

Richard A. Bartsch* and Il-Woo Yang

Department of Chemistry, Texas Tech University,
Lubbock, Texas 79409

Received March 9, 1984

Reactions of *o*-methyl- and *o*-ethylbenzenediazonium tetrafluoroborates with two equivalents of potassium acetate and five mole percent of 18-crown-6 in ethanol-free chloroform produce indazoles in good to excellent yields. Indazoles bearing either electron-withdrawing or electron-donating substituents may be prepared.

J. Heterocyclic Chem., **21**, 1063 (1984).

One of the more common routes to the indazole ring system is diazotization of *o*-toluidines in acidic or neutral aqueous solution or in acetic acid [1-4]. In general, the reactions are successful only for *o*-methylbenzenediazonium salts which bear an electron-withdrawing nitro or halogen group on the aromatic ring [2,3]. For example diazotized 2-methyl-4-nitroaniline gave 5-nitroindazole in 72-80% yield upon standing at room temperature for three days in acetic acid; whereas, a similar reaction with diazotized *o*-toluidine gave only a 3-5% yield of indazole [2]. A more successful preparation of indazole was the reaction of *o*-methylbenzenediazonium chloride with tetramethylammonium acetate in chloroform or *t*-butyl alcohol which gave 87 and 82% yields, respectively, of the parent heterocycle [5]. However, this synthesis required the isolation of an explosive arenediazonium chloride and the use of expensive and hygroscopic tetramethylammonium acetate. Also the generality of this reaction for the preparation of substituted indazoles was not established. We wish to report a facile phase transfer catalyzed synthesis of indazole and indazoles with electron-donating and electron-withdrawing substituents from non-explosive *o*-alkylbenzenediazonium tetrafluoroborates and inexpensive potassium acetate [6].

Reaction of *o*-methylbenzenediazonium tetrafluoroborate with two equivalents of potassium acetate and five mole percent of 18-crown-6 in ethanol-free chloroform at room temperature for one hour followed by a very simple isolation procedure and recrystallization of the crude product gave a 70% yield of indazole (Table I). In the absence of 18-crown-6, no indazole was formed. For this heterogeneous system, the crown ether transfers both the solid benzenediazonium salt and the potassium acetate into solution where reaction occurs [7]. Change of the reaction solvent to dichloromethane lowered the indazole yield to 52%. A very recent, isolated result from another laboratory [8] indicates that the indazole yield in benzene solvent should equal that which we observed in chloroform. Use of co-solvent acetonitrile (CH₃CN:CHCl₃ = 1:9) as a substitute for the crown ether phase transfer catalyst [9] produced only a 30% yield of indazole. The crown ether facilitated reac-

tion of *o*-methylbenzenediazonium tetrafluoroborate with potassium acetate in chloroform was also conducted on a larger scale (10 X) with no apparent reduction in yield.

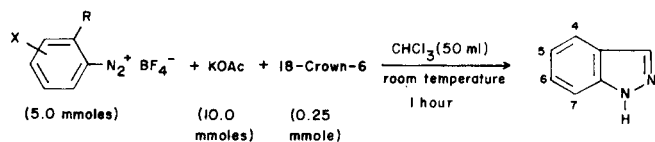
Good to excellent yields of substituted indazoles were provided by *o*-methylbenzenediazonium tetrafluoroborates which bear either electron-withdrawing (nitro, chloro) or electron-donating (methyl, methoxyl) groups (Table I). Although an 85% yield of 3-methylindazole was obtained from *o*-ethylbenzenediazonium tetrafluoroborate, only the reduction product cumene was recovered in 67% yield from the reaction of the *o*-isopropylbenzenediazonium tetrafluoroborate. Very recently, the formation of 3-benzylindazole (55% yield) and 3-(3-phenylpropyl)indazole (36% yield) was reported in 18-crown-6-catalyzed reactions of potassium acetate with 2-(2-phenylethyl)benzenediazonium tetrafluoroborate and 2-(4-phenylbutyl)benzenediazonium tetrafluoroborate, respectively, in 1,1,2-trichloro-1,2,2-trifluoroethane [8].

Gokel and coworkers have reported crown ether catalyzed reactions of benzenediazonium tetrafluoroborates with potassium acetate in: a) aromatic solvents to form biaryls [7,8]; b) chloroform to yield reduction [17]; and c) chloroform in the presence of added iodine or bromine atom sources to produce aryl iodides or bromides, respectively [18]. Convincing evidence for the intermediacy of aryl radicals in these reactions was presented. In the present study, when the crown ether catalyzed reaction of *o*-methylbenzenediazonium tetrafluoroborate with potassium acetate was conducted in chloroform in the presence of equimolar 1,1-diphenylethylene, gc analysis of the reaction mixture filtrate revealed the presence of indazole in 66% yield. Thus, the presence a radical scavenger had no apparent effect upon the indazole yield. This result indicates that the cyclization reaction proceeds by an ionic mechanism.

EXPERIMENTAL

Reagent grade chloroform was shaken repeatedly with concentrated sulfuric acid until the acid layer remained colorless. The resultant chloroform layer was washed with aqueous sodium bicarbonate and water and dried over calcium chloride. The chloroform was fractionally distilled immediately before use. Commercially available *o*-alkylanilines were used as received.

Table I.

Phase Transfer Catalyzed Synthesis of Indazoles from *o*-Alkylbenzenediazonium Tetrafluoroborates

R	diazonium salt X	recrystallized indazole	yield (%)	solvent	product mp (°C)	reported mp (°C)
Me	4-NO ₂	5-NO ₂	82	EtOH	208-209	208-209 [1]
Me	5-NO ₂	6-NO ₂	85	H ₂ O	179-180	181 [10]
Me	6-NO ₂	7-NO ₂	39	H ₂ O	187	186-187 [10]
Me	4-Cl	5-Cl	98	[a]	116-117	119-120 [11]
Me	5-Cl	6-Cl	90	H ₂ O	174-175	175-176 [12]
Me	H	H	70	H ₂ O	143-144	146-147 [6]
Me	3-Me	4-Me	64	hexane	112-113	116.5-117 [13]
Me	4-Me	5-Me	45	pet ether (90-120°)	111	116-117 [14]
Me	5-Me	6-Me	60	C ₆ H ₆ -CHCl ₃ (7:3)	173	177-178 [13]
Me	6-Me	7-Me	70	pet ether (90-120°)	137	138 [14]
Me	4-MeO	5-MeO	60	H ₂ O	167.5-168.5	167 [15]
Et	H	3-Me	85	H ₂ O	110-111	113 [16]

[a] Crude product.

Preparation of Benzenediazonium Tetrafluoroborates.

Diazotization of the *o*-alkylaniline with sodium nitrite in fluoroboric acid or with sodium nitrite in hydrochloric acid followed by the addition of sodium tetrafluoroborate was accomplished by the ordinary procedures [19]. The crude benzenediazonium tetrafluoroborates were purified by dissolution in a minimum amount of acetone, precipitation of the salt with diethyl ether, and air drying. Most of the diazonium salts possessed sufficient stability to be stored for several weeks in a refrigerator. However, solid *o*-isopropylbenzenediazonium tetrafluoroborate decomposed violently to form the Schiemann reaction product, 1-fluoro-2-isopropylbenzene, when it was stored overnight in a refrigerator. It was found that this diazonium salt could be stored safely under petroleum ether (30-60°) in the freezing compartment of the refrigerator.

Preparation of Indazoles.

The *o*-alkylbenzenediazonium tetrafluoroborate (5.0 mmoles) was added in one portion to a stirred mixture of dried and powdered potassium acetate (1.00 g, 10 mmoles) and 18-crown-6 (0.07 g, 0.25 mmole) in 50 ml of ethanol-free chloroform. After magnetic stirring under nitrogen for 1 hour, the mixture was filtered and the filtered solid was washed with chloroform. The filtrate and washings were combined, washed with water (3 × 50 ml), dried with sodium sulfate and evaporated *in vacuo*. The crude, solid indazole was purified by recrystallization, if necessary.

Acknowledgement.

Support of this research by the Donors of the Petroleum Research Fund, administered by the American Chemical Society, is gratefully acknowledged.

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