

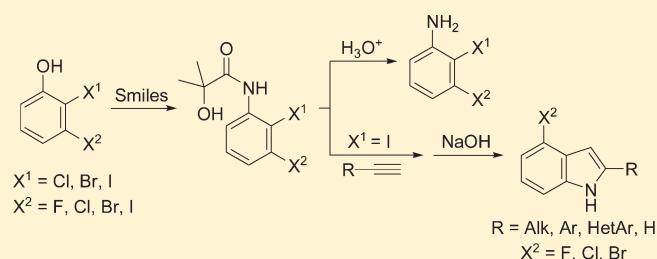
Approaches to the Synthesis of 2,3-Dihaloanilines. Useful Precursors of 4-Functionalized-1*H*-indoles^S

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S Supporting Information

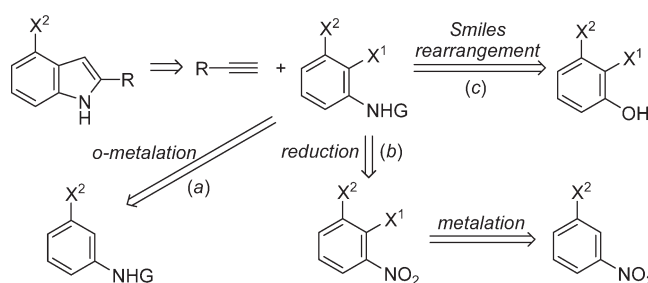
ABSTRACT: 2,3-Dihaloanilines have been proved as useful starting materials for synthesizing 4-halo-1*H*-indoles. Subsequent or in situ functionalization of the prepared haloindoles allows the access to a wide variety of 2,4- or 2,3,4-regioselectively functionalized indoles in good overall yields. As no efficient synthetic routes to 2,3-dihaloanilines have been described in the literature, different approaches to the preparation of these 1,2,3-functionalized aromatic precursors are now presented. The most general one involves a Smiles rearrangement from the corresponding 2,3-dihalophenols and allows the preparation of 2,3-dihaloanilides in a straightforward and synthetically useful manner.



INTRODUCTION

Indole derivatives are usually referred to as privileged structures due to their excellent binding ability to many receptors and so, the indole core represents one of the ubiquitous heterocyclic scaffolds in biologically active compounds.¹ This prevalence in bioactive molecules has prompted the development of efficient and practical syntheses of indoles bearing a variety of substitution patterns, which provides a continual challenge to organic chemists.² In this field, considerable efforts are needed to obtain valuable 4-substituted indoles and few methods have been described. Some reported examples involve the metalation of adequately 3-functionalized indoles,³ regioselective hydrodehalogenation of 4,6-dibromoindoles,⁴ C–H activation of 4-acetoxy-6,7-dihydroindoles,⁵ and selective lithiation of 4,7-dibromoindoles.⁶ In recent years, a few particular examples of 4-haloindoles have also been prepared by different metal-catalyzed processes.⁷ Nevertheless, the most general strategy to prepare these 4-functionalized-1*H*-indoles involves the construction of the heterocyclic ring using an annulative method from properly substituted aromatic precursors.⁸ Its main disadvantage is the requirement of specifically functionalized benzene derivatives that are in general difficult to get. Within the current approach, we reasoned that one of the most direct entries to 4-haloindoles, which are valuable precursors for further functionalization, could involve a selective Sonogashira cross coupling with the appropriate 2,3-dihaloaniline derivative and a subsequent heteroannulation reaction (Scheme 1). However, this easy approach to 4-haloindoles has not been previously reported probably due to the fact that no direct routes are known for accessing to 2,3-dihaloanilines.⁹ Among 3-halo-2-iodoanilines, only 3-bromo-2-iodoaniline has

Scheme 1. Retrosynthetic Analysis of 4-Haloindoles and 2,3-Dihaloanilines

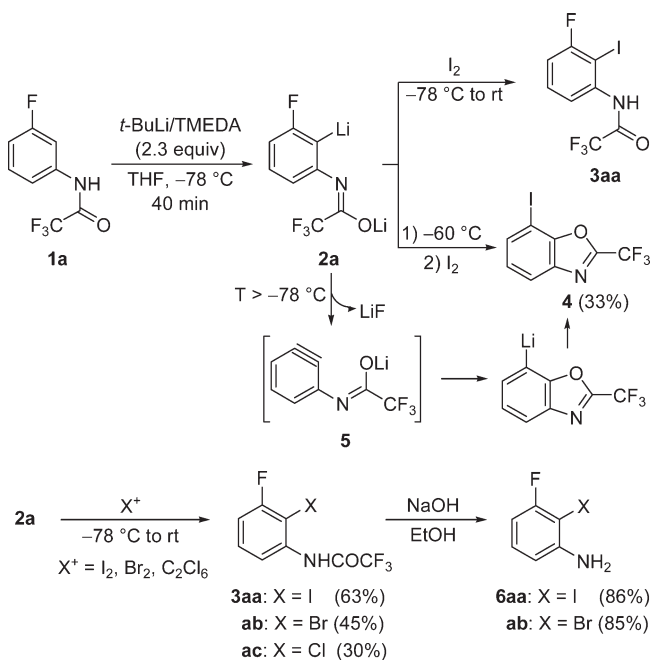


been described although its preparation requires a sequence involving diazotation/iodide displacement/reduction from 2-bromo-6-nitroaniline, which is obtained as the minor isomer in the nitration of 2-bromoaniline.¹⁰ In the same way, the syntheses of 2-bromo-3-chloroaniline¹¹ and 2,3-dibromoaniline¹² have been performed by using analogous multistep and inefficient strategies.

Taking into account the foreseeable potential of 2,3-dihaloanilines as precursors of 4-haloindoles, we decided to develop an efficient synthesis of these 1,2,3-functionalized benzene derivatives. We envisaged three different pathways to access these substrates. As shown in Scheme 1, route a would involve an *ortho*-metalation reaction of a 3-haloaniline derivative. To the best of our knowledge, the only reported example of this approach is due

Received: February 23, 2011

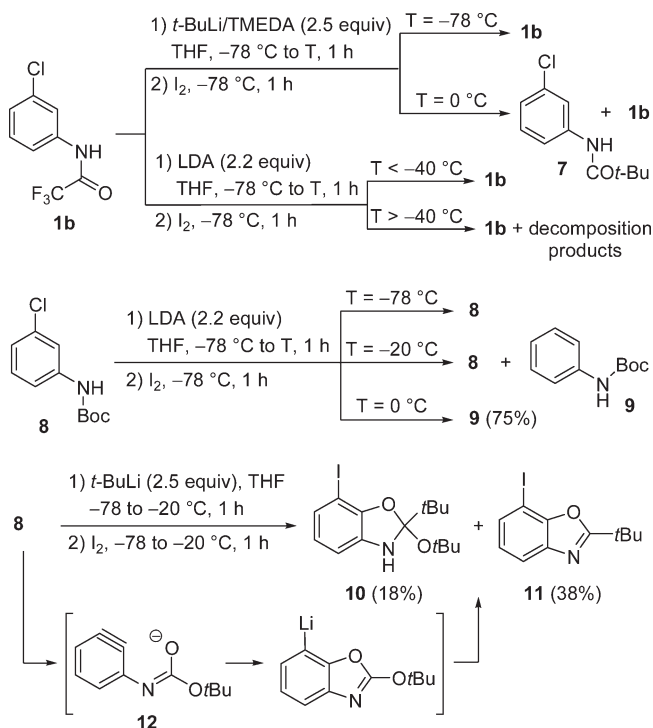
Published: March 28, 2011

Scheme 2. Synthesis of 3-Fluoro-2-halo-trifluoroacetanilides 3 and 3-Fluoro-2-haloanilines 6

to Soll and co-workers, who reported the *ortho*-lithiation of *N*-trifluoroacetyl-3-fluoroaniline (**1a**) and were able to prepare 2-bromo-3-fluoroaniline.¹³ Alternatively, the desired anilines could be prepared by reduction of the corresponding 2,3-dihalonitrobenzenes (Scheme 1, route b).¹⁴ However, the only efficient and direct route to these latter compounds is limited to the synthesis of 2-bromo-3-fluoronitrobenzene by a base-mediated halogenation reaction.¹⁵ Finally, taking advantage of the efficient synthesis of 2,3-dihaloanilines that we have previously developed,¹⁶ we also reasoned that the corresponding 2,3-dihaloanilines could be obtained from their phenol counterparts through a “Smiles rearrangement” strategy (Scheme 1, route c).¹⁷ Herein, we report our results on the synthesis of 2,3-dihaloanilines and their application to the preparation of 4-halo-1*H*-indoles and different regioselectively functionalized indoles.¹⁸

RESULTS AND DISCUSSION

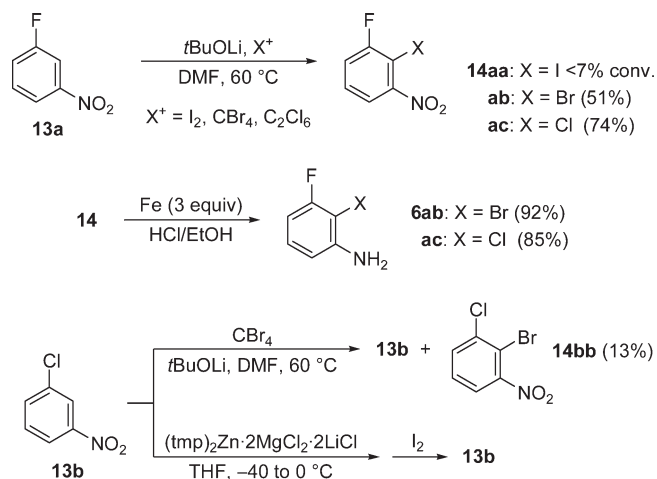
As established above, the *ortho*-lithiation of *N*-trifluoroacetyl-3-fluoroaniline (**1a**) has been previously described.¹³ Its treatment with *t*-BuLi in the presence of TMEDA gives rise to the generation of the organolithium intermediate **2a**, which was trapped with methyl disulfide or bromine. This *ortho*-metalation reaction has not been further used in synthesis in spite of the potential interest in the resulting 2,3-difunctionalized aniline derivatives for the preparation of fluorine-containing indoles. So, first we tried to apply the reported reaction conditions to get 3-fluoro-2-iodotrifluoroacetanilide (**3aa**) from **1a** employing iodine as an electrophile. Thus, using a slight excess of *t*-BuLi/TMEDA in THF at -78°C , we were able to generate the dilithiated species **2a** and trap it with iodine, allowing the isolation of **3aa** in 63% yield (Scheme 2). We also observed that working at temperatures over ca. -60°C a competitive lithium fluoride elimination takes place affording benzyne¹⁹ intermediate **5** that intramolecularly evolves to afford, after

Scheme 3. Unsuccessful Synthesis of 3-Chloro-2-iodoaniline from 3-Chloroaniline Derivatives 1b and 8

electrophilic quenching, the iodinated benzoxazole **4** in moderate yield (Scheme 2). This observation has been previously described by Clark and Caroon in the directed metalation of 3-fluoroaniline bearing pivaloyl, *N*-Boc, or benzoyl as directing groups.²⁰ In an analogous way, the addition of bromine or hexachloroethane as electrophilic reagents to **2a** afforded the corresponding 3-fluoro-2-halo-trifluoroacetanilides **3ab** and **3ac** in 45% and 30% yield. Moreover, the basic hydrolysis of some of these trifluoroacetanilides **3** furnished 3-fluoro-2-haloanilines **6aa** and **6ab** in high yields (Scheme 2).

However, when we tried to apply the *ortho*-lithiation strategy, under the same reaction conditions used for the metalation of **1a** (*t*-BuLi/TMEDA, THF, -78°C), to 3-chlorotrifluoroacetanilide **1b** we could not obtain the corresponding 3-chloro-2-iodoaniline derivative and the starting material was recovered. When the reaction mixture was allowed to reach higher temperatures (over -40°C), the addition of *t*-BuLi to the trifluoroacetamido moiety was observed and *N*-(3-chlorophenyl)-pivalamide (**7**) could be isolated (Scheme 3).²¹ The use of *n*-BuLi instead of *t*-BuLi precludes the addition reaction but no metalation was observed below -30°C .²² On the other hand, the use of LDA as metalating agent did not give satisfactory results either. Thus, below ca. -40°C , no reaction occurred, whereas allowing the reaction mixture to reach higher temperatures led to decomposition products (Scheme 3).²³ Then, we attempted to exploit the well-known *ortho*-directing ability of the Boc group²⁴ for the synthesis of 3-chloro-2-iodoaniline starting from *N*-(Boc)-3-chloroaniline (**8**). In this case, treatment with LDA in THF gave rise to a different result. At low temperature, the starting material remained intact, but upon warming the reaction mixture *N*-(Boc)-aniline (**9**) started to form and at 0°C it could be isolated in high yield (Scheme 3).²⁵ It is known that *t*-BuLi is able to abstract the proton from the double activated

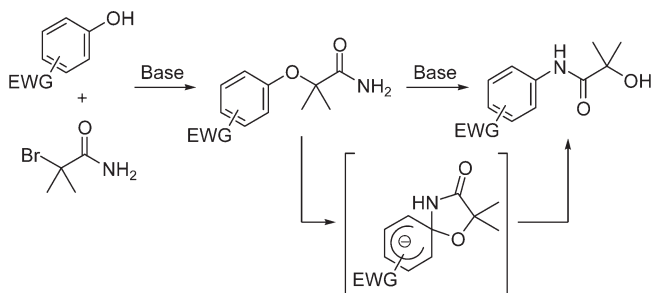
Scheme 4. Synthesis of 2-Halo-3-nitrofluorobenzenes 14 and Alternative Preparation of 3-Fluoro-2-haloanilines 6ab and 6ac



position in the meta isomers of *N*-(Boc)fluoro- and chloroanilines already at low temperature, and also it has been shown that the subsequent elimination of lithium halide and generation of a benzyne intermediate is not possible to prevent, thus leading to 7-lithiobenzoxazole derivatives.²⁶ However, as this reaction has not been carried out with **8**, we decided to check its metalation with *t*-BuLi and further trapping with iodine. As expected from previous results, 7-iodobenzoxazole derivatives **10** and **11**,²⁷ whose formation could be understood through generation of an aryne intermediate, such as **12**, were obtained in a moderate combined yield (Scheme 3).

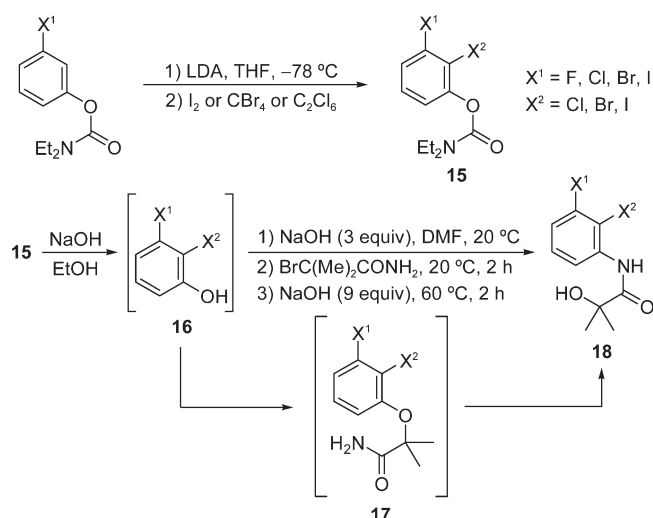
Having seen that the directed *ortho*-metalation strategy for the synthesis of 2,3-dihaloanilines is only useful for preparing 3-fluoro-2-haloanilines, we turned our attention to the preparation of 2,3-dihalonitrobenzenes. Daugulis and co-workers reported the base-mediated halogenation of acidic sp^2 C–H bonds and described the synthesis of 2-bromo-3-nitrofluorobenzene (**14ab**) by treatment of 3-nitrofluorobenzene (**13a**) with lithium *tert*-butoxide and carbon tetrabromide in DMF.¹⁵ We were able to reproduce this result and moreover, we explored the extension of this protocol to the preparation of other 2,3-dihalonitrobenzenes **14**. Therefore 2-chloro-3-nitrofluorobenzene (**14ac**) was formed in high yield with use of hexachloroethane as the electrophile. However, the employment of iodine as the halogen electrophile in order to prepare 2-iodo-3-nitrofluorobenzene (**14aa**) gave rise to low conversion to the desired adduct (<7%) (Scheme 4). With a suitable method for the preparation of 2,3-dihalonitrobenzenes **14ab** and **14ac** from commercially available 3-nitrofluorobenzene (**13a**), the corresponding anilines **6ab** and **6ac** were readily synthesized in high yields by reduction with iron (Scheme 4). Nevertheless, when we applied this strategy to 3-nitrochlorobenzene (**13b**), only a 13% yield of the corresponding 2-bromo-3-nitrochlorobenzene (**14bb**)²⁸ was obtained, showing that the deprotonation of **13b** was not efficient (Scheme 4). In addition, we tried to metalate this arene derivative by using $(\text{tmp})_2\text{Zn} \cdot 2\text{MgCl}_2 \cdot 2\text{LiCl}$ as the base, which has been described by Knochel and co-workers for the chemoselective zincation of sensitive arenes and heteroarenes, such as 2-nitrobenzo[*b*]furan.²⁹ However, **13b** was not zincated with this base even at 0°C (Scheme 4).

Scheme 5. Smiles Rearrangement



Taking into account that only 2-halo-3-fluoroanilines **6aa**–**ac** could be accessed by the first two of our envisaged approaches (Scheme 1, routes a and b), we then examined the use of 2,3-dihalo-phenol derivatives as starting materials (Scheme 1, route c). The direct conversion of phenols into anilines represents an intriguing organic transformation and few general methods have been reported for this reaction. Some of them include the conversion of phenols to aryl diethyl phosphates and subsequent treatment with KNH_2 ,³⁰ their activation with 4-chloro-2-phenylquinazoline and further thermal rearrangement,³¹ as well as the Bucherer reaction of phenols with ammonium sulfite that is generally limited to naphthols and hydroxy- and aminophenols.³² More recently, the Pd-catalyzed coupling of amines with aryl triflates or tosylates has meant an important advance in this field.³³ However, aryl halides are also useful partners for these metal-catalyzed C–N bond forming reactions,³⁴ so the use of this strategy is precluded for our halophenol derivatives. Besides the Pd- and Cu-catalyzed processes, Smiles rearrangement, which works especially well with an activated phenoxy component bearing at least one halogen substituent, could be considered a complementary and valuable alternative for the preparation of *N*-arylamines from phenols (Scheme 5).³⁵ This methodology requires the initial conversion of the corresponding phenol into a substituted aryloxyacetamide derivative in which oxygen and nitrogen atoms are connected by a COC(R)_2 group. The phenol is usually alkylated with 2-bromo-2-methylpropanamide affording a 2-aryloxy-2-methylpropanamide that undergoes rearrangement to give an *N*-aryl-2-hydroxypropanamide under basic conditions.³⁶ The formation of the final product must involve a nucleophilic attack of the amide anion leading to a spiro intermediate followed by its breakdown and protonation (Scheme 5). For this two-step sequence, some one-pot procedures have been reported in literature avoiding the isolation of the intermediate 2-aryloxy-2-methylpropanamide.³⁷ In addition, subsequent hydrolysis of the generated anilide could afford the corresponding aniline.

As we had reported, a new and efficient synthesis of 2,3-dihalo-phenols from 3-halo-phenols using the *O*-carbamate-directed metalation methodology,^{16a} we thought that the Smiles rearrangement could be suitable for our initial purpose of developing an efficient approach to 2,3-dihaloanilines. The required 2,3-dihalo-phenols **16** were obtained by basic hydrolysis of the corresponding *O*-2,3-dihalo-phenyl carbamates **15**, which in turn were efficiently accessed from 3-halo-phenyl carbamates by *ortho*-lithiation and trapping with halogen electrophiles (Scheme 6).^{16a} For the introduction of bromine, better yields have been obtained by using carbon tetrabromide as the electrophilic reagent compared to the use of 1,2-dibromoethane, which was used in our previous

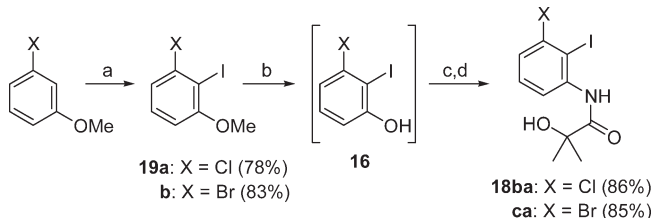
Scheme 6. Synthesis of *N*-(2,3-Dihaloaryl)-2-hydroxy-2-methylpropanamides **18****Table 1.** Preparation of Propanamides **17** and Dihaloanilides **18** from *O*-2,3-Dihaloaryl Carbamates **15**

entry	starting material	X ¹	X ²	17	yield ^a (%)	18	yield ^a (%)
1	15aa	F	I	17aa	86	18aa	83
2	15ab	F	Br	17ab	83	18ab	77
3	15ac	F	Cl	17ac	82	18ac	76
4	15ba	Cl	I	17ba	86	18ba	82
5	15bb	Cl	Br	17bb	80	18bb	78
6	— ^b	Cl	Cl	17bc	87	18bc	84
7	15ca	Br	I	17ca	85	18ca	81
8	15cb	Br	Br	17cb	86	18cb	83
9	15cc	Br	Cl	17cc	82	18cc	77
10	15da	I	I	17da	83	18da	79
11	15db	I	Br	17db	80	18db	77
12	15dc	I	Cl	17dc	79	18dc	75

^a Isolated yield referred to starting material **15**. ^b Commercially available 2,3-dichlorophenol was used as starting material.

report.³⁸ The crude phenols **16** were treated with an excess of 2-bromo-2-methylpropanamide³⁹ and NaOH in DMF at room temperature forming 2-aryloxy-2-methylpropanamides **17** that were isolated in high yields by simple addition of water to the reaction mixture and filtration of the crystallized compound (Scheme 6 and Table 1). Interestingly, without isolation of these derivatives **17**, the addition of an excess of NaOH to their DMF solution and subsequent warming to 60 °C for 2 h afforded *N*-aryl-2-hydroxypropanamides **18** in high overall yields relative to the starting carbamates **15** (Scheme 6 and Table 1). In this way, 2,3-dihaloanilides **18** can be efficiently synthesized from 2,3-dihaloaryl carbamates **15** in a three-step (carbamate hydrolysis—phenol alkylation—rearrangement), two-pot process. Furthermore, simple addition of water at the end of the rearrangement leads to crystallization of anilides **18** from the reaction solution, which proved to be pure enough without further chromatographic purification.

On the other hand, we have also established an alternative synthesis of 3-chloro-2-iodoanisole (**19a**) and 3-bromo-2-iodoanisole

Scheme 7. Alternative Synthesis of *N*-(3-Halo-2-iodophenyl)-2-hydroxy-2-methylpropanamides **18ba** and **18ca**^a

^a Reagents and conditions: (a) (1) *t*-Bu₂Zn(tmp)Li, THF, −45 °C (for X = Cl) or −30 °C (for X = Br); (2) I₂, THF; (b) (1) BBr₃, CH₂Cl₂; (2) NaHCO₃, MeOH; (c) (1) NaOH (3 equiv), DMF, rt; (2) BrC(Me)₂CONH₂ (3 equiv), rt; (d) NaOH (9 equiv), 60 °C.

Table 2. Synthesis of 2,3-Dihaloanilines **6**

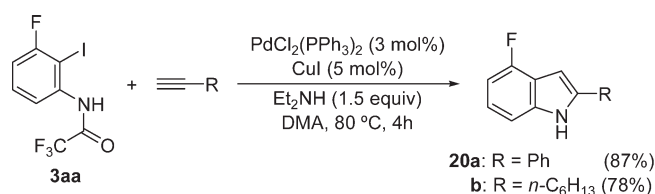
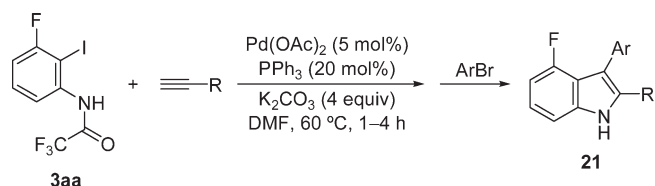
entry	starting material	X ¹	X ²	product	yield ^a (%)
1	18ab	F	Br	6aa	89
2	18ac	F	Cl	6ab	66 ^b
3	18bb	Cl	Br	6bb	94
4	18bc	Cl	Cl	6bc	90
5	18cb	Br	Br	6cb	89
6	18cc	Br	Cl	6cc	95

^a Isolated yield based on the starting material **18**. ^b Lower yield probably due to volatility of this aniline.

(**19b**) by *ortho*-zincation of the corresponding 3-haloanisoles with lithium di-*tert*-butyltetramethylpiperidinozincate,⁴⁰ and further treatment with iodine of the intermediate arylzincate.^{16b} These 2,3-dihaloanisoles **19** also proved to be useful starting materials to afford 2,3-dihaloanilides **18ba** and **18ca** in high yields by an analogous three-step (BBr₃-mediated deprotection—phenol alkylation—rearrangement), two-pot process (Scheme 7).

Once we have developed a reliable procedure for accessing 2,3-dihaloanilides **18** and due to the lack of methods for the preparation of 2,3-dihaloanilines, we tried to synthesize 2,3-dihaloanilines **6** by hydrolysis of the corresponding anilides **18**. We found that, in general, their reaction with ethanolic 6 M HCl at 90 °C for 6 h afforded **6** in high yields (Table 2). However, iodine-containing rearranged amides **18** did not cleanly furnish the expected haloiodoanilines as partial loss of the iodine atom occurred under the reaction conditions. For instance, 2,3-diiodoanilide **18da** led to 2,3-diiodoaniline (**6da**) and 3-iodoaniline in a ca. 1:2 ratio (78% combined yield), whereas 3-chloro-2-iodoanilide **18ba** afforded a 2:3 mixture of 3-chloro-2-iodoaniline (**6ba**) and 3-chloroaniline in 80% overall yield.⁴¹

Considering our retrosynthetic analysis for the synthesis of 4-haloindoles (Scheme 1), and having developed convenient routes for accessing 2,3-dihaloanilides **3** and **18**, then we tackle

Scheme 8. Synthesis of 4-Fluoro-2-substituted-1*H*-indoles **20****Table 3.** Synthesis of 3-Aryl-4-fluoro-2-substituted-1*H*-indoles **21a–h**

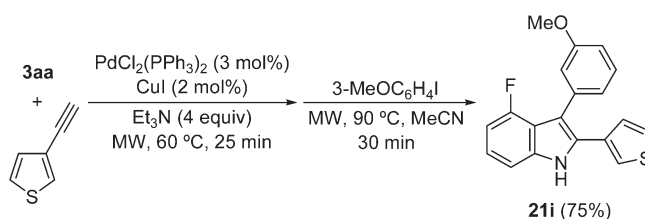
entry	R	Ar	product	yield ^a (%)
1	Ph	2-O ₂ NC ₆ H ₄	21a	72
2	<i>n</i> -Bu	2-O ₂ NC ₆ H ₄	21b	80
3 ^b	Ph	3-MeOC ₆ H ₄	21c	84
4 ^b	<i>n</i> -C ₆ H ₁₃	4-MeO-3-MeC ₆ H ₃	21d	56
5	3-Th	3-NCC ₆ H ₄	21e	86
6	<i>c</i> -C ₆ H ₉	4-O ₂ NC ₆ H ₄	21f	85
7	4-MeOC ₆ H ₄	3-O ₂ NC ₆ H ₄	21g	90
8	<i>n</i> -C ₆ H ₁₃	2-O ₂ NC ₆ H ₄	21h	46

^a Isolated yield based on starting material **3aa**. ^b The aryl bromide was added from the beginning of the reaction.

the preparation of a wide range of different 4-haloindoles. First, an efficient preparation of 4-fluoro-2-substituted-1*H*-indoles **20** was achieved by reaction of 3-fluoro-2-iodotrifluoroacetanilide (**3aa**) with terminal aromatic and aliphatic alkynes through a domino Pd/Cu-catalyzed coupling-cyclization process (Scheme 8).⁴²

On the other hand, the aminopalladation–reductive elimination domino reaction, mainly developed by Cacchi and co-workers,⁴³ has been employed as a useful strategy for the regioselective construction of 2,3-disubstituted indole rings from *o*-alkynyltrifluoroacetanilides. Interestingly, some methodologies have been reported for the one-pot, three-component (*o*-haloanilide, terminal alkyne, aryl halide) synthesis of 2,3-disubstituted-1*H*-indoles.⁴⁴ On the basis of the report of Lu and co-workers,^{44b} we have been able to prepare a wide variety of 3-aryl-4-fluoro-2-substituted-1*H*-indoles **21** from 3-fluoro-2-iodotrifluoroacetanilide (**3aa**), terminal alkynes, and aryl bromides in a one-pot process through tandem Sonogashira–Cacchi reactions (Table 3). Moderate to high yields were obtained for a selection of terminal alkynes and aryl bromides, which could be added after the starting iodoanilide **3aa** was consumed (Table 3, entries 1, 2, and 5–8) or from the beginning of the reaction (Table 3, entries 3 and 4).

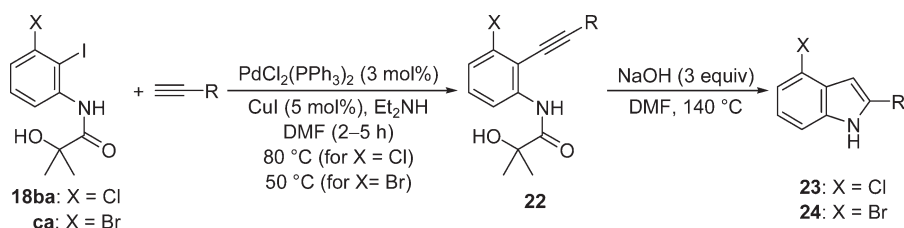
In addition, we have also prepared trisubstituted indole **21i** by a microwave-assisted one-pot, three-component coupling reaction described by Larock and co-workers.^{44c} In this case, an aryl

Scheme 9. Synthesis of 3-Aryl-4-fluoro-2-substituted-1*H*-indole **21i**

iodide was used instead of the corresponding bromide for the introduction of the aryl group at the C-3 position of the indole ring. Interestingly, although the addition of an inorganic base, such as K₂CO₃ or Cs₂CO₃, is usually required for the Cacchi reaction, in our hands this microwave-irradiated process works efficiently under the exclusive influence of Et₃N as base (Scheme 9).

To prepare 4-chloro- and 4-bromo-1*H*-indoles we decided to check the suitability of the 3-halo-2-iodoanilides **18ba** and **18ca** for a selective Sonogashira coupling with terminal alkynes. Gratifyingly, we found that under standard conditions (Pd–Cu catalysis), and without the use of special phosphine ligands, these 2,3-dihaloanilides underwent selective coupling at the iodine atom despite this position being the most sterically crowded one. However, to avoid dialkynylation processes in the case of **18ca**, bearing a bromo substituent, a careful control of the reaction temperature should be exerted. A broad array of terminal alkynes, including aryl-, alkyl-, heteroaryl-, alkenyl-, and trialkylsilyl-substituted ones, were efficiently coupled with anilides **18**, providing 2-alkynyl-3-haloanilides **22** in high yields (Table 4). With these *o*-alkynylanilides **22** in our hands and taking advantage of our previously reported methodology for the synthesis of indoles through NaOH-mediated cyclization of *o*-alkynylaniline derivatives,⁴⁵ we obtained 4-chloro-1*H*-indoles **23** and 4-bromo-1*H*-indoles **24** in usually high yields by treatment of **22** with an excess of NaOH at high temperature (Table 4).⁴⁶ It is interesting to note that *N*-deprotection also occurred under the reaction conditions. In addition, starting from *o*-trimethylsilyl ethynylanilides **22be** or **22ce**, 2-unsubstituted 4-halo-1*H*-indoles **23e** and **24e** were respectively obtained, showing that the cleavage of the silyl group also takes place under the reaction conditions (Table 4, entries 5 and 10).

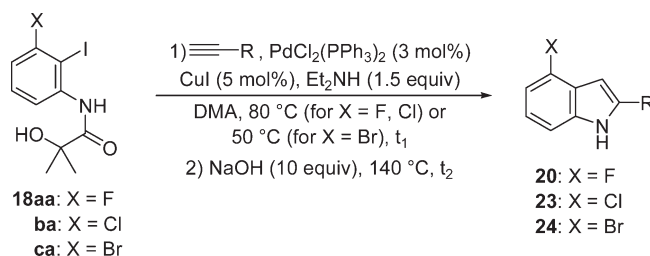
We had also shown that 2-substituted-1*H*-indoles could be prepared in a one-pot manner starting from *o*-iodoaniline derivatives and terminal alkynes, involving an initial Sonogashira coupling, followed by NaOH-mediated cyclization, without the need for isolation of the intermediate *o*-alkynylaniline.⁴⁵ In this way 4-fluoro-, 4-chloro-, and 4-bromo-1*H*-indoles **20**, **23**, and **24**, respectively, were synthesized from 3-halo-2-iodoanilides **18aa–ca** and a selection of terminal alkynes by a one-pot, two-step procedure (Table 5). With use of this procedure, 4-fluoroindoles **20** (Table 5, entries 1 and 2) as well as 4-chloroindoles **23** (Table 5, entries 3–8) were obtained in overall good yields based on the starting materials **18**, whereas 3-bromo-2-iodoanilide **18ca** formed the corresponding 4-bromoindoles **24** in lower yields (Table 5, entries 9–11). As in this one-pot protocol, Pd salts are not removed after the Sonogashira coupling and prior to the subsequent cyclization step; the isolation of these indole derivatives **24** in lower yields could be due to competitive Pd-catalyzed processes involving the C–Br bond, which could lead

Table 4. Selective Sonogashira Couplings from 3-Halo-2-iodoanilides **18 and Synthesis of 4-Halo-1*H*-indoles **23** and **24** from 2-Alkynyl-3-haloanilides **22****

entry	starting material	X	alkyne (R)	time (h)	product	yield ^a (%)	time (h)	product	yield ^b (%)
1	18ba	Cl	Ph	2	22ba	86	4	23a	79
2	18ba	Cl	<i>n</i> -Bu	2.5	22bb	90	2.5	23b	86
3	18ba	Cl	<i>n</i> -C ₅ H ₁₁	2.5	22bc	81	2.5	23c	84
4	18ba	Cl	<i>c</i> -C ₆ H ₉ ^c	3	22bd	80	2.5	23d	81
5	18ba	Cl	SiMe ₃	5.6 ^d	22be	81	4	23e ^e	73
6	18ca	Br	Ph	3.5	22ca	80	5	24a	83
7	18ca	Br	<i>n</i> -Bu	3.5	22cb	85	3	24b	80
8	18ca	Br	<i>n</i> -C ₅ H ₁₁	3.5	22cc	79	2.5	24c	82
9	18ca	Br	<i>c</i> -C ₆ H ₉ ^c	5	22cd	86	4	24d	76
10	18ca	Br	SiMe ₃	3 ^d	22ce	71	5	24e ^f	75
11	18ca	Br	3-thienyl	3.5	22cf	74	3	24f	71

^a Isolated yield based on the corresponding starting material **18**. ^b Isolated yield based on the corresponding starting material **22**. ^c 1-Cyclohexenyl.

^d Conducted at 40 °C for 6 h. ^e 4-Chloro-1*H*-indole (R = H). ^f 4-Bromo-1*H*-indole (R = H).

Table 5. One-Pot Synthesis of 4-Halo-1*H*-indoles **20, **23**, and **24** from 2,3-Dihalonanilides **18****

entry	starting material	X	R	time ₁ (h)	time ₂ (h)	product	yield ^a (%)
1	18aa	F	Ph	3	4	20a	85
2	18aa	F	<i>n</i> -Bu	3	3	20c	77
3	18ba	Cl	Ph	3	4	23a	81
4	18ba	Cl	<i>n</i> -Bu	2.5	3	23b	71
5	18ba	Cl	<i>c</i> -C ₆ H ₉ ^b	2	3	23d	82
6	18ba	Cl	SiMe ₃	5.5	3	23e ^c	61
7	18ba	Cl	3-ClC ₆ H ₄	2	3	23f	75
8	18ba	Cl	4-F-3-MeC ₆ H ₃	2	4	23g	72
9	18ca	Br	Ph	3	4	24a	49
10	18ca	Br	<i>n</i> -Bu	2	3	24b	55
11	18ca	Br	3-ClC ₆ H ₄	2	4	24g	48

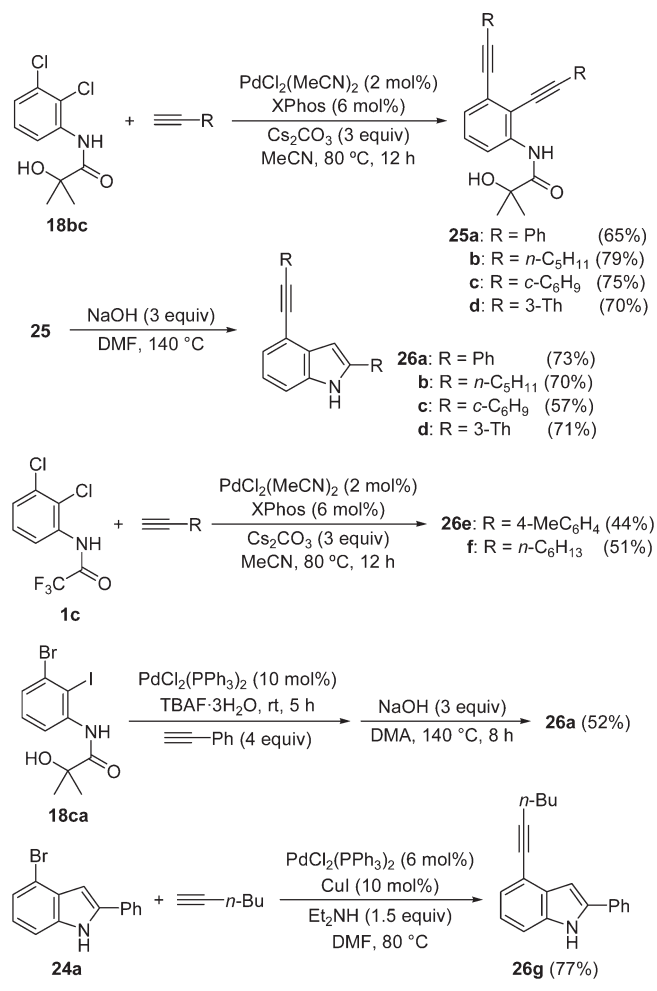
^a Isolated yield based on the corresponding starting material **18**. ^b 1-Cyclohexenyl. ^c 4-Chloro-1*H*-indole (R = H).

to different side products. So, for accessing 4-bromoindoles the two-step sequence involving isolation of intermediates **22** proved more appropriate.

Although selective Sonogashira couplings of 3-halo-2-iodoanilides **18aa**–**ca** have been efficiently achieved (Tables 4 and 5),

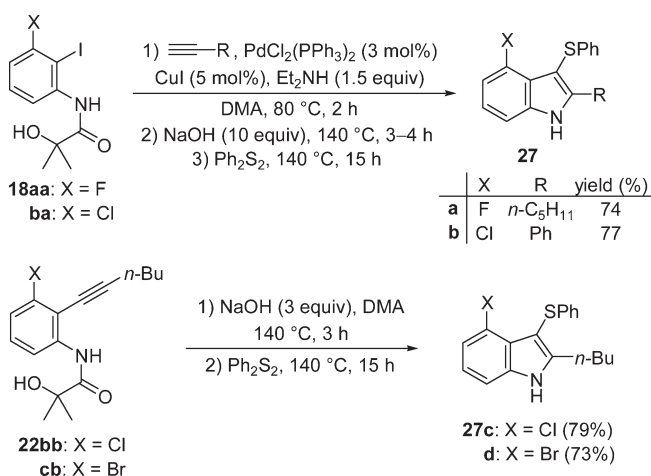
the presence of two halogen atoms in the starting anilides **18** prompted us to attempt the synthesis of 4-alkynyl-2-substituted-1*H*-indoles **26** (Scheme 10). First we chose 2,3-dichloroanilide **18bc** as the starting material and performed the dialkynylation reaction⁴⁷ with different terminal alkynes using the catalytic

Scheme 10. Synthesis of 4-Alkynyl-2-substituted-1*H*-indoles **26** from 2,3-Dichloroanilides **1c** and **18bc**, and 4-Bromoindole **24a**

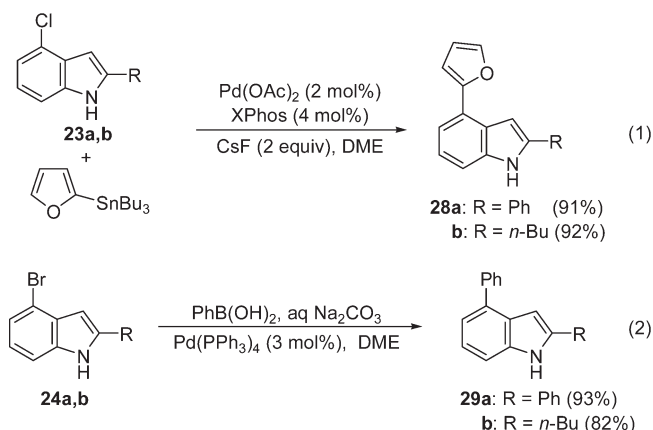


system described by Buchwald and Gelman for the Sonogashira coupling of aryl chlorides.⁴⁸ In this way, 2,3-dialkynylanilides **25** were obtained in good yields. Further cyclization reaction of the former substrates under basic conditions afforded 4-alkynyl-1*H*-indoles **26** bearing the same substituent at the terminal position of the triple bond and at C-2 (Scheme 10). As 2,3-dichloroaniline is commercially available, we also decided to check the usefulness of easily available trifluoroacetamide **1c** for the synthesis of the same type of indoles **26**. Due to the presence of the trifluoroacetamido group on the nitrogen atom, the corresponding intermediates **25** could not be isolated and the final indole derivatives **26e,f** were obtained in a one-pot process though with similar overall yield compared with the two-step protocol. Moreover, other 2,3-dihaloanilides, such as **18ca**, are suitable substrates for the preparation of 4-alkynylindoles **26**. In this case, **26a** was synthesized in moderate yield by using a copper- and solvent-free methodology⁴⁹ for the Sonogashira couplings (Scheme 10). Finally, to prepare a 4-alkynylindole with different substituents at C-2 and at the terminal position of the triple bond, 4-bromoindole **24a** was used as starting material and treated under standard Sonogashira conditions. Using this approach, 4-hex-1-ynyl-2-phenyl-1*H*-indole (**26g**) was obtained in good yield (Scheme 10).

Scheme 11. Synthesis of 4-Halo-3-phenylthio-2-substituted-1*H*-indoles **27**



Scheme 12. 4-(Hetero)aryl-2-substituted-1*H*-indoles **28** and **29** from 4-Haloindoles **23** and **24**



With the aim of getting highly functionalized indole derivatives from our 2,3-dihaloanilides **18**, we tried to introduce an arylthio group at C-3 under the reaction conditions employed for the synthesis of haloindoles **24**.⁵⁰ Starting from 3-halo-2-iodoanilides **18aa** and **18ba** and two different terminal alkynes we were able to prepare 4-halo-3-phenylthio-2-substituted-1*H*-indoles **27** in a one-pot, three-step protocol involving the addition of diphenyl disulfide after the NaOH-mediated cyclization step. It should be noted that these 2,3,4-functionalized indole derivatives **27** have been prepared in high yield from easily available 2, 3-dihaloanilides **18** without the isolation of any intermediate (Scheme 11). Also, this type of trifunctionalized indoles **27** could be accessed from 2-alkynyl-3-haloanilides **22** by their treatment with NaOH and subsequent addition of the disulfide (Scheme 11).

Finally, we decided to explore the synthetic utility of the obtained 4-haloindoles **23** and **24** as precursors of other 4-functionalized-1*H*-indoles using Pd-catalyzed coupling reactions. For instance, 4-heteroarylindoles **28** were formed in high yields by Stille coupling of 4-chloroindoles **23** with 2-(tributylstannyl)furan (Scheme 12, eq 1).⁵¹ In addition, 4-phenyl-2-substituted-1*H*-indoles

29 also have been prepared in high yields by Suzuki coupling of 4-bromoindoles 24 with phenylboronic acid (Scheme 12, eq 2).⁵²

CONCLUSIONS

In summary, we have studied different approaches to the synthesis of 2,3-dihaloanilines and we have found that the most general and efficient route involves a Smiles rearrangement from 2,3-dihaloanilines. By using this strategy, 2,3-dihaloanilines were obtained in high yields from *O*-2,3-dihaloanilines *N,N*-diethylcarbamates or 3-halo-2-iodoanisoles without any chromatographic purification. 3-Halo-2-iodoanilines have been shown as useful precursors for the synthesis of 4-halo-1*H*-indoles through their coupling with terminal alkynes, followed by cyclization under treatment with NaOH. In this way, a wide variety of challenging and interesting 4-haloindoles have been prepared, usually in high yields. In addition, the usefulness of these 4-haloindoles as intermediates for further transformations has been briefly outlined, including reactions that afford 2,4- and 2,3,4-functionalized indoles.

EXPERIMENTAL SECTION

All reactions involving air-sensitive compounds were carried out under a N₂ atmosphere in oven-dried glassware with magnetic stirring. Temperatures are reported as bath temperatures. Solvents used in extraction and purification were distilled prior to use. TLC was performed on alumina-backed plates coated with silica gel 60 with F₂₅₄ indicator; the chromatograms were visualized by UV light (254 nm) and/or by staining with a Ce/Mo reagent, anisaldehyde, or phosphomolybdic acid solution and subsequent heating. *R_f* values refer to silica gel. Flash column chromatography was carried out on silica gel 60, 230–400 mesh. Melting points were obtained with open capillary tubes and are uncorrected. ¹H NMR spectra were recorded at 400 or 300 MHz. Chemical shifts are reported in ppm with the residual solvent resonance as the internal standard (CHCl₃: δ 7.26; acetone-*d*₆: δ 2.05; DMSO-*d*₆: δ 2.50). Data are reported as follows: chemical shift, multiplicity (s: singlet, br s: broad singlet, d: doublet, dd: doublet of doublets, dt: doublet of triplets, ddd: doublet of doublet of doublets, t: triplet, appt: apparent triplet, td: triplet of doublets, tdd: triplet of doublet of doublets, q: quartet, m: multiplet), coupling constants (*J* in Hz), and integration. ¹³C NMR spectra were recorded at 100.6 or 75.4 MHz, using broadband proton decoupling. Chemical shifts are reported in ppm with the solvent resonance as internal standard (CDCl₃: δ 77.16; acetone-*d*₆: δ 29.84; DMSO-*d*₆: δ 39.51). Low-resolution electron impact mass spectra (EI-LRMS) were obtained at 70 eV on a mass spectrometer and only the molecular ions and/or base peaks as well as significant peaks in MS are given. High-resolution mass spectrometry (HRMS) was carried out on a mass spectrometer. Infrared spectra were recorded with a FT-IR spectrophotometer. The microwave heating was performed in a Microwave, CEM Discover S-Class single-mode microwave cavity producing continuous irradiation (temperature measurements were conducted with use of an IR sensor located below the microwave cavity floor, and reaction times refer to the total hold time at the indicated temperature; the maximum wattage supplied was 300 W). All commercially available reagents were used without purification unless otherwise indicated and were purchased from standard chemical suppliers.

Synthesis of Trifluoroacetamides 1. These compounds were prepared following a reported procedure.¹³

2,2,2-Trifluoro-*N*-(3-fluorophenyl)acetamide (1a): Purification by recrystallization in hexane afforded 1a (6.37 g, 77%) as a white solid: mp 67–69 °C (lit.¹³ mp 68–70 °C); ¹H NMR (300 MHz, CDCl₃) δ 8.38 (br s, 1H), 7.48 (dt, *J* = 10.2, 2.1 Hz, 1H), 7.34 (td, *J* = 8.2, 2.1 Hz, 1H), 7.26 (ddd, *J* = 8.2, 2.1, 1.1 Hz, 1H), 6.95 (tdd, *J* = 8.2, 2.5, 1.1 Hz,

1H); ¹³C NMR (75.4 MHz, CDCl₃) δ 162.9 (d, *J* = 246.6 Hz, C), 155.3 (q, *J* = 37.8 Hz, C), 136.5 (d, *J* = 10.6 Hz, C), 130.7 (d, *J* = 9.2 Hz, CH), 116.2 (d, *J* = 3.2 Hz, CH), 115.7 (q, *J* = 288.4 Hz, C), 113.5 (d, *J* = 21.2 Hz, CH), 108.5 (d, *J* = 26.6 Hz, CH); EI-LRMS *m/z* 207 (M⁺, 100), 138 (45), 110 (36), 95 (32), 83 (18).

***N*-(3-Chlorophenyl)-2,2,2-trifluoroacetamide (1b):** Purification by recrystallization in hexane afforded 1b (7.15 g, 80%) as a white solid: mp 68–70 °C (lit.⁵³ mp 66–68 °C); ¹H NMR (300 MHz, CDCl₃) δ 8.24 (br s, 1H), 7.66 (t, *J* = 2.0 Hz, 1H), 7.42 (ddd, *J* = 8.0, 2.0, 1.1 Hz, 1H), 7.31 (t, *J* = 8.0 Hz, 1H), 7.22 (ddd, *J* = 8.0, 2.0, 1.1 Hz, 1H); ¹³C NMR (75.4 MHz, CDCl₃) δ 155.3 (q, *J* = 37.8 Hz, C), 136.2 (C), 135.2 (C), 130.5 (CH), 126.7 (CH), 121.0 (CH), 118.8 (CH), 115.7 (q, *J* = 288.5 Hz, C); EI-LRMS *m/z* 225 (M⁺ + 2, 33), 223 (M⁺, 100), 154 (51), 126 (19).

General Procedure for the Synthesis of *N*-(3-Fluoro-2-halophenyl)-2,2,2-trifluoroacetamides 3. *t*-BuLi (2.5 equiv of a 1.5 M solution in hexane) was added slowly to a solution of *N,N,N',N'*-tetramethylethylenediamine (TMEDA) (2.5 equiv) in anhydrous THF (3.5 mL/mmol) at –80 °C. After 5 min a solution of 1a (1 equiv) in THF (1 mL/mmol) was added dropwise avoiding temperatures exceeding –70 °C. After 40 min at –80 °C, a solution of iodine, bromine, or hexachloroethane (1.4 equiv) in THF (1 mL/mmol) was added dropwise. The resulting solution was stirred for 40 min at –80 °C. Then, the reaction mixture was allowed to reach rt and was quenched with H₂O (a solution of aqueous Na₂S₂O₃ in the case of using iodine as electrophile). The aqueous phase was extracted with Et₂O, and the combined organic layers were washed with 1 M HCl and dried over anhydrous Na₂SO₄, then the solvents were evaporated under reduced pressure. The crude was purified by column chromatography (hexane/EtOAc, 8/1) on silica gel to afford the title compounds 3.

2,2,2-Trifluoro-*N*-(3-fluoro-2-iodophenyl)acetamide (3aa): The reaction of 1a (2.48 g, 12 mmol) with iodine (4.26 g, 16.8 mmol) afforded 3aa (2.51 g, 63%) as a white–pale reddish solid: mp 104–106 °C; ¹H NMR (300 MHz, CDCl₃) δ 8.39 (br s, 1H), 8.05 (d, *J* = 8.3 Hz, 1H), 7.40 (td, *J* = 8.3, 2.1 Hz, 1H), 7.01–6.94 (m, 1H); ¹³C NMR (75.4 MHz, CDCl₃) δ 161.9 (d, *J* = 245.6 Hz, C), 155.0 (q, *J* = 37.7 Hz, C), 137.4 (d, *J* = 3.6 Hz, C), 130.9 (d, *J* = 8.9 Hz, CH), 117.5 (d, *J* = 3.1 Hz, CH), 115.7 (q, *J* = 288.5 Hz, C), 113.3 (d, *J* = 23.8 Hz, CH), 79.0 (d, *J* = 28.8 Hz, C); EI-LRMS *m/z* 333 (M⁺, 53), 206 (100), 186 (26), 137 (13), 109 (22); IR (KBr) 3218, 3061, 1717, 1580, 1548, 1463, 1207, 1165, 788, 733 cm^{–1}; HRMS calcd for C₈H₄F₄INO 332.9274, found 332.9283.

***N*-(2-Bromo-3-fluorophenyl)-2,2,2-trifluoroacetamide (3ab):** The reaction of 1a (414 mg, 2 mmol) with bromine (447 mg, 2.8 mmol) afforded 3ab (256 mg, 45%) as a white solid: mp 55–57 °C (lit.¹³ mp 55–56 °C); ¹H NMR (300 MHz, CDCl₃) δ 8.48 (br s, 1H), 8.14 (dt, *J* = 8.4, 1.3 Hz, 1H), 7.38 (td, *J* = 8.4, 6.0 Hz, 1H), 7.04 (td, *J* = 8.4, 1.3 Hz, 1H); ¹³C NMR (75.4 MHz, CDCl₃) δ 159.3 (d, *J* = 247.9 Hz, C), 154.9 (q, *J* = 37.9 Hz, C), 134.8 (C), 129.6 (d, *J* = 8.7 Hz, CH), 117.3 (d, *J* = 3.3 Hz, CH), 115.6 (q, *J* = 288.9 Hz, C), 113.8 (d, *J* = 22.0 Hz, CH), 102.0 (d, *J* = 24.1 Hz, C); EI-LRMS *m/z* 287 (M⁺ + 2, 21), 285 (M⁺, 21), 206 (100), 186 (20), 109 (22); HRMS calcd for C₈H₄BrF₃NO 284.9412, found 284.9414.

***N*-(2-Chloro-3-fluorophenyl)-2,2,2-trifluoroacetamide (3ac):** The reaction of 1a (1.03 g, 5 mmol) with hexachloroethane (1.66 g, 7 mmol) afforded 3ac (362 mg, 30%) as a pale brown solid: mp 38–40 °C; ¹H NMR (300 MHz, CDCl₃) δ 8.07 (d, *J* = 8.4 Hz, 1H), 7.97 (br s, 1H), 7.07 (td, *J* = 8.4, 5.9 Hz, 1H), 7.04 (td, *J* = 8.4, 1.3 Hz, 1H); ¹³C NMR (75.4 MHz, CDCl₃) δ 158.3 (d, *J* = 249.4 Hz, C), 154.9 (q, *J* = 37.9 Hz, C), 133.7 (C), 128.5 (d, *J* = 8.6 Hz, CH), 117.5 (C), 117.4 (d, *J* = 3.5 Hz, CH), 113.8 (d, *J* = 20.7 Hz, CH), 112.0 (d, *J* = 20.6 Hz, C); EI-LRMS *m/z* 243 (M⁺ + 2, 11), 241 (M⁺, 35), 206 (100), 144 (27), 117 (18), 69 (13); HRMS calcd for C₈H₄ClF₃NO 240.9918, found 240.9924.

Synthesis of 2-(Trifluoromethyl)-7-iodobenzo[d]oxazole (4). *t*-BuLi (16.2 mL of a 1.5 M solution in hexane, 27.5 mmol) was

added slowly to a solution of TMEDA (4.2 mL, 27.8 mmol) in anhydrous THF (40 mL) at -78°C . After 5 min a solution of **1a** (2.27 g, 11 mmol) in THF (10 mL) was added at -78°C . After 40 min at -60°C , a solution of iodine (3.91 g, 15.4 mmol) in THF (10 mL) was added dropwise. The resulting solution was stirred for 40 min at -60°C . Then, the reaction mixture was allowed to reach rt and was quenched with a solution of aqueous $\text{Na}_2\text{S}_2\text{O}_3$. The aqueous phase was extracted with Et_2O (3×30 mL), and the combined organic layers were washed with 1 M HCl and dried over anhydrous Na_2SO_4 , then the solvents were evaporated under reduced pressure. The crude was purified by column chromatography (hexane/EtOAc, 12/1) on silica gel affording **4** (1.13 g, 33%) as a red solid: mp $64-66^{\circ}\text{C}$; ^1H NMR (300 MHz, CDCl_3) δ 7.77 (t, $J = 7.6$ Hz, 2H), 7.17 (t, $J = 8.0$ Hz, 1H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 152.3 (C), 151.1 (q, $J = 44.4$ Hz, C), 138.7 (C), 136.9 (CH), 127.5 (CH), 121.7 (CH), 116.6 (q, $J = 272.1$ Hz, C), 72.9 (C); EI-LRMS m/z 313 (M^+ , 44), 294 (6), 186 (6), 127 (50), 69 (100); HRMS calcd for $\text{C}_8\text{H}_3\text{F}_3\text{INO}$ 312.9211, found 312.9211.

General Procedure for the Synthesis of 3-Fluoro-2-haloanilines 6aa and 6ab. To a solution of the corresponding *N*-(3-fluoro-2-halophenyl)-2,2,2-trifluoroacetamide **3aa** or **3ab** (1 equiv) in EtOH (10 mL/mmol) was added a large excess of NaOH (10 equiv) and the mixture was refluxed for 2 h (completion of the hydrolysis was monitored by GC-MS). After the mixture was cooled to rt, most of the EtOH was removed under reduced pressure and the residue was diluted with EtOAc and water. The aqueous solution was extracted with EtOAc (3×20 mL), and the combined organic layers were washed with brine and dried over anhydrous Na_2SO_4 , then the solvents were evaporated under reduced pressure. The crude was purified by column chromatography on silica gel to afford the title compounds.

3-Fluoro-2-iodoaniline (6aa): Treatment of **3aa** (666 mg, 2 mmol) with NaOH (800 mg, 20 mmol) followed by purification by column chromatography (hexane/EtOAc, 6/1) gave **6aa** (407 mg, 86%) as a white solid: mp $52-54^{\circ}\text{C}$; ^1H NMR (300 MHz, CDCl_3) δ 7.07 (td, $J = 8.1$, 1.6 Hz, 1H), 6.53–6.48 (m, 1H), 6.45 (td, $J = 8.1$, 1.3 Hz, 1H), 4.29 (br s, 2H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 162.2 (d, $J = 242.2$ Hz, C), 148.8 (d, $J = 4.6$ Hz, C), 130.0 (d, $J = 10.0$ Hz, CH), 109.9 (d, $J = 2.4$ Hz, CH), 104.6 (d, $J = 24.4$ Hz, CH), 71.8 (d, $J = 28.2$ Hz, C); EI-LRMS m/z 237 (M^+ , 100), 110 (12), 83 (12); IR (KBr) 3399, 3299, 3184, 1616, 1553, 1456, 1242, 1020, 771 cm^{-1} ; HRMS calcd for $\text{C}_6\text{H}_5\text{FIN}$ 236.9451, found 236.9455. Anal. Calcd for $\text{C}_6\text{H}_5\text{FIN}$: C, 30.41; H, 2.13; N, 5.91. Found: C, 30.52; H, 2.16; N, 5.87.

2-Bromo-3-fluoroaniline (6ab): Treatment of **3ab** (285 mg, 1 mmol) with NaOH (400 mg, 10 mmol) followed by purification by column chromatography (hexane/EtOAc, 6/1) gave **6ab** (160 mg, 85%) as a white solid: mp $32-34^{\circ}\text{C}$; ^1H NMR (300 MHz, CDCl_3) δ 7.04 (tdd, $J = 8.1$, 6.1, 0.7 Hz, 1H), 6.55–6.47 (m, 2H), 4.23 (br s, 2H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 159.9 (d, $J = 244.2$ Hz, C), 146.1 (d, $J = 3.1$ Hz, C), 128.6 (d, $J = 9.8$ Hz, CH), 110.8 (d, $J = 2.7$ Hz, CH), 105.3 (d, $J = 22.6$ Hz, CH), 96.4 (d, $J = 23.6$ Hz, C); EI-LRMS m/z 191 (M^+ , 2, 88), 189 (M^+ , 100), 110 (22), 90 (14), 83 (28); IR (KBr) 3443, 3317, 1625, 1464, 763, 582 cm^{-1} ; HRMS calcd for $\text{C}_6\text{H}_5\text{BrFN}$ 188.9589, found 188.9592.

Synthesis of *N*-(3-Chlorophenyl)pivalamide (7). *t*-BuLi (1.6 mL of a 1.6 M solution in pentane, 2.5 mmol) was slowly added to a solution of TMEDA (0.38 mL, 2.52 mmol) in anhydrous THF (3 mL) at -80°C . After 5 min a solution of **1b** (223 mg, 1 mmol) in THF (2 mL) was added dropwise at this temperature. The reaction mixture was allowed to reach -45°C and, after 1 h at this temperature, iodine (355 mg, 1.4 mmol) was added. The resulting solution was stirred for 40 min at -45°C . Then, the reaction mixture was allowed to reach rt and was quenched with a solution of aqueous $\text{Na}_2\text{S}_2\text{O}_3$. The aqueous phase was extracted with Et_2O (3×30 mL), and the combined organic layers were washed with 1 M HCl and dried over anhydrous Na_2SO_4 , then the solvents were evaporated under reduced pressure. As analyzed

by ^1H NMR and GC-MS, the crude resulted to be a ca. 1:1 mixture of **7** and **1b**. After purification by column chromatography (hexane/EtOAc, 10/1) on silica gel, **7** was isolated as a white solid: mp $124-126^{\circ}\text{C}$ (lit.⁵⁴ mp $124-126^{\circ}\text{C}$); ^1H NMR (300 MHz, CDCl_3) δ 7.67 (t, $J = 2.0$ Hz, 1H), 7.43 (br s, 1H), 7.37–7.32 (m, 1H), 7.21 (t, $J = 8.0$ Hz, 1H), 7.08–7.03 (m, 1H), 1.30 (s, 9H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 176.9 (C), 139.2 (C), 134.6 (C), 130.0 (CH), 124.3 (CH), 120.3 (CH), 118.1 (CH), 39.8 (C), 27.6 ($3 \times \text{CH}_3$); EI-LRMS m/z 213 (M^+ , 2, 11), 211 (M^+ , 34), 168 (5), 127 (49), 57 (100); HRMS calcd for $\text{C}_{11}\text{H}_{14}\text{ClNO}$ 211.0764, found 211.0764.

Synthesis of *N*-(*tert*-Butoxycarbonyl)-3-chloroaniline (8).

The title compound was prepared according to a published procedure.^{24a} The residue was recrystallized from hexane to give **8** as a white solid: mp $67-69^{\circ}\text{C}$ (lit.⁵⁵ mp $69-70^{\circ}\text{C}$); ^1H NMR (300 MHz, CDCl_3) δ 7.51 (br s, 1H), 7.19–7.12 (m, 2H), 6.98 (dt, $J = 7.2$, 1.7 Hz, 1H), 6.58 (br s, 1H), 1.50 (s, 9H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 152.6 (C), 139.7 (C), 134.8 (C), 130.0 (CH), 123.1 (CH), 118.6 (CH), 116.5 (CH), 81.1 (C), 28.4 ($3 \times \text{CH}_3$); EI-LRMS m/z 227 (M^+ , 3), 171 (16), 153 (26), 129 (33), 127 (100).

Synthesis of *N*-(*tert*-Butoxycarbonyl)aniline (9).

n-BuLi (0.7 mL of a 1.6 M solution in hexane, 1.1 mmol) was added to a solution of *i*-Pr₂NH (154 μL , 1.1 mmol) in THF (4 mL) at 0°C . After 30 min at 0°C , the LDA solution was cooled to -78°C , and **8** (114 mg, 0.5 mmol) was added. The resulting solution was stirred for 30 min at 0°C and then iodine (178 mg, 0.7 mmol) was added at -78°C . After 1 h at 0°C , the reaction mixture was allowed to warm to rt and was quenched with aqueous $\text{Na}_2\text{S}_2\text{O}_3$. The aqueous phase was extracted with EtOAc (3×30 mL), the combined organic layers were dried over anhydrous Na_2SO_4 , and the solvents were evaporated under reduced pressure. The crude was purified by column chromatography (hexane/EtOAc, 12/1) on silica gel affording **9** (72 mg, 75%) as a white solid: mp $135-137^{\circ}\text{C}$ (lit.^{24a} mp $136-137^{\circ}\text{C}$); ^1H NMR (300 MHz, CDCl_3) δ 7.36 (d, $J = 8.0$ Hz, 2H), 7.31–7.25 (m, 2H), 7.06–6.99 (m, 1H), 6.56 (br s, 1H), 1.52 (s, 9H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 152.9 (C), 138.4 (C), 129.1 ($2 \times \text{CH}$), 123.1 ($2 \times \text{CH}$), 118.6 (CH), 80.6 (C), 28.5 ($3 \times \text{CH}_3$); EI-LRMS m/z 193 (M^+ , 5), 137 (26), 119 (20), 93 (100).

Synthesis of 2-*tert*-Butoxy-2-*tert*-butyl-7-iodo-2,3-dihydrobenzo[*d*]oxazole (10) and 2-*tert*-butyl-7-iodobenzo[*d*]oxazole (11).

t-BuLi (1.6 mL of a 1.6 M solution in pentane, 2.5 mmol) was added to a solution of **8** (227 mg, 1 mmol) in THF (5 mL) at -78°C . The reaction mixture was allowed to reach -20°C for 1 h. Iodine (355 mg, 1.4 mmol) was added at -78°C and the reaction was stirred at -20°C for 1 h. After this time, the reaction mixture was allowed to warm to rt and was quenched with aqueous $\text{Na}_2\text{S}_2\text{O}_3$. The aqueous phase was extracted with EtOAc (3×30 mL), the combined organic layers were dried over anhydrous Na_2SO_4 , and the solvents were evaporated under reduced pressure. The crude was purified by column chromatography (hexane/EtOAc, 12/1) on silica gel affording a ca. 1:2 mixture of **10** (67 mg, 18%) and **11** (114 mg, 38%).

2-*tert*-Butoxy-2-*tert*-butyl-7-iodo-2,3-dihydrobenzo[*d*]oxazole (10): white solid; mp $134-136^{\circ}\text{C}$; ^1H NMR (300 MHz, CDCl_3) δ 7.94 (d, $J = 7.8$ Hz, 1H), 7.21 (d, $J = 7.8$ Hz, 1H), 6.71 (t, $J = 7.8$ Hz, 1H), 6.28 (br s, 1H), 1.64 (s, 9H), 1.47 (s, 9H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 154.1 (C), 145.2 (C), 143.4 (CH), 136.2 (C), 131.0 (CH), 127.6 (CH), 95.9 (C), 80.4 (C), 38.2 (C), 32.4 ($3 \times \text{CH}_3$), 28.5 ($3 \times \text{CH}_3$); EI-LRMS m/z 375 (M^+ , 6), 319 (99), 275 (77), 260 (99), 232 (25), 127 (67), 57 (100); HRMS calcd for $\text{C}_{15}\text{H}_{22}\text{INO}$ 375.0695, found 375.0693.

2-*tert*-Butyl-7-iodobenzo[*d*]oxazole (11): colorless oil; R_f 0.48 (hexane/EtOAc, 7/1); ^1H NMR (300 MHz, CDCl_3) δ 7.61 (dd, $J = 7.9$, 0.9 Hz, 1H), 7.59 (dd, $J = 7.9$, 0.9 Hz, 1H), 7.03 (t, $J = 7.9$ Hz, 1H), 1.49 (s, 9H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 173.2 (C), 152.5 (C), 140.5 (C), 133.4 (CH), 125.8 (CH), 119.7 (CH), 72.3 (C), 34.4 (C), 28.5 ($3 \times \text{CH}_3$); EI-LRMS m/z 301 (M^+ , 90), 286 (100), 259 (35), 245 (39), 127 (17); HRMS calcd for $\text{C}_{11}\text{H}_{12}\text{INO}$ 300.9964, found 300.9969.

Synthesis of 2-Halo-3-nitrofluorobenzenes 14 from 3-Nitrofluorobenzene (13a). *t*-BuOLi (2.5 equiv) was added to a flask charged under N₂ with 3-nitrofluorobenzene (1 equiv), the halogenating reagent (1.5–2.0 equiv), and dry DMF (1 mL/mmol). The resulting mixture was heated at 60 °C for the indicated time and then was allowed to cool to rt. The crude was subjected to flash chromatography on silica gel (hexane/EtOAc, 10/1) to afford the title compounds.

2-Bromo-1-fluoro-3-nitrobenzene (14ab): Reaction of 13a (350 mg, 2.5 mmol) with CBr₄ (1.25 g, 3.75 mmol) and *t*-BuOLi (500 mg, 6.25 mmol) for 4 h afforded 14ab (279 mg, 51%) as a yellow solid: mp 43–45 °C (lit.¹⁵ mp 42–44 °C); ¹H NMR (300 MHz, CDCl₃) δ 7.63 (dt, *J* = 8.1, 1.4 Hz, 1H), 7.47 (td, *J* = 8.1, 5.2 Hz, 1H), 7.36 (td, *J* = 8.1, 1.4 Hz, 1H); ¹³C NMR (75.4 MHz, CDCl₃) δ 159.8 (d, *J* = 251.1 Hz, C), 151.0 (C), 129.2 (d, *J* = 8.4 Hz, CH), 121.0 (d, *J* = 3.5 Hz, CH), 120.1 (d, *J* = 23.4 Hz, CH), 103.6 (d, *J* = 25.5 Hz, C); EI-LRMS *m/z* 219 (M⁺, 81), 189 (26), 175 (68), 163 (31), 94 (100).

2-Chloro-1-fluoro-3-nitrobenzene (14ac):⁵⁶ Reaction of 13a (350 mg, 2.5 mmol) with C₂Cl₆ (1.18 g, 5 mmol) and *t*-BuOLi (500 mg, 6.25 mmol) for 6 h afforded 14ac (323 mg, 74%) as a colorless oil: *R*_f 0.43 (hexane/EtOAc, 10/1); ¹H NMR (300 MHz, CDCl₃) δ 7.75–7.65 (m, 1H), 7.50–7.39 (m, 2H); ¹³C NMR (75.4 MHz, CDCl₃) δ 158.8 (d, *J* = 252.9 Hz, C), 148.9 (C), 128.1 (d, *J* = 8.3 Hz, CH), 121.0 (d, *J* = 3.7 Hz, CH), 120.5 (d, *J* = 21.9 Hz, CH), 116.0 (d, *J* = 21.8 Hz, C); EI-LRMS *m/z* 177 (M⁺ + 2, 23), 175 (M⁺, 72), 145 (21), 131 (35), 129 (77), 117 (36), 84 (80), 49 (100); HRMS calcd for C₆H₃ClFNO₂ 174.9836, found 174.9837.

2-Bromo-1-chloro-3-nitrobenzene (14bb): Reaction of 13b (788 mg, 5 mmol) with CBr₄ (2.49 g, 5 mmol) and *t*-BuOLi (1000 mg, 12.5 mmol) for 17 h afforded 14bb (154 mg, 13%) as a white solid: mp 83–85 °C (lit.^{11a} mp 83–84 °C); ¹H NMR (300 MHz, CDCl₃) δ 7.67 (dd, *J* = 8.1, 1.5 Hz, 1H), 7.61 (dd, *J* = 8.1, 1.5 Hz, 1H), 7.41 (t, *J* = 8.1 Hz, 1H); ¹³C NMR (75.4 MHz, CDCl₃) δ 137.6 (C), 133.3 (CH), 128.7 (CH), 123.1 (CH), 115.4 (C); EI-LRMS *m/z* 239 (M⁺ + 4, 26), 237 (M⁺ + 2, 100), 235 (M⁺, 76), 191 (89), 179 (63), 110 (71), 75 (74); HRMS calcd for C₆H₃ClBrNO₂ 234.9036, found 234.9025.

Synthesis of 3-Fluoro-2-haloanilines 6ab and 6ac from Nitroaromatics 14. Powder Fe (3 equiv) was added to a solution of the corresponding 2-halo-3-nitrofluorobenzene 14 (1 equiv) in HCl: EtOH (1:7) and the mixture was refluxed for 2 h (completion of the reduction was monitored by GC-MS). After the mixture was cooled to rt, most of the EtOH was removed under reduced pressure and the residue was diluted with EtOAc and water. The aqueous solution was carefully neutralized with a 1 M NaOH solution. The aqueous solution was extracted with EtOAc (3 × 15 mL), the combined organic layers were dried over anhydrous Na₂SO₄, and solvents were evaporated under reduced pressure. The crude was purified by column chromatography on silica gel to afford the title compounds (data for 6ab have been reported above).

2-Chloro-3-fluoroaniline (6ac):⁵⁶ Treatment of 14ac (175 mg, 1 mmol) with Fe (168 mg, 3 mmol) followed by purification by column chromatography (hexane/EtOAc, 6/1) gave 6ac (123 mg, 85%) as a colorless oil: *R*_f 0.35 (hexane/EtOAc, 5/1); ¹H NMR (300 MHz, CDCl₃) δ 7.00 (td, *J* = 8.2, 6.0 Hz, 1H), 6.57–6.49 (m, 2H), 4.18 (br s, 2H); ¹³C NMR (75.4 MHz, CDCl₃) δ 159.0 (d, *J* = 245.6 Hz, C), 144.9 (d, *J* = 2.4 Hz, C), 127.6 (d, *J* = 9.7 Hz, CH), 110.8 (d, *J* = 2.8 Hz, CH), 106.5 (d, *J* = 20.3 Hz, C), 105.4 (d, *J* = 21.3 Hz, CH); EI-LRMS *m/z* 147 (M⁺ + 2, 31), 145 (M⁺, 100), 118 (7), 110 (9), 83 (18); IR (KBr) 3390, 1622, 1470, 987, 767 cm^{−1}; HRMS calcd for C₆H₅ClFN 145.0095, found 145.0103.

General Procedure for the Synthesis of 2-(2,3-Dihalophenoxy)-2-methylpropanamides 17 from O-2,3-Dihalophenyl *N,N*-Diethylcarbamates 15. To a solution of the corresponding carbamate 15^{16a} (1 equiv) in EtOH (10 mL/mmol) was added a large excess of NaOH (10 equiv) and the mixture was refluxed for 5–8 h

(completion of the hydrolysis was monitored by GC-MS). After the mixture was cooled to rt, most of the EtOH was removed under reduced pressure and the residue was diluted with Et₂O and water. The organic phase was rejected and then the aqueous solution was carefully neutralized with a 1 M HCl solution. The aqueous solution was extracted with Et₂O (3 × 10 mL), and the combined organic layers were washed with brine and dried over anhydrous Na₂SO₄, then solvents were evaporated under reduced pressure. Without further purification, the crude product was dissolved in dry DMF (1.5 mL/mmol) under N₂ and NaOH (3 equiv) was added. After 1 h at rt, 2-bromo-2-methylpropanamide (3 equiv) was added and the reaction was stirred for an additional 2 h (completion of the reaction was monitored by GC-MS). The reaction was quenched with H₂O and propanamides 17 were filtrated and recovered as solids that were not further purified.

2-(3-Fluoro-2-iodophenoxy)-2-methylpropanamide (17aa): Reaction of O-3-fluoro-2-iodophenyl *N,N*-diethylcarbamate (15aa, 168 mg, 0.5 mmol) afforded 17aa (138 mg, 86%) as a white solid: mp 100–102 °C; ¹H NMR (300 MHz, CDCl₃) δ 7.23 (td, *J* = 8.2, 6.6 Hz, 1H), 6.85 (br s, 1H), 6.84–6.76 (m, 2H), 5.84 (br s, 1H), 1.65 (s, 6H); ¹³C NMR (75.4 MHz, CDCl₃) δ 177.0 (C), 163.0 (d, *J* = 245.8 Hz, C), 156.1 (d, *J* = 4.9 Hz, C), 129.9 (d, *J* = 9.6 Hz, CH), 114.8 (d, *J* = 3.0 Hz, CH), 110.4 (d, *J* = 24.1 Hz, CH), 83.8 (C), 80.3 (d, *J* = 25.7 Hz, C), 25.0 (2 × CH₃); EI-LRMS *m/z* 323 (M⁺, 1), 279 (41), 238 (81), 196 (60), 152 (19), 112 (19), 86 (100); IR (KBr) 3451, 3416, 1673, 1458, 1237, 1152, 600 cm^{−1}. Anal. Calcd for C₁₀H₁₁FINO₂: C, 37.17; H, 3.43; N, 4.34. Found: C, 37.34; H, 3.48; N, 4.40.

2-(2-Bromo-3-fluorophenoxy)-2-methylpropanamide (17ab): Reaction of O-2-bromo-3-fluorophenyl *N,N*-diethylcarbamate (15ab, 870 mg, 3 mmol) afforded 17ab (684 mg, 83%) as a white solid: mp 91–93 °C; ¹H NMR (300 MHz, CDCl₃) δ 7.19 (td, *J* = 8.3, 6.5 Hz, 1H), 6.98 (br s, 1H), 6.91–6.82 (m, 2H), 6.48 (br s, 1H), 1.60 (s, 6H); ¹³C NMR (75.4 MHz, CDCl₃) δ 177.4 (C), 160.2 (d, *J* = 247.7 Hz, C), 153.4 (d, *J* = 3.0 Hz, C), 128.2 (d, *J* = 9.5 Hz, CH), 116.4 (d, *J* = 3.2 Hz, CH), 111.2 (d, *J* = 22.4 Hz, CH), 104.9 (d, *J* = 21.2 Hz, C), 83.9 (C), 24.8 (2 × CH₃); EI-LRMS *m/z* 277 (M⁺ + 2, 1), 275 (M⁺, 1), 233 (27), 231 (28), 196 (52), 192 (39), 190 (39), 86 (100); IR (KBr) 3428, 3212, 1683, 1463, 1018, 794, 596 cm^{−1}; HRMS calcd for C₁₀H₁₁BrFNO₂ 274.9957, found 274.9953.

2-(2-Chloro-3-fluorophenoxy)-2-methylpropanamide (17ac): Reaction of O-2-chloro-3-fluorophenyl *N,N*-diethylcarbamate (15ac, 922 mg, 0.5 mmol) afforded 17ac (95 mg, 82%) as a white solid: mp 92–94 °C; ¹H NMR (300 MHz, CDCl₃) δ 7.13 (td, *J* = 8.3, 6.3 Hz, 1H), 6.98 (br s, 1H), 6.92–6.84 (m, 2H), 6.73 (br s, 1H), 1.56 (s, 6H); ¹³C NMR (75.4 MHz, CDCl₃) δ 177.5 (C), 159.2 (d, *J* = 249.2 Hz, C), 152.2 (d, *J* = 2.2 Hz, C), 127.1 (d, *J* = 9.4 Hz, CH), 117.0 (d, *J* = 3.2 Hz, CH), 115.3 (d, *J* = 18.1 Hz, C), 111.4 (d, *J* = 21.2 Hz, CH), 83.9 (C), 24.7 (2 × CH₃); EI-LRMS *m/z* 231 (M⁺, 1), 196 (20), 187 (49), 146 (53), 86 (100), 58 (29); IR (KBr) 3425, 3214, 1684, 1465, 1452, 1140, 1020, 795, 605 cm^{−1}; HRMS calcd for C₁₀H₁₁ClFNO₂ 231.0462, found 231.0469.

2-(3-Chloro-2-iodophenoxy)-2-methylpropanamide (17ba): Reaction of O-3-chloro-2-iodophenyl *N,N*-diethylcarbamate (15ba, 176 mg, 0.5 mmol) afforded 17ba (145 mg, 86%) as a white solid: mp 101–103 °C; ¹H NMR (300 MHz, CDCl₃) δ 7.26–7.16 (m, 2H), 6.89–6.82 (m, 2H), 5.71 (br s, 1H), 1.65 (s, 6H); ¹³C NMR (75.4 MHz, CDCl₃) δ 177.1 (C), 156.2 (C), 140.1 (C), 129.5 (CH), 124.1 (CH), 116.8 (CH), 97.3 (C), 83.9 (C), 25.1 (2 × CH₃); EI-LRMS *m/z* 339 (M⁺, 1), 295 (12), 254 (42), 212 (44), 128 (17), 86 (100), 58 (24); IR (KBr) 3453, 3418, 1673, 1563, 1439, 1151, 1134, 980, 958, 771, 576 cm^{−1}; HRMS calcd for C₁₀H₁₁ClINO₂ 338.9523, found 338.9524.

2-(2-Bromo-3-chlorophenoxy)-2-methylpropanamide (17bb): Reaction of O-2-bromo-3-chlorophenyl *N,N*-diethylcarbamate (15bb, 153 mg, 0.5 mmol) afforded 17bb (116 mg, 80%) as a white solid: mp 84–86 °C; ¹H NMR (300 MHz, CDCl₃) δ 7.26–7.13 (m, 2H), 7.01–6.94 (m, 2H), 6.11 (br s, 1H), 1.61 (s, 6H); ¹³C NMR (75.4

MHz, CDCl_3) δ 177.2 (C), 153.4 (C), 136.1 (C), 128.1 (CH), 125.1 (CH), 118.9 (CH), 118.1 (C), 84.0 (C), 24.9 ($2 \times \text{CH}_3$); EI-LRMS m/z 291 (M^+ , 1), 249 (12), 214 (10), 212 (33), 168 (11), 86 (100), 58 (26); IR (KBr) 3467, 3156, 1698, 1570, 1445, 1260, 1149, 963, 544 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{BrClINO}_2$ 290.9662, found 290.9650. Anal. Calcd for $\text{C}_{10}\text{H}_{11}\text{BrClINO}_2$: C, 41.05; H, 3.79; N, 4.79. Found: C, 40.89; H, 3.77; N, 4.75.

2-(2,3-Dichlorophenoxy)-2-methylpropanamide (17bc): 2,3-Dichlorophenol (81 mg, 0.5 mmol) (commercially available) was dissolved in dry DMF (0.75 mL) under N_2 and NaOH (60 mg, 1.5 mmol) was added. After 1 h at rt, 2-bromo-2-methylpropanamide (250 mg, 1.5 mmol) was added and the reaction was stirred for 2 h at rt (completion of the reaction was monitored by GC-MS). The reaction was quenched with H_2O and 17bc (107 mg, 87%) was recovered as a white solid after filtration: mp 100–102 $^\circ\text{C}$; ^1H NMR (300 MHz, CDCl_3) δ 7.26–7.09 (m, 2H), 7.05–6.89 (m, 2H), 6.21 (br s, 1H), 1.58 (s, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 177.3 (C), 152.1 (C), 134.1 (C), 127.2 (CH), 126.7 (C), 125.3 (CH), 119.8 (CH), 84.1 (C), 24.8 ($2 \times \text{CH}_3$); EI-LRMS m/z 249 (M^+ + 2, 1), 247 (M^+ , 1), 212 (23), 203 (30), 162 (50), 126 (14), 86 (100), 58 (25); IR (KBr) 3474, 3155, 1699, 1450, 1264, 1145, 783, 550 cm^{-1} . Anal. Calcd for $\text{C}_{10}\text{H}_{11}\text{Cl}_2\text{NO}_2$: C, 48.41; H, 4.47; N, 5.65. Found: C, 48.59; H, 4.52; N, 5.60.

2-(3-Bromo-2-iodophenoxy)-2-methylpropanamide (17ca): Reaction of *O*-3-bromo-2-iodophenyl *N,N*-diethylcarbamate (**15ca**, 199 mg, 0.5 mmol) afforded 17ca (162 mg, 85%) as a white solid: mp 114–116 $^\circ\text{C}$; ^1H NMR (300 MHz, CDCl_3) δ 7.35 (dd, J = 8.1, 1.1 Hz, 1H), 7.14 (t, J = 8.1 Hz, 1H), 6.89 (dd, J = 8.1, 1.1 Hz, 1H), 6.83 (br s, 1H), 5.82 (br s, 1H), 1.64 (s, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 177.3 (C), 156.2 (C), 131.2 (C), 129.8 (CH), 127.4 (CH), 117.2 (CH), 100.3 (C), 83.9 (C), 25.0 ($2 \times \text{CH}_3$); EI-LRMS m/z 341 (M^+ – CONH_2 + 2, 6), 339 (M^+ – CONH_2 , 6), 300 (25), 298 (25), 258 (25), 256 (26), 207 (14), 86 (100), 58 (27); IR (KBr) 3461, 3146, 1674, 1434, 1146, 966, 911, 575 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{BrINO}_2$ 382.9018, found 382.9005.

2-(2,3-Dibromophenoxy)-2-methylpropanamide (17cb): Reaction of *O*-2,3-dibromophenyl *N,N*-diethylcarbamate (**15cb**, 174 mg, 0.5 mmol) afforded 17cb (144 mg, 86%) as a white solid: mp 111–113 $^\circ\text{C}$; ^1H NMR (300 MHz, CDCl_3) δ 7.35 (d, J = 7.8 Hz, 1H), 7.14–6.94 (m, 3H), 6.42 (br s, 1H), 1.60 (s, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 177.3 (C), 153.2 (C), 128.6 (CH), 128.4 (CH), 126.3 (C), 120.3 (C), 119.5 (CH), 84.0 (C), 24.9 ($2 \times \text{CH}_3$); EI-LRMS m/z 295 (M^+ – CONH_2 + 4, 5), 293 (M^+ – CONH_2 + 2, 11), 291 (M^+ – CONH_2 , 5), 252 (26), 86 (100), 58 (22); IR (KBr) 3467, 3147, 1698, 1440, 1260, 1147, 953, 779, 548 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{Br}_2\text{NO}_2$ 334.9157, found 334.9150. Anal. Calcd for $\text{C}_{10}\text{H}_{11}\text{Br}_2\text{NO}_2$: C, 35.64; H, 3.29; N, 4.16. Found: C, 35.55; H, 3.27; N, 4.12.

2-(3-Bromo-2-chlorophenoxy)-2-methylpropanamide (17cc): Reaction of *O*-3-bromo-2-chlorophenyl *N,N*-diethylcarbamate (**15cc**, 153 mg, 0.5 mmol) afforded 17cc (120 mg, 82%) as a white solid: mp 117–119 $^\circ\text{C}$; ^1H NMR (300 MHz, CDCl_3) δ 7.37 (dd, J = 6.7, 2.7 Hz, 1H), 7.23–7.04 (m, 2H), 6.94 (br s, 1H), 5.67 (br s, 1H), 1.59 (s, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 177.2 (C), 151.9 (C), 128.5 (CH), 127.7 (CH), 124.0 (CH), 120.4 (CH), 84.1 (C), 24.8 ($2 \times \text{CH}_3$); EI-LRMS m/z 293 (M^+ + 2, 1), 291 (M^+ , 1), 258 (11), 249 (19), 247 (14), 208 (33), 206 (24), 86 (100), 58 (23); IR (KBr) 3471, 3153, 1699, 1446, 1263, 1149, 953, 912, 548 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{ClBrNO}_2$ 290.9662, found 290.9667.

2-(2,3-Diiodophenoxy)-2-methylpropanamide (17da): Reaction of *O*-2,3-diiodophenyl *N,N*-diethylcarbamate (**15da**, 222 mg, 0.5 mmol) afforded 17da (179 mg, 83%) as a white solid: mp 131–133 $^\circ\text{C}$; ^1H NMR (300 MHz, CDCl_3) δ 7.59 (dd, J = 7.7, 1.4 Hz, 1H), 7.01 (appt, J = 8.0 Hz, 1H), 6.91 (dd, J = 8.2, 1.4 Hz, 1H), 6.84 (br s, 1H), 6.29 (br s, 1H), 1.63 (s, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 177.2 (C), 155.5 (C), 134.1 (CH), 130.3 (CH), 117.7 (CH), 109.5 (C), 106.4 (C), 83.9 (C), 25.1 ($2 \times \text{CH}_3$); EI-LRMS m/z 431 (M^+ , 1),

387 (16), 346 (88), 304 (100), 260 (10), 218 (11), 86 (59), 58 (18); IR (KBr) 3465, 3263, 1682, 1429, 1141, 953, 564 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{I}_2\text{NO}_2$ 430.8879, found 430.8891.

2-(2-Bromo-3-iodophenoxy)-2-methylpropanamide (17db): Reaction of *O*-2-bromo-3-iodophenyl *N,N*-diethylcarbamate (**15db**, 199 mg, 0.5 mmol) afforded 17db (153 mg, 80%) as a white solid: mp 134–136 $^\circ\text{C}$; ^1H NMR (400 MHz, CDCl_3) δ 7.58 (d, J = 7.6 Hz, 1H), 7.02 (d, J = 7.9 Hz, 1H), 6.98–6.92 (m, 2H), 6.27 (br s, 1H), 1.59 (s, 6H); ^{13}C NMR (100.6 MHz, CDCl_3) δ 177.4 (C), 152.4 (C), 134.9 (CH), 129.2 (CH), 124.8 (C), 120.3 (CH), 102.8 (C), 84.2 (C), 24.9 ($2 \times \text{CH}_3$); EI-LRMS m/z 385 (M^+ + 2, 1), 383 (M^+ , 1), 341 (17), 339 (18), 304 (100), 300 (50), 298 (53), 86 (96); IR (KBr) 3444, 3184, 1680, 1566, 1437, 1154, 966, 764, 584 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{BrINO}_2$ 382.9018, found 382.9001.

2-(2-Chloro-3-iodophenoxy)-2-methylpropanamide (17dc): Reaction of *O*-2-chloro-3-iodophenyl *N,N*-diethylcarbamate (**15dca**, 176 mg, 0.5 mmol) afforded 17dc (133 mg, 79%) as a white solid: mp 130–132 $^\circ\text{C}$; ^1H NMR (400 MHz, CDCl_3) δ 7.58 (dd, J = 8.1, 1.1 Hz, 1H), 7.06 (dd, J = 8.1, 1.1 Hz, 1H), 6.95 (br s, 1H), 6.90 (t, J = 8.1 Hz, 1H), 6.24 (br s, 1H), 1.57 (s, 6H); ^{13}C NMR (100.6 MHz, CDCl_3) δ 177.3 (C), 151.0 (C), 134.9 (CH), 132.2 (C), 128.4 (CH), 121.4 (CH), 99.6 (C), 84.1 (C), 24.9 ($2 \times \text{CH}_3$); EI-LRMS m/z 339 (M^+ , 1), 304 (38), 295 (25), 256 (19), 254 (59), 86 (100); IR (KBr) 3454, 3175, 1680, 1568, 1442, 1155, 968, 765, 586 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{ClINO}_2$ 338.9523, found 338.9524. Anal. Calcd for $\text{C}_{10}\text{H}_{11}\text{ClINO}_2$: C, 35.37; H, 3.27; N, 4.12. Found: C, 35.46; H, 3.31; N, 4.09.

General Procedure for the Synthesis of *N*-(2,3-Dihalophenyl)-2-hydroxy-2-methylpropanamides 18 from *O*-2,3-Dihalophenyl *N,N*-Diethylcarbamates 15. To a solution of the corresponding carbamate **15**^{16a} (1 equiv) in EtOH (10 mL/mmol) was added a large excess of NaOH (10 equiv) and the mixture was refluxed for 5–8 h (completion of the hydrolysis was monitored by GC-MS). After the mixture was cooled to rt, most of the EtOH was removed under reduced pressure and the residue was diluted with Et₂O and water. The organic phase was rejected, and then the aqueous solution was carefully neutralized with a 1 M HCl solution. The aqueous solution was extracted with Et₂O (3×30 mL), the combined organic layers were washed with brine, dried over anhydrous Na₂SO₄, and the solvents were evaporated under reduced pressure. Without further purification, the corresponding crude phenol **16** was dissolved in dry DMF (1.5 mL/mmol) under N_2 and NaOH (3 equiv) was added to the mixture. After 1 h at rt, 2-bromo-2-methylpropanamide (3 equiv) was added and the reaction was stirred for 2 h at rt. After complete formation of the corresponding propanamide **17** (monitored by GC-MS), an excess of NaOH (9 equiv) was added and the mixture was heated at 60 $^\circ\text{C}$ for 2 h. The reaction was quenched with H_2O and the corresponding propanamide **18** was recovered as a solid after filtration, which was not further purified.

***N*-(3-Fluoro-2-iodophenyl)-2-hydroxy-2-methylpropanamide (18aa):** Reaction of *O*-3-fluoro-2-iodophenyl *N,N*-diethylcarbamate (**15aa**, 674 mg, 2 mmol) afforded 18aa (536 mg, 83%) as a white solid: mp 95–97 $^\circ\text{C}$; ^1H NMR (300 MHz, CDCl_3) δ 9.31 (br s, 1H), 8.13 (d, J = 8.3 Hz, 1H), 7.35–7.26 (m, 1H), 6.83 (t, J = 8.3 Hz, 1H), 2.71 (s, 1H), 1.58 (s, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 175.0 (C), 161.8 (d, J = 243.7 Hz, C), 139.8 (d, J = 3.5 Hz, C), 130.5 (d, J = 9.0 Hz, CH), 116.5 (d, J = 2.9 Hz, CH), 111.2 (d, J = 23.8 Hz, CH), 78.1 (d, J = 27.9 Hz, C), 74.7 (C), 28.1 ($2 \times \text{CH}_3$); EI-LRMS m/z 323 (M^+ , 27), 265 (33), 237 (100), 138 (19), 59 (81); IR (KBr) 3420, 3368, 3289, 1661, 1462, 1416, 776 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{FINO}_2$ 322.9819, found 322.9812.

***N*-(2-Bromo-3-fluorophenyl)-2-hydroxy-2-methylpropanamide (18ab):** Reaction of *O*-2-bromo-3-fluorophenyl *N,N*-diethylcarbamate (**15ab**, 580 mg, 2 mmol) afforded 18ab (425 mg, 77%) as a white solid: mp 102–104 $^\circ\text{C}$; ^1H NMR (300 MHz, CDCl_3) δ 9.47 (br s, 1H), 8.20 (dt, J = 8.3, 1.4 Hz, 1H), 7.25 (td, J = 8.3, 6.2 Hz, 1H), 6.87 (td, J = 8.3, 1.4 Hz, 1H), 3.01 (s, 1H), 1.56 (s, 6H); ^{13}C NMR (75.4 MHz,

CDCl_3) δ 175.1 (C), 159.2 (d, J = 245.9 Hz, C), 137.2 (d, J = 2.2 Hz, C), 129.0 (d, J = 8.8 Hz, CH), 116.3 (d, J = 3.2 Hz, CH), 111.6 (d, J = 22.0 Hz, CH), 101.3 (d, J = 23.2 Hz, C), 74.7 (C), 28.0 ($2 \times \text{CH}_3$); EI-LRMS m/z 277 ($\text{M}^+ + 2$, 12), 275 (M^+ , 13), 219 (15), 217 (15), 191 (61), 189 (73), 59 (100); IR (KBr) 3326, 3310, 1665, 1601, 1469, 1422, 1252, 777 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{BrFNO}_2$ 274.9957, found 274.9958. Anal. Calcd for $\text{C}_{10}\text{H}_{11}\text{Cl}_2\text{NO}_2$: C, 43.50; H, 4.02; N, 5.07. Found: C, 43.38; H, 4.06; N, 5.05.

***N*-(2-Chloro-3-fluorophenyl)-2-hydroxy-2-methylpropanamide (18ac):** Reaction of *O*-2-chloro-3-fluorophenyl *N,N*-diethylcarbamate (**15ac**, 490 mg, 2 mmol) afforded **18ac** (351 mg, 76%) as a white solid: mp 106–108 °C; ^1H NMR (300 MHz, CDCl_3) δ 9.44 (br s, 1H), 8.23 (d, J = 8.4 Hz, 1H), 7.27–7.16 (m, 1H), 6.90 (t, J = 8.4 Hz, 1H), 2.84 (s, 1H), 1.56 (s, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 174.9 (C), 158.2 (d, J = 247.4 Hz, C), 136.0 (d, J = 1.2 Hz, C), 128.0 (d, J = 8.7 Hz, CH), 116.0 (d, J = 3.4 Hz, CH), 111.5 (d, J = 20.7 Hz, CH), 111.0 (d, J = 20.0 Hz, C), 74.7 (C), 28.0 ($2 \times \text{CH}_3$); EI-LRMS m/z 233 ($\text{M}^+ + 2$, 7), 231 (M^+ , 21), 173 (25), 147 (28), 145 (97), 59 (100); IR (KBr) 3418, 3340, 1677, 1522, 1472, 1253, 1132, 782 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{ClFNO}_2$ 231.0462, found 231.0462.

***N*-(3-Chloro-2-iodophenyl)-2-hydroxy-2-methylpropanamide (18ba):** Reaction of *O*-3-chloro-2-iodophenyl *N,N*-diethylcarbamate (**15ba**, 3.53 g, 10 mmol) afforded **18ba** (2.78 g, 82%) as a white solid: mp 113–115 °C; ^1H NMR (300 MHz, CDCl_3) δ 9.33 (br s, 1H), 8.21 (dd, J = 7.8, 1.5 Hz, 1H), 7.31–7.21 (m, 2H), 2.47 (s, 1H), 1.58 (s, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 175.0 (C), 140.4 (C), 139.1 (C), 129.8 (CH), 125.1 (CH), 118.9 (CH), 95.1 (C), 74.7 (C), 28.0 ($2 \times \text{CH}_3$); EI-LRMS m/z 341 ($\text{M}^+ + 2$, 3), 339 (M^+ , 8), 281 (10), 253 (62), 194 (15), 154 (24), 59 (100); IR (KBr) 3398, 3291, 1662, 1575, 1539, 1444, 1396, 1126, 776 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{ClINO}_2$ 338.9523, found 338.9514.

***N*-(2-Bromo-3-chlorophenyl)-2-hydroxy-2-methylpropanamide (18bb):** Reaction of *O*-2-bromo-3-chlorophenyl *N,N*-diethylcarbamate (**15bb**, 612 mg, 2 mmol) afforded **18bb** (454 mg, 78%) as a white solid: mp 107–109 °C; ^1H NMR (300 MHz, CDCl_3) δ 9.48 (br s, 1H), 8.34 (dd, J = 7.5, 2.3 Hz, 1H), 7.28–7.19 (m, 2H), 2.56 (s, 1H), 1.57 (s, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 174.7 (C), 137.5 (C), 134.9 (C), 128.7 (CH), 125.5 (CH), 119.1 (CH), 114.4 (C), 74.8 (C), 28.1 ($2 \times \text{CH}_3$); EI-LRMS m/z 293 ($\text{M}^+ + 2$, 5), 291 (M^+ , 4), 235 (5), 233 (5), 207 (35), 205 (27), 154 (14), 59 (100); IR (KBr) 3390, 3315, 1663, 1582, 1543, 1450, 1404, 777 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{BrClNO}_2$ 290.9662, found 290.9661.

***N*-(2,3-Dichlorophenyl)-2-hydroxy-2-methylpropanamide (18bc):** 2,3-Dichlorophenol (1.63 g, 10 mmol) (commercially available) was dissolved in dry DMF (15 mL) under N_2 and NaOH (1.20 g, 30 mmol) was added. After 1 h at rt, 2-bromo-2-methylpropanamide (4.98 g, 30 mmol) was added and the reaction was stirred for 2 h at rt. After completion of the alkylation reaction (monitored by GC-MS), an excess of NaOH (3.60 g, 90 mmol) was added and the mixture was heated at 60 °C for 2 h. The reaction was quenched with H_2O and **18bc** (2.08 g, 84%) was isolated after filtration as a white solid: mp 109–111 °C; ^1H NMR (300 MHz, CDCl_3) δ 9.50 (br s, 1H), 8.37–8.29 (m, 1H), 7.22–7.15 (m, 2H), 3.11 (s, 1H), 1.55 (s, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 175.1 (C), 136.0 (C), 132.8 (C), 127.8 (CH), 125.4 (CH), 122.0 (C), 118.9 (CH), 74.6 (C), 27.9 ($2 \times \text{CH}_3$); EI-LRMS m/z 251 ($\text{M}^+ + 4$, 2), 249 ($\text{M}^+ + 2$, 12), 247 (M^+ , 21), 189 (20), 163 (56), 161 (89), 59 (100); IR (KBr) 3422, 3337, 1671, 1509, 1407, 1124, 778, 701 cm^{-1} . Anal. Calcd for $\text{C}_{10}\text{H}_{11}\text{Cl}_2\text{NO}_2$: C, 48.41; H, 4.47; N, 5.65. Found: C, 48.49; H, 4.47; N, 5.67.

***N*-(3-Bromo-2-iodophenyl)-2-hydroxy-2-methylpropanamide (18ca):** Reaction of *O*-3-bromo-2-iodophenyl *N,N*-diethylcarbamate (**15ca**, 796 mg, 2 mmol) afforded **18ca** (620 mg, 81%) as a white solid: mp 118–120 °C; ^1H NMR (300 MHz, CDCl_3) δ 9.33 (br s, 1H), 8.23 (dd, J = 8.1, 1.4 Hz, 1H), 7.40 (dd, J = 8.1, 1.4 Hz, 1H), 7.22

(t, J = 8.1 Hz, 1H), 2.55 (s, 1H), 1.57 (s, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 174.9 (C), 140.5 (C), 130.4 (C), 130.1 (CH), 128.5 (CH), 119.4 (CH), 98.2 (C), 74.7 (C), 28.0 ($2 \times \text{CH}_3$); EI-LRMS m/z 385 ($\text{M}^+ + 2$, 3), 383 (M^+ , 3), 325 (4), 299 (24), 297 (25), 240 (10), 238 (10), 200 (15), 198 (15), 59 (100); IR (KBr) 3387, 3285, 1652, 1651, 1525, 1392, 776, 693 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{BrINO}_2$ 382.9018, found 382.9012. Anal. Calcd for $\text{C}_{10}\text{H}_{11}\text{BrINO}_2$: C, 31.28; H, 2.89; N, 3.65. Found: C, 31.38; H, 2.92; N, 3.67.

***N*-(2,3-Dibromophenyl)-2-hydroxy-2-methylpropanamide (18cb):** Reaction of *O*-2,3-dibromophenyl *N,N*-diethylcarbamate (**15cb**, 698 mg, 2 mmol) afforded **18cb** (556 mg, 83%) as a white solid: mp 119–121 °C; ^1H NMR (300 MHz, CDCl_3) δ 9.51 (br s, 1H), 8.34 (dd, J = 8.1, 1.4 Hz, 1H), 7.36 (dd, J = 8.1, 1.4 Hz, 1H), 7.15 (t, J = 8.1 Hz, 1H), 3.01 (br s, 1H), 1.55 (s, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 175.1 (C), 137.4 (C), 129.0 (CH), 128.9 (CH), 125.2 (C), 119.7 (CH), 116.6 (C), 74.6 (C), 28.0 ($2 \times \text{CH}_3$); EI-LRMS m/z 339 ($\text{M}^+ + 4$, 2), 337 ($\text{M}^+ + 2$, 5), 335 (M^+ , 2), 279 (6), 253 (19), 251 (38), 249 (19), 58 (100); IR (KBr) 3444, 3224, 1668, 1575, 1567, 1515, 780 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{Br}_2\text{NO}_2$ 334.9157, found 334.9165.

***N*-(3-Bromo-2-chlorophenyl)-2-hydroxy-2-methylpropanamide (18cc):** Reaction of *O*-3-bromo-2-chlorophenyl *N,N*-diethylcarbamate (**15cc**, 612 mg, 2 mmol) afforded **18cc** (448 mg, 77%) as a white solid: mp 114–116 °C; ^1H NMR (300 MHz, CDCl_3) δ 9.51 (br s, 1H), 8.36 (dd, J = 8.2, 1.1 Hz, 1H), 7.34 (dd, J = 8.2, 1.1 Hz, 1H), 7.10 (t, J = 8.2, 1H), 3.22 (s, 1H), 1.55 (s, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 175.2 (C), 135.9 (C), 128.7 (CH), 128.2 (CH), 123.8 (C), 122.7 (C), 119.6 (CH), 74.5 (C), 27.9 ($2 \times \text{CH}_3$); EI-LRMS m/z 295 ($\text{M}^+ + 4$, 2), 293 ($\text{M}^+ + 2$, 10), 291 (M^+ , 9), 258 (5), 256 (5), 235 (11), 233 (11), 209 (14), 207 (60), 205 (46), 200 (12), 198 (12), 125 (9), 90 (12), 59 (100); IR (KBr) 3343, 3323, 1664, 1526, 1406, 1132, 777, 569 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{ClBrNO}_2$ 290.9662, found 290.9672.

***N*-(2,3-Diiodophenyl)-2-hydroxy-2-methylpropanamide (18da):** Reaction of *O*-2,3-diiodophenyl *N,N*-diethylcarbamate (**15da**, 890 mg, 2 mmol) afforded **18da** (680 mg, 79%) as a white solid: mp 144–146 °C; ^1H NMR (300 MHz, CDCl_3) δ 9.28 (br s, 1H), 8.24 (dd, J = 8.2, 1.4 Hz, 1H), 7.67 (dd, J = 7.8, 1.4 Hz, 1H), 7.09 (appt, J = 8.0 Hz, 1H), 2.53 (br s, 1H), 1.57 (s, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 175.1 (C), 140.0 (C), 135.4 (CH), 130.4 (CH), 120.2 (CH), 108.8 (C), 104.5 (C), 74.5 (C), 28.0 ($2 \times \text{CH}_3$); EI-LRMS m/z 431 (M^+ , 21), 372 (8), 345 (85), 286 (62), 246 (44), 218 (14), 91 (15), 59 (100); IR (KBr) 3318, 1651, 1568, 1523, 1386, 773 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{I}_2\text{NO}_2$ 430.8879, found 430.8873.

***N*-(2-Bromo-3-iodophenyl)-2-hydroxy-2-methylpropanamide (18db):** Reaction of *O*-2-bromo-3-iodophenyl *N,N*-diethylcarbamate (**15db**, 796 mg, 2 mmol) afforded **18db** (591 mg, 77%) as a white solid: mp 110–112 °C; ^1H NMR (400 MHz, CDCl_3) δ 9.47 (br s, 1H), 8.36 (dd, J = 8.1, 1.1 Hz, 1H), 7.60 (dd, J = 8.1, 1.1 Hz, 1H), 7.01 (t, J = 8.1 Hz, 1H), 3.01 (br s, 1H), 1.54 (s, 6H); ^{13}C NMR (100.6 MHz, CDCl_3) δ 175.1 (C), 136.7 (C), 135.5 (CH), 129.5 (CH), 121.1 (C), 120.6 (CH), 101.5 (C), 74.5 (C), 27.9 ($2 \times \text{CH}_3$); EI-LRMS m/z 385 ($\text{M}^+ + 2$, 11), 383 (M^+ , 11), 327 (12), 325 (12), 304 (40), 299 (55), 297 (46), 286 (18), 246 (34), 207 (77), 59 (100); IR (KBr) 3334, 1661, 1578, 1529, 1392, 774 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{BrINO}_2$ 382.9018, found 382.9001.

***N*-(2-Chloro-3-iodophenyl)-2-hydroxy-2-methylpropanamide (18dc):** Reaction of *O*-2-chloro-3-iodophenyl *N,N*-diethylcarbamate (**15dc**, 706 mg, 2 mmol) afforded **18dc** (508 mg, 75%) as a white solid: mp 101–103 °C; ^1H NMR (400 MHz, CDCl_3) δ 9.40 (br s, 1H), 8.33 (dd, J = 8.1, 1.2 Hz, 1H), 7.52 (dd, J = 8.1, 1.2 Hz, 1H), 6.89 (t, J = 8.1 Hz, 1H), 2.94 (s, 1H), 1.48 (s, 6H); ^{13}C NMR (100.6 MHz, CDCl_3) δ 175.1 (C), 135.2 (CH), 135.1 (C), 128.8 (CH), 127.5 (C), 120.6 (CH), 98.2 (C), 74.6 (C), 27.9 ($2 \times \text{CH}_3$); EI-LRMS m/z 341 ($\text{M}^+ + 2$, 10), 339 (M^+ , 30), 304 (41), 281 (31), 255 (31), 253 (99), 246 (36), 59 (100); IR (KBr) 3343, 3325, 1662, 1568, 1528, 1397, 776 cm^{-1} ; HRMS calcd for $\text{C}_{10}\text{H}_{11}\text{ClINO}_2$ 338.9523, found 338.9522.

General Procedure for the Synthesis of *N*-(2,3-Dihalophenyl)-2-hydroxy-2-methylpropanamides **18 from 3-Halo-2-iodoanisoles **19**.** BBr_3 (20 mL of a 1 M solution in CH_2Cl_2 , 20 mmol) was added dropwise to a solution of the corresponding 3-halo-2-iodoanisole **19a** or **19b** (4 mmol), prepared as previously described,^{16b} in CH_2Cl_2 (120 mL) at -78°C . The mixture was warmed to rt overnight, and then NaHCO_3 (1.68 g, 20 mmol) was added. The resulting mixture was cooled to 0°C , and MeOH (70 mL) was added dropwise. After 30 min at 0°C , the mixture was warmed to rt and stirred for 1 h. Most of the solvent was removed under reduced pressure and the residue was diluted with water and CH_2Cl_2 . The separated aqueous phase was extracted with CH_2Cl_2 (2×30 mL). The combined organic layers were dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. Without further purification, the corresponding crude dihalophenol **16** was dissolved in anhydrous DMF (6 mL) under N_2 and NaOH (480 mg, 12 mmol) was added to the mixture. After 1 h at rt, 2-bromo-2-methylpropanamide (1.99 g, 12 mmol) was added and the reaction was stirred for 2 h at rt. After complete alkylation of **16** (monitored by GC-MS), NaOH (9 equiv) was added and the mixture was heated at 60°C for 2 h. The reaction was quenched with H_2O and the corresponding propanamide **18ba** or **18ca** was recovered as a solid after filtration. Their spectroscopic data have been reported above.

General Procedure for the Synthesis of 2,3-Dihaloanilines **6 from Anilides **18**.** A solution of the corresponding *N*-(2,3-dihalo-phenyl)-2-hydroxy-2-methylpropanamide **18** (1 mmol) in 6 M HCl: EtOH (1:1) (20 mL) was refluxed for 5–6 h (completion of the hydrolysis was monitored by GC-MS). After the mixture was cooled to rt, most of the EtOH was removed under reduced pressure and the residue was diluted with EtOAc and water. The aqueous solution was carefully neutralized with a 1 M NaOH solution. The aqueous solution was extracted with EtOAc (3×15 mL), the combined organic layers were dried over anhydrous Na_2SO_4 , and the solvents were evaporated under reduced pressure. The crude was purified by column chromatography on silica gel (hexane/EtOAc, 6/1) to afford the title compounds **6**.

2-Bromo-3-fluoroaniline (6ab**):** Reaction of **18ab** (275 mg, 1 mmol) gave **6ab** (169 mg, 89%). Spectroscopic and characterization data are reported above.

2-Chloro-3-fluoroaniline (6ac**):** Reaction of **18ac** (231 mg, 1 mmol) gave **6ac** (96 mg, 66%). Spectroscopic and characterization data are reported above.

2-Bromo-3-chloroaniline (6bb**):**⁵⁷ Reaction of **18bb** (291 mg, 1 mmol) gave **6bb** (193 mg, 94%) as a white solid: mp $41\text{--}43^\circ\text{C}$; ^1H NMR (300 MHz, CDCl_3) δ 7.02 (t, $J = 8.0$ Hz, 1H), 6.84 (dd, $J = 8.0, 1.5$ Hz, 1H), 6.63 (dd, $J = 8.0, 1.5$ Hz, 1H), 4.26 (br s, 2H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 146.1 (C), 135.1 (C), 128.4 (CH), 119.5 (CH), 113.5 (CH), 109.3 (C); EI-LRMS m/z 209 ($\text{M}^+ + 4, 23$), 207 ($\text{M}^+ + 2, 100$), 205 ($\text{M}^+, 77$), 126 (16), 90 (30), 63 (12); IR (KBr) 3473, 3381, 1610, 1462, 1018, 769 cm^{-1} ; HRMS calcd for $\text{C}_6\text{H}_5\text{ClBrN}$ 204.9294, found 204.9293.

2,3-Dichloroaniline (6bc**):** Reaction of **18bc** (248 mg, 1 mmol) gave **6bc** (144 mg, 90%) as a white solid: mp $26\text{--}28^\circ\text{C}$; ^1H NMR (300 MHz, CDCl_3) δ 6.97 (t, $J = 8.0$ Hz, 1H), 6.84 (dd, $J = 8.0, 1.5$ Hz, 1H), 6.63 (dd, $J = 8.0, 1.5$ Hz, 1H), 4.20 (br s, 2H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 144.6 (C), 132.9 (C), 127.6 (CH), 119.4 (CH), 117.3 (C), 113.7 (CH); EI-LRMS m/z 165 ($\text{M}^+ + 4, 9$), 163 ($\text{M}^+ + 2, 61$), 161 ($\text{M}^+, 100$), 126 (9), 90 (17), 63 (9); IR (KBr) 3479, 3390, 1615, 1464, 905, 768 cm^{-1} ; HRMS calcd for $\text{C}_6\text{H}_5\text{Cl}_2\text{N}$ 160.9799, found 160.9792.

2,3-Dibromoaniline (6cb**):** Reaction of **18cb** (335 mg, 1 mmol) gave **6cb** (223 mg, 89%) as a white solid: mp $41\text{--}43^\circ\text{C}$ (lit.⁵⁸ mp $45\text{--}46^\circ\text{C}$); ^1H NMR (300 MHz, CDCl_3) δ 7.01 (dd, $J = 7.8, 1.8$ Hz, 1H), 6.95 (t, $J = 7.8$ Hz, 1H), 6.68 (dd, $J = 7.8, 1.8$ Hz, 1H), 4.28 (br s, 2H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 146.1 (C), 128.9 (CH), 125.7 (C), 122.9 (CH), 114.1 (CH), 111.5 (C); EI-LRMS m/z 253 ($\text{M}^+ + 4,$

48), 251 ($\text{M}^+ + 2, 100$), 249 ($\text{M}^+, 53$), 172 (12), 170 (12), 90 (43); IR (KBr) 3382, 1611, 1455, 1287, 1014, 768, 695 cm^{-1} ; HRMS calcd for $\text{C}_6\text{H}_5\text{Br}_2\text{N}$ 248.8789, found 248.8777.

3-Bromo-2-chloroaniline (6cc**):** Reaction of **18cc** (291 mg, 1 mmol) gave **6cc** (195 mg, 95%) as a white solid: mp $31\text{--}33^\circ\text{C}$; ^1H NMR (400 MHz, CDCl_3) δ 6.99 (dd, $J = 8.0, 1.5$ Hz, 1H), 6.90 (t, $J = 8.0$ Hz, 1H), 6.67 (dd, $J = 8.0, 1.5$ Hz, 1H), 4.16 (br s, 2H); ^{13}C NMR (100.6 MHz, CDCl_3) δ 144.6 (C), 128.1 (CH), 123.2 (C), 122.8 (CH), 119.2 (C), 114.4 (CH); EI-LRMS m/z 209 ($\text{M}^+ + 4, 22$), 207 ($\text{M}^+ + 2, 100$), 205 ($\text{M}^+, 71$), 126 (13), 90 (29), 63 (12); IR (KBr) 3480, 3388, 1615, 1462, 1435, 767 cm^{-1} ; HRMS calcd for $\text{C}_6\text{H}_5\text{ClBrN}$ 204.9294, found 204.9286.

General Procedure for the Synthesis of 4-Fluoro-2-substituted-1*H*-indoles **20 from **3aa**.** A mixture of **3aa** (1 equiv), the corresponding alkyne (1.5 equiv), $\text{PdCl}_2(\text{PPh}_3)_2$ (3 mol %), CuI (5 mol %), and Et_3NH (1.5 equiv) in anhydrous DMA (5 mL/mmol) was heated for 4 h at 80°C under N_2 (cyclization was completed as monitored by GC-MS). CH_2Cl_2 (20 mL) and water (20 mL) were added to the cooled reaction mixture. The separated aqueous phase was extracted with CH_2Cl_2 (2×20 mL). The combined organic layers were washed with water (2×60 mL). The organic layer was dried over anhydrous Na_2SO_4 and concentrated at reduced pressure. The remaining residue was purified by column chromatography (hexane/EtOAc, 10/1) on silica gel affording the corresponding 4-fluoro-1*H*-indoles **20**.

4-Fluoro-2-phenyl-1*H*-indole (20a**):** Treatment of **3aa** (167 mg, 0.5 mmol) with phenylacetylene (77 mg, 0.75 mmol), $\text{PdCl}_2(\text{PPh}_3)_2$ (10 mg, 3 mol %), CuI (5 mg, 5 mol %), and Et_3NH (54 mg, 0.75 mmol) afforded **20a** (92 mg, 87%) as a brown solid: mp $62\text{--}64^\circ\text{C}$ (lit.⁵⁹ mp $65\text{--}67^\circ\text{C}$); ^1H NMR (300 MHz, CDCl_3) δ 8.45 (br s, 1H), 7.70–7.63 (m, 2H), 7.51–7.43 (m, 2H), 7.41–7.33 (m, 1H), 7.21–7.09 (m, 2H), 6.93 (dd, $J = 2.2, 0.7$ Hz, 1H), 6.84 (ddd, $J = 10.3, 7.4, 1.2$ Hz, 1H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 156.5 (d, $J = 246.8$ Hz, C), 139.3 (d, $J = 11.2$ Hz, C), 138.0 (C), 131.9 (C), 129.2 ($2 \times$ CH), 128.1 (CH), 125.3 ($2 \times$ CH), 122.8 (d, $J = 7.6$ Hz, CH), 118.6 (d, $J = 22.4$ Hz, C), 107.1 (d, $J = 3.6$ Hz, CH), 105.1 (d, $J = 18.9$ Hz, CH), 95.8 (CH); EI-LRMS m/z 211 ($\text{M}^+, 100$), 183 (17), 108 (4); HRMS calcd for $\text{C}_{14}\text{H}_{10}\text{FN}$ 211.0797, found 211.0787.

4-Fluoro-2-hexyl-1*H*-indole (20b**):** Treatment of **3aa** (200 mg, 0.6 mmol) with 1-octyne (99 mg, 0.9 mmol), $\text{PdCl}_2(\text{PPh}_3)_2$ (13 mg, 3 mol %), CuI (6 mg, 5 mol %), and Et_3NH (66 mg, 0.9 mmol) afforded **20b** (102 mg, 78%) as a brown oil: R_f 0.45 (hexane/EtOAc, 5/1); ^1H NMR (300 MHz, CDCl_3) δ 7.93 (br s, 1H), 7.15–6.93 (m, 2H), 6.79 (ddd, $J = 10.4, 6.9, 1.7$ Hz, 1H), 6.35 (dd, $J = 2.2, 0.8$ Hz, 1H), 2.74 (t, $J = 7.5$ Hz, 2H), 1.80–1.62 (m, 2H), 1.47–1.21 (m, 6H), 0.94 (t, $J = 6.9$ Hz, 3H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 155.8 (d, $J = 245.1$ Hz, C), 140.2 (C), 138.5 (d, $J = 11.9$ Hz, C), 121.3 (d, $J = 7.7$ Hz, CH), 117.8 (d, $J = 22.4$ Hz, C), 106.5 (d, $J = 3.4$ Hz, CH), 104.5 (d, $J = 19.1$ Hz, CH), 95.4 (CH), 31.7 (CH_2), 29.14 (CH_2), 29.08 (CH_2), 28.2 (CH_2), 22.7 (CH_2), 14.2 (CH_3); EI-LRMS m/z 219 ($\text{M}^+, 27$), 162 (32), 148 (100), 101 (9); HRMS calcd for $\text{C}_{14}\text{H}_{18}\text{FN}$ 219.1423, found 219.1418.

General Procedure for the Synthesis of 3-Aryl-4-fluoro-2-substituted-1*H*-indoles **21a–h.** A mixture of **3aa** (166 mg, 0.5 mmol), $\text{Pd}(\text{OAc})_2$ (6 mg, 5 mol %), PPh_3 (26 mg, 20 mol %), K_2CO_3 (427 mg, 2 mmol), and the corresponding alkyne (0.6 mmol) in DMF (3 mL) was stirred under N_2 at 70°C until the complete formation of the 2-alkynylacetamide was observed (monitored by GC-MS). Then, the corresponding aryl bromide (0.6 mmol) was added and the reaction was stirred overnight at 70°C . For the synthesis of **21c** and **21d**, the corresponding aryl bromide was added from the beginning of the reaction and the mixture was stirred under N_2 at 70°C until the complete formation of the corresponding 2,3-disubstituted-4-fluoroindole was observed (monitored by GC-MS). In both cases, the resulting mixture was quenched with water, and the aqueous solution was extracted with EtOAc (3×15 mL). The combined organic layers were

washed with water (2×30 mL) and dried over anhydrous Na_2SO_4 . The solvent was removed under reduced pressure and the residue was purified by silica gel column chromatography (hexane/EtOAc) on silica gel to afford the title compounds **21**.

4-Fluoro-3-(2-nitrophenyl)-2-phenyl-1H-indole (**21a**):

Treatment of **3aa** with phenylacetylene (61 mg, 0.6 mmol) for 1.5 h, further reaction with 1-bromo-2-nitrobenzene (121 mg, 0.6 mmol), and purification by column chromatography (hexane/EtOAc, 5/1) gave **21a** (119 mg, 72%) as a yellow-orange solid: mp 177–179 °C; ^1H NMR (300 MHz, CDCl_3) δ 8.47 (br s, 1H), 8.10–8.05 (m, 1H), 7.52–7.42 (m, 2H), 7.38–7.34 (m, 1H), 7.29 (s, 4H), 7.16 (t, J = 8.2 Hz, 2H), 7.13–7.06 (m, 1H), 6.74 (dd, J = 11.7, 7.70 Hz, 1H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 156.7 (d, J = 247.1 Hz, C), 150.0 (C), 138.2 (d, J = 10.4 Hz, C), 135.2 (d, J = 0.9 Hz, C), 134.6 (CH), 132.6 (CH), 131.4 (C), 130.7 (d, J = 0.6 Hz, C), 129.0 (2 \times CH), 128.4 (CH), 128.1 (2 \times CH), 128.1 (CH), 124.8 (CH), 123.3 (d, J = 8.0 Hz, CH), 116.9 (d, J = 18.6 Hz, C), 108.4 (d, J = 1.7 Hz, C), 107.5 (d, J = 3.7 Hz, CH), 105.9 (d, J = 19.2 Hz, CH); EI-LRMS m/z 332 (M^+ , 44), 285 (15), 105 (100), 77 (16); HRMS calcd for $\text{C}_{20}\text{H}_{13}\text{FN}_2\text{O}_2$ 332.0961, found 332.0949. Anal. Calcd for $\text{C}_{20}\text{H}_{13}\text{FN}_2\text{O}_2$: C, 72.28; H, 3.94; N, 8.43. Found: C, 71.89; H, 4.00; N, 8.38.

2-Butyl-4-fluoro-3-(2-nitrophenyl)-1H-indole (21b**):** Treatment of **3aa** with 1-hexyne (49 mg, 0.6 mmol) for 2.5 h, further reaction with 1-bromo-2-nitrobenzene (121 mg, 0.6 mmol), and purification by column chromatography (hexane/EtOAc, 5/1) gave **21b** (124 mg, 80%) as an orange solid: mp 85–87 °C; ^1H NMR (300 MHz, CDCl_3) δ 8.19 (br s, 1H), 8.08–8.03 (m, 1H), 7.65–7.58 (m, 1H), 7.52–7.45 (m, 2H), 7.12–7.08 (m, 1H), 7.08–7.00 (m, 1H), 6.70 (ddd, J = 11.1, 7.5, 1.2 Hz, 1H), 2.71–2.54 (m, 2H), 1.64–1.53 (m, 2H), 1.36–1.21 (m, 2H), 0.84 (t, J = 7.3 Hz, 3H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 156.2 (d, J = 245.7 Hz, C), 150.0 (C), 137.8 (d, J = 11.0 Hz, C), 137.2 (C), 134.2 (CH), 132.3 (CH), 130.5 (C), 127.8 (CH), 124.5 (CH), 122.1 (d, J = 7.8 Hz, CH), 116.2 (d, J = 18.8 Hz, C), 107.6 (d, J = 1.6 Hz, C), 107.0 (d, J = 3.5 Hz, CH), 105.3 (d, J = 19.3 Hz, CH), 31.5 (CH_2), 25.8 (CH_2), 22.3 (CH_2), 13.8 (CH_3); EI-LRMS m/z 312 (M^+ , 100), 253 (86), 228 (71), 199 (25); IR (KBr) 3411, 2953, 2927, 1519, 1351, 1046, 779, 753, 740 cm^{-1} ; HRMS calcd for $\text{C}_{18}\text{H}_{17}\text{FN}_2\text{O}_2$ 312.1274, found 312.1276.

4-Fluoro-3-(3-methoxyphenyl)-2-phenyl-1H-indole (**21c**):

Treatment of **3aa** with phenylacetylene (61 mg, 0.6 mmol) and 3-bromoanisole (112 mg, 0.6 mmol) for 5 h followed by purification by column chromatography (hexane/EtOAc, 10/1) gave **21c** (133 mg, 84%) as a brown solid: 120–122 °C; ^1H NMR (300 MHz, CDCl_3) δ 8.39 (s, 1H), 7.41–7.24 (m, 5H), 7.24–7.10 (m, 3H), 7.03 (s, 2H), 6.92–6.77 (m, 2H), 3.76 (s, 3H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 159.2 (C), 157.1 (d, J = 249.0 Hz, C), 138.3 (d, J = 10.8 Hz, C), 136.3 (C), 134.7 (C), 132.2 (C), 128.9 (CH), 128.7 (2 \times CH), 128.4 (2 \times CH), 128.0 (CH), 123.6 (d, J = 1.9 Hz, CH), 122.9 (d, J = 8.0 Hz, CH), 117.2 (d, J = 18.0 Hz, C), 116.3 (d, J = 2.6 Hz, CH), 113.1 (d, J = 3.0 Hz, C), 112.6 (CH), 107.1 (d, J = 3.7 Hz, CH), 105.9 (d, J = 20.1 Hz, CH), 55.2 (CH_3); EI-LRMS m/z 317 (M^+ , 100), 272 (20), 259 (4); HRMS calcd for $\text{C}_{21}\text{H}_{16}\text{FNO}$ 317.1216, found 317.1216.

4-Fluoro-2-hexyl-3-(4-methoxy-3-methylphenyl)-1H-indole (21d**):** Treatment of **3aa** with 1-octyne (66 mg, 0.6 mmol) and 4-bromo-2-methylanisole (120 mg, 0.6 mmol) for 6 h, and purification by column chromatography (hexane/EtOAc, 10/1) gave **21d** (95 mg, 56%) as a brown solid: mp 211–213 °C; ^1H NMR (300 MHz, CDCl_3) δ 8.06 (br s, 1H), 7.27 (s, 2H), 7.15–7.02 (m, 2H), 6.92 (d, J = 8.6 Hz, 1H), 6.77 (dd, J = 10.0, 7.3 Hz, 1H), 3.91 (s, 3H), 2.76 (t, J = 7.7 Hz, 2H), 2.32 (s, 3H), 1.71–1.61 (m, 2H), 1.40–1.20 (m, 6H), 0.90 (t, J = 6.6 Hz, 3H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 156.6 (d, J = 247.4 Hz, C), 156.4 (C), 137.9 (d, J = 11.4 Hz, C), 136.3 (C), 132.9 (d, J = 1.9 Hz, CH), 130.5 (d, J = 2.1 Hz, C), 128.8 (d, J = 1.9 Hz, CH), 127.9 (C), 127.1 (C), 125.8 (CH), 121.6 (d, J = 8.0 Hz, CH), 116.6 (d, J = 18.1 Hz, C), 112.4 (d, J = 2.6 Hz, C), 109.5 (CH), 106.5 (d, J = 3.5 Hz, CH), 105.2 (d, J = 20.2 Hz, CH), 55.4

(CH_3), 31.6 (CH_2), 29.9 (CH_2), 29.1 (CH_2), 26.1 (CH_2), 22.7 (CH_2), 16.5 (CH_3), 14.2 (CH_3); EI-LRMS m/z 339 (M^+ , 100), 295 (21), 268 (43), 253 (12), 237 (23), 224 (36); HRMS calcd for $\text{C}_{22}\text{H}_{26}\text{FNO}$ 339.1998, found 339.1996.

3-(4-Fluoro-2-(thiophen-3-yl)-1H-indol-3-yl)benzonitrile (**21e**):

Treatment of **3aa** with 3-ethynylthiophene (64 mg, 0.6 mmol) for 2.5 h, further reaction with 3-bromobenzonitrile (108 mg, 0.6 mmol), and purification by column chromatography (hexane/EtOAc, 10/1) gave **21e** (136 mg, 86%) as a brown solid: ^1H NMR (300 MHz, $\text{DMSO}-d_6$) δ 11.95 (br s, 1H), 7.82–7.73 (m, 2H), 7.69 (ddd, J = 7.8, 3.1, 1.6 Hz, 1H), 7.62–7.49 (m, 3H), 7.27 (d, J = 8.0 Hz, 1H), 7.11 (td, J = 8.0, 5.1 Hz, 1H), 6.92 (dd, J = 3.9, 2.6 Hz, 1H), 6.77 (dd, J = 11.8, 7.3 Hz, 1H); ^{13}C NMR (75.4 MHz, $\text{DMSO}-d_6$) δ 155.9 (d, J = 245.2 Hz, C), 138.3 (d, J = 10.8 Hz, C), 136.7 (C), 135.7 (C), 134.0 (d, J = 1.9 Hz, C), 132.0 (CH), 131.3 (C), 130.4 (CH), 129.3 (CH), 127.0 (CH), 126.8 (CH), 123.8 (CH), 122.5 (d, J = 7.9 Hz, C), 118.9 (CH), 116.0 (d, J = 17.7 Hz, C), 111.2 (CH), 108.9 (d, J = 2.7 Hz, C), 108.0 (d, J = 3.4 Hz, CH), 104.9 (d, J = 19.4 Hz, CH); EI-LRMS m/z 318 (M^+ , 100), 285 (11), 273 (9); HRMS calcd for $\text{C}_{19}\text{H}_{11}\text{FN}_2\text{S}$ 318.0627, found 318.0621.

2-Cyclohexenyl-4-fluoro-3-(4-nitrophenyl)-1H-indole (**21f**):

Treatment of **3aa** with 1-ethynylcyclohexene (63 mg, 0.6 mmol) for 2.5 h, further reaction with 4-bromonitrobenzene (120 mg, 0.6 mmol), and purification by column chromatography (hexane/EtOAc, 5/1) gave **21f** (142 mg, 85%) as an orange solid: mp 239–241 °C; ^1H NMR (300 MHz, $\text{DMSO}-d_6$) δ 11.7 (s, 1H), 8.19 (d, J = 8.1 Hz, 2H), 7.62 (d, J = 7.5 Hz, 2H), 7.21 (d, J = 8.1 Hz, 1H), 7.07 (dd, J = 12.7, 7.7 Hz, 1H), 6.76 (dd, J = 11.9, 7.7 Hz, 1H), 5.88 (s, 1H), 2.19–1.96 (m, 4H), 1.65–1.46 (m, 4H); ^{13}C NMR (75.4 MHz, $\text{DMSO}-d_6$) δ 155.7 (d, J = 245.0 Hz, C), 145.3 (C), 143.4 (C), 139.2 (C), 138.0 (d, J = 11.0 Hz, C), 131.1 (d, J = 3.0 Hz, 2 \times CH), 130.7 (CH), 129.0 (CH), 122.9 (2 \times CH), 122.2 (d, J = 8.0 Hz, C), 115.1 (d, J = 17.7 Hz, C), 108.3 (d, J = 2.8 Hz, C), 108.0 (d, J = 3.2 Hz, CH), 105.0 (d, J = 20.0 Hz, CH), 27.5 (CH_2), 25.2 (CH_2), 22.2 (CH_3), 21.4 (CH_3); EI-LRMS m/z 336 (M^+ , 100), 290 (35), 261 (24), 248 (29), 235 (21), 222 (10); HRMS calcd for $\text{C}_{20}\text{H}_{17}\text{FN}_2\text{O}_2$ 336.1274, found 336.1274.

3-(4-Fluoro-2-(4-methoxyphenyl)-1H-indol-3-yl)benzonitrile (**21g**):

Treatment of **3aa** with *p*-tolylacetylene (79 mg, 0.6 mmol) for 4 h, further reaction with 3-bromobenzonitrile (108 mg, 0.6 mmol), and purification by column chromatography (hexane/EtOAc, 10/1) gave **21g** (153 mg, 90%) as a pale brown solid: mp 186–188 °C; ^1H NMR (300 MHz, CDCl_3) δ 8.43 (br s, 1H), 7.69 (d, J = 1.7 Hz, 1H), 7.67–7.62 (m, 1H), 7.56–7.52 (m, 1H), 7.43 (t, J = 7.8 Hz, 1H), 7.25–7.19 (m, 3H), 7.18–7.10 (m, 1H), 6.87 (d, J = 8.9 Hz, 2H), 6.83–6.78 (m, 1H), 3.82 (s, 3H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 159.9 (C), 156.7 (d, J = 248.0 Hz, C), 138.2 (d, J = 10.7 Hz, C), 136.7 (C), 135.6 (d, J = 2.4 Hz, CH), 134.4 (d, J = 2.6 Hz, CH), 130.0 (CH), 129.8 (2 \times CH), 128.8 (CH), 123.7 (C), 123.1 (d, J = 8.0 Hz, CH), 119.3 (C), 116.8 (d, J = 18.1 Hz, C), 114.6 (2 \times CH), 112.1 (C), 110.1 (C), 107.2 (d, J = 3.7 Hz, CH), 106.2 (d, J = 20.0 Hz, CH), 55.4 (CH_3); EI-LRMS m/z 342 (M^+ , 100), 297 (17), 272 (4); HRMS calcd for $\text{C}_{22}\text{H}_{15}\text{FN}_2\text{O}$ 342.1168, found 342.1172. Anal. Calcd for $\text{C}_{22}\text{H}_{15}\text{FN}_2\text{O}$: C, 77.18; H, 4.42; N, 8.18. Found: C, 76.99; H, 4.46; N, 8.23.

2-(4-Fluoro-2-hexyl-1H-indol-3-yl)benzonitrile (**21h**):

Treatment of **3aa** with 1-octyne (66 mg, 0.6 mmol) for 2.5 h, further reaction with 2-bromobenzonitrile (108 mg, 0.6 mmol), and purification by column chromatography (hexane/EtOAc, 10/1) gave **21h** (73 mg, 46%) as a pale brown solid: mp 100–102 °C; ^1H NMR (300 MHz, CDCl_3) δ 8.39 (br s, 1H), 7.76 (d, J = 7.5, 1.4 Hz, 1H), 7.62 (td, J = 7.5, 1.4 Hz, 1H), 7.56–7.49 (m, 1H), 7.43 (td, J = 7.5, 1.4 Hz, 1H), 7.14–7.00 (m, 2H), 6.76 (ddd, J = 11.2, 7.5, 1.1 Hz, 1H), 2.80–2.57 (m, 2H), 1.73–1.46 (m, 2H), 1.34–1.08 (m, 6H), 0.82 (t, J = 6.9 Hz, 3H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 156.2 (d, J = 246.6 Hz, C), 139.7 (C), 138.1 (C), 137.8 (d, J = 10.9 Hz, C), 132.7 (CH), 132.4 (d, J = 1.7 Hz, CH), 132.1 (CH), 127.1 (CH), 122.3 (d, J = 7.9 Hz, CH), 119.1 (C), 116.4 (d, J = 18.5 Hz, C), 114.2 (C), 108.8 (d, J = 2.0 Hz, C), 107.0 (d, J = 3.6 Hz, CH), 105.6 (d, J = 19.5 Hz, CH), 31.5 (CH_2), 29.3

(CH₂), 28.9 (CH₂), 26.4 (CH₂), 22.6 (CH₂), 14.1 (CH₃); EI-LRMS *m/z* 320 (M⁺, 74), 263 (22), 249 (100), 229 (22), 84 (18); HRMS calcd for C₂₁H₂₁FN₂ 320.1689, found 320.1691.

Synthesis of 4-Fluoro-3-(3-methoxyphenyl)-2-thiophen-3-yl-1*H*-indole (21i): A mixture of **3aa** (100 mg, 0.3 mmol), PdCl₂(PPh₃)₂ (6.3 mg, 0.009 mmol), CuI (1.4 mg, 0.006 mmol), and 3-ethynylthiophene (39 mg, 0.36 mmol) in Et₃N (1.5 mL) was charged in a 10 mL sealed tube under N₂ and irradiated in the microwave cavity at 60 °C for 25 min. Then, 3-iodoanisole (84 mg, 0.36 mmol) and MeCN (1.5 mL) were added and the mixture was irradiated for 30 min at 90 °C. The reaction was cooled to rt and then EtOAc (10 mL) and water (10 mL) were added. The separated aqueous phase was extracted with EtOAc (2 × 10 mL), and the combined organic layers were dried over anhydrous Na₂SO₄ and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel (hexane/EtOAc, 10/1) to afford **21i** (72 mg, 75%) as a brown oil: *R*_f 0.50 (hexane/EtOAc, 5/1); ¹H NMR (400 MHz, CDCl₃) δ 8.45 (br s, 1H), 7.31 (d, *J* = 8.0 Hz, 1H), 7.26–7.22 (m, 2H), 7.18–7.05 (m, 4H), 6.98 (ddd, *J* = 4.2, 2.2, 0.5 Hz, 1H), 6.95–6.90 (m, 1H), 6.84–6.77 (m, 1H), 3.79 (s, 3H); ¹³C NMR (100.8 MHz, CDCl₃) δ 159.3 (C), 157.0 (d, *J* = 248.9 Hz, C), 138.1 (d, *J* = 10.7 Hz, C), 136.4 (C), 132.9 (C), 130.5 (C), 129.0 (CH), 127.0 (CH), 126.1 (C), 126.0 (CH), 123.6 (d, *J* = 1.7 Hz, CH), 123.0 (d, *J* = 7.9 Hz, CH), 122.4 (CH), 117.4 (d, *J* = 18.0 Hz, C), 116.3 (d, *J* = 2.1 Hz, CH), 112.9 (CH), 107.0 (d, *J* = 3.7 Hz, CH), 105.8 (d, *J* = 19.9 Hz, CH), 55.3 (CH₃); EI-LRMS *m/z* 323 (M⁺, 100), 291 (14), 280 (17), 246 (9), 235 (8); HRMS calcd for C₁₉H₁₄FNOS 323.0780, found 323.0789.

General Procedure for the Synthesis of 2-Alkynyl-3-haloanilides 22. A mixture of the corresponding *N*-(3-halo-2-iodophenyl)propanamide **18ba** or **18ca** (1 equiv), alkyne (1.5 equiv when X = Cl, or 1.2 equiv when X = Br), PdCl₂(PPh₃)₂ (3 mol %), CuI (5 mol %), and Et₃NH (1.5 equiv) in anhydrous DMF (4 mL/mmol) was stirred under N₂ at 40, 50, or 80 °C until complete consumption of starting material, as monitored by GC-MS (2–6 h). CH₂Cl₂ (20 mL/mmol) and 0.5 M HCl (20 mL/mmol) were added to the cooled reaction mixture. The separated aqueous phase was extracted with CH₂Cl₂ (2 × 20 mL). The combined organic layers were washed with water (2 × 40 mL). The organic layer was dried over anhydrous Na₂SO₄ and concentrated at reduced pressure. The remaining residue was purified by column chromatography on silica gel (hexane/EtOAc, 5/1) to afford the title products **22**.

***N*-(3-Chloro-2-(2-phenylethynyl)phenyl)-2-hydroxy-2-methylpropanamide (22ba):** Reaction of **18ba** (339 mg, 1 mmol) with 1-phenylacetylene (153 mg, 1.5 mmol) for 2 h at 80 °C afforded **22ba** (269 mg, 86%) as a white solid: mp 139–141 °C; ¹H NMR (300 MHz, CDCl₃) δ 9.83 (br s, 1H), 8.42 (dd, *J* = 8.2, 1.1 Hz, 1H), 7.65–7.57 (m, 2H), 7.40–7.34 (m, 3H), 7.24 (t, *J* = 8.2 Hz, 1H), 7.15 (dd, *J* = 8.2, 1.1 Hz, 1H), 2.35 (br s, 1H), 1.58 (s, 6H); ¹³C NMR (75.4 MHz, CDCl₃) δ 174.7 (C), 140.2 (C), 135.7 (C), 131.8 (2 × CH), 129.9 (CH), 129.2 (CH), 128.7 (2 × CH), 124.2 (CH), 122.4 (C), 116.8 (CH), 112.9 (C), 101.7 (C), 81.6 (C), 74.8 (C), 28.1 (2 × CH₃); EI-LRMS *m/z* 315 (M⁺ + 2, 17), 313 (M⁺, 51), 254 (54), 229 (33), 227 (100), 190 (27), 59 (41); IR (KBr) 3365, 3321, 1665, 1571, 1534, 1452, 759, 692 cm⁻¹; HRMS calcd for C₁₈H₁₆ClNO₂ 313.0870, found 313.0857. Anal. Calcd for C₁₈H₁₆ClNO₂: C, 68.90; H, 5.14; N, 4.46. Found: C, 69.13; H, 5.21; N, 4.43.

***N*-(3-Chloro-2-(hex-1-ynyl)phenyl)-2-hydroxy-2-methylpropanamide (22bb):** Reaction of **18ba** (339 mg, 1 mmol) with 1-hexyne (123 mg, 1.5 mmol) for 2.5 h at 80 °C afforded **22bb** (263 mg, 90%) as a pale brown solid: mp 66–68 °C; ¹H NMR (300 MHz, CDCl₃) δ 9.65 (br s, 1H), 8.37 (d, *J* = 8.1 Hz, 1H), 7.24–7.07 (m, 2H), 2.55 (t, *J* = 6.9 Hz, 2H), 2.45 (br s, 1H), 1.70–1.46 (m, 4H), 1.56 (s, 6H), 0.95 (t, *J* = 7.1 Hz, 3H); ¹³C NMR (75.4 MHz, CDCl₃) δ 174.8 (C), 140.2 (C), 135.6 (C), 129.0 (CH), 124.1 (CH), 116.7 (CH), 113.5

(C), 103.7 (C), 74.5 (C), 73.1 (C), 30.7 (CH₂), 28.1 (2 × CH₃), 22.1 (CH₂), 19.6 (CH₂), 13.7 (CH₃); EI-LRMS *m/z* 295 (M⁺ + 2, 17), 293 (M⁺, 51), 207 (48), 193 (41), 178 (64), 164 (88), 59 (100); IR (KBr) 3419, 3322, 1670, 1572, 1516, 1450, 981 cm⁻¹; HRMS calcd for C₁₆H₂₀ClNO₂ 293.1183, found 293.1184.

***N*-(3-Chloro-2-(hept-1-ynyl)phenyl)-2-hydroxy-2-methylpropanamide (22bc):** Reaction of **18ba** (339 mg, 1 mmol) with 1-heptyne (144 mg, 1.5 mmol) for 2.5 h at 80 °C afforded **22bc** (248 mg, 81%) as a pale brown solid: mp 76–78 °C; ¹H NMR (300 MHz, CDCl₃) δ 9.77 (br s, 1H), 8.32 (dd, *J* = 7.6, 1.8 Hz, 1H), 7.15–7.05 (m, 2H), 3.49 (s, 1H), 2.49 (t, *J* = 7.1 Hz, 2H), 1.68–1.56 (m, 2H), 1.53 (s, 6H), 1.47–1.21 (m, 4H), 0.88 (t, *J* = 7.1 Hz, 3H); ¹³C NMR (75.4 MHz, CDCl₃) δ 175.3 (C), 140.0 (C), 135.6 (C), 128.8 (CH), 124.0 (CH), 116.6 (CH), 113.6 (C), 103.8 (C), 74.2 (C), 73.0 (C), 31.1 (CH₂), 28.2 (CH₂), 27.9 (2 × CH₃), 22.2 (CH₂), 19.7 (CH₂), 14.0 (CH₃); EI-LRMS *m/z* 309 (M⁺ + 2, 7), 307 (M⁺, 21), 206 (20), 180 (35), 164 (44), 59 (100); IR (KBr) 3311, 2953, 1662, 1569, 1520, 1453, 1139, 790, 731 cm⁻¹; HRMS calcd for C₁₇H₂₂ClNO₂ 307.1339, found 307.1342.

***N*-(3-Chloro-2-(2-cyclohexenylethynyl)phenyl)-2-hydroxy-2-methylpropanamide (22bd):** Reaction of **18ba** (339 mg, 1 mmol) with 1-ethynylcyclohexene (159 mg, 1.5 mmol) for 3 h at 80 °C afforded **22bd** (253 mg, 80%) as a white solid: mp 145–147 °C; ¹H NMR (300 MHz, CDCl₃) δ 9.67 (br s, 1H), 8.36 (dd, *J* = 8.1, 1.3 Hz, 1H), 7.17 (t, *J* = 8.1 Hz, 1H), 7.10 (dd, *J* = 8.1, 1.3 Hz, 1H), 6.36–6.30 (m, 1H), 2.80 (s, 1H), 2.30–2.22 (m, 2H), 2.18–2.10 (m, 2H), 1.72–1.57 (m, 4H), 1.55 (s, 6H); ¹³C NMR (75.4 MHz, CDCl₃) δ 174.9 (C), 139.7 (C), 137.0 (CH), 135.4 (C), 129.2 (CH), 124.1 (CH), 120.3 (C), 116.6 (CH), 113.4 (C), 103.8 (C), 79.0 (C), 74.5 (C), 29.0 (CH₂), 28.0 (2 × CH₃), 26.0 (CH₂), 22.3 (CH₂), 21.5 (CH₂); EI-LRMS *m/z* 319 (M⁺ + 2, 23), 317 (M⁺, 72), 281 (25), 231 (57), 207 (100), 180 (26), 59 (55); IR (KBr) 3372, 3320, 1652, 1572, 1532, 1450, 1435, 1197, 1184, 778, 725 cm⁻¹; HRMS calcd for C₁₈H₂₀ClNO₂ 317.1183, found 317.1190.

***N*-(3-Chloro-2-(2-(trimethylsilyl)ethynyl)phenyl)-2-hydroxy-2-methylpropanamide (22be):** Reaction of **18ba** (339 mg, 1 mmol) with trimethylsilylacetylene (147 mg, 1.5 mmol) for 5.5 h at 40 °C afforded **22be** (251 mg, 81%) as a pale brown solid: mp 144–146 °C; ¹H NMR (300 MHz, CDCl₃) δ 9.66 (br s, 1H), 8.37 (dd, *J* = 8.3, 0.9 Hz, 1H), 7.21 (t, *J* = 8.3 Hz, 1H), 7.09 (dd, *J* = 8.3, 0.9 Hz, 1H), 2.60 (br s, 1H), 1.55 (s, 6H), 0.29 (d, *J* = 0.9 Hz, 9H); ¹³C NMR (75.4 MHz, CDCl₃) δ 175.0 (C), 140.8 (C), 135.8 (C), 130.0 (CH), 124.1 (CH), 116.8 (CH), 112.8 (C), 108.1 (C), 96.6 (C), 74.6 (C), 28.1 (2 × CH₃), 0.0 (3 × CH₃); EI-LRMS *m/z* 311 (M⁺ + 2, 10), 309 (M⁺, 29), 236 (100), 208 (39); HRMS calcd for C₁₅H₂₀ClNO₂Si 309.0952, found 309.951. Anal. Calcd for C₁₅H₂₀ClNO₂Si: C, 58.14; H, 6.51; N, 4.52. Found: C, 58.35; H, 6.46; N, 4.49.

***N*-(3-Bromo-2-(2-phenylethynyl)phenyl)-2-hydroxy-2-methylpropanamide (22ca):** Reaction of **18ca** (383 mg, 1 mmol) with phenylacetylene (122 mg, 1.2 mmol) for 3.5 h at 50 °C afforded **22ca** (285 mg, 80%) as a white solid: mp 131–133 °C; ¹H NMR (300 MHz, CDCl₃) δ 9.86 (br s, 1H), 8.44 (dd, *J* = 8.2, 1.0 Hz, 1H), 7.63–7.58 (m, 2H), 7.38–7.29 (m, 4H), 7.13 (t, *J* = 8.2 Hz, 1H), 2.87 (s, 1H), 1.55 (s, 6H); ¹³C NMR (75.4 MHz, CDCl₃) δ 175.0 (C), 140.1 (C), 131.7 (2 × CH), 130.1 (CH), 129.2 (CH), 128.6 (2 × CH), 127.3 (CH), 125.0 (C), 122.3 (C), 117.3 (CH), 115.0 (C), 101.1 (C), 83.4 (C), 74.7 (C), 28.0 (2 × CH₃); EI-LRMS *m/z* 359 (M⁺ + 2, 62), 357 (M⁺, 62), 300 (60), 298 (58), 273 (100), 271 (100), 191 (60), 165 (53), 59 (83); IR (KBr) 3372, 3312, 1661, 1566, 1532, 1446, 1200, 1131, 752, 726, 689 cm⁻¹; HRMS calcd for C₁₈H₁₆BrNO₂ 357.0364, found 357.0368.

***N*-(3-Bromo-2-(hex-1-ynyl)phenyl)-2-hydroxy-2-methylpropanamide (22cb):** Reaction of **18ca** (576 mg, 1.5 mmol) with 1-hexyne (148 mg, 1.8 mmol) for 3.5 h at 50 °C afforded **22cb** (429 mg, 85%) as a pale brown solid: mp 70–72 °C; ¹H NMR (300 MHz, CDCl₃) δ 9.76 (br s, 1H), 8.36 (dd, *J* = 8.2, 1.0 Hz, 1H), 7.25 (dd, *J* = 8.2,

1.0 Hz, 1H), 7.05 (t, $J = 8.2$ Hz, 1H), 3.42 (s, 1H), 2.50 (t, $J = 7.0$ Hz, 2H), 1.64–1.43 (m, 4H), 1.52 (s, 6H), 0.91 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 175.3 (C), 140.1 (C), 129.2 (CH), 127.2 (CH), 125.0 (C), 117.1 (CH), 115.6 (C), 103.1 (C), 74.8 (C), 74.2 (C), 30.5 (CH_2), 27.9 ($2 \times \text{CH}_3$), 22.1 (CH_2), 19.5 (CH_2), 13.7 (CH_3); EI-LRMS m/z 339 ($\text{M}^+ + 2$, 37), 337 (M^+ , 36), 253 (29), 251 (30), 226 (50), 210 (51), 157 (25), 129 (26), 59 (100); IR (KBr) 3419, 3319, 1673, 1567, 1520, 1427, 980, 729 cm^{-1} ; HRMS calcd for $\text{C}_{16}\text{H}_{20}\text{BrNO}_2$ 337.0677, found 337.0676. Anal. Calcd for $\text{C}_{16}\text{H}_{20}\text{BrNO}_2$: C, 56.82; H, 5.96; N, 4.14. Found: C, 56.99; H, 6.00; N, 4.11.

N-(3-Bromo-2-(hept-1-ynyl)phenyl)-2-hydroxy-2-methylpropanamide (22cc): Reaction of **18ca** (383 mg, 1 mmol) with 1-heptyne (115 mg, 1.2 mmol) for 3.5 h at 50 °C afforded **22cc** (277 mg, 79%) as a white solid: mp 79–81 °C; ^1H NMR (300 MHz, CDCl_3) δ 9.78 (s, 1H), 8.35 (dd, $J = 8.2, 0.8$ Hz, 1H), 7.24 (dd, $J = 8.2, 0.8$ Hz, 1H), 7.03 (t, $J = 8.2$ Hz, 1H), 3.58 (s, 1H), 2.47 (t, $J = 7.2$ Hz, 2H), 1.68–1.57 (m, 2H), 1.52 (s, 6H), 1.49–1.24 (m, 4H), 0.87 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 175.4 (C), 140.1 (C), 129.1 (CH), 127.1 (CH), 125.0 (C), 117.1 (CH), 115.6 (C), 103.2 (C), 74.8 (C), 74.2 (C), 31.1 (CH_2), 28.2 (CH_2), 27.8 ($2 \times \text{CH}_3$), 22.2 (CH_2), 19.7 (CH_2), 14.0 (CH_3); EI-LRMS m/z 353 ($\text{M}^+ + 2$, 15), 351 (M^+ , 15), 226 (28), 210 (30), 157 (21), 59 (100); IR (KBr) 3295, 2930, 1661, 1564, 1520, 1449, 1130, 981, 788, 730 cm^{-1} ; HRMS calcd for $\text{C}_{17}\text{H}_{22}\text{BrNO}_2$ 351.0834, found 351.0822.

N-(3-Bromo-2-(2-cyclohexenylethynyl)phenyl)-2-hydroxy-2-methylpropanamide (22cd): Reaction of **18ca** (383 mg, 1 mmol) with 1-ethynylcyclohexene (127 mg, 1.2 mmol) for 5 h at 50 °C afforded **22cd** (310 mg, 86%) as a white solid: mp 154–156 °C; ^1H NMR (300 MHz, CDCl_3) δ 9.65 (br s, 1H), 8.42 (dd, $J = 8.2, 1.1$ Hz, 1H), 7.29 (dd, $J = 8.2, 1.1$ Hz, 1H), 7.12 (t, $J = 8.2$ Hz, 1H), 6.37–6.32 (m, 1H), 2.48 (br s, 1H), 2.32–2.22 (m, 2H), 2.21–2.12 (m, 2H), 1.77–1.58 (m, 4H), 1.56 (s, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 174.7 (C), 139.9 (C), 137.0 (CH), 129.6 (CH), 127.2 (CH), 124.9 (C), 120.4 (C), 117.2 (CH), 115.4 (C), 103.2 (C), 80.9 (C), 74.7 (C), 29.0 (CH_2), 28.1 ($2 \times \text{CH}_3$), 26.0 (CH_2), 22.3 (CH_2), 21.5 (CH_2); EI-LRMS m/z 363 ($\text{M}^+ + 2$, 100), 361 (M^+ , 100), 277 (53), 275 (53), 167 (34), 59 (63); IR (KBr) 3376, 3318, 2929, 1653, 1566, 1530, 1446, 1433, 976, 775, 724 cm^{-1} ; HRMS calcd for $\text{C}_{18}\text{H}_{20}\text{BrNO}_2$ 361.0677, found 361.0677.

N-(3-Bromo-2-(2-(trimethylsilyl)ethynyl)phenyl)-2-hydroxy-2-methylpropanamide (22ce): Reaction of **18ca** (383 mg, 1 mmol) with trimethylsilylacetylene (147 mg, 1.5 mmol) for 3 h at 40 °C afforded **22ce** (251 mg, 71%) as a pale brown solid: mp 150–152 °C; ^1H NMR (300 MHz, CDCl_3) δ 9.70 (br s, 1H), 8.40 (dt, $J = 8.2, 0.9$ Hz, 1H), 7.27 (td, $J = 8.2, 0.9$ Hz, 1H), 7.12 (t, $J = 8.2$ Hz, 1H), 2.83 (s, 1H), 1.54 (d, $J = 0.6$ Hz, 6H), 0.28 (d, $J = 0.8$ Hz, 9H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 175.1 (C), 140.8 (C), 130.3 (CH), 127.2 (CH), 125.0 (C), 117.3 (CH), 114.8 (C), 107.5 (C), 98.3 (C), 74.4 (C), 28.0 ($2 \times \text{CH}_3$), -0.1 ($3 \times \text{CH}_3$); EI-LRMS m/z 355 ($\text{M}^+ + 2$, 28), 353 (M^+ , 27), 282 (100), 280 (100), 254 (37), 252 (37), 238 (19), 236 (18); HRMS calcd for $\text{C}_{15}\text{H}_{20}\text{BrNO}_2\text{Si}$ 353.0447, found 353.0450.

N-(3-Bromo-2-(2-(thiophen-3-yl)ethynyl)phenyl)-2-hydroxy-2-methylpropanamide (22cf): Reaction of **18ca** (383 mg, 1 mmol) with 3-ethynylthiophene (129 mg, 1.2 mmol) for 3.5 h at 50 °C afforded **22cf** (268 mg, 74%) as a white solid: mp 132–134 °C; ^1H NMR (400 MHz, CDCl_3) δ 9.82 (br s, 1H), 8.41 (d, $J = 8.3$ Hz, 1H), 7.63 (dd, $J = 2.9, 1.1$ Hz, 1H), 7.31–7.27 (m, 2H), 7.24 (dd, $J = 4.9, 1.1$ Hz, 1H), 7.11 (t, $J = 8.3$ Hz, 1H), 2.90 (s, 1H), 1.53 (s, 6H); ^{13}C NMR (100.6 MHz, CDCl_3) δ 175.0 (C), 140.1 (C), 130.0 (CH), 129.9 (CH), 129.8 (CH), 127.3 (CH), 125.9 (CH), 124.7 (C), 121.4 (C), 117.3 (CH), 115.1 (C), 96.3 (C), 83.1 (C), 74.7 (C), 28.0 ($2 \times \text{CH}_3$); EI-LRMS m/z 365 ($\text{M}^+ + 2$, 40), 363 (M^+ , 44), 305 (19), 279 (61), 277 (59), 226 (14), 198 (29), 196 (32), 171 (23), 59 (100); HRMS calcd for $\text{C}_{16}\text{H}_{14}\text{BrNO}_2\text{S}$ 362.9929, found 362.9928. Anal. Calcd for $\text{C}_{16}\text{H}_{14}\text{BrNO}_2\text{S}$: C, 52.76; H, 3.87; N, 3.85. Found: C, 52.92; H, 3.90; N, 3.86.

General Procedure for the Synthesis of 4-Halo-2-substituted-1H-indoles 23 and 24. To a solution of the corresponding 3-halo-2-alkynylpropanamide **22** (1 equiv) in DMF (3 mL/mmol) was added an excess of freshly powdered NaOH (3 equiv). The resulting mixture was refluxed under N_2 at 140 °C until the cyclization was completed (2–5 h), as monitored by GC-MS. CH_2Cl_2 (10 mL) and 0.5 M HCl (10 mL) were added to the cooled reaction mixture. The separated aqueous phase was extracted with CH_2Cl_2 (2×10 mL). The combined organic layers were washed with water (2×20 mL), dried over anhydrous Na_2SO_4 , and concentrated at reduced pressure. The remaining residue was purified by column chromatography on silica gel (hexane/EtOAc) to afford the corresponding 4-haloindoles **23** and **24**.

4-Chloro-2-phenyl-1H-indole (23a): Reaction of **22ba** (94 mg, 0.3 mmol) with NaOH (36 mg, 0.9 mmol) for 4 h followed by purification by column chromatography (hexane/EtOAc, 7/1) afforded **23a** (54 mg, 79%) as a white solid: mp 73–75 °C (lit.⁶⁰ mp 76–77 °C); ^1H NMR (300 MHz, CDCl_3) δ 8.43 (br s, 1H), 7.70–7.63 (m, 2H), 7.50–7.43 (m, 2H), 7.39–7.33 (m, 1H), 7.31–7.27 (m, 1H), 7.17–7.08 (m, 2H), 6.94 (dd, $J = 2.2, 0.8$ Hz, 1H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 138.6 (C), 137.4 (C), 131.8 (C), 129.2 ($2 \times \text{CH}$), 128.3 (CH), 128.2 (C), 125.9 (C), 125.4 ($2 \times \text{CH}$), 122.9 (CH), 120.1 (CH), 109.6 (CH), 98.5 (CH); EI-LRMS m/z 229 ($\text{M}^+ + 2$, 33), 227 (M^+ , 100), 191 (10), 165 (16), 113 (10); IR (KBr) 3449, 2961, 2924, 1452, 1261, 1098, 803, 756, 688 cm^{-1} ; HRMS calcd for $\text{C}_{14}\text{H}_{10}\text{ClN}$ 227.0502, found 227.0501.

2-Butyl-4-chloro-1H-indole (23b): Reaction of **22bb** (88 mg, 0.3 mmol) with NaOH (36 mg, 0.9 mmol) for 2.5 h followed by purification by column chromatography (hexane/EtOAc, 7/1) afforded **23b** (54 mg, 86%) as a colorless oil: R_f 0.46 (hexane/EtOAc, 6/1); ^1H NMR (300 MHz, CDCl_3) δ 7.90 (br s, 1H), 7.18 (dt, $J = 7.7, 1.0$ Hz, 1H), 7.12 (dd, $J = 7.7, 1.0$ Hz, 1H), 7.05 (t, $J = 7.7$ Hz, 1H), 6.38 (dd, $J = 2.2, 0.9$ Hz, 1H), 2.74 (t, $J = 7.6$ Hz, 2H), 1.77–1.66 (m, 2H), 1.51–1.38 (m, 2H), 0.99 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 141.0 (C), 136.5 (C), 127.6 (C), 125.0 (C), 121.6 (CH), 119.4 (CH), 109.1 (CH), 98.1 (CH), 31.2 (CH_2), 28.0 (CH_2), 22.5 (CH_2), 14.0 (CH_3); EI-LRMS m/z 209 ($\text{M}^+ + 2$, 10), 207 (M^+ , 33), 164 (100), 128 (8), 101 (6); IR (KBr) 3417, 2957, 2929, 1575, 1548, 1433, 1330, 1182, 941, 765 cm^{-1} ; HRMS calcd for $\text{C}_{12}\text{H}_{14}\text{ClN}$ 207.0815, found 207.0822.

4-Chloro-2-pentyl-1H-indole (23c):⁶⁰ Reaction of **22bc** (154 mg, 0.5 mmol) with NaOH (60 mg, 1.5 mmol) for 2.5 h followed by purification by column chromatography (hexane/EtOAc, 7/1) afforded **23c** (93 mg, 84%) as a pale brown solid: mp 24–26 °C; ^1H NMR (300 MHz, CDCl_3) δ 7.96 (br s, 1H), 7.19 (dd, $J = 7.6, 0.9$ Hz, 1H), 7.11–7.00 (m, 2H), 6.36 (d, $J = 0.9$ Hz, 1H), 2.75 (t, $J = 7.6$ Hz, 2H), 1.79–1.68 (m, 2H), 1.43–1.25 (m, 4H), 0.93 (t, $J = 6.7$ Hz, 3H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 141.0 (C), 136.5 (C), 127.7 (C), 125.0 (C), 121.6 (CH), 119.4 (CH), 109.0 (CH), 98.1 (CH), 31.6 (CH_2), 28.8 (CH_2), 28.3 (CH_2), 22.6 (CH_2), 14.1 (CH_3); EI-LRMS m/z 223 ($\text{M}^+ + 2$, 11), 221 (M^+ , 34), 178 (24), 164 (100), 128 (9), 101 (6); IR (KBr) 3417, 2956, 2928, 1547, 1433, 1329, 1182, 939, 765 cm^{-1} ; HRMS calcd for $\text{C}_{13}\text{H}_{16}\text{ClN}$ 221.0971, found 221.0980.

4-Chloro-2-cyclohexenyl-1H-indole (23d): Reaction of **22bd** (94 mg, 0.3 mmol) with NaOH (36 mg, 0.9 mmol) for 2.5 h followed by purification by column chromatography (hexane/EtOAc, 8/1) afforded **23d** (56 mg, 81%) as a pale brown oil: R_f 0.70 (hexane/EtOAc, 6/1); ^1H NMR (300 MHz, CDCl_3) δ 8.21 (br s, 1H), 7.21–7.17 (m, 1H), 7.09–7.02 (m, 2H), 6.54 (d, $J = 2.0$ Hz, 1H), 6.17–6.12 (m, 1H), 2.51–2.44 (m, 2H), 2.29–2.21 (m, 2H), 1.85–1.76 (m, 2H), 1.75–1.65 (m, 2H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 140.1 (C), 136.8 (C), 128.8 (C), 127.8 (C), 125.6 (C), 123.8 (CH), 122.5 (CH), 119.5 (CH), 109.1 (CH), 97.1 (CH), 26.0 (CH_2), 25.6 (CH_2), 22.5 (CH_2), 22.2 (CH_2); EI-LRMS m/z 233 ($\text{M}^+ + 2$, 32), 231 (M^+ , 100), 203 (35), 164 (34), 151 (29); IR (neat) 3433, 2928, 1569, 1432, 1334, 1184, 947, 764, 731 cm^{-1} ; HRMS calcd for $\text{C}_{14}\text{H}_{14}\text{ClN}$ 231.0815, found 231.0814.

4-Chloro-1H-indole (23e): Reaction of **22be** (154 mg, 0.5 mmol) with NaOH (60 mg, 1.5 mmol) for 4 h followed by purification by column chromatography (hexane/EtOAc, 8/1) afforded **23e** (56 mg, 73%) as a brown oil: R_f 0.33 (hexane/AcOEt, 5/1); ^1H NMR (300 MHz, CDCl_3) δ 8.25 (br s, 1H), 7.31–7.21 (m, 2H), 7.16–7.08 (m, 2H), 6.70–6.62 (m, 1H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 136.6 (C), 126.9 (C), 126.2 (C), 124.9 (CH), 122.7 (CH), 119.7 (CH), 109.8 (CH), 101.4 (CH); EI-LRMS m/z 153 ($\text{M}^+ + 2$, 31), 151 (M^+ , 100), 116 (18), 89 (27).

4-Bromo-2-phenyl-1H-indole (24a): Reaction of **22ca** (178 mg, 0.5 mmol) with NaOH (60 mg, 1.5 mmol) for 5 h followed by purification by column chromatography (hexane/EtOAc, 8/1) afforded **24a** (113 mg, 83%) as a white solid: mp 100–102 °C; ^1H NMR (300 MHz, CDCl_3) δ 8.42 (br s, 1H), 7.65 (dd, J = 8.4, 1.0 Hz, 2H), 7.49–7.42 (m, 2H), 7.40–7.29 (m, 3H), 7.06 (t, J = 7.9 Hz, 1H), 6.91–6.89 (m, 1H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 138.5 (C), 137.0 (C), 131.7 (C), 130.1 (C), 129.2 (2 \times CH), 128.3 (CH), 125.3 (2 \times CH), 123.2 (CH), 114.6 (C), 110.2 (CH), 100.2 (CH); EI-LRMS m/z 273 ($\text{M}^+ + 2$, 98), 271 (M^+ , 100), 191 (27), 165 (34), 136 (11); IR (KBr) 3445, 1475, 1452, 1352, 1289, 1181, 916, 758, 691 cm^{-1} ; HRMS calcd for $\text{C}_{14}\text{H}_{10}\text{BrN}$ 270.9997, found 270.9995. Anal. Calcd for $\text{C}_{14}\text{H}_{10}\text{BrN}$: C, 61.79; H, 3.70; N, 5.15. Found: C, 61.62; H, 3.67; N, 5.19.

4-Bromo-2-butyl-1H-indole (24b): Reaction of **22cb** (101 mg, 0.3 mmol) with NaOH (36 mg, 0.9 mmol) for 3 h followed by purification by column chromatography (hexane/EtOAc, 7/1) afforded **24b** (60 mg, 80%) as a white solid: mp 29–31 °C; ^1H NMR (300 MHz, CDCl_3) δ 7.95 (br s, 1H), 7.26 (dd, J = 7.8, 0.8 Hz, 1H), 7.22 (dt, J = 7.8, 0.8 Hz, 1H), 6.99 (t, J = 7.8 Hz, 1H), 6.32 (dd, J = 2.2, 0.9 Hz, 1H), 2.74 (t, J = 7.6 Hz, 2H), 1.77–1.66 (m, 2H), 1.50–1.37 (m, 2H), 0.98 (t, J = 7.3 Hz, 3H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 141.0 (C), 136.0 (C), 129.6 (C), 122.5 (CH), 121.9 (CH), 113.7 (C), 109.6 (CH), 99.8 (CH), 31.2 (CH_2), 28.0 (CH_2), 22.5 (CH_2), 14.0 (CH_3); EI-LRMS m/z 253 ($\text{M}^+ + 2$, 37), 251 (M^+ , 37), 210 (100), 208 (98), 129 (32); IR (KBr) 3407, 2958, 2929, 1539, 1430, 1329, 1178, 917, 763, 729 cm^{-1} ; HRMS calcd for $\text{C}_{12}\text{H}_{14}\text{BrN}$ 251.0310, found 251.0309.

4-Bromo-2-pentyl-1H-indole (24c): Reaction of **22cc** (123 mg, 0.35 mmol) with NaOH (42 mg, 1.05 mmol) for 2.5 h followed by purification by column chromatography (hexane/EtOAc, 7/1) afforded **24c** (76 mg, 82%) as a pale brown oil: R_f 0.42 (hexane/EtOAc, 6/1); ^1H NMR (300 MHz, CDCl_3) δ 7.97 (br s, 1H), 7.28–7.20 (m, 2H), 6.98 (t, J = 8.0 Hz, 1H), 6.31 (dd, J = 2.2, 0.8 Hz, 1H), 2.74 (t, J = 7.7 Hz, 2H), 1.79–1.68 (m, 2H), 1.43–1.34 (m, 4H), 0.93 (t, J = 7.0 Hz, 3H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 141.0 (C), 136.1 (C), 129.6 (C), 122.5 (CH), 121.9 (CH), 113.7 (C), 109.6 (CH), 99.9 (CH), 31.6 (CH_2), 28.9 (CH_2), 28.3 (CH_2), 22.6 (CH_2), 14.1 (CH_3); EI-LRMS m/z 267 ($\text{M}^+ + 2$, 41), 265 (M^+ , 42), 224 (19), 210 (100), 208 (98), 129 (32); IR (neat) 3411, 2956, 2928, 1548, 1430, 1327, 1178, 917, 763 cm^{-1} ; HRMS calcd for $\text{C}_{13}\text{H}_{16}\text{BrN}$ 265.0466, found 265.0467.

4-Bromo-2-cyclohexenyl-1H-indole (24d): Reaction of **22cd** (180 mg, 0.5 mmol) with NaOH (60 mg, 1.5 mmol) for 4 h followed by purification by column chromatography (hexane/EtOAc, 10/1) afforded **24d** (105 mg, 76%) as a colorless oil: R_f 0.5 (hexane/EtOAc, 6/1); ^1H NMR (300 MHz, CDCl_3) δ 8.27 (br s, 1H), 7.27–7.20 (m, 2H), 6.99 (t, J = 7.8 Hz, 1H), 6.48 (d, J = 1.9 Hz, 1H), 6.17–6.12 (m, 1H), 2.51–2.43 (m, 2H), 2.28–2.20 (m, 2H), 1.84–1.75 (m, 2H), 1.75–1.65 (m, 2H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 140.2 (C), 136.4 (C), 129.7 (C), 128.9 (C), 123.8 (CH), 122.8 (CH), 122.7 (CH), 114.3 (C), 109.7 (CH), 98.9 (CH), 26.1 (CH_2), 25.6 (CH_2), 22.6 (CH_2), 22.2 (CH_2); EI-LRMS m/z 277 ($\text{M}^+ + 2$, 98), 275 (M^+ , 100), 247 (24), 195 (23), 167 (38); IR (KBr) 3427, 2927, 1568, 1524, 1429, 1332, 1179, 917, 762, 730 cm^{-1} ; HRMS calcd for $\text{C}_{14}\text{H}_{14}\text{BrN}$ 275.0310, found 275.0314.

4-Bromo-1H-indole (24e): Reaction of **22ce** (176 mg, 0.5 mmol) with NaOH (60 mg, 1.5 mmol) for 5 h followed by purification by column chromatography (hexane/EtOAc, 10/1) afforded **24e** (74 mg,

75%) as a colorless oil: R_f 0.29 (hexane/EtOAc, 6/1); ^1H NMR (300 MHz, CDCl_3) δ 8.28 (br s, 1H), 7.37–7.23 (m, 3H), 7.06 (t, J = 7.9 Hz, 1H), 6.64–6.60 (m, 1H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 136.1 (C), 128.8 (C), 124.8 (CH), 123.0 (CH), 122.9 (CH), 114.9 (C), 110.4 (CH), 103.2 (CH); EI-LRMS m/z 197 ($\text{M}^+ + 2$, 100), 195 (M^+ , 100), 184 (7), 116 (77), 89 (44); HRMS calcd for $\text{C}_8\text{H}_6\text{BrN}$ 194.9684, found 194.9679.

4-Bromo-2-(thiophen-3-yl)-1H-indole (24f): Reaction of **22cf** (181 mg, 0.5 mmol) with NaOH (60 mg, 1.5 mmol) for 3 h followed by purification by column chromatography (hexane/EtOAc, 10/1) afforded **24f** (99 mg, 71%) as a pale brown solid: mp 44–46 °C; ^1H NMR (300 MHz, CDCl_3) δ 8.35 (br s, 1H), 7.47–7.38 (m, 3H), 7.29 (d, J = 7.7 Hz, 2H), 7.07–7.00 (m, 1H), 6.75 (d, J = 2.1 Hz, 1H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 136.6 (C), 134.6 (C), 133.5 (C), 129.9 (C), 127.0 (CH), 125.7 (CH), 123.25 (CH), 123.19 (CH), 119.9 (CH), 114.5 (C), 110.0 (CH), 100.2 (CH); EI-LRMS m/z 281 ($\text{M}^+ + 2$, 100), 279 (M^+ , 96), 198 (38), 171 (61), 154 (27), 126 (32); HRMS calcd for $\text{C}_{12}\text{H}_8\text{BrNS}$ 276.9561, found 276.9576. Anal. Calcd for $\text{C}_{12}\text{H}_8\text{BrNS}$: C, 51.81; H, 2.90; N, 5.04. Found: C, 51.66; H, 2.92; N, 5.06.

General Procedure for the One-Pot Synthesis of 4-Halo-2-substituted-1H-indoles 20, 23, and 24 from 2,3-Dihaloanilides 18. A mixture of the corresponding 2,3-dihaloanilide **18** (1 equiv), alkyne (1.5 equiv when X = F, Cl, or 1.2 equiv if X = Br), $\text{PdCl}_2(\text{PPh}_3)_2$ (3 mol %), CuI (5 mol %) and Et_2NH (1.5 equiv) in DMA (4 mL/mmol) was stirred under N_2 at 80 (for **18aa** and **18ba**), 50 (for **18ca**), or 40 °C (when trimethylsilylacetylene was used as alkyne) until complete consumption of starting material, as monitored by GC-MS (2–6 h). Then, a large excess of freshly powdered NaOH (10 equiv) was added to the reaction mixture and it was refluxed under N_2 at 140 °C until the cyclization was completed (2–12 h), as monitored by GC-MS. CH_2Cl_2 (20 mL) and 0.5 M HCl (20 mL) were added to the cooled reaction mixture. The separated aqueous phase was extracted with CH_2Cl_2 (2 \times 20 mL). The combined organic layers were washed with water (2 \times 40 mL). The organic layer was dried over anhydrous Na_2SO_4 and concentrated at reduced pressure. The remaining residue was purified by column chromatography on silica gel (hexane/EtOAc) to afford the corresponding 4-haloindoles **20**, **23**, and **24**. The characterization data of **20a**, **23a–e** and **24a–f** have been reported above.

2-Butyl-4-fluoro-1H-indole (20c): Treatment of **18aa** (161 mg, 0.5 mmol) with 1-hexyne (62 mg, 0.75 mmol) for 3 h and then with NaOH (200 mg, 5 mmol) for 3 h followed by purification by column chromatography (hexane/EtOAc, 8/1) afforded **20c** (73 mg, 77%) as a pale brown oil: R_f 0.50 (hexane/EtOAc, 4/1); ^1H NMR (300 MHz, CDCl_3) δ 7.92 (br s, 1H), 7.11–7.00 (m, 2H), 6.78 (ddd, J = 10.4, 6.9, 1.7 Hz, 1H), 6.35 (dd, J = 2.2, 0.8 Hz, 1H), 2.75 (t, J = 7.6 Hz, 2H), 1.77–1.66 (m, 2H), 1.51–1.38 (m, 2H), 0.99 (t, J = 7.3 Hz, 3H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 155.9 (d, J = 245.2 Hz, C), 140.1 (C), 138.6 (d, J = 11.8 Hz, C), 121.4 (d, J = 7.6 Hz, CH), 117.8 (d, J = 22.4 Hz, C), 106.5 (d, J = 3.4 Hz, CH), 104.5 (d, J = 19.1 Hz, CH), 95.4 (CH), 31.3 (CH_2), 27.9 (CH_2), 22.5 (CH_2), 14.0 (CH_3); HRMS calcd for $\text{C}_{12}\text{H}_{14}\text{FN}$ 191.1110, found 191.1106.

4-Chloro-2-(3-chlorophenyl)-1H-indole (23f): Treatment of **18ba** (170 mg, 0.5 mmol) with 1-chloro-3-ethynylbenzene (102 mg, 0.75 mmol) for 2 h and then with NaOH (200 mg, 5 mmol) for 3 h followed by purification by column chromatography (hexane/EtOAc, 7/1) afforded **23f** (98 mg, 75%) as a brown solid: mp 80–82 °C; ^1H NMR (300 MHz, CDCl_3) δ 8.44 (br s, 1H), 7.62 (t, J = 1.6 Hz, 1H), 7.50 (dt, J = 7.5, 1.6 Hz, 1H), 7.36 (t, J = 7.5 Hz, 1H), 7.32–7.24 (m, 2H), 7.17–7.08 (m, 2H), 6.92 (dd, J = 2.2, 0.7 Hz, 1H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 137.5 (C), 136.9 (C), 135.1 (C), 133.5 (C), 130.4 (CH), 128.1 (CH), 128.0 (C), 126.1 (C), 125.3 (CH), 123.39 (CH), 123.38 (CH), 120.3 (CH), 109.7 (CH), 99.4 (CH); EI-LRMS m/z 265 ($\text{M}^+ + 4$, 13), 263 ($\text{M}^+ + 2$, 62), 261 (M^+ , 100), 226 (13), 199 (30), 190 (35), 164 (30), 89 (49); HRMS calcd for $\text{C}_{14}\text{H}_9\text{Cl}_2\text{N}$ 261.0112,

found 261.0112. Anal. Calcd for $C_{14}H_9Cl_2N$: C, 64.15; H, 3.46; N, 5.34. Found: C, 64.34; H, 3.49; N, 5.32.

4-Chloro-2-(4-fluoro-3-methylphenyl)-1H-indole (23g): Treatment of **18ba** (136 mg, 0.4 mmol) with 4-ethynyl-1-fluoro-2-methylbenzene (80 mg, 0.6 mmol) for 2 h and then with NaOH (160 mg, 4 mmol) for 4 h followed by purification by column chromatography (hexane/EtOAc, 8/1) afforded **23g** (74 mg, 72%) as a brown solid: mp 114–116 °C; 1H NMR (300 MHz, $CDCl_3$) δ 8.41 (br s, 1H), 7.49 (d, J = 7.1 Hz, 1H), 7.46–7.39 (m, 1H), 7.29–7.24 (m, 1H), 7.15–7.03 (m, 3H), 6.84 (d, J = 0.9 Hz, 1H), 2.34 (br s, 3H); ^{13}C NMR (75.4 MHz, $CDCl_3$) δ 161.4 (d, J = 247.0 Hz, C), 138.0 (C), 137.4 (C), 128.6 (d, J = 5.3 Hz, CH), 128.2 (C), 127.8 (d, J = 3.7 Hz, C), 125.9 (d, J = 7.2 Hz, C), 125.7 (C), 124.4 (d, J = 8.2 Hz, CH), 122.9 (CH), 120.1 (CH), 115.8 (d, J = 22.9 Hz, CH), 109.6 (CH), 98.2 (CH), 14.8 (d, J = 3.4 Hz, CH_3); EI-LRMS m/z 261 (M^+ + 2, 49), 259 (M^+ , 100), 223 (14), 208 (13), 197 (14), 129 (16), 111 (23); HRMS calcd for $C_{15}H_{11}ClFN$ 259.0564, found 0.259.0561. Anal. Calcd for $C_{15}H_{11}ClFN$: C, 69.37; H, 4.27; N, 5.39. Found: C, 69.18; H, 4.30; N, 5.37.

4-Bromo-2-(3-chlorophenyl)-1H-indole (24g): Treatment of **18ca** (191 mg, 0.5 mmol) with 1-chloro-3-ethynylbenzene (102 mg, 0.75 mmol) for 2 h and then with NaOH (200 mg, 5 mmol) for 4 h followed by purification by column chromatography (hexane/EtOAc, 8/1) afforded **24g** (73 mg, 48%) as a brown solid: mp 89–91 °C; 1H NMR (300 MHz, $CDCl_3$) δ 8.47 (br s, 1H), 7.67–7.64 (m, 1H), 7.55 (ddd, J = 7.6, 2.8, 1.3 Hz, 1H), 7.43–7.27 (m, 4H), 7.06 (td, J = 8.1, 1.2 Hz, 1H), 6.90–6.87 (m, 1H); ^{13}C NMR (75.4 MHz, $CDCl_3$) δ 137.1 (C), 137.0 (C), 135.2 (C), 133.6 (C), 130.5 (CH), 129.9 (C), 128.2 (CH), 125.4 (CH), 123.8 (CH), 123.5 (CH), 123.4 (CH), 114.9 (C), 110.3 (CH), 101.2 (CH); EI-LRMS m/z 309 (M^+ + 4, 23), 307 (M^+ + 2, 100), 305 (M^+ , 80), 226 (16), 199 (34), 190 (74), 163 (60); HRMS calcd for $C_{14}H_9BrClN$ 304.9607, found 304.9620.

General Procedure for the Synthesis of N-(2,3-Dialkynylphenyl)-2-methylpropanamides 25. A mixture of **18bc** (148 mg, 0.6 mmol), $PdCl_2(MeCN)_2$ (3 mg, 2 mol %), XPhos (17 mg, 3 mol %), and CS_2CO_3 (586 mg, 1.8 mmol) in anhydrous MeCN (2 mL) was stirred under N_2 at rt for 25 min. Then, the corresponding alkyne (1.8 mmol) was added and the reaction was stirred at reflux overnight. AcOEt and water were added to the cooled reaction mixture. The separated aqueous phase was extracted with AcOEt (3 \times 15 mL). The combined organic layers were dried over anhydrous Na_2SO_4 and concentrated at reduced pressure. The remaining residue was purified by column chromatography on silica gel (hexane/EtOAc) to afford the corresponding title compounds **25**.

N-(2,3-Bis(2-phenylethynyl)phenyl)-2-hydroxy-2-methylpropanamide (25a): Reaction of **18bc** with phenylacetylene (198 μ L, 1.8 mmol) followed by purification by column chromatography (hexane/EtOAc, 5/1) afforded **25a** (147 mg, 65%) as a brown solid: mp 162–164 °C; 1H NMR (300 MHz, $CDCl_3$) δ 9.84 (br s, 1H), 8.53–8.45 (m, 1H), 7.65–7.54 (m, 4H), 7.41–7.33 (m, 6H), 7.34–7.27 (m, 2H), 2.45 (s, 1H), 1.60 (s, 6H); ^{13}C NMR (75.4, $CDCl_3$) δ 174.7 (C), 139.0 (C), 131.8 (2 \times CH), 131.6 (2 \times CH), 129.1 (CH), 129.0 (CH), 128.7 (3 \times CH), 128.6 (2 \times CH), 127.0 (CH), 125.8 (C), 123.2 (C), 122.8 (C), 118.5 (CH), 115.1 (C), 100.8 (C), 93.7 (C), 88.2 (C), 83.6 (C), 74.8 (C), 28.1 (2 \times CH_3); EI-LRMS m/z 379 (M^+ , 61), 361 (73), 321 (61), 292 (58), 265 (56), 189 (20), 59 (100); HRMS calcd for $C_{26}H_{21}NO_2$ 379.1572, found 379.1569.

N-(2,3-Di(hept-1-ynyl)phenyl)-2-hydroxy-2-methylpropanamide (25b): Reaction of **18bc** with 1-heptyne (236 μ L, 1.8 mmol) followed by purification by column chromatography (hexane/EtOAc, 5/1) afforded **25b** (173 mg, 79%) as a brown oil: R_f 0.48 (hexane/EtOAc, 3/1); 1H NMR (400 MHz, $CDCl_3$) δ 9.59 (s, 1H), 8.34 (dd, J = 7.9, 1.3 Hz, 1H), 7.15 (t, J = 7.9 Hz, 1H), 7.08 (dd, J = 7.9, 1.3 Hz, 1H), 2.72 (s, 1H), 2.51 (t, J = 7.1 Hz, 2H), 2.43 (t, J = 7.1 Hz, 2H), 1.68–1.57 (m, 4H), 1.53 (s, 6H), 1.49–1.41 (m, 4H), 1.39–1.30 (m, 4H), 0.90 (td, J = 7.2, 3.8 Hz, 6H); ^{13}C NMR (100.6, $CDCl_3$) δ 174.8 (C), 138.9 (C),

128.1 (CH), 127.0 (CH), 126.6 (C), 117.7 (CH), 115.8 (C), 101.8 (C), 94.4 (C), 79.5 (C), 75.0 (C), 74.4 (C), 31.23 (CH_2), 31.17 (CH_2), 28.58 (CH_2), 28.56 (CH_2), 28.0 (2 \times CH_3), 22.4 (2 \times CH_2), 19.9 (CH_2), 19.7 (CH_2), 14.11 (CH_3), 14.09 (CH_3); EI-LRMS m/z 367 (M^+ , 20), 320 (37), 296 (87), 278 (100), 167 (29), 59 (40); HRMS calcd for $C_{24}H_{33}NO_2$ 367.2511, found 367.2518.

N-(2,3-Bis(2-cyclohexenylethynyl)phenyl)-2-hydroxy-2-methylpropanamide (25c): Reaction of **18bc** with 1-ethynylcyclohexene (212 μ L, 1.8 mmol) followed by purification by column chromatography (hexane/EtOAc, 5/1) afforded **25c** (174 mg, 75%) as a pale yellow solid: mp 156–158 °C; 1H NMR (300 MHz, $CDCl_3$) δ 9.60 (br s, 1H), 8.38 (dd, J = 8.0, 1.3 Hz, 1H), 7.27–7.19 (m, 1H), 7.17–7.12 (m, 1H), 6.33–6.27 (m, 1H), 6.27–6.22 (m, 1H), 2.50 (br s, 1H), 2.30–2.21 (m, 4H), 2.20–2.11 (m, 4H), 1.72–1.59 (m, 8H), 1.56 (d, J = 1.1 Hz, 6H); ^{13}C NMR (75.4 MHz, $CDCl_3$) δ 174.7 (C), 138.5 (C), 136.3 (CH), 135.9 (CH), 128.4 (CH), 126.8 (CH), 126.0 (C), 120.9 (C), 120.7 (CH), 117.9 (C), 115.3 (C), 102.6 (C), 95.4 (C), 85.7 (C), 81.0 (C), 74.6 (C), 29.3 (CH_2), 29.2 (CH_2), 28.1 (2 \times CH_3), 26.03 (CH_2), 25.98 (CH_2), 22.45 (CH_2), 22.40 (CH_2), 21.61 (CH_2), 21.55 (CH_2); EI-LRMS m/z 387 (M^+ , 92), 369 (32), 328 (38), 300 (36), 207 (100), 59 (83); HRMS calcd for $C_{26}H_{29}NO_2$ 387.2198, found 387.2198.

N-(2,3-Bis(2-(thiophen-3-yl)ethynyl)phenyl)-2-hydroxy-2-methylpropanamide (25d): Reaction of **18bc** with 3-ethynylthiophene (211 μ L, 1.8 mmol) followed by purification by column chromatography (hexane/EtOAc, 5/1) afforded **25d** (164 mg, 70%) as a pale brown solid: mp 206–208 °C; 1H NMR (400 MHz, acetone- d_6) δ 10.1 (s, 1H), 8.56 (dd, J = 8.3, 1.2 Hz, 1H), 7.83 (dd, J = 3.0, 1.2 Hz, 1H), 7.81 (dd, J = 3.0, 1.2 Hz, 1H), 7.57 (dd, J = 5.0, 3.0 Hz, 2H), 7.39 (t, J = 8.0 Hz, 1H), 7.32 (dd, J = 5.0, 1.2 Hz, 1H), 7.30 (dd, J = 2.2, 1.2 Hz, 1H), 7.28 (dd, J = 1.2, 0.4 Hz, 1H), 5.41 (s, 1H), 1.51 (s, 6H); ^{13}C NMR (75.4, acetone- d_6) δ 176.0 (C), 140.6 (C), 130.7 (CH), 130.6 (CH), 130.5 (CH), 130.4 (CH), 129.9 (CH), 127.3 (CH), 127.2 (CH), 127.0 (CH), 126.2 (C), 122.8 (C), 122.4 (C), 118.8 (CH), 115.3 (C), 96.8 (C), 89.6 (C), 88.1 (C), 83.6 (C), 74.6 (C), 28.1 (2 \times CH_3); EI-LRMS m/z 391 (M^+ , 82), 372 (20), 345 (100), 305 (76), 277 (57), 245 (23), 207 (78), 59 (47); HRMS calcd for $C_{22}H_{17}NO_2S_2$ 391.0701, found 391.0701. Anal. Calcd for $C_{22}H_{17}NO_2S_2$: C, 67.49; H, 4.38; N, 3.58. Found: C, 67.65; H, 4.41; N, 3.56.

General Procedure for the Synthesis of 4-Alkynyl-2-substituted-1H-indoles 26a–d. To a solution of the corresponding 2,3-dialkynylpropanamide **25** (1 equiv) in DMF (3 mL/mmol) was added an excess of freshly powdered NaOH (3 equiv). The resulting mixture was refluxed under N_2 at 140 °C until the cyclization was completed (6 h), as monitored by GC-MS. CH_2Cl_2 (10 mL) and 0.5 M HCl (10 mL) were added to the cooled reaction mixture. The separated aqueous phase was extracted with CH_2Cl_2 (2 \times 10 mL). The combined organic layers were washed with water (2 \times 30 mL). The organic layer was dried over anhydrous Na_2SO_4 and concentrated at reduced pressure. The remaining residue was purified by column chromatography on silica gel (hexane/EtOAc) to afford the corresponding title compounds **26a–d**.

2-Phenyl-4-(2-phenylethynyl)-1H-indole (26a): Reaction of **25a** (189 mg, 0.5 mmol) with NaOH (60 mg, 1.5 mmol) followed by purification by column chromatography (hexane/EtOAc, 15/1) afforded **26a** (106 mg, 73%) as a pale brown solid: mp 132–134 °C; 1H NMR (300 MHz, $CDCl_3$) δ 8.49 (br s, 1H), 7.73–7.57 (m, 4H), 7.50–7.34 (m, 8H), 7.19 (t, J = 7.7 Hz, 1H), 7.10 (d, J = 2.2 Hz, 1H); ^{13}C NMR (75.4 MHz, $CDCl_3$) δ 138.6 (C), 136.5 (C), 132.1 (C), 131.8 (2 \times CH), 130.9 (C), 129.1 (2 \times CH), 128.5 (2 \times CH), 128.2 (CH), 128.1 (CH), 125.4 (2 \times CH), 124.2 (CH), 123.9 (C), 122.2 (CH), 114.7 (C), 111.6 (CH), 99.8 (CH), 92.1 (C), 88.5 (C); EI-LRMS m/z 293 (M^+ , 100), 207 (12), 189 (10), 146 (12); IR (KBr) 3427, 3056, 1597, 1487, 1451, 1422, 1283, 753, 687 cm^{-1} ; HRMS calcd for $C_{22}H_{15}N$ 293.1204, found 293.1205. Anal. Calcd for $C_{22}H_{15}N$: C, 90.07; H, 5.15; N, 4.77. Found: C, 89.78; H, 5.17; N, 4.76.

4-(Hept-1-ynyl)-2-pentyl-1H-indole (26b): Reaction of **25b** (147 mg, 0.4 mmol) with NaOH (48 mg, 1.2 mmol) followed by purification by column chromatography (hexane/EtOAc, 15/1) afforded **26b** (78 mg, 70%) as a pale brown oil: R_f 0.50 (hexane/EtOAc, 5/1); ^1H NMR (300 MHz, CDCl_3) δ 7.88 (br s, 1H), 7.24–7.13 (m, 2H), 7.03 (t, J = 7.6 Hz, 1H), 6.40 (dd, J = 1.5, 0.6 Hz, 1H), 2.74 (t, J = 7.6 Hz, 2H), 2.52 (t, J = 7.0 Hz, 2H), 1.81–1.61 (m, 4H), 1.61–1.45 (m, 2H), 1.45–1.26 (m, 6H), 0.94 (dt, J = 9.2, 7.2 Hz, 6H); ^{13}C NMR (75.4, CDCl_3) δ 140.6 (C), 135.4 (C), 130.6 (C), 123.2 (CH), 120.8 (CH), 114.7 (C), 110.2 (CH), 99.3 (CH), 92.5 (C), 79.6 (C), 31.6 (CH_2), 31.3 (CH_2), 28.95 (CH_2), 28.86 (CH_2), 28.4 (CH_2), 22.6 (CH_2), 22.4 (CH_2), 19.8 (CH_2), 14.22 (CH_3), 14.16 (CH_3); EI-LRMS m/z 281 (M^+ , 89), 238 (24), 224 (100), 167 (53); HRMS calcd for $\text{C}_{20}\text{H}_{27}\text{N}$ 281.2143, found 281.2141.

2-Cyclohexenyl-4-(2-cyclohexenylethynyl)-1H-indole (26c): Reaction of **25c** (116 mg, 0.3 mmol) with NaOH (36 mg, 0.9 mmol) followed by purification by column chromatography (hexane/EtOAc, 15/1) afforded **26c** (51 mg, 57%) as a colorless oil: R_f 0.40 (hexane/EtOAc, 5/1); ^1H NMR (300 MHz, CDCl_3) δ 8.15 (br s, 1H), 7.23 (dt, J = 7.9, 1.0 Hz, 1H), 7.16 (dd, J = 7.4, 1.0 Hz, 1H), 7.09–7.03 (m, 1H), 6.58 (d, J = 1.8 Hz, 1H), 6.29–6.25 (m, 1H), 6.17–6.12 (m, 1H), 2.52–2.45 (m, 2H), 2.37–2.22 (m, 4H), 2.21–2.14 (m, 2H), 1.84–1.76 (m, 2H), 1.75–1.60 (m, 6H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 140.0 (C), 135.8 (C), 134.7 (CH), 130.5 (C), 130.0 (C), 129.2 (C), 123.5 (CH), 123.3 (CH), 121.9 (CH), 121.3 (C), 115.0 (C), 110.5 (CH), 98.7 (CH), 93.8 (C), 85.9 (C), 29.7 (CH_2), 26.2 (CH_2), 26.0 (CH_2), 25.7 (CH_2), 22.7 (CH_2), 22.6 (CH_2), 22.3 (CH_2), 21.7 (CH_2); EI-LRMS m/z 301 (M^+ , 100), 273 (9), 230 (6), 204 (8), 191 (6); HRMS calcd for $\text{C}_{22}\text{H}_{23}\text{N}$ 301.1830, found 301.1835.

2-(Thiophen-3-yl)-4-(2-(thiophen-3-yl)ethynyl)-1H-indole (26d): Reaction of **25d** (117 mg, 0.3 mmol) with NaOH (36 mg, 0.9 mmol) followed by purification by column chromatography (hexane/EtOAc, 15/1) afforded **26d** (64 mg, 71%) as a white solid: mp 200–202 °C; ^1H NMR (300 MHz, acetone- d_6) δ 10.92 (s, 1H), 7.88 (dd, J = 2.9, 1.3 Hz, 1H), 7.80 (dd, J = 2.9, 1.3 Hz, 1H), 7.69 (dd, J = 5.0, 1.3 Hz, 1H), 7.59 (ddd, J = 6.7, 5.0, 2.9 Hz, 2H), 7.42 (dt, J = 8.0, 1.0 Hz, 1H), 7.33 (dd, J = 5.0, 1.3 Hz, 1H), 7.22 (dd, J = 7.4, 1.0 Hz, 1H), 7.12 (dd, J = 8.0, 7.4 Hz, 1H), 7.03 (dd, J = 2.3, 1.0 Hz, 1H); ^{13}C NMR (100.6, acetone- d_6) δ 137.5 (C), 136.1 (C), 134.9 (C), 131.4 (C), 130.7 (CH), 129.4 (CH), 127.6 (CH), 126.9 (CH), 126.8 (CH), 124.1 (CH), 123.6 (C), 122.4 (CH), 120.8 (CH), 114.8 (C), 112.5 (CH), 99.4 (CH), 88.8 (C), 87.4 (C); EI-LRMS m/z 305 (M^+ , 100), 281 (27), 253 (12), 207 (98), 191 (10); HRMS calcd for $\text{C}_{18}\text{H}_{11}\text{NS}_2$ 305.0333, found 305.0333.

General Procedure for the Synthesis of 4-Alkynyl-2-substituted-1H-indoles 26e–f. A mixture of **1c** (231 mg, 0.9 mmol), $\text{PdCl}_2(\text{MeCN})_2$ (5 mg, 2 mol %), XPhos (26 mg, 3 mol %), and Cs_2CO_3 (880 mg, 2.7 mmol) in anhydrous MeCN (3 mL) was stirred under N_2 at rt for 25 min. Then, the corresponding alkyne (2.7 mmol) was added and the reaction was stirred at reflux for 40 h. AcOEt and water were added to the cooled reaction mixture. The separated aqueous phase was extracted with AcOEt (3 \times 15 mL). The combined organic layers were dried over anhydrous Na_2SO_4 and concentrated at reduced pressure. The remaining residue was purified by column chromatography on silica gel (hexane/EtOAc) to afford the corresponding title compounds **26e,f**.

2-*p*-Tolyl-4-(2-*p*-tolylethynyl)-1H-indole (26e): Reaction of **1c** (231 mg, 0.9 mmol) with *p*-tolylacetylene (313 mg, 2.7 mmol) followed by purification by column chromatography (hexane/EtOAc, 15/1) afforded **26e** (127 mg, 44%) as a brown oil: R_f 0.40 (hexane/EtOAc, 5/1); ^1H NMR (400 MHz, CDCl_3) δ 8.42 (br s, 1H), 7.59 (d, J = 8.2 Hz, 2H), 7.53 (d, J = 8.2 Hz, 2H), 7.36–7.30 (m, 2H), 7.25 (d, J = 7.9 Hz, 2H), 7.18 (d, J = 7.9 Hz, 2H), 7.14 (t, J = 7.9 Hz, 1H), 7.02 (d, J = 1.3 Hz, 1H), 2.39 (d, J = 1.8 Hz, 6H); ^{13}C NMR (100.4, CDCl_3) δ 138.8 (C), 138.3 (C), 138.1 (C), 136.4 (C), 131.7 (2 \times CH), 131.0 (C), 129.9 (2 \times CH), 129.4 (C), 129.2 (2 \times CH), 125.3 (2 \times CH), 124.1 (CH),

122.0 (CH), 120.9 (C), 114.8 (C), 111.3 (CH), 99.3 (CH), 92.2 (C), 87.9 (C), 21.7 (CH_3), 21.4 (CH_3); EI-LRMS m/z 321 (M^+ , 100), 281 (10), 207 (31), 160 (7); HRMS calcd for $\text{C}_{24}\text{H}_{19}\text{N}$ 321.1517, found 321.1518.

2-Hexyl-4-(oct-1-ynyl)-1H-indole (26f): Reaction of **1c** (231 mg, 0.9 mmol) with 1-octyne (398 μL , 2.7 mmol) followed by purification by column chromatography (hexane/EtOAc, 20/1) afforded **26f** (141 mg, 51%) as a brown oil: R_f 0.50 (hexane/EtOAc, 5/1); ^1H NMR (400 MHz, CDCl_3) δ 7.90 (br s, 1H), 7.19 (dt, J = 8.1, 0.9 Hz, 1H), 7.15 (dd, J = 7.4, 0.9 Hz, 1H), 7.02 (dd, J = 8.1, 7.4 Hz, 1H), 6.39 (dd, J = 2.2, 0.9 Hz, 1H), 2.73 (t, J = 7.7 Hz, 2H), 2.51 (t, J = 7.0 Hz, 2H), 1.77–1.63 (m, 4H), 1.57–1.48 (m, 2H), 1.44–1.18 (m, 10H), 0.96–0.87 (m, 6H); ^{13}C NMR (100.6, CDCl_3) δ 140.6 (C), 135.5 (C), 130.7 (C), 123.2 (CH), 120.8 (CH), 114.8 (C), 110.2 (CH), 99.4 (CH), 92.5 (C), 79.7 (C), 31.8 (CH_2), 31.6 (CH_2), 29.25 (CH_2), 29.18 (CH_2), 29.15 (CH_2), 28.8 (CH_2), 28.5 (CH_2), 22.8 (CH_2), 22.7 (CH_2), 19.9 (CH_2), 14.23 (CH_3), 14.23 (CH_3); EI-LRMS m/z 309 (M^+ , 100), 281 (19), 252 (27), 238 (84), 207 (46), 167 (56); HRMS calcd for $\text{C}_{22}\text{H}_{31}\text{N}$ 309.2457, found 309.2456.

Synthesis of 2-Phenyl-4-(2-phenylethynyl)-1H-indole 26a from 3-Bromo-2-iodoanilide 18ca. A mixture of anilide **18ca** (383 mg, 1 mmol), phenylacetylene (408 mg, 4 mmol), $\text{PdCl}_2(\text{PPh}_3)_2$ (70 mg, 10 mol %), and TBAF \cdot $3\text{H}_2\text{O}$ (947 mg, 3 mmol) was stirred under N_2 at 60 °C until complete consumption of starting material, as monitored by GC-MS (5 h). The mixture was washed with water, extracted with Et_2O (3 \times 20 mL), and evaporated under reduced pressure. To remove Pd salts, the crude was filtered through a short pad of silica gel. The residue was treated with an excess of freshly powdered NaOH (120 mg, 3 mmol) in DMA (3 mL) under N_2 at 140 °C for 8 h. The formation of the indole was monitored by GC-MS. CH_2Cl_2 (20 mL) and 0.5 M HCl (20 mL) were added to the cooled reaction mixture. The separated aqueous phase was extracted with CH_2Cl_2 (2 \times 20 mL). The combined organic layers were washed with water (2 \times 30 mL). The organic layer was dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The remaining residue was purified by column chromatography on silica gel (hexane/EtOAc, 10/1) to afford **26a** (152 mg, 52%), whose spectroscopic data have been reported above.

Synthesis of 4-(Hex-1-ynyl)-2-phenyl-1H-indole 26g. A mixture of 4-bromo-2-phenyl-1H-indole **24a** (81 mg, 0.3 mmol), phenylacetylene (46 mg, 0.45 mmol), $\text{PdCl}_2(\text{PPh}_3)_2$ (12 mg, 6 mol %), CuI (6 mg, 10 mol %), and Et_2NH (33 mg, 0.45 mmol) in DMF (2 mL) was stirred under N_2 at 80 °C for 17 h. CH_2Cl_2 (20 mL) and 0.5 M HCl (20 mL) were added to the cooled reaction mixture. The separated aqueous phase was extracted with CH_2Cl_2 (3 \times 10 mL). The combined organic layers were washed with water (2 \times 20 mL). The organic layer was dried over anhydrous Na_2SO_4 and concentrated at reduced pressure. The remaining residue was purified by column chromatography on silica gel (hexane/EtOAc, 8/1) to afford **26g** (63 mg, 77%) as a brown solid: mp 33–35 °C; ^1H NMR (300 MHz, CDCl_3) δ 8.39 (br s, 1H), 7.69 (d, J = 7.3 Hz, 2H), 7.45 (t, J = 7.7 Hz, 2H), 7.33 (d, J = 7.3 Hz, 2H), 7.21 (d, J = 7.3 Hz, 1H), 7.11 (t, J = 7.7 Hz, 1H), 6.99–6.97 (m, 1H), 2.55 (t, J = 6.9 Hz, 2H), 1.75–1.63 (m, 2H), 1.62–1.50 (m, 2H), 1.00 (t, J = 7.2 Hz, 3H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 138.2 (C), 136.5 (C), 132.3 (C), 131.1 (C), 129.2 (2 \times CH), 128.0 (CH), 125.3 (2 \times CH), 123.9 (CH), 122.3 (CH), 115.8 (C), 110.7 (CH), 99.9 (CH), 93.2 (C), 79.3 (C), 31.2 (CH_2), 22.2 (CH_2), 19.6 (CH_2), 13.9 (CH_3); EI-LRMS m/z 273 (M^+ , 89), 258 (16), 244 (38), 230 (100), 202 (29), 127 (23); HRMS calcd for $\text{C}_{20}\text{H}_{19}\text{N}$ 273.1517, found 273.1511. Anal. Calcd for $\text{C}_{20}\text{H}_{19}\text{N}$: C, 87.87; H, 7.01; N, 5.12. Found: C, 87.55; H, 6.98; N, 5.10.

General Procedure for the Synthesis of 4-Halo-3-(phenylthio)-2-substituted-1H-indoles 27a,b from Anilides 18. A mixture of the corresponding anilide **18aa** or **18ba** (0.4 mmol),

alkyne (0.6 mmol), PdCl₂(PPh₃)₂ (8 mg, 3 mol %), CuI (4 mg, 5 mol %), and Et₃NH (44 mg, 0.6 mmol) in DMA (2 mL) was stirred for 2 h at 80 °C, and then freshly powdered NaOH (160 mg, 4 mmol) was added. The resulting mixture was heated under N₂ at 140 °C for 3 h (until the cyclization was completed as monitored by GC-MS). Then, Ph₂S₂ (105 mg, 0.48 mmol) was added and the reaction mixture was stirred overnight at 140 °C. Then, CH₂Cl₂ (10 mL) and 0.5 M HCl (10 mL) were added to the cooled reaction mixture. The separated aqueous phase was extracted with CH₂Cl₂ (3 × 10 mL). The combined organic layers were washed with water (2 × 30 mL), dried over anhydrous Na₂SO₄, and concentrated under reduced pressure. The remaining residue was purified by column chromatography on silica gel (hexane/EtOAc, 6/1) to afford the title compounds 27.

4-Fluoro-2-pentyl-3-(phenylthio)-1H-indole (27a): Reaction of 18aa (129 mg, 0.4 mmol) with 1-heptyne (58 mg, 0.6 mmol) and then with Ph₂S₂ afforded 27a (92 mg, 74%) as a brown solid: mp 78–80 °C; ¹H NMR (300 MHz, CDCl₃) δ 8.50 (br s, 1H), 7.26–7.02 (m, 7H), 6.76 (ddd, *J* = 10.9, 7.5, 1.1 Hz, 1H), 2.89 (t, *J* = 7.5 Hz, 2H), 1.70–1.60 (m, 2H), 1.34–1.24 (m, 4H), 0.84 (t, *J* = 7.0 Hz, 3H); ¹³C NMR (75.4 MHz, CDCl₃) δ 156.4 (d, *J* = 248.9 Hz, C), 146.1 (C), 140.3 (C), 138.2 (C), 128.7 (2 × CH), 125.8 (2 × CH), 124.7 (CH), 122.5 (d, *J* = 7.8 Hz, CH), 118.7 (d, *J* = 17.3 Hz, C), 107.1 (d, *J* = 3.9 Hz, CH), 106.4 (d, *J* = 19.2 Hz, CH), 97.0 (d, *J* = 2.3 Hz, C), 31.5 (CH₂), 29.3 (CH₂), 26.2 (CH₂), 22.5 (CH₂), 14.0 (CH₃); EI-LRMS *m/z* 313 (M⁺, 100), 256 (48), 222 (16), 148 (24), 69 (16); HRMS calcd for C₁₉H₂₀FNS 313.1300, found 313.1291. Anal. Calcd for C₁₉H₂₀FNS: C, 72.81; H, 6.43; N, 4.47. Found: C, 73.01; H, 6.47; N, 4.45.

4-Chloro-2-phenyl-3-(phenylthio)-1H-indole (27b): Reaction of 18ba (136 mg, 0.4 mmol) with phenylacetylene (61 mg, 0.6 mmol) and then with Ph₂S₂ afforded 27b (103 mg, 77%) as a white solid: mp 131–133 °C; ¹H NMR (300 MHz, CDCl₃) δ 8.70 (br s, 1H), 7.66 (dd, *J* = 6.6, 2.9 Hz, 2H), 7.43–7.38 (m, 3H), 7.36–7.29 (m, 1H), 7.26–7.05 (m, 7H); ¹³C NMR (75.4 MHz, CDCl₃) δ 144.3 (C), 141.4 (C), 137.3 (C), 131.0 (C), 129.2 (CH), 128.9 (2 × CH), 128.7 (4 × CH), 127.0 (C), 126.8 (C), 125.3 (2 × CH), 124.6 (CH), 123.7 (CH), 122.8 (CH), 110.2 (CH), 98.8 (C); EI-LRMS *m/z* 337 (M⁺ + 2, 22), 335 (M⁺, 51), 299 (16), 267 (15), 223 (100), 190 (12), 121 (22), 119 (23), 77 (86), 51 (67); HRMS calcd for C₂₀H₁₄ClNS 335.0535, found 335.0534.

General Procedure for the Synthesis of 4-Halo-3-phenylsulfanyl-1H-indoles 27c,d from 3-Halo-2-alkynylpropanamides 22. An excess of freshly powdered NaOH (120 mg, 3 mmol) was added to a solution of the corresponding 3-halo-2-alkynylpropanamide 22bb or 22cb (0.3 mmol) in DMA (1 mL). The resulting mixture was refluxed under N₂ at 140 °C until the cyclization was completed (2–3 h) (monitored by GC-MS). Then, Ph₂S₂ (78 mg, 0.36 mmol) was added to the mixture and the reaction was stirred overnight at 140 °C. CH₂Cl₂ (10 mL) and 0.5 M HCl (10 mL) were added to the cooled reaction mixture. The separated aqueous phase was extracted with CH₂Cl₂ (3 × 10 mL). The combined organic layers were washed with water (2 × 30 mL). The organic layer was dried over anhydrous Na₂SO₄ and concentrated at reduced pressure. The remaining residue was purified by column chromatography on silica gel (hexane/EtOAc, 6/1) to afford the title compounds 27.

2-Butyl-4-chloro-3-(phenylthio)-1H-indole (27c): Reaction of 22bb (88 mg, 0.3 mmol) with NaOH for 3 h at 140 °C and then with Ph₂S₂ afforded 27c (74 mg, 79%) as a white solid: mp 76–78 °C; ¹H NMR (300 MHz, CDCl₃) δ 8.47 (br s, 1H), 7.25 (ddd, *J* = 6.5, 2.4, 0.4 Hz, 1H), 7.22–7.15 (m, 2H), 7.12–7.03 (m, 5H), 2.91 (t, *J* = 7.6 Hz, 2H), 1.68–1.56 (m, 2H), 1.41–1.27 (m, 2H), 0.99 (t, *J* = 7.3 Hz, 3H); ¹³C NMR (75.4 MHz, CDCl₃) δ 147.5 (C), 141.3 (C), 136.9 (C), 128.7 (2 × CH), 126.3 (C), 126.1 (C), 125.4 (2 × CH), 124.4 (CH), 122.6 (CH), 122.2 (CH), 109.8 (CH), 98.6 (C), 31.6 (CH₂), 26.2 (CH₂), 22.5 (CH₂), 13.9 (CH₃); EI-LRMS *m/z* 317 (M⁺ + 2, 39), 315 (M⁺, 83),

272 (22), 236 (100), 204 (50), 164 (96), 119 (23), 77 (59); HRMS calcd for C₁₈H₁₈ClNS 315.0848, found 315.0849.

4-Bromo-2-butyl-3-(phenylthio)-1H-indole (27d): Reaction of 22cb (101 mg, 0.3 mmol) with NaOH for 2.5 h and then with Ph₂S₂ afforded 27d (78 mg, 73%) as a pale brown solid: mp 86–88 °C; ¹H NMR (300 MHz, CDCl₃) δ 8.42 (br s, 1H), 7.30 (tdd, *J* = 8.0, 4.4, 0.9 Hz, 2H), 7.22–7.15 (m, 2H), 7.09–6.99 (m, 4H), 2.92 (t, *J* = 7.7 Hz, 2H), 1.67–1.56 (m, 2H), 1.41–1.26 (m, 2H), 0.89 (td, *J* = 7.1, 0.7 Hz, 3H); ¹³C NMR (75.4 MHz, CDCl₃) δ 147.9 (C), 141.5 (C), 136.7 (C), 128.7 (2 × CH), 127.3 (C), 125.7 (CH), 125.3 (2 × CH), 124.4 (CH), 123.0 (CH), 113.9 (C), 110.4 (CH), 99.4 (C), 31.6 (CH₂), 26.3 (CH₂), 22.5 (CH₂), 13.9 (CH₃); EI-LRMS *m/z* 361 (M⁺ + 2, 25), 359 (M⁺, 25), 236 (100), 223 (27), 208 (30), 77 (60), 51 (59); HRMS calcd for C₁₈H₁₈BrNS 359.0343, found 359.0346. Anal. Calcd for C₁₈H₁₈BrNS: C, 60.00; H, 5.04; N, 3.89. Found: C, 60.15; H, 5.02; N, 3.91.

General Procedure for the Synthesis of 4-(Furan-2-yl)-2-substituted-1H-indoles 28. A mixture of premilled Pd(OAc)₂ (1.3 mg, 2 mol %) and XPhos (5.7 mg, 4 mol %), CsF (100 mg, 0.66 mmol), the corresponding 4-chloroindole 23a or 23b (0.3 mmol), and tributyl(furan-2-yl)stannane (118 mg, 0.33 mmol) in DME (0.8 mL) were stirred under N₂ at 80 °C for 3 h (the completion of the coupling reaction was monitored by GC-MS). The reaction mixture was allowed to cool to rt and the crude was filtered through Celite and washed with EtOAc (20 mL). The solvent was concentrated under reduced pressure and the residue was purified by column chromatography on silica gel (hexane/EtOAc) to afford the title compounds 28.

4-(Furan-2-yl)-2-phenyl-1H-indole (28a): Reaction of 23a (68 mg, 0.3 mmol) followed by purification by column chromatography (hexane/EtOAc, 8/1) afforded 28a (71 mg, 91%) as a colorless oil: *R*_f 0.31 (hexane/AcOEt, 8/1); ¹H NMR (300 MHz, CDCl₃) δ 8.43 (br s, 1H), 7.73–7.64 (m, 3H), 7.58 (dd, *J* = 6.7, 1.6 Hz, 1H), 7.47 (t, *J* = 7.6 Hz, 2H), 7.40–7.35 (m, 2H), 7.31–7.24 (m, 2H), 6.92 (d, *J* = 3.3 Hz, 1H), 6.63 (dd, *J* = 3.3, 1.8 Hz, 1H); ¹³C NMR (75.4 MHz, CDCl₃) δ 154.6 (C), 141.8 (CH), 138.5 (C), 137.6 (C), 132.1 (C), 129.0 (2 × CH), 127.9 (CH), 125.3 (2 × CH), 124.9 (C), 123.0 (C), 122.4 (CH), 116.9 (CH), 111.7 (CH), 110.5 (CH), 106.5 (CH), 100.2 (CH); EI-LRMS *m/z* 259 (M⁺, 100), 230 (40), 202 (8), 127 (8); HRMS calcd for C₁₈H₁₃NO 259.0997, found 259.0994.

2-Butyl-4-(furan-2-yl)-1H-indole (28b): Reaction of 23b (62 mg, 0.3 mmol) followed by purification by column chromatography (hexane/EtOAc, 7/1) afforded 28b (66 mg, 92%) as a white solid: mp 50–52 °C; ¹H NMR (300 MHz, CDCl₃) δ 7.85 (br s, 1H), 7.61 (d, *J* = 1.8 Hz, 1H), 7.56–7.52 (m, 1H), 7.23–7.20 (m, 2H), 6.85 (d, *J* = 3.3 Hz, 1H), 6.75 (s, 1H), 6.60 (ddd, *J* = 3.3, 1.8, 0.6 Hz, 1H), 2.76 (t, *J* = 7.6 Hz, 2H), 1.79–1.68 (m, 2H), 1.52–1.39 (m, 2H), 1.01 (t, *J* = 7.3 Hz, 3H); ¹³C NMR (75.4 MHz, CDCl₃) δ 154.8 (C), 141.5 (CH), 141.0 (C), 136.6 (C), 124.4 (C), 122.1 (C), 121.0 (CH), 116.4 (CH), 111.6 (CH), 110.0 (CH), 106.2 (CH), 99.6 (CH), 31.4 (CH₂), 28.1 (CH₂), 22.5 (CH₂), 14.0 (CH₃); EI-LRMS *m/z* 239 (M⁺, 56), 196 (100), 167 (14), 154 (4); HRMS calcd for C₁₆H₁₇NO, 239.1310 found 239.1319. Anal. Calcd for C₁₆H₁₇NO: C, 80.30; H, 7.16; N, 5.85. Found: C, 80.17; H, 7.19; N, 5.83.

General Procedure for the Synthesis of 4-Aryl-1H-indoles 29. In a Schlenk tube 4-bromo-1H-indole 24a or 24b (1 equiv), phenylboronic acid (1.5 equiv), and [Pd(PPh₃)₄] (3 mol %) were introduced under N₂. Then, DME (15 mL/mmol) was added followed by the addition of Na₂CO₃ (1.5 equiv) in H₂O (7 mL/mmol). The reaction mixture was vigorously stirred and heated at 80 °C overnight (the progress of the reaction was monitored by GC-MS). Then, CH₂Cl₂ (10 mL) and H₂O were added to the cooled reaction mixture. The separated aqueous phase was extracted with CH₂Cl₂ (3 × 20 mL). The combined organic extracts were dried over anhydrous Na₂SO₄ and evaporated under reduced pressure. The residue was purified by column chromatography (hexane/EtOAc, 8/1) on silica gel to afford the title compounds 29.

2,4-Diphenyl-1H-indole (29a): Reaction of **24a** (81 mg, 0.3 mmol) with phenylboronic acid (55 mg, 0.45 mmol) and $[\text{Pd}(\text{PPh}_3)_4]$ (10 mg, 3 mol %) followed by the addition of Na_2CO_3 (48 mg, 0.45 mmol) in H_2O (2 mL) afforded **29a** (74 mg, 93%) as a white solid: mp 205–207 °C (lit.⁶¹ mp 209 °C); ^1H NMR (300 MHz, CDCl_3) δ 8.42 (br s, 1H), 7.89–7.82 (m, 2H), 7.67 (d, J = 8.1 Hz, 2H), 7.61 (t, J = 7.7 Hz, 2H), 7.53–7.44 (m, 3H), 7.43–7.25 (m, 4H), 7.12 (d, J = 2.2 Hz, 1H); ^{13}C NMR (75.4 MHz, CDCl_3) δ 141.3 (C), 138.3 (C), 137.3 (C), 134.5 (C), 132.2 (C), 129.1 (2 \times CH), 128.9 (2 \times CH), 128.7 (2 \times CH), 127.8 (CH), 127.6 (C), 127.1 (CH), 125.2 (2 \times CH), 122.7 (CH), 120.2 (CH), 110.2 (CH), 99.6 (CH); EI-LRMS m/z 269 (M^+ , 100), 190 (10), 165 (53), 133 (11), 77 (28); HRMS calcd for $\text{C}_{20}\text{H}_{15}\text{N}$ 269.1204, found 269.1204.

2-Butyl-4-phenyl-1H-indole (29b): Reaction of **24b** (200 mg, 0.8 mmol) with phenylboronic acid (146 mg, 1.2 mmol) and $[\text{Pd}(\text{PPh}_3)_4]$ (24 mg, 3 mol %) followed by the addition of Na_2CO_3 (127 mg, 1.2 mmol) in H_2O (6 mL) afforded **29b** (163 mg, 82%) as a pale brown oil: R_f 0.64 (hexane/EtOAc, 6/1); ^1H NMR (400 MHz, CDCl_3) δ 7.88–7.83 (m, 3H), 7.60 (t, J = 7.6 Hz, 2H), 7.48 (t, J = 7.6 Hz, 1H), 7.33–7.30 (m, 3H), 6.56 (d, J = 1.7 Hz, 1H), 2.77 (t, J = 7.6 Hz, 2H), 1.81–1.71 (m, 2H), 1.54–1.44 (m, 2H), 1.05 (t, J = 7.3 Hz, 3H); ^{13}C NMR (100.6 MHz, CDCl_3) δ 141.6 (C), 140.6 (C), 136.3 (C), 133.4 (C), 128.8 (2 \times CH), 128.5 (2 \times CH), 127.0 (C), 126.8 (CH), 121.3 (CH), 119.6 (CH), 109.7 (CH), 98.9 (CH), 31.4 (CH_2), 28.0 (CH_2), 22.5 (CH_2), 14.0 (CH_3); EI-LRMS m/z 249 (M^+ , 23), 206 (100), 178 (15), 165 (16); HRMS calcd for $\text{C}_{18}\text{H}_{19}\text{N}$ 249.1517, found 249.1528.

■ ASSOCIATED CONTENT

Supporting Information. Copies of ^1H and ^{13}C NMR spectra of all products. This material is available free of charge via the Internet at <http://pubs.acs.org>.

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■ ACKNOWLEDGMENT

We thank the Ministerio de Ciencia e Innovación (MICINN) and FEDER (CTQ2010-15358) and Junta de Castilla y León (BU021A09 and GR-172) for financial support. V.G. thanks Ministerio de Educación y Ciencia for a MEC-FPU predoctoral fellowship. P.G.-G. and M.A.F.-R. thank MICINN for “Juan de la Cierva” and “Ramón y Cajal” contracts.

DEDICATION

⁵This paper is dedicated to the memory of Prof. Rafael Suau.

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