CHEMISTRY
AN ASIAN JOURNAL
www.chemasianj.org

Accepted Article

Title: Divergent Functionalization of N-Alkyl-2-alkenylanilines: Efficient Synthesis of Substituted Indoles and Quinolines

Authors: Jayanta Ghorai, Angula Chandra Shekar Reddy, and Pazhamalai Anbarasan

To be cited as: *Chem. Asian J.* 10.1002/asia.201800441

Link to VoR: http://dx.doi.org/10.1002/asia.201800441

A Journal of
ACES Asian Chemical Editorial Society

A sister journal of Angewandte Chemie and Chemistry – A European Journal

WILEY-VCH

10.1002/asia.201800441

WILEY-VCH

Divergent Functionalization of *N*-Alkyl-2-alkenylanilines: Efficient Synthesis of Substituted Indoles and Quinolines

Jayanta Ghorai, Angula Chandra Shekar Reddy and Pazhamalai Anbarasan*[a]

Dedication ((optional))

Abstract: An efficient divergent functionalization of *N*-alkylated *ortho*-alkenylanilines to substituted indoles and quinolines has been accomplished employing rhodium catalyzed cross-dehydrogenative coupling and silver mediated oxidative cyclization, respectively. The developed methods tolerate various functional groups and allow the synthesis of substituted indoles and quinolines in good to excellent yield. Synthetic utility is demonstrated through the conversion to indole having antimicrobial activity and C-H bond functionalization of 2-arylquinolines. Furthermore, the plausible mechanism was proposed based on the preliminary mechanistic investigations.

Introduction

N-Heterocycles are the common framework frequently encountered in various fields. Particularly, indoles[1] and quinolines[2] are the important class of alkaloids and play major role in diverse biologically important molecules, materials and natural products. The representative examples of therapeutically important molecules containing indole and quinoline moieties are shown in Figure 1. Several syntheses of these *N*-heterocycles have been documented in the literature[3] including the traditional condensation methods and the recent transition metal catalyzed annulations. However, given the importance of *N*-heterocycles, particularly indoles and quinolines, as potential scaffold in various fields, the development unified and practical strategy for their synthesis is still in great demand.

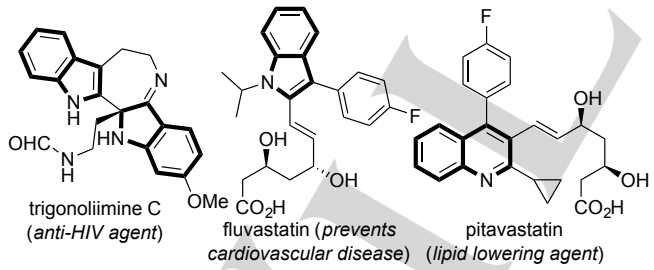
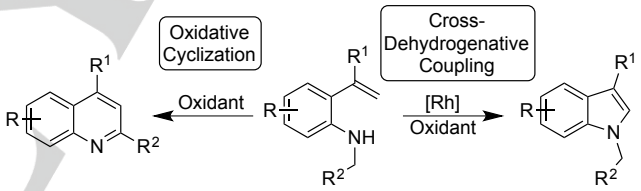


Figure 1. Representative examples therapeutically important molecules containing indole and quinoline motif.

[a] Mr. J. Ghorai, Mr. A. C. S. Reddy, Prof. Dr. P. Anbarasan
Department of Chemistry
Indian Institute of Technology Madras
Chennai - 600036
E-mail: anbarasansp@iitm.ac.in

Supporting information for this article is given via a link at the end of the document.((Please delete this text if not appropriate))

ortho-Alkenylanilines served as potential synthon in organic synthesis for the construction of various nitrogen based heterocyclic systems.[4] For examples, synthesis of indoles from *ortho*-alkenylanilines through cross-dehydrogenative coupling (CDC) of C-H/N-H bonds have been demonstrated employing various transition metal catalysts such as palladium,[5] copper,[6] ruthenium[7] and cobalt[8] along with suitable oxidant. Secondly, transition metal catalyzed and metal free [5+1]-annulations of *ortho*-alkenylanilines with suitable one carbon source has also been disclosed as efficient strategy for the construction of quinolines and its derivatives.[9] However, *N*-alkylated *ortho*-alkenylanilines was not studied in most of these transformations, possibly due to the presence of highly basic nitrogen that would hinder the catalytic cycle and would allow possible oxidative side reactions. Thus, we envisioned exploring the potential of *ortho*-alkenylanilines through divergent functionalization to therapeutically important heterocycles.



Scheme 1. Divergent functionalization of *N*-alkyl-2-alkenylanilines.

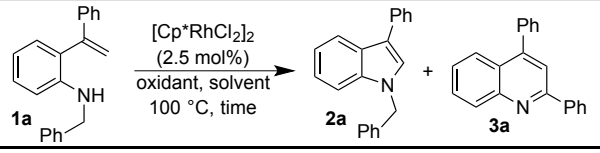
Recently, we have demonstrated the cross-dehydrogenative coupling of C-H/N-H bonds of *N*-alkylated *ortho*-alkenylanilines to *N*-alkylated indole derivatives employing cobalt(III) based catalyst.[8] Based on this study and our continued interest in the development of novel methodology based on rhodium(III) catalysts[10] and *ortho*-alkenylanilines,[9h, 11] we envisioned the related rhodium(III) catalyzed cross-dehydrogenative coupling of C-H/N-H bonds of *N*-alkylated *ortho*-alkenylanilines to compare the reactivity and efficiency. In addition, construction of quinoline moiety was also anticipated through the oxidative cyclization[12] of *N*-alkylated *ortho*-alkenylanilines (Scheme 1). It is important to note that oxidative C-C forming cyclization of *N*-alkylated *ortho*-alkenylanilines is not yet documented. Thus, we herein disclose the divergent functionalization of *N*-alkylated *ortho*-alkenylanilines to substituted indoles and quinolines via rhodium-catalyzed cross-dehydrogenative coupling and silver mediated oxidative cyclization.

Results and Discussion

10.1002/asia.201800441

We commenced our investigations by employing *N*-benyl-2-(1-phenylvinyl)aniline **1a** as model substrate for the divergent functionalization. Reaction of **1a** with 2.5 mol% of $[Cp^*RhCl_2]_2$ and 1.2 equivalents of CuI in toluene at 100 °C for 45 h afforded the 2:1 mixture of indole **2a** and quinoline **3a** in 18% yield (Table 1, entry 1). To improve the selectivity and yield, various additives were examined. Copper triflate gave the faster reaction with 86% yield, but poor ratio of **2a** and **3a**. In contrary, CuO afforded the improved selectivity with poor yield (Table 1, entries 2 and 3). Interestingly, use of 1.2 equivalents of copper acetate furnished only indole **2a** in 74% yield after 32 h (Table 1, entry 4). However, other oxidants such as Selectfluor, $PhI(OAc)_2$ and AgOAc afforded either poor yield or selectivity (Table 1, entries 5-7). On the other hand, selective formation of **3a** was observed with 1.2 equivalents of $(CF_3CO_2)Ag$ in 55% yield (Table 1, entry 8).

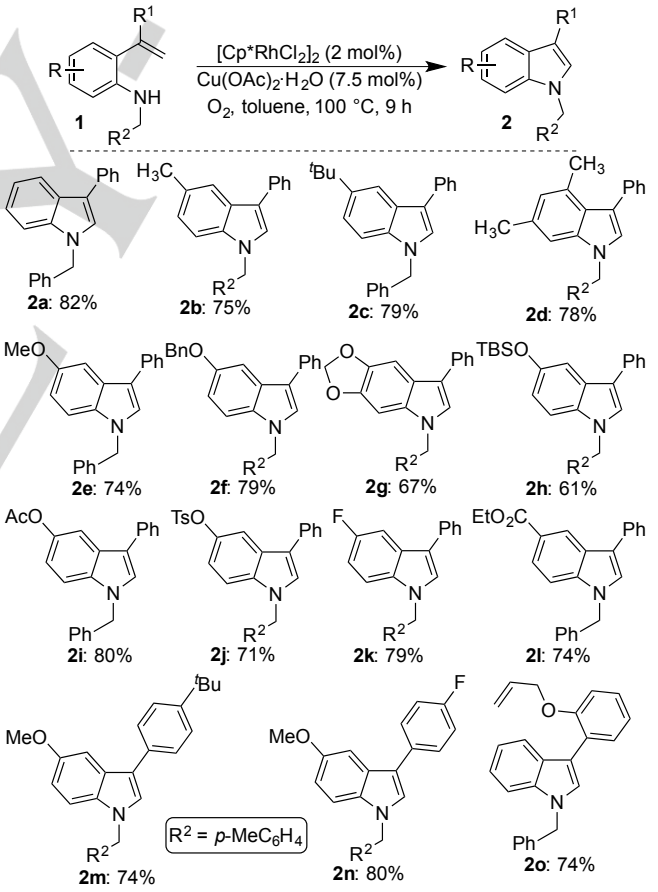
Table 1. Functionalization of *N*-alkyl-2-alkenylaniline **1a** to indole **2a** and quinoline **3a**: optimization[a]



Entry	Oxidant (mol%)	Solvent	Time (h)	Conversion (%)[b]	Yield (%)[c]	Ratio[d] (**2a** : **3a**)
1	CuI (120)	Toluene	45	32	18	2 : 1
2	$Cu(OTf)_2$ (120)	Toluene	3	100	86	1 : 1
3	CuO (120)	Toluene	39	54	38	5 : 1
4	$Cu(OAc)_2{\cdot}H_2O$ (120)	Toluene	32	100	74	1 : 0
5	Selectfluor (120)	Toluene	45	46	22	5 : 1
6	$PhI(OAc)_2$ (120)	Toluene	45	52	34	1 : 1
7	AgOAc (120)	Toluene	45	20	6	1 : 0
8	$(CF_3CO_2)Ag$ (120)	Toluene	40	66	55	0 : 1
9[e]	$Cu(OAc)_2{\cdot}H_2O$ (7.5)	Toluene	9	100	81 (82)[f]	1 : 0
10[e]	$Cu(OAc)_2{\cdot}H_2O$ (7.5)	DCE	9	50	38	1 : 0
11[e]	$Cu(OAc)_2{\cdot}H_2O$ (7.5)	Dioxane	9	80	54	5 : 1
12	$(CF_3CO_2)Ag$ (200)	Toluene	40	100	72	0 : 1
13[g]	$(CF_3CO_2)Ag$ (240)	Toluene	8	100	82	0 : 1
14[g]	$(CF_3CO_2)Ag$ (240)	Dioxane	8	100	71	0 : 1
15[g]	$(CF_3CO_2)Ag$ (240)	DCE	8	100	69	0 : 1
16[g]	$(CF_3CO_2)Ag$ (240)	DMF	8	100	54	0 : 1

[a] Reaction conditions: 1a (0.17 mmol, 1 equiv), $[Cp^*RhCl_2]_2$ (2.5 mol%), oxidant (mol%), solvent (2 mL for 0.17 mmol), temp, time. [b] Based on recovered starting material. [c] All are isolated and combined yield of **2a** and **3a**. [d] Based on isolated yields. [e] O_2 atmosphere. [f] 2 mol% of $[Cp^*RhCl_2]_2$ was used. [g] Without $[Cp^*RhCl_2]_2$.

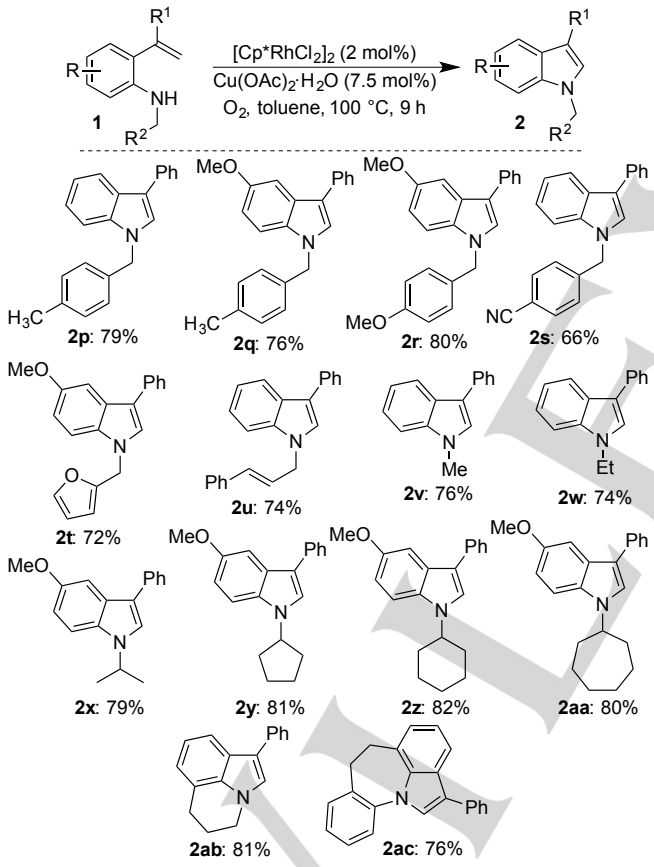
Subsequently, the focus was directed to reduce the amount of oxidant by performing the reaction under oxygen atmosphere. The reaction of **1a** and Rh(III)-catalyst with 7.5 mol% of copper acetate under oxygen atmosphere in toluene at 100 °C afforded the indole **2a** in 81% yield after 9 h. Similar results were observed with 2 mol% of rhodium catalyst (Table 1, entry 9). However, screening other solvent like DCE and dioxane did not give any comparable results (Table 1, entries 10 and 11). Next, to improve the yield of quinoline **3a**, equivalents of $(CF_3CO_2)Ag$ was tested. Increasing the amount of $(CF_3CO_2)Ag$ to 2 equivalents furnished the product **3a** in 72% yield (Table 1, entries 12). Interestingly, further increment in the yield (82%) of **3a** was observed with 2.4 equivalents of $(CF_3CO_2)Ag$ and in the absence of $[Cp^*RhCl_2]_2$ (Table 1, entries 13). Furthermore, changing solvents from toluene to dioxane, DCE and DMF demonstrated the supremacy of toluene for the present oxidative cyclization of **1a**.



Scheme 2. Rhodium catalysed cross-dehydrogentative coupling of *N*-(*p*-methlyphenyl)-2-alkenylanilines.

Having achieved the suitable conditions for the cross-dehydrogenative coupling and oxidative cyclization of *N*-alkylated *ortho*-alkenylanilines to indole and quinoline,

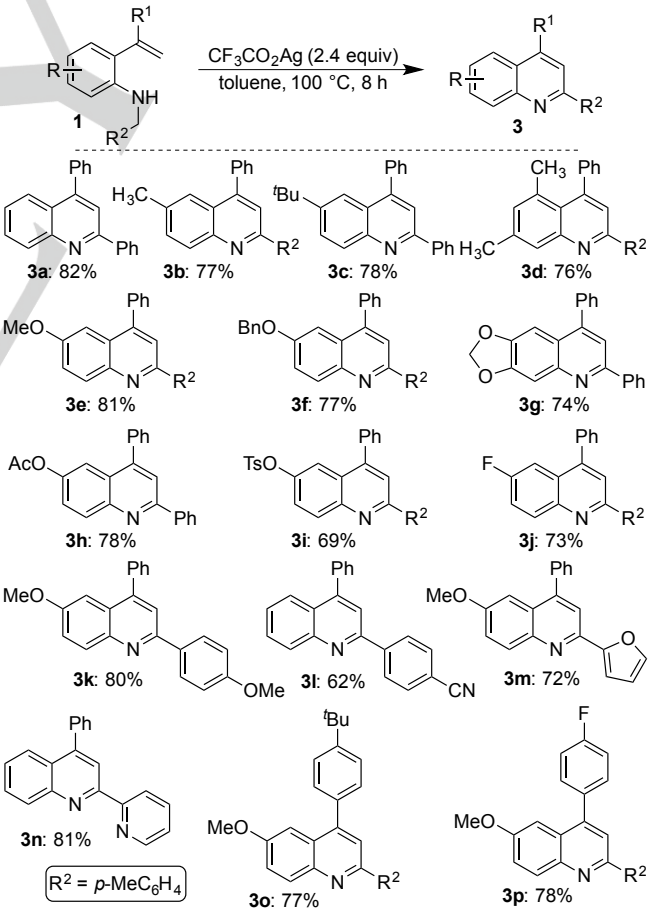
respectively, the scope and generality of the transformation was investigated. As can be seen in Scheme 2, various substituted *N*-(*p*-methlyphenyl)-2-alkenylanilines were subjected under the rhodium catalyzed CDC conditions, which led to the formation of corresponding indole in good to excellent yield. For instance, 4-alkyl substituted *ortho*-alkenylanilines gave the product **2b** and **2c** in 75 and 79% yield. Sterically demanding 3,5-dimethyl substituted *ortho*-alkenylanilines underwent smooth reaction to give the indole **2d** in 78% yield. Similarly, electron rich substituents, methoxy and benzyloxy as well as electron withdrawing fluoro, acyloxy, tosyloxy and ethoxycarbonyl were well tolerated under the present rhodium catalyzed CDC conditions to afford the corresponding indoles **2e**, **2f**, **2i**, **2j**, **2k** and **2l** respectively in excellent yields. Acid sensitive acetal and silyl ethers showed high compatibility and led to the formation of indole **2g** and **2h** in 67 and 61%, respectively. Subsequently, substitution on the aryl moeity in vinyl group were various to afford the indoles **2m**-**2o** in ~75% yield



Scheme 3. Rhodium catalysed cross-dehydrogentative coupling of *N*-alkyl-2-alkenylanilines.

Next, effect of substitutions on the nitrogen was investigated. Methyl and methoxy substituted benzyl derivatives on the nitrogen were converted to corresponding indole **2p**-**2r** in good yield, however, the cyano substitutent benzyl derivative afforded the product **2s** in 66% yield, possibly due the unfavorable coordination of cyano group to the catalyst. Importantly, (fur-2-yl)methyl and cinnamyl substituted aniline derivatives also furnished indoles **2t** and **2u** in 72 and 74% yield. Various alkyl (methyl, ethyl, isopropyl) and cycloalkyl (cyclopentyl, cyclohexyl, cycloheptyl) substituted aniline derivatives were also well tolerated under the optimized conditions and led to the formation of indoles **2v**-**2aa** in ~80% yield. Furthermore, 8-alkenyltetrahydroquinoline and 4-alkenyldibenzoazepane also led the indole fused heterocyclic system **2ab** and **2ac** in 81 and 76%, respectively. All yield and efficiency reported in Scheme 2 and 3 are highly comparable to the cobalt catalyzed CDC and is the alternative method for the CDC of *ortho*-alkenylanilines.

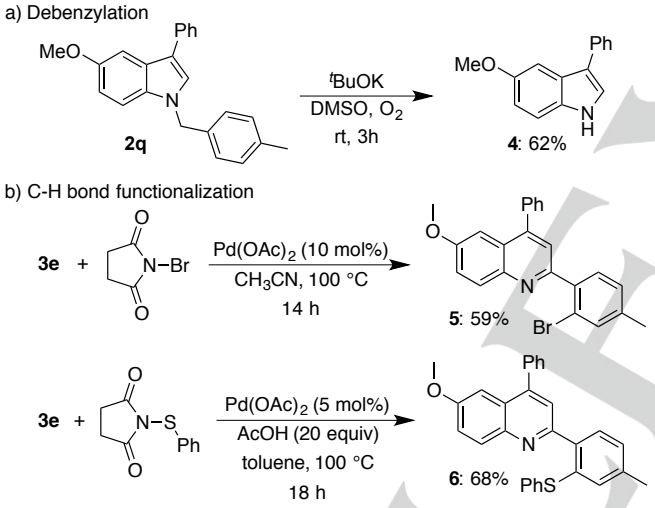
Having successfully demonstrated synthesis of indoles from *ortho*-alkenylanilines, we next focused our attention to investigate the scope and generality of silver mediated oxidative cyclization of *ortho*-alkenylanilines to quinoline derivatives. 6-Alkyl and 5,7-dialkly substituted quinolines (**3a**-**3d**) were achieved in excellent yield from corresponding *ortho*-alkenylaniline derivatives (Scheme 4). Electron donating methoxy and benzyloxy-substituted *ortho*-alkenylanilines were successfully converted to quinolines **3e** and **3f** in excellent yield.



Scheme 4. Silver mediated oxidative cyclization of *N*-alkyl-2-alkenylanilines.

Similarly, acetal that is sensitive to acid was well tolerated under the present optimized conditions to afford quinoline **3g** in 74% yield. Electron withdrawing and reactive functional groups such as acetyloxy, tosyloxy and fluoro substituted *ortho*-alkenylanilines gave the product **3h**, **3i** and **3j** in 78, 69 and 73% yield. 2-(4-methoxyphenyl) and 2-(4-cyanophenyl) containing quinolines (**3k** and **3l**) were synthesized in good yield, as mentioned earlier, significant influence of cyano group was observed. Interestingly, 2-furylquinoline and benzofused bipyridine derivatives (**3m** and **3n**), which are known as potential bidenate ligands, were readily construction employing the present methodology in high yields. Moreover, substitutions on the aryl moiety of *α*-arylalkene were also found to highly compatible under the optimized conditions.

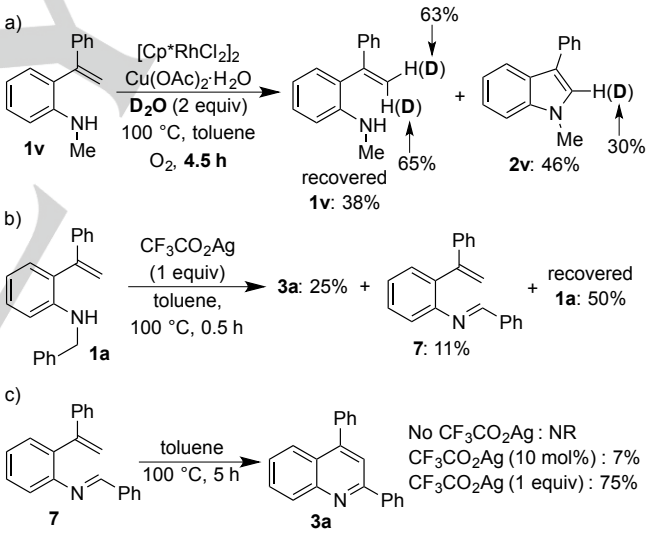
Subsequently, synthetic utility of the developed method was demonstrated through synthesis of therapeutically important indole derivative and ready C-H bond functionalization. 3-Arylindoles were shown to exhibit widespread therapeutic activities.[13] Thus, the simple debenzylation of **2q** with potassium tert-butoxide in DMSO afforded the indole **4**, an antimicrobial and antifungal active agent.



Scheme 5. Synthetic transformations.

On the other hand, aryl moiety at 2-position of quinoline could be readily functionalized employing C-H bond functionalization strategies. For instance, palladium catalyzed *ortho*-selective bromination of C-H bond of **3e** with *N*-bromosuccinimide afforded the brominated product 5 in 59% yield. Furthermore, phenylthiolation of C-H bond of **3e** was achieved in 68% yield with *N*-(phenylthio)succinimide in the presence of palladium acetate and acetic acid.[14]

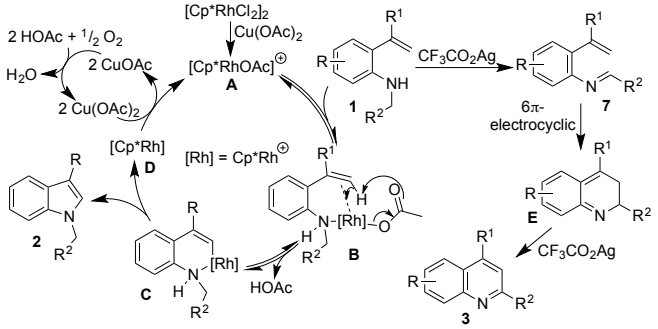
Next, preliminary mechanistic investigation was performed to probe the possible mechanism. At first deuterium-scrambling study was performed to understand the similarity of rhodium catalyzed cross-dehydrogenative coupling with cobalt-catalyzed method. Thus, the reaction of **1v** and 2 equivalents of D_2O under the rhodium catalyzed conditions afforded the indole **2v** in 46% along with 38% of recovered starting material. ^{1}H NMR analysis of both indole **2v** and recovered **1v** showed significant incorporation of deuterium at C2-position of indole **2v** and alkene proton of **1v**. This suggested that the possible C-H bond functionalization in the rhodium catalyzed cross-dehydrogenative coupling reaction, similar to cobalt-based methodology. Hence, it is expected to follow similar mechanism for the rhodium catalyzed indole formation. Next, to identify the possible intermediate that formed in the silver mediated oxidative cyclization of *ortho*-alkenylanilines, *ortho*-alkenylaniline **1a** was treated with one equivalent of CF_3CO_2Ag in toluene at 100 °C for 0.5 h. The treatment led to the isolation of quinoline **3a** in 25%, unreacted **1a** in 50% along with 11% of imine **7**. Further to prove the involvement of imine **7** in the oxidative cyclization, the isolated imine was subjected under thermal induced cyclization with and without CF_3CO_2Ag. In the absence of silver salt no reaction was observed revealing the reversible nature of electrocyclic reaction. Similarly, 10 mol% of silver salt led to the formation of only 7% of **3a**. On the other hand, one equivalent CF_3CO_2Ag gave the quinoline **3a** in 75% yield. These studies demonstrated that the imine **7** is potential intermediate in the silver mediated oxidative cyclization and minimum two equivalents of silver salt required for the initial oxidation to imine and final cyclization-*cum*-oxidation[15].



Scheme 6. Mechanistic investigation.

Based on the preliminary mechanistic investigation and the literature precedence,[8] the plausible mechanism for the divergent functionalization of *ortho*-alkenylanilines is proposed. As shown in Scheme 7, rhodium catalyzed cross-dehydrogenative coupling of *ortho*-alkenylanilines starts with the generation of active rhodium species **A** through ligand exchange. Coordination of *ortho*-alkenylaniline **1** would generate a chelated rhodium complex **B**. The rhodacycle **C** could be formed from **B** through the base assisted C-H bond functionalization. C-N bond reductive elimination from C would give the product indole **2** along with the reduced rhodium species **D**. Regeneration of

active rhodium species **A** could be readily visualized through the copper catalyzed oxidation, which in turn gets regenerated by oxidation with oxygen.



Scheme 7. Plausible mechanism.

On the other hand, silver mediated oxidative cyclization starts with initial oxidation of *N*-alkylanilines to corresponding imine derivative **7**. 6π-Electrocyclic ring closure of imine **7** would afford the dearomatized cyclic intermediate **E**. The formation of quinoline **3** from intermediate **E** could be rationalized through the silver mediated oxidation aromatization.

Conclusions

In conclusion, we have demonstrated an efficient divergent functionalization of *N*-alkylated *ortho*-alkenylanilines to various substituted indoles and quinolines employing rhodium catalyzed cross-dehydrogenative coupling and silver mediated oxidative cyclization, respectively. The developed methods showed excellent compatibility to various functional groups and allowed the access to diverse substituted indoles and quinolines in good to excellent yield. The synthetic potential of the developed methods were demonstrated through the conversion to indole having antimicrobial activity and C-H bond functionalization 2-arylquinolines. Furthermore, the plausible mechanism was postulated based on deuterium scrambling studies and isolation of possible imine intermediate in the preliminary mechanistic investigations.

Experimental Section

Rhodium catalyzed cross-dehydrogenative coupling of 1a: *ortho*-Vinylaniline derivative **1a** (0.173 mmol, 1 equiv), was taken in an oven dried Schlenk tube. $[Cp^*RhCl_2]_2$ (2.1 mg, 2 mol%) and $Cu(OAc)_2{\cdot}H_2O$ (2.58 mg, 7.5 mol%) were added to the Schlenk tube under normal atmosphere. The Schlenk tube was filled with oxygen through successive evacuation and refilled with oxygen. Dry toluene (2.0 mL) was added to the reaction mixture and was stirred at 100 °C for 9 hours under oxygen atmosphere. After completion the reaction, the reaction mixture was cooled to room temperature and dissolved in 4 mL DCM, filtered through a small pad of Celite. Crude product was obtained after evaporation of the solvent was purified by column chromatography to afford indoles **2a** in 82% yield as pale yellow solid. R_f= 0.46 in 1:3.5 EtOAc/Hexane; IR (ν_{max}, cm^{-1}): 2921, 1606, 1467, 1346, 1020, 696; ^1H NMR (400 MHz, $CDCl_3$, 24 °C): δ 7.98 (d, J = 7.2 Hz, 1H, ArH), 7.68 (dd, J = 8.2, 1.2 Hz, 2H, ArH), 7.46-7.42 (m, 2H, ArH), 7.35–7.17 (m, 10H, ArH), 5.37 (s, 2H, CH_2); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$, 24 °C): δ 137.3 (C), 137.2 (C), 135.6 (C), 128.9 (CH), 128.8 (CH), 127.8 (CH), 127.4 (CH), 127.0 (CH), 126.5 (C), 126.0 (CH), 125.9 (CH), 122.2 (CH), 120.2 (CH), 120.1 (CH), 117.6 (C), 110.1 (CH), 50.2 (CH_2); HRMS: m/z: $[M+H]^+$ Calcd. for $C_{21}H_{18}N$, 284.1433, found 284.1434.

Silver mediated oxidative cyclization of 1a: *ortho*-Vinylaniline derivatives **1** (0.173 mmol, 1 equiv) was taken in an oven dried Schlenk tube. Silver trifluoroacetate ($AgOCOCF_3$, 2.4 equiv) was added to the reaction mixture and the Schlenk tube was sealed with a septum and dry toluene (2.0 mL) was added to the reaction mixture. The reaction was stirred at 100 °C for 8 hours. After completion the reaction, the reaction mixture was cooled to room temperature and dissolved in 4 mL DCM, filtered through a small pad of Celite. Combined organic layer was evaporated to get the crude product, which was further purified through column chromatography to give the expected quinoline **3a** in 82% yield as pale yellow solid. R_f = 0.42 in 1:9 EtOAc/Hexane; IR (ν_{max}, cm^{-1}):2918, 2854, 1723, 1605, 1452, 1263, 699; ^1H NMR (400 MHz, $CDCl_3$, 24 °C): δ 8.28 (dd, J = 8.3, 1.5 Hz, 1H, ArH), 8.22 (d, J = 7.9 Hz, 2H, ArH), 7.93 (d, J = 8.4 Hz, 1H, ArH), 7.84 (d, J = 1.0 Hz, 1H, ArH), 7.75 (t, J = 8.1 Hz, 1H, ArH), 7.58–7.47 (m, 9H, ArH); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$, 24 °C): δ 157.0 (C), 149.2 (C), 148.9 (C), 139.7 (C), 138.5 (C), 130.2 (CH), 129.6 (CH), 129.6 (CH), 129.4 (CH), 128.9 (CH), 128.7 (CH), 128.5 (CH), 127.7 (CH), 126.4 (CH), 125.8 (C), 125.7 (CH), 119.4 (CH); HRMS: m/z: $[M+H]^+$ Calcd. for $C_{24}H_{22}NO$, 282.1282, found 282.1281.

Acknowledgements

We thank Indian Institute of Technology Madras (Project No. CHY/16-17/840/RFIR/ANBA) for financial support. J.G. thanks UGC, New Delhi and A. C. S. R. thanks CSIR, New Delhi for a fellowship.

Keywords: rhodium • indole • quinoline • 2-alkenylaniline • silver

[1] a) A. Fernando Rodrigues de Sa, J. B. Eliezer, F. Carlos Alberto Manssour, *Mini-Rev. Med. Chem.* **2009**, *9*, 782-793; b) T. V. Sravanthi, S. L. Manju, *Eur. J. Pharm. Sci.* **2016**, *91*, 1-10; c) K. N. Kaushik, N. Kaushik, P. Attri, N. Kumar, H. C. Kim, K. A. Verma, H. E. Choi, *Molecules* **2013**, *18*, 6620-6662.

[2] a) T. L. S. Kishbaugh, K. Lehman, in *Progress in Heterocyclic Chemistry, Vol. 29* (Eds.: G. W. Gribble, J. A. Joule), Elsevier, **2017**, pp. 383-439; b) A. P. Gorka, A. de Dios, P. D. Roepe, *J. Med. Chem.* **2013**, *56*, 5231-5246; c) J. P. Michael, *Nat. Prod. Rep.* **2008**, *25*, 166-187.

[3] a) M. Inman, C. J. Moody, *Chem. Sci.* **2013**, *4*, 29-41; b) D. F. Taber, P. K. Tirunahari, *Tetrahedron* **2011**, *67*, 7195-7210; c) R. Vicente, *Org. Biomol. Chem.* **2011**, *9*, 6469-6480; d) K. Krüger, A. Tillack, M. Beller, *Adv. Synth. Catal.* **2008**, *350*, 2153-2167; e) G. R. Humphrey, J. T. Kuethe, *Chem. Rev.* **2006**, *106*, 2875-2911; f) V. K. Vladimir, Y. V. M. Leonor, M. M. G. Carlos, *Curr. Org. Chem.* **2005**, *9*, 141-161; g) S. M. Prajapati, K. D. Patel, R. H. Vekariya, S. N. Panchal, H. D. Patel, *RSC Adv.* **2014**, *4*, 24463-24476.

[4] a) D. Li, F. Zeng, *Org. Lett.* **2017**, *19*, 6498-6501; b) L. Wu, Y. Meng, J. Ferguson, L. Wang, F. Zeng, *J. Org. Chem.* **2017**, *82*, 4121-4128; c) B. Cendón, N. Casanova, C. Comanescu, R. García-Fandiño, A. Seoane, M. Gulías, J. L. Mascareñas, *Org. Lett.* **2017**, *19*, 1674-1677; d) T. Shen, Y. Zhang, Y.-F. Liang, N. Jiao, *J. Am. Chem. Soc.* **2016**, *138*,

13147-13150; e) C. J. Evoniuk, S. P. Hill, K. Hanson, I. V. Alabugin, *Chem. Commun.* **2016**, *52*, 7138-7141; f) L.-Z. Yu, X.-B. Hu, Q. Xu, M. Shi, *Chem. Commun.* **2016**, *52*, 2701-2704.

[5] a) P. J. Harrington, L. S. Hegedus, K. F. McDaniel, *J. Am. Chem. Soc.* **1987**, *109*, 4335-4338; b) P. J. Harrington, L. S. Hegedus, *J. Org. Chem.* **1984**, *49*, 2657-2662; c) M. E. Krolski, A. F. Renaldo, D. E. Rudisill, J. K. Stille, *J. Org. Chem.* **1988**, *53*, 1170-1176; d) D. Tsvelikhovsky, S. L. Buchwald, *J. Am. Chem. Soc.* **2010**, *132*, 14048-14051.

[6] a) T. W. Liwosz, S. R. Chemler, *Chem. –Eur. J.* **2013**, *19*, 12771-12777; b) T. W. Liwosz, S. R. Chemler, *Synlett* **2015**, *26*, 335-339.

[7] S. Maity, N. Zheng, *Angew. Chem., Int. Ed.* **2012**, *51*, 9562-9566.

[8] J. Ghorai, A. C. S. Reddy, P. Anbarasan, *Chem. –Eur. J.* **2016**, *22*, 16042-16046.

[9] a) J. Ferguson, F. Zeng, N. Alwis, H. Alper, *Org. Lett.* **2013**, *15*, 1998-2001; b) L. Wang, J. Ferguson, F. Zeng, *Org. Biomol. Chem.* **2015**, *13*, 11486-11491; c) Q. Zheng, Q. Ding, C. Wang, W. Chen, Y. Peng, *Tetrahedron* **2016**, *72*, 952-958; d) P. Xu, T.-H. Zhu, T.-Q. Wei, S.-Y. Wang, S.-J. Ji, *RSC Adv.* **2016**, *6*, 32467-32470; e) Y.-N. Huang, Y.-L. Li, J. Li, J. Deng, *J. Org. Chem.* **2016**, *81*, 4645-4653; f) S. P. Midya, M. K. Sahoo, V. G. Landge, P. R. Rajamohanan, E. Balaraman, *Nature Communications* **2015**, *6*, 6032-6010; g) J. Yuan, J.-T. Yu, Y. Jiang, J. Cheng, *Org. Biomol. Chem.* **2017**, *15*, 1334-1337; h) A. C. S. Reddy, P. Anbarasan, *Proc. Indian Natn. Sci. Acad.* **2016**, *82*, 1271-1281; i) X. Zhang, X. Xu, L. Yu, Q. Zhao, *Tetrahedron Lett.* **2014**, *55*, 2280-2282; j) L. G. Qiang, N. H. Baine, *Tetrahedron Lett.* **1988**, *29*, 3517-3520; k) J. Zhu, W. Hu, S. Sun, J. T. Yu, J. Cheng, *Adv. Synth. Catal.* **2017**, *359*, 3725-3728.

[10] a) M. Chaitanya, D. Yadagiri, P. Anbarasan, *Org. Lett.* **2013**, *15*, 4960-4963; b) M. Chaitanya, P. Anbarasan, *Org. Lett.* **2015**, *17*, 3766-3769; c) M. Chaitanya, P. Anbarasan, *J. Org. Chem.* **2015**, *80*, 3695-3700.

[11] a) A. C. S. Reddy, V. S. K. Choutipalli, J. Ghorai, V. Subramanian, P. Anbarasan, *ACS Catal.* **2017**, 6283-6288; b) D. Yadagiri, A. C. S. Reddy, P. Anbarasan, *Chem. Sci.* **2016**, *7*, 5934-5938.

[12] a) J. Wu, Z. Liao, D. Liu, C. W. Chiang, Z. Li, Z. Zhou, H. Yi, X. Zhang, Z. Deng, A. Lei, *Chem. –Eur. J.* **2017**, *23*, 15874-15878; b) X. Zhang, X. Xu, *Chem. Asian J.* **2014**, *9*, 3089-3093.

[13] a) T. C. Leboho, J. P. Michael, W. A. L. van Otterlo, S. F. van Vuuren, C. B. de Koning, *Bioorg. Med. Chem. Lett.* **2009**, *19*, 4948-4951; b) T. I. Richardson, C. A. Clarke, K.-L. Yu, Y. K. Yee, T. J. Bleisch, J. E. Lopez, S. A. Jones, N. E. Hughes, B. S. Muehl, C. W. Lugar, T. L. Moore, P. K. Shetler, R. W. Zink, J. J. Osborne, C. Montrose-Rafizadeh, N. Patel, A. G. Geiser, R. J. S. Galvin, J. A. Dodge, *ACS Med. Chem. Lett.* **2011**, *2*, 148-153.

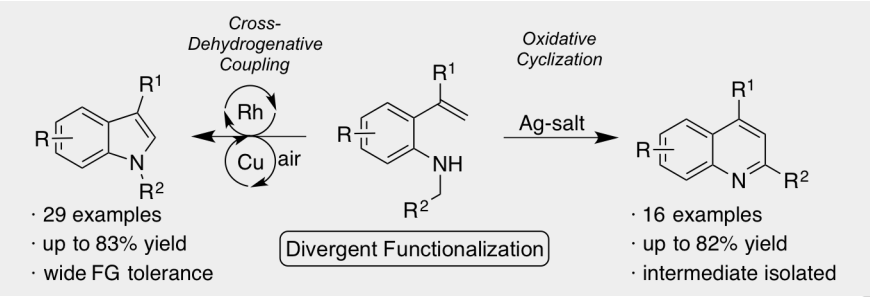
[14] P. Saravanan, P. Anbarasan, *Org. Lett.* **2014**, *16*, 848-851.

[15] a) F. Xiao, Y. Chen, Y. Liu, J. Wang, *Tetrahedron* **2008**, *64*, 2755-2761; b) J. A. Damavandi, M. A. Zolfigol, B. Karami, *Synth. Commun.* **2001**, *31*, 3183-3187.

10.1002/asia.201800441

Entry for the Table of Contents (Please choose one layout)

FULL PAPER



An efficient divergent functionalization of *N*-alkylated *ortho*-alkenylanilines to substituted indoles and quinolines has been accomplished employing rhodium catalyzed cross-dehydrogenative coupling and silver mediated oxidative cyclization,

*Jayanta Ghorai, Angula Chandra Shekar Reddy and Pazhamalai Anbarasan**

Page No. – Page No.

Divergent Functionalization of *N*-Alkyl-2-alkenylanilines: Efficient Synthesis of Substituted Indoles and Quinolines