Annelation Reactions of 3-Phenylthiobut-3-en-2-one. A New Method of Constructing Fused Phenols

By Ken Takaki,* Michikazu Okada, Michio Yamada, and Kenji Negoro

(*Department of Applied Chemistry, Faculty of Engineering, Hiroshima University, Sendamachi-3, Hiroshima 730, Japan*)

Summary Reactions of 3-phenylthiobut-3-en-2-one with enolate anions of cyclohexanone and cyclopentanone gave good yields of 8a-hydroxy-3-phenylthio-2-decalone and 3a-hydroxy-6-phenylthiohexahydroindan-5-one which were readily converted into 5,6,7,8-tetrahydro-2-naphthol and indan-5-ol, respectively, on exposure to toluene-*p*-sulphonic acid: a similar reaction of the enolate of cycloheptanone and subsequent treatment with sodium ethoxide gave 2-hydroxy-5,6,7,8-tetrahydrobenzocycloheptene.

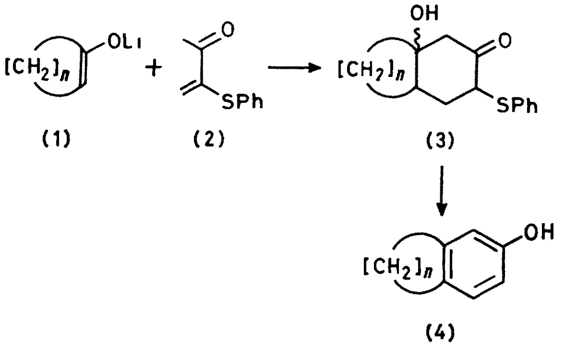
The utility of Robinson annelation has been widely recognized in connection with the total synthesis of natural products[1] and some modified methyl vinyl ketones have been reported for this purpose.[2] Attempted annelation reactions of corresponding reagents with sulphur substituents† failed, however, in spite of their expected properties.[3] The formation of six-membered rings with suitable substituents for transformation into the desired products has been also achieved by Diels–Alder reaction.[4] In this respect, Danishefsky[5] and Trost[6] have recently described the synthesis of aromatic compounds from

---

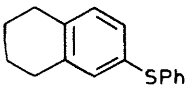
† There are two reports concerning 3-phenylthiobut-3-en-2-one (**2**); one reported its synthesis (I. G. Tishchenko and P. M. Malashko, *Khim. Gerotsikl. Soedin.*, 1966, 483; *Chem. Abs.*, 1967, **66**, 28407*q*) but our investigation has shown that the product was in fact the dimer, and the other reported that attempted annelations failed owing to polymerization (G. M. Ksander, J. E. McMurry, and M. Johnson, *J. Org. Chem.*, 1977, **42**, 1180).

1-methoxy-3-trimethylsilyloxy- or 2-methoxy-3-phenylthio-buta-1,3-diene and dienophiles We now report the synthesis of naphthol, indanol, and hydroxybenzocycloheptene derivatives from 3-phenylthiobut-3-en-2-one (**2**)‡ and cyclic ketones by an annelative method

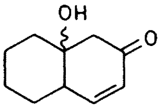
Reaction of (**2**) with 1 equiv of lithium cyclohex-1-enolate (**1b**) (tetrahydrofuran, −70 °C, 1 h, then room temperature, 4·5 h) gave 8a-hydroxy-3-phenylthio-2-decalone (**3b**)§ in 80% yield Similarly, 3a-hydroxy-6-phenylthiohexahydroindan-5-one (**3a**) was obtained in 68% yield from the enolate (**1a**) Acid treatment (p-MeC$_6$H$_4$SO$_3$H, benzene, reflux, 6·5 h) of (**3b**) afforded 5,6,7,8-tetrahydro-2-naphthol (**4b**) as the major product in 74% yield along with 6-phenylthio-1,2,3,4-tetrahydronaphthalene (**5**) (21%) In the case of (**3a**), indan-5-ol (**4a**) was isolated in 98% yield under similar conditions and no compound corresponding to (**5**) was detected The products (**4a**) and (**4b**) were identified by comparison with authentic samples and the structure of (**5**) was confirmed by hydrogenolysis on Raney-Ni to give 1,2,3,4-tetrahydronaphthalene The aromatization described above may, of course, be accomplished by the following alternative method [7] Oxidation (m-chloroperbenzoic acid, CH$_2$Cl$_2$, room temperature, 1 h) of (**3b**) and subsequent thermolysis (benzene, CaCO$_3$,, reflux, 4 h) gave a mixture of the octalone (**6**) and (**4b**) (2:1 ratio), acid treatment (p-MeC$_6$H$_4$SO$_3$H, benzene, reflux, 3·5 h) then yielded solely (**4b**), in 70% yield



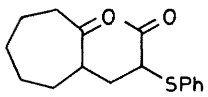
a, n=3, b, n=4, c, n=5



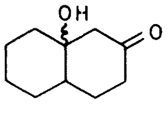
(5)



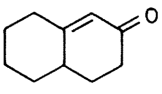
(6)



(7)



(8)



(9)

The reaction of (**2**) with lithium cyclohept-1-enolate (**1c**) gave only the non-cyclised cycloheptanone (**7**) in 85% yield under the same conditions as for (**1a**) and (**1b**) When (**7**) was treated with base (EtONa, EtOH, room temperature, 4 h, then 50 °C, 1·5 h) in an attempt to obtain (**3c**), the tetrahydrobenzocycloheptene (**4c**) was obtained directly in 86% yield

In addition to the use of this method for the synthesis of phenols, 2-octalone (**9**) could also be readily prepared from (**3b**) *via* the 8a-hydroxy-2-decalone (**8**) by removal of the phenylsulphenyl group (Raney-Ni, EtOH, reflux, 26 h, 91%) and dehydration [8]

(*Received*, 4*th August* 1980, *Com* 848)

---

‡ The butenone (**2**) was prepared by McMurry's method (G M Ksander, J E McMurry, and M Johnson, *J Org Chem* , 1977, **42**, 1180) or by oxidation of 3-phenylthiobut-3-en-2-ol with 2,3-dichloro-5,6-dicyano-1,4-benzoquinone, this should be carried out at low temperatures to avoid dimerization

§ All compounds had the expected elemental analyses and spectral data The products (**3a**), (**3b**), and (**8**) are mixtures of two diastereoisomers in the ratios 1 : 1·3, 1 : 3, and 1 : 3, respectively, but their separation and assignment has not yet been undertaken

[1] M E Jung, *Tetrahedron*, 1976, **32**, 3

[2] G Stork and B Ganem, *J Am Chem Soc* , 1973, **95**, 6152, G Stork and J Singh, *ibid* , 1974, **96**, 6181, R K Boeckman, Jr , *ibid* , 1974, **96**, 6179, G Stork and M E Jung, *ibid* , 1974, **96**, 3682

[3] A H Davidson, P K G Hodgson, D Howells, and S Warren, *Chem Ind* (*London*), 1975, 455

[4] M E Jung, *J Chem Soc* , *Chem Commun* , 1974, 956, J F W Keana and P E Eckler, *J Org Chem* , 1976, **41**, 2625, T Cohen, A J Mura, Jr , D W Shull, E R Fogel, R J Ruffner, and J R Falck, *ibid* , 1976, **41**, 3218, D A Evans, C A Bryan, and C L Sims, *J Am Chem Soc* , 1972, **94**, 2891, J Banville and P Brassard, *J Chem Soc* , *Perkin Trans* 1, 1976, 1852

[5] S Danishefsky and T Kitahara, *J Am Chem Soc* , 1974, **96**, 7807, S Danishefsky, M Hirama, K Gombatz, T Hirayama, E Berman, and P Schuda, *ibid* , 1978, **100**, 6536

[6] B M Trost, J Ippen, and W C Vladuchick, *J Am Chem Soc* , 1977, **99**, 8116, B M Trost, W C Vladuchick, and A J Bridges, *ibid* , 1980, **102**, 3554

[7] B M Trost, T N Salzmann, and K Hiroi, *J Am Chem Soc* , 1976, **98**, 4887

[8] J A Marshall and W I Fanta, *J Org Chem* , 1964, **29**, 2501