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Modular De Novo Synthesis of Unsymmetrical BODIPY Dyes possessing four different Aryl Substituents

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Abstract

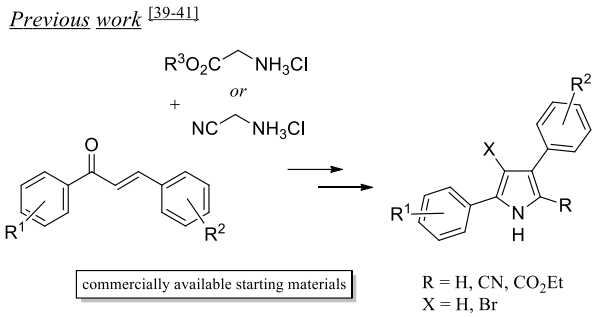
A modular synthesis of unsymmetrical BODIPY dyes based on a [6π]-electrocyclization to construct the two pyrrole rings is presented. The products carry four aryl moieties in positions 1, 3, 5, and 7 which can be freely selected as well as optional substitution in positions 2 and 8. The method employs acetophenones, benzaldehydes as well as glycine nitrile or glycine ethyl ester as the key building blocks.

Introduction

4,4-Difluoro-4-bora-3a,4a-diaza-*s*-indacenes (BODIPYs) are fluorescence dyes with remarkable properties, such as high fluorescence quantum yields, high extinction coefficients, good electron transfer properties, thermal, chemical and photochemical stability, as well as a generally good solubility.[1] Moreover, lowering the HOMO-LUMO gap of the BODIPY dyes by the introduction of aromatic substituents has shown to cause shift of its emission wavelength to the near Infrared

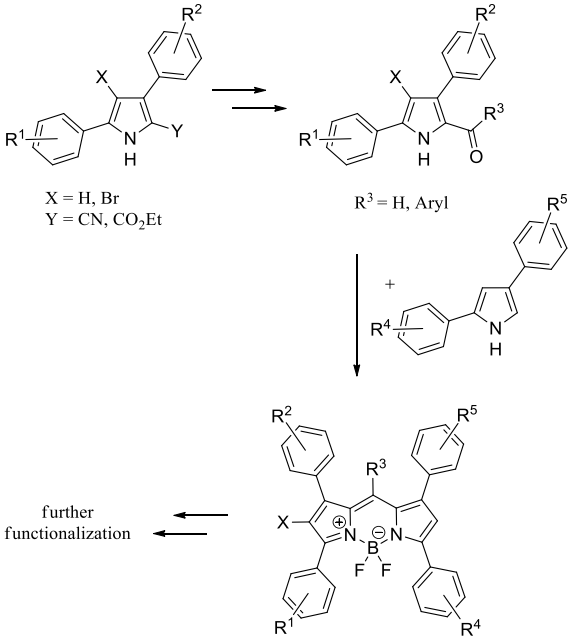
region. [2-6] They have found numerous applications in photodynamic therapy,[7-9] biological labeling[10-12] and fluorescence sensing,[13-15] and the possibility of varying substituent patterns confers widely tunable spectral characteristics.[16,17] Syntheses of symmetrical BODIPY dyes[18-23] as well as the functionalization of the BODIPY-core have been previously described.[24-34] Several functionalization methods allow the desymmetrization of symmetrical BODIPY dyes,[35,36] e.g. by stepwise halogenation and subsequent cross coupling reactions.[37-39] In contrast, the introduction of more than one symmetry-breaking substituent requires a modular synthesis from two non-identical pyrrole units and is generally underused and mostly relies on commercial coupling partners of limited structural diversity.[1,40-42] The synthesis of non-symmetrically substituted BODIPYs is e.g. desirable for generating specific fluorescent ligands for biomolecules or for the extension of electronic tuning properties.[43-45] Here, we demonstrate the synthesis of non-symmetrical 1,3,5,7-tetraaryl-substituted BODIPY dyes through a modular approach in which both pyrrole units are de novo synthesized in a [6π]-electrocyclization developed earlier in our laboratory.[46-48] A major advantage of this method is the possibility of introducing at will four different substituents in the BODIPY system in a simple and efficient manner and through a short convergent synthetic sequence.

This cyclocondensation uses chalcones and glycine derivatives as the starting substrates and converts them in high yield to 3,5-disubstituted pyrrole-2-carboxylates[46] and pyrrole-2-carbonitriles or 2,4-disubstituted pyrroles.[47,48] The syntheses of pyrrole-2-carboxylates and pyrrole-2-carbonitriles were performed in a one-pot procedure which can be extended by an in situ halogenation of the pyrrole core. Chalcones are readily available through aldol condensation from aryl ketones and aromatic aldehydes commercially available with wide structural variety.



Scheme 1. Synthesis of Pyrroles from Enones.

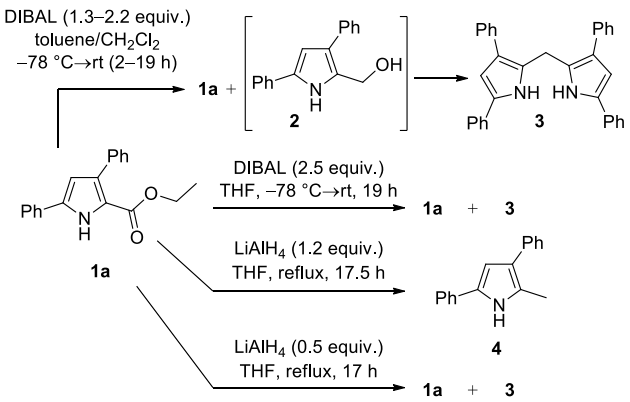
To join the two individual pyrrole units in a Friedel-Crafts reaction, the pyrrole-2-carboxylates and -nitriles are converted into the more electrophilic pyrrole-2-carbaldehydes and 2-acylpyrroles. The facile access to halogenated pyrroles allows for a further functionalization of the BODIPY core at a later stage.



Scheme 2. Modular Synthesis of BODIPYs.

Results and Discussion

To obtain the desired pyrrole-2-carbaldehydes **7a-g** the DIBAL reduction of pyrrole-2-carboxylate **1a** was attempted first. Unfortunately, reduction of ethyl ester **1a** in toluene or dichloromethane did not produce the corresponding aldehyde but rather afforded small amount of dipyrromethane **3** resulting from the formation of alcohol intermediate **2** which dimerizes in a Friedel-Crafts/retro-Friedel-Crafts sequence mediated by the Lewis-acidic reductant (Scheme 3). DIBAL reduction in THF also gave dipyrromethane **3**, whereas $NaBH_4$ reduction of **1a** did not result in any conversion. Reduction with $LiAlH_4$ was tested in order to furnish alcohol **2** without accompanying dimerization, which should then be oxidized to yield the desired carbaldehyde. Employing 1.2 equivalents of $LiAlH_4$, the 2-methyl derivative **4** was obtained, while smaller amounts of $LiAlH_4$ again led to the formation of dipyrromethane **3**.

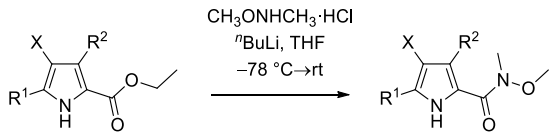


Scheme 3. DIBAL- and $LiAlH_4$-reduction of **1a**.

Based on these results, we chose to synthesize the Weinreb amides, from which the carbaldehydes should be easily obtained via $LiAlH_4$ or DIBAL reduction. Furthermore, the Weinreb amides could alternatively be transformed into the corresponding ketones through reaction with organolithium or magnesium compounds. Reaction of **1a** with *N*,*O*-Dimethylhydroxylamine hydrochloride (2 equiv) and isopropylmagnesium chloride in THF gave

a mixture of starting material **1a**, amide **5a**, and a high percentage of a by-product, which was later identified as urea **6** (Scheme 4). Employing 3 equivalents of deprotonated *N*,*O*-dimethylhydroxylamine, Weinreb amides **5a–g** could be obtained in yields up to 89% (table 1).

Table 1. Synthesis of Weinreb amides from pyrrole-2-carboxylates **1a–g**.



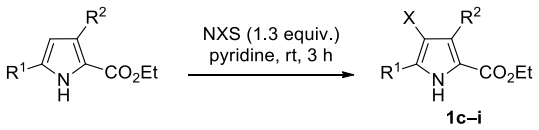
1a–g **5a–g**

entry	R^1	R^2	X	Yield %	Compound
1	Ph	Ph	H	89	**5a**
2	Ph	Ph	Br	75	**5b**
3	Ph	Ph	I	68	**5c**
4	2-Naph	Ph	Br	68	**5d**
5	4-F-C_6H_4	4-MeO-C_6H_4	Br	85	**5e**
6	4-F-C_6H_4	2-Cl-C_6H_4	Br	44 (89 brsm) [a]	**5f**
7	4-Cl-C_6H_4	3-NO_2-C_6H_4	Br	53	**5g**

[a] brsm: *based on recovered starting material.*.

The starting pyrrole-2-carboxylates **1a–b** were synthesized via the previously published one-pot procedure.[46] Halogenated pyrrole-2-carboxylates **1c–i** were synthesized from pyrrole-2-carboxylates by direct halogenation of the corresponding esters using *N*-halosuccinimides (Table 2).

Table 2. Halogenation to generate pyrrole-2-carboxylates **1c–i**.

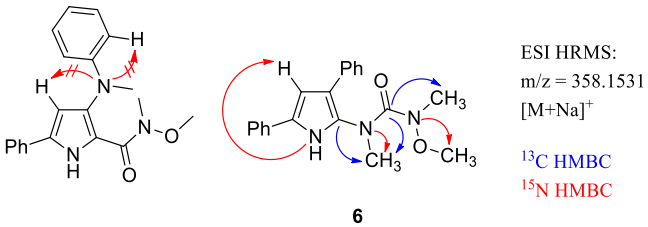


1c–i

entry	R^1	R^2	X	Yield %	Compound
1	Ph	Ph	I	91	**1c**
2	2-Naph	Ph	Br	75	**1d**
3	4-F-C_6H_4	4-MeO-C_6H_4	Br	78	**1e**
4	4-F-C_6H_4	2-Cl-C_6H_4	Br	36	**1f**
5	4-Cl-C_6H_4	3-NO_2-C_6H_4	Br	77	**1g**
6	4-Cl-C_6H_4	3-NO_2-C_6H_4	I	54[a]	**1h**
7	3,4-$(MeO)_2$-C_6H_3	3,4-$(MeO)_2$-C_6H_3	Br	79	**1i**

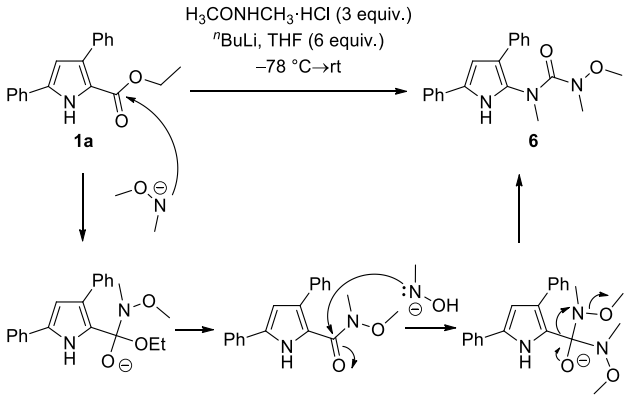
[a] 1.9 equiv of NIS were added in 3 portions.

When batch sizes were increased (ca. 4 mmol), the same side reaction caused by the excess of deprotonated *N*,*O*-dimethylhydroxylamine was observed (Scheme 4). A possible explanation for this reaction is the nucleophilic attack of excess *N*,*O*-dimethylhydroxylamide at the carbonyl group to produce a tetrahedral intermediate which undergoes 1,2-migration of the pyrrole core while cleaving the weak N–O bond and the expulsion of methanolate to produce the urea derivative **6** (Scheme 5).



6

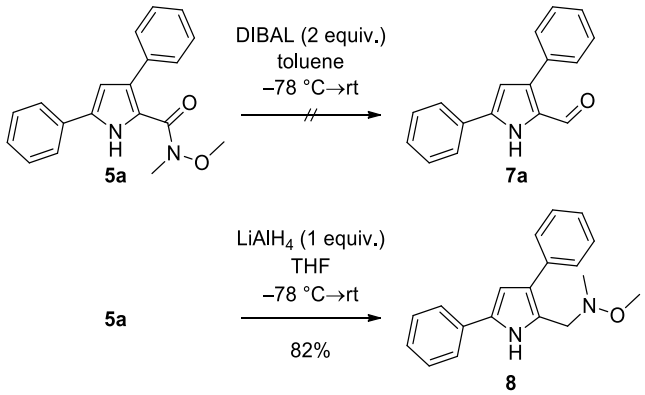
Scheme 4. Structure elucidation of side product **6**.



Scheme 5. Possible mechanism for the formation of urea **6**.

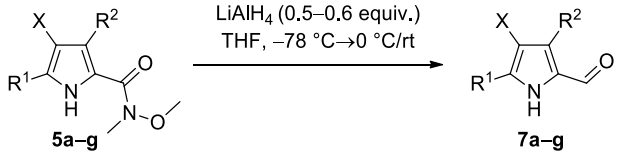
While reduction of **5a** with DIBAL did not furnish aldehyde **7a** but rather a complex product mixture, the use of $LiAlH_4$ (1.0 equiv) gave *N*,*O*-dimethylhydroxylamine **8** (Scheme 6). Smaller amounts (0.6 equiv) of the same reductant gave a mixture of **5a**, **7a** and **8** in a ratio of 1:2.5:3.6. Addition of the amide **5a** to a solution of $LiAlH_4$ (3 equiv) in THF (–78 °C) and raising the temperature to –30 °C within 2.5 h gave better results (table 3, entry 2).

Employing 0.6 equivalents of $LiAlH_4$, Weinreb amides **5b**–**g** were easily transformed into the corresponding pyrrole-2-carbaldehydes **7b**–**g** in yields ranging between 42 and 62% (table 3). The synthesis via the Weinreb amides was particularly suitable for preparing the 4-halogenated pyrrole-2-carbaldehydes, which could not be accomplished by any other method tested.



Scheme 6. Attempted reduction of Weinreb amide **5a**.

Table 3. Synthesis of pyrrole-2-carbaldehydes **7a–g** from Weinreb amides **5a–g**.



entry	R^1	R^2	X	Yield %	Compound
1	Ph	Ph	H	35[a]/[b]	**7a**
2	Ph	Ph	H	70[a]/[c]	**7a**
3	Ph	Ph	Br	62	**7b**
4	Ph	Ph	I	42 (57 brsm) [d]	**7c**
5	2-Naph	Ph	Br	48	**7d**
6	4-F-C_6H_4	4-MeO-C_6H_4	Br	57	**7e**
7	4-F-C_6H_4	2-Cl-C_6H_4	Br	53 (62 brsm) [d]	**7f**
8	4-Cl-C_6H_4	3-NO_2-C_6H_4	Br	55	**7g**

[a] yield judged by ^{1}H NMR. [b] Mixture of **5a**, **8a** and **7** was yielded (1:2.5:3.6). [c] 3 equiv $LiAlH_4$, warming to –30 °C. [d] brsm: *based on recovered starting material*.

The conversion of Weinreb amides into the corresponding ketones was attempted using AllylMgBr, PhMgBr, and PhLi in THF, unfortunately without any appreciable conversion.

Based on the methods developed by Bergner et al. and Kücükdisli et al.[47,48] two further cyanopyrrolines, 2,4-disubstituted pyrroles and pyrrole-2-carbonitriles were synthesized (table 4). Enone **9b** could not be transformed into the cyanopyrroline, since elimination of HCN already took place during the cyclocondensation. Microwave-induced elimination of HCN worked for pyrrole **11d**, but this compound could not be purified due to its instability.

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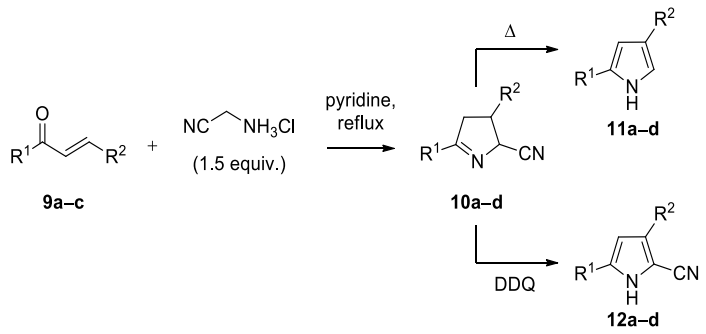
Table 4. Synthesis of cyanopyrrolines and pyrroles.

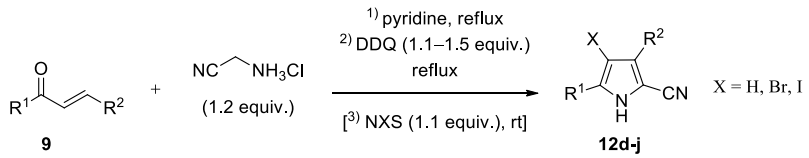


Starting material	R^1	R^2	Yield %	Product
9a	3,4-$(MeO)_2$-C_6H_3	3,4-$(MeO)_2$-C_6H_3	45[a]	**10a**
9b	4-NO_2-C_6H_4	4-NO_2-C_6H_4	–[b]	**10b**
9c	Ph	Indol-3-yl	41	**10c**
10a	3,4-$(MeO)_2$-C_6H_3	3,4-$(MeO)_2$-C_6H_3	44	**11a**
10c	Ph	Indol-3-yl	41	**11c**
10d	3-NO_2-C_6H_4	4-Cl-C_6H_4	–[c]	**11d**
10a	3,4-$(MeO)_2$-C_6H_3	3,4-$(MeO)_2$-C_6H_3	50	**12a**
10c	Ph	Indol-3-yl	56	**12c**

[a] 1.75 equiv aminoacetonitrile hydrochloride/7 h. [b] Concomitant HCN-elimination took place. [c] Purification unsuccessful.

Furthermore, the procedure by Kücükdisli et al.[47,48] was modified for implementation in a one-pot procedure. Therefore the amounts of aminoacetonitrile hydrochloride were reduced to 1.2 equivalents. The one-pot procedure could also be extended by an in situ bromination with NBS while the 4-iodo-derivative was obtained by direct halogenation of **12d**. The results are summarized in table 5.

Table 5. One-pot synthesis of pyrrole-2-carbonitriles.



9 12d-j

entry	R^1	R^2	X	Yield %	Compound
1	Ph	Ph	H	60	**12d**
2	Ph	Ph	Br	40	**12e**
3	Ph	Ph	I	82	**12f**[a]
4	2-Naph	Ph	H	49	**12g**
5	4-Cl-C_6H_4	3-NO_2-C_6H_4	H	53	**12h**
6	Ph	2,3-Cl_2-C_6H_3	H	47	**12i**
7	4-F-C_6H_4	4-MeO-C_6H_4	H	38	**12j**

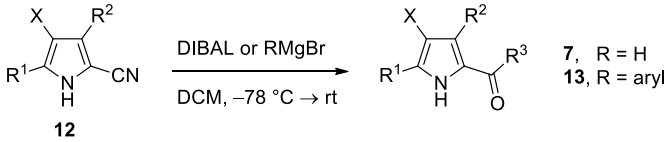
[a] direct halogenation of **12d**.

The conversion of pyrrole-2-carbonitriles **12** into pyrrole-2-carbaldehydes **7** with DIBAL proceeded smoothly in the case of the phenyl-substituted compound **12d** while lower yields were observed for more complex substitution patterns (table 6). An encountered difficulty was the surprisingly high stability of the imine intermediates to hydrolysis. In addition, the sensitivity of the aldehydes towards oxidative and acidic conditions (homocondensation) complicated their handling and further reduced the overall yields of the procedure. Treatment of 4-halogenated pyrrole-2-carbonitriles with DIBAL resulted in complex mixtures of undesired products.

The conversion of pyrrole-2-carbonitriles **12d,e,h,i** into the corresponding ketones **13a-e** could be achieved with the corresponding Grignard reagents, while organolithium reagents did not result in any appreciable conversion. Possibly, a certain Lewis acidity of the metal is required in this case. The resulting imines had to be hydrolyzed with 4N sodium hydroxide/ethanol/80 °C to

yield the ketones **13a–e** in yields ranging from 55 to 87% while acid hydrolysis was unsuccessful.

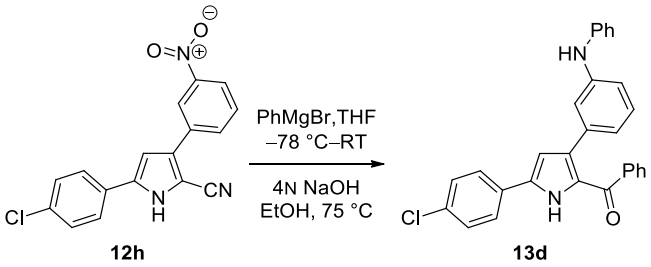
Table 6. Synthesis of pyrrole-2-carbaldehydes **7** and ketones **13** from pyrrole-2-carbonitriles **12**.



entry	R^1	R^2	R^3	X	Yield %	Compound
1	Ph	Ph	H	H	67	**7a**
2	Ph	Ph	Ph	H	62[a]	**13a**
3	Ph	Ph	H	Br	–[b]	**7b**
4	Ph	Ph	Ph	Br	88	**13b**
5	Ph	Ph	Thienyl	Br	82	**13c**
6	Ph	Ph	Vinyl	Br	–	
7	2-Naph	Ph	H	H	26	**7h**
8	4-F-C_6H_4	4-MeO-C_6H_4	H	H	43	**7i**
9	4-F-C_6H_4	2-Cl-C_6H_4	H	H	41	**7j**
10	4-Cl-C_6H_4	3-NO_2-C_6H_4	Ph	H	–[c]	**13d**
11	Ph	2,3-Cl_2-C_6H_3	H	H	54	**7k**
12	Ph	2,3-Cl_2-C_6H_3	Ph	H	75	**13e**
13	3,4-$(MeO)_2$-C_6H_3	3,4-$(MeO)_2$-C_6H_3	H	H	30	**7l**
14	Ph	Indol-3-yl	H	H	35	**7m**

[a] Two-step synthesis, imine was purified via column chromatography. [b] A complex mixture was obtained. [c] Side reaction, see Scheme 7.

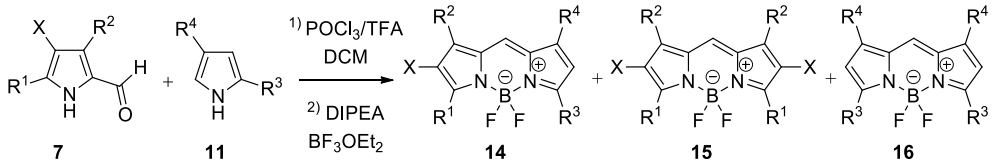
The reaction of **12h** with phenylmagnesium bromide (4 equiv) not only led to the ketone formation, but also the nitro substituent was reduced to the secondary amine in this case (Scheme 7).[49]



Scheme 7. Reaction of **12h** with PhMgBr.

For the BODIPY synthesis, pyrrole-2-carbaldehydes **7** and 2,4-disubstituted pyrroles **11** were dissolved in dichloromethane and 1 equiv of TFA or $POCl_3$ was added. The desired unsymmetrical BODIPY dyes **14a-n** were obtained after reaction of the dipyrromethenes with $BF_3{\cdot}OEt_2$ in situ in 23–80% yield. Remarkably, symmetrically substituted BODIPYs **16a–b** and **15a** were also isolated from the reaction mixture in certain cases (table 7, entries 2–5 and 12–13). The mechanism of the formation of these side products probably involves an intermediate tripyrrylmethane, which is formed from one molecule of pyrrole carbaldehyde and two molecules of the disubstituted pyrrole or a deformylation in the case of the "aldehyde dimers" **15**.[23] Elimination of one pyrrole moiety then affords the symmetrical BODIPY **16a–b**. The synthesized BODIPYs, including the isolated symmetrical byproducts are depicted in table 7.

Table 7. Synthesis of BODIPYs.

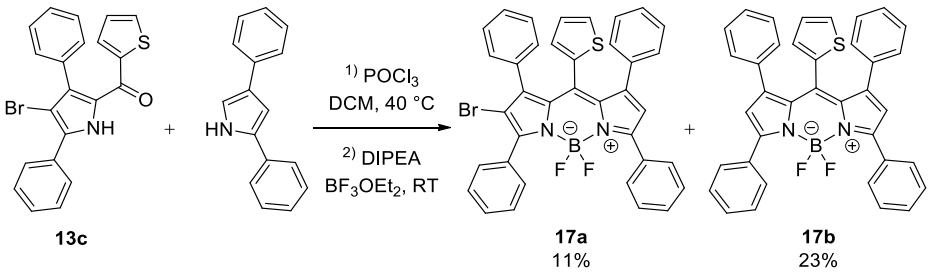


entry	R^1	R^2	R^3	R^4	X	Yield %[a]	Compound
1	Ph	Ph	Ph	Ph	Br	80	**14a**
2	2-Naph	Ph	4-F-C_6H_4	2-Cl-C_6H_4	H	37	**14b**
	–	–	4-F-C_6H_4	2-Cl-C_6H_4	H	40	**16a**
3	Ph	Ph	4-F-C_6H_4	2-Cl-C_6H_4	H	45	**14c**
	–	–	4-F-C_6H_4	2-Cl-C_6H_4	H	45	**16a**
4	Ph	2,3-Cl_2-C_6H_3	4-F-C_6H_4	4-MeO-C_6H_4	H	76	**14d**
	Ph	2,3-Cl_2-C_6H_3	–	–	H	22	**15a**
	–	–	4-F-C_6H_4	4-MeO-C_6H_4	H	40	**16b**
5	Ph	Ph	4-F-C_6H_4	4-MeO-C_6H_4	Br	42	**14e**
	–	–	4-F-C_6H_4	4-MeO-C_6H_4	H	9	**16b**
6	Ph	Ph	4-F-C_6H_4	4-MeO-C_6H_4	H	40	**14f**
7	4-F-C_6H_4	2-Cl-C_6H_4	4-F-C_6H_4	4-MeO-C_6H_4	H	55	**14g**
9	4-F-C_6H_4	2-Cl-C_6H_4	4-F-C_6H_4	2-Cl-C_6H_4	H	43	**16a**
10	4-F-C_6H_4	2-Cl-C_6H_4	Ph	Indol-3-yl	H	58	**14h**
11	4-F-C_6H_4	2-Cl-C_6H_4	3,4-$(MeO)_2$-C_6H_3	3,4-$(MeO)_2$-C_6H_3	H	51	**14i**
12	2-Naph	Ph	4-F-C_6H_4	4-MeO-C_6H_4	H	32	**14j**
	–	–	4-F-C_6H_4	4-MeO-C_6H_4	H	43	**16b**
13	Ph	2,3-Cl_2-C_6H_3	4-F-C_6H_4	2-Cl-C_6H_4	H	49	**14k**
	–	–	4-F-C_6H_4	2-Cl-C_6H_4	H	47	**16a**
	Ph	2,3-Cl_2-C_6H_3	–	–	H	25	**15a**

14	Ph	Indol-3-yl	Ph	2,3-Cl_2-C_6H_3	H	44	**14l**
15	Ph	Indol-3-yl	4-F-C_6H_4	4-MeO-C_6H_4	H	23	**14m**
17	4-Cl-C_6H_4	3-NO_2-C_6H_4	Ph	Indol-3-yl	Br	56	**14n**

[a] The yields of the cross-coupling products and the symmetrical by-products partly originate from separate reations, see experimental section for details.

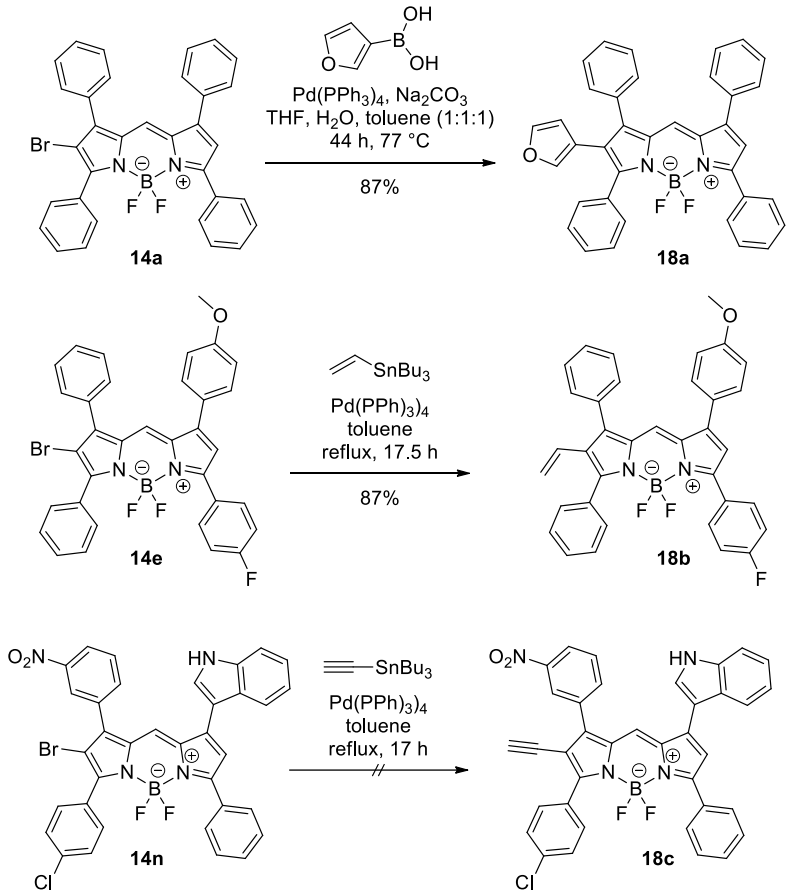
2-Acylpyrroles **13** were also condensed with 2,4-disubstituted pyrroles **11**, but the above-mentioned conditions did not provide the desired dipyrromethenes in this case. The use of larger amounts of TFA or $POCl_3$ or heating also did not improve the conversion. A model reaction was instead accomplished employing a modified procedure by Liras et al.[50] The ketone **13c** and phosphorous oxychloride were stirred together for 30 min and after addition of 2,4-diphenylpyrrole, the mixture was heated to 40 °C. An inseparable mixture of cross condensation product **17a** and symmetrical products **17b** was obtained in a 1:2 ratio (Scheme 8).



Scheme 8. Reaction of ketone **13c** with 2,4-diphenylpyrrole.

The selective construction of 2-halogenated BODIPYs offers the possibility of further and selective stepwise functionalization. BODIPYs **14a**, **14e** and **14n** were further functionalized via Suzuki and Stille-cross coupling-reactions, to yield **18a** and **18b** (Scheme 9). Unfortunately, the reaction with tributyl(ethynyl)stannane did not afford the desired compound **18c**. Subsequent

bromination and functionalization could render 1,2,3,5,6,7-trisubstituted BODIPYs with completely selectable substituent patterns.



Scheme 9. Functionalization of BODIPY dyes via Suzuki and Stille-cross coupling.

UV-Vis-absorbing and fluorescence properties of the synthesized compounds were determined in MeCN solution, the results are shown in Table 8. Molar extinction-coefficients are mostly larger than 30,000 $L \cdot mol^{-1} \cdot cm^{-1}$. Replacing the phenyl substituents by 4-fluorophenyl, 2-chlorophenyl, 2,3-dichlorophenyl or 4-methoxyphenyl-substituents had little influence on absorption- and emission wavelength whereas naphthalen-2-yl- and indol-3-yl-substituents as well as 3,4-dimethoxyphenyl-substituents led to a more or less pronounced red shift. Vinyl-substitution of

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the 2-position of the BODIPY-core results in bathochromic, 2-bromo- or furan-3-yl-substitution on the other hand to hypsochromic shift of the absorption- and emission maxima. Although fluorescence quantum yields were not determined, the presence of an indole moiety clearly leads to fluorescence quenching.

Table 8. Absorption and emission maxima for synthesized BODIPY dyes in acetonitrile.

Compound	$\lambda_{max\ abs}$/nm	$\lambda_{max\ emiss}$/nm	Stokes-Shift/nm
14a	556	586	30
14b	564	604	40
14c	562	591.5	29.5
14d	564	595	31
14e	560	585	25
14f	564	593.5	29.5
14g	564	594	30
14h	574	606.5	32.5
14i	586	620	34
14j	572	606	34
14k	562	595	33
14l	576	622	46
14m	578	633.5	55.5
14n	568	603	35
18a	556	580	24
18b	572	608.5	36.5
15a	562	595	33
16a	562	593	31
16b	568	596	28

In summary, an easy and efficient modular synthesis of BODIPY dyes from easy accessible or commercially available starting materials has been developed. A total of 16 non-symmetrically

substituted and three symmetrically substituted BODIPY dyes were synthesized and characterized. Since the synthetic scheme is general, pyrrole building blocks prepared along other routes may also be incorporated to further increase the structural diversity of the products.

Experimental Section

All reactions involving air or moisture sensitive reagents or intermediates were performed under an inert atmosphere of argon in oven dried glassware. Pyrrole building blocks, the synthesis of which are not described herein, were prepared as described previously.[46,48] All reagents and solvents were obtained from commercial suppliers and used without further purification unless stated otherwise. Anhydrous toluene, THF, and diethyl ether were distilled from sodium / benzophenone under argon. Dichloromethane was distilled from calcium hydride. NMR spectra were recorded with a Bruker AV-III 400 (400 MHz ^{1}H and 100.6 MHz ^{13}C) or with a Bruker AV-III 600 spectrometer (600 MHz ^{1}H and 151 MHz ^{13}C) equipped with 5 mm probes (BBFO for AV 400, TCI cryoprobe for AV 600). The chemical shifts were referenced to the residual solvent signal ($CHCl_3$, 7.26 ppm or DMSO, 2.50 ppm).[51] IR spectra were recorded on a Bruker Tensor 27 instrument using a diamond ATR. UV-VIS spectra were recorded on a Perkin Elmer Lambda 16 spectrometer, a Perkin Elmer LS 50B instrument was used for measuring the fluorescence spectra. ESI-HRMS spectra were recorded on a Waters Q-TOF Ultima-III instrument with a dual source and a suitable external calibrant. Thin-layer chromatography (TLC) was carried out on 0.25 mm silica gel plates with fluorescence indicator. Flash chromatography was performed on 35–70 μm silica gel (Acros) using the solvent systems indicated.

Ethyl 4-Iodo-3,5-diphenyl-1*H*-pyrrole-2-carboxylate (1c). Ethyl 3,5-diphenyl-1*H*-pyrrole-2-carboxylate (**1a**[46], 46 mg, 0.501 mmol) was dissolved in pyridine (10 mL) and NIS (125 mg,

0.556 mmol, 1.1 equivequiv) was added. After 19 h of stirring at room temperature, another portion of NIS (30 mg, 0.13 mmol, 0.26 equivequiv) was added After 3 h of stirring at room temperature, the solvent was removed in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 10:1) yielded the title compound (191 mg, 91%) as a colorless solid. mp 149.6–152.0 °C. R_f = 0.56 (silica, cylcohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3269, 1669, 1434, 1290, 1265, 1155, 762, 696. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 9.74 (s_{br}, 1H, N*H*), 7.75–7.70 (m, 2H, *H*-2''/6''), 7.51–7.35 (m, 8H), 4.08 (q, *J* = 7.1 Hz, 2H, CH_2), 1.05 (t, *J* = 7.1 Hz, 3H, CH_3). ^{13}C NMR (100.6 MHz, $CDCl_3$) δ (ppm) = 160.8 (*C*=O), 136.8 (C_q5), 136.1 (C_q), 135.4 (C_q), 131.7 (C_q), 130.7 (2C), 128.8 (1C), 128.7 (2C), 128.5 (2C), 127.6 (1C), 127.6 (2C), 120.5 (C_q2), 69.9 (C_q4), 60.7 (*C*H_2), 14.0 (*C*H_3). ESI-HRMS calcd for $[C_{19}H_{16}NO_2{}^{127}I + Na]^+$ 440.0124, found 440.0122.

Ethyl 4-Bromo-5-(naphthalen-2-yl)-3-phenyl-1*H*-pyrrole-2-carboxylate (1d). The corresponding ester[46] (118 mg, 0.346 mmol) was dissolved in pyridine (7 mL) and NBS (80.0 mg, 0.449 mmol) was added. After 3 h of stirring at room temperature the solvent was removed in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 10:1) yielded the title compound (108.9 mg, 0.259 mmol, 75%) as a colorless solid. mp 193.3–194.1 °C. R_f = 0.50 (silica, cylcohexane/EtOAc, 4:1). IR (ATR) ν (cm^{-1}) = 3334, 1652, 1431, 1262, 1243, 1165, 1020, 895, 722, 748, 698. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 9.71 (s, 1H, N*H*), 8.23 (d, *J* = 1.7 Hz, 1H, *H*-1''), 7.94 (d, *J* = 8.6 Hz, 1H, *H*-4''), 7.93–7.86 (m, 2H, Naph), 7.87 (dd, *J* = 8.6, 1.7 Hz, 1H, *H*-3''), 7.57–7.51 (m, 2H, Naph), 7.48–7.36 (m, 5H, Ph), 4.10 (q, *J* = 7.1 Hz, 2H, CH_2), 1.06 (t, *J* = 7.1 Hz, 3H, CH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 161.0 (*C*=O), 133.4 (C_q), 133.3 (2×C_q), 133.1 (C_q), 132.5 (C_q3), 130.8 (*C*2'/6'), 128.6 (1C, Naph), 128.4 (1C, Naph), 128.1 (C_q), 127.9 (1C, Naph), 127.7 (*C*4'), 127.6 (*C*3'/5'), 127.2 (*C*1''), 126.9 (1C, Naph), 126.8 (1C, Naph), 125.2 (*C*3''), 119.5 (C_q2), 99.3

(C_q4), 60.8 (CH_2), 14.0 (CH_3). ESI-HRMS calcd for $[C_{23}H_{18}{}^{79}BrNO_2 + Na]^+$ 442.0419, found 442.0430.

Ethyl 4-Bromo-5-(4-fluorophenyl)-3-(4-methoxyphenyl)-1*H*-pyrrole-2-carboxylate (1e). The corresponding ester[46] (93.6 mg, 0.28 mmol) was dissolved in pyridine (5.6 mL) and NBS (64mg, 0.36 mmol, 1.3 equivequiv) was added. After 3 h of stirring at room temperature, the solvent was removed in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 6:1) yielded the title compound (91.4 mg, 0.219 mmol, 78%) as a colorless solid. mp 167.1–167.9 °C. R_f = 0.33 (silica, cylcohexane/EtOAc, 4:1). IR (ATR) ν (cm^{-1}) = 3284, 1658, 1505, 1439, 1290, 1248, 1221, 1034, 837, 812, 774, 721. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 9.52 (s_{br}, 1H, N*H*), 7.77–7.66 (m, 2H, *H*-2‘‘/6‘‘), 7.41–7.31 (m, 2H, *H*-2‘/6‘), 7.22–7.11 (m, 2H, *H*-3‘‘/5‘‘), 7.00–6.92 (m, 2H, *H*-3‘/5‘), 4.14 (q, *J* = 7.2 Hz, 2H, CH_2), 3.86 (s, 3H, OCH_3), 1.14 (t, *J* = 7.2 Hz, 3H, CH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 162.9 (d, $^1J_{C,F}$ = 249.3 Hz, C_q4‘‘), 160.9 (*C*=O), 159.2 (C_q4‘), 132.3 (C_q5), 132.0 (C_q3), 131.9 (*C*2‘/6‘), 129.8 (d, $^3J_{C,F}$ = 8.2 Hz, *C*2‘‘/6‘‘), 126.9 (d, $^4J_{C,F}$ = 3.4 Hz, C_q1‘‘), 125.5 (C_q1‘), 119.2 (C_q2), 116.0 (d, $^2J_{C,F}$ = 21.8 Hz, *C*3‘‘/5‘‘), 113.1 (*C*3‘/5‘), 99.3 (C_q4), 60.8 (CH_2), 55.4 (OCH_3), 14.2 (CH_3). ESI-HRMS calcd for $[C_{20}H_{17}{}^{79}BrFNO_3 + Na]^+$ 440.0274, found 440.0276.

Ethyl 4-Bromo-3-(2-chlorophenyl)-5-(4-fluorophenyl)-1*H*-pyrrole-2-carboxylate (1f). The corresponding ester[46] (163 mg, 0.47 mmol) was dissolved in pyridine (9.4 mL) and NBS (110 mg, 0.62 mmol, 1.3 equivequiv) was added. After 3 h of stirring at room temperature, the solvent was removed in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 3:2) yielded the title compound (72 mg, 0.17 mmol, 36%) as a colorless solid. mp 180.5–181.1°C. R_f = 0.22 (silica, cylcohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3280, 1666, 1441, 1290, 1259, 1228, 1160, 1016, 839, 753, 733, 661. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 9.82 (s_{br}, 1H, N*H*), 7.79–7.72 (m, 2H, *H*-2‘‘/6‘‘), 7.50–7.45 (m, 1H, *H*-6‘),

7.37–7.30 (m, 3H, *H*-3‘,4‘,5‘), 7.20–7.13 (m, 2H, *H*-3‘‘/5‘‘), 4.17–3.96 (m, 2H, CH_2), 1.00 (t, *J* = 7.1 Hz, 3H, CH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 162.9 (d, *J* = 249.2 Hz, C_q4‘‘), 160.9 (*C*=O), 134.6 (C_q1‘), 133.3 (C_q2‘), 132.4 (C_q5), 132.2 (1C), 129.7 (d, *J* = 8.2 Hz, *C*2‘‘/6‘‘), 129.5 (C_q3), 129.3 (1C), 129.2 (*C*6‘), 126.7 (d, *J* = 3.4 Hz, C_q1‘‘), 126.2 (*C*4‘), 120.2 (C_q2), 116.0 (d, *J* = 21.8 Hz, *C*3‘‘/5‘‘), 99.1 (C_q4), 60.9 (*C*H_2), 13.8 (*C*H_3). ESI-HRMS calcd for $[C_{19}H_{14}{}^{79}BrClFNO_2 + Na]^+$ 443.9778, found 443.9788.

Ethyl 4-Bromo-5-(4-chlorophenyl)-3-(2-nitrophenyl)-1*H*-pyrrole-2-carboxylate (1g). The corresponding ester[46] (174.5 mg, 0.471 mmol) was dissolved in pyridine (9.4 mL) and NBS (108.6 mg, 0.610 mmol, 1.3 equivequiv) was added. After 3 h of stirring at room temperature the solvent was removed in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 6:1) yielded the title compound (163 mg, 0.362 mmol, 77%) as a colorless solid. mp 197.3–198.4 °C. R_f = 0.47 (silica, cylcohexane/EtOAc, 3:1). IR (ATR) ν (cm^{-1}) = 3300, 1670, 1537, 1518, 1443, 1344, 1285, 1255, 1175, 1092, 827, 693. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 9.75 (s_{br}, 1H, N*H*), 8.36–8.30 (m, 1H, *H*-2‘), 8.25 (ddd, *J* = 8.3, 2.3, 1.1 Hz, 1H, *H*-4‘), 7.77 (ddd, *J* = 7.7, 1.7, 1.1 Hz, 1H, *H*-6‘), 7.72–7.64 (m, 2H, 4-Cl-Ph), 7.59 (*pseudo*-t, *J* = 8.0 Hz, 1H, *H*-5‘), 7.50–7.41 (m, 2H, 4-Cl-Ph), 4.12 (q, *J* = 7.1 Hz, 2H, CH_2), 1.08 (t, *J* = 7.1 Hz, 3H, CH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 160.4 (*C*=O), 147.8 (C_q3‘), 137.0 (*C*6‘), 135.1 (C_q), 134.9 (C_q1‘), 132.7 (C_q), 129.5 (C_q3), 129.3, 129.2 (2×2C, *C*2‘‘/3‘‘/5‘‘/6‘‘), 128.6 (2C, *C*5‘+C_q), 126.2 (*C*2‘), 122.7 (*C*4‘), 119.9 (C_q2), 98.9 (C_q4), 61.3 (*C*H_2), 14.0 (*C*H_3). ESI-HRMS calcd for $[C_{19}H_{14}{}^{79}BrClN_2O_4 + Na]^+$ 470.9723, found 470.9734.

Ethyl 4-Iodo-5-(4-chlorophenyl)-3-(2-nitrophenyl)-1*H*-pyrrole-2-carboxylate (1h). The corresponding ester[46] (136 mg, 0.368 mmol) was dissolved in pyridine (7.4 mL) and NIS (107.5 mg, 0.478 mmol, 1.3 equivequiv) was added. After 3 h of stirring at room temperature the TLC did not show complete conversion. Another portion of NIS (24.8 mg, 0.11 mmol,

0.3 equivequiv) was added. After 3 h of stirring at room temperature, starting material could still be detected (TLC) and another portion of NIS (24.8 mg, 0.11 mmol, 0.3 equivequiv) was added. After stirring at room temperature overnight, the solvent was removed in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 10:1) yielded the title compound (99 mg, 0.19 mmol, 54%) as a colorless solid. mp 194.0–194.8°C. R_f = 0.32 (silica, cylcohexane/EtOAc, 5:1). IR (ATR) ν (cm^{-1}) = 3305, 1671, 1534, 1516, 1440, 1343, 1284, 1253, 1171, 826, 694, 661. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 9.81 (s_{br}, 1H, N*H*), 8.28 (ddd, *J* = 2.2, 1.6, 0.6 Hz, 1H, *H*-2‘), 8.26 (ddd, *J* = 8.1, 2.2, 1.2 Hz, 1H, *H*-4‘), 7.72 (ddd, *J* = 7.7, 1.6, 1.2 Hz, 1H, *H*-6‘), 7.69–7.61 (m, 2H, *H*-2‘‘/6‘‘), 7.60 (ddd, *J* = 8.1, 7.7, 0.6 Hz, 1H, *H*-5‘), 7.51–7.42 (m, 2H, *H*-3‘‘/5‘‘), 4.09 (q, *J* = 7.1 Hz, 2H, CH_2), 1.05 (t, *J* = 7.1 Hz, 3H, CH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 160.2 (*C*=O), 147.8 (C_q3‘), 137.1 (*C*6‘), 136.8 (C_q1‘), 136.3 (C_q5), 135.3 (C_q4‘‘), 133.2 (C_q3), 129.8 (*C*2‘‘/6‘‘), 129.7 (C_q1‘‘), 129.2 (*C*3‘‘/5‘‘), 128.6 (*C*5‘), 126.2 (*C*2‘), 122.7 (*C*4‘), 121.1 (C_q2), 69.5 (C_q4), 61.2 (*C*H_2), 14.0 (*C*H_3). ESI-HRMS calcd for $[C_{19}H_{14}Cl^{127}IN_2O_4 + Na]^+$ 518.9585, found 518.9583.

Ethyl 4-Bromo-3,5-bis(3,4-dimethoxyphenyl)-1*H*-pyrrole-2-carboxylate (1i). The corresponding ester[46] (30 mg, 73 μmol) was dissolved in pyridine (2 mL) and NBS (14 mg, 79 μmol) was added. After 20.5 h of stirring at room temperature the solvent was removed in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 3:2) yielded the title compound (28 mg, 79%) as a yellow oil. R_f = 0.21 (silica, cylcohexane/EtOAc, 1:1). IR (ATR) ν (cm^{-1}) = 3287, 2836, 1688, 1666, 1510, 1463, 1433, 1226, 1136, 1025, 913, 730. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 9.40 (s, 1H, N*H*), 7.30 (d, *J* = 2.0 Hz, 1H, *H*-2‘‘), 7.25 (dd, *J* = 8.3. 2.0 Hz, 1H, *H*-6‘‘), 7.00 (dd, *J* = 8.2, 1.9 Hz, 1H, *H*-6’), 6.98–6.91 (m, 3H, *H*-5‘‘, *H*-2’, *H*-5’), 4.16 (q, *J* = 7.1 Hz, 2H, CH_2), 3.94 (s, 3H, OCH_3), 3.93 (s, 6H, 2 x OCH_3), 3.90 (s, 3H, OCH_3), 1.14 (t, *J* = 7.1 Hz, 3H, CH_3). ^{13}C NMR (100.6 MHz, $CDCl_3$) δ (ppm) = 160.9 (*C*=O), 149.5

(*C*OMe), 149.1 (*C*OMe), 148.6 (*C*OMe), 148.0 (*C*OMe), 133.3 (C_q5), 132.1 (C_q3), 125.8 (C_q1'), 123.4 (*C*6'), 123.3 (C_q1''), 120.4 (*C*6''), 118.7 (C_q2), 114.2 (*C*5''), 111.3 (*C*2'), 111.1 (*C*2''), 110.3 (*C*5'), 98.7 (C_q4), 60.7 (CH_2), 56.2 (OCH_3), 56.1 (OCH_3), 56.0 (OCH_3), 55.3 (OCH_3), 14.3 (CH_3). ESI-HRMS calcd for $[C_{23}H_{24}NO_6{}^{79}Br + H]^+$ 490.0865, found 490.0848.

2-Methyl-3,5-diphenyl-1*H*-pyrrole (4). In a Schlenk flask, compound **1a**[46] (146 mg, 0.501 mmol) was dissolved in dry THF (1 mL), lithium aluminum hydride (2M in THF, 0.3 mL, 0.6 mmol) was added and the mixture was heated to reflux for 17.5 h. After cooling to 0 °C, the mixture was quenched with 1n aqueous NaOH and extracted with ethyl acetate. The combined organic layers were washed with brine, dried with $MgSO_4$ and concentrated in vacuo to yield the title compound **(**116 mg, 0.497 mmol, quant.) as a colorless to light pink oil. R_f = 0.51 (silica, cyclohexane/EtOAc, 2:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 8.18 (s_{br}, 1H, N*H*), 7.52–7.44 (m, 4H), 7.42–7.34 (m, 4H), 7.25–7.17 (m, 2H), 6.63 (d, *J* = 2.9 Hz, 1H, *H*-4), 2.48 (s, 3H, CH_3). The spectroscopic data were in accordance with the literature. [47,52]

General procedure for the synthesis of Weinreb amides 5a–g. A Schlenk flask was charged with *N*,*O*-dimethylhydroxylamine hydrochloride (2–3 equivequiv) under argon, dry THF (10 mL/mmol ester) was added and the homogeneous solution was cooled to −78 °C. ^{n}BuLi (2.5M in hexane, 4–6 equivequiv) was slowly added. The mixture was stirred for 35 minmin at −78 °C and for 1 h at room temperature. After cooling to −78 °C, a solution of ester **1a–g** (1 equivequiv) in dry THF was added followed by stirring at −78 °C for 1 h and at room temperature overnight (10–16 h). The mixture was quenched with sat. NH_4Cl-solution and extracted with ethyl acetate. The combined organic layers were washed with brine, dried over $MgSO_4$ and concentrated in vacuo. Flash column chromatography yielded the desired product.

***N*-Methoxy-*N*-methyl-3,5-diphenyl-1*H*-pyrrole-2-carboxamide (5a).** According to the general procedure using *N*,*O*-dimethylhydroxylamine hydrochloride (301 mg, 3.09 mmol), ^{n}BuLi (2.5M

in hexane, 2.5 mL, 6.25 mmol) and **1a**[46] (292 mg, 1.00 mmol). Purification by flash column chromatography (cyclohexane/EtOAc, 3:2) yielded the title compound (280 mg, 89%) as a light yellow foam. R_f = 0.26 (silica, cyclohexane/EtOAc, 1:1). IR (ATR) ν (cm^{-1}) = 3216, 1599, 1478, 1457, 1439, 1368, 1263, 1083, 908, 759, 728, 695. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 10.68 (s_{br}, 1H, N*H*), 7.62–7.58 (m, 2H, *H*-2''/6''), 7.50–7.46 (m, 2H, *H*-2'/6'), 7.42–7.35 (m, 4H, *H*-3'/5', *H*-3''/5''), 7.34–7.30 (m, 1H, *H*-4'), 7.30–7.24 (m, 1H, *H*-4''), 6.60 (d, *J* = 3.0 Hz, 1H, *H*-4), 3.60 (s, 3H, OCH_3), 3.07 (s, 3H, NCH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, CDCl3) δ (ppm) = 162.7 (C=O), 136.4 (Cq1'), 135.0 (Cq5), 131.7 (C_q1''), 130.7 (C_q3), 129.0, 128.5, 128.3 (3×2C, *C*3'/5', *C*2'/6', *C*3''/5''), 127.4 (*C*4''), 126.9 (*C*4'), 124.8 (2C, *C*2''/6''), 120.3 (C_q2), 108.3 (*C*4), 60.7 (OCH_3), 35.5 (NCH_3). ESI-HRMS calcd for $[C_{19}H_{18}N_2O_2 + Na]^+$ 329.1266, found 329.1258.

***N*-(3,5-Diphenyl-1*H*-pyrrole-2-yl)-*N*'-methoxy-*N*,*N*'-dimethylurea (6).** The title compound was prepared according to the general procedure using *N*,*O*-dimethylhydroxylamine hydrochloride (1.15 g, 11.8 mmol, 3.1 equivequiv), ^{n}BuLi (2.5M in hexane, 9.5 mL, 24 mmol, 6.2 equivequiv) and **1a**[46] (1.12 g, 3.84 mmol). Purification by flash column chromatography (cyclohexane/EtOAc, 3:2) yielded the title compound (707 mg, 2.11 mmol, 55%) as a colorless foam. R_f = 0.48 (silica, cyclohexane/EtOAc, 1:1). IR (ATR) ν (cm^{-1}) = 3258, 2932, 1648, 1605, 1593, 1501, 1458, 1441, 1375, 909, 759, 732, 695. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 10.17 (s, 1H, N*H*), 7.77–7.68 (m, 4H, *H*-2'/6'/2''/6''), 7.48–7.40 (m, 4H, *H*-3'/5'/3''/5''), 7.30–7.24 (m, 2H, *H*-4'/4''), 6.84 (d, *J* = 3.0 Hz, 1H, *H*-4), 3.24 (s, 3H, NCH_3), 3.08 (s, 3H, NCH_3(OCH_3)), 3.04 (s, 3H, OCH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 163.0 (*C*=O), 134.7 (C_q1'), 132.3 (C_q1''), 129.1 (2C), 129.0 (C_q2), 128.7 (2C), 128.6 (C_q5), 126.3 (*C*4''), 126.2 (*C*2'/6'), 125.8 (*C*4'), 123.5 (*C*2''/6''), 117.2 (C_q3), 104.4 (*C*4), 60.1

(O*C*H$_3$), 39.0 (N*C*H$_3$), 36.1 (N*C*H$_3$). ESI-HRMS calcd for [$C_{20}H_{21}N_3O_2$ + Na]$^+$ 358.1531, found 358.1531.

4-Bromo-*N*-methoxy-*N*-methyl-3,5-diphenyl-1*H*-pyrrole-2-carboxamide (5b). The title compound was prepared according to the general procedure using *N*,*O*-dimethylhydroxylamine hydrochloride (303 mg, 3.11 mmol), ^{n}BuLi (2.5M in hexane, 2.5 mL, 6.3 mmol, 6.3 equivequiv) and **1b**[46] (371 mg, 1.00 mmol). Purification by flash column chromatography (cyclohexane/EtOAc, 3:2) yielded the title compound (287 mg, 75%) as a light yellow foam. R_f = 0.23 (silica, cyclohexane/EtOAc, 1:1). IR (ATR) ν (cm^{-1}) = 3181, 1615, 1600, 1480, 1438, 1263, 1094, 1025, 908, 766, 729, 696. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 12.22 (s, 1H, N*H*), 7.76–7.71 (m, 2H, *H*-2''/6''), 7.51–7.46 (m, 2H, *H*-3''/5''), 7.44–7.33 (m, 6H, Ph', *H*-4''), 3.44 (s, 3H, OC*H*$_3$), 2.96 (s, 3H, NC*H*$_3$). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 161.2 (*C*=O), 133.6 (C_q1'), 130.7 (C_q1''), 130.6 (C_q5), 129.5 (*C*3'/5'), 128.4 (*C*3''/5''), 128.1(*C*3'/5'), 127.8 (*C*2''/6''), 127.7 (*C*4''), 127.0 (*C*4'), 125.7 (C_q3), 122.6 (C_q2), 94.9 (C_q4), 60.2 (O*C*H$_3$), 34.1 (N*C*H$_3$). ESI-HRMS calcd for [$C_{19}H_{17}N_2O_2{}^{79}Br$ + H]$^+$ 385.0549, found 385.0552.

4-Iodo-*N*-methoxy-*N*-methyl-3,5-diphenyl-1*H*-pyrrole-2-carboxamide (5c). The title compound was prepared according to the general procedure using *N*,*O*-dimethylhydroxylamine hydrochloride (120 mg, 1.13 mmol), ^{n}BuLi (2.5M in hexane, 1.0 mL, 2.5 mmol, 6.2 equivequiv) and **1c** (169 mg, 0.405 mmol). Purification by flash column chromatography (cyclohexane/EtOAc, 2:1→3:2). yielded the title compound (119 mg, 68%) as a colorless foam. R_f = 0.08 (silica, cyclohexane/EtOAc, 2:1) IR (ATR) ν (cm^{-1}) = 3176, 1614, 1600, 1480, 1437, 1261, 1092, 1024, 909, 765, 730, 697. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 10.72 (s_{br}, 1H, N*H*), 7.64–7.56 (m, 2H, *H*-2''/6''), 7.46–7.34 (m, 8H, Ph), 3.49 (s, 3H, OC*H*$_3$), 2.96 (s, 3H, NC*H*$_3$). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 161.3 (*C*=O), 136.1 (C_q5),

136.0 (C_q), 133.4 (C_q), 132.0 (C_q), 130.3 (2C, Ph), 128.7 (2C, Ph), 128.5 (3C, *C*2‘‘/6‘‘, Ph), 128.1 (2C, Ph), 127.6 (1C, Ph), 122.0 (C_q2), 60.8 (O*C*H$_3$), 35.0 (N*C*H$_3$). *C*4 could not be identified. ESI-HRMS calcd for $[C_{19}H_{17}{}^{127}IN_2O_2 + I]^+$ 455.0232, found 455.0225.

4-Bromo-*N*-methoxy-*N*-methyl-5-(naphthalen-2-yl)-3-phenyl-1*H*-pyrrole-2-carboxamide (5d). The title compound was prepared according to the general procedure using *N*,*O*-dimethylhydroxylamine hydrochloride (69 mg, 0.71 mmol), ^{n}BuLi (2.2M in hexane, 0.64 mL, 1.4 mmol) and **1d** (99 mg, 0.24 mmol). Purification by flash column chromatography (cyclohexane/EtOAc, 3:2) yielded the title compound (87 mg, 0.20 mmol, 85%) as a colorless oil. R_f = 0.11 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3188, 1730, 1600, 1491, 1462, 1371, 1239, 1093, 1023, 819, 748, 699. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 10.99 (s_{br}, 1H, N*H*), 8.15 (d, *J* = 1.7 Hz, 1H, *H*-1‘‘), 7.88 (d, *J* = 8.8 Hz, 1H, *H*-4‘‘), 7.87–7.84 (m, 2H, Naph), 7.79 (dd, *J* = 8.5, 1.8 Hz, 1H, *H*-3‘‘), 7.55–7.44 (m_C, 2H, Naph), 7.40–7.28 (m, 5H, Ph), 3.46 (s, 3H, OC*H*$_3$), 2.95 (s, 3H, NC*H*$_3$). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 161.7 (*C*=O), 134.3 (C_q), 133.3 (C_q), 133.0 (C_q), 132.6 (C_q), 130.1 (2C, Ph), 129.5 (C_q3), 128.4 (2×1C, Naph+C_q), 128.1 (2C, Ph), 127.8 (1C), 127.5 (1C), 127.1 (*C*1‘‘), 126.6 (2C, Naph), 125.5 (*C*3‘‘), 121.1 (C_q2), 97.8 (C_q4), 60.7(O*C*H$_3$), 35.2 (N*C*H$_3$). One carbon resonane is missing due to overlap. ESI-HRMS calcd for $[C_{23}H_{19}{}^{79}BrN_2O_2 + Na]^+$ 457.0528, found 457.0523.

4-Bromo-5-(4-fluorophenyl)-*N*-methoxy-3-(4-methoxyphenyl)-*N*-methyl-1*H*-pyrrole-2-carboxamide (5e). The title compound was prepared according to the general procedure using *N*,*O*-dimethylhydroxylamine hydrochloride (36 mg, 0.37 mmol), ^{n}BuLi (2.2M in hexane, 0.3 mL, 0.66 mmol) and **1e** (75 mg, 0.18 mmol). After purification by flash column chromatography (cyclohexane/EtOAc, 10:1→3:2) 38 mg (91 µmol) of ethyl carboxylate **1e** could be recovered. The title compound (34 mg, 78 µmol, 44%, 89% brsm) was obtained as a colorless amorphous

solid. R_f = 0.09 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3247, 2933, 1714, 1670, 1606, 1510, 1252, 1177, 1162, 1032, 838, 732. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 10.96 (s_{br}, 1H, N*H*), 7.60–7.55 (m, 2H, *H*-2‘‘/6‘‘), 7.30–7.26 (m, 2H, *H*-2‘/6‘), 7.12–7.05 (m, 2H, *H*-3‘‘/5‘‘), 6.99–6.94 (m, 2H, *H*-3‘/5‘), 3.86 (s, 3H, OCH_3), 3.51 (s, 3H, NOCH_3), 2.94 (s, 3H, NCH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 162.6 (d, $^1J_{C,F}$ = 248.4 Hz, C_q4‘‘), 161.8 (*C*=O), 159.2 (C_q4‘), 131.7 (C_q5), 131.1 (*C*2‘/6‘), 129.8 (d, $^3J_{C,F}$ = 8.1 Hz, *C*2‘‘/6‘‘), 128.9 (C_q3), 127.3 (d, $^4J_{C,F}$ = 3.4 Hz, C_q1‘‘), 126.4 (C_q1‘), 120.7 (C_q2), 115.7 (d, $^2J_{C,F}$ = 21.8 Hz, *C*3‘‘/5‘‘), 113.7 (*C*3‘/5‘), 97.5 (C_q4), 60.8 (NO*C*H_3), 55.4 (O*C*H_3), 35.5 (N*C*H_3). ESI-HRMS calcd for $[C_{20}H_{18}{}^{79}BrFN_2O_3 + H]^+$ 433.0563, found 433.0572.

4-Bromo-3-(2-chlorophenyl)-5-(4-fluorophenyl)-*N*-methoxy-*N*-methyl-1*H*-pyrrole-2-carboxamide (5f). The title compound was prepared according to the general procedure using *N*,*O*-dimethylhydroxylamine hydrochloride (32 mg, 0.325 mmol), ^{n}BuLi (2.2M in hexane, 0.30 mL, 6.6 mmol) and **1f** (44 mg, 0.10 mmol). Purification by flash column chromatography (cyclohexane/EtOAc, 3:2 und 3:1) yielded the title compound (24 mg, 55 μmol, 53%) as a colorless oil. R_f = 0.17 (silica, cyclohexane/EtOAc, 3:1). IR (ATR) ν (cm^{-1}) = 3196, 1608, 1594, 1569, 1482, 1458, 1437, 1234, 1161, 838, 756. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 10.00 (s_{br}, 1H, N*H*), 7.77–7.67 (m, 2H, *H*-2‘‘/6‘‘), 7.53–7.44 (m, 1H, 2-Cl-Ph), 7.37–7.26 (m, 3H, 2-Cl-Ph), 7.22–7.11 (m, 2H, *H*-3‘‘/5‘‘), 3.51 (s, 3H, OCH_3), 3.16 (s, 3H, NCH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 162.7 (d, *J* = 248.9 Hz, C_q4‘‘), 160.7 (*C*=O), 134.3 (C_q), 134.2 (C_q), 132.2 (1C, 2-Cl-Ph), 131.0 (C_q5), 129.5 (d, *J* = 8.3 Hz, *C*2‘‘/6‘‘), 129.4 (1C, 2-Cl-Ph), 129.1 (1C, 2-Cl-Ph), 128.3 (C_q3), 127.0 (d, *J* = 3.2 Hz, C_q1‘‘), 126.4 (1C, 2-Cl-Ph), 121.6 (C_q), 116.0 (d, *J* = 21.8 Hz, *C*3‘‘/5‘‘), 99.0 (C_q4), 61.5 (O*C*H_3), 34.0 (N*C*H_3). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –113.66 (tt, *J* = 8.5, 5.5 Hz). ESI-HRMS calcd for $[C_{19}H_{15}{}^{79}BrClFN_2O_2 + H]^+$ 437.0068, found 437.0066.

4-Bromo-5-(4-chlorophenyl)-*N*-methoxy-*N*-methyl-3-(3-nitrophenyl)-1*H*-pyrrole-2-carboxamide (5g). The title compound was prepared according to the general procedure using *N*,*O*-dimethylhydroxylamine hydrochloride (34 mg, 0.35 mmol), ^{n}BuLi (2.2M in hexane, 0.31 mL, 0.68 mmol) and **1g** (52 mg, 0.12 mmol). Purification by flash column chromatography (cyclohexane/EtOAc, 3:2) yielded the title compound (25 mg, 54 µmol, 47%) as a yellow oil. R_f = 0.10 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3189, 1620, 1534, 1517, 1478, 1442, 1347, 1092, 832, 754, 726. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 10.67 (s_{br}, 1H, N*H*), 8.23–8.19 (m, 2H, *H*-2‘, *H*-4‘), 7.67–7.54 (m, 4H, *H*-5‘, *H*-6‘, Ph‘), 7.45–7.40 (m, 2H, Ph‘),3.52 (s, 3H, OCH_3), 3.11 (s, 3H, NCH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 160.7 (C=O), 148.0 (C_q3‘), 136.1 (C_q+*C*6‘), 134.7 (C_q), 131.4 (C_q), 129.1 (2×2C, *C*2‘‘/3‘‘/5‘‘/6‘‘), 128.9 (C_q+*C*5‘), 128.1 (C_q3), 124.9 (*C*2‘), 122.4 (*C*4‘), 121.3 (C_q2), 97.9 (C_q4), 61.4 (NO*C*H_3), 34.1 (N*C*H_3). One carbon resonance missing due to overlap. ESI-HRMS calcd for $[C_{19}H_{15}{}^{79}BrClN_3O_4 + Na]^+$ 485.9832, found 485.9836.

1-(3,5-Diphenyl-1*H*-pyrrol-2-yl)-*N*-methoxy-*N*-methylmethanamine (8). In a Schlenk flask **5a** (31 mg, 0.10 mmol, 1.0 equivequiv) was put under argon, dissolved in dry THF (2 mL) and cooled to –78 °C. Lithium aluminum hydride (2M in THF, 0.05 mL, 0.1 mmol, 1 equivequiv) was added and the reaction mixture stirred for 20 minmin at –78 °C, then slowly warmed to room temperature. After stirring a room temperature for 1.5 h the reaction was quenched with 1N aqueous NaOH and extracted with ethyl acetate. The combined organic phases were washed with brine, dried with $MgSO_4$ and concentrated in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 10:1) yielded the title compound (24 mg, 82 µmol, 82%) as a light pink oil. R_f = 0.31 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3436, 1607, 1497, 1454, 1440, 1350, 1075, 1044, 1007, 810, 758, 699. ^{1}H NMR, COSY (400 MHz, DMSO-d_6) δ (ppm) = 11.30 (s, 1H, N*H*), 7.72 (d, *J* = 7.6 Hz, 2H, *H*-2‘‘/6‘‘), 7.66 (d, *J* = 7.7 Hz, 2H,

H-2‘/6‘), 7.36 (t, *J* = 7.7 Hz, 4H, *H*-3‘/5‘/3‘‘/5‘‘), 7.22–7.14 (m, 2H, *H*-4‘/4‘‘), 6.74 (d, *J* = 2.8 Hz, 1H, *H-4*), 3.86 (s, 2H, CH_2), 3.35 (s, 3H, OCH_3), 2.57 (s, 3H, NCH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 136.5, 132.5 (*C*1‘, C1‘‘), 130.6 (*C*5), 128.7 (*C*3‘‘/5‘‘), 128.3 (*C*3‘/5‘), 127.4 (*C*2‘/6‘), 125.6 (2C, *C2/*4‘‘), 125.2 (*C*4‘), 123.9 (*C*3), 123.6 (*C*2‘‘/6‘‘), 105.6 (*C*4), 59.3 (O*C*H_3), 55.2 (*C*H_2), 44.5 (N*C*H_3). ESI-HRMS calcd for $[C_{19}H_{20}N_2O - N(CH_3)OCH_3]^+$ 232.1121, found 232.1126.

General procedure for the synthesis of pyrrole-2-carbaldehydes 7a–g from Weinreb amides. A Schlenk flask was charged with Weinreb amide under argon, dry THF (ca. 2 mL/0.1 mmol) was added and the solution was cooled to −78 °C. Lithium aluminum hydride (solution in THF, 0.6 equiv) was slowly added. When conversion was completed, the reaction was cooled to 0 °C, quenched with 1N aqueous NaOH and extracted with ethyl acetate. The combined organic phases were washed with brine, dried with $MgSO_4$ and concentrated in vacuo. Flash column chromatography yields the desired product.

4-Bromo-3,5-diphenyl-1*H*-pyrrole-2-carbaldehyde (7b). Following the general procedure, the reaction of amide **5b** (44 mg, 0.11 mmol, 1.0 equiv) and lithium aluminum hydride (2M in THF, 0.03 mL, 0.06 mmol, 0.6 equiv) was stirred for 20 minmin at –78 °C and then slowly warmed to room temperature within 1 h. Purification by flash column chromatography (cylcohexane/EtOAc, 10:1) yielded the title compound (23 mg, 62%) as a light yellow oil. R_f = 0.42 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3233, 2954, 2924, 2854, 1644, 1626, 1495, 1434, 1379, 1255, 763, 696. ^{1}H NMR, COSY (400 MHz, DMSO-d_6) δ (ppm) = 12.88 (s, 1H, N*H*), 9.36 (s, 1H, C*H*O), 7.80–7.76 (m, 2H, *H*-2''/6''), 7.55–7.42 (m, 8H). ^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 178.8 (*C*HO), 136.3 (C_q5), 135.3 (C_q3), 131.2 (C_q), 130.5 (2C), 129.7 (C_q), 129.1 (2C, *C*2''/6''), 128.9 (1C), 128.7 (C_q), 128.4 (2×2C), 128.1 (1C), 97.3 (C_q4). ESI-HRMS calcd for $[C_{17}H_{12}BrNO + H]^+$ 326.0181, found 326.0194.

4-Iodo-3,5-diphenyl-1*H*-pyrrole-2-carbaldehyde (7c). Following the general procedure, the reaction of amide **5c** (99 mg, 0.23 mmol, 1.0 equivequiv) and lithium aluminum hydride (2M in THF, 0.07 mL, 0.14 mmol, 0.6 equivequiv) was stirred for 20 minmin at –78 °C and then slowly warmed to room temperature within 1 h and stirred overnight at room temperature. After purification by flash column chromatography (cylcohexane/EtOAc, 10:1→3:2) 26 mg (0.60 mmol) Weinreb amide could be recovered. The title compound (36 mg, 96 μmol, 42%, 57% brsm) was yielded as a light pink foam. R_f = 0.42 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3239, 1647, 1638, 1625, 1456, 1431, 1378, 1290, 1253, 816, 764, 668. ^{1}H NMR, COSY (400 MHz, DMSO-d_6) δ (ppm) = 12.87 (s_{br}, 1H, N*H*), 9.30 (s, 1H, C*H*O), 7.77–7.69 (m, 2H, *H*-2''/6''), 7.55–7.40 (m, 8H, Ph). ^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 178.8 (*C*HO), 139.8 (C_q5), 139.6 (C_q3), 133.0, 130.9 (2×C_q, C_q1'/C_q1''), 130.6 (*C*2'/6'), 130.5 (C_q2), 129.3 (*C*2''/6''), 128.8 (*C*4''), 128.3, 128.2 (2×2C, *C*3'/5'/3''/5''), 128.0 (*C*4'), 70.0 (C_q4). ESI-HRMS calcd for $[C_{17}H_{12}INO +]^+$ 374.0042, found 374.0045.

4-Bromo-5-(naphthalen-2-yl)-3-phenyl-1*H*-pyrrole-2-carbaldehyde (7d). Following the general procedure, the reaction of amide **5d** (85.0 mg, 0.195 mmol, 1.0 equivequiv) and lithium aluminum hydride (1M in THF, 0.12 mL, 0.12 mmol, 0.6 equivequiv) was stirred for 20 minmin at –78 °C and then warmed to room temperature overnight. Since the TLC did not show complete conversion of the nitrile, the mixture was cooled to –78 °C again and another portion of lithium aluminum hydride (1M in THF, 0.1 mL, 0.1 mmol, 0.5 equivequiv) was added. After 20 minmin stirring at –78 °C the reaction was warmed to room temperature and stirred for 1 h. Workup according to the general procedure and purification by flash column chromatography (cylcohexane/EtOAc, 10:1) yielded the title compound (35 mg, 93 μmol, 48%) as a colorless foam. R_f = 0.43 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3404, 1657, 1644, 1432, 1266, 1048, 1025, 997, 823, 770, 751, 702. ^{1}H NMR, COSY (400 MHz, DMSO-d_6) δ (ppm) = 13.02 (s, 1H, N*H*), 9.39 (s, 1H, C*H*O), 8.36 (d, *J* = 1.8 Hz, 1H, *H*-1‘‘), 8.04 (d, *J* = 8.6 Hz, 1H, *H*-4‘‘), 8.02–7.96 (m, 2H, Naph), 7.92 (dd, *J* = 8.6, 1.8 Hz, 1H, *H*-3‘‘), 7.64–7.41 (m, 7H, Naph, Ph). ^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 178.9 (*C*HO), 136.3 (C_q5), 135.4 (C_q3), 132.7 (C_q), 132.5 (C_q), 131.2 (C_q1‘), 130.5 (*C*2‘/6‘), 129.3 (C_q2), 128.4 (*C*3‘/5‘), 128.3 (1C), 128.2 (1C), 128.1 (1C), 127.9 (1C), 127.7 (1C), 127.2 (C_q), 127.0 (1C), 126.8 (1C), 126.1 (*C*3‘‘), 97.7 (C_q4). ESI-HRMS calcd for $[C_{21}H_{14}{}^{79}BrNO + H]^+$ 376.0337, found 376.0337.

4-Bromo-5-(4-fluorophenyl)-3-(4-methoxyphenyl)-1*H*-pyrrole-2-carbaldehyde (7e). Following the general procedure, the reaction of amide **5e** (33 mg, 79 μmol, 1.0 equivequiv) and lithium aluminum hydride (2M in THF, 0.03 mL, 0.06 mmol, 0.8 equivequiv) was stirred for 20 min at –78 °C and then slowly warmed to room temperature within 1 h and stirred at room temperature. After purification by flash column chromatography (cylcohexane/EtOAc, 10:1→3:2) 5 mg (0.01 mmol) of Weinreb amide could be recovered. The title compound (15 mg,

40 μmol, 53%, 62% brsm) was obtained as a colorless oil. R_f = 0.36 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3243, 1643, 1611, 1511, 1450, 1379, 1254, 1178, 1038, 827, 668. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 12.83 (s, 1H, N*H*), 9.34 (s, 1H, C*H*O), 7.84–7.78 (m, 2H, *H*-2''/6''), 7.47–7.42 (m, 2H, *H*-2'/6'), 7.39–7.32 (m, 2H, *H*-3''/5''), 7.09–7.03 (m, 2H, *H*-3'/5'), 3.82 (s, 3H, OCH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 178.8 (*C*HO), 162.3 (d, *J* = 246.7 Hz, C_q4''), 159.2 (C_q4'), 135.3 (C_q5), 135.2 (C_q3), 131.7 (*C*2'/6'), 131.0 (d, *J* = 8.4 Hz, *C*2''/6''), 129.0 (C_q2), 126.2 (d, *J* = 3.3 Hz, C_q1''), 123.2 (C_q1'), 115.5 (d, *J* = 21.7 Hz, *C*3''/5''), 113.9 (*C*3'/5'), 97.4 (C_q4), 55.2 (CH_3). ESI-HRMS calcd for $[C_{18}H_{13}{}^{79}BrFNO_2 + Na]^+$ 396.0011, found 396.006.

4-Bromo-3-(2-chlorophenyl)-5-(4-fluorophenyl)-1*H*-pyrrole-2-carbaldehyde (7f). Following the general procedure, the reaction of amide **5f** (23 mg, 53 μmol, 1.0 equivequiv) and lithium aluminum hydride (1M in THF, 0.016 mL, 0.016 mmol, 0.3 equivequiv) was stirred for 20 min at –78 °C and then slowly warmed to room temperature and stirredat room temperature for 1 h. Purification by flash column chromatography (cylcohexane/EtOAc, 10:1) yielded the title compound (11 mg, 29 μmol, 55%) as a colorless oil. R_f = 0.15 (silica, cyclohexane/EtOAc, 10:1). IR (ATR) ν (cm^{-1}) = 3236, 1642, 1610, 1498, 1428, 1252, 1237, 1161, 840, 805, 764, 737. ^{1}H NMR, COSY (600 MHz, DMSO-d_6) δ (ppm) = 13.03 (s, 1H, N*H*), 9.22 (s, 1H, C*H*O), 7.87–7.83 (m, 2H, *H*-2''/6''), 7.64–7.61 (m, 1H, Cl-Ph), 7.51–7.44 (m, 3H, Cl-Ph), 7.39–7.34 (m, 2H, *H*-3''/5''). ^{13}C NMR, HSQC, HMBC (151 MHz, DMSO-d_6) δ (ppm) = 178.4 (*C*HO), 162.3 (d, *J* = 247.0 Hz, C_q4''), 134.9 (C_q5), 133.6 (C_q3), 133.1 (Cl-Ph), 132.5 (C_q), 130.8 (d, *J* = 8.5 Hz, *C*2''/6''), 130.6 (C_q), 130.4 (Cl-Ph), 129.5 (Cl-Ph), 129.1 (C_q2), 127.1 (Cl-Ph), 126.0 (d, *J* = 3.0 Hz, C_q1''), 115.6 (d, *J* = 21.7 Hz, *C*3''/5''), 98.6 (C_q4). ESI-HRMS calcd for $[C_{17}H_{10}{}^{79}BrClFNO + Na]^+$ 399.9516, found 399.9526.

4-Bromo-5-(4-chlorophenyl)-3-(3-nitrophenyl)-1*H*-pyrrole-2-carbaldehyde (7g). Following the general procedure, the reaction of amide **5g** (48 mg, 0.10 mmol, 1.0 equivequiv) and lithium aluminum hydride (1M in THF, 0.06 mL, 0.06 mmol, 0.6 equivequiv) was stirred for 20 min at –78 °C and then slowly warmed to room temperature overnight. Since the TLC did not show complete conversion of the nitrile, the reaction was cooled to –78 °C again and another portion of lithium aluminum hydride (1M in THF, 0.1 mL, 0.1 mmol, 0.5 equivequiv) was added. After 20 min stirring at –78 °C the reaction was warmed to room temperature and stirred for 1 h. Workup according to the general procedure and purification by flash column chromatography (cylcohexane/EtOAc, 8:1→6:1) yielded the title compound (24 mg, 59 μmol, 57%) as a colorless foam. R_f = 0.36 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3220, 1646, 1532, 1440, 1351, 1282, 1256, 881, 832, 738, 725, 695. ^{1}H NMR, COSY (400 MHz, DMSO-d_6) δ (ppm) = 13.15 (s, 1H, N*H*), 9.43 (s, 1H, C*H*O), 8.35 (*pseudo*-t, *J* = 2.0 Hz, 1H, *H*-2‘), 8.31 (ddd, *J* = 8.3, 2.4, 1.1 Hz, 1H, *H*-4‘), 8.01 (ddd, *J* = 7.7, 1.7, 1.1 Hz, 1H, *H*-6‘), 7.84–7.78 (m, 3H, *H*-2‘, 4-Cl-Ph), 7.65–7.56 (m, 2H, 4-Cl-Ph). ^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 179.1 (*C*HO), 147.7 (C_q3‘), 137.1 (*C*6‘), 135.0 (C_q), 133.7 (C_q), 132.9 (C_q), 131.9 (C_q3), 130.4 (2C, 4-Cl-Ph), 130.0 (*C*5‘), 129.5 (C_q2), 128.6 (2C, 4-Cl-Ph), 128.3 (C_q), 124.9 (*C*2‘), 122.9 (*C*4‘), 97.7 (C_q4). ESI-HRMS calcd for $[C_{17}H_{10}{}^{79}BrClN_2O_3 + Na]^+$ 404.9642, 404.9658.

3,5-Bis(3,4-dimethoxyphenyl)-3,4-dihydro-2*H*-pyrrole-2-carbonitrile (10a). According to the procedure by Kücükdisli et al.[48] the corresponding enone (2.629 g, 8.006 mmol) and aminoacetonitrile hydrochloride (1.144 g, 12.36 mmol, 1.54 equivequiv) were suspended in pyridine (40 mL) and heated to reflux for 19.5 h. Since the conversion was incomplete (TLC), another portion of aminoacetonitrile hydrochloride (154 mg, 1.66 mmol) was added and the reaction mixture refluxed for 3 h. After addition of another portion of aminoacetonitrile

hydrochloride (154 g, 1.68 mmol) and heating to reflux for 3.5 h, the TLC shows complete conversion and the solvent was removed in vacuo. The residue was dissolved in ethyl acetate and washed with sat. aq. $NaHCO_3$-solution, dried over $MgSO_4$ and concentrated in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 2:1) yielded the title compound (1.314 g, 3.585 mmol, 44.8%). It was obtained in form of the *trans*-isomer (809 mg, 27.6% yellow solid), a mixture of *cis*- and *trans*-isomer (231 mg, 7.9%, light brown solid) and the *cis*-isomer (274 mg,9.3%, light brown solid). *Trans*-isomer: mp 169.5–171.0 °C. R_f = 0.32 (silica, cylcohexane/EtOAc, 1:2). IR (ATR) ν (cm^{-1}) = 2938, 2837, 2254, 1602, 1577, 1516, 1464, 1422, 1261, 1024, 807, 765, 730. ^{1}H NMR (300 MHz, $CDCl_3$) δ (ppm) = 7.61 (d, *J* = 1.9 Hz, 1H, *H*-2''), 7.30 (dd, *J* = 8.3, 1.9 Hz, 1H, *H*-6''), 6.89 (d, *J* = 8.3 Hz, 1H, *H*-5''), 6.84 (d, *J* = 8.3 Hz, 1H, *H*-5'), 6.80 (dd, *J* = 8.3, 1.9 Hz, 1H, *H*-6'), 6.76 (d, *J* = 1.9 Hz, 1H, *H*-2'), 4.86 (dt, *J* = 7.2, 1.8 Hz, 1H, *H*-2), 3.95 (s, 3H, OCH_3), 3.94 (s, 3H, OCH_3), 3.90–3.82 (m, 1H, *H*-3), 3.87 (s, 6H, 2×OCH_3), 3.63 (ddd, *J* = 17.2, 9.4, 1.8 Hz, 1H, *H*-4_A), 3.20 (ddd, *J* = 17.2, 7.8, 1.8 Hz, 1H, *H*-4_B). ^{13}C NMR (100.6 MHz, $CDCl_3$) δ (ppm) = 176.2 (C_q5), 152.5, 149.5, 149.3, 148.7 (4C, C_q3'/C_q3''/C_q4'/C_q4''), 132.7 (C_q1'), 125.8 (C_q1''), 122.6 (*C*6''), 119.7 (C_qN), 118.8 (*C*6'), 111.7 (*C*5'), 110.4 (*C*5''), 110.0 (*C*2'), 109.9 (*C*2''), 69.0 (*C*2), 56.2, 56.1 (4C, 4×O*C*H_3), 48.9 (*C*3), 43.6 (*C*4). *Cis*-isomer: mp 143.0–144.5 °C. R_f = 0.24 (silica, cylcohexane/EtOAc, 1:2). IR (ATR) ν (cm^{-1}) = 2937, 2838, 2252, 1601, 1578, 1516, 1464, 1422, 1264, 1025, 765, 731. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 7.62 (d, *J* = 2.0 Hz, 1H, *H*-2''), 7.33 (dd, *J* = 8.3, 2.0 Hz, 1H, *H*-6''), 6.90 (d, *J* = 8.3 Hz, 1H, *H*-5''), 6.84 (d, *J* = 8.3 Hz, 1H, *H*-5'), 6.81 (dd, *J* = 8.3, 1.8 Hz, 1H, *H*-6'), 6.77 (d, *J* = 1.8 Hz, 1H, *H*-2'), 5.27 (dt, *J* = 8.1, 1.3 Hz, 1H, *H*-2), 3.96 (s, 3H, OCH_3), 3.94 (s, 3H, OCH_3), 3.92–3.86 (m, 1H, *H*-3), 3.86 (s, 3H, OCH_3), 3.86 (s, 3H, OCH_3), 3.47 (ddd, *J* = 17.1, 8.6, 1.3 Hz, 1H, *H*-4_A), 3.35 (ddd, *J* = 17.1, 6.7, 1.3 Hz, 1H, *H*-4_B). ^{13}C NMR (100.6 MHz, $CDCl_3$) δ (ppm) = 177.3 (C_q5), 152.5, 149.3, 149.2, 148.8 (4C,

C_q3'/C_q3''/C_q4'/C_q4''), 131.1 (C_q1'), 125.9 (C_q1''), 122.6 (*C*6''), 119.9 (*C*6'), 117.5 (C_qN), 111.4 (*C*5'), 111.0 (*C*2'), 110.4 (*C*5''), 109.9 (*C*2''), 67.3 (*C*2), 56.2, 56.1, 56.0 (4C, 4×OCH_3), 46.2 (*C*3), 42.4 (*C*4). ESI-HRMS calcd for $[C_{21}H_{22}N_2O_4 + H]^+$ 367.1658, found 367.1643.

3-(1*H*-Indol-3-yl)-5-phenyl-3,4-dihydro-2*H*-pyrrole-2-carbonitrile (10c). According to the procedure by Kücükdisli et al.[48] the corresponding enone[53] (3.951 g, 15.98 mmol) and aminoacetonitrile hydrochloride (2.282 g, 24.66 mmol, 1.54 equivequiv) were suspended in pyridine (80 mL) and refluxed for 18 h. After removing the solvent in vacuo, the residue was dissolved in ethyl acetate and washed with sat. aq. $NaHCO_3$-solution, dried over $MgSO_4$ and concentrated in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 4:1) yielded the title compound (1.890 g, 41.4%, *trans*-isomer) as a light brown foam. R_f = 0.54 (silica, cylcohexane/EtOAc, 1:2). IR (ATR) ν (cm^{-1}) = 3409, 2247, 1609, 1575, 1458, 1448, 1425, 1345, 908, 764, 742, 692. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 8.23 (s_{br}, 1H, N*H*), 7.95–7.90 (m, 2H, *H*-2''/6''), 7.57–7.51 (m, 2H, , *H*-4', *H*-4''), 7.50–7.45 (m, 2H, *H*-3''/5''), 7.42 (dt, *J* = 8.2, 0.8 Hz, 1H, *H*-7'), 7.25 (ddd, *J* = 8.2, 7.1, 1.1 Hz, 1H, *H*-6'), 7.16–7.11 (m, 2H, *H*-2', *H*-5'), 5.14 (dt, *J* = 7.1, 1.9 Hz, 1H, *H*-2), 4.22 (d-*pseudo*-t, *J* = 9.4, 7.3 Hz, 1H, *H*-3), 3.70 (ddd, *J* = 17.4, 9.4, 1.9 Hz, 1H, *H*-4_A), 3.42 (ddd, *J* = 17.4, 7.6, 1.9 Hz, 1H, *H*-4_B). ^{13}C NMR (100.6 MHz, $CDCl_3$) δ (ppm) = 177.4 (C_q5), 137.0 (C_q7'a), 133.0 (C_q1''), 132.0 (*C*4''), 128.9 (*C*3''/5''), 128.3 (*C*2''/6''), 125.5 (C_q3'a), 122.9 (*C*6'), 121.7 (*C*2'), 120.2 (*C*5'), 119.9 (C_qN), 118.9 (*C*4'), 114.6 (C_q3'), 111.9 (*C*7'), 67.6 (*C*2), 42.8 (*C*4), 41.2 (*C*3). ESI-HRMS calcd for $[C_{19}H_{15}N_3 + H]^+$ 286.1344, found 286.1355.

2,4-Bis(3,4-dimethoxyphenyl)-1*H*-pyrrole (11a). According to the procedure by Kücükdisli et al.[48] the corresponding nitrile **10a**[48] (126 mg, 0.344mmol) was placed in a microwave vessel and irradiated (max. 300 W) for 60 min without any solvent added. The temperature reached a maximum of 240 °C. Purification by flash column chromatography (cylcohexane/EtOAc, 1.7:1)

yielded the title compound (51 mg, 44%) as a colorless to light yellow oil. R_f = 0.27 (silica, cylcohexane/EtOAc, 1:1). IR (ATR) ν (cm^{-1}) = 3361, 2935, 2836, 1511, 1464, 1249, 1227, 1170, 1142, 1025, 855, 804, 764. ^{1}H NMR (400 MHz, DMSO-d_6) δ (ppm) = 11.21 (t_{br}, *J* = 2.7 Hz, 1H, N*H*), 7.28 (d, *J* = 2.0 Hz, 1H, *H*-2‘), 7.23–7.21 (m, 2H, *H*-5, *H*-2‘‘), 7.18 (dd, *J* = 9.0, 2.0 Hz, 1H, *H*-6‘), 7.11 (dd, *J* = 8.2, 2.0 Hz, 1H, *H*-6‘‘), 6.95 (d, *J* = 8.5 Hz, 1H, *H*-5‘), 6.89 (d, *J* = 8.4 Hz, 1H, *H*-5‘‘), 6.82 (dd, *J* = 2.7, 1.7 Hz, 1H, *H*-3), 3.83 (s, 3H, OCH_3), 3.82 (s, 3H, OCH_3), 3.76 (s, 3H, OCH_3), 3.74 (s, 3H, OCH_3). ^{13}C NMR (100.6 MHz, DMSO-d_6) δ (ppm) = 149.0 (2C, C_q3‘, C_q3‘‘), 147.1 (C_q4‘), 146.6 (C_q4‘‘), 132.2 (C_q2), 129.1 (C_q1‘‘), 126.1 (C_q1‘), 124.6 (C_q4), 116.5 (*C*6‘‘), 115.7 (*C*6‘), 115.1 (*C*5), 112.3, 112.2 (2×1C, *C*5‘, *C*5‘‘), 108.8 (*C*2‘‘), 107.8 (*C*2‘), 102.3 (*C*3), 55.6 (4×O*C*H_3). ESI-HRMS calcd for $[C_{20}H_{21}NO_4 + H]^+$ 340.1549, found 340.1553.

3-(5-Phenyl-1*H*-pyrrol-3-yl)-1*H*-indole (11c). The corresponding nitrile **10c**[48] (117 mg, 0.410 mmol) was placed in a microwave vessel and irradiated (max. 300 W) for 60 min without any solvent added. The temperature reached a maximum of 150 °C. Purification by flash column chromatography (cylcohexane/EtOAc, 4:1 + 1%TEA) and recrystallization from a cylcohexane/ethyl acetate-mixture yielded the title compound (43 mg, 41%) as a colorless solid. mp 265.5–267.0 °C. R_f = 0.13 (silica, cylcohexane/EtOAc, 5:1). IR (ATR) ν (cm^{-1}) = 3407, 2956, 2923, 2853, 1658, 1455, 1113, 1025, 993, 799, 764, 730, 691. ^{1}H NMR (400 MHz, DMSO-d_6) δ (ppm) = 11.26 (s_{br}, 1H, N*H*-1‘), 11.00 (s_{br}, 1H, N*H*-1), 7.86 (d, *J* = 7.8 Hz, 1H, *H*-4), 7.70 (d, *J* = 7.7 Hz, 2H, *H*-2‘‘/6‘‘), 7.51 (d, *J* = 2.1 Hz, 1H, *H*-2), 7.43–7.32 (m, 3H, *H*-7, *H*-3‘‘/6‘‘), 7.21 (t, *J* = 1.8 Hz, 1H, *H*-2‘), 7.16 (t, *J* = 7.4 Hz, 1H, *H*-4‘‘), 7.11 (t, *J* = 7.3 Hz, 1H, *H*-6), 7.05 (t, *J* = 7.3 Hz, 1H, *H*-5), 6.89 (t, *J* = 1.8 Hz, 1H, *H*-4‘). ^{13}C NMR (100.6 MHz, DMSO-d_6) δ (ppm) = 136.5 (C_q7a), 133.0 (C_q1‘‘), 131.2 (C_q5’), 128.7 (*C*3‘‘/5‘‘), 125.4 (*C*4‘‘, C_q3a), 123.3 (*C*2‘‘/6‘‘), 121.0, 120.9 (2×1C, *C*2, *C*6), 119.6 (*C*4), 119.3 (C_q3‘), 118.8 (*C*5), 115.3 (*C*2‘), 111.5 (*C*7), 111.2 (C_q3), 104.1 (*C*4‘). ESI-HRMS calcd for $[C_{18}H_{14}N_2 + H]^+$ 259.1235, found 259.1235.

3,5-Bis(3,4-dimethoxyphenyl)-1*H*-pyrrole-2-carbonitrile (12a). The title compound was prepared according to the procedure by Kücükdisli et al.[48] Cyanopyrroline **10a** (696 mg, 1.90 mmol) and DDQ (550 g, 2.42 mmol, 1.28 equivequiv) were dissolved in toluene (40 mL) and refluxed for 2.5 h. After removing the solvent in vacuo, the residue was dissolved in ethyl acetate and washed with 10% aqueous NaOH solution, dried over $MgSO_4$ and concentrated in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 4:1) yielded the title compound (337 mg, 50%) as a light brown solid. mp 234.5–235.5 °C. R_f = 0.46 (silica, cylcohexane/EtOAc, 1:2). IR (ATR) ν (cm^{-1}) = 3303, 2836, 2202, 1514, 1464, 1440, 1267, 1245, 1137, 1024, 804, 729. ^{1}H NMR, COSY (400 MHz, DMSO-d_6) δ (ppm) = 12.49 (d, *J* = 2.1 Hz, 1H, N*H*), 7.40 (d, *J* = 2.0 Hz, 1H, *H*-2''), 7.36 (dd, *J* = 8.3, 2.0 Hz, 1H, *H*-6''), 7.31 (d, *J* = 2.0 Hz, 1H, *H*-2'), 7.29 (dd, *J* = 8.2, 2.0 Hz, 1H, *H*-6'), 7.05 (d, *J* = 8.2 Hz, 1H, *H*-5'), 7.04–7.01 (m, 2H, *H*-4, *H*-5''), 3.85 (s, 3H, OCH_3), 3.83 (s, 3H, OCH_3), 3.80 (s, 3H, OCH_3), 3.79 (s, 3H, OCH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 149.0, 148.9, 148.7, 148.5 (4C, C_q3'/C_q3''/C_q4'/C_q4''), 137.4 (C_q5), 135.1 (C_q3), 125.5 (C_q1'), 123.4 (C_q1''), 118.5 (*C*6'), 117.5 (*C*6''), 116.2 (C_qN), 112.1, 112.0 (2C, *C*5', *C*5''), 110.1 (*C*2'), 108.6 (*C*2''), 105.1 (*C*4), 95.8 (C_{q2}), 55.7, 55.6, 55.5 (4C, 4×OCH_3). ESI-HRMS calcd for $[C_{21}H_{20}N_2O_4 + Na]^+$ 387.1321, found 387.1310.

3-(1*H*-Indol-3-yl)-5-phenyl-1*H*-pyrrole-2-carbonitrile (12c). The title compound was prepared according to the procedure by Kücükdisli et al.[48] Cyanopyrroline **10c** (714 mg, 2.50 mmol) and DDQ (723 g, 3.19 mmol, 1.27 equivequiv) were dissolved in toluene (50 mL) and refluxed for 2.5 h. After removing the solvent in vacuo, the residue was dissolved in ethyl acetate and washed with 10% aqueous NaOH solution, dried over $MgSO_4$ and concentrated in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 4:1) yielded the title compound (395 mg, 55.8%) as a brown solid. mp 259.0–261.0 °C. R_f = 0.35 (silica, cylcohexane/EtOAc, 2:1). IR

(ATR) ν (cm^{-1}) = 3412, 3288, 2203, 1576, 1455, 1443, 1330, 1268, 1107, 761, 737, 694. ^{1}H NMR, COSY (400 MHz, DMSO-d_6) δ (ppm) = δ 12.54 (s, 1H, N*H*-1), 11.40 (s, 1H, N*H*-1‘), 7.91 (d, *J* = 7.9 Hz, 1H, *H*-4’), 7.88–7.84 (m, 2H), 7.68 (d, *J* = 2.6 Hz, 1H, *H*-2’), 7.51–7.41 (m, 3H, *H*-7’, *H*-3’’/5’’), 7.34 (tt, *J* = 6.8, 1.1 Hz, 1H, *H*-4’’), 7.18 (ddd, *J* = 8.1, 7.0, 1.2 Hz, 1H, *H*-6’), 7.12 (ddd, *J* = 8.0, 7.1, 1.1 Hz, 1H, *H*-5’), 7.09 (d, *J* = 2.6 Hz, 1H, *H*-4). ^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 137.1 (C_q5), 136.0 (C_q7’a), 130.8 (C_q3), 130.4 (C_q1’’), 129.0 (*C*3’’/5’’), 127.8 (*C*4’’), 125.4 (C_q3’a), 124.9 (*C*2’’/6’’), 123.1 (*C*2’), 121.7 (*C*6’), 119.6, 119.5 (2×1C, *C*4’, *C*5’), 116.2 (C_qN), 111.9 (*C*7’), 107.7 (C_q3’), 106.1 (*C*4), 96.7 (C_q2). ESI-HRMS calcd for $[C_{19}H_{13}N_3 + Na]^+$ 306.1007, found 306.1017.

3,5-Diphenyl-1*H*-pyrrole-2-carbonitrile (12d). Chalcone (4.17 g, 20.0 mmol) and aminoacetonitrile hydrochloride (2.80 g, 30.3 mmol, 1.5 equivequiv) were refluxed for 16 h, then DDQ (5.02 g, 22.1 mmol, 1.1 equivequiv) was added and the mixture was heated for 26 h. Another portion of DDQ (1.55 g, 6.83 mmol, 0.34 equivequiv) was added and the mixture refluxed for further 22.5 h. The solvent was removed in vacuo and purification by flash column chromatography (cyclohexane/EtOAc, 10:1→8:1) yielded **12d** (2.93 g, 12.0 mmol, 60%) as a colorless solid. mp 194.2–198.7 °C (Lit.[48] 192–193 °C). R_f = 0.49 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3277, 2210, 1495, 1465, 1455, 1263, 760, 693. ^{1}H NMR (400 MHz, DMSO-d_6) δ (ppm) = 12.77 (s_{br}, 1H, N*H*), 7.81 (d, *J* = 7.8 Hz, 2H, Ph), 7.74 (d, *J* = 7.8 Hz, 2H, Ph), 7.51–7.43 (m, 4H, Ph), 7.39–7.31 (m, 2H, Ph), 7.12 (s, 1H, *H*-4). The spectroscopic data were in accordance with the literature.[48]

4-Bromo-3,5-diphenyl-1*H*-pyrrole-2-carbonitrile (12e). Chalcone (4.17 g, 20.0 mmol) and aminoacetonitrile hydrochloride (2.80 g, 30.3 mmol, 1.51 equivequiv) were refluxed for 16 h, then DDQ (5.04 g, 22.2 mmol, 1.11 equivequiv) was added and the mixture was heated for 26 h. Another portion of DDQ (1.58 g, 6.96 mmol, 0.35 equivequiv) was added and the mixture

refluxed for further 22.5 h. The reaction mixture was cooled to room temperature and NBS (4.00 g, 22.5 mmol, 1.12 equivequiv) was added. After 15 h of stirring at room temperature, the solvent was removed in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 10:1) yielded the title compound (2.73 g, 42.2%) as a yellow solid. mp 199.6–201.7 °C. R_f = 0.48 (silica, cylcohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3226, 3111, 2218, 1495, 1449, 1428, 1263, 1076, 966, 913, 762, 692. ^{1}H NMR, COSY (400 MHz, DMSO-d_6) δ (ppm) = 13.21 (s, 1H, N*H*), 7.79–7.71 (m, 2H, *H*-2‘‘/6‘‘), 7.58–7.50 (m, 6H, Ph), 7.48–7.42 (m, 2H, Ph). ^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 135.0 (C_q5), 134.2 (C_q3), 131.1, 129.7 (2×C_q, *C*1‘/*C*1‘‘), 129.0 (2C), 128.8 (1C), 128.7 (2C), 128.7 (2C), 128.3 (1C), 127.9 (2C, *C*2‘‘/6‘‘), 114.0 (C_qN), 99.1 (C_q2), 94.3 (C_q4). FD-MS ($C_{17}H_{11}N_2Br$): 322.2. ESI-HRMS analysis was not possible due to poor ionization.

4-Iodo-3,5-diphenyl-1*H*-pyrrole-2-carbonitrile (12f). 3,5-Diphenyl-1*H*-pyrrole-2-carbonitrile **12d** (124 mg, 0.508 mmol) was dissolved in pyridine (10 mL) and NIS (150 mg, 0.667 mmol, 1.3 equivequiv) was added. After 3 h of stirring at room temperature the solvent was removed in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 10:1) yielded the title compound (153 mg, 82%) as a yellow solid. mp 202.7–205.6 °C. R_f = 0.34 (silica, cylcohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3329, 2218, 1493, 1447, 1422, 1284, 1255, 909, 765, 734, 695, 673. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 9.93 (s, 1H, N*H*), 7.70–7.65 (m, 2H, Ph), 7.61–7.55 (m, 2H, Ph), 7.53–7.42 (m, 6H, Ph). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 139.9, 139.1 (2×C_q, *C*3/*C*5), 132.5, 131.0 (2×C_q, *C*1‘,*C*1‘‘), 129.6 (2C), 129.4 (1C), 129.0 (2C), 128.7 (1C), 128.7 (2C), 128.4 (2C), 114.2 (C_qN), 100.6 (C_q2), 66.0 (C_q4). ESI-HRMS calcd for $[C_{17}H_{11}N_2{}^{127}I + Na]^+$ 392.9865, found 392.9857.

5-(Naphthalen-2-yl)-3-phenyl-1*H*-pyrrole-2-carbonitrile (12g). Chalcone (517 mg, 2.00 mmol) and aminoacetonitrile hydrochloride (295 mg, 3.19 mmol, 1.6 equivequiv) were

refluxed for 19 h, then DDQ (533 mg, 2.35 mmol, 1.2 equivequiv) was added and the mixture was heated for 47 h. The solvent was removed in vacuo and purification by flash column chromatography (silica, cyclohexane/EtOAc, 8:1+1%TEA) yielded **12g** (287 mg (0.975 mmol, 49%), as a light brown solid. mp 221.0–224.0°C (Lit.[48] 227–229 °C). R_f = 0.42 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3272, 3055, 2210, 1605, 1509, 1455, 1264, 857, 811, 764, 695. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 9.13 (s_{br}, 1H, N*H*), 8.02 (d, *J* = 1.6 Hz, 1H, *H*-1‘‘), 7.98–7.84 (m, 4H, *H*-3‘‘, *H*-4‘‘, Naph), 7.80–7.74 (m, 2H, *H*-2‘/6‘), 7.69 (dd, *J* = 8.6, 1.9 Hz, 1H, Naph), 7.56–7.43 (m, 3H, *H*-3‘/5‘, Naph), 7.41–7.34 (m, 1H, *H*-4‘), 6.91 (d, *J* = 2.9 Hz, 1H, *H*-4‘). The spectroscopic data were in accordance with the literature.[48]

5-(4-Chlorophenyl)-3-(3-nitrophenyl)-1*H*-pyrrole-2-carbonitrile (12h). Chalcone (1.157 g, 4.02 mmol) and aminoacetonitrile hydrochloride (0.569 g, 6.15 mmol, 1.5 equivequiv) were refluxed for 18.5 h, then DDQ (1.061 g, 4.674 mmol, 1.2 equivequiv) was added and the mixture was heated for 53.5 h. The solvent was removed in vacuo and purification by flash column chromatography (cyclohexane/EtOAc, 4:1) yielded **12h** (690 mg,2.13 mmol, 53 %) as a yellow solid. mp 300.2–301.5 °C. R_f = 0.35 (Silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3292, 2361, 2208, 1531, 1509, 1347, 1261, 1093, 1023, 1005, 800, 738, 660. ^{1}H NMR (400 MHz, $CDCl_3$+DMSO-d_6) δ (ppm) = 12.41 (s, 1H, N*H*), 8.36 (t, *J* = 2.0 Hz, 1H, *H*-2), 8.04–7.90 (m, 2H, *H*-4‘, *H*-6‘), 7.57–7.50 (m, AA‘ of AA‘BB‘-System, 2H, *H*-2‘‘/6‘‘), 7.47 (t, *J* = 8.0 Hz, 1H, *H*-5‘), 7.26–7.20 (BB‘ of AA‘BB‘-System, 2H, *H*-3‘‘/5‘‘), 6.67 (d, *J* = 2.7 Hz, 1H, *H*-4). The spectroscopic data were in accordance with the literature.[48]

3-(2,3-Dichlorophenyl)-5-phenyl-1*H*-pyrrole-2-carbonitrile (12i). Chalcone (554 mg, 2.00 mmol) and aminoacetonitrile hydrochloride (296 mg, 3.20 mmol, 1.60 equivequiv) were refluxed for 19 h, then DDQ (539 mg, 2.37 mmol, 1.19 equivequiv) was added and the mixture was heated for 47 h. Another portion of DDQ (101 mg, 0.445 mmol, 0.22 equiv) was added and

the mixture refluxed for further 21.5 h. The solvent was removed in vacuo and purification by flash column chromatography (cyclohexane/EtOAc, 8:1+1% TEA) yielded **12i** (294 mg, 0.939 mmol, 47%) as a yellow solid. mp 210.0–211.0 °C (Lit.[48] 204–205 °C). R_f = 0.41 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3263, 2215, 1703, 1485, 1460, 1447, 1437, 1269, 787, 762, 693. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 9.16 (s, 1H, N*H*), 7.59 – 7.53 (m, 2H, *H*-2‘‘/6‘‘), 7.51 (dd, *J* = 8.0, 1.7 Hz, 1H, *H*-4‘), 7.49–7.43 (m, 2H, *H*-3‘‘/5‘‘), 7.43–7.36 (m, 2H, *H*-6‘, *H*-4‘‘), 7.30 (*pseudo*-t, *J* = 7.9 Hz, 1H, *H*-5‘), 6.77 (d, *J* = 2.8 Hz, 1H, *H*-4). The spectroscopic data are in accordance with the literature.[48]

5-(4-Fluorophenyl)-3-(4-methoxyphenyl)-1*H*-pyrrole-2-carbonitrile (12j). Chalcone (514 mg, 2.01 mmol) and aminoacetonitrile hydrochloride (298 mg, 3.22 mmol, 1.6 equiv) were refluxed for 19 h, then DDQ (535 mg, 2.36 mmol, 1.2 equiv) was added and the mixture was heated for 47 h. Another portion of DDQ (65 mg, 0.29 mmol, 0.14 equiv) was added and the mixture refluxed for further 20 h. The solvent was removed in vacuo and purification by flash column chromatography (cyclohexane/EtOAc, 8:1+1% TEA) yielded **12j** (222 mg, 0.759 mmol, 38%) as a colorless solid. mp 239.0–241.0 °C. R_f = 028 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3303, 2210, 1615, 1508, 1254, 1229, 1179, 1167, 839, 810. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 8.79 (s, 1H, N*H*), 7.70–7.63 (m, 2H, *H*-2‘‘/6‘‘), 7.56–7.49 (m, AA‘ of AA’BB‘-system, 2H, *H*-2‘/6‘), 7.22–7.09 (m, 2H, *H*-3‘‘/5‘‘), 7.01–6.96 (m, 2H, *H*-3‘/5‘), 6.66 (d, *J* = 2.9 Hz, 1H, *H*-4), 3.86 (s, 3H, OCH_3). The spectroscopic data were in accordance with the literature.[48]

General procedure for the synthesis of pyrrole-2-carbaldehydes 7a and 7h–x from pyrrole-2-carbonitriles. A Schlenk flask was charged with pyrrole-2-carbonitrile **12** under argon, dry dichloromethane (ca. 12 mL/mmol) was added and the solution was cooled to −78 °C. DIBAL (1M in hexane, 1 equiv.) was slowly added. When the conversion was complete, the mixture was

quenched with an aqueous solution of Rochelle salt, diluted with ethyl acetate, dried with $MgSO_4$ and concentrated in vacuo. Flash column chromatography yields the desired product.

3,5-Diphenyl-1*H*-pyrrole-2-carbaldehyde (7a). Following the general procedure, the reaction of nitrile **12d** (250 mg, 1.02 mmol) and DIBAL (1M in hexane, 1.0 mL, 1.0 mmol) was slowly warmed to 0 °C within 3 h. Purification by flash column chromatography (cylcohexane/ EtOAc, 10:1→8:1) yielded the title compound (168 mg, 0.679 mmol, 66.6%) as a colorless to light pink oil. R_f = 0.47 (silica, cyclohexane/EtOAc, 1:1). IR (ATR) ν (cm^{-1}) = 2954, 2924, 2854, 1659, 1633, 1465, 1378, 1262, 1101, 1032, 808, 700. ^{1}H NMR, COSY (400 MHz, DMSO-d_6) δ (ppm) = 12.44 (s, 1H, N*H*), 9.59 (s, 1H, C*H*O), 8.00–7.95 (m, 2H, *H*-2‘‘/6‘‘), 7.64–7.59 (m, 2H, Ph, *H*-2‘/6‘), 7.49–7.42 (m, 4H, *H*-3‘/5‘, *H*-3‘‘/5‘‘), 7.41–7.37 (m, 1H, *H*-4‘), 7.37–7.32 (m, 1H, *H*-4‘‘), 6.98 (d, *J* = 2.6 Hz, 1H, *H*-4). ^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 178.6 (*C*HO), 138.8 (C_q5), 136.9 (C_q3), 133.6 (C_q1‘), 130.5 (C_q1‘‘), 129.1 (C_q2), 129.0 (*C*2‘/6‘), 128.8, 128.7 (4C, *C*3‘/5‘, 3‘‘/5‘‘), 128.2 (*C*4‘‘), 127.6 (*C*4‘), 125.8 (*C*2‘‘/6‘‘), 109.2 (*C*4). The spectroscopic data were in accordance with the literature.[23]

5-(Naphthalen-2-yl)-3-phenyl-1*H*-pyrrole-2-carbaldehyde (7h). Following the general procedure, the reaction of nitrile **12g** (326 mg, 1.11 mmol) and DIBAL (1M in hexane, 1.1 mL, 1.1 mmol) was slowly warmed to room temperature within 4 h. Purification by flash column chromatography (cylcohexane/ EtOAc, 10:1) yielded the title compound (87 mg, 29 μmol, 26%) as a colorless oil. R_f = 0.42 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3279, 1630, 1485, 1458, 1440, 1377, 1263, 812, 765, 749, 700. ^{1}H NMR, COSY (400 MHz, DMSO-d_6) δ (ppm) = 12.57 (s, 1H, N*H*), 9.63 (s, 1H, C*H*O), 8.61 (d, *J* = 1.2 Hz, 1H, *H*-1‘‘), 8.11 (dd, *J* = 8.7, 1.8 Hz, 1H, *H*-3‘‘), 7.98 (d, *J* = 8.7 Hz, 1H, *H*-4‘‘), 7.95–7.89 (m, 2H, *H*-5‘‘/8‘‘), 7.68–7.62 (m, 2H, *H*-2‘/6‘), 7.59–7.45 (m, 4H, *H*-3‘/5‘, *H*-6‘‘/7‘‘), 7.43–7.38 (m, 1H, *H*-4‘), 7.14 (s, 1H, *H*-4). ^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 178.7 (*C*HO), 138.7 (C_q5),

136.9 (C_q3), 133.6 (C_q1‘), 133.1 (C_q8a‘‘), 132.6 (C_q4a‘‘), 129.4 (C_q2), 129.0 (2C, *C*2‘/6‘), 128.8 (2C, *C*3‘/5‘), 128.4 (*C*4‘‘), 128.1 (*C*8‘‘), 128.0 (C_q2‘‘), 127.7 (2C, *C*4‘, *C*5‘‘), 126.8, 126.5 (2C, *C*6‘‘,7‘‘), 124.4 (*C*1‘‘), 123.9 (*C*3‘‘), 109.7 (*C*4). ESI-HRMS calcd for $[C_{21}H_{15}NO + Na]^+$ 320.1051, found 320.1050.

5-(4-Fluorophenyl)-3-(4-methoxyphenyl)-1*H*-pyrrole-2-carbaldehyde (7i). Following the general procedure, the reaction of nitrile **12j** (333 mg, 1.14 mmol) and DIBAL (1M in hexane, 1.2 mL, 1.2 mmol) was slowly warmed to 0 °C within 3 h and stirred overnight at room temperature. Purification by flash column chromatography (cylcohexane/ EtOAc, 10:1→8:1) yielded the title compound (146 mg, 0.494 mmol, 43%) as a colorless oil. R_f = 0.29 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3277, 2927, 1631, 1609, 1507, 1462, 1250, 1162, 1037, 839, 809, 782. ^{1}H NMR, COSY (400 MHz, DMSO-d_6) δ (ppm) = 12.35 (s, 1H, N*H*), 9.55 (s, 1H, C*H*O), 8.05–7.98 (m, 2H, *H*-2‘‘/6‘‘), 7.56–7.51 (m, 2H, *H*-2‘/6‘), 7.31–7.24 (m, 2H, *H*-3‘‘/5‘‘), 7.05–7.00 (m, 2H, *H*-3‘/5‘), 6.90 (s, 1H, *H*-4), 3.80 (s, 3H, OCH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 178.4 (*C*HO), 162.0 (d, *J* = 245.8 Hz, C_q4‘‘), 159.0 (C_q4‘), 137.8 (C_q5), 136.9 (C_q3), 130.2 (*C*2‘/6‘), 129.0 (C_q2), 127.9 (d, *J* = 8.3 Hz, *C*2‘‘/6‘‘), 127.3 (d, *J* = 3.1 Hz, C_q1‘), 125.9 (C_q1‘), 115.7 (d, *J* = 21.6 Hz, *C*3‘‘/5‘‘), 114.2 (*C*3‘/5‘), 108.9 (*C*4), 55.2 (O*C*H_3). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –114.50 (tt, *J* = 9.1, 5.4 Hz). ESI-HRMS calcd for $[C_{18}H_{14}FNO_2 + Na]^+$ 318.0906, found 318.0914.

3-(2-Chlorophenyl)-5-(4-fluorophenyl)-1*H*-pyrrole-2-carbaldehyde (7j). Following the general procedure, the reaction of nitrile[48] (185 mg, 0.623 mmol) and DIBAL (1M in hexane, 0.7 mL, 0.7 mmol) was stirred at –78 °C for 1 h and stirred at room temperature overnight. Purification by flash column chromatography (cylcohexane/ EtOAc, 10:1) yielded the title compound (76 mg, 0.25 mmol, 41%) as a light pink oil. R_f = 0.38 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3275, 1640, 1495, 1467, 1436, 1381, 1259, 1236, 1162, 807, 758, 716.

^{1}H NMR, COSY (400 MHz, DMSO-d_6) δ (ppm) = 12.57 (s, 1H, N*H*), 9.31 (s, 1H, C*H*O), 8.04–7.97 (m, 2H, *H*-2''/6''), 7.61–7.56 (m, 1H, *H*-3'), 7.54–7.50 (m, 1H, *H*-6'), 7.45–7.40 (m, 2H, *H*-4'/5'), 7.28 (t, *J* = 8.8 Hz, 2H, *H*-3''/5''), 6.87 (s, 1H, *H*-4). ^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 178.3 (*C*HO), 162.0 (d, *J* = 246.1 Hz, *C*4''), 137.4 (C_q5), 133.3 (C_q3), 132.7 (*C*6'), 132.5, 132.4 (2×C_q, C_q1'/2'), 129.7 (*C*3'), 129.7 (C_q2), 129.6 (*C*4'), 127.9 (d, *J* = 8.2 Hz, *C*2''/6''), 127.2 (*C*5'+C_q1''), 115.8 (d, *J* = 21.4 Hz, *C*3''/5''), 110.5 (*C*4). ESI-HRMS calcd for $[C_{17}H_{11}ClFNO + H]^+$ 300.0591, found 300.0587.

3-(2,3-Dichlorophenyl)-5-phenyl-1*H*-pyrrole-2-carbaldehyde (7k). Following the general procedure, the reaction of nitrile **12i** (130 mg, 0.415 mmol) and DIBAL (1.2M in toluene, 0.40 mL, 0.48 mmol, 1.2 equiv) was warmed to room temperature overnight. Since TLC did not show complete conversion, the reaction was cooled to –78 °C and another portion of DIBAL (1.2M in toluene, 0.04 mL, 0.05 mmol, 0.1 equiv). After stirring at room temperature for 1 h, the reaction was cooled to 0 °C. Workup according to the general procedure and purification by flash column chromatography (cylcohexane/ EtOAc, 10:1) yielded the title compound (70 mg, 0.22 mmol, 54%) as a light red oil. R_f = 0.41 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3276, 1636, 1465, 1435, 1411, 1379, 1261, 836, 788, 764, 722, 692. ^{1}H NMR, COSY (400 MHz, DMSO-d_6) δ (ppm) = 12.64 (s, 1H, N*H*), 9.34 (s, 1H, C*H*O), 7.98–7.91 (m, 2H, *H*-2''/6''), 7.67 (dd, *J* = 8.0, 1.6 Hz, 1H, *H*-4'), 7.49 (dd, *J* = 7.7, 1.6 Hz, 1H, *H*-6'), 7.46–7.38 (m, 3H, *H*-5', *H*-3''/5''), 7.38–7.29 (m, 1H, *H*-4''), 6.90 (s, 1H, *H*-4). ^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 178.3 (*C*HO), 138.3 (C_q5), 135.1 (C_q1'), 132.6 (C_q3), 132.3 (C_q3'), 131.2 (*C*6'), 130.9 (C_q2'), 130.4 (C_q1''), 130.0 (*C*4'), 129.7 (C_q2), 128.9 (*C*3''/5''), 128.3 (*C*4''), 127.9 (*C*5'), 125.7 (*C*2''/6''), 110.5 (*C*4). ESI-HRMS calcd for $[C_{17}H_{11}Cl_2NO + H]^+$ 316.0296, found 316.0298.

3,5-Bis(3,4-dimethoxyphenyl)-1*H*-pyrrole-2-carbaldehyde (7l). Following the general procedure, the reaction of nitrile **12a** (93 mg, 0.255 mmol) and DIBAL (1M in hexane, 0.26 mL, 0.26 mmol) was stirred at room temperature overnight (14 h). Purification by flash column chromatography (cylcohexane/ EtOAc, 3:2) yielded the title compound (28 mg, 76 μmol, 30%) as a colorless oil. R_f = 0.31 (silica, cyclohexane/EtOAc, 1:2). IR (ATR) ν (cm^{-1}) = 3264, 2835, 1633, 1516, 1473, 1273, 1138, 1025, 792, 742. ^{1}H NMR, COSY (400 MHz, DMSO-d_6) δ (ppm) = 12.24 (d, *J* = 2.6 Hz, 1H, N*H*), 9.55 (s, 1H, C*H*O), 7.64 (d, *J* = 2.0 Hz, 1H, *H*-2‘‘), 7.50 (dd, *J* = 8.4, 2.0 Hz, 1H, *H*-6‘‘), 7.17 (d, *J* = 2.0 Hz, 1H, *H*-2‘), 7.12 (dd, *J* = 8.4, 2.0 Hz, 1H, *H*-6‘), 7.03 (d, *J* = 8.4 Hz, 1H, *H*-5‘), 7.01 (d, *J* = 8.5 Hz, 1H, *H*-5‘‘), 6.90 (d, *J* = 2.6 Hz, 1H, *H*-4), 3.86 (s, 3H, OCH_3), 3.84 (s, 3H, OCH_3), 3.80 (s, 3H, OCH_3), 3.79 (s, 3H, OCH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 178.0 (*C*HO), 149.0, 148.9, 148.8, 148.6 (4×C_q, *C*3‘/4‘/3‘‘/4‘‘), 139.2 (C_q5), 137.4 (C_q3), 128.6 (C_q2), 126.4 (C_q1‘), 123.3 (C_q1‘‘), 121.4 (*C*6‘), 118.6 (*C*6‘‘), 112.6 (*C*2‘), 111.9 (2C, *C*5‘/5‘‘), 109.3 (*C*2‘‘), 108.3 (*C*4), 55.7, 55.6 (4×O*C*H_3). ESI-HRMS calcd for $[C_{21}H_{21}NO_5 + H]^+$ 368.1498, found 368.1505.

3-(1*H*-Indol-3-yl)-5-phenyl-1*H*-pyrrole-2-carbaldehyde (7m). Following the general procedure, the reaction of nitrile **12c** (175 mg, 0.618 mmol) and DIBAL (1.2M in toluene, 0.60 mL, 0.72 mmol, 1.17 equiv) was stirred at –78 °C for 1 h and stirred at room temperature overnight. Purification by flash column chromatography (cylcohexane/ EtOAc, 2:1) yielded the title compound (62 mg, 0.22 mmol, 35%) as a green oil. R_f = 0.15 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3409, 3271, 1617, 1456, 1412, 1377, 1282, 1262, 1242, 801, 745, 694. ^{1}H NMR, COSY (400 MHz, DMSO-d_6) δ (ppm) = 12.27 (s_{br}, 1H, N*H*-1), 11.43 (s_{br}, 1H, N*H*-1’), 9.64 (s, 1H, C*H*O), 8.04–8.00 (m, 2H, *H*-2’‘/6’‘), 7.81 (d, *J* = 7.9 Hz, 1H, *H*-4’), 7.71 (d, *J* = 2.1 Hz, 1H, *H*-2’), 7.49–7.41 (m, 3H, *H*-7’, *H*-3’‘/5’‘), 7.38–7.32 (m, 1H, *H*-4’‘), 7.18 (ddd, *J* = 8.0, 6.8, 1.0 Hz, 1H, *H*-6’), 7.11 (ddd, *J* = 7.9, 6.8, 1.0 Hz, 1H, *H*-5’), 7.04 (d, *J* = 2.3 Hz, 1H, *H*-4).

^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 178.1 (*C*HO), 139.4 (C_q5), 136.5 (C_q7'a), 131.2 (C_q3), 130.8 (C_q1''), 129.3 (C_q2), 128.8 (*C*3''/5''), 128.1 (*C*4''), 126.3 (C_q3'a), 125.8 (*C*2''/6''), 125.2 (*C*2'), 121.7 (*C*6'), 119.6 (*C*5'), 119.2 (*C*4'), 111.8 (*C*7'), 108.7 (*C*4), 107.8 (*C*3'a). ESI-HRMS calcd for $[C_{19}H_{14}N_2O + Na]^+$ 309.1004, found 309.1011.

1-(3,5-Diphenyl-1*H*-pyrrol-2-yl)-1-phenylmethanone (13a). Nitrile **12d** (32.7 mg, 0.134 mmol) was placed in a Schlenk flask, dissolved in dry THF (1 mL) and cooled to –78 °C. Phenylmagnesium bromide (1M in THF, 0.30 mL, 0.30 mmol, 2.2 equiv) was added and the reaction mixture was stirred for 1 h at –78 °C and 15 h at room temperature. The reaction was quenched with sat. aqueous NH_4Cl-solution and extracted with ethyl acetate. The combined organic layers were dried with $MgSO_4$ and concentrated in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 1:3) yielded the imine, which was dissolved ethanol (5 mL), 4M NaOH (5 mL) was added and the mixture was stirred for 4 h at 80 °C. The reaction mixture was acidified with conc. HCl and extracted with dichloromethane. The combined organic layers were dried with $MgSO_4$ and concentrated in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 9:1) yielded the title compound (27 mg, 83 μmol, 62%) as a yellow oil. R_f = 0.47 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3290, 3060, 1596, 1573, 1493, 1463, 1428, 1295, 1274, 908, 761, 733, 696. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 9.98 (s_{br}, 1H, N*H*), 7.74–7.66 (m, 2H, *H*-2'''/6'''), 7.53–7.40 (m, 4H, *H*-2/6, *H*-3'''/5'''), 7.41–7.31 (m, 1H, *H*-4'''), 7.28–7.21 (m, 1H, *H*-4),7.14–7.00 (m, 7H, *H*-3/5, Ph''), 6.70 (d, *J* = 3.0 Hz, 1H, *H*-4'). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 187.0 (*C*=O), 138.1 (C_q1), 137.5 (C_q5'), 135.5 (2×C_q, C_q3', C_q1''), 131.4 (*C*4), 130.9 (C_q1'''), 129.8 (2C), 129.5 (*C*2/6), 129.3 (*C*3'''/5'''), 128.5 (*C*4'''), 128.1 (C_q2'), 127.8 (2C), 127.6 (2C), 126.8 (*C*4''), 125.3 (*C*2'''/6'''), 110.5 (*C*4'). ESI-HRMS calcd for $[C_{23}H_{17}NO + Na]^+$ 346.1208, found 346.1208.

(4-Bromo-3,5-diphenyl-1*H*-pyrrol-2-yl)(phenyl)methanone (13b). Nitrile **12e** (763 mg, 2.36 mmol) was placed in a Schlenk flask, dissolved in dry THF (24 mL) and cooled to –78 °C. Phenylmagnesium bromide (1M in THF, 7.0 mL, 7.0 mmol, 3.0 equiv) was added and the reaction mixture was stirred for 1 h at –78 °C and 15 h at room temperature. The reaction was quenched with sat. aqueous NH_4Cl-solution and extracted with ethyl acetate. The combined organic phases were dried with $MgSO_4$ and concentrated in vacuo. The residue was dissolved in ethanol (50 mL) and 4N aqueous NaOH (50 mL) was added and the mixture was stirred for 7 h at 80 °C. The reaction mixture was acidified with conc. HCl and extracted with dichloromethane. The combined organic phases were dried with $MgSO_4$ and concentrated in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 9:1) yielded the title compound (831 mg, 88%) as a yellow solid. R_f = 0.49 (silica, cyclohexane/EtOAc, 2:1). mp 147.5–149.2 °C. IR (ATR) ν (cm^{-1}) = 3256, 1602, 1574, 1493, 1448, 1420, 1294, 1269, 908, 765, 733, 694. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 10.22 (s, 1H, N*H*), 7.87–7.82 (m, 2H, *H*-2‘‘‘/6‘‘‘), 7.54–7.39 (m, 3H, *H*-3‘‘‘/4‘‘‘/5‘‘‘), 7.41–7.33 (m, 2H, *H*-2/6), 7.21 (ddt, *J* = 8.8, 7.0, 1.3 Hz, 1H, *H*-4), 7.14–7.05 (m, 5H, Ph‘‘), 7.05–6.96 (m, 2H, *H*-3/5). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 186.8 (*C*=O), 137.3 (C_q1), 135.3 (C_q5‘), 133.8 (C_q3‘), 133.3 (C_q1‘‘), 131.4 (*C*4), 131.1 (2C, Ph‘‘), 130.4 (C_q1‘‘‘), 129.2 (2C, *C*2/6), 129.0 (1C, *C*4‘‘‘), 128.9 (2C, *C*3‘‘‘/*C*5‘‘‘), 128.1 (C_q2‘+2C, *C*2‘‘‘/6‘‘‘), 127.7(2C, Ph‘‘), 127.5 (*C*3/5), 127.4 (*C*4‘‘), 99.4 (C_q4‘). ESI-HRMS calcd for $[C_{23}H_{16}BrNO + H]^+$ 402.0494, found 402.0504.

1-(4-Bromo-3,5-diphenyl-1*H*-pyrrol-2-yl)-1-(thiophen-2-yl)methanone (13c). Nitrile **12e** (411 mg, 1.27 mmol) was placed in a Schlenk flask, dissolved in dry THF (13 mL) and cooled to –78 °C. Phenylmagnesium bromide (1M in THF, 8 mL, 8 mmol, 6.3 equiv) was added and the reaction mixture was stirred for 1 h at 0 °C and 6 h at room temperature. The reaction was quenched with sat. aqueous NH_4Cl-solution and extracted with dichloromethane. The combined

organic phases were dried with $MgSO_4$ and concentrated in vacuo. The residue was dissolved in ethanol (25 mL) and 4N aqueous NaOH (25 mL) was added and the mixture was stirred for 5 h at 85 °C. The reaction mixture was acidified with conc. hydrochloric acid and extracted with dichloromethane. The combined organic phases were dried with $MgSO_4$ and concentrated in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 12:1) yielded the title compound (423 mg, 1.04 mmol, 81.6%) as a yellow solid. R_f = 0.48 (silica, cyclohexane/EtOAc, 2:1). mp 163–168.8 °C. IR (ATR) ν (cm^{-1}) = 3236, 1574, 1517, 1423, 1295, 1268, 908, 835, 759, 719, 684. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 12.61 (s, 1H, N*H*), 7.84–7.79 (m, 3H, Ph‘‘‘, *H*-4), 7.54–7.49 (m, 2H, Ph‘‘‘), 7.46–7.41 (m, 1H, *H*-4‘‘), 7.32 (dd, *J* = 3.8, 1.2 Hz, 1H, *H*-3), 7.30–7.21 (m, 5H, Ph‘‘), 6.89 (dd, *J* = 4.9, 3.8 Hz, 1H, *H*-4). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 177.3 (*C*=O), 142.9 (*C*2), 134.5 (*C*3), 134.0 (*C*5), 133.7 (C_q5‘), 133.5 (C_q1‘‘), 130.5 (2C+C_q, Ph‘‘‘, C_q1‘‘‘), 130.2 (C_q3‘), 128.5 (5C, Ph‘‘), 128.1 (C_q2‘), 127.9 (3C, *C*4+Ph‘‘‘), 127.1 (*C*4‘‘‘), 97.8 (C_q4‘). ESI-HRMS calcd for $[C_{21}H_{14}NO^{79}BrS + H]^+$ 408.0058, found 408.0070.

[3-(3-Anilinophenyl)-5-(4-chlorophenyl)-1*H*-pyrrole-2-yl](phenyl)methanone (13d). Nitrile **12h** (121 mg, 0.374 mmol) was placed in a Schlenk flask, dissolved in dry THF (4 mL) and cooled to 0°C. Phenylmagnesium bromide (1m in THF, 1.5 mL, 1.5 mmol, 4.0 equiv) was added and the reaction mixture was stirred for 1 h at –78 °C and 6 h at room temperature. The reaction was quenched with sat. aqueous NH_4Cl-solution and extracted with dichloromethane. The combined organic phases were dried with $MgSO_4$ and concentrated in vacuo. The residue was dissolved in ethanol (15 mL) and 4N aqueous NaOH (15 mL) was added and the mixture was stirred for 2.5 h at 80 °C. The reaction mixture was acidified with conc. HCl and extracted with dichloromethane. The combined organic phases were dried with $MgSO_4$ and concentrated in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 12:1→8:1) yielded

the title compound **(**31 mg, 69 μmol, 18%) as a yellow oil. R_f = 0.42 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3292, 3057, 2925, 1593, 1573, 1495, 1457, 1423, 1317, 1290, 1093, 751, 738, 695. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 12.20 (d, *J* = 2.1 Hz, 1H, *H*-1‘), 8.02–7.94 (m, 3H, N*H*Ph, *H*-2‘‘‘‘/6‘‘‘‘), 7.61–7.53 (m, 2H, *H*-2/6), 7.53–7.44 (m, 2H, *H*-3‘‘‘/5‘‘‘), 7.43–7.33 (m, 1H, *H*-4), 7.26–7.13 (m, 4H, *H*-3/5, *H*-3‘‘‘‘/5‘‘‘‘), 6.96 (*pseudo*-t, *J* = 7.8 Hz, 1H, *H*-5‘‘), 6.91–6.81 (m, 4H, *H*-4‘, *H*-2‘‘, *H-2*‘‘‘/6‘‘‘), 6.79 (tt, *J* = 7.3, 1.1 Hz, 1H, *H*-4‘‘‘), 6.74 (ddd, *J* = 8.1, 2.4, 1.0 Hz, 1H, *H*-4‘‘), 6.60 (d-*pseudo*-t, *J* = 7.6, 1.3 Hz, 1H, *H*-6‘‘). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 186.0 (*C*=O), 143.2 (C_q1‘‘‘), 142.8 (C_q3‘‘), 138.0 (C_q1), 136.2 (C_q1‘‘), 135.1 (C_q5‘), 133.6 (C_q3‘), 132.1 (C_q4‘‘‘‘), 131.7 (*C*4), 129.9 (C_q1‘‘‘‘), 129.3 (*C*2/6), 129.1 (*C*3‘‘‘/5‘‘‘), 128.7 (*C*3‘‘‘‘/5‘‘‘‘), 128.6 (*C*5‘‘), 128.2 (C_q1‘), 127.7 (*C*3/5), 127.1 (*C*2‘‘‘‘/6‘‘‘‘), 120.8 (*C*6‘‘), 119.6 (*C*4‘‘‘), 117.2 (*C*2‘‘), 116.7 (*C*2‘‘‘/6‘‘‘), 115.4 (*C*4‘‘), 110.1 (*C*4‘). ESI-HRMS calcd for $[C_{29}H_{21}ClN_2O + Na]^+$ 449.1421, found 449.1422.

[3-(2,3-Dichlorophenyl)-5-phenyl-1*H*-pyrrole-2-yl](phenyl)methanone (13e). Nitrile **12i** (125 mg, 0.399 mmol) was placed in a Schlenk flask, dissolved in dry THF (4 mL) and cooled to 0°C. Phenylmagnesium bromide (1M in THF, 1.6 mL, 1.6 mmol, 4.0 equiv) was added and the reaction mixture was stirred for 1 h at 0 °C and 14 h at room temperature. The reaction was quenched with sat. aqueous NH_4Cl-solution and extracted with dichloromethane. The combined organic phases were dried with $MgSO_4$ and concentrated in vacuo. The residue was dissolved in ethanol (15 mL) and 4N aqueous NaOH (15 mL) was added and the mixture was stirred for 5.5 h at 80 °C. The reaction mixture was acidified with conc. HCl and extracted with dichloromethane. The combined organic phases were dried with $MgSO_4$ and concentrated in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 10:1) yielded the title compound (118 mg, 0.301 mmol, 75.4%) as a light brown solid. mp 243–246 °C. R_f = 0.39 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3296, 1601, 1572, 1449, 1428, 1295, 1274, 917,

761, 739, 699. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 10.10 (s_{br}, 1H, N*H*), 7.73–7.68 (m, 2H, *H*-2‘‘‘/6‘‘‘), 7.47–7.41 (m, 4H, *H*-2/6, *H*-3‘‘‘/5‘‘‘), 7.39–7.34 (m, 1H, *H*-4‘‘‘), 7.26–7.21 (m, 1H, *H*-4), 7.18 (dd, *J* = 7.7, 1.8 Hz, 1H, *H*-4‘‘/*H*-6‘‘), 7.11–7.05 (m, 2H, *H*-3/5), 6.92 (dd, *J* = 7.7, 1.8 Hz, 1H, *H*-4‘‘/*H*-6‘‘), 6.86 (*pseudo*-t, *J* = 7.8 Hz, 1H, *H*-5‘‘), 6.68 (d, *J* = 3.0 Hz, 1H, *H*-4‘). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 186.8 (*C*=O), 138.1 (C_q1), 137.4 (C_q5‘), 137.1 (C_q1‘‘), 133.1 (C_q3‘‘), 132.1 (C_q2‘‘), 131.4 (*C*4), 131.2 (C_q), 130.7 (1C, *C*4‘‘/*C*6‘‘), 130.7 (C_q), 129.3 (*C*3‘‘‘/5‘‘‘), 129.2 (1C, *C*4‘‘/*C*6‘‘), 129.1 (C_q), 128.8 (*C*2/6), 128.6 (*C*4‘‘‘), 127.4 (*C*3/5), 126.5 (*C*5‘‘), 125.3 (*C*2‘‘‘/6‘‘‘), 111.1 (*C*4‘). ESI-HRMS calcd for $[C_{23}H_{15}Cl_2NO + Na]^+$ 414.0428, found 414.0435.

General procedure for the synthesis of BODIPY dyes.

Pyrrole carbaldehyde (1 equiv) and pyrrole (1 equiv) were placed in a Schlenk flask and dissolved in dry dichloromethane (7.5 mL/0.1 mmol) under argon atmosphere. Phosphorus oxychloride (1 equiv) or TFA (1 drop) were added and the mixture was stirred at room temperature until TLC shows complete conversion. DIPEA (8–9 equiv) and $BF_3{\cdot}OEt_2$ (9–10 equiv) were added and the mixture was stirred at room temperature until TLC shows complete conversion. The reaction mixture was diluted with ethyl acetate and water. The organic layer was washed with water (3 times), dried over $MgSO_4$ and concentrated in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc or petroleum ether/toluene) afforded the BODIPYs.

2-Bromo-4,4-difluoro-1,3,5,7-tetraphenyl-4-bora-3a,4a-diaza-s-indacene (14a). Pyrrole carbaldehyde **7b** (22 mg, 67 μmol) and pyrrole (15 mg, 68 μmol) were dissolved in dry dichloromethane (5.5 mL) and TFA (1 drop) was added. After 66.5 h, DIPEA (0.07 mL, 0.4 mmol, 6 equiv) and $BF_3{\cdot}OEt_2$ (0.07 mL, 0.6 mmol, 9 equiv) were added. After a further 24.5 h at room temperature, another portion of DIPEA (0.03 mL, 0.2 mmol, 3 equiv) and

$BF_3{\cdot}OEt_2$ (0.02 mL, 0.2 mmol, 2 equiv) were added. After a further 5.5 h at room temperature, workup according to the general procedure and purification by flash column chromatography (cylcohexane/EtOAc, 15:1) yielded the title compound (31 mg, 54 μmol, 80%) as a green solid. R_f = 0.51 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3060, 1606, 1586, 1390, 1202, 1167, 1127, 1072, 1059, 762, 695. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 7.92–7.88 (m, 2H, *H*-2‘‘‘/6‘‘‘), 7.74–7.70 (m, 2H, *H*-2‘‘/6‘‘), 7.57–7.40 (m, 16H, Ph), 7.34 (s, 1H, *H*-8), 6.76 (d, *J* = 0.8 Hz, 1H, *H*-6). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 160.1 (C_q5), 154.0 (C_q3), 147.6 (C_q7), 142.0 (C_q1), 135.5 (C_q7a), 133.0 (C_q8a), 132.8 (C_q1‘‘‘‘), 132.0, 131.8, 130.8 (3×C_q, *C*1‘–*C*1‘‘‘), 130.6 (t, *J* = 1.9 Hz, 2C, *C*2‘‘/6‘‘), 130.3 (1C, Ph), 130.2 (2C, *C*2‘/6‘), 129.8 (1C, Ph), 129.6 (t, *J* = 3.6 Hz, 2C, *C*2‘‘‘/6‘‘‘), 129.3 (3C, Ph), 129.1 (1C, Ph), 128.9 (2C, Ph), 128.8 (2C, Ph), 128.5 (2C, Ph), 128.2 (*C*8), 127.9 (2C, Ph), 120.0 (*C*6) 107.8 (C2). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –133.53 (dd, *J* = 62.4, 31.1 Hz). ESI-HRMS calcd for $[C_{33}H_{22}{}^{11}B^{79}BrF_2N_2 + Na]^+$ 597.0925, found 597.0908.

1-(2-Chlorophenyl)-4,4-difluoro-3-(4-fluorophenyl)-5-(naphthalen-2-yl)-7-phenyl-4-bora-3a,4a-diaza-*s*-indacene (14b). Pyrrole carbaldehyde **7h** (15 mg, 50 μmol) and pyrrole (13.7 mg, 50 μmol) were dissolved in dry dichloromethane (4 mL) and phosphorus oxychloride (5 μL) was added. After 70 h, DIPEA (0.08 mL, 0.5 mmol, 9 equiv) and $BF_3{\cdot}OEt_2$ (0.05 mL, 0.5 mmol, 10 equiv) were added. After a further 15 h at room temperature, workup according to the general procedure and purification by flash column chromatography (petroleum ether/toluene, 5:2 and 3:1) yielded **14b** (11 mg, 19 μmol, 37%) as a green solid. R_f = 0.32 (silica, petroleum ether/toluene, 1:1). IR (ATR) ν (cm^{-1}) = 2924, 2853, 1602, 1587, 1506, 1489, 1465, 1203, 1133, 1038, 765, 733. ^{1}H NMR, COSY (600 MHz, $CDCl_3$) δ (ppm) = 8.43 (s, 1H, *H*-1‘‘‘), 8.06 (dd, *J* = 8.5, 1.4 Hz, 1H, *H*-3‘‘‘), 7.97–7.91 (m, 4H, *H*-2‘‘/6‘‘, *H*-4‘‘‘), 7.88–7.85 (m, 1H, Cl-Ph), 7.57–

7.50 (m, 5H, *H*-2‘‘‘‘/6‘‘‘‘), 7.49–7.46 (m, 2H, *H*-3‘‘‘‘/5‘‘‘‘), 7.44–7.41 (m, 1H, *H*-4‘‘‘‘), 7.39–7.34 (m, 3H, Cl-Ph), 7.27 (s, 1H, *H*-8), 7.14–7.10 (m, 2H, *H*-3‘‘/5‘‘), 6.86 (s, 1H), 6.78 (s, 1H). ^{13}C NMR, HSQC, HMBC (151 MHz, $CDCl_3$) δ (ppm) = 163.7 (d, $^1J_{C,F}$ = 250.7 Hz, C_q4‘‘), 159.0 (C_q5), 155.8 (C_q3), 146.5 (C_q7), 141.6 (C_q1), 135.0 (2×C_q, C_q7a/8a), 134.0 (C_q4‘‘‘), 133.5 (C_q), 133.2 (C_q1‘‘‘‘), 133.0 (C_q), 132.2 (1C), 132.0 (C_q), 131.7 (dt, $^3J_{C,F}$ = 8.1, $^5J_{C,F}$ = 3.9 Hz, *C*2‘‘/6‘‘), 130.7 (1C), 130.0 (1C), 129.7 (1C), 129.8 (*C*1‘‘‘+C_q), 129.3 (*C*3‘‘‘‘/5‘‘‘‘), 129.1 (2×1C, *C*8‘‘‘, *C*4‘‘‘‘), 129.0 (*C*2‘‘‘‘/6‘‘‘‘), 128.6 (d, $^4J_{C,F}$ = 3.2 Hz, C_q1‘‘), 128.1 (1C), 127.8 (1C), 127.6 (*C*8), 127.4 (1C), 127.1 (1C), 126.6 (t, $^5J_{C,F}$ = 3.8 Hz, *C*3‘‘‘), 126.6 (1C), 121.2 (*C*2), 120.0 (*C*6), 115.6 (d, $^2J_{C,F}$ = 21.7 Hz, *C*3‘‘/5‘‘). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –112.07 (tt, *J* = 8.7, 5.5 Hz), –133.01 (dd, *J* = 64.4, 32.5 Hz). ESI-HRMS calcd for $[C_{37}H_{23}{}^{11}BClF_3N_2 + Na]^+$ 621.1493, found 621.1489.

1,7-Bis(2-chlorophenyl)-4,4-difluoro-3,5-bis(4-fluorophenyl)-4-bora-3a,4a-diaza-*s*-indacene (16a). The reaction of pyrrole carbaldehyde **7h** (15 mg, 50 μmol) and pyrrole (13.7 mg, 50 μmol) yielded the symmetrical by-product **16a** (6 mg, 10 μmol, 40%) as a green solid. R_f = 0.41 (silica, petroleum ether/toluene, 1:1). IR (ATR) ν (cm^{-1}) = 2954, 2923, 2852, 1606, 1587, 1505, 1466, 1201, 1147, 1133, 762. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 7.98–7.92 (m, 4H, *H*-2‘‘/6‘‘/2‘‘‘/6‘‘‘), 7.53–7.49 (m, 2H, Cl-Ph), 7.36–7.31 (m, 6H, Cl-Ph), 7.19–7.12 (m, 4H, *H*-3‘‘/5‘‘/3‘‘‘/5‘‘‘), 7.02 (s, 1H, *H*-8), 6.79 (s, 2H, *H*-2/6). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 163.9 (d, $^1J_{C,F}$ = 251.1 Hz, C_q4‘‘/4‘‘‘), 156.9 (C_q3/5), 142.3 (C_q1/7), 135.2 (C_q7a/8a), 133.6 (2C_q), 132.2 (2C, Cl-Ph), 131.8 (dt, $^3J_{C,F}$ = 8.2, $^5J_{C,F}$ = 3.5 Hz, *C*2‘‘/6‘‘/2‘‘‘/6‘‘‘+2C_q), 130.7 (2C, Cl-Ph), 130.0 (2C, Cl-Ph), 128.4 (d, $^4J_{C,F}$ = 3.2 Hz, C_q1‘‘/1‘‘‘), 127.6 (*C*8), 127.1 (2C, Cl-Ph), 121.6 (*C*2/6), 115.7 (d, $^2J_{C,F}$ = 21.8 Hz, *C*3‘‘/5‘‘/3‘‘‘/5‘‘‘). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –111.52 (tt, *J* = 8.9, 5.4 Hz), –

133.35 (dd, J = 61.8, 30.9 Hz). ESI-HRMS calcd for $[C_{33}H_{19}{}^{11}BCl_2F_4N_2 + Na]^+$ 623.0852, found 623.0872.

1-(2-Chlorophenyl)-4,4-difluoro-3-(4-fluorophenyl)-5,7-diphenyl-4-bora-3a,4a-diaza-s-indacene (14c). Pyrrole carbaldehyde **7a** (20 mg, 81 μmol) and pyrrole (22 mg, 81 μmol) were dissolved in dry dichloromethane (6 mL) and phosphorus oxychloride (8 μL) was added. After 70 h, DIPEA (0.11 mL, 0.6 mmol, 8 equiv) and $BF_3{\cdot}OEt_2$ (0.09 mL, 0.7 mmol, 9 equiv) were added. After further 1.5 h at room temperature, workup according to the general procedure and purification by flash column chromatography (petroleum ether/toluene, 2:1 and 3:1) yielded the title compound (20 mg, 36 μmol, 45%) as a green solid. R_f = 0.27 (silica, petroleum ether/toluene, 1:1). IR (ATR) ν (cm^{-1}) = 2924, 2854, 1605, 1586, 1506, 1477, 1466, 1202, 1146, 1133, 1038, 761. ^{1}H NMR, COSY (600 MHz, $CDCl_3$) δ (ppm) = 7.97–7.92 (m, 4H, *H*-2’’/6’’, *H*-2’’’/6’’’’), 7.56–7.52 (m, 1H, Cl-Ph), 7.51–7.44 (m, 7H, *H*-3’’’/4’’’/5’’’, *H*-2‘’‘‘/3‘’‘‘/5‘’‘‘/6‘’‘‘), 7.44–7.40 (m, 1H, *H*-4’’’’), 7.38–7.33 (m, 3H, Cl-Ph), 7.25 (s, 1H, *H*-8), 7.16–7.11 (m, 2H, *H*-3’’/5’’), 6.77 (s, 1H), 6.74 (s, 1H). ^{13}C NMR, HSQC, HMBC (151 MHz, $CDCl_3$) δ (ppm) = 163.8 (d, $^1J_{C,F}$ = 250.5 Hz, C_q4’’), 159.1 (C_q5), 155.8 (C_q3), 146.5 (C_q7), 141.7 (C_q1), 135.0 (C_q8a), 134.8 (C_q7a), 133.5 (C_q), 133.2 (C_q1’’’), 132.3 (C_q), 132.2 (Cl-Ph), 132.0 (Cl-Ph), 131.7 (dt, $^3J_{C,F}$ = 8.3, $^5J_{C,F}$ = 4.1 Hz, *C*2’’/6’’), 131.5 (1C), 130.7 (Cl-Ph), 130.1 (*C*4’’’), 130.0 (Cl-Ph), 129.6 (t, $^5J_{C,F}$ = 3.7 Hz, *C*2’’’/6’’’), 129.2 (2C), 129.0 (2C+1C, *C*2’’’’/4’’’’/6’’’’), 128.6 (d, $^4J_{C,F}$ = 3.2 Hz, C_q1’’), 128.5 (2C), 127.8 (*C*8), 127.1 (Cl-Ph), 121.1 (*C*2), 119.6 (*C*6), 115.6 (d, $^2J_{C,F}$ = 21.6 Hz, *C*3’’/5’’). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –112.04 (tt, J = 9.1, 5.4 Hz), –133.16 (dd, J = 64.2, 32.3 Hz). ESI-HRMS calcd for $[C_{33}H_{21}{}^{11}BClF_3N_2 + Na]^+$ 571.1336, found 571.1332.

1-(2,3-Dichlorophenyl)-4,4-difluoro-5-(4-fluorophenyl)-7-(4-methoxyphenyl)-3-phenyl-4-bora-3a,4a-diaza-*s*-indacene (14d). Pyrrole carbaldehyde **7k** (19 mg, 60 μmol) and pyrrole (15 mg, 56 μmol) were dissolved in dry dichloromethane (4.5 mL) and phosphorus oxychloride (6 μL) was added. After 19 h DIPEA (0.08 mL, 0.5 mmol, 8 equiv) and $BF_3{\cdot}OEt_2$ (0.08 mL, 0.5 mmol, 8 equiv) were added. After a further 1.5 h at room temperature, workup according to the general procedure and purification by flash column chromatography (cylcohexane/EtOAc, 15:1) yielded the title compound (26 mg, 42 μmol, 76%) as a green solid.. R_f = 0.29 (silica, cyclohexane/EtOAc, 5:1). IR (ATR) ν (cm^{-1}) = 2936, 2838, 1596, 1579, 1518, 1484, 1253, 1234, 1203, 1135, 823, 738. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 7.98–7.90 (m, 4H, *H*-2''/6'', *H*-2'''/6'''), 7.52 (dd, *J* = 7.2, 2.4 Hz, 1H, *H*-4'), 7.51–7.38 (m, 5H, *H*-3''/4''/5'', *H*-2''''/6''''), 7.32–7.24 (m, 2H, *H*-5'/6'), 7.18–7.08 (m, 2H, *H*-3'''/5'''), 7.16 (s, 1H, *H*-8), 7.03–6.96 (m, 2H, *H*-3''''/5''''), 6.78 (s, 1H, *H*-2), 6.64 (s, 1H, *H*-6), 3.86 (s, 3H, O*C*H_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 163.9 (d, $^1J_{C,F}$ = 251.0 Hz, C_q4'''), 160.7 (C_q4''''), 158.5 (C_q5), 156.4 (C_q3), 146.9 (C_q7), 140.6 (C_q1), 135.1 (C_q7a), 134.6 (C_q8a), 134.5 (C_q), 134.4 (C_q), 132.4 (C_q1''), 132.1 (C_q), 131.7 (dt, $^3J_{C,F}$ = 8.1, $^5J_{C,F}$ = 3.9 Hz, *C*2'''/6'''), 130.7 (*C*4'), 130.3 (*C*6'), 130.2 (*C*2''''/6''''), 129.8 (*C*4''), 129.5 (t, $^5J_{C,F}$ = 3.5 Hz, *C*2''/6''), 128.5 (d, $^4J_{C,F}$ = 3.4 Hz, C_q1'''), 128.5 (*C*3''/5''), 127.4 (*C*5'), 127.2 (*C*8), 125.5 (C_q1''''), 121.1 (*C*2), 118.9 (*C*6), 115.7 (d, $^2J_{C,F}$ = 21.7 Hz, *C*3'''/5'''), 114.8 (*C*3''''/5''''), 55.6 (O*C*H_3). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –(111.35–111.46) (m, $C_{ar}F$), –132.97 (s_{br}, BF_2). ESI-HRMS calcd for $[C_{34}H_{22}{}^{11}BCl_2F_3N_2O + Na]^+$ 635.1052, found 635.1051.

1,7-Bis(2,3-dichlorophenyl)-4,4-difluoro-5,3-diphenyl-4-bora-3a,4a-diaza-*s*-indacene (15a). The reaction of pyrrole carbaldehyde **7k** (18 mg, 57 μmol) and pyrrole (15.2 mg, 56.9 μmol) yielded the symmetrical by-product **15a** (4 mg, 6 μmol, 22%) as a green solid. R_f = 0.40 (silica,

cyclohexane/EtOAc, 5:1). IR (ATR) ν (cm^{-1}) = 2923, 2852, 1608, 1578, 1518, 1493, 1454, 1202, 1131, 1010, 768, 696. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 7.96–7.92 (m, 4H, *H*-2‘‘/6‘‘/2‘‘‘/6‘‘‘), 7.51 (dd, *J* = 7.8, 1.9 Hz, 2H, *H*-4‘/4‘‘‘‘), 7.48–7.44 (m, 6H, *H*-3‘‘/4‘‘/5‘‘/3‘‘‘/4‘‘‘/5‘‘‘), 7.28 (t, *J* = 7.7 Hz, 2H, *H*-5‘/5‘‘‘‘), 7.23 (dd, *J* = 7.7, 1.9 Hz, 2H, *H*-6‘/6‘‘‘‘), 6.90 (s, 1H, *H*-8), 6.81 (s, 2H, *H*-2/6). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 158.3 (C_q3/5), 141.8 (C_q1/7), 135.2 (C_q7a/8a), 134.5 (2×C_q), 134.0 (2×C_q), 132.1 (4×C_q, C_q1‘‘/1‘‘‘), 130.9 (*C*4‘/4‘‘‘‘), 130.3 (*C*6‘/6‘‘‘‘), 130.1 (*C*4‘/4‘‘‘), 129.7 (t, $^{5}J_{C,F}$ = 3.6 Hz, *C*2‘‘/6‘‘/2‘‘‘/6‘‘‘), 128.5 (*C*3‘‘/5‘‘/3‘‘‘/5‘‘‘), 127.4 (*C*5‘/5‘‘‘‘), 126.9 (*C*8), 122.0 (*C*2/6). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –133.28 (s_{br}, BF_2). ESI-HRMS calcd for $[C_{33}H_{19}{}^{11}BCl_4F_2N_2 + Na]^+$ 655.0261, found 655.0261.

4,4-Difluor-3,5-bis(4-fluorophenyl)-1,7-bis(4-methoxyphenyl)-4-bora-3a,4a-diaza-*s*-indacene (16b). The reaction of pyrrole carbaldehyde **7k** (18 mg, 57 μmol) and pyrrole (15.2 mg, 56.9 μmol) yielded the symmetrical by-product **16b** (6.8 mg, 11 μmol, 40%) as a green solid. R_f = 0.21 (silica, cyclohexane/EtOAc, 5:1). IR (ATR) ν (cm^{-1}) = 2937, 1585, 1520, 1489, 1442, 1253, 1205, 1146, 1136, 1031, 822, 735. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 7.94–7.88 (m, 4H, *H*-2‘‘/6‘‘/2‘‘‘/6‘‘‘), 7.47–7.42 (m, 5H, *H*-8, *H*-2‘/6‘/2‘‘‘‘/6‘‘‘‘), 7.16–7.10 (m, 4H, *H*-3‘‘/5‘‘/3‘‘‘/5‘‘‘), 7.03–6.98 (m, 4H, *H*-3‘/5‘/3‘‘‘‘/5‘‘‘‘), 6.62 (d, *J* = 1.1 Hz, 2H, *H*-2/6), 3.87 (s, 6H, 2×OCH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 163.8 (d, $^{1}J_{C,F}$ = 250.5 Hz, C_q4‘‘/4‘‘‘), 160.5 (C_q4‘/4‘‘‘‘), 156.6 (C_q3/5), 145.8 (C_q1/7), 134.5 (C_q7a/8a), 131.6 (dt, $^{3}J_{C,F}$ = 8.0, $^{5}J_{C,F}$ = 3.8 Hz, *C*2‘‘/6‘‘/2‘‘‘/6‘‘‘), 130.2 (*C*2‘/6‘/2‘‘‘‘/6‘‘‘‘), 128.8 (d, $^{4}J_{C,F}$ = 3.3 Hz, C_q1‘‘/1‘‘‘), 127.6 (*C*8), 125.9 (C_q1‘/1‘‘‘‘), 118.3 (*C*2/6), 115.6 (d, $^{2}J_{C,F}$ = 21.7 Hz, *C*3‘‘/5‘‘/3‘‘‘/5‘‘‘), 114.8 (*C*3‘/5‘/3‘‘‘‘/5‘‘‘‘), 55.6 (2×O*C*H_3). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ

(ppm) = –112.04 (tt, J = 8.8, 5.4 Hz, $C_{ar}F$), –132.86 (dd, J = 65.5, 32.6 Hz, BF_2). ESI-HRMS calcd for $[C_{35}H_{25}BF_4N_2O_2 + Na]^+$ 615.1843, found 615.1850.

2-Bromo-4,4-difluoro-5-(4-fluorophenyl)-7-(4-methoxyphenyl)-1,3-diphenyl-4-bora-3a,4a-diaza-*s*-indacene (14e). Pyrrole carbaldehyde **7a** (24 mg, 74 μmol) and pyrrole (19.5 mg, 73.0 μmol) were dissolved in dry dichloromethane (5.5 mL) and phosphorus oxychloride (7 μL) was added. After 65 h, DIPEA (0.1 mL, 0.6 mmol, 8 equiv) and $BF_3{\cdot}OEt_2$ (0.08 mL, 0.6 mmol, 9 equiv) were added. After a further 23 h at room temperature, workup according to the general procedure and purification by flash column chromatography (cylcohexane/EtOAc, 15:1) yielded the title compound (19 mg, 30 μmol, 42%, green solid. R_f = 0.52 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 2929, 1606, 1586, 1517, 1255, 1167, 1153, 1087, 1074, 1031, 837, 698. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 7.93–7.86 (m, 2H, *H*-2‘‘‘/6‘‘‘), 7.74–7.69 (m, 2H, *H*-2‘‘/6‘‘), 7.57–7.45 (m, 8H, Ph‘/Ph‘‘), 7.43–7.39 (m, 2H, *H*-2‘‘‘‘/6‘‘‘‘), 7.31 (s, 1H, *H*-8), 7.13–7.07 (m, 2H, *H*-3‘‘‘/5‘‘‘), 7.01–6.96 (m, 2H, *H*-3‘‘‘‘/5‘‘‘‘), 6.66 (d, J = 1.4 Hz, 1H, *H*-6), 3.86 (s, 3H, O*C*H_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 164.0 (d, $^1J_{C,F}$ = 251.6 Hz, C_q4‘‘‘), 160.8 (C_q4‘‘‘‘), 159.2 (C_q5), 153.5 (C_q3), 147.8 (C_q7), 141.7 (C_q1), 135.6 (C_q7a), 132.6 (C_q8a), 131.9–131.7 (m, 2C+C_q, *C*2‘‘‘/6‘‘‘), 130.9 (C_q), 130.5 (*C*2‘‘/6‘‘), 130.2 (4C), 129.7 (*C*4‘‘), 129.0 (1C), 128.8 (2C), 128.2 (d, $^4J_{C,F}$ = 3.2 Hz, C_q1‘‘‘), 127.9 (3C, *C*8, *C*3‘‘/5‘‘), 125.3 (C_q1‘‘‘‘), 119.0 (*C*6), 115.7 (d, $^2J_{C,F}$ = 21.8 Hz, *C*3‘‘‘/5‘‘‘), 114.9 (d, $^2J_{C,F}$ = 21.8 Hz, *C*3‘‘‘‘/5‘‘‘‘), 55.6 (O*C*H_3). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –110.94 (ddt, J = 11.1, 8.6, 4.6 Hz, $C_{ar}F$), –133.46 (ddd, J = 63.1, 31.4, 13.2 Hz). ESI-HRMS calcd for $[C_{34}H_{23}{}^{11}B^{79}BrF_3N_2O + Na]^+$ 645.0937, found 645.0924.

4,4-Difluoro-3-(4-fluorophenyl)-1-(4-methoxyphenyl)-5,7-diphenyl-4-bora-3a,4a-diaza-*s*-indacene (14f). Pyrrole carbaldehyde **7a** (18 mg, 73 μmol) and pyrrole (19.5 mg, 73.0 μmol)

were dissolved in dry dichloromethane (5.5 mL) and phosphorus oxychloride (7 μL) was added. After 65 h DIPEA (0.1 mL, 0.6 mmol, 8 equiv) and $BF_3{\cdot}OEt_2$ (0.08 mL, 0.6 mmol, 9 equiv) were added. After further 20.5 h at room temperature, workup according to the general procedure and purification by flash column chromatography (cylcohexane/EtOAc, 15:1) yielded the title compound (16 mg, 29 μmol, 40%) as a green solid. R_f = 0.46 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 2924, 2851, 1604, 1586, 1523, 1487, 1476, 1205, 1146, 1135, 763, 697. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 7.95–7.89 (m, 4H, *H*-2‘‘/6‘‘, *H*-2‘‘‘/6‘‘‘), 7.54–7.40 (m, 11H, *H*-8, *H*-2’/6’, *H*-3’’’/4’’’/5’’’, Ph’’’’), 7.17–7.10 (m, 2H, *H*-3‘‘/5‘‘), 7.04–6.97 (m, 2H, *H*-3‘/5‘), 6.73 (s, 1H, *H*-6), 6.63 (s, 1H, *H*-2), 3.87 (s, 3H, O*CH*$_3$). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 163.8 (d, $^1J_{C,F}$ = 250.5 Hz, C_q4‘‘), 160.5 (C_q4‘), 157.5 (C_q5), 157.0 (C_q3), 146.1 (C_q1), 145.6 (C_q7), 134.7 (C_q8a), 134.4 (C_q7a), 133.5, 132.6 (2×C_q, C_q1‘‘‘/1‘‘‘‘), 131.6 (dt, $^3J_{C,F}$ = 8.2, $^5J_{C,F}$ = 4.0 Hz, *C*2‘‘/6‘‘), 130.2 (2C), 129.8 (1C, *p*-*C*), 129.5 (t, $J_{C,F}$ = 3.6 Hz, *C*2‘‘‘/6‘‘‘),129.2 (2C), 128.9 (2C), 128.9 (1C, *p*-*C*), 128.7 (d, $^4J_{C,F}$ = 3.3 Hz, C_q1‘‘), 128.4 (2C), 127.8 (*C*8), 125.8 (C_q1’), 119.1 (*C*6), 118.4 (*C*2), 115.6 (d, $^2J_{C,F}$ = 21.7 Hz, *C*3‘‘/5‘‘), 114.8 (*C*3‘/5‘), 55.6 (O*C*H$_3$). ^{19}F NMR (282 MHz, $CDCl_3$) δ (ppm) = –111.99 (tt, *J* = 8.6, 5.3 Hz), –132.93 (dd, *J* = 64.8, 32.4 Hz). ESI-HRMS calcd for $[C_{34}H_{24}{}^{11}BF_3N_2O + Na]^+$ 567.1831, found 567.1828.

1-(2-Chlorophenyl)-4,4-difluoro-3,5-bis(4-fluorophenyl)-7-(4-methoxyphenyl)-4-bora-3a,4a-diaza-*s*-indacene (14g). Pyrrole carbaldehyde **7j** (13 mg, 43 μmol) and pyrrole (12 mg, 45 μmol) were dissolved in dry dichloromethane (3.5 mL) and phosphorus oxychloride (5 μL) was added. After 21 h, DIPEA (0.06 mL, 0.3 mmol, 8 equiv) and $BF_3{\cdot}OEt_2$ (0.05 mL, 0.4 mmol, 9 equiv) were added. After a further 1.5 h at room temperature, workup according to the general procedure and purification by flash column chromatography (petroleum ether/toluene, 3:2) yielded the title compound (14 mg, 23 μmol, 55%) as a green solid. R_f = 0.24 (silica, petroleum ether/toluene,

1:1). IR (ATR) ν (cm^{-1}) = 2923, 2852, 1603, 1586, 1512, 1486, 1465, 1203, 1146, 1134, 827, 762. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 7.97–7.88 (m, 4H, *H*-2’’/6’’/2’’’/6’’’), 7.59–7.49 (m, 1H, Ph’), 7.45–7.41 (m, 2H, *H*-2’’’’/6’’’’), 7.37–7.33 (m, 3H, Ph’), 7.22 (s, 1H, *H*-8), 7.19–7.08 (m, 4H, *H*-3’’/5’’/3’’’/5’’’), 7.03–6.94 (m, 2H, *H*-3‘‘‘/5‘‘‘), 6.75 (s, 1H, *H*-2), 6.64 (s, 1H, *H*-6), 3.86 (s, 3H, OCH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 163.9 (d, $^1J_{C,F}$ = 251.1 Hz), 163.7 (d, $^1J_{C,F}$ = 250.6 Hz, C_q4’’/4’’’), 160.7 (C_q4’’’’), 158.1 (C_q5), 155.4 (C_q3), 146.8 (C_q7), 141.4 (C_q1), 134.9 (C_q7a), 134.8 (C_q8a), 133.5 (C_q), 132.2 (1C, Cl-Ph), 132.1 (C_q), 131.7 (4C, dt, $^3J_{C,F}$ = 8.6, $^5J_{C,F}$ = 4.4 Hz, C2’’/C6’’, C2’’’/C6’’’), 130.7 (1C, Cl-Ph), 130.2 (*C*2’’’’/6’’’’), 129.9 (1C, Cl-Ph), 128.7 (d, $^4J_{C,F}$ = 3.5 Hz), 128.6 (d, $^4J_{C,F}$ = 3.3 Hz, C_q1’’/1’’’), 127.6 (*C*8), 127.1 (1C, Cl-Ph), 125.6 (C_q1’’’’), 121.0 (d, $^4J_{C,F}$ = 3.2 Hz, *C*2), 118.8 (*C*6), 115.7 (d, $^2J_{C,F}$ = 21.6 Hz), 115.6 (d, $^2J_{C,F}$ = 21.7 Hz, *C*3’’/5’’/3’’’/5’’’), 114.8 (*C*3’’’’/5’’’’), 55.6 (O*C*H_3). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –111.50 (tt, *J* = 8.4, 5.1 Hz, $C_{ar}F$), –112.12 (tt, *J* = 8.7, 5.4 Hz, $C_{ar}F$), –133.10 (dd, *J* = 64.9, 32.8 Hz, BF_2). ESI-HRMS calcd for $[C_{34}H_{22}{}^{11}BClF_4N_2O + Na]^+$ 619.1348, found 619.1359.

equivequiv**1,7-Bis(2-chlorophenyl)-4,4-difluoro-3,5-bis(4-fluorophenyl)-4-bora-3a,4a-diaza-*s*-indacene (16a).** Pyrrole carbaldehyde **7j** (13 mg, 43 μmol) and pyrrole (12 mg, 44 μmol) were dissolved in dry dichloromethane (3.5 mL) and phosphorus oxychloride (5 μL) was added. After 21 h, DIPEA (0.06 mL, 0.3 mmol, 8 equiv) and $BF_3{\cdot}OEt_2$ (0.05 mL, 0.4 mmol, 9 equiv) were added. After a further 1.5 h at room temperature, workup according to the general procedure and purification by flash column chromatography (petroleum ether/toluene, 2:1) yielded the title compound (11 mg, 18 μmol, 43%) as a green solid.

1-(2-Chlorophenyl)-4,4-difluoro-3-(4-fluorophenyl)-7-(1*H*-indol-3-yl)-5-phenyl-4-bora-3a,4a-diaza-*s*-indacene (14h). Pyrrole carbaldehyde **7j** (19 mg, 63 μmol) and pyrrole **11c**

(16 mg, 62 μmol) were dissolved in dry dichloromethane (4.7 mL) and phosphorus oxychloride (6 μL) was added. After 17 h, DIPEA (0.09 mL, 0.5 mmol, 8 equiv) and $BF_3{\cdot}OEt_2$ (0.07 mL, 0.6 mmol, 9 equiv) were added. After a further 3 h at room temperature, workup according to the general procedure and purification by flash column chromatography (cylcohexane/EtOAc, 5:1) yielded the title compound (21 mg, 36 μmol, 58%) as a purple/brownish solid. R_f = 0.35 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3427, 2361, 2341, 1605, 1585, 1480, 1463, 1202, 1141, 1125, 1018, 760, 714. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 8.47 (s_{br}, 1H, N*H*), 8.00–7.96 (m, 2H, *H*-2‘‘‘/6‘‘‘), 7.96–7.91 (m, 2H, *H*-2‘‘/6‘‘), 7.91–7.87 (m, 1H, *H*-4‘‘‘‘), 7.55–7.42 (m, 4H, *H*-3‘‘‘/4‘‘‘/5‘‘‘, Ph‘), 7.46–7.38 (m, 1H, *H*-7‘‘‘‘), 7.37–7.22 (m, 7H, *H*-8, Ph‘, *H*-2‘‘‘‘/5‘‘‘‘/6‘‘‘‘), 7.16–7.06 (m, 2H, *H*-3‘‘/5‘‘), 6.86 (s, 1H, *H*-6), 6.73 (s, 1H, *H*-2). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 163.5 (d, $^1J_{C,F}$ = 249.8 Hz, C_q4‘‘), 160.9 (C_q5), 154.0 (C_q3), 141.1 (C_q7), 140.1 (C_q1), 136.7 (C_q7a‘‘‘‘), 136.0 (C_q7a), 134.2 (C_q8a), 133.5 (C_q), 132.5 (C_q), 132.4 (C_q+1C), 131.6 (dt, $^3J_{C,F}$ = 7.9, $^5J_{C,F}$ = 3.8 Hz, *C*2‘‘/6‘‘), 130.5 (1C), 130.1 (*C*4‘‘‘), 129.7 (1C), 129.6 (t, $^5J_{C,F}$ = 3.7 Hz, *C*2‘‘‘/6‘‘‘), 129.0 (d, $^4J_{C,F}$ = 3.2 Hz, C_q1‘‘), 128.5 (*C*3‘‘‘/5‘‘‘), 127.0 (1C), 126.5 (1C), 126.1 (C_q3a‘‘‘‘), 124.5 (1C), 123.6 (*C*6‘‘‘‘), 121.4 (*C*5‘‘‘‘), 120.3 (*C*2), 120.1 (*C*4‘‘‘‘), 118.5 (*C*6), 115.5 (d, $^2J_{C,F}$ = 21.7 Hz, *C*3‘‘/5‘‘), 111.8 (*C*7‘‘‘‘), 110.3 (C_q3‘‘‘‘). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –112.73 (tt, *J* = 8.7, 5.3 Hz, $C_{ar}F$), –132.60 (dd, *J* = 64.9, 32.4 Hz, BF_2). ESI-HRMS calcd for $[C_{35}H_{22}{}^{11}BClF_3N_3 + Na]^+$ 610.1445, found 610.1445.

1-(2-Chlorophenyl)-4,4-difluoro-3-(4-fluorophenyl)-5,7-bis(3,4-dimethoxyphenyl)-4-bora-3a,4a-diaza-*s*-indacene (14i). Pyrrole carbaldehyde **7j** (17.5 mg, 58.4 μmol) and pyrrole **11a** (21.0 mg, 61.9 μmol) were dissolved in dry dichloromethane (4.5 mL) and phosphorus oxychloride (6 μL) was added. After 35 h, DIPEA (0.08 mL, 0.5 mmol, 8 equiv) and $BF_3{\cdot}OEt_2$

(0.07 mL, 0.6 mmol, 10 equiv) were added. After a further 3 h at room temperature, workup according to the general procedure and purification by flash column chromatography (cylcohexane/EtOAc, 4:1→3:1) yielded the title compound (20 mg, 30 μmol, 51%) as a green solid. R_f = 0.44 (silica, cyclohexane/EtOAc, 1:1). IR (ATR) ν (cm^{-1}) = 2928, 2361, 2342, 1602, 1587, 1506, 1490, 1464, 1267, 1201, 1135, 764. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 7.99–7.92 (m, 2H, *H*-2‘‘/6‘‘), 7.69 (d, *J* = 2.1 Hz, 1H, *H*-2‘‘‘), 7.55 (dd, *J* = 8.4, 2.1 Hz, 1H, *H*-6‘‘‘), 7.53–7.50 (m, 1H, Cl-Ph), 7.40–7.31 (m, 3H, Cl-Ph), 7.21 (s, 1H, *H*-8), 7.15–7.08 (m, 2H, *H*-3‘‘/5‘‘), 7.09 (dd, *J* = 8.1, 2.0 Hz, 1H, *H*-6‘‘‘‘), 7.00 (d, *J* = 2.0 Hz, 1H, *H*-2‘‘‘‘), 6.94 (d, *J* = 8.4 Hz, 2H, *H*-5‘‘‘/5‘‘‘‘), 6.72 (s, 2H, *H*-2/6), 3.95 (s, 3H, OCH_3), 3.94 (s, 3H, OCH_3), 3.92 (s, 3H, OCH_3), 3.91 (s, 3H, OCH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 163.6 (d, $^1J_{C,F}$ = 250.0 Hz, C_q4‘‘), 159.6 (C_q5), 154.2 (C_q3), 151.1 (C_q4‘‘‘), 150.2 (C_q4‘‘‘‘), 149.4 (C_q3‘‘‘‘), 148.7 (C_q3‘‘‘), 146.9 (C_q7), 140.3 (C_q1), 135.4, 134.3 (2×C_q, C_q7a/8a), 133.5 (C_q), 132.4 (C_q), 132.2 (*C*6‘‘), 131.6 (dt, $^3J_{C,F}$ = 8.3, $^5J_{C,F}$ = 4.0 Hz, *C*2‘‘/6‘‘), 130.5 (1C, Cl-Ph), 129.8 (1C, Cl-Ph), 128.9 (d, $^4J_{C,F}$ = 3.4 Hz, C_q1‘‘), 127.0 (1C, Cl-Ph), 126.5 (*C*8), 125.9, 124.8 (2×C_q, C_q1‘‘‘/1‘‘‘‘), 123.3 (*C*6‘‘‘), 121.7 (*C*6‘‘‘‘), 120.3, 118.9 (*C*2, *C*6), 115.4 (d, $^2J_{C,F}$ = 21.7 Hz, *C*3‘‘/5‘‘), 112.9 (t, $^5J_{C,F}$ = 6.1 Hz, *C*2‘‘‘), 111.7 (2C, *C*2‘‘‘‘+*C*5‘‘‘/5‘‘‘‘), 110.9 (1C, *C*5‘‘‘/5‘‘‘‘), 56.2 (OCH_3), 56.1 (3×OCH_3). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –112.64 (tt, *J* = 8.7, 5.3 Hz, $C_{ar}F$), –132.80 (dd, *J* = 65.3, 33.0 Hz, BF_2). ESI-HRMS calcd for $[C_{37}H_{29}{}^{11}BClF_3N_2O_4 + Na]^+$ 691.1759, found 691.1750. calcd for $[C_{37}H_{29}{}^{11}BClF_3N_2O_4 - F]^+$ 649.1877, found 649.1866.

4,4-Difluoro-3-(4-fluorophenyl)-1-(4-methoxyphenyl)-5-(naphthalen-2-yl)-7-phenyl-4-bora-3a,4a-diaza-*s*-indacene (14j). Pyrrole carbaldehyde **7h** (14 mg, 47 μmol) and pyrrole (12.6 mg, 47.1 μmol) were dissolved in dry dichloromethane (3.5 mL) and phosphorus oxychloride (5 μL) was added. After 86 h DIPEA (0.06 mL, 0.3 mmol, 7 equiv) and BF_3·OEt_2 (0.05 mL, 0.4 mmol,

9 equiv) were added. After a further 1.5 h at room temperature, workup according to the general procedure and purification by flash column chromatography (petroleum ether/toluene, 1:1→1:2) yielded the title compound (9 mg, 15µmol, 32%, green solid. R_f = 0.23 (silica, petroleum ether/toluene, 1:1). IR (ATR) ν (cm^{-1}) = 2924, 2361, 2342, 1587, 1521, 1488, 1206, 1135, 820, 675. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 8.41 (s, 1H, *H*-1‘‘‘), 8.06 (dd, *J* = 8.6, 1.8 Hz, 1H, *H*-3‘‘‘), 7.98–7.87 (m, 4H, *H*-2‘‘/6‘‘, *H*-4‘‘‘, Naph), 7.89–7.84 (m, 1H, Naph), 7.59–7.41 (m, 10H, *H*-8, *H*-2‘/6‘, *H*-6‘‘‘/7‘‘‘, Ph‘‘‘‘), 7.17–7.06 (m, 2H, *H*-3‘‘/5‘‘), 7.04–6.99 (m, 2H, *H*-3‘/5‘), 6.85 (s, 1H, *H*-6), 6.65 (s, 1H, *H*-2), 3.87 (s, 3H, O*CH*$_3$). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 163.6 (d, $^1J_{C,F}$ = 153.2 Hz, C_q4‘‘), 160.6 (C_q4’), 157.5 (C_q5), 157.1 (C_q3), 146.1 (C_q1), 145.6 (C_q7), 134.8 (C_q8a), 134.6 (C_q7a), 133.9 (C_q4a‘‘‘), 133.6 (C_q1‘‘‘‘), 133.1 (C_q8a‘‘‘), 131.7 (dt, $^3J_{C,F}$ = 7.6, $^5J_{C,F}$ = 3.7 Hz, *C*2‘‘/6‘‘), 130.2 (*C*2‘/6‘), 130.1 (C_q2‘‘‘), 129.6 (t, $^5J_{C,F}$ = 3.3 Hz, *C*1‘‘‘), 129.3 (2C, Ph‘‘‘‘), 129.1 (*C*4‘‘‘), 129.0 (2C, Ph‘‘‘‘), 128.9 (1C), 128.7 (d, $^4J_{C,F}$ = 2.8 Hz, C_q1‘‘), 128.0 (1C), 127.8 (1C), 127.6 (1C), 127.2 (1C), 126.7 (*C*3‘‘‘), 126.5 (1C), 125.9 (C_q1’), 119.5 (*C*6), 118.4 (*C*2), 115.6 (d, $^2J_{C,F}$ = 21.7 Hz, *C*3‘‘/5‘‘), 114.8 (*C*3’/5’), 55.6 (O*C*H$_3$). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –110.85 (tt, *J* = 9.4, 5.4 Hz, $C_{ar}F$), –131.61 (dd, *J* = 65.0, 32.5 Hz, BF_2). ESI-HRMS calcd for $[C_{38}H_{26}{}^{11}BF_3N_2O + Na]^+$ 617.1988, found 617.1995.

4,4-Difluoro-3,5-bis(4-fluorophenyl)-1,7-bis(4-methoxyphenyl)-4-bora-3a,4a-diaza-*s*-indacene (16b). The reaction of pyrrole carbaldehyde **7h** (14 mg, 47 µmol) and pyrrole (12.6 mg, 47.1 µmol) yielded the symmetrical by-product **16b** (6 mg, 10 µmol, 11%) as a green solid.

1-(2,3-Dichlorophenyl)-7-(2-chlorophenyl)-4,4-difluoro-5-(4-fluorophenyl)-3-phenyl-4-bora-3a,4a-diaza-*s*-indacene (14k). Pyrrole carbaldehyde **7k** (18 mg, 57 µmol) and pyrrole (16.2 mg, 59 µmol) were dissolved in dry dichloromethane (4.5 mL) and phosphorus oxychloride (6 µL)

was added. After 22 h, DIPEA (0.08 mL, 0.5 mmol, 8 equiv) and $BF_3{\cdot}OEt_2$ (0.06 mL, 0.5 mmol, 9 equiv) were added. After a further 2.5 h at room temperature, workup according to the general procedure and purification by flash column chromatography (petroleum ether/toluene, 3:1 and 7:1→4:1) yielded **14k** (17 mg, 28 μmol, 49%) as a green solid. R_f = 0.43 (silica, petroleum ether/toluene, 1:1). IR (ATR) ν (cm^{-1}) = 2925, 2854, 1605, 1579, 1497, 1465, 1453, 1199, 1126, 1036, 907, 732, 699. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 7.98–7.91 (m, 4H, *H*-2''/6'', *H*-2'''/6'''), 7.54–7.44 (m, 5H, *H*-3''/4''/5''), 7.36–7.32 (m, 3H), 7.29–7.22 (m, 2H), 7.18–7.11 (m, 2H, *H*-3'''/5'''), 6.96 (s, 1H, *H*-8), 6.81 (s, 1H, *H*-2), 6.79 (s, 1H, *H*-6). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 163.9 (d, $^1J_{C,F}$ = 251.2 Hz, C_q4'''), 157.9 (C_q3), 157.2 (C_q5), 142.5 (C_q7), 141.6 (C_q1), 135.3 (C_q7a), 135.1 (C_q8a), 134.5 (1C), 134.0 (1C), 133.5 (1C), 132.2 (2C), 132.1 (1C), 131.8 (dt, $^3J_{C,F}$ = 8.3, $^5J_{C,F}$ = 4.1 Hz, *C*2'''/6'''), 131.7 (1C), 131.6 (1C), 130.8 (1C), 130.7 (1C), 130.3 (1C), 130.1 (2C), 129.6 (t, $^5J_{C,F}$ = 3.7 Hz, *C*2''/6''),129.5 (1C), 128.4 (d, $^4J_{C,F}$ = 3.5 Hz, C_q1'''), 127.4 (1C), 127.2 (*C*8), 127.1 (1C), 121.8 (2C, *C*2/6), 115.7 (d, $^2J_{C,F}$ = 21.8 Hz, *C*3'''/5'''). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –111.47 (tt, *J* = 8.3, 5.4 Hz, $C_{ar}F$), –133.32 (s_{br}, BF_2). ESI-HRMS calcd for $[C_{33}H_{19}{}^{11}BCl_3F_3N_2 + Na]^+$ 639.0557, found 639.0541.

1,7-Bis(2-chlorophenyl)-4,4-difluoro-3,5-bis(4-fluorophenyl)-4-bora-3a,4a-diaza-*s*-indacene (16a). The reaction of pyrrole carbaldehyde **7k** (18 mg, 57 μmol) and pyrrole (16.2 mg, 59 μmol) yielded the symmetrical by-product **16a** (8 mg, 13 μmol, 47%) as a green solid.

1,7-Bis(2,3-dichlorophenyl)-4,4-difluoro-5,3-diphenyl-4-bora-3a,4a-diaza-*s*-indacene (15a). The reaction of pyrrole carbaldehyde **7k** (18 mg, 57 μmol) and pyrrole (16.2 mg, 59 μmol) yielded the symmetrical by-product **15a** (4.5 mg, 7.1 μmol, 25%) as a green solid.

1-(2,3-Dichlorophenyl)-4,4-difluoro-7-(indol-3-yl)-3,5-bis(phenyl)-4-bora-3a,4a-diaza-*s*-indacene (14l). Pyrrole carbaldehyde **7m** (12 mg, 42 μmol) and pyrrole (12 mg, 42 μmol) were

dissolved in dry dichloromethane (3 mL) and phosphorus oxychloride (4 μL) was added. After 19.5 h DIPEA (0.06 mL, 0.3 mmol, 8 equiv) and $BF_3{\cdot}OEt_2$ (0.05 mL, 0.4 mmol, 10 equiv) were added. After a further 1.5 h at room temperature, workup according to the general procedure and purification by flash column chromatography (cylcohexane/EtOAc, 10:1→5:1) yielded the title compound (11 mg, 18 μmol, 44%) as a purple/brown solid. R_f = 0.35 (silica, cyclohexane/EtOAc, 2:1). IR (ATR) ν (cm^{-1}) = 3425, 1606, 1593, 1578, 1479, 1455, 1204, 1140, 1025, 768, 743, 696. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 8.48 (s_{br}, 1H, N*H*), 8.01–7.96 (m, 2H, *H*-2‘‘‘/6‘‘‘), 7.96–7.92 (m, 2H, *H*-2‘‘/6‘‘), 7.88 (dd, *J* 7.3, 1.5 Hz, 1H, *H*-4‘‘‘‘), 7.50–7.39 (m, 8H, *H*-4, *H*-3‘‘/4‘‘/5‘‘/3‘‘‘/4‘‘‘/5‘‘‘, *H*-7‘‘‘‘), 7.32 (d, = *J* = 2.4 Hz, 1H, *H*-2‘‘‘‘), 7.31–7.20 (m, 5H, *H*-8, *H*-5‘/6‘, *H*-5‘‘‘‘/6‘‘‘‘) 6.86 (s, 1H, *H*-6), 6.74 (s, 1H, *H*-2). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 161.3 (C_q5), 155.1 (C_q3), 141.3 (C_q7), 139.5 (C_q1), 136.7 (C_q7a‘‘‘‘), 136.2 (C_q7a), 134.8 (C_q1‘), 134.3 (C_q3‘), 134.1 (C_q8a), 132.8, 132.5, 132.1 (3×C_q, C_q2‘, C_q1‘‘, C_q1‘‘‘), 130.5, 130.4 (2×1C, *C*4‘/6‘), 130.2 (*C*4‘‘‘), 129.6 (t, *J* = 3.7 Hz, 2C, *o*-Ph), 129.5 (t, *J* = 3.9 Hz, 2C, *o*-Ph). 129.4 (*C*4‘‘), 128.5, 128.4 (2×2C, *m*-Ph), 127.3, 126.1 (2×1C, *C*8, *C*5‘), 126.0 (C_q3a‘‘‘‘), 124.6 (*C*2‘‘‘‘), 123.6 (*C*6‘‘‘‘), 121.4 (*C*5‘‘‘‘), 120.5 (*C*2), 120.0 (*C*4‘‘‘‘), 118.6 (*C*6), 111.9 (*C*7‘‘‘‘), 110.2 (C_q3‘‘‘‘). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –132.57 (dd, *J* = 64.1, 32.3 Hz). ESI-HRMS calcd for $[C_{35}H_{22}{}^{11}BCl_2F_2N_3 + Na]^+$ 626.1150, found 626.1140.

4,4-Difluoro-5-(4-fluorophenyl)-1-(indol-3-yl)-7-(4-methoxyphenyl)-3-phenyl-4-bora-3a,4a-diaza-*s*-indacene (14m). Pyrrole carbaldehyde **7m** (24 mg, 84 μmol) and pyrrole (22 mg, 82 μmol) were dissolved in dry dichloromethane (6 mL) and phosphorus oxychloride (8 μL) was added. After 17.5 h DIPEA (0.11 mL, 0.63 mmol, 8 equiv) and $BF_3{\cdot}OEt_2$ (0.09 mL, 0.7 mmol, 9 equiv) were added. After a further 2 h at room temperature, workup according to the general procedure and purification by flash column chromatography (cylcohexane/EtOAc, 5:1) yielded

the title compound (11 mg, 19 µmol, 23%) as a purple/brown solid. R_f = 0.13 (silica, cyclohexane/EtOAc, 5:1). IR (ATR) ν (cm^{-1}) = 3420, 2923, 1586, 1487, 1475, 1203, 1145, 1129, 1096, 819, 770, 747. ^{1}H NMR, COSY (600 MHz, DMSO-d_6) δ (ppm) = 11.87 (d, J = 2.7 Hz, 1H, N*H*), 8.00 (dt, J = 8.5, 1.6 Hz, 4H, *H*-2‘‘/6‘‘), 7.97–7.94 (m, 2H, *H*-2‘‘‘/6‘‘‘), 7.72–7.66 (m, 2H, *H*-2‘‘‘‘/6‘‘‘‘), 7.65 (s, 1H, *H*-8), 7.54–7.48 (m, 4H, *H*-7‘, *H*-3‘‘/4‘‘/5‘‘), 7.37–7.32 (m, 2H, *H*-3‘‘‘/5‘‘‘), 7.26–7.23 (m, 1H, *H*-6‘), 7.23–7.19 (m, 1H, *H*-5‘), 7.09–7.05 (m, 3H, *H*-2, *H*-3‘‘‘‘/5‘‘‘‘), 6.94 (s, 1H, *H*-6), 3.81 (s, 3H, OCH_3). ^{13}C NMR, HSQC, HMBC (151 MHz, DMSO-d_6) δ (ppm) = 162.7 (d, $^1J_{C,F}$ = 247.7 Hz, C_q4‘‘‘), 159.9 (C_q4‘‘‘‘), 158.8 (C_q3), 153.4 (C_q5), 143.4 (C_q7), 141.2 (C_q1), 136.9 (C_q7a‘), 134.9 (C_q8a), 132.7 (C_q7a), 132.2 (C_q1‘‘), 131.4 (dt, $^3J_{C,F}$ = 8.2 Hz, $^5J_{C,F}$ = 4.1 Hz, *C*2‘‘‘/6‘‘‘), 130.2 (*C*2‘‘‘‘/6‘‘‘‘), 129.9 (*C*4‘‘), 129.3 (t, $^5J_{C,F}$ = 3.4 Hz, 2C, C2’’/6’’), 129.0 (d, $^4J_{C,F}$ = 3.3 Hz, C_q1‘‘‘), 128.3 (*C*3‘‘/5‘‘), 127.2 (*C*2‘), 126.9 (*C*8), 125.5, 125.4 (2×C_q, C_q3a‘, C_q1‘‘‘‘) 122.6 (*C*6‘), 120.6 (*C*5‘), 119.7 (*C*4‘), 117.7 (*C*6), 117.1 (*C*2), 115.3 (d, $^2J_{C,F}$ = 21.6 Hz, *C*3‘‘‘/5‘‘‘), 114.7 (*C*3‘‘‘‘/5‘‘‘‘), 112.3 (*C*7‘), 108.3 (C_q3‘), 55.3 (O*C*H$_3$). ^{19}F NMR (376.3 MHz, DMSO-d_6) δ (ppm) = –112.68 (tt, J = 8.6, 5.2 Hz), –132.54 (dd, J = 65.3, 32.6 Hz). ESI-HRMS calcd for [$C_{36}H_{25}{}^{11}BF_3N_3O$ + Na]$^+$ 606.1940, found 606.1942.

5-(4-Chlorophenyl)-4,4-difluoro-1-(indol-3-yl)-7-(3-nitrophenyl)-3-phenyl-4-bora-3a,4a-diaza-*s*-indacene (14n). Pyrrole carbaldehyde **7g** (20 mg, 49 µmol) and pyrrole **11c** (13 mg, 50 µmol) were dissolved in dry dichloromethane (4 mL) and phosphorus oxychloride (5 µL) was added. After 16.5 h, DIPEA (0.07 mL, 0.4 mmol, 8 equiv) and $BF_3{\cdot}OEt_2$ (0.06 mL, 0.5 mmol, 10 equiv) were added. After a further 2.5 h at room temperature, workup according to the general procedure and purification by flash column chromatography (petroleum ether/toluene, 2:1→1:2) yielded the title compound (19 mg, 27 µmol, 56%) as a purple/black solid. R_f = 0.21 (silica, petroleum ether/toluene, 2:1). IR (ATR) ν (cm^{-1}) = 2957, 2924, 2854, 1604, 1557, 1536, 1591, 1454, 1387, 1209, 1171, 1128, 745, 697. ^{1}H NMR, COSY (400 MHz, DMSO-d_6)

δ (ppm) = 12.03 (d, *J* = 2.3 Hz, 1H, N*H*), 8.52 (*pseudo*-t, *J* = 2.0 Hz, 1H, *H*-2‘‘‘‘), 8.33 (ddd, *J* = 8.3, 2.3, 1.0 Hz, 1H, *H*-4‘‘‘‘), 8.16 (ddd, *J* = 7.7, 1.5, 1.0 Hz, 1H, *H*-6‘‘‘‘), 8.05 (d, *J* = 2.9 Hz, 1H, *H*-2‘), 8.04–7.98 (m, 3H, *H*-4‘, *H*-2‘‘/6‘‘), 7.83 (*pseudo*-t, *J* = 8.0 Hz, 1H, *H*-5‘‘‘‘), 7.64–7.56 (m, 4H, *H*-2‘‘‘/3‘‘‘/5‘‘‘/6‘‘‘), 7.55–7.47 (m, 5H, *H*-8, *H*-7, *H*-3‘‘74‘‘/5‘‘), 7.27–7.17 (m, 3H, *H*-2, *H*-5‘/6‘). ^{13}C NMR, HSQC, HMBC (100.6 MHz, DMSO-d_6) δ (ppm) = 163.7 (C_q3), 148.0 (C_q3‘‘‘‘), 146.9 (C_q5), 144.9 (C_q1), 137.2 (C_q8a), 137.0 (C_q7a‘), 136.6 (*C*6‘‘‘‘), 135.1 (C_q7), 134.2 (C_q1‘‘‘/4‘‘‘), 133.1 (C_q1‘‘‘‘), 132.2 (*C*3‘‘‘/5‘‘‘), 131.2 (C_q1‘‘), 130.9 (*C*4‘‘), 130.5 (C_q7a), 130.4 (*C*5‘‘‘‘), 129.7 (C_q1‘‘‘/4‘‘‘), 129.5 (*C*2‘‘/6‘‘), 128.7 (*C*2‘), 128.5 (*C*3‘‘/5‘‘), 128.1 (*C*2‘‘‘/6‘‘‘), 126.5 (*C*8), 125.2 (C_q3a‘), 124.4 (*C*2‘‘‘‘), 123.2 (*C*4‘‘‘‘), 122.9 (*C*6‘), 121.0 (*C*5‘), 119.8 (*C*4‘), 117.8 (*C*2), 112.4 (*C*7‘), 108.1 (C_q3‘), 105.0 (C_q6). ^{19}F NMR (376.3 MHz, DMSO-d_6) δ (ppm) = –130.57 (dd, *J* = 64.2, 31.9 Hz). ESI-HRMS calcd for $[C_{35}H_{21}{}^{11}B^{79}BrClF_2N_4O_2 + Na]^+$ 715.0495, found 715.0502.

2-Bromo-4,4-difluoro-1,3,5,7-tetraphenyl-8-(thien-2-yl)-4-bora-3a,4a-diaza-s-indacene (17a) and 4,4-Difluoro-1,3,5,7-tetraphenyl-8-(thien-2-yl)-4-bora-3a,4a-diaza-s-indacene (17b). The title compound was prepared according to a modified procedure by Liras et al.[50] ketone **13c** (83 mg, 0.20 mmol) was dissolved in dry dichloromethane (1 mL) and phosphorous oxychloride (20 µL) was added. The reaction mixture was stirred at room temperature for 30 min, then pyrrole (44 mg, 0.20 mmol) dissolved in dry dichloromethane (0.7 mL) was added and the mixture was stirred at 40 °C. After 24 h, the mixture was cooled to room temperature and DIPEA (0.20 mL, 1.1 mmol, 5.7 equiv) and $BF_3{\cdot}OEt_2$ (0.15 mL, 0.12 mmol, 6.1 equiv) were added. After a further 1.5 h at room temperature, workup according to the general procedure and purification by flash column chromatography (cylcohexane/EtOAc, 10:1 and 40:1→20:1) yielded an inseparable mixture of **17a** and **17b** (41 mg, constant ratio of 0.55:1.0) as a green solid, containing 22 µmol, 11% **17a** and 46 µmol, 23% **17b** (NMR). R_f = 0.40 (silica,

cyclohexane/EtOAc, 5:1). IR (ATR) ν (cm^{-1}) = 3060, 3029, 1537, 1514, 1494, 1471, 1452, 1226, 1163, 1139, 1072, 757, 695. Compound **17a**: ^{1}H NMR, COSY (600 MHz, $CDCl_3$) δ (ppm) = 7.87–7.84 (m, 2H, *H*-2'''/6'''),7.71–7.68 (m, 2H, *H*-2''/6''), 7.50–7.39 (m, 6H, *H*-3''/4''/5''/3'''/4'''/5'''), 7.05–6.89 (m, 10H, Ph'/Ph''''), 6.69 (dd, *J* = 5.0, 1.2 Hz, 1H, thienyl), 6.58–6.55 (m, 1H, *H*-6), 6.51 (dd, *J* = 3.6, 1.2 Hz, 1H, thienyl), 6.06 (dd, *J* = 5.0, 3.5 Hz, 1H, *H*-4'''''). ^{13}C NMR, HSQC, HMBC (151 MHz, $CDCl_3$) δ (ppm) = 159.3 (C_q5), 153.4 (C_q3), 149.9 (C_q7), 144.0 (C_q1), 138.8 (C_q), 135.7 (C_q), 134.4 (C_q), 134.1 (C_q), 133.8 (1C, thienyl), 132.0 (C_q), 131.5 (C_q), 131.5 (C_q), 131.0 (C_q), 130.5 (*C*2''/6''), 130.2 (1C), 129.6 (*C*2'''/6'''), 129.5 (*C*3''/5''+1C), 129.4 (1C, thienyl), 128.4 (2C), 128.1 (2C), 127.8 (2C), 127.5 (2C), 127.4 (2C), 126.9 (1C), 126.8 (1C), 126.3 (*C*4'''''), 124.8 (*C*6), 112.0 (*C*2). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –133.13 (dd, *J* = 61.7, 30.9 Hz). ESI-HRMS calcd for $[C_{37}H_{24}{}^{11}B^{79}BrF_2N_2S + Na]^+$ 679.0802, found 679.0816. Compound **17b**: ^{1}H NMR, COSY (600 MHz, $CDCl_3$) δ (ppm) = 7.90–7.87 (m, 4H, *H*-2''/6''/2'''/6'''), 7.50–7.39 (m, 6H, *H*-3''/4''/5''/3'''/4'''/5'''), 7.05–6.89 (m, 10H, Ph'/Ph''''), 6.72 (dd, *J* = 5.1, 1.2 Hz, 1H, thienyl), 6.58–6.55 (m, 3H, *H*-2/6, thienyl), 6.10 (dd, *J* = 5.0, 3.6 Hz, 1H, *H*-4'''''). ^{13}C NMR, HSQC, HMBC (151 MHz, $CDCl_3$) δ (ppm) = 157.4 (C_q3/5), 148.2 (C_q1/7), 138.5 (C_q), 136.2 (C_q7a/8a), 133.9 (1C, thienyl), 133.1 (2×C_q), 132.6 (2×C_q), 132.3 (C_q), 129.7 (*C*4''/4'''), 129.6 (t, $^{5}J_{C,F}$ = 3.8 Hz, *C*2''/6''/2'''/6'''), 129.5 (1C, thienyl), 128.3 (2×2C), 128.2 (2×2C), 127.5 (2×2C), 126.5 (*C*4'/4''''), 126.2 (*C*4'''''), 123.9 (*C*2/6). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –132.52 (dd, *J* = 63.6, 31.7 Hz). ESI-HRMS calcd for $[C_{37}H_{25}{}^{11}BF_2N_2S + Na]^+$ 601.1697, found 601.1705.

Functionalization of BODIPY Dyes.

4,4-Difluoro-2-(furan-3-yl)-1,3,5,7-tetraphenyl-4-bora-3a,4a-diaza-s-indacene (18a). In a Schlenk flask, **14a** (23.5 mg, 40.9 μmol), furan-3-yl-boronic acid (8.4 mg, 75 μmol, 1.8 equiv) and sodium carbonate (13.1 mg, 124 μmol, 3.0 equiv) were placed under argon. THF, toluene and water (1.2 mL each) were added, the mixture was degassed and $Pd(PPh)_3)_4$ (3.5 mg, 3.0 μmol, 7.4 mol%) was added. The reaction mixture was stirred at 77 °C for 46 h and then diluted with ethyl acetate and water. The aqueous layer was extracted with ethyl acetate. The combined organic layers were dried over magnesium sulfate and concentrated. Purification by flash column chromatography (petroleum ether/toluene, 3:1→2:1 and cyclohexane/EtOAc, 30:1) yielded the title compound (20 mg, 36 μmol, 87%) as a purple/black solid.. R_f = 0.38 (silica, petroleum ether/toluene, 2:1). IR (ATR) ν (cm^{-1}) = 2925, 16008, 1582, 1477, 1193, 1149, 1126, 1071, 1059, 1029, 760, 695, 682. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 7.94–7.89 (m, 2H, *H*-2‘‘‘‘/6‘‘‘‘), 7.60–7.56 (m, 2H, *H*-2‘‘‘/6‘‘‘), 7.52–7.36 (m, 16H, Ph‘, *H*-3‘‘‘/4‘‘‘/5‘‘‘, *H*-3‘‘‘‘/4‘‘‘‘/5‘‘‘‘, Ph‘‘‘‘‘), 7.34 (s, 1H, *H*-8), 7.16 (*pseudo*-t, *J* = 1.7 Hz, 1H, *H*-5‘‘), 6.78 (dd, *J* = 1.5, 0.9 Hz, 1H, *H*-2‘‘), 6.75 (d, *J* = 1.3 Hz, 1H, *H*-6), 5.75 (dd, *J* = 1.9, 0.9 Hz, 1H, *H*-4‘‘). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 158.5 (C_q5), 156.1 (C_q3), 146.1 (C_q7), 142.1 (*C*5‘‘), 141.3 (C_q1), 140.9 (*C*2‘‘),134.9 (C_q7a), 134.3 (C_q), 133.4 (C_q), 132.8 (C_q), 132.4 (C_q), 132.0 (C_q), 130.3 (*C*2‘‘‘/6‘‘‘), 130.2 (2C), 129.9 (*C*4‘‘‘‘), 129.6 (t, $^5J_{C,F}$ = 3.7 Hz, *C*2‘‘‘‘/6‘‘‘‘), 129.4 (1C), 129.2 (2C), 128.9 (3C+C_q), 128.7 (2C), 128.6 (1C), 128.4 (2C), 128.0 (2C), 127.6 (*C*8), 119.3 (*C*6), 117.2 (C_q3‘‘), 111.2 (*C*4‘‘).^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = –133.82 (dd, *J* = 63.0, 31.4 Hz). ESI-HRMS calcd for $[C_{37}H_{25}{}^{11}BF_2N_2O + H]^+$ 563.2106, found 563.2104.

4,4-Difluoro-5-(4-fluorophenyl)-7-(4-methoxyphenyl)-1,3-diphenyl-2-vinyl-4-bora-3a,4a-diaza-*s*-indacene (18b). In a Schlenk flask **14e** (12.5 mg, 20.1 μmol) and vinyltributylstannane

(18 mg, 57 μmol, 2.8 equiv) were placed under argon. Dry toluene (4 mL) was added, the reaction mixture was degassed and $Pd(PPh_3)_4$ (2.4 mg, 2.1 μmol, 10 mol%) was added. The reaction was refluxed (115°C bath temperature) for 17.5 h then filtered and concentrated in vacuo. Purification by flash column chromatography (cylcohexane/EtOAc, 20:1) yielded the title compound (10 mg, 18 μmol, 87%) as a purple/black solid. R_f = 0.32 (silica, petroleum ether/toluene, 1 :1). IR (ATR) ν (cm^{-1}) = 2934, 1606, 1585, 1516, 1487, 1442, 1253, 1240, 1200, 1174, 1160, 1131, 1107. ^{1}H NMR, COSY (400 MHz, $CDCl_3$) δ (ppm) = 7.90–7.84 (m, 2H, *H*-2‘‘‘/6‘‘‘), 7.63–7.59 (m, 2H, *H*-2‘‘/6‘‘), 7.49–7.37 (m, 10H, *H*-2‘/3‘/4‘/5‘/6‘, *H*-3‘‘/4‘‘/5‘‘, *H*-2‘‘‘‘/6‘‘‘‘), 7.24 (s, 1H, *H*-8), 7.11–7.04 (m, 2H, *H*-3‘‘‘/5‘‘‘), 6.99–6.94 (m, 2H, *H*-3‘‘‘‘/5‘‘‘‘), 6.61 (s_{br}, 1H, *H*-6), 6.35 (dd, *J* = 17.9, 11.7 Hz, 1H, C*H*=CH_2), 4.94 (dd, *J* = 11.7, 1.5 Hz, 1H, CH=CH_{2A}), 4.82 (dd, *J* = 17.9, 1.5 Hz, 1H, CH=CH_{2B}), 3.85 (s, 3H, OCH_3). ^{13}C NMR, HSQC, HMBC (100.6 MHz, $CDCl_3$) δ (ppm) = 163.8 (d, $^1J_{C,F}$ = 250.7 Hz, C_q4‘‘‘), 160.5 (C_q4‘‘‘‘), 157.5 (C_q5), 156.2 (C_q3), 146.3 (C_q7), 141.1 (C_q1), 135.0 (C_q7a), 134.1 (C_q8a), 132.8 (C_q), 132.0 (C_q), 131.6 (dt, $^3J_{C,F}$ = 8.0, $^5J_{C,F}$ = 3.9 Hz, *C*2‘‘‘/6‘‘‘), 130.2 (2C), 130.1 (3C), 129.3 (*C*4‘‘), 128.8 (2C), 128.6 (d, $^4J_{C,F}$ = 3.3 Hz, C_q1‘‘‘), 128.5 (*C*4‘), 128.1 (2C), 127.5 (*C*8+C_q2), 127.3 (*C*H=CH_2), 125.8 (C_q1‘‘‘‘), 118.5 (*C*6), 117.4 (CH=*C*H_2), 115.6 (d, $^2J_{C,F}$ = 21.7 Hz, *C*3‘‘‘/5‘‘‘), 114.8 (*C*3‘‘‘‘/5‘‘‘‘), 55.6 (O*C*H_3). ^{19}F NMR (376.3 MHz, $CDCl_3$) δ (ppm) = -111.86 (tt, *J* = 8.8, 5.4 Hz), –133.75 (dd, *J* = 63.6, 31.7 Hz). ESI-HRMS calcd for $[C_{36}H_{26}{}^{11}BF_3N_2O + H]^+$ 571.2169, found 571.2172.

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Supporting Information

(see footnote on the first page of this article): ^{1}H and ^{13}C NMR spectra of all synthesized compounds.

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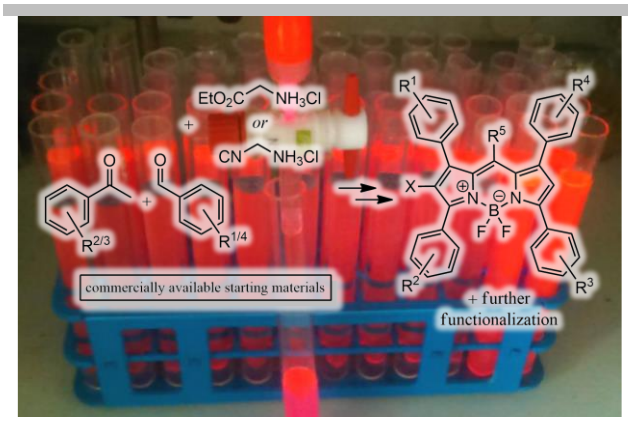

Modular Fluorophores*

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Modular De Novo Synthesis of Unsymmetrical BODIPY Dyes possessing four different Aryl Substituents

*one or two words that highlight the emphasis of the paper or the field of the study