Palladium-catalyzed cross-coupling of 6-bromo-2-methylbenzothiazole with arylzinc chlorides

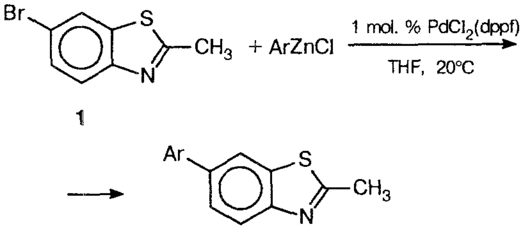
N. A. Bumagin,* A. F. Sokolova, and I. P. Beletskaya

M. V. Lomonosov Moscow State University, Department of Chemistry,
Leninskie gory, 119899 Moscow, Russian Federation.
Fax: +7 (095) 939 1854

2-Methylbenzothiazoles containing various substituents at position 6 are used as starting compounds in the syntheses of thiacarbocyanines, a broad class of cyanine dyes that are used as sensitizers for photographic emulsions in the long-wave spectral region.[1,2]

We elaborated an efficient method for introducing an aryl group at position 6 of benzothiazoles by the reaction of 6-bromo-2-methylbenzothiazole (**1**) with arylzinc chloride (obtained by treatment of the respective organomagnesium compounds with $ZnCl_2$ in THF) catalyzed by the $PdCl_2(dppf)$ complex [where dppf is 1,1′-bis(diphenylphosphino)ferrocene]. The reaction proceeds quickly and selectively at room temperature in THF to give 6-aryl-2-methylbenzothiazoles (**2**) in high yields. The reaction times and yields of cross-coupling products **2** are given in parentheses below the Scheme.

$$\mathrm{ArMgBr + ZnCl_2 \xrightarrow[\text{1 h, 20°C}]{\text{THF}} ArZnCl + MgClBr}$$



1

2

Ar = Ph (0.5 h, 73 %), 4-$CH_3OC_6H_4$ (1.5 h, 95 %), 3,4-$(CH_3O)_2C_6H_3$ (1.5 h, 97 %)

Compound **1** (2 mmol) and THF (2 mL) were placed under argon into a flask equipped with a magnetic stirrer. Then, a ~0.3 *M* solution (10.6 mL, 3.2 mmol) of an arylzinc chloride [obtained from 9 mL of 1 *M* solution (9 mmol) of ArMgBr and 17 mL of a solution of $ZnCl_2$ (1.21 g, 9 mmol) in THF] and $PdCl_2(dppf)$ (0.015 g, 0.02 mmol) were added. The reaction mixture was stirred at ~20°C. After the reaction was completed, the mixture was treated with saturated aqueous NH_4Cl and extracted with ether. The ethereal extract was dried with Na_2SO_4. The solvent was distilled off, and the residue was chromatographed on SiO_2 (40/100 μ, hexane:ether = 4:1). The following compounds were obtained.

6-(4′-Methoxyphenyl)-2-methyl-benzothiazole, m.p. 110.4—110.6°C (from pentane). Found (%): C, 69.25; H, 5.21; N, 5.06. $C_{15}H_{13}NOS$. Calculated (%): C, 70.56; H, 5.13; N, 5.48. ^1H NMR (CD_2Cl_2), δ: 2.81 (s, 3 H, Me); 3.84 (s, 3 H, MeO); 6.99 (d, $J_{3',2'}$ = 8.8 Hz, 2 H, H-3′, H-5′); 7.57 (d, $J_{2',3'}$ = 8.8 Hz, 2 H, H-2′, H-6′); 7.63 (dd, $J_{5,4}$ = 8.5 Hz, $J_{5,7}$ = 2.1 Hz, 1 H, H-5); 7.94 (d, $J_{4,5}$ = 8.5 Hz, 1 H, H-4); 7.97 (d, $J_{7,5}$ = 2.1 Hz, 1 H, H-7).

2-Methyl-6-phenylbenzothiazole, m.p. 89.5—90.5°C (from ether). Found (%): C, 74.41; H, 4.93; N, 5.99. $C_{14}H_{11}NS$. Calculated (%): C, 74.61; H, 4.93; N, 6.21. ^1H NMR (CD_2Cl_2), δ: 2.83 (s, 2 H, Me); 7.38 (t, $J_{4',3'}$ = 7.6 Hz, 1 H, H-4′); 7.48 (dd, H-5′, $J_{3',2'}$ = $J_{3',4'}$ = 7.6 Hz, 2 H, H-3′); 7.66 (d, $J_{2',3'}$ = 7.6 Hz, 2 H, H-2′, H-6′); 7.69 (dd, $J_{5,4}$ = 8.3 Hz; $J_{5,7}$=1.8 Hz, 1 H, H-5); 7.98 (d, $J_{4,5}$ = 8.3 Hz, 1 H, H-4); 8.05 (d, $J_{7,5}$ = 1.8 Hz, 1 H, H-7).

6-(3′,4′-Dimethoxyphenyl)-2-methyl-benzothiazole, m.p. 104.0—104.5°C (from ether). Found (%): C, 67.06; H, 5.28; N, 4.55. $C_{16}H_{15}NO_2S$. Calculated (%): C, 67.34; H, 5.31; N, 4.91. ^1H NMR (CD_2Cl_2), δ: 2.81 (s, 3 H, Me); 3.87 (s, 3 H, 3′-MeO); 3.91 (s, 3 H, 4′-MeO); 6.95 (d, $J_{5',6'}$ = 8.1 Hz, 1 H, H-5′); 7.17 (d, 1 H, H-2′); 7.18 (dd, $J_{6',5'}$ = 8.1 Hz, $J_{6',2'}$ = 2.2 Hz,

Translated from *Izvestiya Akademii Nauk. Seriya Khimicheskaya,* No. 11, pp. 2008—2009, November, 1993.

1066-5285/93/4211-1925 $12.50

1 H, H-6′); 7.64 (dd, $J_{5,4}$ = 8.5 Hz, $J_{5,7}$ = 1.8 Hz, 1 H, H-5); 7.94 (d, $J_{4,5}$ = 8.5 Hz, 1 H, H-4); 8.00 (d, $J_{7,5}$ = 1.8 Hz, 1 H, H-7).

References

1. A. I. Kiprianov, *Tsvet i stroenie tsianinovykh krasitelei* (*Color and Structure of Cyanine Dyes*), Naukova Dumka, Kiev, 1979, 23—106 (in Russian).
2. B. I. Shapiro, L. I. Mikheeva, A. G. Vakar, Yu. L. Slominskii, and A. I. Tolmachev, *V Vsesoyuz. simp. "Fizika i khimiya polimetinovykh krasitelei" (Vth All-Union Symp. "Physics and Chemistry of Polymethine Dyes)*, Chernogolovka, December 4—8, 1989, Moscow, 1989, 231—233 (in Russian).

Received June 13, 1993
in revised form October 14, 1993

Palladium-catalyzed synthesis of 3-substituted pyrroles from 3-pyrrolylmagnesium bromide

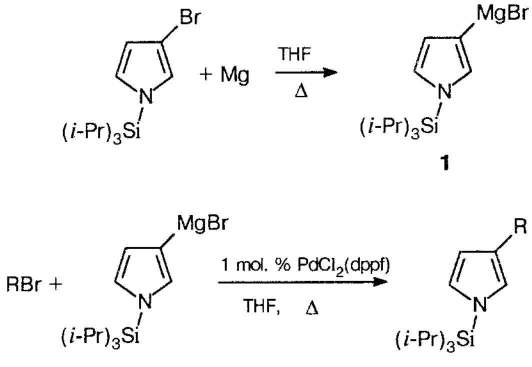
N. A. Bumagin,* A. F. Sokolova, and I. P. Beletskaya

M. V. Lomonosov Moscow State University, Department of Chemistry,
Leninskie gory, 119899 Moscow, Russian Federation.
Fax: +7 (095) 939 1854

It is known that pyrroles with free α-(2,5) positions can be used for synthesizing porphyrins. However, the preparation of 3-substituted pyrroles encounters difficulties due to the tendency of the pyrrole ring to undergo electrophilic substitution at position 2. Therefore, various indirect methods for synthesizing these compounds are being developed.[1,2]

We were the first to obtain 3-1-(triisopropylsilyl)-pyrrolylmagnesium bromide (**1**) from the respective 3-bromo derivative and elaborate an efficient procedure for the synthesis of 3-substituted pyrroles (**2**) based on cross-coupling of the above Grignard reagent with organic halides. The reaction is catalyzed by $PdCl_2$(dppf) [dppf = 1,1′-bis(diphenylphosphino)ferrocene].

If the aryl bromide contains a hydroxyl and carboxyl group sensitive to the action of organomagnesium compounds, then the organic halide is pretreated with a stoichiometric amount of any Grignard reagent, *e.g.*, *p*-methoxyphenylmagnesium bromide, in order to protect these groups. In all cases, the cross-coupling was completed in 1—1.5 h, and the 3-substituted pyrroles were obtained in 65—90% yields.



2a: R = Ph
2b: R = 4-$HOOCC_6H_4$
2c: R = 4-HOC_6H_4
2d: R = 4-FC_6H_4

Translated from *Izvestiya Akademii Nauk. Seriya Khimicheskaya,* No. 11, pp. 2010—2011, November, 1993.