Tetrahedron Letters 53 (2012) 1354–1357

Contents lists available at SciVerse ScienceDirect

Tetrahedron Letters

journal homepage: www.elsevier.com/locate/tetlet

An efficient copper mediated synthetic methodology for benzo[*d*]isothiazol-3(2*H*)-ones and related sulfur–nitrogen heterocycles

Bhagat Singh Bhakuni, Shah Jaimin Balkrishna, Amit Kumar, Sangit Kumar *

Department of Chemistry, Indian Institute of Science Education and Research Bhopal (IISER), MP 462 023, India

ARTICLE INFO

Article history:
Received 3 November 2011
Revised 3 January 2012
Accepted 4 January 2012
Available online 10 January 2012

Keywords:
Copper catalysis
Benzo[*d*]isothiazol-3(2*H*)-ones
Carbon–sulfur bond formation
Sulfur

ABSTRACT

A copper mediated sulfur–nitrogen coupling reaction for the synthesis of benzo[*d*]isothiazol-3(2*H*)-ones and related sulfur–nitrogen heterocycles has been presented, which requires 2-halo-arylamides, sulfur powder, 25–50 mol % of copper iodide/1,10-phenanthroline, and potassium carbonate as base.

Transition metal catalyzed carbon hetero-atom coupling reactions have emerged as a new method to synthesize a diverse series of hetero-atom (S, Se, and Te) containing organic molecules.[1,2] Among these, copper catalyzed synthesis of unsymmetrical diaryl sulfides, diaryl disulfides, arylthiols, arylsulfinamides, benzothiazoles, and copper catalyzed 1,2-hydroxysulfenylation of alkenes have been well explored.[2–4] It is of interest to note that the catalytic methods to synthesize sulfur–nitrogen heterocycles (benzoisothiazolones) have not been reported till date.

Organosulfur–nitrogen heterocycles are well known for their biological activity, ability to eject Zn^{2+} ion from certain proteins and redox regulation of tyrosine protein phosphatase.[4,5] Benzoisothiazolone derivatives have been studied for their synthetic utility in carbon–carbon bond forming reactions.[6] In view of their potential applications, several methods have been developed to synthesize S–N heterocycles.[7,8,6b,9–15] The reported methods on benzoisothiazolones are depicted in Scheme 1.

In the classical method, 2-mercaptobenzoic acid was converted into 2-sulfenylchloro-benzoylchloride by the treatment of thionyl chloride and chlorine gas. Thereafter, quenching with primary amines gives respective benzoisothiazolones (Eq. 1).[7] Alternative route for the synthesis of S–N has been developed by employing environmentally benign hyper-valent iodine reagent [phenyl iodine (III)-bistrifluoroacetate] on 2-mercapto-*N*-aryl/alkylbenzamide substrates (Eq. 2).[8] Conversion of 2-(*t*-butylthio)-5-nitrobenzamide into S–N heterocycle has been reported by the treatment of trimethylsilyl chloride (Eq. 3).[6b,9] The introduction of *t*-butylthiol into the aromatic ring is the key step in this transformation and seems to be facile only for activated 2-chloro-5-nitro-arylamide substrate. Wright et al. has reported *t*-butyl sulfoxide and benzylbutyl sulfoxide as sulfenyl halide equivalent for ring closing S–N bond formation reaction (Eq. 4).[10]

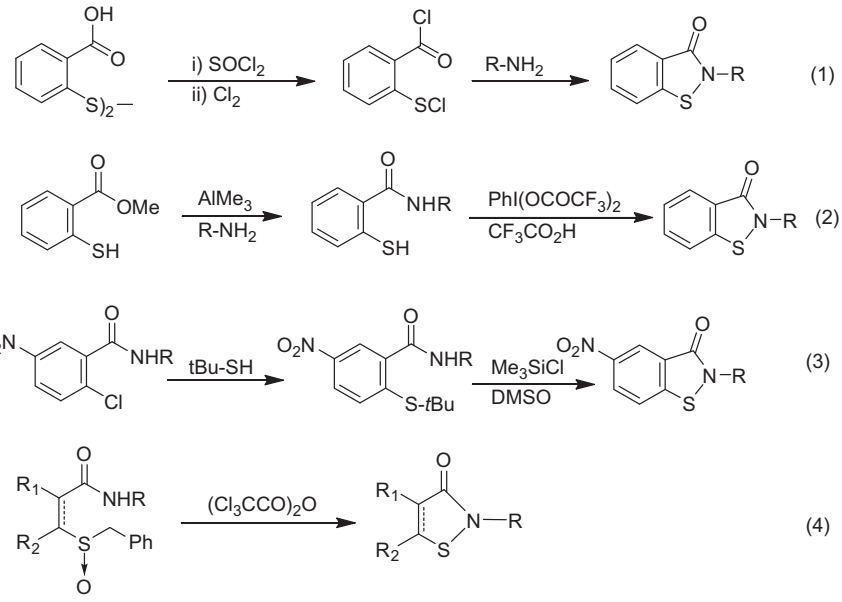
From our literature survey on benzoisothiazolones, it seems that the synthesis of S–N heterocycles mainly relies on 2-mercaptobenzoic acid.[7,8,11–14] Although, 2-mercaptobenzoic acid is commercially available, conversion of this into S–N heterocycle involves multi-steps (Eq. 2) and/or use of highly toxic and corrosive reagents. Furthermore, synthesis of substituted aromatic S–N heterocycles has not been well documented presumably due to poor availability of substituted 2-mercaptobenzoic acid. Therefore, it would be desirable to explore a practical and environmentally benign method by which a diverse library of aryl benzoisothiazolones could be accessed from readily available substrates.

Our group has recently developed a copper catalyzed Se–N coupling reaction for the synthesis of organoselenium–nitrogen heterocycles.[16] Here in this study, for the first time, we report the application of this copper catalyzed reaction for the synthesis of sulfur-nitrogen heterocycles from readily accessible 2-halo-arylamide substrates and sulfur powder (Eq. 5).

We began our studies on 2-iodo-, 2-bromo-, 2-chloro-*N*-benzylbenzamides to utilize chloro, bromo, iodo substrates in the copper catalyzed S–N coupling reaction. It was noticed that iodo, bromo, and chloro substrates reacted smoothly with sulfur powder in the presence of potassium carbonate as base by employing 25, 30, and 50 mol % of copper iodide/1,10-phenanthroline catalyst,[17] respectively, at 110 °C in DMF (Table 1, entry 1). As expected iodo and bromo substrates gave **1** in 89 and 69% yields, respectively.

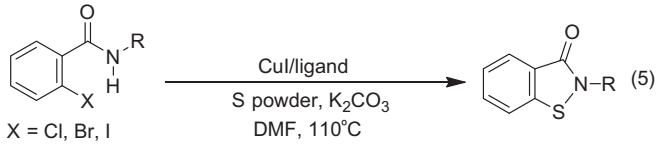
* Corresponding author.
E-mail address: Sangitkumar@iiserbhopal.ac.in (S. Kumar).

0040-4039/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.tetlet.2012.01.003



Scheme 1. Reported reaction path for the synthesis of sulfur–nitrogen heterocycles.

Table 1
Synthesis of benzo[*d*]isohiazol-3(2*H*)-ones by CuI/L coupling reaction



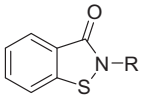
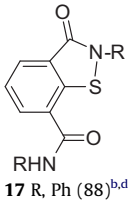
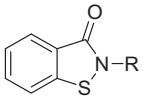
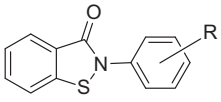
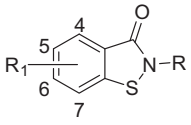
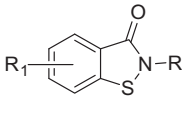
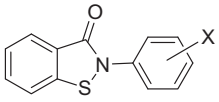
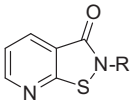
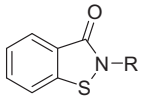
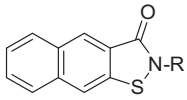
Entry	Product[a] (yield %)	Entry	Product[a] (yield %)
			
1	**1** R, Benzyl (89), (69),[b] (47)[c]	17	**17** R, Ph (88)[b,d]
2	**2** R, Ph (84)	18	**18** R, Phenylethyl (89)[b,d]
			
3	**3** R, Me (80)	19	**19** R, 3-CO_2Et (71)
4	**4** R, Butyl (82)	20	**20** R, 4-CO_2Et (72)
5	**5** R, Phenylethyl (88)	21	**21** R, 2-OMe (90)
6	**6** R, Cyclohexyl (90)	22	**22** R, 4-OMe (91)
7	**7** R, Allyl (91)	23	**23** R, 3,5-di-OMe (85)
			
8	**8** R_1,7-NO_2, R, Benzyl (65)[c]	24	**24** R_1, 7-OMe, R, Ph (62)[c,e]
9	**9** R_1, 5-NO_2, R, Benzyl (92)[c]	25	**25** R_1, 5-OMe, R, Benzyl (61)[b,e]
10	**10** R_1, 5-NO_2, R, Allyl (95)[c]	26	**26** R_1, 7-Me, R, Benzyl (91)
			
11	**11** 4-F (94)	27	**27** R, Cyclohexyl (60)[c,f]
12	**12** 3-F (90)	28	**28** R, Benzyl (40)[c,f]

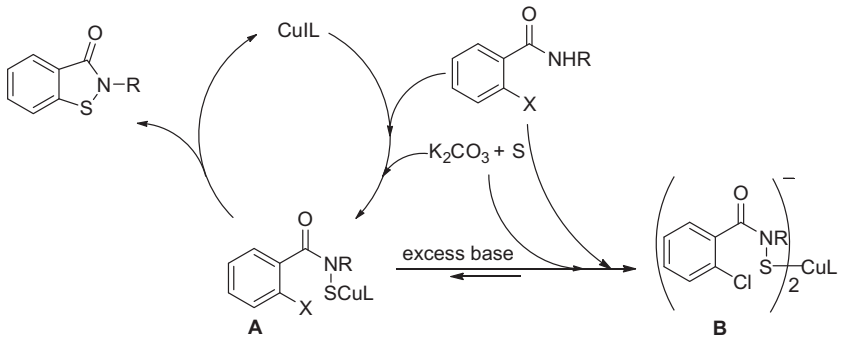
Table 1 (*continued*)

Entry	Product[a] (yield %)	Entry	Product[a] (yield %)
13	**13** 4-Cl (85)		
14	**14** 4-Br (80)		
			
15	**15** R, $-(CH_2)_2OH$ (90)[d]	29	**29** R, Benzyl (91)
16	**16** R, $-(CH_2)_3OH$ (70)[d]		

[a] Isolated yield and product was obtained from 2-iodo-arylamide, 1.2 equiv of S powder, 25 mol % of CuI/1,10-phenanthroline (L) in the presence of 1.2 equiv K_2CO_3, otherwise noted.
[b] Product was obtained from 2-bromo-aryl amide substrates.
[c] Product was obtained from 2-chloro-aryl amide.
[d] 30 mol % of CuI/L was used.
[e] 50 mol % of CuI/L was used.
[f] 100 mol % CuI/L was used. For more information on reagents and reaction conditions, please see Table 2.

However, chloro substrate gave low yield (47%) in the presence of 50 mol % CuI/L. It was observed that reaction did not go to completion in the presence of 10 mol % of CuI/L for 2-iodo-*N*-benzylbenzamide substrate. Furthermore, even prolonged heating from 5 to 24 h did not improve the yield of S–N product. Therefore, high catalyst loading (25–50 mol %) seems to be crucial for the complete conversion of substrates. Copper iodide and 1,10-phenanthroline are indispensable, as the reaction does not occur with only copper iodide or ligand alone.

By employing 25–50 mol % of CuI/L complex, a series of S–N heterocycles **1–29** were synthesized and isolated in 42–95% yield (Table 1).[18,19] The synthesis of benzoisothiazolone **1**, which is a multi-step reaction, has been reported by many researchers.[6b,9,8,12a] In our CuI/L reaction system, benzoisothiazolone **1** was obtained in single pot from readily accessible 2-chloro-, 2-bromo-, and 2-iodobenzylbenzamides in 47–89% yield. Similarly, *N*-phenylisothiazolone **2** was obtained from respective iodo substrate in an 84% yield. A small amount (~5%) of respective diaryl monosulfide was also observed in the reaction mixture of **2**. However, formation of



Scheme 2. Proposed mechanism for copper mediated synthesis of S–N heterocycles.

Table 2
Amounts of substrates and reagents used for the synthesis of respective arylisothiazolones

Entry	Substrate mg (mmol)	Sulfur mg (mmol)	CuI mg (mmol)	Ligand mg (mmol)	K_2CO_3 mg (mmol)	Time (h)	Product, yield (mg)
1a	Ar-I, 674 (2.0)	80 (2.4)	95 (0.5)	90 (0.5)	360 (2.5)	3	**1** (429)
1b	Ar-Br, 290 (1.0)	41 (1.3)	57 (0.3)	54 (0.3)	180 (1.3)	12	**1** (166)
1c	Ar-Cl, 246 (1.0)	43 (1.3)	95 (0.5)	90 (0.5)	186 (1.3)	18	**1** (113)
2	Ar-I, 646 (2.0)	80 (2.5)	95 (0.5)	90 (0.5)	350 (2.5)	3	**2** (380)
3	Ar-I, 154 (0.6)	23 (0.7)	28 (0.15)	27 (0.15)	124 (0.9)	3	**3** (78)
4	Ar-I, 240 (0.8)	30 (0.9)	38 (0.2)	36 (0.2)	165 (1.2)	3	**4** (134)
5	Ar-I, 180 (0.5)	20 (0.6)	24 (0.1)	22 (0.1)	103 (0.7)	3	**5** (115)
6	Ar-I, 362 (1.1)	42 (1.3)	52 (0.3)	49 (0.3)	228 (1.6)	3	**6** (231)
7	Ar-I, 145 (0.5)	19 (0.6)	24 (0.1)	23 (0.1)	104 (0.7)	3	**7** (88)
8	Ar-Cl, 320 (1.1)	42 (1.3)	52 (0.3)	50 (0.3)	228 (1.6)	5	**8** (205)
9	Ar-Cl, 430 (1.5)	57 (1.8)	70 (0.4)	67 (0.4)	306 (2.2)	5	**9** (389)
10	Ar-Cl, 100 (0.4)	16 (0.5)	20 (0.1)	19 (0.1)	86 (0.6)	5	**10** (93)
11	Ar-I, 515 (1.5)	58 (1.8)	72 (0.4)	68 (0.4)	313 (2.3)	3	**11** (348)
12	Ar-I, 680 (2.0)	76 (2.4)	95 (0.5)	90 (0.5)	413 (3.0)	3	**12** (440)
13	Ar-I, 350 (1.0)	37 (1.2)	47 (0.2)	44 (0.2)	203 (1.5)	3	**13** (217)
14	Ar-I, 240 (0.6)	23 (0.7)	28 (0.15)	27 (0.15)	123 (0.9)	3	**14** (146)
15	Ar-I, 171 (0.6)	22 (0.7)	33 (0.17)	32 (0.17)	162 (1.2)	8	**15** (103)
16	Ar-I, 361 (1.2)	45 (1.4)	68 (0.35)	64 (0.35)	350 (2.5)	8	**16** (173)
17	Ar-Br, 500 (1.3)	49 (1.5)	72 (0.4)	68 (0.4)	350 (2.5)	3	**17** (385)
18	Ar-Br, 316 (0.7)	27 (0.8)	40 (0.2)	38 (0.2)	193 (1.4)	3	**18** (250)
19	Ar-I, 395 (1.0)	38 (1.2)	48 (0.25)	45 (0.25)	207 (1.5)	3	**19** (212)
20	Ar-I, 310 (0.8)	30 (0.9)	37 (0.2)	35 (0.2)	162 (1.2)	3	**20** (215)
21	Ar-I, 275 (0.8)	30 (0.9)	37 (0.2)	35 (0.2)	161 (1.2)	3	**21** (180)
22	Ar-I, 430 (1.2)	47 (1.5)	58 (0.3)	55 (0.3)	252 (1.8)	3	**22** (285)
23	Ar-I, 380 (1.0)	38 (1.2)	47(0.25)	45 (0.25)	205 (1.5)	3	**23** (242)
24	Ar-Cl, 370 (1.4)	54 (1.6)	134 (0.7)	128 (0.7)	292 (2.0)	48	**24** (226)
25	Ar-Br, 250 (0.8)	30 (0.9)	74 (0.4)	70 (0.4)	162 (1.2)	38	**25** (129)
26	Ar-I, 430 (1.2)	47 (1.5)	58 (0.3)	55 (0.3)	253 (1.8)	3	**26** (284)
27	Ar-Cl, 365 (1.5)	59 (1.8)	291 (1.5)	276 (1.5)	633 (4.6)	24	**27** (214)
28	Ar-Cl, 300 (1.2)	47 (1.5)	232 (1.2)	220 (1.2)	504 (3.6)	24	**28** (118)
29	Ar-I, 200 (0.5)	20 (0.6)	25 (0.1)	23 (0.1)	107 (0.8)	3	**29** (137)

corresponding monosulfide (as monitored by TLC), was not observed in benzoisothiazolones **1** and **3**–**29**. 2-Iodo-arylamides with alkyl groups such as methyl, *n*-butyl, phenylethyl, and cyclohexyl successfully underwent S–N coupling reaction and gave respective benzoisothiazolones quantitatively (entries 3–6). Also arylamides having allyl group are compatible with copper catalyzed S–N coupling reaction (entries 7 and 10). Synthesis of allyl bezoisothiazolone **7** proved to be difficult by the earlier reported methods. Gravace has isolated **7** in impure form.[12b] The synthesis of **7** from *N*-allyl-2-mercaptobenzamide was unsuccessful by using phenyliodine (III)-bistrifluoroacetate reagent (Eq. 2).[8] Synthesis of allyl benzoisothiazolone **10** has been reported from 2-chloro-5-nitroarylamide by using *t*-butylthiol as a sulfur source and finally ring closure by trimethylsilyl chloride (Eq. 3).[6b] Sulfur–nitrogen coupling reaction yielded allyl benzoisothiazolones **7** and **10** quantitatively from readily available substrates in one pot. We have also studied nitro-substituted substrates in the S–N coupling reaction. By exploiting CuI/L catalyst, not only 5-NO_2 substituted but also 7-NO_2 substituted S–N heterocycles (**8**–**10**) were obtained in good to excellent yield (entries 8–10). 2-Iodo-arylamide substrates with fluorine, chlorine, and bromine substituents were also tolerated in the S–N coupling reaction and the reaction shows good selectivity among chloro vs iodo and bromo versus iodo substituents within the substrate (entries 13 and 14). Furthermore, substrates with an additional acidic proton such as alcohol and amide (entries 15–18) also underwent S–N coupling reaction and the yield remains unaffected. Substrates with methoxy and ester functional groups are also amenable to the copper catalyzed coupling reaction.

This coupling reaction was then extended to other aromatics such as pyridyl and naphthyl substrates (entries 27–29). As expected, S–N coupling reaction occurred smoothly with the iodonaphthyl substrate and produced naphthyl S–N heterocycle **29** quantitatively. However, coupling reaction was sluggish on the

readily accessible chloro-nicotinamides under optimized conditions. The use of stoichiometric amount of CuI/L improved the yield to a satisfactory level (40–60%).

A possible mechanistic pathway is depicted in Scheme 2, which is similar to the earlier proposed mechanism.[16] We believe that the reaction proceeds via LCu–NR amide complex.[20] Insertion of sulfur into LCu–NR bond would lead to intermediate A, which could further react intramolecularly to carbon–iodine, followed by reductive elimination to give benzoisothiazolone and regeneration of CuIL complex. It is worth noting that the choice and amount of base are important in the copper mediated S–N coupling reaction. The use of excess of K_2CO_3 lowers the yield of benzoisothiazolone 1. It is evident from the Table 2 (vide supra) that most of the benzoisothiazolones were obtained by employing 1.2–1.5 equiv of K_2CO_3. Furthermore, strong bases such as K_3PO_4 and KOH were found to be less effective for clean and complete conversion of substrates. This is possibly due to the formation of cuprate intermediate B, which is presumably unreactive.[20] This type of intermediate could be expected in the case of electron rich 2-chloro/bromo-arylamide substrates where carbon–chlorine bond is strong and difficult to undergo sulfur–carbon coupling reaction (entries 24–25, Table 1). High CuI/L complex loading would circumvent the formation of intermediate B and therefore seems reasonable that high CuI/L loading improves the yield satisfactorily in 2-chrloro-arylamide substrates.

In summary, we have presented a general, mild, and practical method for the synthesis of benzo[*d*]isothiazol-3(2*H*)-ones and related sulfur–nitrogen heterocycles. The developed copper catalyzed/mediated S–N coupling reaction system is tolerant to a wide variety of functional groups. Biological studies on S–N heterocycles are currently in progress in our laboratory.

Acknowledgments

This study is financially supported by DST-New Delhi. BSB and JBS thank IISER Bhopal for fellowship. SK thanks Professor Harkesh B Singh and Dr. Vijay Pal (Department of Chemistry, IIT Bombay) for mass and HRMS data collections. We are thankful to Dr. Deepak Chopra for editing this manuscript.

Supplementary data

Supplementary data (references for 2-halo-arylamides (substrates for the synthesis of S–N heterocycles), general experimental details, characterization data, copies of NMR (^{1}H and ^{13}C), and Mass spectra for compounds) associated with this article can be found, in the online version, at doi:10.1016/j.tetlet.2012.01.003.

References and notes

1. (a) Beletskaya, I. P.; Ananikov, V. P. *Chem. Rev.* **2011**, *111*, 1596; (b) Kumar, S.; Engman, L. *J. Org. Chem.* **2006**, *71*, 5400; (c) Singh, D.; Deobald, A. M.; Camarago, L. R. S.; Tabarellie, G.; Rodrigues, O. E. D.; Braga, A. L. *Org. Lett.* **2010**, *12*, 3288.
2. (a) Taniguchi, N. *J. Org. Chem.* **2004**, *69*, 6904; (b) Taniguchi, N.; Onami, T. *J. Org. Chem.* **2004**, *69*, 915; (c) Taniguchi, N. *Synlett* **2005**, 1185; (d) Taniguchi, N. *J. Org. Chem.* **2006**, *71*, 7874; (e) Taniguchi, N. *J. Org. Chem.* **2007**, *72*, 1241; (f) Taniguchi, N. *Eur. J. Org. Chem.* **2010**, 2670; (g) Taniguchi, N. *Tetrahedron* **2009**, *65*, 2782; (h) Taniguchi, N. *Synlett* **2011**, 1308.
3. (a) Jiang, Y.; Qin, Y.; Xie, S.; Zhang, X.; Dong, J.; Ma, D. *Org. Lett.* **2009**, *11*, 5250; (b) Ke, F.; Qu, Y.; Jiang, Z.; Li, Z.; Wu, D.; Zhou, X. *Org. Lett.* **2011**, *13*, 454; (c) Zeni, G. *Teterahedron Lett.* **2005**, *46*, 2647; (d) Carril, M.; Martin, R. S.; Domìnguez, E.; Tellitu, I. *Chem. Eur. J.* **2007**, *13*, 5100; (e) Sharma, A.; Schwab, R. S.; Braga, A.; Barcellos, T.; Paixao, M. W. *Teterahedron Lett.* **2008**, *49*, 5172; (f) Herrero, M. T. R.; Martin, S.; Domìnguez, E. *Tetrahdron* **2009**, *65*, 1500; (g) Gan, J.; Ma, D. *Org. Lett.* **2009**, *11*, 2788; (h) Ma, D.; Xie, S.; Xue, P.; Zhang, X.; Dong, J.; Jiang, Y. *Angew. Chem. Int. Ed.* **2009**, *48*, 4222; (i) Alves, D.; Santos, C.; Cayane, G.; Paixao, M. W.; Marcio, W.; Soares, L. C.; Souza, D.; Rodrigues, O. E. D.; Braga, A. L. *Teterahedron Lett.* **2009**, *50*, 6635; (j) Ma, D.; Geng, Q.; Zhang, H.; Jiang, Y. *Angew. Chem. Int. Ed.* **2010**, *49*, 1291; (k) Shi, L.; Liu, X.; Zhang, H.; Jiang, Y.; Ma, D. *J. Org. Chem.* **2011**, *76*, 4200; (l) Ma, D.; Lu, X.; Shi, L.; Zhang, H.; Jiang, Y.; Liu, X. *Angew. Chem. Int. Ed.* **2011**, *50*, 1118.
4. (a) Okachi, R.; Niino, H.; Kitaura, K.; Mineura, K.; Nakamizo, Y.; Murayama, Y.; Ono, T.; Nakamizo, A. *J. Med. Chem.* **1985**, *28*, 1772; (b) Baggaley, K. H.; English, P. D.; Jennings, L. J. A.; Morgan, B.; Nunn, B.; Tyrrell, A. W. R. *J. Med. Chem.* **1985**, *28*, 1661; (c) v Montfort, R. L. M.; Congreeve, M.; Tisi, D.; Carr, R.; Jhoti, H. *Nature* **2003**, *423*, 773; (d) Gorsuch, S.; Bavetsias, V.; Rowlands, M. G.; Aherne, G. W.; Workman, P.; Jarman, M.; McDonald, E. *Bioorg. Med. Chem.* **2009**, *17*, 467; (e) Dahl, R.; Bravo, Y.; Sharma, V.; Ichikawa, M.; Dhanya, R.-P.; Hedrick, M.; Brown, B.; Rascon, J.; Vicchiarelli, M.; M -Novo, A.; Yang, L.; Stonich, D.; Su, Y.; Smith, L. H.; Sergienko, E.; Freeze, H. H.; Cosford, N. D. P. *J. Med. Chem.* **2011**, *54*, 3661.
5. (a) Sivaramakrishnan, S.; Keerthi, K.; Gates, K. S. *J. Am. Chem. Soc.* **2005**, *127*, 10830; (b) Sarma, B. K.; Mugesh, G. *J. Am. Chem. Soc.* **2007**, *129*, 8872; (c) Brahemi, G.; Kona, F. R.; Fiasella, A.; Buac, B.; Soukupová, J.; Brancale, A.; Burger, A. M.; Westwell, A. D. *J. Med. Chem.* **2010**, *53*, 2757.
6. (a) Villalobos, J. M.; Srogl, J.; Liebeskind, L. S. *J. Am. Chem. Soc.* **2007**, *129*, 15734; (b) Henke, A.; Srogl, J. *Chem. Commun.* **2010**, *46*, 6819.
7. (a) Gialdi, F.; Ponci, R.; Barrufini, A. *Farmaco Ed. Sci.* **1961**, *16*, 509; (b) P.-Ottlik, M.; Potaczek, P.; Piasecki, E.; Mlochowski, J. *Molecules* **2010**, *15*, 8214. and references cited therein.
8. Correa, A.; Tellitu, I.; Domínguez, E.; Martin, R. S. *Org. Lett.* **2006**, *8*, 4811.
9. Henke, A.; Srogl, J. *J. Org. Chem.* **2008**, *73*, 7783.
10. (a) Wright, S. W.; Abelman, M. M.; Bostrom, L. L.; Corbett, R. L. *Teterahedron Lett.* **1992**, *33*, 153; (b) Wright, S. W.; Petraitis, J. J.; Batt, D. G.; Corbett, R. L.; Meo, S. V. D.; Freimark, B.; Giannaras, J. V.; Orwat, M. J.; Pinto, D. J.; Pratta, M. A.; Sherk, S. R.; Stampfli, H. F.; Williams, J. M.; Magolda, R. L.; Arner, E. C. *Bioorg. Med. Chem.* **1995**, *3*, 227; (c) Volonterio, A.; Bravo, P.; Zanda, M. *Teterahedron Lett.* **2002**, *43*, 6537.
11. Honek, J. F.; Manchini, M. L.; Belleau, B. *Synth. Commun.* **1983**, *13*, 997.
12. (a) Grivas, J. C. Ger. Offen. Patent: DE 2119730, 1971 [Chem. Abstr. **1972**, *76*, 46193].; (b) Grivas, J. C. *J. Org. Chem.* **1975**, *40*, 2029.
13. Shimizu, M.; Sugano, Y.; Konakahara, T.; Gama, Y.; Shibuya, I. *Tetrahedron* **2002**, *58*, 3779.
14. (a) Jin, C. K.; Moon, J.-K.; Lee, W. S.; Nam, K. S. *Synlett* **2003**, 1967; (b) Sano, T.; Takagi, T.; Gama, Y.; Shibuya, I.; Shimizu, M. *Synthesis* **2004**, 1585.
15. Engman, L.; Anders, H. *J. Org. Chem.* **1989**, *54*, 2964.
16. (a) Balkrishna, S. J.; Bhakuni, B. S.; Chopra, D.; Kumar, S. *Org. Lett.* **2010**, *12*, 5394; (b) Balkrishna, S. J.; Bhakuni, B. S.; Kumar, S. *Tetrahedron* **2011**, *67*, 9565.
17. (a) Goodbrand, H. B.; Hu, N.-X. *J. Org. Chem.* **1999**, *64*, 670; (b) Murru, S.; Patel, B. K.; Le Bras, J.; Muzart, J. *J. Org. Chem.* **2009**, *74*, 2217; (c) Sekar, R.; Srinivasan, M.; Marcelis, At. M.; Sambandam, A. *Tetrahedron Lett.* **2011**, *52*, 3347; (d) Murru, S.; Ghosh, H.; Sahoo, S. K.; Patel, B. K. *Org. Lett.* **2009**, *11*, 4254.
18. Synthesis of 2-benzylbenzo[*d*]isothiazol-3(2*H*)-one (**1**); A typical procedure. Sulfur–nitrogen coupling reactions on 2-halo aryl amides were carried out using mentioned amount of reagents and solvents in Table 2 (vide supra). In a single neck flask (25 mL) containing DMF (5 mL), CuI (95 mg, 0.5 mmol) and 1,10-phenanthroline (90 mg, 0.5 mmol) were added and stirred for 15 min under N_2. After this, 2-iodo-*N*-benzylbenzamide (0.67 g, 2.0 mmol), sulfur powder (80 mg, 2.4 mmol), and anhydrous K_2CO_3 powder (360 mg, 2.5 mmol) were added in the same sequence, stirred for 15 min at room temperature and then refluxed at 110 °C for 3 h under N_2. After this, reaction mixture was poured into brine solution (50 mL), stirred for 3 h, reaction mixture together with brine was extracted with ethyl acetate (20 mL × 3), dried over Na_2SO_4 (5.0 g), concentrated under vacuo to obtain brown color solid. Purification by column chromatography using hexane/ethyl acetate (8:2) yielded white colored crystalline solid. Yield 414 mg (89%), mp 79–80 °C (86–89 °C).[6b,8] ^{1}H NMR δ 8.07 (d J = 8.0 Hz, 1H), 7.58 (t, J = 7.5 Hz, 1H), 7.48 (d, J = 8.0 Hz, 1H), 7.39 (t, J = 7.5 Hz, 1H), 7.35–7.32 (m, 5H), 5.05 (s, 2H). ^{13}C NMR δ 165.4, 140.4, 136.2, 131.8, 128.8, 128.4, 128.3, 126.8, 125.5, 124.5, 120.4, 47.6. IR (plate): 3064, 2923, 1651, 1598, 1447, 1333, 1246, 1186, 1079 cm^{-1}; ES-MS (ESI) m/z 242 (M+H$^+$). Benzoisothiazolones (**2**–**29**) were purified by column chromatography using hexane/EtOAc (8:2) for **2**–**14**, **19**–**26**, and **29**; CH_2Cl_2/MeOH (97:3) for **15**–**18**, **27**, and **28**.
19. Characterization data for 2-phenylbenzo[*d*]isothiazol-3(2*H*)-one (**2**). Mp 139–140 °C (139–140 °C).[16] ^{1}H NMR δ 8.07 (d, J = 8.0 Hz, 1H), 7.97 (d, J = 8.0 Hz, 1H), 7.77 (t, J = 7.5 Hz, 1H), 7.72 (d, J = 8.0 Hz, 2H), 7.56–7.50 (m, 3H), 7.38 (t, J = 7.5 Hz, 1H). IR (plate): 2918, 1660, 1590, 1484, 1301, 1265, 1123 cm^{-1}; ES-MS (ESI) m/z 228.0 (M+H$^+$).
20. (a) Klapars, A.; Huang, X.; Buchwald, S. L. *J. Am. Chem. Soc.* **2002**, *124*, 7421. See references therein on the mechanistic consideration on copper catalyzed amidation reactions. (b) Cuprate intermediate **B** is proposed based on the Ref. 20a.