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Straightforward Synthesis of 4-Formyl- and 4,4'-Diformyl-2,2'-Bipyridines: Access to New Dialkenyl Substituted Bipyridyl Ligands.

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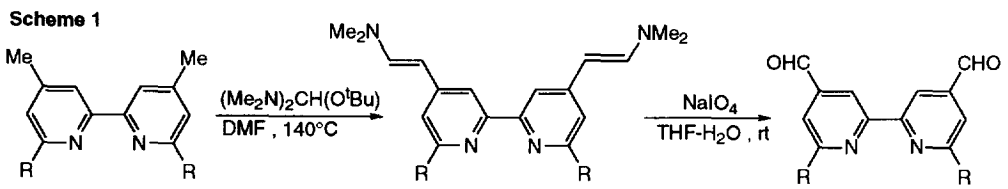
Abstract. 4-Formyl- and 4,4'-diformyl-2,2'-bipyridines have been prepared in two steps and in 52-71% overall yields *via* enamination of the corresponding 4-methyl and 4,4'-dimethyl-2,2'-bipyridine derivatives. The synthesis of two new 4,4'-dialkenyl- 2,2'-bipyridyl ligands is also described.

4,4'-Diformyl-2,2'-bipyridines such as **3a** and **3b** are useful synthons for the elaboration of functionalized bipyridines and oligobipyridines. However their syntheses involve several steps and are low yielding.[1,2] In the course of our research on the synthesis of 4,4'-dialkenyl-2,2'-bipyridine metal complexes for nonlinear optics[3,4] we have become interested in developing a more convenient method for the preparation of **3a** and **3b**. Here we describe a two-steps and good yield procedure to mono and diformyl-2,2'-bipyridines which is based on the enamination of the readily available mono and dimethyl-2,2'-bipyridine derivatives. In addition the synthesis of two new 4,4'-dialkenyl-2,2'- bipyridines containing π-acceptor nitrophenyl and nitrothienyl groups is described.

The formation of the enamine of 4-methylpyridine using *tert*-butoxybis(dimethylamino)methane (Bredereck's reagent) is well established.[5,6] Based on this result, we found that treatment of 4,4'-dimethyl-2,2'-bipyridine **1a** with the Bredereck's reagent in DMF at 140°C gave the corresponding 4,4'-dienamine-2,2'-bipyridine **2a** in 89 % yield.[7] Interestingly, **1b** was selectively converted into the desired 4,4'-dienamine-6,6'-dimethyl-2,2'-bipyridine **2b** in 87 % yield under the same reaction conditions (Scheme 1). The diformyl bipyridines **3a** and **3b** were then easily obtained in 80 % and 60 % yield respectively, *via* the oxidative cleavage of the enamine groups by sodium periodate[8] in aqueous THF at room temperature (Scheme 1).[9]

Scheme 1



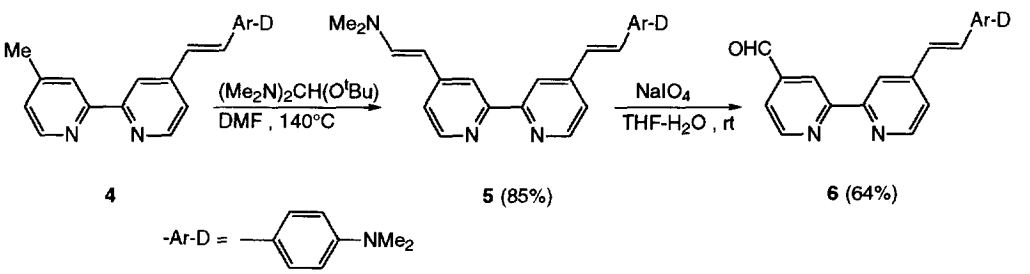
1a : R=H
1b : R=Me

2a (89%)
2b (87%)

3a (80%)
3b (60%)

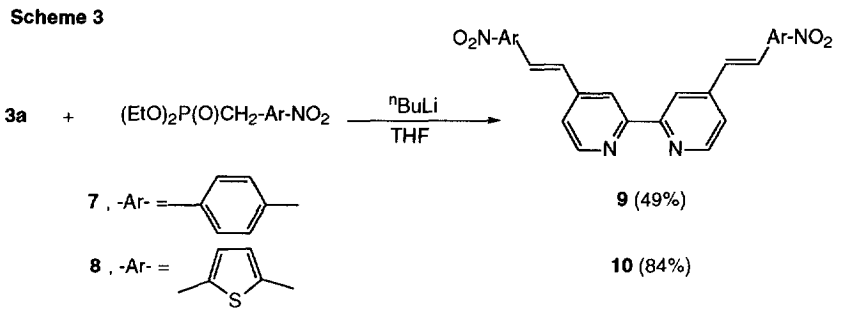
These reactions were next applied to the synthesis of the new monoformylbipyridine **6**. Thus upon treatment of 4-[*p*-(*N*,*N*-dimethylamino)styryl]-4'-methyl-2,2'-bipyridine **4**[3] with Bredereck's reagent, the enamine **5** was obtained in 85 % isolated yield, which was in turn selectively oxidized with $NaIO_4$ to give the desired compound **6** in 64 % yield (Scheme 2).

Scheme 2



Finally the 4,4'-dialkenyl-2,2'-bipyridines **9** and **10** were prepared by a Wadworth-Emmons olefination (Scheme 3) : Condensation of phosphonates **7** and **8**[10], with **3a** in the presence of butyllithium in THF gave the expected *E* isomers of **9** and **10** in 49 and 84 % isolated yields respectively.[11]

Scheme 3



In summary, the above described procedure is an efficient way to synthesize mono and diformyl bipyridine derivatives.We believe that this methodology will open the route to new unsymmetrical "donor-acceptor" 4,4'-dialkenyl-2,2'-bipyridines. Work toward this end and the synthesis of their ruthenium(II) complexes is currently under investigation.

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REFERENCES AND NOTES

1. Kocian, O.; Mortimer, R. J.; Beer, P. D. *Tetrahedron Lett.* **1990**, *31*, 5069-5072.
2. Harding, M. M.; Koert, U.; Lehn, J-M.; Marquis-Rigault, A.; Piguet, C.; Siegel, J. *Helv. Chim. Acta* **1991**, *74*, 594-610.
3. Bourgault, M.; Mountassir, C.; Le Bozec, H.; Ledoux, I.; Pucetti, G.; Zyss, J. *J. Chem. Soc. Chem. Commun.* **1993**, 1623-1624.
4. Dhenault, C.; Ledoux, I.; Samuel, I. D. W.; Zyss, J.; Bourgault, M.; Le Bozec, H. *Nature*, **1995**, *374*, 339-342.
5. Bredereck, H.; Simchen, G.; Wahl, R. *Chem. Ber.*, **1968**, *101*, 4048-4056.
6. Abdulla, R. F.; Brinkmeyer, R. S. *Tetrahedron*, **1979**, *35*, 1675-1735.
7. In a typical reaction, a degassed solution of **1a** (1 g, 5.4 mmol) and *tert*-butoxybis(dimethylamino)methane (4.7 ml, 22.7 mmol) in dry DMF (5 ml) was heated under argon for 18 h. The reaction mixture was cooled to RT and water (50 ml) was added. The mixture was then extracted with dichloromethane (5 x 15 ml). The organic layers were dried over $MgSO_4$, concentrated *in vacuo* and precipitated by adding Et_2O to give pure **2a** : ^1H NMR ($CDCl_3$) δppm 8.33 (d, *J*=5.5 Hz, 2H, H6,6'), 8.10 (d, *J*=2 Hz, 2H, H3,3'), 7.19 (d, *J*=14 Hz, 2H, CH=), 6.93 (dd, *J*=5.5 and 2 Hz, 2H, H5,5'), 5.07 (d, *J*=14 Hz, 2H, =CH), 2.86 (s, 12H, $-NMe_2$). HRMS : calc. for $C_{18}H_{22}N_4$: 294.1844, found : 294.1862.
   2b : ^1H NMR ($CDCl_3$) δppm 7.87 (d, *J*=1.5 Hz, 2H, H3,3'), 7.15 (d, *J*=14 Hz, 2H, CH=), 6.84 (d, *J*=1.5 Hz, 2H, H5,5'), 5.06 (d, *J*=14 Hz, 2H, =CH), 2.86 (s, 12H, $-NMe_2$), 2.52 (s, 6H, -Me); HRMS : calc. for $C_{20}H_{26}N_4$: 321.2157, found : 322.2149.
   5 : ^1H NMR (CD_2Cl_2) δppm 8.56 (d, *J*=5.5 Hz, 1H, H6), 8.43 (d, *J*=1 Hz, 1H, H3), 8.37 (d, *J*=5.5 Hz, 1H, H6'), 8.13 (d, *J*=2 Hz, 1H, H3'), 7.44 (d, *J*=9 Hz, 2H, C_6H_4), 7.38 (d, 1H, =CH, J=16 Hz), 7.30 (dd, *J*=5.5 and 1 Hz, 1H, H5), 7.20 (d, *J*=14 Hz, 1H, CH=), 6.97 (dd, 1H, H5', *J*=5.5 and 2 Hz), 6.89 (d, *J*=16 Hz, 1H, CH=), 6.70 (d, *J*=9 Hz, 2H, C_6H_4), 5.08 (d, *J*=14 Hz, 1H, =CH), 2.98 (s, 6H, $-NMe_2$), 2.87 (s, 6H, $-NMe_2$); HRMS : calc. for $C_{24}H_{26}N_4$: 370.2157, found : 370.2175.
8. Vetelino, M. G.; Coe, J. W. *Tetrahedron Lett.*, **1994**, *35*, 219-222.
9. In a typical reaction, **2a** (1.43 g, 4.8 mmol) was dissolved in THF. An aqueous solution of $NaIO_4$ (8 g, 37.4 mmol) was added dropwise at RT and the reaction mixture was stirred for 18 h. The insolubles were removed by filtration and washed with THF. The solvent was evaporated *in vacuo* and dichloromethane (60 ml) was added. The organic layer was washed with saturated $NaHCO_3$ solution (3 x 20 ml), dried over $MgSO_4$ and then evaporated to dryness to give pure **3a**. ^1H NMR ($CDCl_3$) δppm 10.19 (s, 2H, CHO), 8.95 (d, *J*=5 Hz, 2H, H6,6'), 8.88 (d, *J*=1.5 Hz, 2H, H3,3'), 7.78 (dd, *J*=5 and 1.5 Hz, 2H, H5,5').
   3b : ^1H NMR ($CDCl_3$) δppm 10.16 (s, 2H , CHO), 8.67 (s, 2H, H3), 7.60 (s, 2H, H5), 2.74 (s, 6H, -Me).

6 : ^{1}H NMR (DMSO-d_6) δppm 10.21 (s, 1H, CHO), 8.89 (d, *J*=5 Hz, 1H, H6'), 8.84 (s, 1H, H3'), 8.62 (d, *J*=5 Hz, 1H, H6), 8.50 (s ,1H, H3), 7.88 (d, *J*=5 Hz, 1H, H5'), 7.60 (d, *J*=5 Hz, 1H, H5), 7.55 (d, *J*=8.5 Hz, 2H, C_6H_4), 7.52 (d, *J*=16.5 Hz, 1H, =CH), 7.11 (d, *J*=16.5 Hz, 1H, CH=), 6.75 (d, *J*=8.5 Hz, 2H, C_6H_4), 2.97 (s, 6H, -NMe_2); HRMS : calc. for $C_{21}H_{19}N_3O$: 329.1528, found : 329.1458.

10. The phosphonates **7** and **8** were obtained from the appropriate bromides by the Arbuzov reaction.
11. **9** : ^{1}H NMR (DMSO-d_6) δppm 8.75 (d, *J*=5 Hz, 2H, H6,6'), 8.64 (s, 2H, H3,3'), 8.28 (d, *J*=8.5 Hz, 4H, C_6H_4), 8.00 (d, *J*=8.5 Hz, 4H, C_6H_4), 7.81 (d, =CH, *J*=16.5 Hz, 2H), 7.75 (d, *J*=5 Hz, 2H, H5,5'), 7.70 (d, *J*=16.5 Hz, 2H, CH=); HRMS : calc. for $C_{26}H_{18}N_4O_4$: 450.1328, found : 450.1339.
10 : ^{1}H NMR (DMSO-d_6) δppm 8.74 (d, *J*=5 Hz, 2H, H6,6'), 8.62 (s, 2H, H3,3'), 8.15 (d, *J*=4 Hz, 2H, C_4H_2S), 7.93 (d, *J*=16 Hz, 2H, =CH), 7.70 (d, *J*=5 Hz, 2H, H5,5'), 7.56 (d, *J*=16 Hz, 2H, CH=), 7.52 (d, *J*=4 Hz, 2H, C_4H_2S); HRMS : calc. for $C_{22}H_{14}N_4O_4S_2$: 462.0456, found : 462.0428.

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