

NOTE

A Rapid and Convenient Synthesis of α -Diketones

SHAO-RUI CHEN^{1,2}, JI-HAI MA², XUE-QIN ZHOU¹ and DONG-ZHI LIU^{1,*}

¹School of Chemical Engineering and Technology, Tianjin University, Tianjin 300072, P.R. China

²College of Science, Hebei University of Science and Technology, Shijiazhuang 050018, P.R. China

*Corresponding author: Fax: +86 22 27892283; Tel: +86 22 27892283; E-mail: sjz_wgq@126.com

(Received: 8 April 2010;

Accepted: 4 September 2010)

AJC-9086

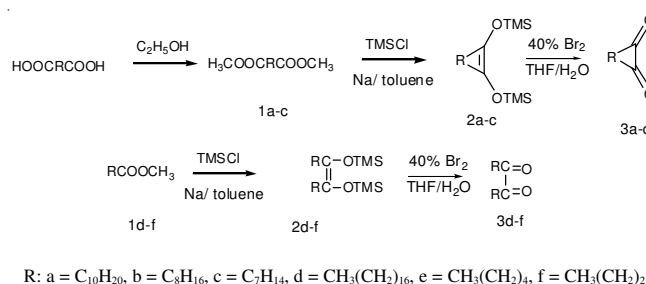
A novel and simple synthetic method for the preparation of series of α -diketones is reported. α -Ditrimethylsiloxenylenes were obtained from the readily available materials diacids or diesters through acyloin condensation, which was oxidized to α -diketones using bromine as the oxidation reagent in presence of water. The structures of α -diketones were confirmed by IR, MS, ¹H NMR.

Key Words: α -Diketones, Acyloin condensation, Oxidation, Synthesis.

α -Diketones are useful synthetic intermediates having been employed, using in preparation of many pharmaceutical compounds¹, heterocyclic compounds², heterocyclic-metal complexes³ and ring-expanding reaction⁴. For example, cyclododecandione can be utilized in the production of muscone as well as in the synthesis of its analogues⁵⁻⁷. Many methods for the synthesis of α -diketone have been developed and reported including: (a) nucleophilic addition-elimination method⁸, (b) coupling method⁹, (c) oxidation method (including oxidate the α -hydroxy acetone, monoketone, alkyne or olefin into the diketone)¹⁰⁻¹³. In contrast to their growing utility in organic synthesis, the preparative methods are limited *e.g.*, harsh reaction condition, long reaction time, expensive reagents, poor yield or too much side-products. To the best of our knowledge, less study has been focused on using bromine to oxidate the α -ditrimethylsiloxyene in presence of water at room temperature.

As an extension of our study on the synthesis of the muscone, we need a practical and convenient preparative method for the cyclododecandione. Here we report a convenient synthesis of α -diketones from the cheap acids or esters as shown in **Scheme-I**.

All the reagents and solvents were purchased from common commercial suppliers and were used without further purification. Melting points were measured on a X4 apparatus and were uncorrected. IR spectra were determined as KBr pellets on a FTS-135 spectrophotometer. ¹H and ¹³C NMR spectra were recorded on BRUKER 400 spectrometer in CDCl₃ as the solvent with TMS as internal standard. MS were performed on a VGZAB-HS spectrometer (EI at 70 eV).



Scheme-I

The compounds **1** were prepared from the diacids in high yield according to the literature method¹⁴. The compounds **2** were prepared according to Rühlmann¹⁵. The physical data are according with the data reported by Rühlmann¹⁵.

General procedure for the synthesis of 3a-f: 40 % bromine water was added quickly to the stirred mixture of compound **2** (5 g), THF (35 mL) and H₂O (30 mL) until the colour didn't change at room temperature, then allyl alcohol was dropped into the mixture to neutralize the excess of bromine. The resulting solution was extracted with ether (3 × 50 mL), the combined organic phases were dried over MgSO₄. After the removal of the solvent *in vacuo*, the residue was subjected to chromatography through a silica gel column with petroleum ether/ethyl acetate to yield compound **3**. The physical and spectra data of the compounds **3a-f** are as follows.

1,2-Cyclododecandione (3a): Yellow solid, yield 79 %, m.p. 39-41 °C (lit.¹⁶ 40-42 °C) IR (KBr, ν_{\max} , cm⁻¹): 2936, 2875, 1705. ¹H NMR(CDCl₃, 400MHz) δ : 2.81 (t, *J* = 6 Hz, 4H, H3, H12), 1.75 (m, 4H, H4, H11), 1.38 (m, 12H, H5-10). ¹³C NMR

(CDCl₃, 400 MHz) δ : 202.06, 77.06, 35.25, 26.21, 25.09, 23.39, 22.67, 22.30.

1,2-Cyclodecanedione (3b): Yellow solid, yield 65 %, m.p. 32-34 °C (lit.¹⁶ 32-34 °C) IR (KBr, ν_{\max} , cm⁻¹): 2936, 2856, 1669. ¹H NMR (CDCl₃, 400 MHz) δ : 2.64 (t, *J* = 6 Hz, 4H, H3, H10), 1.93 (m, 4H, H4, H9), 1.47 (m, 4H, H5, H8), 1.23 (m, 4H, H6, H7); MS (EI) *m/z*: 168.1 (M⁺), 121.0, 98.1, 55.0, 41.0, 27.0.

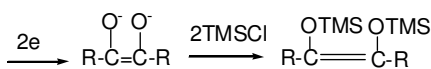
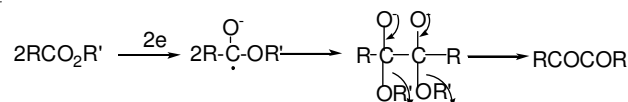
1,2-Cyclononanedione (3c)¹⁶: Pale yellow liquid, yield 17 %, IR (KBr, ν_{\max} , cm⁻¹): 2936, 2875, 1702. ¹H NMR (CDCl₃, 400 MHz) δ : 2.72 (t, *J* = 6.4 Hz, 4H, H3, H9), 1.86 (m, 4H, H4, H8), 1.52 (m, 4H, H5, H7), 1.28 (m, 2H, H6). MS(EI) *m/z*: 154.0 (M⁺), 98.0, 84.0, 55.0, 41.0, 27.0.

18,19-Hexatriacontanedione (3d): IR (KBr, ν_{\max} , cm⁻¹): 2926, 2854, 1713, 1464. ¹H NMR (CDCl₃, 400 MHz) δ : 2.71 (t, 4H), 1.57-1.59 (m, 4H), 1.24-1.29 (m, 60H), 0.89 (t, 6H). MS(EI) *m/z* (%): 534.4 (M⁺), 268, 240, 43.

6,7-Dodecandione (3e)¹⁷: Pale yellow liquid, yield 69 %, IR (KBr, ν_{\max} , cm⁻¹): 2958, 2934, 1712. ¹H NMR (CDCl₃, 400 MHz) δ : 2.71 (t, *J* = 7.3 Hz, 4H, H5, H8), 1.57 (m, 4H, H4, H9), 1.24-1.29 (m, 8H, H2,3, H10-11), 0.88 (m, 6H, H1, H12). MS(EI) *m/z* (%): 197.0 (M⁺-H), 151.9, 99.0, 71.1, 43.0, 27.0.

4,5-Decanedione (3f): Pale yellow liquid, yield 57 %, b.p. 60-62 °C/12 mmHg (lit.¹⁸ 70-71 °C/24 mmHg), IR (KBr, ν_{\max} , cm⁻¹): 2971, 2940, 1718. ¹H NMR (CDCl₃, 400 MHz) δ : 2.72 (t, *J* = 7.2 Hz, 4H, H3, H6), 1.65 (q, 4H, H2, H7), 0.89 (q, 6H, H1, H8). MS (EI) *m/z* (%): 142.0 (M⁺), 101.0, 71.0, 43.0, 27.0

In the present studies, we reported a rapid and convenient method for the synthesis of α -diketones under ambient conditions. α -Ditrimethylsiloxyenes were obtained from the readily available materials diacids or diesters through acyloin condensation. The suggested mechanism for the compounds **2** is shown in **Scheme-II**.

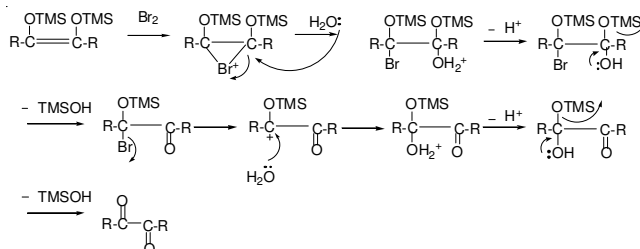


Scheme-II

The compounds **2** was oxidized to α -diketones using bromine as the oxidation reagent in the presence of water. The structure of α -diketones **3a-f** was characterized by IR, EI-MS and ¹H NMR spectra. The compound **3a** for example, the IR spectra showed a strong carbonyl absorption band at 1705 ν (C=O) cm⁻¹. In the ¹H NMR spectra the methylene protons connected to C=O clearly split to triplet at δ 2.81, which contributed to the methylene adjacent to it and the other eight methylene

units showed the multiplet peaks at δ 1.75 and δ 1.38. Because of the symmetric structure, in the ¹³C NMR spectra, only six carbon signals can be seen, which showed at δ 202.06, 77.06, 35.25, 26.21, 25.09, 23.39, 22.67, 22.30. The other target compounds are also characterized by IR, EI-MS and ¹H NMR.

Although the exact reaction mechanism has not been confirmed, on the basis of the above-mentioned reaction results, it is reasonable to propose a mechanism for the formation of α -diketones (**Scheme-III**).



Scheme-III

Conclusion

A rapid and efficient synthesis method is successively developed for α -diketones. The reaction conditions are mild with moderate to excellent yield. All of the products are characterized by IR, ¹H NMR, MS spectral data .

ACKNOWLEDGEMENTS

The authors acknowledge the Hebei Natural Science Foundation of China for financial support. (No. B200400278).

REFERENCES

- D.R. Bender, L.F. Bjeldanes and H. Rapoport, *J. Org. Chem.*, **40**, 1264 (1975).
- J.C. Sheehan and Y.S. Lo, *J. Org. Chem.*, **40**, 191 (1975).
- S. Matsubara, K. Ukai, H. Fushimi, Y. Yokota, H. Yoshino, K. Oshima, K. Omoto, A. Ogawa, Y. Hioki and H. Fujimoto, *Tetrahedron*, **58**, 8255 (2002).
- A. Flores-Gaspar, P. Pinedo-González, M.G. Crestani, M. Muñoz-Hernández, D. Morales-Morales, B.A. Warsop, W.D. Jones and J.J. García, *J. Mol. Catal. A: Chem.*, **309**, 1 (2009).
- S.P. Palli and A.B. Dobrov, *J. Coord. Chem.*, **22**, 282 (1996).
- E.P. Balskus, R.M. Arbit and L.A. Paquette, *J. Org. Chem.*, **66**, 6695 (2001).
- G. Ruledi, M.A. Oberli and M. Nagel, *Org. Lett.*, **6**, 3179 (2004).
- B. Gregoire, M.C. Carre and P. Caubere, *J. Org. Chem.*, **51**, 1419 (1986).
- R.H. Mitchell and V.S. Iyer, *Tetrahedron Lett.*, **34**, 3683 (1993).
- Z.G. Yao, W. Ren and X.B. Wan, CN 101337866A (2008).
- M.C. Carre and P. Caubere, *Tetrahedron Lett.*, **26**, 3103 (1985).
- F. Hagig, S. Alireza and B. Husan, *Bull. Chem. Soc. (Japan)*, **69**, 685 (1996).
- J.M. Khurana and B.M. Kandpal, *Tetrahedron Lett.*, **44**, 4909 (2003).
- V. Prelog and L. Frenkiel, *Helv. Chim. Acta*, **30**, 1741 (1947).
- K. Rühlmann, *Synthesis*, **5**, 236 (1971).
- B. Gregoire, M.C. Carre and P. Caubere, *J. Org. Chem.*, **51**, 1419 (1986).
- N.J. Leonard, H.A. Laitinen and E.H. Mottus, *J. Org. Chem.*, **75**, 3300 (1953).
- S. Kashimura, Y. Murai and C. Washika, *Tetrahedron Lett.*, **38**, 6717 (1997).