

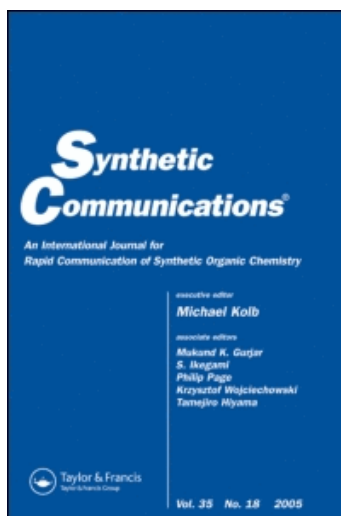
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Synthetic Communications

Publication details, including instructions for authors and subscription information:

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Online publication date: 17 June 2010

To cite this Article Meshram, H. M. , Goud, P. Ramesh , Reddy, B. Chennakesava and Kumar, D. Aravind(2010) 'Triton B-Mediated Efficient and Convenient Alkoxylation of Activated Aryl and Heteroaryl Halides', Synthetic Communications, 40: 14, 2122 – 2129

To link to this Article: DOI: 10.1080/00397910903219518

URL: <http://dx.doi.org/10.1080/00397910903219518>

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TRITON B-MEDIATED EFFICIENT AND CONVENIENT ALKOXYLATION OF ACTIVATED ARYL AND HETEROARYL HALIDES

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A simple and convenient one-pot synthesis of aryl alkyl ethers by the alkoxylation of aryl halides with alcohol in the presence of Triton B as a base is described. The procedure is applicable for a variety of aryl and heteroaryl halides, and yields are very good. The use of a nonmetallic base and solvent-free conditions are important features of the reaction.

Keywords: Alkoxylation; aryl halides; ethers; Triton B

Aryl alkyl ethers form the core structures of many natural products and serve as intermediates for the preparation of dyes, plant-protection agents, fragrances, and end products in agriculture and the pharmaceutical industry.^[1] Ethers are also used as phenol precursors, which in turn are versatile intermediates for the preparation of oxygenated heterocycles.^[2] There are numerous methods for the synthesis of ethers. Among these, the Ullmann coupling^[3] is a straightforward method for ether formation. However, this method has limited utility because of high temperatures (200 °C), the use of high-boiling solvents, and the sensitivity of other functional group at high temperatures. Some of the methods^[4] use alkylating phenols with alkyl halides or alkyl sulfates, which are very toxic and release acid. A green version of the Williamson ether synthesis, using weak alkylation agents, has been reported.^[1] Recently, catalytic methods^[5] have been developed to increase the efficiency of the reaction in mild conditions. Parrish and Buchwald^[6] reported the synthesis of ethers from aryl halides and butoxide in the presence of Pd catalyst and ligand. Another method^[7] demonstrated the synthesis of ether from aryl halides using Pd catalyst via the formation of phenoxide, followed by the addition of alkyl iodide. Zinc was also found to catalyze ether formation under microwave irradiation in dimethylformamide (DMF) in the absence of a base.^[8] However, MeOH as alkylation reagent has been reported at very high temperature (250 °C), which leads to C-alkylation as side reaction.^[9] Most commonly, the ethers are prepared by the alkylation of phenol

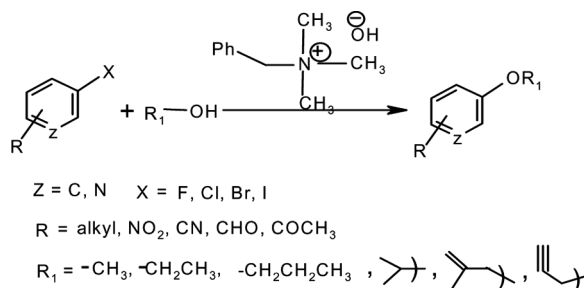
Received May 4, 2009.

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with alkyl halides, but this method has limitations because of instability, low vapor pressure, and the toxic nature of alkyl halides. Moreover, some of the methods suffer from certain drawbacks such as use of expensive catalyst or ligand and an inert atmosphere. In addition, the contamination of metal ions in the product may pose environmental concerns.^[10] Though few procedures provide ligand-free conditions,^[11] the use of a copper catalyst generates copper salt as a by-product. So, it remains a challenge to develop an aryl alkyl ether synthesis from aryl halides and alcohols that would not require a ligand, Pd catalyst, or copper salt. Recently, Triton B has become more popular because of its efficiency and nonmetallic nature. It has been successfully employed for Michael addition,^[12] nitro-aldol condensation,^[13] and carbamate formation reactions.^[14] However, there is no report of aryl alkyl ether formation using a nonmetallic base. In continuation of our work in the development of nonmetallic reagents,^[15] herein we report aryl alkyl ether formation by the alkoxylation of active aryl halides with alcohol in the presence of Triton B as a base (Scheme 1).

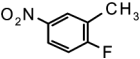



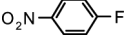



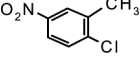



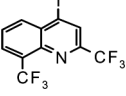







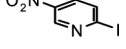



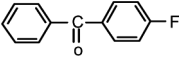

When the reaction of 4-fluoro nitrobenzene (1 equiv.) and Triton B (1.1 equiv. 40% methanolic solution) was carried out at rt, the reaction remained incomplete after 3 hr. To increase the efficiency of the reaction, we have performed the reaction with 3 equiv. of Triton B (40% methanolic solution), and to our surprise, the reaction proceeded efficiently and completed in 10 min at rt. After workup, the product, 4-nitrophenyl methyl ether, was isolated in good yield (95%). The formation of methyl ether indicated that methoxide ions are generated from methanol. This protocol was extended to other alcohols to obtain a variety of ethers. We presume that reaction may proceed via nucleophilic substitution. Initially, the alkoxide may be formed, and then nucleophilic displacement of aryl halide occurs (Table 1).

First, we concentrated our study on making the protocol more general by examining the substrates with different electron-withdrawing groups. For example, 2-methyl-4-nitro fluorobenzene (entry 1) and 2-methyl-4-nitro chlorobenzene (entry 3) reacted smoothly with alcohols (a–f) to give excellent yields of aryl alkyl ethers, which are comparable to those obtained using ligand and copper catalysts.^[16] During the investigation, it was noticed that the electron-donating system suppresses the reaction whereas the electron-withdrawing substituent facilitates the reaction. Next, we examined the effect of other electron-withdrawing groups for alkoxylation. Thus, 2,8-bis (trifluoromethyl)-4-iodo quinoline (entry 4) reacted rapidly with Triton B to



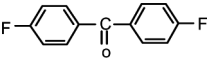

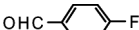

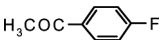



Scheme 1. Triton B-mediated efficient and convenient alkoxylation of activated aryl/hetero aryl halides.

Table 1. Synthesis of aryl alkyl ethers^a from aryl halides

Entry	Aryl halides	Alcohols	Product	Reaction condition	Time (min)	Yield ^b
1		a) CH ₃ OH	1a	rt	15	93
		b) CH ₃ CH ₂ OH	1b	50	30	90
		c) CH ₃ CH ₂ CH ₂ OH	1c	50	40	89
		d) 	1d	70	60	87
		e) 	1e	70	60	85
		f) 	1f	70	70	81
2		a) CH ₃ OH	2a	rt	10	95
		b) CH ₃ CH ₂ OH	2b	50	20	93
		c) CH ₃ CH ₂ CH ₂ OH	2c	50	30	91
		d) 	2d	70	45	89
		e) 	2e	70	55	88
		f) 	2f	70	60	85
3		a) CH ₃ OH	3a	rt	15	93
		b) CH ₃ CH ₂ OH	3b	50	35	89
		c) CH ₃ CH ₂ CH ₂ OH	3c	50	50	84
		d) 	3d	70	65	80
		e) 	3e	70	60	78
		f) 	3f	70	70	75
4		a) CH ₃ OH	4a	rt	05	93
		b) CH ₃ CH ₂ OH	4b	50	20	91
		c) CH ₃ CH ₂ CH ₂ OH	4c	50	35	89
		d) 	4d	70	45	85
		e) 	4e	70	50	83
		f) 	4f	70	60	81
5		a) CH ₃ OH	5a	rt	15	88
		b) CH ₃ CH ₂ OH	5b	50	25	85
		c) CH ₃ CH ₂ CH ₂ OH	5c	50	40	84
		d) 	5d	70	50	81
		e) 	5e	70	60	79
		f) 	5f	70	70	75
6		a) CH ₃ OH	6a	rt	05	95
		b) CH ₃ CH ₂ OH	6b	50	15	90
		c) CH ₃ CH ₂ CH ₂ OH	6c	50	15	89
		d) 	6d	70	30	86
		e) 	6e	70	35	84
		f) 	6f	70	50	81
7		a) CH ₃ OH	7a	rt	15	93
		b) CH ₃ CH ₂ OH	7b	50	30	89
		c) CH ₃ CH ₂ CH ₂ OH	7c	50	45	87
		d) 	7d	70	60	83

(Continued)

Table 1. Continued

Entry	Aryl halides	Alcohols	Product	Reaction condition	Time (min)	Yield ^b
8		a) CH ₃ OH	8a	rt	10	91
		b) CH ₃ CH ₂ OH	8b	50	20	88
		c) CH ₃ CH ₂ CH ₂ OH	8c	50	30	85
		d) 	8d	70	45	81
9		a) CH ₃ OH	9a	rt	15	87
		b) CH ₃ CH ₂ OH	9b	50	25	82
		c) CH ₃ CH ₂ CH ₂ OH	9c	50	40	81
		d) 	9d	70	50	78
10		a) CH ₃ OH	10a	rt	20	86
		b) CH ₃ CH ₂ OH	10b	50	40	84
		c) CH ₃ CH ₂ CH ₂ OH	10c	50	55	80
		d) 	10d	70	65	76
11		a) CH ₃ OH	11a	rt	25	82
		b) CH ₃ CH ₂ OH	11b	50	45	81
		c) CH ₃ CH ₂ CH ₂ OH	11c	50	60	78
		d) 	11d	70	70	72

^aAll products exhibited physical and spectral (NMR, mass, IR) properties in accordance with their assigned structures.

^bIsolated yield.

afford a good yield of expected methyl ethers. This may be because of the strong electron-withdrawing effect of the $-\text{CF}_3$ group. The aryl halides bearing a carbonyl or a cyano group also successfully underwent the alkoxylation with different alcohols (a–e). 4-Fluoroacetophenone (entry 10) and 4-fluorobenzaldehyde (entry 9) reacted with aliphatic alcohols (a–d) and led to corresponding ethers in good yields. *o*-Fluorobenzonitrile (entry 11) also gave analogous results with alcohols. Alkoxylation of 4,4'-difluoro benzophenone (1 equiv) with methanolic Triton B (1 equiv) gave a mixture of monomethoxy and dimethoxy benzophenone products, while the use of 2 equiv. of Triton B resulted in the formation of only 4,4'-dimethoxy benzophenone. Further, we studied the reaction of different alcohols as alkoxyating reagents. The reaction of Triton B was very fast, but as the number of carbons increases (alcohols a–c), heating was necessary for optimum conversion. Allylic and propargylic alcohol required higher temperatures for completion of the reactions. However, the aryl halides bearing carbonyl and nitrile groups (entries 7–10) were not reacted with allylic and propargyl alcohol. The substrates bearing nitro and two different halogens were studied to show the selectivity among halogens. Thus, in the reaction of 2-bromo-5-chloro nitrobenzene (entry 5) with Triton B (40% methanolic solution) at rt, the bromo reacted selectively to afford 4-chloro-2-nitroanisole in good yield. As expected, the formation of dimethoxy product was not observed because once one halogen reacts, the formed methoxy group would suppress the reactivity of system. Many pharmaceutical products contain aliphatic alkoxy groups; in this context, the present protocol may be an attractive alternate for the preparation of alkoxy aryl ethers. The additional advantage of the present reaction is that it avoids any metal contamination in the pharmaceutical products. Moreover, the

present method uses alcohols that are stable and easily available. It is worth mentioning that the method tolerates the presence of aldehyde and nitrile functionality. In addition, double and triple bonds remain unaffected in the same reaction conditions.

In conclusion, we demonstrate a one-pot method for alkoxylation of aryl and heteroaryl halides with lower alcohols in the presence of Triton B. This protocol avoids the use of lachrymatory alkyl halides and Pd complexes or ligands. Generality toward a variety of aryl halides and the nonmetallic nature of the base makes this protocol an ecofriendly alternative.

EXPERIMENTAL

General

All reactions were carried out without any special precautions in an atmosphere of air. Chemicals were purchased from Fluka and S. D. Fine Chemicals. Thin-layer chromatography (TLC) used precoated silica gel plates (60 F₂₅₄, 0.2-mm layer; E. Merck). ¹H NMR spectra were measured on a Varian 200 or Bruker 300 spectrometer in CDCl₃; δ in parts per million and J in hertz. Mass spectra were measured on a VG Autospec in *m/z*.

Experimental Procedure

Triton B (1.5 equiv., after removing of methanol) was dissolved in alcohol (1.1 equiv.) and stirred for 10 min. Then, aryl halide (1 equiv.) was added slowly with stirring, and the reaction continued for the stipulated time period (see Table 1). After completion of reaction as indicated by TLC, excess alcohol was removed under reduced pressure, and the residue was diluted with water. It was extracted with ethyl acetate, the organic layer washed with water and dried over Na₂SO₄, and the solvent was removed under reduced pressure. The crude product was purified through a column (hexane–EtoAc) to give the pure product.

Characteristic Data of Some Representative Compounds

Compounds 1a and 3a. Solid; mp 50–51 °C; ¹H NMR (200 MHz, CDCl₃): δ (ppm) 2.26 (s, 3H), 3.92–3.94 (m, 3H), 6.81 (d, 1H, *J* = 7.0 Hz), 8.02 (d, 1H, *J* = 2.5 Hz), 8.10 (dd, 1H, *J* = 2.5 Hz, *J* = 9.0 Hz); FABMS: *m/z* 168 (*M*⁺ + 1). IR (KBr) ν = 1610, 1592, 1510, 1498, 1260, 1100, 1020 cm⁻¹. Anal. calcd. for C₈H₉NO₃: C, 57.48; H, 5.43; N, 8.38. Found: C, 57.43; H, 5.40; N, 8.39.

Compounds 1b and 3b. White solid; mp 66–68 °C; ¹H NMR (200 MHz, CDCl₃): δ (ppm) 1.5 (t, 3H, *J* = 7.0 Hz), 2.3 (s, 3H), 4.1 (q, 2H, *J* = 7.0 Hz), 6.85 (d, 1H, *J* = 8.5 Hz), 8.0 (s, 1H), 8.1–8.2 (m, 1H); FABMS: *m/z* 181 (*M*⁺). IR (KBr) ν = 2921, 2855, 1510, 1345, 1257 cm⁻¹. Anal. calcd. for C₉H₁₁NO₃: C, 59.66; H, 6.12; N, 7.73. Found: C, 59.68; H, 6.10; N, 7.79.

Compounds 1d and 3d. Yellowish red liquid; ¹H NMR (200 MHz, CDCl₃): δ (ppm) 1.45 (d, 6H, *J* = 6.0 Hz), 2.25 (s, 3H), 4.6–4.8 (m, 1H), 6.85 (d, 1H,

$J=9.0$ Hz), 8.02 (m, 1H), 8.1 (m, 1H); FABMS: m/z 195 (M^+). IR (KBr) $\nu=3005$, 2927, 1540, 1240 cm^{-1} . Anal. calcd. for $\text{C}_{10}\text{H}_{13}\text{NO}_3$: C, 61.53; H, 6.71; N, 7.17. Found: C, 61.43; H, 6.60; N, 7.19.

Compounds 1e and 3e. Semisolid; ^1H NMR (200 MHz, CDCl_3): δ (ppm) 1.8 (s, 3H), 4.6 (s, 2H), 5.1 (s, 1H), 5.2 (s, 1H), 6.8 (d, 1H, $J=8.5$ Hz), 7.9 (s, 1H), 8.1–8.15 (m, 1H); FABMS: m/z 230 (M^+ Na), 207 (M^+). IR (KBr) $\nu=2922$, 2852, 1591, 1514, 1341, 1259 cm^{-1} . Anal. calcd. for $\text{C}_{11}\text{H}_{13}\text{NO}_3$: C, 63.76; H, 6.32; N, 6.76. Found: C, 63.78; H, 6.34; N, 6.74.

Compound 2a. White solid; mp 52–53 °C; ^1H NMR (200 MHz, CDCl_3): δ (ppm) 3.9 (s, 3H), 6.9 (d, 2H, $J=9.0$ Hz), 8.2 (d, 2H, $J=9.0$ Hz); FABMS: m/z 176 (M^+ Na), 132. IR (KBr) $\nu=3031$, 1535, 1256 cm^{-1} . Anal. calcd. for $\text{C}_7\text{H}_7\text{NO}_3$: C, 54.90; H, 4.61; N, 9.15. Found: C, 54.92; H, 4.65; N, 9.19.

Compound 2f. White solid; mp 112–114 °C; ^1H NMR (200 MHz, CDCl_3): δ (ppm) 2.5 (s, 1H), 4.8 (s, 2H), 7.05 (d, 2H, $J=9.0$ Hz), 8.25 (d, 2H, $J=9.0$ Hz); FABMS: m/z 178 (M^+ 1), 177 (M^+). IR (KBr) $\nu=3111$, 2925, 2123, 1493, 1332, 1174 cm^{-1} . Anal. calcd. for $\text{C}_9\text{H}_7\text{NO}_3$: C, 61.02; H, 3.98; N, 7.91. Found: C, 61.12; H, 3.94; N, 7.89.

Compound 4a. White solid; mp 85–88 °C; ^1H NMR (200 MHz, CDCl_3): δ (ppm) 4.1 (s, 3H), 7.1 (s, 1H), 7.65 (t, 1H, $J=8.0$ & 7.3 Hz), 8.1 (d, 1H, $J=7.3$ Hz), 8.4 (d, 1H, $J=8.0$ Hz); FABMS: m/z 296 (M^+ 1), 295 (M^+), 177; IR (KBr): $\nu=3050$, 3012, 2928, 1579, 1498, 1237 cm^{-1} . Anal. calcd. for $\text{C}_{12}\text{H}_7\text{F}_6\text{NO}$: C, 46.02; H, 2.90; F, 36.40; N, 4.47. Found: C, 44.08; H, 2.96; F, 36.44; N, 4.43.

Compound 4e. Light yellow solid; mp 72–73 °C; ^1H NMR (200 MHz, CDCl_3): δ (ppm) 1.8 (s, 3H), 4.8 (s, 2H), 5.1 (s, 1H), 5.2 (s, 1H), 7.1 (s, 1H), 7.6 (t, 1H, $J=6.6$ Hz, $J=8.0$ Hz), 8.1 (d, 1H, $J=6.6$ Hz), 8.5 (d, 1H, $J=8.0$ Hz); FABMS: m/z 335 (M^+). IR (KBr): $\nu=3057$, 2970, 1598, 1476, 1220 cm^{-1} . Anal. calcd. for $\text{C}_{15}\text{H}_{11}\text{F}_6\text{NO}$: C, 53.74; H, 3.31; F, 34.00; N, 4.18. Found: C, 53.70; H, 3.34; F, 34.08; N, 4.20.

Compound 5a. Light yellow solid; mp 93–95 °C; ^1H NMR (200 MHz, CDCl_3): δ (ppm) 3.9 (s, 3H), 7.2 (s, 1H), 7.65–7.70 (m, 1H), 7.8–7.9 (m, 1H); FABMS: m/z 188 (M^+ 1), 187 (M^+). IR (KBr): $\nu=2998$, 2926, 1570, 1255 cm^{-1} . Anal. calcd. for $\text{C}_7\text{H}_8\text{ClNO}_3$: C, 44.82; H, 3.22; Cl, 18.90; N, 7.47. Found: C, 44.88; H, 3.20; Cl, 18.80; N, 7.50.

Compound 6a. White floppy solid; mp 106–108 °C; ^1H NMR (200 MHz, CDCl_3): δ (ppm) 4.05 (s, 3H), 6.9 (d, 1H, $J=9.1$ Hz), 8.4 (dd, 1H, $J=3.0$ Hz), 9.05 (d, 1H, $J=3.0$ Hz); FABMS: m/z 154 (M^+). IR (KBr): $\nu=3007$, 2967, 1591, 1482, 1260 cm^{-1} . Anal. calcd. for $\text{C}_6\text{H}_6\text{N}_2\text{O}_3$: C, 46.76; H, 3.92; N, 18.18. Found: C, 46.70; H, 3.98; N, 18.14.

Compound 6d. Pale yellow solid; mp 52–53 °C; ^1H NMR (200 MHz, CDCl_3): δ (ppm) 1.38 (d, 6H, $J=6.2$ Hz), 5.43 (heptet, 1H, $J=6.2$ Hz), 6.74 (d, 1H, $J=9.1$ Hz), 8.33 (dd, 1H, $J=2.8$ Hz, $J=9.1$ Hz), 9.07 (d, 1H, $J=2.8$ Hz); FABMS: m/z 183 (M^+ 1), 182 (M^+), 167, 140. IR (KBr): $\nu=3170$, 3090, 3070, 2970, 1695,

1510, 1470, 1310, 1265 cm^{-1} . Anal. calcd. for $\text{C}_8\text{H}_{10}\text{N}_2\text{O}_3$: C, 52.74; H, 5.53; N, 15.38. Found: C, 52.70; H, 5.50; N, 15.39.

Compound 6f. Yellow solid; mp 149–150 $^{\circ}\text{C}$; ^1H NMR (200 MHz, CDCl_3): δ (ppm) 2.5 (s, 1H), 5.2 (s, 2H), 7.4 (s, 1H), 8.1 (d, 1H, $J=2.9$ Hz), 8.5 (d, 1H, $J=2.9$ Hz); FABMS: m/z 178 (M^+), 176, 175, 163. IR (KBr): $\nu=3111, 2925, 2123, 1589, 1493, 1332, 1247\text{ cm}^{-1}$. Anal. calcd. for $\text{C}_8\text{H}_6\text{N}_2\text{O}_3$: C, 53.94; H, 3.39; N, 15.72. Found: C, 53.97; H, 3.40; N, 15.79.

Compound 8a. White solid; mp 146 $^{\circ}\text{C}$; ^1H NMR (200 MHz, CDCl_3): δ (ppm) 3.85 (s, 6H), 6.9 (d, 4H, $J=8.8$ Hz), 7.9 (d, 4H, $J=8.8$ Hz); FABMS: m/z 265 ($\text{M}^+ \text{Na}$). IR (KBr): $\nu=3067, 3017, 2921, 1640, 1598, 1256\text{ cm}^{-1}$. Anal. calcd. for $\text{C}_{15}\text{H}_{14}\text{O}_3$: C, 74.36; H, 5.82; Found: C, 74.40; H, 5.80.

Compound 9a. Brown liquid; ^1H NMR (200 MHz, CDCl_3): δ (ppm) 3.9 (s, 3H), 7.0 (d, 2H, $J=8.5$ Hz), 7.8 (d, 2H, $J=8.5$ Hz), 9.87 (s, 1H); FABMS: m/z 175 ($\text{M}^+ \text{K}$), 135 ($\text{M} - 1^+$). IR (KBr): $\nu=2924, 2854, 1741, 1602, 1255\text{ cm}^{-1}$. Anal. calcd. for $\text{C}_8\text{H}_8\text{O}_2$: C, 70.58; H, 5.93. Found: C, 70.53; H, 5.90.

Compound 9b. Liquid; ^1H NMR (200 MHz, CDCl_3): δ (ppm) 1.38 (t, 3H, $J=6.0$ Hz), 4.15 (q, 2H, $J=6.0$ Hz), 7.13 (d, 2H, $J=12.0$ Hz), 7.88 (d, 2H, $J=12.0$ Hz); FABMS: m/z 150 (M^+). IR (KBr): $\nu=2934, 2844, 1731, 1600, 1255\text{ cm}^{-1}$. Anal. calcd. for $\text{C}_9\text{H}_{10}\text{O}_2$: C, 71.98; H, 6.71. Found: C, 71.93; H, 6.70.

Compound 9d. Pale yellow liquid; ^1H NMR (200 MHz, CDCl_3): δ (ppm) 1.06 (t, 3H, $J=7.6$ Hz), 1.80–1.87 (m, 2H), 4.0 (t, 2H, $J=6.6$ Hz), 7.0 (d, 2H, $J=8.8$ Hz), 7.83 (d, 2H, $J=8.8$ Hz), 9.88 (s, 1H); FABMS: m/z 164 (M^+). IR (KBr): $\nu=2944, 2864, 1745, 1602, 1250\text{ cm}^{-1}$. Anal. calcd. for $\text{C}_{10}\text{H}_{12}\text{O}_2$: C, 73.15; H, 7.37. Found: C, 73.13; H, 7.40.

Compound 10a. Semisolid; ^1H NMR (200 MHz, CDCl_3): δ (ppm) 2.53 (s, 3H), 3.86 (s, 3H), 6.89 (d, 2H, $J=9.0$ Hz), 7.89 (d, 2H, $J=9.0$ Hz); FABMS: m/z 173 ($\text{M}^+ \text{Na}$), 135; IR (KBr) $\nu=3005, 2963, 2842, 1675, 1601, 1256\text{ cm}^{-1}$. Anal. calcd. for $\text{C}_9\text{H}_{10}\text{O}_2$: C, 71.98; H, 6.71. Found: C, 71.94; H, 6.70.

Compound 10b. Semisolid; ^1H NMR (200 MHz, CDCl_3): δ (ppm) 1.3 (t, 3H), 2.6 (s, 3H), 4.0 (q, 2H), 6.9 (d, 2H, $J=8.9$ Hz), 7.9 (d, 2H, $J=8.9$ Hz); FABMS: m/z 187 ($\text{M}^+ \text{Na}$), 149; IR (KBr) $\nu=3005, 2963, 2842, 1675, 1601, 1256\text{ cm}^{-1}$. Anal. calcd. for $\text{C}_{10}\text{H}_{12}\text{O}_2$: C, 73.15; H, 7.37. Found: C, 73.14; H, 7.40.

Compound 11d. Liquid; ^1H NMR (200 MHz, CDCl_3): (ppm) 1.39 (d, 6H, $J=6.1$ Hz), 4.64–4.65 (m, 1H), 6.91–6.98 (m, 2H), 7.45–7.57 (m, 2H); FABMS: m/z 161 ($\text{M}^+ 1$), 119, 91, 64. IR (KBr): $\nu=2924, 2854, 2224, 1602, 1255\text{ cm}^{-1}$. Anal. calcd. for $\text{C}_{10}\text{H}_{11}\text{NO}$: C, 74.51; H, 6.83; N, 8.69. Found: C, 74.53; H, 6.85; N, 8.67.

ACKNOWLEDGMENTS

P. R. G., B. C. K. R., and D. A. K. thank the Council of Scientific and Industrial Research/University Grants Commission, New Delhi, for the award of fellowships.

REFERENCES

1. Fuhrmann, E.; Talbiersky, J. Synthesis of alkyl ethers by catalytic Williamson ether synthesis with weak alkylation agents. *Org. Process Res. Develop.* **2005**, *9*, 206–211.
2. Kotschy, A.; Timari, G. *Heterocycles from Transition Metal Catalysis*; Springer: Dordrecht, The Netherlands, 2002; Fyfe, C. A. In *The Chemistry of the Hydroxyl Group*; Patai, S. (Ed.); Wiley Interscience: New York, 1971; vol. 1; Barton, D.; Nakanishi, K.; Meth-Cohn, O. *Comprehensive Natural Products Chemistry*; Elsevier Science: Oxford, UK, 1999; vol. 1, p. 38.
3. Naidu, A. B.; Sekar, G. An efficient intermolecular BINAM–copper (I)–catalyzed Ullmann-type coupling of aryl iodides/bromides with aliphatic alcohols. *Tetrahedron Lett.* **2008**, *49*, 3147.
4. Ono, Y. Dimethyl carbonate for environmentally benign reactions. *Pure Appl. Chem.* **1996**, *68*, 367–375.
5. Schlummer, B.; Scholz, U. Palladium-catalyzed C–N and C–O coupling: A practical guide from an industrial vantage point. *Adv. Synth. Catal.* **2004**, *346*, 1599–1626.
6. Parrish, C. A.; Buchwald, S. L. Palladium-catalyzed formation of aryl *tert*-butyl ethers from unactivated aryl halides. *J. Org. Chem.* **2001**, *66*, 2498–2500.
7. Chen, G.; Chan, A. S. C.; Kwong, F. Y. L. Palladium-catalyzed C–O bond formation: Direct synthesis of phenols and aryl/alkyl ethers from activated aryl halides. *Tetrahedron Lett.* **2007**, *48*, 473–476.
8. Paul, S.; Gupta, M. Zinc-catalyzed Williamson ether synthesis in the absence of base. *Tetrahedron Lett.* **2004**, *48*, 8825–8829.
9. Lee, S.; Lee, S. W.; Kim, K. S.; Lee, J. J.; Hyun, D.; Kim, J. C. O-alkylation of phenol derivatives over basic zeolites. *Catal. Today* **1998**, *44*, 253–258.
10. Leadbeater, N. E.; Marco, M. Transition-metal-free Suzuki-type coupling reactions. *Angew. Chem. Int. Ed.* **2003**, *42*, 1407.
11. Sperotto, E.; De Vries, J. G.; VanKlink, G. P. M.; Van Koten, G. Ligand-free copper(I) catalyzed N- and O-arylation of aryl halides. *Tetrahedron Lett.* **2007**, *48*, 7366–7370.
12. Mayer, S.; Merour, J.-Y.; Joseph, B.; Guillamet, G. Synthesis and reactivity of 1,4-oxazinoindole derivatives. *Eur. J. Org. Chem.* **2002**, *10*, 1646–1653.
13. Bulbule, V. J.; Jnaneshwara, G. K.; Deshmukh, R. R.; Borate, H. B.; Deshpande, V. H. Benzyl trimethyl ammonium hydroxide-catalysed nitroaldol condensation. *Synth. Commun.* **2001**, *31*, 3623–3626.
14. Chaturvedi, D.; Ray, S. A high yielding, one-pot, Triton-B-catalyzed synthesis of dithiocarbamates using alcoholic tosylates. *Monatsh. Chem.* **2006**, *137*, 465–469.
15. Varma, R. S.; Meshram, H. M. Solid state deoximation with ammonium persulfate–silica gel: Regeneration of carbonyl compounds using microwaves. *Tetrahedron Lett.* **1997**, *38*, 5427–5428; Varma, R. S.; Meshram, H. M. Solid state cleavage of semicarbazones and phenylhydrazones with ammonium persulfate–clay using microwave or ultrasonic irradiation. *Tetrahedron Lett.* **1997**, *38*, 7973–7976; Meshram, H. M.; Reddy, G. S.; Yadav, J. S. Clay-supported ammonium nitrate “Clayan”: A mild and eco-friendly reagent for dethioacetalization. *Tetrahedron Lett.* **1997**, *38*, 8891–8894; Meshram, H. M.; Ganesh, Y. S. S.; Yadav, J. S. Clay-supported ammonium nitrate “Clayan”: A new reagent for selective nitration of arenes. *Synth. Commun.* **2003**, *33*, 2497–2503.
16. Chen, G.; Chan, A. S. C.; Kwong, F. Y. Palladium-catalyzed C–O bond formation: Direct synthesis of phenols and aryl/alkyl ethers from activated aryl halides. *Tetrahedron Lett.* **2007**, *48*, 473–476; Wolter, G.; Nordmann, M.; Job, G. E.; Buchwald, S. L. Copper-catalyzed coupling of aryl iodides with aliphatic alcohols. *Org. Lett.* **2002**, *4*, 973–976.