a).

To a stirred mixture of 1-methyl-1*H*-indole-2, 3-dione **1a** (0.621 mmol, 1equiv), CuI (10 mol %), and phenylacetylene **2a** (0.745 mmol, 1.2equiv) in anhyd toluene (3 mL), DBU (0.31 mmol, 0.5 equiv) was added at 25 °C under a N_2 atmosphere. After 15 min added phenyl isocyanate **3a** (0.745 mmol, 1.2 equiv). Stirring was continued at 25 °C temperature until the starting material was completely consumed (TLC monitoring). After completion, the mixture was quenched with sat.aq NH_4Cl (5 mL) and extracted with EtOAc (2 × 25 mL). The combined organic layers were dried (anhyd Na_2SO_4) and evaporated under reduced pressure to dryness. The crude product thus obtained was purified by column chromatography (60–120 mesh, and EtOAc : hexane, 5:95) to afford pure **4a** as a white solid; yield: 205mg (86%); m.p 216-218 ^{0}C.

Experimental procedure for the Preparation of (Z)-4-benzylidene-3-phenyl-1-oxa-3-azaspiro[4.5]decan-2-one (6a). To a stirred mixture of Cyclohexanone **5a** (0.621 mmol, 1equiv), CuI (10 mol %), and phenylacetylene **2a** (0.745 mmol, 1.2equiv) in anhyd toluene (3 mL), DBU (0.31 mmol, 0.5 equiv) was added at 25 °C under a N_2 atmosphere. After 15 min added phenyl isocyanate **3a** (0.745 mmol, 1.2 equiv).Stirring was continued at this temperature until the starting material was completely consumed (TLC monitoring). After completion, the mixture was quenched with sat.aq NH_4Cl (5 mL) and extracted with EtOAc (2 × 25 mL). The combined organic layers were dried (anhyd Na_2SO_4) and evaporated under reduced pressure to dryness. The crude product thus obtained was purified by column chromatography (activated silica gel, 60–120 mesh, and EtOAc : hexane, 3:97) to afford pure **6a** as a white solid; yield: 130mg (65%); 160-162 ^{0}C.

Experimental procedure for the Preparation of ((Z)-4'-benzylidene-3'-(p-tolyl)spiro[fluorene-9,5'-oxazolidin]-2'-one (8a) OR (Z)-4'-benzylidene-3'-(p-tolyl)-2H-spiro[acenaphthylene-

1,5'-oxazolidine]-2,2'-dione **(10a).** To a stirred mixture of 9-fluorenone **7** or acenapthoquinone **9** (0.621 mmol, 1equiv), CuI (10 mol %), and phenylacetylene **2a** (0.745 mmol, 1.2equiv) in anhyd toluene (3 mL), DBU (0.31 mmol, 0.5 equiv) was added at 25 °C under a N_2 atmosphere. After 15 min added phenyl isocyanate **3a** (0.745 mmol, 1.2 equiv).Stirring was continued at this temperature until the starting material was completely consumed (TLC monitoring). After completion, the mixture was quenched with sat.aq NH_4Cl (5 mL) and extracted with EtOAc (2 × 25 mL). The combined organic layers were dried (anhyd Na_2SO_4) and evaporated under reduced pressure to dryness. The crude product thus obtained was purified by column chromatography (activated silica gel, 60–120 mesh, and EtOAc : hexane, 3:97)

(Z)-4'-Benzylidene-1-methyl-3'-phenylspiro[indoline-3,5'-oxazolidine]-2,2'-dione (4a)

4a as white solid (205mg, 86% yield); m.p 216-218 ^{O}C; eluent, hexane/ethyl acetate 95:5; ^{1}H NMR (300 MHz, $CDCl_3$+DMSO-d_6) δ 7.53 (t, *J* = 7.0 Hz, 2H), 7.23 (t, *J* = 7.6 Hz, 1H), 7.12 (m, 5H), 7.03 (d, *J* = 7.9 Hz, 1H), 6.92 – 6.79 (m, 3H), 6.63 (d, *J* = 7.2 Hz, 2H), 5.31 (s, 1H), 3.32 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$+DMSO-d_6) δ 171.0, 154.6, 144.6, 134.0, 131.6, 127.8, 127.7, 126.7, 126.5, 125.8, 125.3, 125.0, 123.5, 108.8, 103.6, 26.2; IR (KBr): 1777, 1723, 1611, 1213, 1106, 1020, 758, 698 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{24}H_{19}O_3N_2$ (M+H) 383.1392; found 383.1400.

(Z)-4'-Benzylidene-1-methyl-3'-(p-tolyl)spiro[indoline-3,5'-oxazolidine]-2,2'-dione (4b).

4b as a white solid (185mg, 75% yield); m.p 210-212 ^{O}C; eluent, hexane/ethyl acetate 95:5; ^{1}H NMR (300 MHz, $CDCl_3$+DMSO-d_6) δ 7.53 (m 2H), 7.22 (t, *J* = 7.4 Hz, 1H), 7.02 (m, 3H), 6.90 (m, 3H), 6.83 (t, *J* = 7.2 Hz, 2H), 6.63 (d, *J* = 7.2 Hz, 2H), 5.27 (s, 1H), 3.32 (s, 3H), 2.23 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$+DMSO-d_6) δ 171.1, 154.8, 144.5, 136.7, 134.2, 131.6, 131.4, 128.3, 127.8, 126.4, 125.6, 125.3, 124.9, 124.0, 123.5, 108.7, 103.2,

26.2, 20.4; IR (KBr): 1781, 1723, 1611, 1211, 1106, 1020, 753, 704 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{25}H_{21}O_3N_2$ (M+H) 397.1547; found 397.1552.

(Z)-4'-Benzylidene-3'-(4-methoxyphenyl)-1-methylspiro[indoline-3,5'-oxazolidine]-2,2'-dione (4c).

4c as a white solid (208mg, 81% yield); m.p 160-162 ^{O}C; eluent, hexane/ethyl acetate 95:5; ^{1}H NMR (300 MHz, $CDCl_3$+DMSO-d_6) δ 7.55 (t, *J* = 7.2 Hz, 2H), 7.37 (d, *J* = 9.0 Hz, 1H), 7.25 (t, *J* = 7.3 Hz, 1H), 7.06 (d, *J* = 8.8 Hz, 2H), 6.97 – 6.89 (m, 1H), 6.88 – 6.82 (m, 2H), 6.66 (d, *J* = 3.6 Hz, 2H), 6.64 (d, *J* = 5.9 Hz, 2H), 5.29 (s, 1H), 3.73 (s, 3H), 3.34 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$+DMSO-d_6) δ 171.0, 158.0, 144.5, 134.4, 131.6, 127.8, 126.8, 126.4, 125.6, 125.9, 123.9, 123.4, 120.0, 113.4, 113.0, 108.7, 102.9, 54.9, 26.2; IR (KBr): 1781, 1722, 1608, 1222, 1102, 1019, 753, 704 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{25}H_{21}O_4N_2$ (M+H) 413.1496; found 413.1497.

(Z)-4'-Benzylidene-3'-(4-fluorophenyl)-1-methylspiro[indoline-3,5'-oxazolidine]-2,2'-dione (4d).

4d as a white solid (163mg, 65% yield); m.p 240-242 ^{O}C; eluent, hexane/ethyl acetate 95:5; ^{1}H NMR (300 MHz, $CDCl_3$+DMSO-d_6) δ 7.54 (t, *J* = 7.4 Hz, 2H), 7.24 (t, *J* = 7.5 Hz, 1H), 7.14 (d, *J* = 4.8 Hz, 1H), 7.11 (d, *J* = 4.8 Hz, 1H), 7.06 (d, *J* = 7.9 Hz, 1H), 6.92 (m, 3H), 6.81 (t, *J* = 8.6 Hz, 2H), 6.66 (d, *J* = 7.2 Hz, 2H), 5.33 (s, 1H), 3.32 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$+DMSO-d_6) δ 170.9, 154.4, 144.5, 134.1, 131.6, 131.3, 130.0, 127.7, 126.9, 126.8, 126.5, 125.9, 125.2, 123.5, 123.4, 114.7, 114.4, 108.7, 103.4, 26.1; C-F Coupling constants: (126.8 $J_{C\text{-}F}$, 8.6 Hz, 114.5 $J_{C\text{-}F}$ 23.0); IR (KBr): 1783, 1723, 1610, 1513, 1251, 1104, 1022, 753, 702 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{24}H_{18}O_3N_2F$ (M+H) 401.1296; found 401.1313.

(Z)-4'-Benzylidene-3'-(4-chlorophenyl)-1-methylspiro[indoline-3,5'-oxazolidine]-2,2'-dione (4e).

4e as a white solid (228mg, 88% yield); m.p 220-222 ^{O}C; eluent, hexane/ethyl acetate 95:5; ^{1}H NMR (300 MHz, $CDCl_3$+DMSO-d_6) δ 7.59 – 7.48 (m, 2H), 7.25 (d, *J* = 5.2 Hz, 1H), 7.22 (d, *J* = 7.1 Hz, 1H), 7.10 (m, 3H), 7.04 (d, *J* = 8.0 Hz, 1H), 6.99 – 6.87 (m, 3H), 6.66 (d, *J* = 7.3 Hz, 2H), 5.34 (s, 1H), 3.32 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$+DMSO-d_6) δ 171.0, 154.4, 144.6, 133.8, 132.6, 132.1, 131.8, 131.4, 128.1, 127.8, 126.7, 126.3, 126.1, 125.4, 123.6, 119.3, 108.9, 104.0, 26.3; IR (KBr): 1784, 1722, 1610, 1493, 1209, 1091, 1018, 753, 704 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{24}H_{18}O_3N_2Cl$ (M+H) 417.1001; found 417.1019.

(Z)-4'-Benzylidene-3'-(3,4-dichlorophenyl)-1-methylspiro[indoline-3,5'-oxazolidine]-2,2'-dione (4f).

4f as a white solid (208mg, 74% yield); m.p 208-210 ^{O}C; eluent, hexane/ethyl acetate 95:5; ^{1}H NMR (300 MHz, $CDCl_3$+DMSO-d_6) δ 7.59 – 7.52 (m, 2H), 7.27 – 7.20 (m, 2H), 7.19 (d, *J* = 5.8 Hz, 1H), 7.06 (m, 2H), 7.01 (d, *J* = 9.3 Hz, 1H), 6.98 – 6.91 (m, 2H), 6.70 (d, *J* = 6.9 Hz, 2H), 5.41 (s, 1H), 3.32 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$+DMSO-d_6) δ 170.7, 153.9, 144.5, 133.5, 133.1, 131.8, 131.3, 131.2, 130.2, 129.1, 127.6, 126.9, 126.7, 126.3, 125.4, 124.3, 123.5, 123.1, 108.8, 104.4, 26.2; IR (KBr): 1788, 1721, 1610, 1472, 1206, 1102, 1022, 753, 702 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{24}H_{17}O_3N_2Cl_2$ (M+H) 451.0611; found 451.0619.

(Z)-4'-Benzylidene-1-methyl-3'-(4-nitrophenyl)spiro[indoline-3,5'-oxazolidine]-2,2'-dione (4g).

4g as yellow solid (125mg, 47% yield); m.p 222-224 ^{O}C; eluent, hexane/ethyl acetate 95:5; ^{1}H NMR (300 MHz, $CDCl_3$+DMSO-d_6) δ 7.95 (d, *J* = 9.1 Hz, 2H), 7.60 – 7.53 (m, 2H), 7.35 (d, *J* = 9.0 Hz, 2H), 7.25 (t, *J* = 7.5 Hz, 1H), 7.06 (d, *J* = 8.0 Hz, 1H), 6.97 – 6.86 (m, 3H), 6.71 (d, *J* = 6.6 Hz, 2H), 5.49 (s, 1H), 3.33 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$+DMSO-d_6) δ 170.4, 153.4, 144.6, 144.4, 139.3, 132.7, 131.8, 131.1, 127.4, 126.7, 126.4, 125.3, 124.6,

123.4, 122.7, 122.5, 108.8, 105.5, 26.0; IR (KBr): 1782, 1734, 1610,1524, 1231, 1112, 1015, 754, 700 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{24}H_{18}O_5N_3$ (M+H) 428.1241; found 428.1258.

(Z)-4'-Benzylidene-3'-hexyl-1-methylspiro[indoline-3,5'-oxazolidine]-2,2'-dione (4h).

4h as a white solid (158mg, 65% yield); m.p 160-162 ^{O}C; eluent, hexane/ethyl acetate 97:3; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.42 (m, 1H), 7.37 (dd, *J* = 7.5, 0.8 Hz, 1H), 7.30 – 7.27 (m, 1H), 7.26 – 7.22 (m, 2H), 7.19 – 7.14 (m, 1H), 7.12 (dd, *J* = 6.7, 0.8 Hz, 2H), 6.91 (d, *J* = 7.9 Hz, 1H), 5.19 (s, 1H), 3.58 – 3.45 (m, 1H), 3.43 – 3.32 (m, 1H), 3.25 (s, 3H), 1.31 – 1.17 (m, 2H), 1.16 – 1.07 (m, 2H), 1.04 – 0.94 (m, 2H), 0.88 (ddd, *J* = 12.5, 9.7, 6.1 Hz, 2H), 0.78 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.7, 156.5, 145.0, 135.7, 133.7, 132.0, 131.8, 130.5, 129.3, 129.0, 128.2, 127.9, 127.2, 125.6, 125.5, 124.7, 123.9, 123.7, 108.9, 101.7, 43.8, 40.7, 31.1, 26.8, 25.6, 22.4, 13.9; IR (KBr): 1780, 1723, 1612, 1468, 1354, 1077, 1016, 753, 705 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{24}H_{27}O_3N_2$ (M+H) 391.2016; found 391.2024.

(Z)-4'-Benzylidene-3'-isopropyl-1-methylspiro[indoline-3,5'-oxazolidine]-2,2'-dione (4i).

4i as a white solid (150mg, 70% yield); m.p 190-192 ^{O}C; eluent, hexane/ethyl acetate 97:3; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 (td, *J* = 7.8, 1.2 Hz, 1H), 7.39 (d, *J* = 7.5 Hz, 1H), 7.29 (t, *J* = 7.3 Hz, 2H), 7.22 (dd, *J* = 8.7, 6.0 Hz, 1H), 7.16 (m, 3H), 6.90 (d, *J* = 7.9 Hz, 1H), 5.09 (s, 1H), 3.76 (m, 1H), 3.25 (s, 3H), 1.40 (dd, *J* = 9.8, 6.8 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$+DMSO) δ 171.3, 155.1, 144.4, 136.2, 133.4, 131.4, 128.1, 127.7, 126.8, 125.0, 124.9, 123.5, 108.7, 101.6, 47.9, 26.2, 18.4; IR (KBr): 1774, 1727, 1611, 1467, 1296, 1102, 1018, 762, 704 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{21}H_{21}O_3N_2$ (M+H) 349.1547; found 349.1562.

(Z)-4'-Benzylidene-5-bromo-1-methyl-3'-phenylspiro[indoline-3,5'-oxazolidine]-2,2'-dione (4j).

4j as a white solid (188mg, 66% yield); m.p 206-208 ^{O}C; eluent, hexane/ethyl acetate 95:5; ^{1}H NMR (300 MHz, $CDCl_3$+DMSO-d_6) δ 7.79 (s, 1H), 7.67 (dd, *J* = 8.4, 2.0 Hz, 1H), 7.12

(br, 5H), 7.05 (d, *J* = 8.4 Hz, 1H), 6.93 – 6.79 (m, 3H), 6.66 (d, *J* = 7.1 Hz, 2H), 5.33 (s, 1H), 3.31 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$+MSO-d_6) δ 169.8, 153.5, 151.7, 143.1, 138.4, 133.8, 133.2, 132.8, 130.6, 127.6, 127.5, 127.0, 126.1, 125.8, 125.2, 125.0, 124.3, 120.7, 117.2, 114.8, 110.1, 102.9, 25.7; IR (KBr): 1779, 1743, 1610, 1493, 1221, 1110, 1022, 755, 694 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{24}H_{18}O_3N_2Br$ (M+H) 461.0495; found 461.0510.

(Z)-4'-Benzylidene-1,5-dimethyl-3'-phenylspiro[indoline-3,5'-oxazolidine]-2,2'-dione (4k).

4k as a white solid (168mg, 68% yield); m.p 208-210 ^{O}C; eluent, hexane/ethyl acetate 95:5; ^{1}H NMR (300 MHz, $CDCl_3$+DMSO-d_6) δ 7.34 (s, 1H), 7.31 (d, *J* = 8.1 Hz, 1H), 7.17 – 7.07 (m, 5H), 6.91 (d, *J* = 8.0 Hz, 1H), 6.84 (dd, *J* = 13.3, 5.9 Hz, 3H), 6.64 (d, *J* = 7.1 Hz, 2H), 5.31 (s, 1H), 3.29 (s, 3H), 2.38 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$+DMSO-d_6) δ 170.9, 154.5, 142.0, 133.9, 133.8, 133.1, 131.8, 131.4, 127.6, 127.5, 126.51, 126.3, 125.7, 125.6, 124.9, 123.6, 108.5, 103.4, 26.1, 20.3; IR (KBr): 1780, 1738, 1625, 1499, 1219, 1111, 1022, 757,694 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{25}H_{21}O_3N_2$ (M+H) 397.1547; found 397.1569.

(Z)-4'-Benzylidene-5-methoxy-1-methyl-3'-phenylspiro[indoline-3,5'-oxazolidine]-2,2'-dione (4l).

4l as a white solid (164 mg, 71 % yield); m.p 228-230 ^{O}C; eluent, hexane/ethyl acetate 95:5; ^{1}H NMR (300 MHz, $CDCl_3$+DMSO-d_6) δ 7.12 (m, 6H), 7.05 (dd, *J* = 8.6, 2.4 Hz, 1H), 6.97 (d, *J* = 8.5 Hz, 1H), 6.92 – 6.79 (m, 3H), 6.64 (d, *J* = 7.2 Hz, 2H), 5.31 (s, 1H), 3.83 (s, 3H), 3.30 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$+DMSO-d_6) δ 170.0, 155.4, 153.7, 136.9, 133.3, 130.8, 127.0, 126.9, 125.9, 125.7, 125.0, 124.3, 124.0, 115.5, 111.3, 108.9, 102.6, 54.6, 25.5; IR (KBr): 1781, 1722, 1608, 1220, 1102, 1019, 753, 704 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{25}H_{21}O_4N_2$ (M+H) 413.1496; found 413.1503.

(Z)-1-Methyl-4'-(3-methylbenzylidene)-3'-phenylspiro[indoline-3,5'-oxazolidine]-2,2'-dione (4m).

4m as a white solid (175mg, 71% yield); m.p 208-210 ^{O}C; eluent, hexane/ethyl acetate 95:5; ^{1}H NMR (300 MHz, $CDCl_3$+DMSO-d_6) δ 7.53 (dd, *J* = 5.5, 3.8 Hz, 1H), 7.22 (t, *J* = 7.6 Hz, 1H), 7.19 – 7.07 (m, 5H), 7.03 (d, *J* = 8.0 Hz, 1H), 6.78 (t, *J* = 7.5 Hz, 1H), 6.70 (d, *J* = 7.5 Hz, 1H), 6.49 (d, *J* = 7.4 Hz, 1H), 6.40 (s, 1H), 5.27 (s, 1H), 3.32 (s, 3H), 1.96 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$+DMSO-d_6) δ 171.2, 154.8, 144.7, 136.1, 134.3, 133.9, 131.7, 131.5, 129.1, 127.9, 126.8, 126.7, 126.6, 125.4, 125.1, 124.8, 124.1, 123.6, 108.8, 103.9, 26.3, 20.4; IR (KBr): 1778,1725, 1610,1485, 1217, 1101, 1021, 754, 696 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{25}H_{20}O_3N_2Na$ (M+Na) 419.1366; found 419.1380.

(Z)-4'-(3-Methoxybenzylidene)-1-methyl-3'-phenylspiro[indoline-3,5'-oxazolidine]-2,2'-dione (4n).

4n as a white solid (188mg, 73% yield); m.p 168-170 ^{O}C; eluent, hexane/ethyl acetate 95:5;^{1}H NMR (300 MHz, $CDCl_3$+DMSO-d_6) δ 7.53 (t, *J* = 7.5 Hz, 2H), 7.23 (t, *J* = 7.6 Hz, 1H), 7.13 (m, 5H), 7.05 (d, *J* = 7.9 Hz, 1H), 6.78 (t, *J* = 7.9 Hz, 1H), 6.45 (dd, *J* = 8.2, 1.9 Hz, 1H), 6.27 (d, *J* = 7.6 Hz, 1H), 6.15 (s, 1H), 5.29 (s, 1H), 3.52 (s, 3H), 3.32 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$+DMSO-d_6) δ 170.9, 157.8, 154.5, 144.5, 134.1, 134.0, 132.9, 131.6, 127.7, 127.5, 126.6, 125.3, 124.8, 123.7, 123.5, 120.4, 112.8, 112.3, 108.8, 103.5, 54.3, 26.2; IR (KBr): 1782, 1727, 1609, 1470, 1215,1104,1021, 749, 694 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{25}H_{21}O_4N_2$ (M+H) 413.1496; found 413.1513.

(Z)-4'-(4-Fluorobenzylidene)-1-methyl-3'-(p-tolyl)spiro[indoline-3,5'-oxazolidine]-2,2'-dione (4o).

4o as a white solid (165mg, 64% yield); m.p 260-262 ^{O}C; eluent, hexane/ethyl acetate 95:5; ^{1}H NMR (300 MHz, $CDCl_3$+DMSO-d_6) δ 7.52 (dd, *J* = 6.8, 4.1 Hz, 2H), 7.22 (t, *J* = 7.6 Hz, 1H), 7.13 (t, *J* = 4.8 Hz,, 4H), 7.04 (d, *J* = 8.1 Hz, 1H), 6.64 (d, *J* = 7.9 Hz, 2H), 6.51 (d, *J* = 8.0 Hz, 2H), 5.26 (s, H), 3.32 (s, 3H), 2.12 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$+DMSO-d_6) δ 171.0, 152.7, 144.5, 136.4, 135.5, 134.0, 133.2, 131.6, 130.7, 128.6, 127.7, 127.6, 127.1,

126.5, 125.2, 124.9, 123.8, 123.4, 118.1, 108.7, 103.8, 26.1, 20.0; IR (KBr):1781, 1724, 1610, 1472, 1211, 1106, 1020, 753, 704 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{25}H_{20}O_3N_2F$ (M+H) 415.1453; found 415.1453.

(Z)-4-Benzylidene-3-phenyl-1-oxa-3-azaspiro[4.5]decan-2-one (6a).

6a as a white solid (130mg, 65% yield); m.p 160-162 ^{O}C; eluent, hexane/ethyl acetate 97:3; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.07 – 7.01 (m, 3H), 7.00 – 6.96 (m, 2H), 6.91 – 6.82 (m, 3H), 6.65 (dd, *J* = 7.2, 1.0 Hz, 2H), 5.59 (s, 1H), 2.15 (d, *J* = 13.0 Hz, 2H), 1.90 – 1.71 (m, 7H), 1.36 (m, 1H).^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 142.4, 135.0, 133.4, 128.3, 128.2, 127.0, 126.8, 125.9, 125.6, 99.9, 84.8, 37.2, 24.7, 21.8. IR (KBr):1761, 1666, 1404, 1274, 1212, 1110, 757, 702 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{21}H_{22}O_2N$ (M+H) 320.1645; found 320.1652.

(Z)-4-Benzylidene-3-(p-tolyl)-1-oxa-3-azaspiro[4.5]decan-2-one (6b).

6b as a white solid (127mg, 61% yield); m.p 144-146 ^{O}C; eluent, hexane/ethyl acetate 97:3; ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.91 – 6.81 (m, 7H), 6.65 (dd, *J* = 7.2, 1.0 Hz, 2H), 5.55 (s, 1H), 2.18 (s, 3H), 2.14 (d, *J* = 13.3 Hz, 2H), 1.89 – 1.69 (m, 7H), 1.42 – 1.26 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 142.7, 136.8, 133.5, 132.4, 128.7, 128.4, 126.9, 125.7, 125.5, 99.6, 84.6, 37.2, 24.7, 21.8, 20.9; IR (KBr): 1761, 1666, 1404, 1273, 1213, 1111, 758, 702 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{22}H_{24}O_2N$ (M+H) 334.1802; found 334.1805.

(Z)-4-Benzylidene-3-(4-methoxyphenyl)-1-oxa-3-azaspiro[4.5]decan-2-one (6c).

6c as a white solid (136mg, 62% yield); m.p 142-143 ^{O}C; eluent, hexane/ethyl acetate 97:3; ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.93 – 6.83 (m, 5H), 6.66 (dd, *J* = 7.2, 1.0 Hz, 2H), 6.59 – 6.52 (m, 2H), 5.56 (s, 1H), 3.68 (s, 3H), 2.13 (d, *J* = 12.4 Hz, 2H), 1.91 – 1.68 (m, 7H), 1.45 – 1.25 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 155.8, 142.9, 133.4, 128.5, 127.9, 127.2, 127.0, 125.6, 113.5, 99.5, 84.6, 55.5, 37.3, 24.7, 21.8; IR (KBr):1756, 1661, 1513,

1408, 1274, 1215, 1111, 760, 700 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{22}H_{24}O_3N$ (M+H) 350.1751; found 350.1755.

(Z)-4-Benzylidene-3-(4-nitrophenyl)-1-oxa-3-azaspiro[4.5]decan-2-one (6d).

6d as a yellow solid (95mg, 42% yield); m.p 166-168 ^{O}C; eluent, hexane/ethyl acetate 97:3; ^1H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 1.9 Hz, 2H), 7.19 – 7.14 (m, 2H), 6.96 – 6.86 (m, 3H), 6.68 (dd, *J* = 7.0, 1.2 Hz, 2H), 5.76 (s, 1H), 2.15 (d, *J* = 11.4 Hz, 2H), 1.90 – 1.74 (m, 7H), 1.45 – 1.31 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 154.4, 145.2, 141.2, 140.5, 133.0, 128.1, 127.4, 126.6, 125.7, 123.3, 101.8, 85.4, 37.0, 24.6, 21.7; IR (KBr):1757,1665, 1523, 1495, 1270, 1230, 1113, 1074, 757, 695 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{21}H_{21}O_4N_2$ (M+H) 365.1496; found 365.1513.

(Z)-4-Benzylidene-3-(4-fluorophenyl)-1-oxa-3-azaspiro[4.5]decan-2-one (6e).

6e as a white solid (122mg, 58% yield); m.p 158-160 ^{O}C; eluent, hexane/ethyl acetate 97:3; ^1H NMR (400 MHz, $CDCl_3$) δ 6.98 – 6.87 (m, 5H), 6.75 – 6.68 (m, 2H), 6.68 – 6.63 (m, 2H), 5.61 (s, 1H), 2.14 (d, *J* = 12.3 Hz, 2H), 1.89 – 1.69 (m, 7H), 1.41 – 1.30 (m, 1H).^{13}C NMR (125 MHz, $CDCl_3$) δ 162.1,160.1, 155.5, 142.5, 133.2, 131.0, 128.4, 127.8, 127.6, 127.1, 125.9, 115.1, 114.9, 99.9, 84.9, 37.2, 24.7, 21.8; C-F Coupling constants: (161.1, $J_{C\text{-}F}$ 247.2 Hz, 127.7 $J_{C\text{-}F}$, 8.7 Hz, 115.1 $J_{C\text{-}F}$ 23.1) ; IR (neat):1752,1664, 1602, 1506, 1271, 1217, 1113, 1090, 758, 707 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{21}H_{21}O_2NF$ (M+H) 338.1551; found 338.1554.

(Z)-4-Benzylidene-3-(4-chlorophenyl)-1-oxa-3-azaspiro[4.5]decan-2-one (6f).

6f as a white solid (132mg, 60% yield); m.p 160-162 ^{O}C; eluent, hexane/ethyl acetate 97:3; ^1H NMR (400 MHz, $CDCl_3$) δ 7.01 – 6.96 (m, 2H), 6.96 – 6.88 (m, 5H), 6.66 (d, *J* = 7.5 Hz, 2H), 5.62 (s, 1H), 2.13 (d, *J* = 12.2 Hz, 2H), 1.91 – 1.70 (m, 7H), 1.36 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.2, 142.2, 133.5, 133.2, 132.5, 128.4, 128.2, 127.2, 127.1, 126.0, 100.2, 84.9, 37.2, 24.7, 21.7; IR (neat):1753,1664, 1602, 1506, 1447, 1272, 1218, 1113,

1090, 758, 695 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{21}H_{21}O_2NCl$ (M+H) 354.1255; found 354.1271.

(Z)-4-Benzylidene-3-(3,4-dichlorophenyl)-1-oxa-3-azaspiro[4.5]decan-2-one (6g).

6g as a white solid (140mg, 57% yield); m.p 178-180 ^{O}C; eluent, hexane/ethyl acetate 97:3; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.10 (d, *J* = 8.6 Hz, 1H), 7.01 (d, *J* = 2.4 Hz, 1H), 6.99 – 6.92 (m, 3H), 6.89 (dd, *J* = 8.6, 2.4 Hz, 1H), 6.69 (d, *J* = 6.7 Hz, 2H), 5.67 (s, 1H), 2.13 (d, *J* = 11.9 Hz, 2H), 1.89 – 1.70 (m, 7H), 1.41 – 1.30 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.8, 142.0., 134.2, 133.1, 132.0, 130.7, 129.6, 128.3, 128.0, 127.4, 126.4, 125.2, 100.7, 85.1, 37.2, 24.6, 21.7; IR (KBr):1770,1674, 1473, 1400, 1271, 1221, 1110, 1027, 753, 698 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{21}H_{20}O_2NCl_2$ (M+H) 388.0866; found 388.0876.

(Z)-4-Benzylidene-3-hexyl-1-oxa-3-azaspiro[4.5]decan-2-one (6h)

6h as a color less oil (126mg, 62% yield); eluent, hexane/ethyl acetate 97:3; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 (m, 2H), 7.28 (m, 3H), 4.71 (s, 1H), 3.15 (dd, *J* = 12.9, 6.4 Hz, 2H), 2.28 – 2.17 (m, 2H), 2.05 – 1.84 (m, 2H), 1.74 – 1.60 (m, 5H), 1.55 – 144 (m, 2H), 1.28 (s, 6H), 0.87 (t, *J* = 5.5 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.7, 131.8, 128.0, 122.9, 89.8, 85.7, 75.3, 40.7, 37.5, 31.4, 29.9, 26.4, 25.2, 22.75, 22.5, 13.9; IR (neat); 1700, 1508, 1491, 1444, 1268, 1237, 1454, 1068, 754, 690 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{21}H_{30}NO_2$ (M+H) 328.2271; found 328.2283.

(Z)-4'-Benzylidene-3'-(p-tolyl)spiro[fluorene-9,5'-oxazolidin]-2'-one (8a)

8a as a white solid (160mg, 62% yield); m.p 172-174 ^{O}C; eluent, hexane/ethyl acetate 95:5 ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (d, *J* = 7.6 Hz, 2H), 7.55 (d, *J* = 7.5 Hz, 2H), 7.48 (t, *J* = 7.5 Hz, 2H), 7.35 (t, *J* = 7.5 Hz, 2H), 7.08 (d, *J* = 8.4 Hz, 2H), 6.93 (d, *J* = 8.0 Hz, 2H), 6.89 – 6.83 (m, 1H), 6.80 (t, *J* = 7.3 Hz, 2H), 6.58 (d, *J* = 7.0 Hz, 2H), 5.24 (s, 1H), 2.24 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.2, 144.2, 140.6, 137.4, 137.0, 132.9, 132.5, 130.6, 129.0, 128.8, 128.4, 126.9, 125.9, 125.1, 124.5, 120.5, 103.1, 89.8, 21.0; IR (neat); 1776, 1673,

1512, 1450, 1283, 1221, 1107, 1006, 753, 737 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{29}H_{22}NO_2$ (M+H) 416.1645; found 416.1646.

(Z)-4'-Benzylidene-3'-(p-tolyl)-2H-spiro[acenaphthylene-1,5'-oxazolidine]-2,2'-dione (10a)

10a as a white solid (168mg, 65% yield); m.p 184-186 ^{O}C; eluent, hexane/ethyl acetate 95:5; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (t, *J* = 8.1 Hz, 2H), 7.71 – 7.62 (m, 4H), 7.52 (d, *J* = 8.3 Hz, 2H), 7.42 (d, *J* = 7.1 Hz, 1H), 7.40 – 7.37 (m, 3H), 7.28 (d, *J* = 8.2 Hz, 2H), 7.10 (d, *J* = 7.0 Hz, 1H), 6.01 (s, 1H), 2.42 (s, 3H).; ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.7, 155.2, 138.5, 137.8, 137.5, 136.4, 132.4, 132.0, 130.3, 129.9, 129.0, 128.7, 128.5, 128.2, 126.5, 126.1, 125.9, 125.8, 120.4, 107.8, 99.8, 96.7, 77.3, 77.0, 76.8, 21.2; IR (neat); 1764, 1635, 1514, 1493, 1273, 1218, 1085, 1017, 770, 726 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{28}H_{20}NO_3$ (M+H) 418.1438; found 418.1444

3-Hydroxy-1-methyl-3-(phenylethynyl)indolin-2-one (11)

11 as a very light yellow solid (146mg, 89% yield); m.p 164-166 ^{O}C; eluent, hexane/ethyl acetate 80:20; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.3 Hz, 1H), 7.42 (dd, *J* = 8.2, 1.5 Hz, 2H), 7.37 (t, *J* = 7.8 Hz, 1H), 7.33 – 7.27 (m, 1H), 7.28 – 7.22 (m, 2H), 7.15 (t, *J* = 7.6 Hz, 1H), 6.85 (d, *J* = 7.8 Hz, 1H), 4.03 (s, 1H), 3.22 (s, 3H).; ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.0, 143.0, 132.0, 130.4, 128.9, 128.1, 124.7, 123.7, 121.6, 108.8, 86.2, 85.5, 69.51, 26.6; IR (neat); 3346, 2222, 1709, 1614, 1470, 1371, 1200, 1091, 993, 753, 692 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{17}H_{13}NO_2Na$ (M+Na) 286.0838; found 286.0839.

1-methyl-2-oxo-3-(phenylethynyl)indolin-3-yl phenylcarbamate (12)

12 as a white solid (129mg, 88% yield); m.p 162-164 ^{O}C; eluent, hexane/ethyl acetate 95:5; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51 (d, *J* = 7.4 Hz, 1H), 7.38 (d, *J* = 6.7 Hz, 2H), 7.31 (t, *J* = 8.4 Hz, 1H), 7.25 – 7.14 (m, 7H), 7.05 (t, *J* = 7.6 Hz, 1H), 6.96 (m, 1H), 6.87 (s, 1H), 6.82 (d, *J* = 7.9 Hz, 1H), 3.25 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.9, 150.3, 143.5, 138.3, 136.8, 132.2, 130.7, 129.3, 129.2, 129.0, 128.2, 127.1, 124.1, 123.97, 123.7, 123.5, 121.2,

120.6, 118.9, 108.9, 87.7, 82.2, 27.01; IR (KBr); 3286, 2230, 1723, 1640, 1605, 1365, 1222, 1078, 1015, 752, 690 cm^{-1}; HRMS (ESI) m/z: calcd for $C_{24}H_{19}N_2O_3$ (M+H) 383.1395; found 383.1401.

ASSOCIATED CONTENT

Supporting Information

Copies of ^{1}H, ^{13}C NMR spectra and Crystal data for the new compounds **4e** and **6f** including CIF files. This material is available free of charge via the Internet at http://pubs.acs.org.

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ACKNOWLEDMENT

We would like to thanks Director, CSIR-IICT and AcSIR for facilities. PGR thanks CSIR and IDR thanks DST, New Delhi for fellowship. Manuscript communication number: IICT/Pubs./2018/254.

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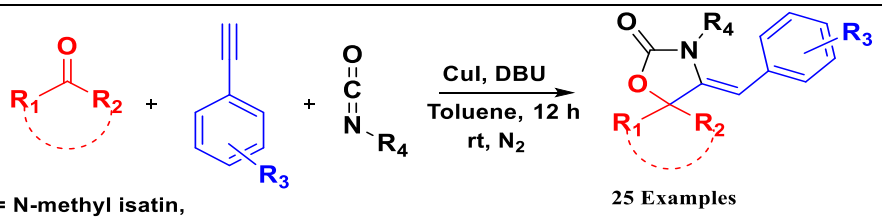

R_1= R_2 = N-methyl isatin, Cyclohexanone, 9-Fluorenone, Acenaphthoquinone.

25 Examples

* Domino C-C, C-O, and C-N Bond Formation
* Cyclization *Via* intramolecular Hydroamination
* Good Functional group Tolerance
* Yields Upto 88%