SYNTHETIC COMMUNICATIONS, 29(17), 2973-2978 (1999)

A SIMPLE SYNTHESIS OF 1-METHYLCYCLOBUTENE[1]

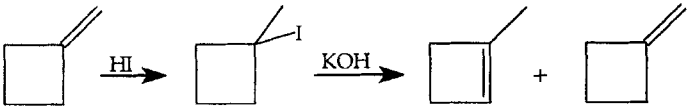
Abigail L. Person[a] and Dasan M. Thamattoor*[a,b]

[a]Department of Chemistry, Oberlin College, Oberlin, OH 44074
[b]Department of Chemistry, Princeton University, Princeton, NJ 08544

Abstract: Controlled thermal decomposition of the sodium salt of cyclopropyl methyl ketone tosylhydrazone gives 1-methylcyclobutene of excellent purity in good yield.

A number of reports have appeared in the literature, over the years, concerning the synthesis of 1-methylcyclobutene (**3**). The initial route to this important compound, shown in equation 1, involved addition of hydrogen iodide to methylenecyclobutane (**1**) followed by dehydroiodination of the resulting 1-iodo-1-methylcyclobutane (**2**).[2] At first it was reported that this method produced a 2:1 mixture of **3** and **1**,[2a] but later work showed that the two alkenes were formed in nearly equimolar amounts.[2b] Extensive fractional distillation was then employed to separate the desired isomer **3** from **1**.

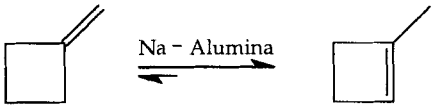
*To whom correspondence should be addressed. Current address: Department of Chemistry and Biochemistry, 251 Nieuwland Science Hall, University of Notre Dame, Notre Dame, IN 46556.



(1)

1 2 3 1

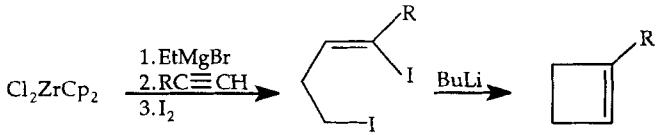
A few years later it was shown that **1** could be directly isomerized to **3** in the presence of a sodium-alumina catalyst at low temperatures (equation 2).[3] Under these conditions, the equilibrium mixture contained **3** and **1** in a ratio of 86:14. Subsequently it was reported that the equilibration of the two alkenes could be also carried out with other bases such as *N*-lithioethylenediamine[4] and potassium *tert*-butoxide.[5]



(2)

1 3

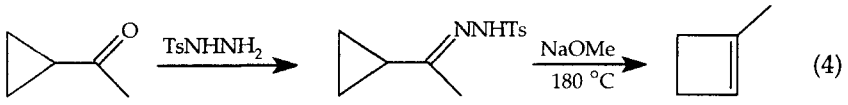
More recently, it was shown that the reaction of diiodoalkenes **4** with butyllithium gave 1-monoalkylated cyclobutenes (equation 3).[6] It must be noted, however, that such cyclizations are typically carried out in ether or tetrahydrofuran and therefore could pose isolation problems with the low boiling **3**.



4 (3)

Of particular relevance to our synthetic approach is the fact that cyclopropyl methyl ketone tosylhydrazone (**6**), when treated with sodium methoxide and heated, is known to produce mostly **3** (equation 4).[7] Yet, as has been observed before, "although this ring-expansion reaction is of potential interest, it does not seem to have been examined as a

preparative method."[3b] We now wish to report that the process shown in equation 4, with some modifications, does indeed lend itself to an exceptionally easy synthesis of **3**.



(4)

5 **6** **3** (92%**)

**Relative yield. Other products reported were vinylcyclopropane (1%) 2-methyl-1,3-butadiene (2%), methylacetylene and ethylene (3%).[7]

We prepared the tosylhydrazone **6**, in 86% yield, by the reaction of cyclopropyl methyl ketone (**5**) with *p*-toluenesulfonhydrazide ($TsNHNH_2$) in ethanol.[7b] In the following step, sodium hydride (1.25 equivalents) was added to a solution of **6** in di(ethyleneglycol) diethyl ether, and the mixture heated to decompose the resulting sodium salt. The product **3** was distilled directly out of the reaction flask, through a short fractionating column, into a receiver cooled in a Dry Ice/acetone bath. We have also observed that it is important to control the decomposition temperature as excessive heating causes small amounts of 2-methyl-1,3-butadiene to form, presumably from the ring-opening of **3**. After several trials aimed at optimizing the yield and purity of **3**, we have determined that the best temperature for decomposing the sodium salt of **6** is between 145 and 150 °C.

Our findings present an interesting contrast to the earlier report[7b] that reaction of **6** with sodium hydride (or sodium amide) produces vinylcyclopropane, almost exclusively, via the Bamford-Stevens reaction.[8] From a mechanistic point of view, based on recent observations,[9] it is unlikely that decomposition of the sodium salt of **6** to produce **3** involves a real cyclopropylmethylcarbene intermediate.

In conclusion, the method we suggest for the preparation of **3** is an important synthetic alternative that employs readily available and inexpensive starting materials. Furthermore, the convenient reaction conditions and an exceptionally easy isolation procedure are central to the utility of our approach.

EXPERIMENTAL

Cyclopropyl methyl ketone tosylhydrazone (6): Cyclopropyl methyl ketone (20 g, 0.24 mol) was added with a disposable pipet to a hot solution of *p*-toluenesulfonhydrazide (50 g, 0.27 mol) in 75 mL of ethanol. The clear solution was allowed to stand at room temperature overnight. The thick white solid that precipitated was filtered and recrystallized from ethanol to get the tosylhydrazone (51.5 g, 86%): mp 121-122 °C (lit.[7b] 123 °C); ^{1}H NMR (DMSO-*d6*) δ 9.87 (br s, 1H), 7.71 (d, *J* = 8.2 Hz, 2H), 7.39 (d, *J* = 8.5 Hz, 2H), 2.38 (s, 3H), 1.59 (s, 3H), 1.49 (m, 1H), 0.65-0.54 (m, 4H); ^{13}C NMR (DMSO-*d6*) δ 160.0, 142.9, 136.2, 129.1, 127.4, 20.9, 17.4, 13.6, 5.4.

1-Methylcyclobutene (3): A solution of cyclopropyl methyl ketone tosylhydrazone (10 g, 40 mmol) in 150 mL of di(ethyleneglycol) diethyl ether was magnetically stirred in a 500 mL three-neck flask equipped with a nitrogen inlet, thermometer, and 10-inch fractionating column. Sodium hydride (60% dispersion in mineral oil, 2.0 g, 50 mmol) was added in portions, at room temperature, under a slow stream of nitrogen. The fractionating column was attached to an ordinary distillation assembly and the receiver cooled in a Dry Ice/acetone bath. The stirred reaction mixture was gradually heated with an oil bath, over 45 minutes, to an internal temperature of 145 °C and held at that temperature for 1 hour to yield 1-methylcyclobutene (1.8 g, 67 %) in the receiver. Purity of the

distilled material was ~ 99% by GC: bp 36-37 °C (lit[3b] 37.3 °C); ^{1}H NMR ($CDCl_3$) δ 5.65 (s, 1H), 2.41 (br s, 2H), 2.32 (br s, 2H), 1.68 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 146.4, 127.9, 32.7, 26.4, 16.9.

ACKNOWLEDGMENT: We gratefully acknowledge Oberlin College for supporting portions of this work. We are also indebted to Professor Maitland Jones, Jr. for initial support through a grant from the National Science Foundation (Princeton, NSF CHE-9322579).

REFERENCES

1. Portions of this work were taken from the Ph.D. Dissertation of Dasan M. Thamattoor, Princeton University, 1997.
2. (a) Shand, W., Jr.; Schomaker, V.; Fischer, J. R. *J. Am. Chem. Soc.* **1944**, *66*, 636. (b) Riesz, P.; Taft, R. W., Jr.; Boyd, R. H. *J. Am. Chem. Soc.* **1957**, *79*, 3724.
3. (a) Gil-Av, E.; Herling, J. *Tetrahedron Lett.* **1961**, 27. (b) Shabtai, J.; Gil-Av, E. *J. Org. Chem.* **1963**, *28*, 2893.
4. Brown, H. C.; Liotta, R.; Brener, L. *J. Am. Chem. Soc.* **1977**, *99*, 3427.
5. Batalin, O. E.; Idlis, G. S.; Vilyatser, A. Yu.; Zinenkov, A. V.; Morzhakova, T. M.; Fedulova, L. V.; Shefter, V. E. *Zh. Prikl. Khim. (Leningrad)* **1986**, *59*, 1825.
6. Negishi, E.; Liu, F.; Choueiry, D.; Mohamud, M. M.; Silviera, A., Jr.; Reeves, M. *J. Org. Chem.* **1996**, *61*, 8325.
7. (a) Friedman, L.; Shechter, H. *J. Am. Chem. Soc.* **1960**, *82*, 1002. (b) Kirmse, W.; von Bülow, B.; Schepp, H. *Justus Liebigs Ann. Chem.* **1966**, *691*, 41.

8. Shapiro, R. H. *Org. React.* **1976**, *23*, 405.

9. Thamattoor, D. M.; Jones, M., Jr.; Pan, W.; Shevlin, P. B. *Tetrahedron Lett.* **1996**, *37*, 8333.

(Received in the USA 08 February 1999)