Tetrahedron Letters, Vol. 34, No. 21, pp. 3445-3448, 1993
Printed in Great Britain

0040-4039/93 $6.00 + .00
Pergamon Press Ltd

Tandem Reactions of N,N-Dialkylamides with Organolithium Compounds and Cyclopentadiene. A New Efficient Synthesis of Pentafulvenes

Hiroyuki Kurata, Tatsuya Ekinaka, Takeshi Kawase, and Masaji Oda*
Department of Chemistry, Faculty of Science, Osaka University,
Toyonaka, Osaka 560, Japan

Abstract: Reactions of N,N-dialkylamides with organolithium compounds followed by addition of cyclopentadiene furnish 6-mono- or 6,6-di-substituted pentafulvenes in moderate to high yields, providing a new and simple pentafulvene synthesis.

Base-catalyzed condensation of aldehydes and ketones with cyclopentadiene has been a most useful method for the synthesis of pentafulvenes.[1] The scope and limitation of this method depend on the availability and reactivity of the carbonyl compounds as well as on the stability of the pentafulvenes to be formed.

In the course of our attempts to synthesize oligomers of 6-(2-thienyl)pentafulvene,[2,3] we encountered with some difficulties because the precursor ketones tended to become hardly soluble or unstable as the number of monomer unit increased. We therefore sought a new method for the synthesis of pentafulvenes which does not require isolation of precursor ketones.

Reactions of organolithium compounds with N,N-dialkylamides, chlorocarbamates and carbamate esters have been reported to yield aldehydes or ketones after hydrolysis.[4] The intermediate adduct of an organolithium compound and a dialkylamide is an tertiary alkoxide as well as a protected carbonyl compound. Quenching of this intermediate with cyclopentadiene instead of water should generate a ketone and cyclopentadienyl anion (and dialkylamine) in situ, and accordingly yield a pentafulvene. We report here a new synthesis of pentafulvenes by one-pot reactions of N,N-dialkylamides or dimethylcarbamyl chloride with organolithium compounds and then cyclopentadiene (Scheme 1).

A typical procedure for the new pentafulvene synthesis is as follows. To a stirred solution of p-bromoanisole (950 mg, 5.1 mmol) in dry THF (5 mL) was added dropwise through a syringe a 1.5 M solution of n-butyllithium in hexane (3.5 mL, 5.3 mmol) at -50 °C under nitrogen atmosphere. After 1 h stirring at -50 °C, a solution of N,N-dimethylbenzamide (900 mg, 6.0 mmol) in THF (5 mL) was added and the mixture stirred in an ice-bath for 1 h. Cyclopentadiene (1 mL, 12.1 mmol) was added and the stirring continued at 0 °C for 3 h. The mixture was added with water (20 mL), extracted with hexane (2 x 20 mL), and worked up as usual. The reddish residue was chromatographed on silica gel (30 g, hexane/benzene elution) to give 6-(4'-methoxyphenyl)-6-phenylfulvene (974 mg, 81% from p-bromoanisole). Use of a small excess of

Scheme 1

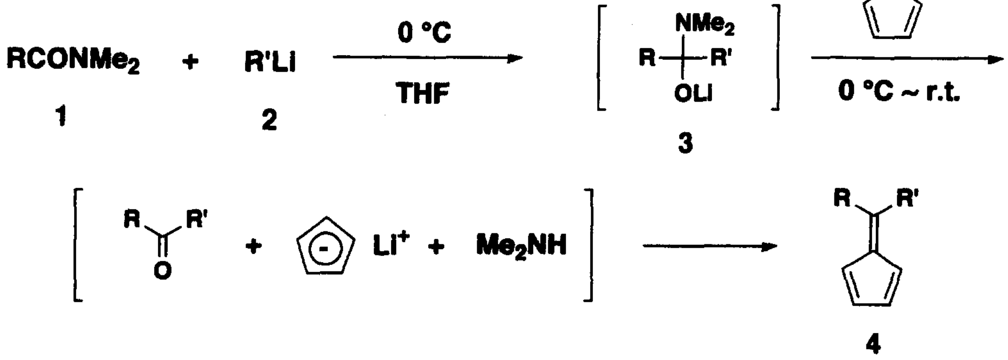


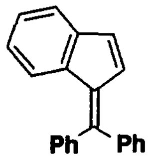
Table 1. Synthesis of 6-Substituted Pentafulvenes by Successive Reactions of N, N-Dimethylamides with Organolithium Compounds and Cyclopentadiene[a)]

Entry	RCONMe2 **1** R =	R'Li **2** R' =	Temperature and time[b)]	Pentafulvene **4**[c)] %
1	H	Phenyl	0°C, 3 h	56
2	"	p-Tolyl	"	62
3	"	p-Anisyl	"	74
4	"	2-Thienyl	"	59
5	Methyl	Butyl	"	33
6	"	Phenyl	"	30
7	Phenyl	Methyl	"	95
8	"	Butyl	20 °C, 24 h	51
9	"	Phenyl	0 °C, 3 h	85
10	"	p-Anisyl	"	81
11	"	p-Bromophenyl	"	79
12	"	2-Thienyl	"	64
13	1-Naphthyl	Phenyl	20 °C, 8 h	80
14	2-Naphthyl	"	20 °C, 3 h	92
15	(PhCONEt2)	"	0 °C, 3 h	76

a)See the typical procedure in the text for the experimental conditions. b)Conditions after addition of cyclopentadiene. c)All the products were identified by comparison with authentic samples or correct mass and NMR data.

organolithium reagents for the amide was also satisfactory.

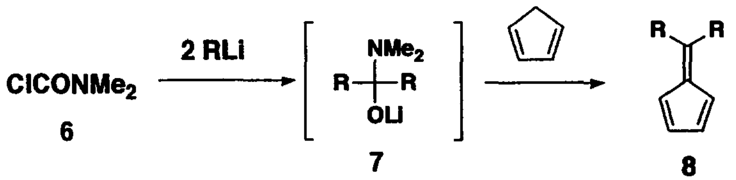
Table 1 summarizes the one-pot synthesis of 6-substituted pentafulvenes **4** from N,N-dimethylamides **1** and organolithium compounds **2** through the intermediate adduct **3**. While formamide (Entry 1-4), benzamide (Entry 7-11) and naphthamide (Entry 12, 13) afford **4** in moderate to high yields (56-98%), acetamide (Entry 5, 6) does **4** in rather poor yields (ca. 30%). Possible deprotonation from the methyl group of acetamide by **2** may be responsible for the poor results. N,N-Diethylamides can replace N,N-dimethylamides in these reactions as exemplified in Entry 15, though it might be less favorable when nucleophiles **2** become bulkier. Furthermore, addition of indene instead of cyclopentadiene to the reaction mixture of N,N-dimethylbenzamide and phenyllithium afforded the corresponding benzopentafulvene **5**[5] in 75% yield, thus expanding the scope of the present pentafulvene synthesis.



5

Dimethylcarbamyl chloride **6** is also a useful synthon, in particular, for the synthesis of symmetrically 6,6-disubstituted pentafulvenes such as **8a-d** by use of two molar equivalents of **2** (Scheme 2). Considerably lower yield of **8c** (50%) than **8d** (75%) is probably due to some transmetalation between 2-thienyllithium and the intermediate adduct **7c** in which 5-positions of the thienyl groups are open to metalation.

Scheme 2

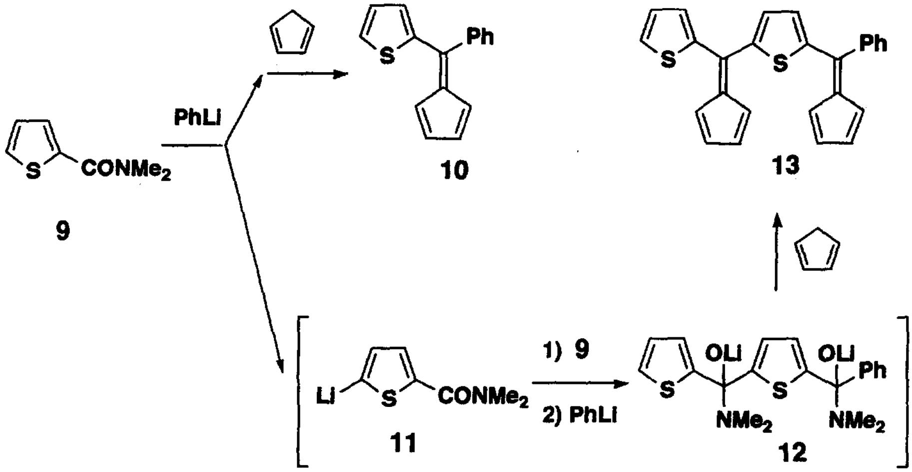


8a : R = Butyl 69 %
8b : R = Phenyl 83 %
8c : R = 2-Thienyl 50 %
8d : R = 5-(2-Methylthienyl) 75 %

Competitive transmetalation would make the reaction complicated in many cases, but can be of synthetic utility in some cases; for example, the reaction of 2-thienylcarbamide **9** with phenyllithium and then cyclopentadiene gave, in one step, bispentafulvene **13** (21%) in addition to monopentafulvene **10** (Scheme 3). The intermediacy of **11** and **12** explains the formation of **13**. Appreciably easy metalation of **9** to **11** for the presence of electron-withdrawing amide group and less easy metalation of **12** for lack of any electron-withdrawing group probably play key roles in this novel transformation.

In conclusion, the present one-pot procedure considerably widens access to pentafulvenes and would allow, in particular, the synthesis of pentafulvenoid compounds with complex structures.

Scheme 3



Acknowledgement: We thank the Ministry of Education, Science and Culture of Japan and the Sumitomo Foundation for financial support.

References and Notes

1. For an extensive review see, Zeller,K.-P., *Carbocyclische π-Electronen Systeme, Methoden der Organischen Chemie (Houben Weyl), Band 5, Teil 2C,* Georg Thieme Verlag, Stuttgart, 1985, pp 505-584.
2. Kurata,H.; Morikawa,T.; Kumagai,T.; Kawase,T.; Oda,M., *Chemistry Express,* 1991, **6**, 853.
3. Kawase,T.; Kurata,H.; Morikawa,T.; Oda,M., *Tetrahedron Lett.,* the accompanying paper.
4. For reviews see a) Wakefield,B.J., *The Chemistry of Organolithium Compounds,* Pergamon Press, Oxford, 1974; b) Wakefield,B.J., *Organolithium Methods,* Academic Press, London, 1988, pp 82-88.
5. Thiele,J.; Merck,K., *Liebigs Ann. Chem.,* 1918, **415**, 257.
6. **13**: red crystals, mp 111-112 °C; MS (EI, 70 eV), m/z 394 (M^+); ^{1}H NMR (270 MHz/ $CDCl_3$), δ 6.03 (1H, dt, J=1.8, 5.3 Hz), 6.49 (2H, m), 6.58 (3H, m), 6.63 (1H, dt, J=1.7, 5.6 Hz), 6.81 (1H, dt, J=1.7, 5.3 Hz), 7.08 (1H, d, J=4.0 Hz), 7.11 (1H, dd, J= 3.6, 5.0 Hz), 7.23 (1H, d, J=4.0 Hz), 7.29 (1H, dd, 1.0, 3.6 Hz), 7.41 (5H, m), 7.54 (1H, dd, J=1.0, 5.0 Hz).

(Received in Japan 23 January 1993)