Direct Synthesis of Fluorescent Oxazolo-phenoxazines by Copper-Catalyzed/Hypervalent Iodine(III)-Mediated Dimerization/Cyclization of 2-Benzylamino-phenols

Camilla Loro,[§] *Letizia Molteni,*[‡] *Marta Papis,*[§] *Egle M. Beccalli,*[‡] *Donatella Nava,*[‡] *Leonardo Lo Presti,*[#] *Stefano Brenna,*[§] *Gioele Colombo,*[§] *Francesca Foschi*[§] *and Gianluigi Broggini**[§]

[§] Dipartimento di Scienza e Alta Tecnologia, Università dell'Insubria, via Valleggio 11, 22100 Como, Italy, [‡]DISFARM, Sezione di Chimica Generale e Organica "A. Marchesini" Università degli Studi di Milano, via Venezian 21, 20133 Milano, Italy; [#]Dipartimento di Chimica, Università degli Studi di Milano, via Golgi 19, 20133 Milano, Italy.

gianluigi.broggini@uninsubria.it

RECEIVED DATE

Abstract. A dimerization/cyclization reaction of 2-benzylamino-phenols for the direct synthesis of oxazolo-phenoxazine skeleton is reported. The reaction occurs under copper-catalysis in the presence of hypervalent iodine(III) giving selectively the 5*H*-oxazolo[4,5-*b*]phenoxazine compounds. The cascade process which allows the conversion of the substrates into the tetracylic products involves three C-H functionalization steps. An initial oxidation of the electron-rich arenes by the hypervalent iodine is essential for the dimerization of the substrates, whereas the formation of the five-membered rings is promoted by the copper species. 1-Benzyl-2-phenyl-6-(aryl-benzyl)amino-benzimidazoles are

regioselectively obtained using of *N,N'*-dibenzyl-phenylenediamines as starting substrates. The fluorescence emission properties of these classes of products have been evaluated.

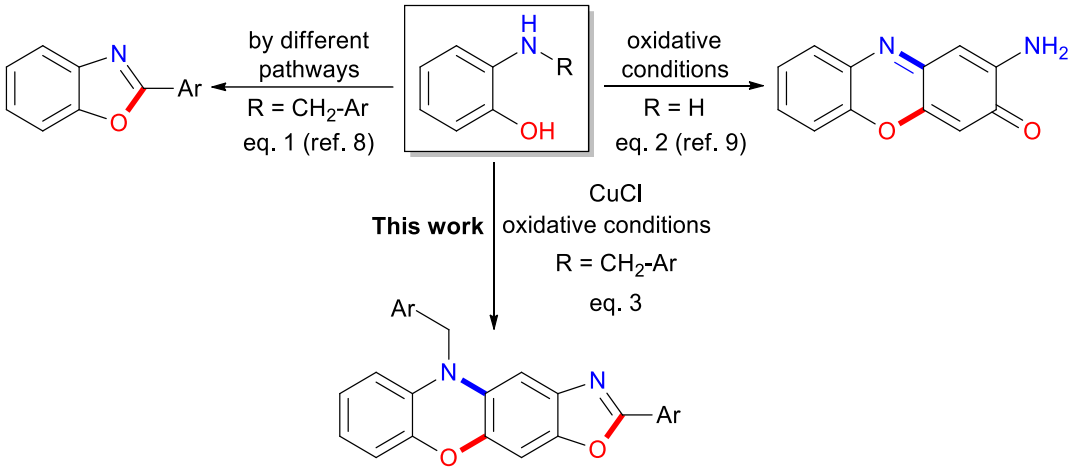
Introduction

The formation of new bonds by transition metal-catalyzed reactions under oxidative conditions has had a notable development as it allows the use of non-activated compounds as substrates.[1] In the context of C-H functionalization processes under oxidative conditions, copper-catalyzed reactions have proved to be a valuable alternative to the well-known versatility demonstrated by palladium-catalyzed reactions.[2,3] Different combinations of copper species with suitable oxidants have been successfully used to functionalize Csp-H, Csp_2-H and Csp_3-H bonds.[4] Several copper-catalyzed reactions performed in the presence of hypervalent iodine(III) in the dual role of oxidant and source of functional groups are reported in the literature.[5]

The benzoxazole nucleus represents a frequently occurring motif in natural and pharmaceutical compounds, also endowed with chemical and physical properties that make its presence useful in organic materials for optical applications.[6] The most convenient procedures for the synthesis of benzoxazoles are based on various methodologies of cyclization starting from 2-aminophenol derivatives.[7] Among them, the intramolecular C-H functionalization of 2-benzylaminophenols represents the easiest approach to build 2-aryl-substituted benzoxazoles (Scheme 1, eq. 1).[8]

In this context, taking into account the tendency of 2-aminophenols to transform into *o*-quinones in the presence of oxidants giving dimerization (Scheme 1, eq. 2),[9] we have envisaged the possibility of coupling 2-benzylaminophenols to give a benzoxazole moiety inserted in a tetracyclic structure (Scheme 1, eq. 3). On the basis of the light emitting properties known from the literature for phenoxazine analogous structures,[10] the expected 5*H*-oxazolo[4,5-*b*]phenoxazines should have fluorescent properties.

Scheme 1. Representative cyclization reactions of 2-aminophenols

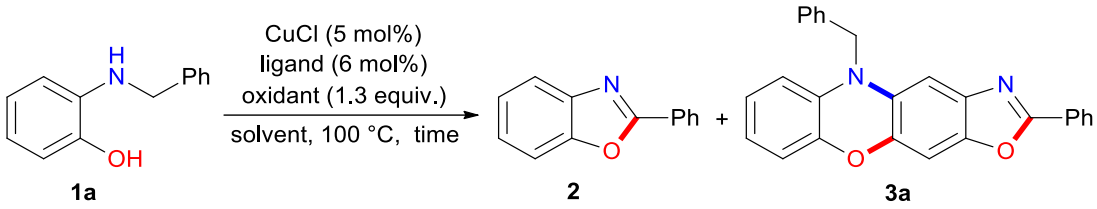


Results and discussion

Devoting continuous interest in cyclization reactions in oxidative conditions and, more recently, to copper-catalyzed synthetic processes,[11] we initially screened the behavior of the 2-benzylamino-phenol **1a** as model substrate in the presence of catalytic CuCl and different oxidizing agents. The reaction conditions investigated to optimize the procedure are summarized in Table 1. Combination of the copper catalyst with *t*-butyl-hydroperoxide or benzoquinone afforded total consumption of the substrate, but was ineffective for the dimerization giving the 2-phenyl-benzoxazole **2** in low yields (entries 1-3). No conversion of **1a** was observed using H_2O_2 (entry 4). The addition of neither 8-OH-quinoline nor 1,10-phenantroline as ligands changed the outcome of the reaction, although traces of compound **3a** were identified in the crude reaction mixtures (entries 5 and 6).[12] In obvious contrast to the results so far described, the use of PIDA as oxidant in chlorobenzene inhibited the formation of the benzoxazole product and enhanced the efficiency toward **3a**, isolated in 24% yield (entry 7). Access to the oxazolo[4,5-*b*]phenoxazine product was improved combining the copper salt and PIDA to a *N,N*-bidentate ligand (entries 8 and 9). Further investigations proved PIFA as an ineffective oxidizing agent (entry 10) and revealed that the dimerization/cyclization process took place even in absence of the CuCl catalyst, although giving a complex mixture of degradation compounds from which **3a** was isolated in only 18% yield (entry 11). By changing the solvent, very different results were observed: working in the presence of bathophenanthroline in DMF or acetonitrile no substrate conversion was observed (entries 12 and 13),

while carrying out the reaction in toluene **3a** was obtained in 67% yield (entry 14). Finally, the use of PIDA as oxidant in toluene was more effective performing the reaction in 0.5 M solution at 100 °C (entry 15 *vs* 16).

Table 1. Optimization for dimerization/cyclization reaction of 2-benzylamino-phenol[a]

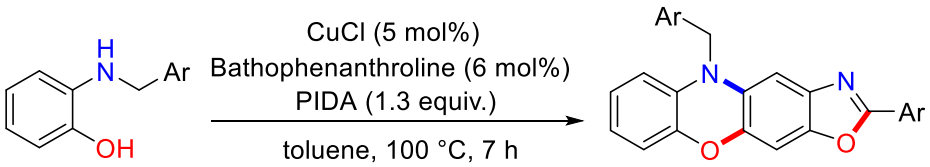


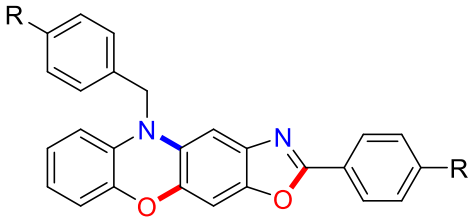
Entry	Oxidant	Ligand	Solvent	Time (h)	Product (%yield)
1	TBHP	-	dioxane	4	**2** (10)
2	TBHP	-	PhCl	4	**2** (44)
3	BQ	-	toluene	4	**2** (15)
4	H_2O_2	-	MeCN	4	S.M.
5	TBHP	8-OH quinoline	PhCl	1	**2** (66) + **3a** (traces)
6	TBHP	Phen	PhCl	4	**2** (15) + **3a** (traces)
7	PIDA	-	PhCl	4	**3a** (24)
8	PIDA	Phen	PhCl	3	**3a** (58)
9	PIDA	BPhen[b]	PhCl	3	**3a** (53)
10	PIFA	BPhen	PhCl	3	S.M.
11	PIDA[c]	-	toluene[d]	4	**3a** (18)
12	PIDA	BPhen	DMF	3	S.M.
13	PIDA	BPhen	MeCN	3	S.M.
14	PIDA	BPhen	toluene	3	**3a** (67)
15	PIDA	BPhen	toluene[c,e]	8	**3a** (72)
16	PIDA	BPhen	toluene[f]	8	**3a** (42)

[a] Reaction conditions: **1a** (1.0 mmol), CuCl (0.05 mmol), ligand (0.06 mmol), oxidant (1.3 mmol), solution concentration 0.07 M, at 100 °C for the indicated time in a sealed tube. [b] The use of 8-OH quinoline as ligand provided only degradation products. [c] No improvement of yields of **3a** was observed using of 1.5 mmol or 3.0 mmol of PIDA. [d] Reaction performed without CuCl. [e] In a 0.5 M solution. [f] At 80 °C in a 0.1 M solution.

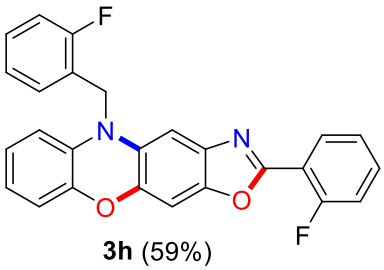
Application of the conditions of Table 1, entry 15 to other substrates showed that oxazolo-phenoxazines could be obtained from 2-arylamino-phenols bearing highly diversified benzyl groups (Scheme 2). Overall, the presence of both strongly electron-donating and electron-withdrawing substituents was tolerated, although the presence of the latter resulted in lower yields. Particularly noteworthy is the formation of the tetracyclic derivative **3c** without any observable reaction of the *p*-bromophenyl moiety. Heterocyclic groups such as the thien-2-yl ring were suitable for the dimerization/cyclization reaction, and naphthyl and mesityl groups led to the expected reaction products. Moreover, in the synthesis of compound **3b**, single crystals suitable for X-ray diffraction analysis were obtained from the crude reaction mixture. The crystal structure determination provided unambiguous evidences for the 5*H*-oxazolo[4,5-*b*]phenoxazine structure. Aminophenols with methyl and nitro substituent at 3- and 6-positions were also considered as candidates for the reaction, but their treatment under standard conditions provided only mixtures of degradation products.

Scheme 2. Scope of the dimerization/cyclization reaction[a]

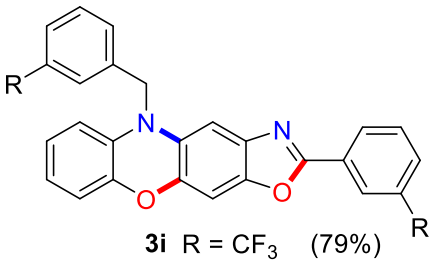




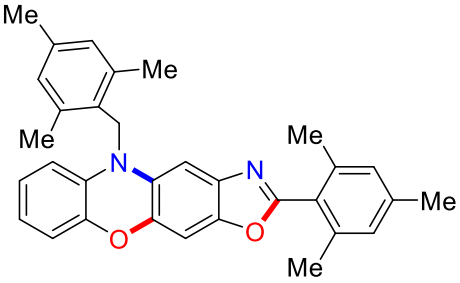
3b^{b} R = Me (82%)
3c R = Br (69%)
3d R = OMe (71%)
3e R = CN (31%)
3f R = F (73%)
3g R = NO_2 (28%)



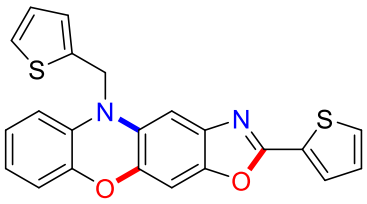
3h (59%)



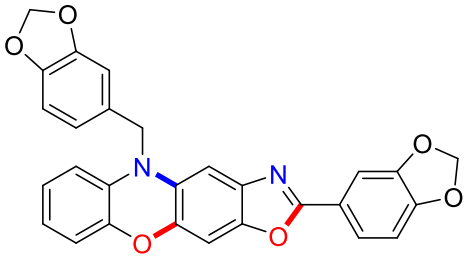
3i R = CF_3 (79%)
3j R = OMe (60%)



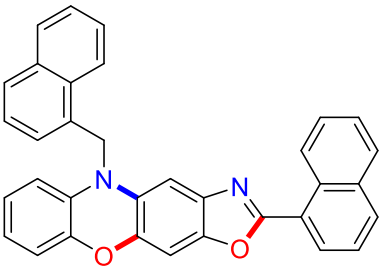
3k (63%)



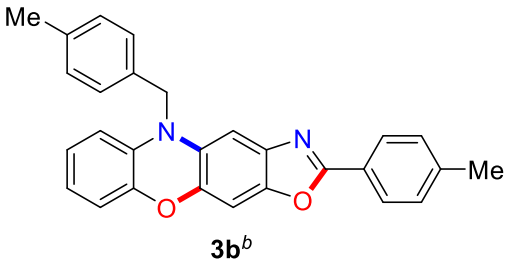
3l (81%)



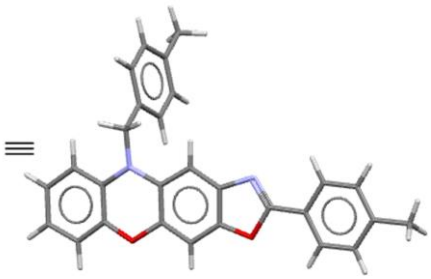
3m (72%)



3n (66%)



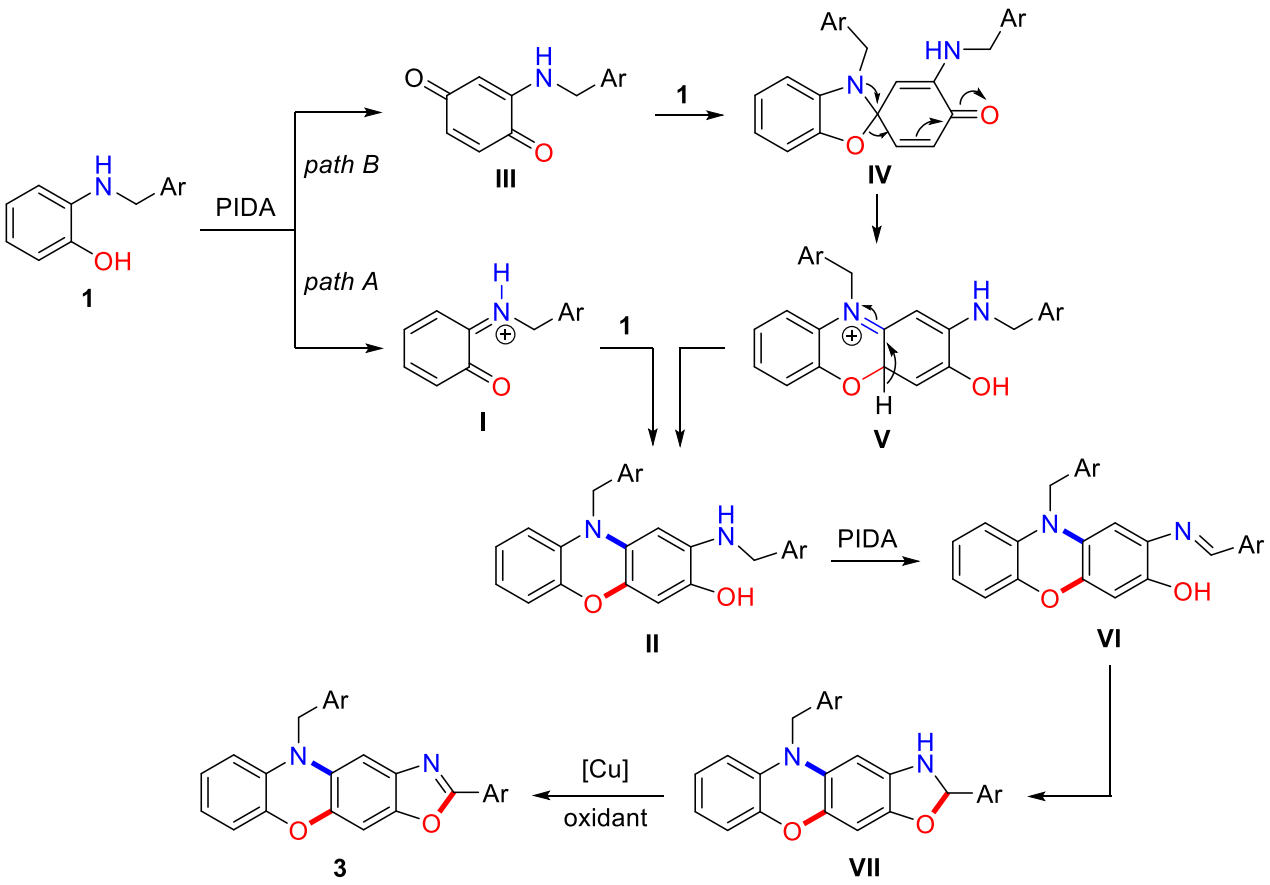
3b^{b}



[a] Reaction conditions: **1b-n** (1.0 mmol), CuCl (0.05 mmol), bathophenanthroline (0.06 mmol), PIDA (1.3 mmol), toluene (2 mL), 80 °C, 8 h. [b] The molecular structure was determined experimentally through accurate single-crystal X-ray diffraction experiments at room temperature. Full details are deposited in the Supporting Information. CCDC 2085399 contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/structures.

On the basis of the known tendency of 2-aminophenols to undergo oxidative dimerization[9] and due to the formation of the tetracyclic product only in traces when the reaction was performed with an excess of PIDA without the copper salt (Table 1, entry 11), a plausible mechanism is proposed in Scheme 3. The key-intermediate, although never isolated, is the phenoxazine **II**, which may arise from dimerization of the substrate following two different paths. The first one involves the oxidation/dearomatization of the 2-benzylamino-phenol induced by the hypervalent iodine with generation of the *o*-quinone-type intermediate **I**,[13] which interacts with **1** directly affording **II** (Scheme 3, *path A*).[9] Alternatively, **II** could be generated from the spiro-cyclohexandienone **IV** arising from coupling of **1** on the *p*-quinone intermediate **III** formed through the PIDA oxidative intervention (Scheme 3, *path B*).[14] Spiro-oxazolidine **IV** promptly rearranges to the more stable phenoxazine **II** via a regioselective ring expansion process, plausibly favors by the presence of the acetate anion able to capture the acid H atom in **V**. The intermediate **II** plausibly evolves through oxidation to imine **VI**, followed by a copper-assisted acetalization step that generates the 2,3-dihydrobenzoxazole derivative **VII**.[15] Finally, the copper-catalyzed oxidation of **VII** provides the product **3**. The occurrence of an initial dimerization is supported by the lack of reactivity of substrates bearing substituents on 4- and 5-positions of the 2-amino-phenol moiety essayed under the standard reaction conditions.

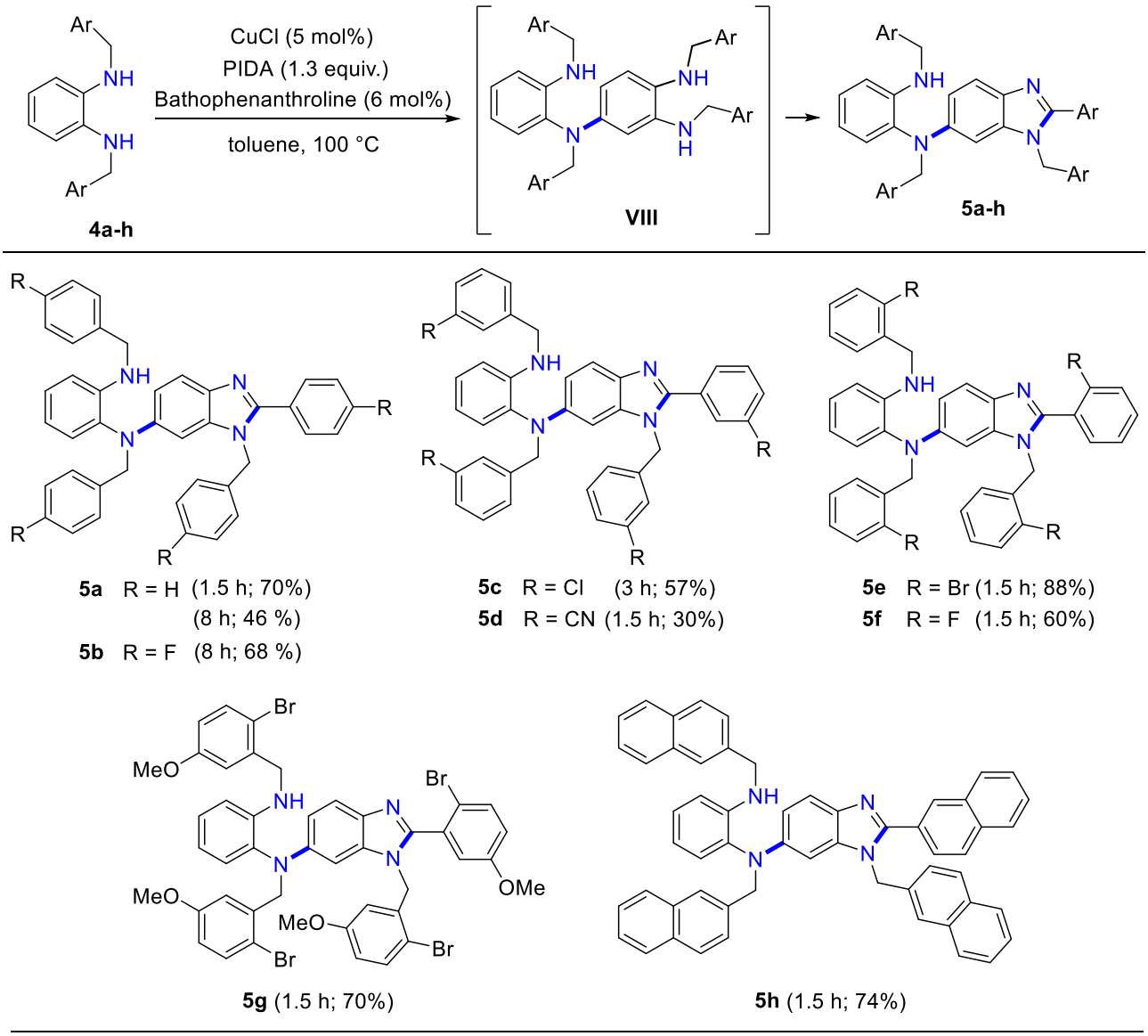
Scheme 3. The proposed mechanism of dimerization/cyclization reaction



Likewise, considering the structural and electronic analogy with the 2-aminophenols, we evaluated the reactivity of the *N,N'*-dibenzyl-1,2-benzendiamines (Scheme 4). The compounds **4a-h**, treated under standard conditions, although giving rise to a dimerization process with formation of a five-membered ring, did not provide tetracyclic fused-ring products. Therefore, a regiospecific reaction was observed in all cases leading to the products **5a-h** as the only isomers, isolated in good yields (57-88%) with the exception of the substrate **4d** bearing a nitrile group at meta position. The substituents on the benzimidazole structure were assigned on the base of NMR studies and the selective substitution of the amino group at 6-position was inferred by NOESY experiments (Figure 1). In particular, the interaction between the aromatic proton at 6.36 ppm and the N1 benzylic signal at 5.19 ppm, consistent only for the assigned structure, was found to be diagnostic (see Supporting Information). The obtained results suggest that, most probably, the presence of a second benzylamino substituent instead of the hydroxyl group inhibits the formation of the second C-N bond, hampering the access to the phenazine nucleus. As the dimerization/cyclization process of 2-benzylamino-phenols, the reaction plausibly involves the oxidation

of **VIII** to imino derivatives, which in turn furnish the 2,3-dihydrobenzimidazole intermediates as precursors of the benzimidazole products **5**.[15d]

Scheme 4. Reaction performed on *N*,*N'*-dibenzyl-1,2-benzendiamine **4**[a]



[a] Reaction conditions: substrate **4** (1.0 mmol), CuCl (0.05 mmol), bathophenanthroline (0.06 mmol), PIDA (1.3 mmol), toluene (2 mL), 100 °C.

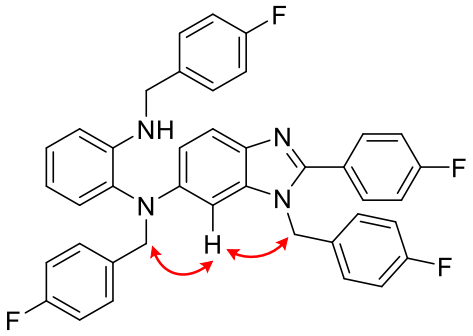


Figure 1. Determination of structure **5b** by NOESY experiments

Interestingly, the 5*H*-oxazolo[4,5-*b*]phenoxazine derivatives **3a-n** are characterized by an intense fluorescence in solution, with the exception of **3g**, which shows a very feeble emission due to the quenching effect of nitro groups.[16] The lower energy absorption (Table S1) falls in the range 351-414 nm, with all species showing a large Stokes shift (0.72-0.92 eV). As depicted in Figure 2, the emission maxima differ depending on the substitution on the oxazole ring: in general, λ_{em} varies from blue to orange with decreasing the electron donating character of the substituent (i.e., from 474 nm for **3k** to 584 nm for **3e**).[17] Fluorescence lifetime decays are in the range 3.8-5.9 ns (Table S1).[18]

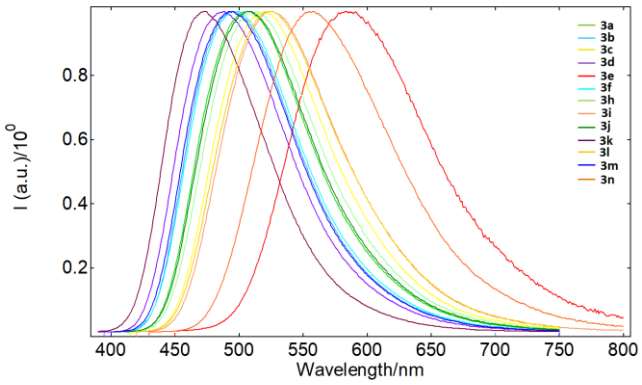


Figure 2. Normalized emission spectra of 5*H*-oxazolo[4,5-*b*]phenoxazines **3a-f**, **3h-n** (CH_2Cl_2, $5 \cdot 10^{-5}$ M).

TD-DFT calculations were performed on compound **3a**, and a great accordance between calculated and experimental UV-vis traces was observed (Figure 3). Accordingly, the main absorption is a HOMO-LUMO transition (>98%): the HOMO is localized on the 5*H*-oxazolo[4,5-*b*]phenoxazine nucleus, whereas LUMO mainly involves the aromatic substituent at oxazole 2-position.

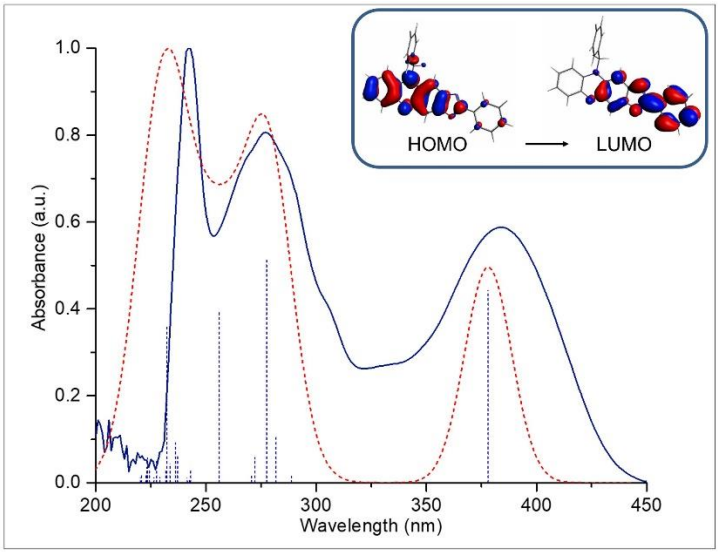


Figure 3. Calculated (dashed red) *vs*. experimental (solid blue) UV-vis spectra (CH_2Cl_2, $5 \cdot 10^{-5}$ M) for compound **3a**, taken as a representative example of the series. Vertical bars represent calculated transitions with oscillator strength $f > 0.01$. Inset: calculated HOMO and LUMO orbitals for **3a**.

Preliminary measurements showed that 1*H*-benzo[*d*]imidazol-6-yl)benzene-1,2-diamine derivatives are also characterized by a fluorescence emission (Figure S2), centered in the UV to blue region (370-450 nm), which however is less intense than what observed for 5*H*-oxazolo[4,5-*b*]phenoxazines.

Conclusions

In summary, we have developed an oxidative/copper catalyzed procedure for direct coupling of 2-benzylamino-phenols to oxazolo[4,5-*b*]phenoxazines. A catalytic amount of CuCl combined with PIDA allowed selective access to the tetracyclic products through the initial formation of the phenoxazine structure, obtained by dimerization of the aminophenol substrate, then followed by cyclization of the imine intermediate to the oxazole ring. This synthetic protocol proved to be general and regiospecific. Replacement of the starting amino-phenols with *N*,*N*-dibenzyl-1,2-diaminobenzenes lead to the formation of 1*H*-benzo[*d*]imidazol-6-yl)benzene-1,2-diamine products. Additionally, the luminescence of these oxazolo[4,5-*b*]phenoxazines **3** and 1*H*-benzo[*d*]imidazol-6-yl)benzene-1,2-diamines **5** could be modulated depending on the substituent, leading to fluorescent organic dyes with a broad emission range.

Experimental Section

General Information: All available chemicals and solvents were purchased from commercial sources and were used without any further purification. Thin layer chromatography (TLC) was performed using 0.25 mm silica gel precoated plates Si 60-F254 (Merck, Darmstadt, Germany) visualized by UV-254 light and CAM staining. Purification by flash column chromatography (FCC) was conducted by using silica gel Si 60, 230-400 mesh, 0.040-0.063 mm (Merck). Melting points were determined on a Stuart Scientific SMP3 and are corrected. ^{1}H, ^{13}C NMR and NOESY spectra were recorded on a Bruker Avance 400 (400 and 101 MHz, respectively); chemical shifts are indicated in parts per million downfield from $SiMe_4$. Coupling constants values *J* are given in Hz. The UV-vis, excitation and emission spectra were measured using a fluorescence spectrometer (Edinburgh Instruments FS5) equipped with a 150 W continuous Xenon lamp as a light source and were corrected for the wavelength response of the instrument. Lifetime measurements were performed on the same FS5 Edinburgh Instruments equipped with an EPLED-320 (Edinburgh Instruments) pulsed source. Analysis of the lifetime decay curve was done using Fluoracle® Software package (Ver. 1.9.1), which runs the FS5 instrument.

General procedure for the synthesis of 2-benzylamino-phenols 1a-n. In a round bottom flask the appropriate benzaldehyde (1.0 mmol, 1.0 equiv.) was added to a solution of aminophenol (1.0 mmol, 1.0 equiv., 109.1 mg) in MeOH dry (6.7 mL, 0.15M). The resulting solution was stirred at room temperature for 1 hour. After cooling to 0 °C, $NaBH_4$ or $NaBH(OAc)_3$ (2.0 mmol, 2.0 equiv.) was added portionwise and the solution was stirred for 1 hour. Then, after evaporation of the solvent, the reaction mixture was extracted with DCM (10 mL x 2), washed with water (10 mL x 2) and brine (10 mL x 1), dried over $MgSO_4$ and filtered. The solvent was evaporated under reduced pressure and the residue was purified by FCC. Yields, spectroscopic and analytical data of benzylamino-phenols **1a-n** are as follows.

***N*-Benzyl-2-aminophenol (1a) –** Benzaldehyde (106.1 mg); $NaBH_4$ (75.7 mg). White crystalline solid. FCC–AcOEt/hexane (1:9). Yield: 95% (189.3 mg). ^{1}H NMR and ^{13}C NMR are consistent with the literature.[19]

***N*-(4-Methylbenzyl)-2-aminophenol (1b) –** 4-Methylbenzaldehyde (120.2 mg); $NaBH_4$ (75.7 mg). Pale green crystalline solid. FCC–AcOEt/hexane (1:9). Yield: 91% (194.1 mg). ^1H NMR and ^{13}C NMR are consistent with the literature.[20]

***N*-(4-Bromobenzyl)-2-aminophenol (1c) –** 4-Bromobenzaldehyde (185.0 mg); $NaBH_4$ (75.7 mg). Light brown liquid. FCC–AcOEt/hexane (1:4). Yield: 89% (247.6 mg). ^1H NMR and ^{13}C NMR are consistent with the literature.[19]

***N*-(4-Methoxybenzyl)-2-aminophenol (1d) –** 4-Methoxybenzaldehyde (136.2 mg); $NaBH_4$ (75.7 mg). White crystalline solid. FCC–AcOEt/hexane (1:9). Yield: 91% (208.6 mg). ^1H NMR and ^{13}C NMR are consistent with the literature.[21]

***N*-(4-Cyanobenzyl)-2-aminophenol (1e) –** 4-Formylbenzonitrile (131.1 mg); $NaBH(OAc)_3$ (432.9 mg). Light brown wax. FCC–AcOEt/hexane (1:9). Yield: 97 % (217.5 mg). ^1H NMR and ^{13}C NMR are consistent with the literature.[22]

***N*-(4-Fluorobenzyl)-2-aminophenol (1f) –** 4-Fluorobenzaldehyde (124.1 mg); $NaBH(OAc)_3$ (432.9 mg). Pale green crystalline solid. FCC–AcOEt/hexane (1:9). Yield: 97 % (210.7 mg). ^1H NMR and ^{13}C NMR are consistent with the literature.[20]

***N*-(4-Nitrobenzyl)-2-aminophenol (1g)** – 4-Nitrobenzaldehyde (151.1 mg); $NaBH(OAc)_3$ (432.9 mg). Yield: 91% (222.3 mg). Beige solid. M.p.: 86-88 °C. FCC–AcOEt/hexane (3:7). ^1H NMR ($CDCl_3$, 400 MHz) δ 8.19 (d, 2H, *J* = 8.7 Hz), 7.54 (d, 2H, *J* = 8.7 Hz), 6.82-6.75 (m, 2H), 6.65 (t, 1H, *J* = 6.1 Hz), 6.50 (d, 1H, *J* = 9.4 Hz), 4.71 (bs, 1H), 4.50 (s, 2H); ^{13}C {^1H} NMR ($CDCl_3$, 101 MHz) δ 147.5, 147.2, 143.2, 136.1, 127.9, 123.9, 121.8, 118.2, 114.5, 112.1, 47.7. Anal. Calcd. for $C_{13}H_{12}N_2O_3$: C, 63.93; H, 4.95; N, 11.47. Found: C, 64.15; H, 5.09; N, 11.30.

***N*-(2-Fluorobenzyl)-2-aminophenol (1h) –** 2-Fluorobenzaldhyde (124.1 mg); $NaBH(OAc)_3$ (432.9 mg). Yield: 83% (180.3 mg). Yellow oil. FCC–AcOEt/hexane (1:9). ^1H NMR ($CDCl_3$, 400 MHz) δ 7.37 (t, 1H, *J* = 7.3 Hz), 7.29-7.22 (m, 1H), 7.12-7.06 (m, 2H), 6.85-6.81 (m, 1H), 6.78-6.74 (m, 1H), 6.71-6.64

(m, 2H), 4.42 (s, 2H); ^{13}C {^{1}H} NMR ($CDCl_3$, 101 MHz) δ 161.0 (d, *J* = 245.7 Hz), 143.9, 136.5, 129.5 (d, *J* = 4.1 Hz), 128.8 (d, *J* = 8.1 Hz), 126.4 (d, *J* = 15.6 Hz), 124.2 (d, *J* = 3.5 Hz), 121.6, 118.3, 115.3 (d, *J* = 21.6 Hz), 114.5, 112.9, 42.3. Anal. Calcd. for $C_{13}H_{12}FNO$: C, 71.87; H, 5.57; N, 6.45. Found: C, 72.13; H, 5.86; N, 6.27.

***N*-[3-(Trifluoromethyl)lbenzyl]-2-aminophenol (1i) –** 3-(Trifluoromethyl)benzaldehyde (174.1 mg); $NaBH(OAc)_3$ (432.9 mg). Yield: 97% (259.2 mg). Brown solid. M.p.: 80-83 °C. FCC–AcOEt/hexane (1:4). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.69 (s, 1H), 7.59 (t, 2H, *J* = 7.4 Hz), 7.47 (t, 1H, *J* = 7.7 Hz), 6.88 (t, 1H, *J* = 7.4 Hz), 6.75–6.66 (m, 3H), 4.92 (bs, 1H), 4.44 (s, 2H); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 101 MHz) δ 143.5, 140.5, 136.6, 131.3 (d, *J* = 32.2 Hz), 130.8 (q, *J* = 1.4 Hz), 129.1, 124.3 (q, *J* = 3.8 Hz), 124.2 (q, *J* = 272.3 Hz), 124.1 (q, *J* = 3.8 Hz), 121.8, 118.4, 114.6, 112.6, 48.2. Anal. Calcd. for $C_{14}H_{12}F_3NO$: C, 62.92; H, 4.53; N, 5.24. Found: C, 62.81; H, 4.37; N, 5.37.

***N*-(3-Methoxybenzyl)-2-aminophenol (1j) –** 3-Methoxybenzaldehyde (136.2 mg); $NaBH(OAc)_3$ (432.9 mg). Yield: 79% (181.1 mg). Beige oil. FCC–AcOEt/hexane (1:4). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.29 (t, 1H, *J* = 7.8 Hz), 7.01-6.98 (m, 2H), 6.86-6.84 (m, 2H), 6.75-6.63 (m, 3H), 4.65 (bs, 1H), 4.35 (s, 2H), 3.82 (s, 3H); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 101 MHz) δ 159.9, 143.5, 141.1, 136.9, 129.6, 121.7, 119.9, 117.9, 114.5, 113.1, 112.7, 112.6, 55.3, 48.6. Anal. Calcd. for $C_{14}H_{15}NO_2$: C, 73.34; H, 6.59; N, 6.11. Found: C, 73.54; H, 6.72; N, 5.97.

***N*-(2,4,6-Trimethylbenzyl)-2-aminophenol (1k) –** 2,4,6-Trimethylbenzaldehyde (148.2 mg); $NaBH(OAc)_3$ (432.9 mg). Yield: 98% (236.5 mg). White solid. M.p.: 117-118 °C. FCC–AcOEt/hexane (1:9). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 6.95 (s, 3H), 6.88 (d, 1H, *J* = 7.8 Hz), 6.70 (s, 2H), 4.25 (s, 2H), 2.40 (s, 6H), 2.35 (s, 3H); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 101 MHz) δ 143.7, 137.6, 137.4, 132.2, 129.2, 121.8, 117.8, 114.4, 112.3, 42.9, 21.0, 19.4. Anal. Calcd. for $C_{16}H_{19}NO$: C, 79.63; H, 7.94; N, 5.80. Found: C, 79.51; H, 7.80; N, 5.95.

***N*-(Thien-2-ylmethyl)-2-aminophenol (1l) –** Thiophene-2-carbaldehyde (150.1 mg); $NaBH(OAc)_3$ (432.9 mg). Yield: 83% (170.4 mg). Brown solid. M.p.: 81-84 °C. FCC–AcOEt/hexane (1:4). ^1H NMR ($CDCl_3$, 400 MHz) δ 7.08 (d, 1H, *J* = 5.1 Hz), 6.89-6.88 (m, 1H), 6.83 (t, 1H, *J* = 5.1 Hz), 6.76–6.71 (m, 1H),6.65 (d, 1H, *J* = 7.7 Hz), 6.56-6.54 (m, 2H), 4.79 (bs, 1H), 4.38 (s, 2H); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 101 MHz) δ 144.1, 142.8, 136.3, 126.9, 125.3, 124.7, 121.6, 118.9, 114.8, 113.3, 43.9. Anal. Calcd. for $C_{11}H_{11}NOS$: C, 64.36; H, 5.40; N, 6.82. Found: C, 64.27; H, 5.29; N, 6.90.

***N*-(Benzo[*d*][1,3]dioxol-5-yl-methyl)-2-aminophenol (1m) –** Piperonal (150.1 mg); $NaBH(OAc)_3$ (432.9 mg). Yield: 88% (214.1 mg). Yellow oil. FCC–AcOEt/hexane (2:3). ^1H NMR ($CDCl_3$, 400 MHz) δ 6.89 (s, 1H), 6.85-6.80 (m, 2H), 6.79-6.72 (m, 2H), 6.69-6.63 (m, 2H), 5.95 (s, 2H), 4.26 (s, 2H); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 101 MHz) δ 147.9, 146.8, 143.7, 136.4, 133.1, 121.7, 120.8, 118.3, 114.5, 112.9, 108.3, 108.2, 100.9, 48.6. Anal. Calcd. for $C_{14}H_{13}NO_3$: C, 69.12; H, 5.39; N, 5.76. Found: C, 69.36; H, 5.56; N, 5.62.

***N*-(Naphthalen-1-yl-methyl)-2-aminophenol (1n) –** 1-Naphthaldehyde (156.2 mg); $NaBH(OAc)_3$ (432.9 mg). Yield: 89% (221.9 mg). Beige solid. M.p.: 117-120 °C. FCC–AcOEt/hexane (1:9). ^1H NMR ($CDCl_3$, 400 MHz) δ 8.13-8.10 (m, 1H), 7.94-7.91 (m, 1H), 7.84 (d, 1H, *J* = 8.2 Hz), 7.57-7.53 (m, 3H), 7.45 (t, 1H, *J* = 8.2 Hz), 6.91 (t, 1H, *J* = 10.5 Hz), 6.81 (d, 1H, *J* = 7.9 Hz), 6.76-6.74 (m, 2H), 4.78 (s, 2H), 4.58 (bs, 1H); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 101 MHz) δ 143.6, 137.0, 134.4, 133.9, 131.6, 128.8, 128.1, 126.3, 125.9, 125.8, 125.6, 123.5, 121.9, 118.0, 114.5, 112.6, 46.6. Anal. Calcd. for $C_{17}H_{15}NO$: C, 81.90; H, 6.06; N, 5.62. Found: C, 81.77; H, 5.90; N, 5.73.

General procedure for the synthesis of *N*,*N*'-dibenzylbenzene-1,2-diamines 4a-h. In a round bottom flask triethylamine (2.0 mmol, 2.0 equiv., 202.4 mg) was added to a solution of 1,2-phenylenediamine (1.0 mmol, 1.0 equiv., 108.1 mg), the appropriate benzylbromide (2.0 mmol, 2.0 equiv.) in MeCN dry (6.7 mL, 0.15M). The resulting solution was stirred at room temperature for 3 hours. Then, after evaporation of the solvent, the reaction mixture was extracted with DCM (10 mL x 2), washed with water

(10 mL x 2) and brine (10 mL x 1), dried over $MgSO_4$ and filtered. The solvent was evaporated under reduced pressure and the residue was purified by FCC. Yields, spectroscopic and analytical data of benzylamino-phenols **1a-n** are as follows.

***N,N'*-Dibenzylbenzene-1,2-diamine (4a)** – Benzylbromide (342.1 mg). Light yellow crystalline solid. FCC–AcOEt/hexane (1:9). Yield: 74% (213.4 mg). ^{1}H NMR and ^{13}C NMR are consistent with the literature.[23]

***N,N'*-Di(4-fluorobenzyl)benzene-1,2-diamine (4b)** – 4-Fluorobenzyl bromide (378.0 mg). Light yellow crystalline solid. FCC–AcOEt/hexane (1:4). Yield: 38% (123.3 mg). ^{1}H NMR and ^{13}C NMR are consistent with the literature.[24]

***N,N'*-Di(3-chlorobenzyl)benzene-1,2-diamine (4c)** – 3-Chlorobenzyl bromide (410.9 mg). Yield: 56% (200.1 mg). Yellow oil. FCC-DCM/PE (7:3). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.46 (s, 2H), 7.33-7.28 (m, 6H), 6.89-6.85 (m, 2H), 6.76-6.72 (m, 2H), 4.33 (s, 4H), 3.89 (br s, 2H); ^{13}C{^{1}H} NMR ($CDCl_3$, 101 MHz) δ 141.7, 136.9, 134.6, 130.0, 127.9, 127.6, 125.9, 120.0, 112.6, 48.4. Anal. Calcd. for $C_{20}H_{18}Cl_2N_2$: C, 67.24; H, 5.08; N, 7.84. Found: C, 64.02; H, 5.33; N, 8.11.

***N,N'*-bis(3-cianobenzyl)benzene-1,2-diamine (4d)** – 3-(Bromomethyl)benzonitrile (392.1 mg). Yield: 39% (131.9 mg). Orange wax. FCC-AcOEt/toluene (1:4). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.72 (s, 2H), 7.67 (d, 2H, *J* = 7.6 Hz), 7.53 (d, 2H, *J* = 7.6 Hz), 7.48-7.44 (m, 2H), 6.82-6.79 (m, 2H), 6.66-6.62 (m, 2H), 4.43 (s, 4H), 4.02 (br s, 2H); ^{13}C{^{1}H} NMR ($CDCl_3$, 101 MHz) δ 141.3, 136.5, 132.1, 131.0, 130.9, 129.4, 119.9, 119.0, 112.5, 112.4, 47.8; Anal. Calcd. for $C_{22}H_{18}N_4$: C, 78.08; H, 5.36; N, 16.56. Found: C, 77.91; H, 5.51; N, 16.83.

***N,N'*-Di(2-bromobenzyl)benzene-1,2-diamine (4e)** – 2-Bromobenzyl bromide (499.9 mg). Yield: 53% (236.5 mg). Yellow oil. FCC-AcOEt/hexane (1:4). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.47 (d, 2H, *J* = 7.8 Hz), 7.29-7.25 (m, 2H), 7.16 (dd, 2H, *J* = 7.4, 7.4 Hz), 7.05-7.02 (m, 2H), 6.69-6.64 (m, 2H), 6.56-6-51

(m, 2H), 4.29 (s, 4H), 3.78 (br s, 2H); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 101 MHz) δ 138.3, 136.9, 132.9, 129.6, 128.8, 127.6, 123.7, 119.9, 113.1, 49.0. Anal. Calcd. for $C_{20}H_{18}Br_2N_2$: C, 53.84; H, 4.07; N, 6.28. Found: C, 54.07; H, 4.36; N, 6.02.

***N*,*N*'-Di(2-fluorobenzyl)benzene-1,2-diamine (4f)** – 2-Fluorobenzyl bromide (378.0 mg). Yield: 32% (103.8 mg). Yellow oil. FCC-AcOEt/hexane (0.5:9.5). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.45-7.40 (m, 2H), 7.34-7.28 (m, 2H), 7.17-7.11 (m, 4H), 6.88-6-83 (m, 2H), 6.70-6.75 (m, 2H), 4.44 (s, 4H), 3.80 (br s, 2H); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 101 MHz) δ 161.1 (d, *J* = 245.9 Hz), 137.2, 129.8 (d, *J* = 4.5 Hz), 128.8 (d, *J* = 8.2 Hz), 126.4 (d, *J* = 14.6 Hz), 124.2 (d, *J* = 3.6 Hz), 119.8, 115.4 (d, *J* = 21.6 Hz), 112.7, 42.4 (d, *J* = 3.9 Hz). Anal. Calcd. for $C_{20}H_{18}F_2N_2$: C, 74.06; H, 5.59; N, 8.64. Found: C, 73.85; H, 5.92; N, 8.39.

***N*,*N*'-Di(2-bromo-5-methoxybenzyl)benzene-1,2-diamine (4g)** – 2-Bromo-5-methoxybenzyl bromide (559.9 mg). Yield: 30% (151.9 mg). Yellow oil. FCC-DCM/PE (9:1). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.36 (d, 2H, *J* = 8.7 Hz), 6.87 (d, 1H, *J* = 3.0 Hz), 6.72-6.68 (m, 2H), 6.62-6.53 (m, 5H), 4.25 (s, 4H), 3.79 (br s, 2H), 3.62 (s, 6H); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 101 MHz) δ 159.2, 139.4, 137.0, 133.4, 120.0, 115.4, 114.2, 113.8, 113.2, 55.5, 49.1. Anal. Calcd. for $C_{22}H_{22}Br_2N_2O_2$: C, 52.20; H, 4.38; N, 5.53. Found: C, 52.67; H, 4.56; N, 5.78.

***N*,*N*'-Di(naphthalen-2-ylmethyl)benzene-1,2-diamine (4h)** – 2-(Bromomethyl)naphthalene (442.2 mg). Yield: 28% (108.8 mg). Orange oil. FCC-AcOEt/hexane (0.5:9.5). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.92-7.75 (m, 8H), 7.56-7.54 (m, 2H), 7.49-7.44 (m, 4H), 6.82 (s, 4H), 4.52 (s, 4H), 3.82 (br s, 2H); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 101 MHz) δ 137.3, 136.9, 133.5, 132.8, 128.3, 127.8, 127.7, 126.3, 126.2, 126.1, 125.7, 119.6, 112.3, 49.1. Anal. Calcd. for $C_{28}H_{24}N_2$: C, 86.56; H, 6.23; N, 7.21. Found: C, 85.98; H, 6.78; N, 6.99.

General procedure for the dimerization/cyclization of the 2-benzylamino-phenols 1a-n and *N*,*N*'-dibenzyl-benzene-1,2-diamine 4a-h. In a sealed tube, CuCl (0.05 mmol, 4.9 mg) was added to a solution of bathophenanthroline (0.06 mmol, 10.8 mg) in toluene (4.0 mL, 0.25 M). After 10 minutes, the

appropriate 2-benzylamino-phenol **1a-n** or *N*,*N*'-disubstituted benzene-1,2-diamine **4a-h** (1.0 mmol, 1.0 equiv.) and (diacetoxyiodo)benzene (1.3 mmol, 1.3 equiv., 418.7 mg) were added. The resulted solution was magnetically stirred and heated at 100 °C in oil bath for time given below. The reaction mixture was extracted with DCM (10 mL x 2) and the solvent was evaporated under reduced pressure. The residue was purified by FCC. Yields, spectroscopic and analytical data of compounds **3a-n** and **5a-h** are as follows**.**

5-Benzyl-2-phenyl-*5H*-oxazolo[4,5-*b*]phenoxazine (3a) – Reaction time: 7 h. Yield: 72% (140.6 mg from 199.3 mg of **1a**). Yellow solid. M.p.: 237-239 °C. FCC–AcOEt/hexane (1:15). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.16-8.11 (m, 2H), 7.51-7.47 (m, 3H), 7.37-7.28 (m, 5H), 6.98 (s, 1H), 6.81-6.70 (m, 4H), 6.45 (d, 1H, *J* = 8.1 Hz), 4.89 (s, 2H); ^{13}C{^{1}H} NMR ($CDCl_3$, 101 MHz) δ 162.6, 145.6, 144.6, 144.5, 137.4, 135.6, 133.5, 132.4, 131.2, 129.0, 128.9, 127.3, 127.1, 126.9, 126.0, 124.2, 121.4, 115.4, 112.4, 102.2, 98.3, 50.2. Anal. Calcd. for $C_{26}H_{18}N_2O_2$: C, 79.98; H, 4.65; N, 7.17. Found: C, 79.85; H, 4.49; N, 7.34.

5-(4-Methylbenzyl)-2-(*p*-tolyl)-5*H*-oxazolo[4,5-*b*]phenoxazine (3b) – Reaction time: 7 h. Yield: 82% (171.6 mg from 213.3 of **1b**). Yellow solid. M.p.: 213-214 °C. FCC–AcOEt/hexane (1:11). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.91 (d, 2H, *J* = 8.3 Hz), 7.18 (d, 2H, *J* = 8.3 Hz), 7.11 (d, 2H, *J* = 8.2 Hz), 7.06 (d, 2H, *J* = 8.2 Hz), 6.85 (s, 1H), 6.71-6.62 (m, 3H), 6.58 (s, 1H), 6.36 (d, 1H, *J* = 7.9 Hz), 4.75 (s, 2H), 2.32 (s, 3H), 2.25 (s, 3H); ^{13}C{^{1}H} NMR ($CDCl_3$, 101 MHz) δ 162.8, 145.5, 144.6, 144.4, 141.5, 137.7, 136.9, 133.7, 132.6, 132.2, 129.7, 129.6, 127.0, 125.9, 124.3, 124.1, 121.2, 115.3, 112.3, 102.2, 98.2, 49.9, 21.6, 21.0. Anal. Calcd. for $C_{28}H_{22}N_2O_2$: C, 80.36; H, 5.30; N, 6.69. Found: C, 80.47; H, 5.44; N, 6.51.

5-(4-Bromobenzyl)-2-(4-bromophenyl)-5*H*-oxazolo[4,5-*b*]phenoxazine (3c) – Yield: 69% (189.1 mg from 278.1 mg of **1c**). Yellow solid. M.p.: 253-254 °C. FCC–AcOEt/hexane (1:11). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.99 (d, 2H, *J* = 8.6 Hz), 7.62 (d, 2H, *J* = 8.6 Hz), 7.48 (d, 2H, *J* = 8.4 Hz), 7.21 (d, 2H, *J* = 8.4 Hz), 6.97 (s, 1H), 6.82-6.73 (m, 3H), 6.63 (s, 1H), 6.40 (d, 1H, *J* = 7.8 Hz), 4.83 (s, 2H); ^{13}C{^{1}H}

NMR ($CDCl_3$, 101 MHz) δ 155.1, 141.5, 140.4, 140.2, 133.5, 130.4, 128.9, 127.9, 124.1, 123.6, 121.7, 121.4, 119.9, 117.4, 116.9, 111.2, 110.3, 107.9, 102.3, 97.8, 94.2, 45.4. Anal. Calcd. for $C_{26}H_{16}Br_2N_2O_2$: C, 56.96; H, 2.94; N, 5.11. Found: C, 57.15; H, 3.17; N, 4.93.

5-(4-Methoxybenzyl)-2-(4-methoxyphenyl)-5*H*-oxazolo[4,5-*b*]phenoxazine (3d) – Reaction time: 7 h. Yield: 71% (159.9 mg from 229.3 mg of **1d**). Yellow solid. M.p.: 242-243 °C. FCC–AcOEt/hexane (1:3). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.06 (d, 2H, *J* = 9.0 Hz), 7.24 (d, 2H, *J* = 9.0 Hz), 6.99 (d, 2H, *J* = 10.0 Hz), 6.94 (s, 1H), 6.88 (d, 2H, *J* = 8.8 Hz), 6.78-6.75 (m, 3H), 6.68 (s, 1H), 6.46 (s, 1H), 4.83 (s, 2H), 3.88 (s, 3H), 3.79 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 101 MHz) δ 161.5, 158.4, 158.3, 144.9, 144.2, 143.6, 137.3, 133.3, 131.5, 128.3, 127.0, 126.7, 123.6, 120.7, 119.2, 114.8, 113.9, 113.8, 111.8, 101.6, 97.7, 54.9, 54.8, 49.0. Anal. Calcd. for $C_{28}H_{22}N_2O_4$: C, 74.65; H, 4.92; N, 6.22. Found: C, 74.89; H, 5.19; N, 6.01.

4-(5-(4-Cyanobenzyl)-*5H*-oxazolo[4,5-*b*]phenoxazin-2-yl)benzonitrile (3e) – Reaction time: 7 h. Yield: 31% (68.3 mg from 224.3 mg of **1e**). Brown oil. FCC–AcOEt/hexane (1:3). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.21 (d, 2H, *J* = 8.3 Hz), 7.76 (d, 2H, *J* = 8.3 Hz), 7.67 (d, 2H, *J* = 8.2 Hz), 7.46 (d, 2H, *J* = 8.2 Hz), 7.01 (s, 1H), 6.82-6.78 (m, 3H), 6.58 (s, 1H), 6.36 (d, 1H, *J* = 7.6 Hz), 4.93 (s, 2H); ^{13}C{^{1}H} NMR ($CDCl_3$, 101 MHz) δ 160.7, 146.3, 145.3, 144.3, 141.5, 137.9, 132.9, 132.7, 130.9, 127.3, 126.9, 124.4, 122.1, 118.5, 118.2, 115.8, 114.2, 112.1, 111.6, 102.1, 98.8, 50.0 Anal. Calcd. for $C_{28}H_{16}N_4O_2$: C, 76.35; H, 3.66; N, 12.72. Found: C, 76.58; H, 3.94; N, 12.49.

5-(4-Fluorobenzyl)-2-(4-fluorophenyl)-*5H*-oxazolo[4,5-*b*]phenoxazine (3f) – Reaction time: 7 h. Yield: 73% (155.6 mg from 217.2 mg of **1f**). Green solid. M.p.: 205-206 °C. FCC–AcOEt/hexane (1:4). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.05-8.01 (m, 2H), 7.22-6.94 (m, 6H), 6.87 (s, 1H), 6.72-6.65 (m, 3H), 6.56 (s, 1H), 6.32 (d, 1H, *J* = 7.7 Hz), 4.76 (s, 2H); ^{13}C{^{1}H} NMR ($CDCl_3$, 101 MHz) δ 164.5 (d, *J* = 250.7 Hz), 162.1 (d, *J* = 245.2 Hz), 161.8 (d, *J* = 4.6 Hz), 145.7, 144.5 (d, *J* = 1.5 Hz), 137.6, 133.3, 132.2 (d, *J* = 3.1 Hz), 129.2 (d, *J* = 8.8 Hz), 127.7 (d, *J* = 8.1 Hz), 124.2, 123.4, 121.5, 116.3, 116.1, 116.0,

115.9, 112.2, 102.1, 98.4, 49.6. Anal. Calcd. for $C_{26}H_{16}F_2N_2O_2$: C, 73.23; H, 3.78; N, 6.57. Found: C, 73.44; H, 4.02; N, 6.37.

5-(4-Nitrobenzyl)-2-(4-nitrophenyl)-*5H*-oxazolo[4,5-*b*]phenoxazine (3g) – Reaction time: 7 h. Yield: 28% (67.3 mg from 244.2 mg of **1g**). Red solid. M.p.: 229-231 °C. FCC–AcOEt/hexane (1:4). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.37-8.33 (m, 2H), 8.29-8.24 (m, 4H), 7.54 (d, 2H, *J* = 7.2 Hz), 7.05 (s, 1H), 6.82 (s, 3H), 6.61 (s, 1H), 6.38 (d, 1H, *J* = 5.0 Hz), 4.99 (s, 2H); ^{13}C{^{1}H} NMR ($CDCl_3$, 101 MHz) δ 174.8, 151.9, 150.7, 150.2, 147.1, 146.4, 143.3, 139.5, 136.9, 134.7, 131.6, 127.7, 127.1, 124.4, 124.3, 122.2, 115.9, 112.1, 102.1, 98.8, 49.8. Anal. Calcd. for $C_{26}H_{16}N_4O_6$: C, 65.00; H, 3.36; N, 11.66. Found: C, 65.13; H, 3.58; N, 11.49.

5-(2-Fluorobenzyl)-2-(2-fluorophenyl)-5*H*-oxazolo[4,5-*b*]phenoxazine (3h) – Reaction time: 7 h. Yield: 59% (125.8 mg from 217.2 mg of **1h**). Yellow oil. FCC–AcOEt/hexane (1:10). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.11 (dd, 1H, *J* = 7.5, 7.4 Hz), 7.50-7.44 (m, 1H), 7.31-7.14 (m, 5H), 7.04 (d, 1H, *J* = 7.4 Hz), 7.01 (s, 1H), 6.80-6.72 (m, 3H), 6.71 (s, 1H), 6.42 (d, 1H, *J* = 7.9 Hz), 4.93 (s, 2H); ^{13}C{^{1}H} NMR ($CDCl_3$, 101 MHz) δ 160.9 (d, *J* = 243.9 Hz), 160.4 (d, *J* = 257.0 Hz), 158.9 (d, *J* = 5.8 Hz), 145.5, 144.9, 144.6, 133.7, 133.2, 132.5 (d, *J* = 8.8 Hz), 132.0, 129.8 (d, *J* = 1.5 Hz), 128.9 (d, *J* = 8.1 Hz), 127.5 (d, *J* = 3.8 Hz), 124.5 (d, *J* = 3.8 Hz), 124.4 (d, *J* = 3.8 Hz), 124.3, 122.4, 122.2, 117.0 (d, *J* = 21.6 Hz), 115.8 (d, *J* = 20.4 Hz), 115.5, 112.2, 102.4, 98.4, 44.5. Anal. Calcd. for $C_{26}H_{16}F_2N_2O_2$: C, 73.23; H, 3.78; N, 6.57. Found: C, 73.12; H, 3.62; N, 6.72.

5-((3-Trifluoromethyl)benzyl)-2-(3-(trifluoromethyl)phenyl)-5*H*-oxazolo[4,5-*b*]phenoxazine (3i) – Reaction time: 7 h. Yield: 79% (207.9 mg from 267.3 mg of **1i**). Yellow solid. M.p.: 209-210 °C. FCC–DCM. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.38 (s, 1H), 8.28 (d, 1H, *J* = 7.9 Hz), 7.72 (d, 1H, *J* = 7.9 Hz), 7.62-7.56 (m, 3H), 7.52-7.45 (m, 2H), 6.99 (s, 1H), 6.78 (s, 3H), 6.61 (s, 1H), 6.39 (d, 1H, *J* = 7.7 Hz), 4.92 (s, 2H); ^{13}C{^{1}H} NMR ($CDCl_3$, 101 MHz) δ 161.2, 145.9, 145.0, 144.4, 137.7, 137.0, 132.9, 132.2, 131.8 (d, *J* = 6.9 Hz), 131.4 (d, *J* = 7.3 Hz), 129.9, 129.6, 129.5, 129.3, 127.9, 127.4 (q, *J* = 3.0

Hz), 125.2 (d, *J* = 26.2), 124.4 (q, *J* = 3.6 Hz), 124.3, 123.8 (q, *J* = 3.7 Hz), 122.9 (q, *J* = 3.7 Hz), 122.5 (d, *J* = 26.3 Hz), 121.8, 115.6, 112.2, 102.1, 98.6, 50.2. Anal. Calcd. for $C_{28}H_{16}F_6N_2O_2$: C, 63.88; H, 3.06; N, 5.32. Found: C, 63.74; H, 2.88; N, 5.45.

5-(3-Methoxybenzyl)-2-(3-methoxyphenyl)-5*H*-oxazolo[4,5-*b*]phenoxazine (3j) – Reaction time: 7 h. Yield: 60% (135.1 from 229.3 mg of **1j**). Green solid. M.p.: 220-222 °C. FCC–AcOEt/hexane (1:4). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.61 (d, 1H, *J* = 7.8 Hz), 7.54 (s, 1H), 7.28 (dd, 1H, *J* = 6.9, 7.3 Hz), 7.17 (dd, 1H, *J* = 6.9, 7.3 Hz), 6.93-6.59 (m, 9H), 6.35 (d, 1H, *J* = 7.8 Hz), 4.74 (s, 2H), 3.78 (s, 3H), 3.68 (s, 3H) ; ^{13}C{^{1}H} NMR ($CDCl_3$, 101 MHz) δ 162.5, 160.2, 159.9, 145.7, 144.6, 137.8, 137.5, 133.5, 132.3, 130.1, 129.9, 128.3, 124.2, 121.3, 119.5, 118.3, 117.9, 115.3, 112.4, 112.3, 111.2, 102.4, 98.3, 55.5, 55.2, 50.3. Anal. Calcd. for $C_{28}H_{22}N_2O_4$: C, 74.65; H, 4.92; N, 6.22. Found: C, 74.91; H, 5.23; N, 6.02.

5-(2,4,6-Trimethylbenzyl)-2-(2,4,6-trimethylphenyl)-5*H*-oxazolo[4,5-*b*]phenoxazine (3k) – Reaction time: 7 h. Yield: 63% (149.5 mg from 241.3 mg of **1k**). Yellow oil. FCC–DCM/petroleum ether (1:1). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.01 (s, 1H), 6.95 (s, 2H), 6.85 (d, 3H, *J* = 6.9 Hz), 6.79 (d, 2H, *J* = 7.8 Hz), 6.75-6.71 (m, 1H), 6.51 (d, 1H, *J* = 8.0 Hz), 4.81 (s, 2H), 2.43 (s, 6H), 2.34 (s, 3H), 2.26 (s, 6H), 2.25 (s, 3H) ; ^{13}C {^{1}H} NMR ($CDCl_3$, 101 MHz) δ 162.7, 146.2, 145.7, 145.5, 140.1, 138.5, 137.2, 136.7, 136.5, 134.3, 132.9, 130.1, 128.6, 124.9, 123.9, 121.3, 120.2, 115.6, 113.5, 103.3, 98.6, 46.9, 21.3, 20.8, 20.7, 20.3. Anal. Calcd. for $C_{32}H_{30}N_2O_2$: C, 80.98; H, 6.37; N, 5.90. Found: C, 81.21; H, 6.72; N, 5.71.

2-(Thien-2-yl)-5-(thien-2-ylmethyl)-5*H*-oxazolo[4,5-*b*]phenoxazine (3l) – Reaction time: 7 h. Yield: 81% (163.0 mg from 205.3 mg of **1l**). Yellow solid. M.p.: 226-227 °C. FCC–AcOEt/hexane (1:4). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.79 (d, 1H, *J* = 3.9 Hz), 7.49 (d, 1H, *J* = 4.9 Hz), 7.23 (d, 1H, *J* = 4.9 Hz), 7.16 (dd, 1H, *J* = 3.9, 4.9 Hz), 6.99 (s, 1H), 6.96-6.94 (m, 2H), 6.86-6.82 (m, 2H), 6.78-6.76 (m, 2H), 6.62 (d, 1H, *J* = 7.7 Hz), 5.00 (s, 2H); ^{13}C{^{1}H} NMR ($CDCl_3$, 101 MHz) δ 158.7, 145.4, 144.6, 144.5, 138.9, 137.6, 132.9, 131.9, 129.6, 129.5, 129.1, 128.2, 127.2, 125.2, 124.7, 124.1, 121.6, 102.3, 93.3, 46.4. Anal. Calcd. for $C_{22}H_{14}N_2O_2S_2$: C, 65.65; H, 3.51; N, 6.96. Found: C, 65.90; H, 3.84; N, 6.75.

2-(Benzo[1,3]dioxol-5-yl)-5-(benzo[1,3]dioxol-5-ylmethyl)-*5H*-oxazolo[4,5-*b*]phenoxazine (3m) – Reaction time: 7 h. Yield: 72% (172.2 mg from 243.3 mg of **1m**). Yellow solid. M.p.: 264-265 °C. FCC–DCM/petroleum ether (9:1). ^{1}H NMR (DMSO-d_6, 400 MHz) δ 7.68 (d, 1H, *J* = 8.2 Hz), 7.55 (s, 1H), 7.15 (d, 1H, *J* = 8.2 Hz), 6.96-6.93 (m, 2H), 6.91-6.82 (m, 6H), 6.68 (d, 1H, *J* = 8.0 Hz), 6.19 (s, 2H), 6.05 (s, 2H), 4.96 (s, 2H); ^{13}C{^{1}H} NMR (DMSO-d_6, 101 MHz) δ 161.7, 150.1, 148.0, 147.6, 144.9, 143.5, 143.1, 137.5, 132.9, 131.5, 129.,8, 124.4, 121.8, 121.2, 120.3, 119.2, 115.1, 112.5, 108.9, 108.5, 106.8, 106.3, 102.1, 101.9, 100.9, 98.5, 47.4. Anal. Calcd. for $C_{28}H_{18}N_2O_6$: C, 70.29; H, 3.79; N, 5.86. Found: C, 70.49; H, 4.06; N, 5.72.

2-(Naphthalen-1-yl)-5-(naphthalen-1-ylmethyl)-*5H*-oxazolo[4,5-*b*]phenoxazine (3n) – Reaction time: 7 h. Yield: 66% (161.9 mg from 249.3 mg of **1n**). Yellow solid. M.p.: 240-242 °C. FCC– AcOEt/hexane (1.5:8.5). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.24 (d, *J* = 8.5 Hz, 1H), 8.24 (d, *J* = 7.3 Hz, 1H), 7.95 (d, *J* = 8.1 Hz, 1H), 7.89 (t, *J* = 8.2 Hz, 2H), 7.80 (d, *J* = 7.9 Hz, 1H), 7.74 (d, *J* = 7.8 Hz, 1H), 7.68-7.40 (m, 5H), 7.39-7.26 (m, 2H), 6.98 (s, 1H), 6.74 (dd, *J* = 5.7, 3.6 Hz, 1H), 6.69-6.64 (m, 2H), 6.63 (s, 1H), 6.30 (dd, *J* = 5.7, 3.6 Hz, 1H), 5.27 (s, 2H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 162.3, 145.2, 144.8, 144.7, 138.2, 134.2, 133.9, 133.5, 132.2, 131.9, 130.8, 130.4, 129.2, 129.0, 128.7, 128.6, 127.9, 127.7, 126.4, 126.3, 126.2, 126.0, 125.6, 124.9, 124.2, 123.5, 123.1, 122.3, 121.3, 115.3, 112.6, 102.7, 98.2, 48.9. Anal. Calcd. for $C_{34}H_{22}N_2O_2$: C, 83.25; H, 4.52; N, 5.71. Found: C, 83.44; H, 4.82; N, 5.53.

***N*,*N*'-Dibenzyl-*N*-(1-benzyl-2-phenyl-1*H*-benzo[*d*]imidazol-6-yl)benzene-1,2-diamine (5a) –** Reaction time: 1.5 h. Yield: 70% (199.8 mg from 288.4 mg of **4a**). Yellow oil. FCC-AcOEt/hexane (1:4). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.56-7.50 (m, 3H), 7.33-7.28 (m, 3H), 7.14-7.08 (m, 11H), 7.05-7.93 (m, 4H), 6.89-6.84 (m, 2H), 6.61-6.52 (m, 3H), 6.37 (d, 1H, *J* = 2.1 Hz), 5.12 (s, 2H), 4.66 (s, 2H), 4.50 (br s, 1H), 4.09 (d, 2H, *J* = 3.7 Hz); ^{13}C{^{1}H} NMR ($CDCl_3$, 101 MHz) δ 152.6, 145.5, 144.9, 139.4, 138.9, 137.1, 136.4, 136.3, 133.8, 130.4, 129.5, 129.2, 129.0, 128.7, 128.6, 128.5, 128.4, 127.7, 127.6, 127.3, 127.1, 127.0, 126.9 126.3, 120.1, 117.6, 112.7, 111.6, 95.3, 56.7, 48.4, 47.7. Anal. Calcd. for $C_{40}H_{34}N_4$: C, 84.18; H, 6.00; N, 9.82. Found: C, 84.63; H, 5.91; N, 9.69.

***N*,*N*'-Di(4-fluorobenzyl)-*N*-(1-(4-fluorobenzyl)-2-(4-fluorophenyl)-1*H*-benzo[*d*]imidazol-6-yl)benzene-1,2-diamine (5b) –** Reaction time: 8 h. Yield: 68% (218.5 mg from 324.4 mg of **4b**). Yellow oil. FCC-AcOEt/hexane (1:4). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.63-7.60 (m, 3H), 7.21-7.15 (m, 3H), 7.11-7.06 (m, 5H), 6.96-6.90 (m, 8H), 6.73-6.70 (m, 2H), 6.65 (d, 1H, *J* = 8.0 Hz), 6.36 (d, 1H, *J* = 1.9 Hz), 5.19 (s, 2H), 4.74 (s, 2H), 4.48 (br s, 1H), 4.18 (d, 2H, *J* = 2.8 Hz); ^{13}C{^{1}H} NMR ($CDCl_3$, 101 MHz) δ 163.6 (d, *J* = 251.5 Hz), 162.2 (d, *J* = 247.9 Hz), 161.9 (d, *J* = 246.1 Hz), 160.8 (d, *J* = 246.3 Hz), 151.6, 145.4, 144.7, 136.8, 134.8 (d, *J* = 3.1 Hz), 134.3 (d, *J* = 3.1 Hz), 133.5, 131.7 (d, *J* = 3.2 Hz), 130.9 (d, *J* = 8.5 Hz), 128.7 (d, *J* = 8.5 Hz), 128.6 (d, *J* = 8.4 Hz), 128.5, 127.8 (d, *J* = 8.4 Hz), 126.2 (d, *J* = 2.7 Hz), 120.2, 117.9, 116.0 (d, *J* = 21.9 Hz), 115.9 (d, *J* = 21.8 Hz), 115.3 (d, *J* = 21.5 Hz), 112.8, 111.7, 95.3, 55.8, 47.7, 47.0. Anal. Calcd. for $C_{40}H_{30}F_4N_4$: C, 74.75; H, 4.71; N, 8.72. Found: C, 75.06; H, 5.14; N, 9.21.

***N*,*N*'-Di(3-chlorobenzyl)-*N*-(1-(3-chlorobenzyl)-2-(3-chlorophenyl)-1*H*-benzo[*d*]imidazol-6-yl)benzene-1,2-diamine (5c) –** Reaction time: 3 h. Yield: 57% (201.9 mg from 357.3 mg of **4c**). Yellow oil. FCC-AcOEt/hexane (3:7). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.64–7.56 (m, 2H), 7.42 (d, 1H, *J* = 7.3 Hz), 7.37 (d, 1H, *J* = 8.3 Hz), 7.31 (d, 1H, *J* = 7.7 Hz), 7.19 (s, 2H), 7.15–7.00 (m, 9H), 6.96 (s, 1H), 6.92 (s, 1H), 6.74 (d, 1H, *J* = 7.6 Hz), 6.69 – 6.62 (m, 2H), 6.53 (d, 1H, *J* = 7.9 Hz), 6.24 (d, 1H, *J* = 2.0 Hz), 5.14 (s, 2H), 4.69 (s, 2H), 4.42 (br s, 1H), 4.14 (s, 2H); ^{13}C{^{1}H} NMR ($CDCl_3$, 101 MHz) δ 153.9, 145.6, 144.3, 141.4, 140.8, 137.7, 137.6, 136.7, 136.7, 135.1, 135.0, 134.5, 134.5, 133.1, 130.4, 130.2, 129.9, 129.9, 129.3, 128.9, 128.4, 128.3, 128.0, 127.4, 127.3, 127.1, 127.1, 127.0, 126.3, 125.1, 125.1, 124.2, 120.4, 118.2, 113.1, 111.8, 94.8, 56.4, 48.0, 47.2. Anal. Calcd. for $C_{40}H_{30}Cl_4N_4$: C, 67.81; H, 4.27; N, 7.91. Found: C, 66.89; H, 4.91; N, 7.69.

***N*,*N*'-Di(3-cianobenzyl)-*N*-(1-(3-cianobenzyl)-2-(3-cianophenyl)-1*H*-benzo[*d*]imidazol-6-yl)benzene-1,2-diamine (5d) –** Reaction time: 1.5 h. Yield: 30% (100.6 mg from 338.4 mg of **4d**). Yellow oil. FCC-AcOEt/hexane (1:1). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.96 (s, 1H), 7.85 (d, 1H, *J* = 6.7 Hz), 7.76 (d, 1H, *J* = 7.5 Hz), 7.71 (d, 1H, *J* = 8.8 Hz), 7.63 –7.51 (m, 2H), 7.48 – 7.40 (m, 4H), 7.38 (d,

4H, *J* = 6.4 Hz), 7.21 (d, 1H, *J* = 6.7 Hz), 7.18 (d, 2H, *J* = 3.4 Hz), 7.14 (d, 1H, *J* = 8.0 Hz), 7.11 (d, 1H, *J* = 7.7 Hz), 6.80 (d, 1H, *J* = 7.6 Hz), 6.76 (d, 1H, *J* = 7.5 Hz), 6.57 (d, 1H, *J* = 8.0 Hz), 6.22 (s, 1H), 5.31 (s, 2H), 4.87 (s, 2H), 4.56 (br s, 1H), 4.33 (s, 2H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 150.1, 145.6, 143.9, 140.9, 140.0, 137.2, 136.8, 136.4, 133.2, 133.0, 132.5, 131.9, 131.5, 131.3, 131.1, 131.0, 130.5, 130.4, 130.2, 130.1, 129.9, 129.5, 129.5, 129.5, 128.5, 128.4, 118.8, 118.6, 118.1, 117.8, 113.5, 113.4, 112.7, 112.7, 94.7, 55.9, 47.8, 46.9. Anal. Calcd. for $C_{44}H_{30}N_8$: C, 78.79; H, 4.51; N, 16.71. Found: C, 78.23; H, 4.91; N, 16.04.

***N*,*N*'-Di(2-bromobenzyl)-*N*-(1-(2-bromobenzyl)-2-(2-bromophenyl)-1*H*-benzo[*d*]imidazol-6-yl)benzene-1,2-diamine (5e) –** Reaction time: 1.5 h. Yield: 88% (389.9 mg from 446.2 mg of **4e**). Yellow oil. FCC-AcOEt/hexane (3:7). ^{1}H NMR ($CDCl_3$, 400 MHz) 7.55 – 7.51 (m, 2H), 7.45–7.32 (m, 2H), 7.31 (d, 1H, *J* = 7.6 Hz), 7.28-7.14 (m, 4H), 7.05 (d, 1H, *J* = 7.1 Hz), 7.01 (d, 1H, *J* = 7.2 Hz), 6.98–6.91 (m, 5H), 6.90– 6.83 (m, 2H), 6.66–6.49 (m, 3H), 6.43 (d, 1H, *J* = 8.0 Hz), 6.35–6.20 (m, 1H), 5.05 (s, 2H), 4.70 (s, 2H), 4.62, (br s, 1H), 4.16 (d, 2H, *J* = 5.6 Hz); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 101 MHz) δ 151.9, 145.3, 144.6, 138.0, 136.9, 136.4, 135.8, 134.7, 133.2, 133.0, 132.9, 132.8, 132.7, 132.5, 131.4, 129.2, 129.1, 128.7, 128.6, 128.5, 128.4, 127.9, 127.7, 127.6, 127.5, 127.4, 124.2, 123.2, 123.1, 122.7, 120.6, 117.9, 112.6, 111.8, 95.4, 56.9, 48.2, 47.8. Anal. Calcd. for $C_{40}H_{30}Br_4N_4$: C, 54.21; H, 3.41; N, 6.32. Found: C, 54.63; H, 3.91; N, 6.59.

***N*,*N*'-Di(2-fluorobenzyl)-*N*-(1-(2-fluorobenzyl)-2-(2-fluorophenyl)-1*H*-benzo[*d*]imidazol-6-yl)benzene-1,2-diamine (5f) –** Reaction time: 1.5 h. Yield: 60% (192.8 mg from 324.4 mg of **4f**). Yellow wax. FCC-AcOEt/hexane (2:3). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.68–7.60 (m, 2H), 7.53–7.44 (m, 1H), 7.36–7.26 (m, 2H), 7.25–7.15 (m, 5H), 7.13 (d, J = 7.6 Hz, 1H), 7.08 (d, J = 7.5 Hz, 1H), 7.05–6.95 (m, 3H), 6.95 – 6.86 (m, 3H), 6.81–6.64 (m, 4H), 6.51 (d, J = 1.9 Hz, 1H), 5.21 (s, 2H), 4.86 (s, 2H), 4.65 (br s, 1H), 4.32 (s, 2H); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 101 MHz) δ 160.7 (d, *J* = 246.0 Hz), 160.6 (d, *J* = 246.3 Hz), 160.2 (d, *J* = 247.5 Hz), 160.1 (d, *J* = 247.3 Hz), 147.7, 145.4, 144.8, 136.7, 136.3, 133.2, 132.4 (d, *J* = 2.2 Hz), 131.9 (d, *J* = 8.2 Hz), 129.5 (d, *J* = 7.9 Hz), 129.4 (d, *J* = 3.9 Hz), 128.9, 128.8 (d, *J* = 4.3 Hz),

128.7, 128.6 (d, *J* = 8.6 Hz), 127.8, 126.2 (d, *J* = 14.0 Hz), 125.4 (d, *J* = 14.0 Hz), 124.7 (d, *J* = 3.5 Hz), 124.3 (d, *J* = 3.6 Hz), 124.1 (d, *J* = 3.6 Hz), 124.0 (d, *J* = 3.6 Hz), 122.8 (d, *J* = 14.1 Hz, d, *J* = 3.8 Hz), 120.3, 118.7 (d, *J* = 14.8 Hz, d, *J* = 3.8 Hz), 117.8, 116.0 (d,*J* = 21.5 Hz), 115.4 (d, *J* = 13.0 Hz), 115.3, 115.1 (d, *J* = 6.7 Hz), 112.5, 111.6, 95.1, 50.0 (d, *J* = 4.1 Hz), 42.06, 41.04 (d, *J* = 4.5 Hz). Anal. Calcd. for $C_{40}H_{30}F_4N_4$: C, 74.75; H, 4.71; N, 8.72. Found: C, 74.11; H, 5.03; N, 8.96.

***N*,*N*'-Di(2-bromo-5-methoxybenzyl)-*N*-(1-(2-bromo-5-methoxybenzyl)-2-(2-bromo-5-methoxyphenyl)-1*H*-benzo[*d*]imidazol-6-yl)benzene-1,2-diamine (5g) –** Reaction time: 1.5 h. Yield: 70% (352.3 mg from 506.2 mg of **4g**). Yellow oil. FCC-AcOEt/hexane (2:3). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.50 (d, 1H, *J* = 8.9 Hz), 7.45 (d, 1H, *J* = 8.9 Hz), 7.3 –7.23 (m, 2H), 7.14 (d, 1H, *J* = 8.8 Hz), 7.08 (d, 1H, *J* = 7.3 Hz), 7.02 (t, *J* = 7.7 Hz, 1H), 6.88 (d, 1H, *J* = 2.9 Hz), 6.84–6.75 (m, 2H), 6.69 (d, 1H, *J* = 2.8 Hz), 6.66–6.56 (m, 2H), 6.54 (dd, 1H, *J* = 3.0, 8.8 Hz), 6.50 (d, 2H, *J* = 7.2 Hz), 6.46 (dd, 1H, J = 2.9, 8.8 Hz), 6.33 (d, *J* = 1.7 Hz, 1H), 6.12 (d, 1H, *J* = 2.8 Hz), 5.05 (s, 2H), 4.70 (s, 2H), 4.58 (br s, 1H), 4.17 (d, 2H, *J* = 3.7 Hz), 3.62 (s, 3H), 3.54 (s, 3H), 3.43 (s, 3H), 3.41 (s, 3H); ^{13}C{^{1}H} NMR ($CDCl_3$, 101 MHz) δ 159.2, 159.0, 158.9, 158.8, 150.8, 145.0, 144.5, 139.0, 137.9, 136.3, 135.8, 135.7, 133.7, 133.4, 133.3, 133.2, 133.1, 132.7, 128.5, 127.9, 120.5, 118.0, 117.9, 117.4, 115.1, 114.4, 114.3, 114.3, 114.2, 114.1, 113.2, 113.1, 113.0, 112.9, 112.4, 111.9, 95.3, 57.1, 55.6, 55.4, 55.3, 55.2, 48.2, 48.0. Anal. Calcd. for $C_{44}H_{38}Br_4N_4O_4$: C, 52.51; H, 3.81; N, 5.57. Found: C, 52.73; H, 4.22; N, 5.79.

***N*,*N*'-Di(Naphthalen-2-ylmethyl)-*N*-(1-(naphthalen-2-ylmethyl)-2-(naphthalen-2-yl)-1*H*-benzo[*d*]imidazol-6-yl)benzene-1,2-diamine (5h) –** Reaction time: 1.5 h. Yield: 74% (285.3 mg from 388.5 mg of **4h**). Yellow oil. FCC-AcOEt/hexane (2:3). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.17 (s, 1H), 7.91 (d, 1H, *J* = 8.7 Hz), 7.89–7.82 (m, 2H), 7.81–7.72 (m, 5H), 7.70 (d, 1H, *J* = 4.8 Hz), 7.63 (d, 1H, *J* = 8.4 Hz), 7.59 – 7.50 (m, 7H), 7.48 (d, 1H, *J* = 6.7 Hz), 7.46–7.40 (m, 6H), 7.39–7.31 (m, 2H), 7.20 (d, 1H, *J* = 7.6 Hz), 7.15 (d, 1H, *J* = 8.4 Hz), 7.12–7.05 (m, 2H), 6.86 (dd, 1H, *J* = 2.2, 8.9 Hz), 6.73–6.66 (m, 1H), 6.63 (d, 1H, *J* = 8.1 Hz), 6.60 (d, 1H, *J* = 2.0 Hz), 5.42 (s, 2H), 4.96 (s, 2H), 4.67 (br s, 1H), 4.22 (d, 2H, *J* = 2.2 Hz); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 152.8, 145.5, 144.8, 137.5, 136.8, 136.5, 134.0, 133.7,

133.6, 133.4, 133.3, 133.0, 132.8, 132.6, 132.6, 128.8, 128.6, 128.5, 128.4, 128.2, 128.2, 127.9, 127.8, 127.7, 127.6, 127.6, 127.6, 127.0, 126.6, 126.4, 126.3, 126.1, 126.0, 125.9, 125.7, 125.6, 125.5, 125.4, 125.3, 125.1, 124.1, 120.3, 117.7, 112.8, 111.7, 95.4, 57.0, 48.8, 47.7. Anal. Calcd. for $C_{56}H_{42}N_4$: C, 87.24; H, 5.49; N, 7.27. Found: C, 87.63; H, 5.91; N, 6.69.

Supporting Information: ^{1}H and ^{13}C NMR spectra, photophysical data for compounds **3a-f**, **3h-n** and **5a-h**, DFT calculation and crystallographic data for compound **3b**.

Acknowledgment We thank Università degli Studi dell'Insubria and Università degli Studi di Milano for financial support. Prof. A. Ardizzoia is warmly acknowledged for helping with DFT calculations.

Notes and references

(1) (a) Bäckvall, J.-E., *Modern Oxidation Methods*, 2nd ed. Wiley-VCH, Weinheim, **2011**. (b) Yeung, C. S.; Dong, V. M. Catalytic Dehydrogenative Cross-Coupling: Forming Carbon-Carbon Bonds by Oxidizing Two Carbon-Hydrogen Bonds. *Chem. Rev.,* **2011**, *111*, 1215-1292. (c) Liu, C.; Zhang, H.; Shi, W.; Lei, A. Bond Formations between Two Nucleophiles: Transition Metal Catalyzed Oxidative Cross-Coupling Reactions. *Chem. Rev.*, **2011**, *111*, 1780-1824. (d) Zhou, M.; Crabtree, R. H. C-H Oxidation by Platinum Group Metal Oxo or Peroxo Species. *Chem. Soc. Rev.,* **2011**, *40*, 1875-1884.

(2) For some reviews on palladium-catalyzed C-H functionalization, see: (a) Stahl, S.S. Palladium Oxidase Catalysis: Selective Oxidation of Organic Chemicals by Direct Dioxygen-Coupled Turnover. *Angew. Chem. Int. Ed.* **2004**, *43*, 3400-3420. (b) Beccalli, E. M.; Broggini, G.; Martinelli, M.; Sottocornola, S. C-C, C-O, C-N Bond Formation on sp^2 Carbon by Pd(II)-Catalyzed Reactions Involving Oxidant Agents. *Chem. Rev.* **2007**, *107*,5318-5365. (c) Chen, X.; Engle, K. M.; Wang, D.-H.; Yu, J.-Q. Palladium(II)-Catalyzed C-H Activation/C-C Cross-Coupling Reactions: Versatility and Practicality. *Angew. Chem. Int. Ed.* **2009**, *48*, 5094-5115. (d) McMurray, L.; O'Hara, F.; Gaunt, M. J. Recent Developments in Natural Product Synthesis Using Metal-Catalysed C-H Bond Functionalization. *Chem. Soc. Rev.* **2011**, *40*, 1885-1898.

(3) For some reviews on copper-catalyzed C-H functionalization in oxidative conditions, see: (a) Wendlandt, A. E.; Suess, A. M.; Stahl, S. S. Copper-Catalyzed Aerobic Oxidative C-H Functionalizations: Trends and Mechanistic Insights. *Angew. Chem. Int. Ed.* **2011**, *50*, 11062-11087. (b) Guo, X.-X.; Gu, D.-W.; Wu, Z.; Zhang, W. Copper-Catalyzed C-H Functionalization Reactions: Efficient Synthesis of Heterocycles. *Chem. Rev.* **2015**, *115*, 1622-1651. (c) Zhu, X.; Chiba, S. Copper-Catalyzed Oxidative Carbon-Heteroatom Bond Formation: A Recent Update. *Chem. Soc. Rev.* **2016**, *45*, 4504-4523. (d) Aneeja, T.; Neetha, M.; Afsina, C. M. A.; Anilkumar, G. Progress and Prospects in Copper-Catalyzed C-H Functionalization. *RSC Adv.* **2020**, *10*, 34429-34458.

(4) (a) Li, J.; Neuville, L. Copper-Catalyzed Oxidative Diamination of Terminal Alkynes by Amidines: Synthesis of 1,2,4-Trisubstituted Imidazoles. *Org. Lett.* **2013**, *15*, 1752-1755. (b) Zeng, W.; Chemler, S. R. Copper(II)-Catalyzed Enantioselective Intramolecular Carboamination of Alkenes. *J. Am. Chem. Soc.* **2007**, *129*, 12948-12949. (c) Takamatsu, K.; Hirano, K.; Satoh, T. Miura, M. Synthesis of Carbazoles by Copper-Catalyzed Intramolecular C-H/N-H Coupling. *Org. Lett.* **2014**, *16*, 2892-2895. (d) Bovino, M. T.; Liwosz, T. W.; Kendel, N. E.; Miller, Y.; Tyminska, N.; Zurek, E.; Chemler, S. R. Enantioselective Copper-Catalyzed Carboetherification of Unactivated Alkenes. *Angew. Chem. Int. Ed.* **2014**, *53*, 6383-6387. (e) Wang, Z.; Ni, J.; Kuninobu, Y.; Kanai, M. Copper-Catalyzed Intramolecular C(sp^3)-H and C(sp^2)-H Amidation by Oxidative Cyclization. *Angew. Chem. Int. Ed.* **2014**, *53*, 3496-3499. (f) Takemura, N.; Kuninobu, Y.; Kanai, M. Copper-Catalyzed Benzylic C(sp^3)-H Alkoxylation of Heterocyclic Compounds. *Org. Biomol. Chem.* **2014**, *12*, 2528-2532.

(5) (a) Zhu, R.; Buchwald S. L. Copper-Catalyzed Oxytrifluoromethylation of Unactivated Alkenes. *J. Am. Chem. Soc.* **2012**, *134*, 12462-1265. (b) Kong, W.; Casimiro, M.; Merino, E.; Nevado, C. Copper-Catalyzed One-Pot Trifluoromethylation/Aryl Migration/Desulfonylation and C(sp^2)-*N* Bond Formation of Conjugated Tosyl Amides. *J. Am. Chem. Soc.* **2013**, *135*, 14480-14483. (c) Wang, F.; Qi, X.; Liang, Z.; Chen, P.; Liu, G. Copper-Catalyzed Intermolecular Trifluoromethylazidation of Alkenes: Convenient Access to CF_3-Containing Alkyl Azides. *Angew. Chem. Int. Ed.* **2014**, *53*, 1881-1886. (d) Zhu, R.; Buchwald, S. L. Versatile Enantioselective Synthesis of Functionalized Lactones via Copper-Catalyzed

Radical Oxyfunctionalization of Alkenes. *J. Am. Chem. Soc.* **2015**, *137*, 8069-8077. (e) Wang, F.; Wang, D.; Wan., X.; Wu., L.; Chen, P.; Liu, G. Enantioselective Copper-Catalyzed Intermolecular Cyanotrifluoromethylation of Alkenes via Radical Process. *J. Am. Chem. Soc.* **2016**, *138*, 15547-15550. (f) Shen, K.; Wang, Q. Copper-Catalyzed Alkene Aminoazidation as a Rapid Entry to 1,2-Diamines and Installation of an Azide Reporter onto Azaheterocycles. *J. Am. Chem. Soc.* **2017**, *139*, 13110-13116.

(6) For some articles on benzoxazole nucleus in natural and pharmaceutical compounds, see: (a) Rodríguez, A. D.; Ramírez, C.; Rodríguez, I. I.; González, E. Novel Antimycobacterial Benzoxazole Alkaloids, from the West Indian Sea Whip *Pseudopterogorgia elisabethae. Org. Lett.* **1999**, *1*, 527-530. (b) Kumar, D.; Jacob, M. R.; Reynolds, M. B.; Kerwin, S. M. Synthesis and Evaluation of Anticancer Benzoxazoles and Benzimidazoles Related to UK-1. B*ioorg. Med. Chem.* **2002**, *10*, 3997-4004. (c) Don, M.-J.; Shen, C.-C.; Lin, Y.-L.; Syu, W.-J.; Ding, Y.-H.; Sun, C.-M. Nitrogen-Containing Compounds from *Salvia miltioeehiza. J. Nat. Prod.* **2005**, *68*, 1066-1070. (d) Sommer, P. S. M.; Almeida, R. C.; Schneider, K.; Beil, W.; Süssmuth, R. D.; Fiedler, H.-P. Nataxazole, a New Benzoxazole Derivative with Antitumor Activity Produced by *Streptomyces* sp. Tü 6176. *J. Antibiot.* **2008**, *61*, 683-686. (e) Song, H.; Rao, C.; Deng, Z.; Yu, Y.; Naismith, J. H. The Biosynthesis of the Benzoxazolee in Nataxazole Proceeds via an Unstable Ester and has Synthetic Utility. *Angew. Chem. Int. Ed.* **2020**, *59*, 6054-6061. For some articles on benzoxazole nucleus in organic materials with optical applications, see: (f) Taki, M.; Wolford, J. L.; O'Halloran, T. V. Emission Ratiometric Imaging of Intracellular Zinc: Desigm of a Benzoxazole Fluorescent Sensor and Its Application in Two-Proton Microscopy. *J. Am. Chem. Soc.* **2004**, *126*, 712-713. (g) Wang, Y.-N.; Xu, B.; Qiu, L.-H.; Sun, R.; Xu, Y.-J.; Ge, J.-G. Viscosity Sensitive Fluorescent Dyes with Excellent Photostability Based on Hemicyanine Dyes for Targeting Cell Membrane. *Sens. Actuators B Chem.* **2021**, *337*, 129787. (h) Cui, W.-R.; Zhang, C.-R.; Xu, R.-H.; Chen, X.-R.; Yan, R.-H.; Jiang, W.; Liang, R.-P.; Qiu, J.-D. Low Band Gap Benzoxazole-Linked Covalent Organic Frameworks for Photo-Enhanced Targeted Uranium Recovery. *Small*, **2021**, *17*, 2006882.

(7) (a) Kiwai, M.; Bansal, V.; Saxena, A.; Aerry, S.; Mozumdar, S. Cu-Nanoparticles: Efficient Catalysts for the Oxidative Cyclization of Shiffs' Bases. *Tetrahedron Lett.* **2006**, *47*, 8049-8053. (b) Endo, Y.; Bäckvall, J.-E. Biomimetic Oxidative Coupling of Benzylamines and 2-Aminophenols: Synthesis of Benzoxazoles. *Chem. Eur. J.* **2012**, *18*, 13609-13613. (c) Ferlin, F.; van der Hulst, M. K.; Santoro, S.; Lanari, D.; Vaccaro, L. Continuous Flow/Waste-Minimized Synthesis of Benzoxazoles Catalysed by Heterogeneous Manganese Systems. *Green Chem.* **2019**, *21*, 5298-5305. (d) Gan, H. Facile Preparation of Benzoxazoles from S8-Promoted Cyclization of 2-Nitrophenols with Arylmethyl Chloride. *ChemistrySelect* **2019**, *4*, 2858-2860.

(8) (a) Xue, D.; Long, Y.-D. Metal-Free TEMPO-Promoted C(sp^3)-H Amination To Afford Multisubstited Benzimidazoles. *J. Org. Chem.* **2014**, *79*, 4727-4734. (b) Laha, J. K.; Tummalapalli, K. S. S.; Nair, A.; Patel, N. J. Sulfate Radical Anion (SO_4^{-}) Mediated C(sp^3)-H Nitrogenation/Oxygenation in *N*-Aryl Benzylic Amines Expanded the Scope for the Synthesis of Benzamidine/Oxazine Heterocycles. *J. Org. Chem.* **2015**, *80*, 11351-11359. (c) Gan H.; Miao, D.; Pan, Q.; Hu, R.; Li, X.; Han, S. S8-Mediated Cyclization of 2-Aminophenols/thiophenols with Arylmethyl Chloride: Approach to Benzoxazoles and Benzothiazoles. *Chem. Asian J.* **2016**, *11*, 1770-1774. (d) Meng, X.; Wang, Y.; Chen, B.; Chen, G.; Jing, Z.; Chao, P. OMS-2/H_2O_2/Dimethyl Carbonate: An Environmentally-Friendly Heterogeneous Catalytic System for the Oxidative Synthesis of Benzoxazoles at Room Temperature. *Org. Process Res. Dev.* **2017**, *21*, 2018-2024.

(9) (a) Yano, Y.; Ikuta, M.; Amamiya, Y.; Nabeshima, T. Isophenoxazine Synthase Model. Oxidation of *o*-Aminophenol by an Oxidation-Active Flavin Mimic in an Aqueous Solution. *Chem. Lett.* **1991**, 461-464. (b) Pasceri, R.; Siegel, D.; Ross, D.; Moody, C. J. Aminophenoxazinones as Inhibitors of Indoleamine 2,3-Dioxygenase (IDO). Synthesis of Exfoliazone and Chandrananimycin A. *J. Med. Chem.* **2013**, *56*, 3310-3317. (c) Ferlin, F.; Marini, A.; Ascani, N.; Ackermann, L.; Lanari, D.; Vaccaro, L. Heterogeneous Manganese-Catalyzed Oxidase C-H/C-O Cyclization to Access Pharmaceutically Active Compounds. *ChemCatChem* **2020**, *12*, 449-454. (d) Ferlin, F.; Navarro, P. M. L.; Gu, Y.; Lanari, D.;

Vaccaro, L. Waste Minimized Synthesis of Pharmaceutically Active Compounds *via* Heterogeneus Manganese Catalysed C-H Oxidation in Flow. *Green Chem.* **2020**, *22*, 397-403.

(10) (a) Osman, A. M.; Metwally, S. A. M.; Youssef, M. S. K. Heterocyclic compounds. VIII. Studies on Oxazolophenoxazines. *Can. J. Chem.* **1976**, *54*, 37-43. (b) Nowakowska-Oleksy, A.; Soloducho, J.; Cabaj, J. Phenoxazine Based Units- Synthesis, Photophysics and Electrochemistry. *J. Fluoresc.* **2011**, *21*, 169-178. (c) Chen, Z.; Liang, J.; Li, Z.; Yang, T.; Lin, C.; Mu, X.; Wang, Y. Photoluminescent Manipulation of Phenoxazine-Based Molecules via Regulating Conformational Isomerization, and the Corresponding Electroluminescent Properties. *J. Mater. Chem. C* **2019**, *7*, 14255-14263. (d) Pandidurai, J.; Jayakumar, J.; Senthilkumar, N.; Cheng, C.-H. Effects of Intramolecular Hydrogen Bonding on the Conformation and Luminescence Properties of Dibenzoylpyridine-Based Thermally Activated Delayed Fluorescence Materials. *J. Mater. Chem. C* **2019**, *7*, 13104-13110. (e) Huang, T.; Liu, D.; Jiang, J.; Jiang, W. Quinoxaline and Pyrido[x,y-*b*]pyrazine-Based Emitters: Tuning Normal Fluorescence to Thermally Activated Delayed Fluorescence and Emitting Color over the Entire Visible-Light Range. *Chem. Eur. J.* **2019**, *25*, 10926-10937. (f) Chen, Y.; Peng, Z.; Tao, Y.; Wang, Z.; Lu, P.; Wang, Y. Polymorphism-Dependent Emissions of Two Phenoxazine Derivatives. *Dyes and Pigments* **2019**, *161*, 44-50.

(11) (a) Giofrè, S.; Loro, C.; Molteni, L.; Castellano, C.; Contini, A.; Nava, D.; Broggini, G.; Beccalli, E. M. Copper(II)-Catalyzed Aminohalogenation of Alkynyl Carbamates. *Eur. J. Org. Chem.* **2021**, 1750-1757. (b) Foschi, F.; Loro, C.; Sala, R.; Oble, J.; Lo Presti, L.; Beccalli, E. M.; Poli, G.; Broggini, G. Intramolecular Aminoazidation of Unactivated Terminal Alkenes by Palladium-Catalyzed Reactions with Hydrogen Peroxide as the Oxidant. *Org. Lett.* **2020**, *22*, 1402-1406. (c) Giofrè, S.; Beccalli, E. M.; Foschi, F.; La Rosa, C.; Lo Presti, L.; Christodoulou, M. S. Chemo- and Regioselective Palladium(II)-Catalyzed Aminoarylation of *N*-Allylureas Providing 4-Arylmethyl Imidazolidinones. *Synthesis* **2019**, *51*, 3462-3470. (d) Borelli, T.; Brenna, S.; Broggini, G.; Oble, J.; Poli, G. (Diacyloxyiodo)benzenes-Driven Palladium-Catalyzed Cyclizations of Unsaturated *N*-Sulfonylamides: Opportunities of Path Selection. *Adv. Synth. Catal.* **2017**, *359*, 623-628. (e) Gazzola, S.; Beccalli, E. M.; Borelli, T.; Castellano, C.;

Chiacchio, M. A.; Diamante, D.; Broggini, G.; Copper(II)-Catalyzed Alkoxyhalogenation of Alkynyl Ureas and Amides as a Route to Haloalkylidene-Substituted Heterocycles. *J. Org. Chem.* **2015**, *80*, 7226-7234.

(12) Osman, A.-M.; Bassiouni, I. Synthesis of Oxazolo-Phenoxazines. *J. Am. Chem. Soc.* **1960**, *82*, 1607-1609.

(13) (a) Morawietz, J.; Sander, W. Matrix Isolation of o-Quinoid Compounds – 6-Imino-2,4-cyclohexadien-1-one and 1,2-Diimino-3,5-cyclohexadiene. *Liebigs. Ann.* **1996**, 2029-2037. (b) Tomioka, H.; Matsushita, T.; Murata, S.; Koseki, S. Photochemistry of Phenyl Azides Bearing 2-Hydroxy and 2-Amino Groups Studied by Matrix-Isolation Spectroscopy: Generation and Characterization of Reactive o-Quinoid Compounds. *Liebigs. Ann.* **1996**, 1971-1980.

(14) (a) Camps, P.; Gonzalez, A.; Munoz-Torrero, D.; Montserrat, S.; Zuniga, A.; Martins, M. A.; Font-Bardia, M.; X. Solans Synthesis of Polysubstituted Bicyclo[3.3.1]nonane-3,7-diones fromCyclohexa-2,5-dienones and Dimethyl 1,3-Acetonedicarboxylate. *Tetrahedron*, **2000**, *56*, 8141-8151. (b) Dong, S.; Frings, M.; Zhang, D.; Guo, Q.; Daniliuc, C. G.; Cheng, H; Bolm, C. Organocatalytic Asymmetric Synthesis of trans-g-Lactams. *Chem. Eur. J.* **2017**, *23*, 13888-13892. (c) Eipert, M.; Maichle-Mossmer, C.; Maier, M. E. Acid-Induced Rearrangement Reactions of Reduced Benzoquinone Cyclopentadiene Cycloadducts. *J. Org. Chem.* **2002**, *67*, 8692-8695. (d) Dohi, T.; Nakae, T.; Takenaga, N.; Uchiyama, T.; Fukushima, K.; Fujioka, H.; Kita Y. μ-Oxo-Bridged Hypervalent Iodine(III) Compound as an Extreme Oxidant for Aqueous Oxidations. *Synthesis* **2012**, *44*, 1183-1189.

(15) (a) Kalkhambkar, R. G.; Laali, K. K. $Pd(OAc)_2$ Catalyzed Synthesis of 2-Aryl- and 2-Heteroaryl-Benzoxazoles and Benzothiazoles in Imidazolium Ionic Liquids (ILs) without Additives and with Recycling/Reuse of the IL. *Tetrahedron Lett.* **2012**, *53*, 4212-4215. (b) Yang, D.; Zhu, X.; Wei, W.; Sun, N.; Yuan, L.; Jiang, M.; You, J.; Wang, H. Magnetically Recoverable and Reusable $CuFe_2O_4$ Nanoparticle-Catalyzed Synthesis of Benzoxazoles, Benzothiazoles and Benzoimidazoles Using Dioxygen as Oxydant. *RSC Adv.* **2014**, *4*, 17832-17839. (c) Wang, D.; Li, H.; Sun, S.; Xu, Y. Cyanide

Boosting Copper Catalysis: A Mild Approach to Fluorescent Benzazole Derivatives from Nonemissive Schiff Bases in Biological Media. *Org. Lett.* **2020**, *22*, 3361-3366. (d) Thapa, P.; Palacios, P. M.; Tran, T.; Pierce, B. S.; Foss, F. W. J. 1,2-Disubstituted Benzimidazoles by the Iron Catalyzed Cross-Dehydrogenative Coupling of Isomeric *o*-Phenylenediamine Substrates. *J. Org. Chem.* **2020**, *85*, 1991-2009. (e) Aboonajmi, J.; Sharghi, H.; Aberi, M.; Shiri, P. Consecutive Oxidation/Condensation/Cyclization/Aromatization Sequence Catalyzed by Nanostructured Iron(III)-Phorphyrin Complex toward Benzoxazole Derivatives. *Eur. J. Org. Chem.* **2020**, 5978-5984.

(16) (a) Ardizzoia, G. A.; Colombo, G.; Therrien, B.; Brenna, S. Tuning the Fluorescence Emission and HOMO-LUMO Band Gap in Homoleptic Zinc(II) Complexes with N,O-Bidentate (Imidazo[1,5-*a*]pyrid-3-yl)phenols. *Eur. J. Inorg. Chem.* **2019**, 1825-1831. (b) G. Yuan, G.; Huo, Y.; Nie, X.; Jiang, H.; Liu, B.; Fang, X.; Zhao, F. Controllable Supramolecular Structures and Luminescent Properties of Unique Trimeric Zn(II) 8-Hydroxyquinolinates Tuned by Functional Substituents. *Dalton Trans.* **2013**, *42*, 2921-2929.

(17) The wide range of emission exhibited by these molecules is clearly visualized in the CIE 1931 chromaticity plot reported in Supporting Information, Figure S1.

(18) All the photophysical data for these compounds are collected in Table S1 of Supporting Information.

(19) Xie, M.; Liu, X; Zhu, X.; Zhao, X.; Xia, Y.; Lin, L.; Feng., X. Asymmetric Synthesis of Tetrahydroquinolines with Quaternary Stereocenters through the Povarov Reaction. *Chem. Eur. J.* **2011**, *17*, 13800-13805.

(20) Ding, D.; Lv, X.; Li, J.; Qiu, L.; Xu, G.; Sun, J. A Pd-Catalyzed Cascade Reaction of N-H Insertion and Oxidative Dehydrogenative Aromatization: A New Entry to 2-Amino-Phenols. *Org. Biomol. Chem.* **2014**, *12*, 4084-4088.

(21) Bernardo, J. R.; Sousa, S. C. A.; Florindo, P.R.; Wolff, M.; Machura, B.; Fernandes, A. C. Efficient and Chemoselective Direct Reductive Amination of Aromatic Aldehydes Catalyzed by Oxo-Rhenium Complexes Containing Heterocyclic Ligands. *Tetrahedron* **2013**, *69*, 9145-9154.

(22) Yadagiri, B.; Lown, J. W. Selective Cleavage of Benzoxazoles to *o*-Hydroxy-*N*-Substituted Anilines with Sodium Borohydride-Acetic Acid. *Synth. Commun.* **1990**, *20*, 175-181.

(23) Qian, C.; Tang, W. A Versatile Synthesis of Vinyl-Substituted Heterocycles via Regio- and Enantioselective Pd-Catalyzed Tandem Allylic Substitution. *Org. Lett.* **2020**, *22*, 4483-4488.

(24) Thapa, P.; Palacios, P. M.; Tran, T.; Pierce B. S.; Foss Jr., F. W. 1,2-Disubstituted Benzimidazoles by the Iron Catalyzed Cross- Dehydrogenative Coupling of Isomeric *o*-Phnylendiamine Substrates. *J. Org. Chem.* **2020**, *85*, 1991-2009.

Graphical abstract