Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/lsyc20

# Knoevenagel Condensation Catalyzed by a Mexican Bentonite Using Infrared Irradiation

Francisco Delgado [a] , Joaquin Tamariz [a] , Gerard Zepeda [a] , Miguel Landa [b] , René Miranda [b] & José García [b]

[a] Escuela Nacional de Ciencias Biológicas-IPN, Depto. de Quimica Orgánica , Prolongación Carpio y Plan de Ayala, Casco de Santo Tomás, México , D.F., C.P., 11340.

[b] Facultad de Estudios Superiores Cuautitlán-UNAM, Depto. de Química Orgánica , Sección de Química Orgánica, Campo 1, Av. Quetzalcoatl s/n, Cuautitlán Izcalli Estado de, México , C.P., 54740

To cite this article: Francisco Delgado , Joaquin Tamariz , Gerard Zepeda , Miguel Landa , René Miranda & José García (1995) Knoevenagel Condensation Catalyzed by a Mexican Bentonite Using Infrared Irradiation, Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry, 25:5, 753-759, DOI: 10.1080/00397919508011413

To link to this article: http://dx.doi.org/10.1080/00397919508011413

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the “Content”) contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at [http://www.tandfonline.com/page/terms-and-conditions](http://www.tandfonline.com/page/terms-and-conditions)

Downloaded by [McGill University Library] at 02:19 03 February 2015

SYNTHETIC COMMUNICATIONS, 25(5), 753-759 (1995)

# KNOEVENAGEL CONDENSATION CATALYZED BY A MEXICAN BENTONITE USING INFRARED IRRADIATION

Francisco Delgado (1),* Joaquín Tamariz (1), Gerardo Zepeda (1), Miguel Landa (2),
René Miranda (2) and José García (2).

(1) Escuela Nacional de Ciencias Biológicas-IPN, Depto. de Química Orgánica,
Prolongación Carpio y Plan de Ayala, Casco de Santo Tomás, México, D.F.,
C.P. 11340.
(2) Facultad de Estudios Superiores Cuautitlán-UNAM, Depto. de Química Orgánica,
Sección de Química Orgánica, Campo 1, Av. Quetzalcoatl s/n, Cuautitlán Izcalli, Estado
de México, C.P. 54740.

**ABSTRACT**: Diethyl malonate undergoes condensation with aromatic aldehydes without solvents, in the presence of a Mexican bentonite using infrared irradiation as the energy source, to give the benzylidenemalonate compounds in fair yield.

The Knoevenagel condensation is a base-catalyzed reaction, but has also been performed with acid catalysts. Commonly, it is promoted by weak bases under homogeneous conditions (pyridine,[1] piperidine,[2] $TiCl_4$-pyridine[3]) or heterogeneous conditions (xonotlite/*t*-butoxide,[4] montmorillonite/silylpropylethylenediamine[5] and aluminium oxide[6]).

As a part of our research work, we have shown that *Tonsil*, a bentonitic clay,[7] is an efficient heterogeneous acid catalyst for the conversion of various imino derivatives to the corresponding carbonyl compounds,[8] the generation of dithiolanes from ketones,[9] the solvolytic opening of oxiranes,[10] as well as for the preparation of phenylmethanes from toluene.[11] We have also demonstrated that the conversion of aromatic aldehydes to the corresponding nitriles with

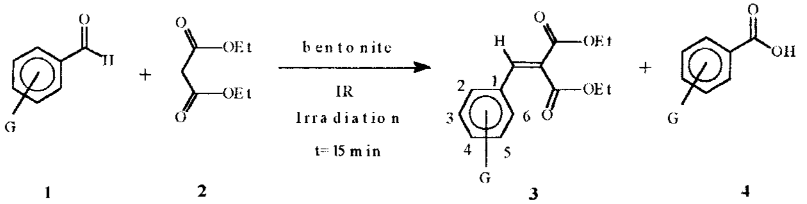
---

*To whom correspondence should be addressed hydroxylamine hydrochloride can be effectively accomplished by the use of the clay in the presence of infrared or microwave irradiation.[12]

Hereby, we report a novel way to induce the Knoevenagel condensation of diethyl malonate with aromatic aldehydes by the use of Mexican bentonite and infrared irradiation, in the absence of a solvent. The results are summarized in Table I, showing that the corresponding benzylidenemalonates **3a-3i** are obtained in competitive yields with respect to other methods previously reported.[2,13]

It also shows that the highest yields were obtained from aldehydes **1f-1i**, suggesting that the presence of electron-withdrawing groups in the aromatic ring favors the Knoevenagel condensation. In all cases, the best yields of condensation were obtained by 15 min irradiation, while longer times favor the formation of carboxylic acids 4 as side products.

**Table I.** IR-Promoted Condensation of Diethyl malonate (2) and Aromatic Aldehydes (1) Catalyzed by Bentonite.



| Compound | G | Yields (%) | |
|---|---|---|---|
| | | **3** | **4** |
| **3a** | H | 32 | 5 |
| **3b** | *p*-OH | 25 | 13 |
| **3c** | *p*-N(Me)$_2$ | 48 | 3 |
| **3d** | *p*-OMe | 57 | 10 |
| **3e** | *o*-OMe | 38 | 17 |
| **3f** | *p*-Br | 61 | 7 |
| **3g** | *p*-Cl | 67 | 5 |
| **3h** | *p*-NO$_2$ | 73 | 2 |
| **3i** | *m*-NO$_2$ | 64 | 3 |

In addition, this method was not applicable for the conversion of aliphatic aldehydes into alkylidenemalonates, since only polymeric products were produced. In conclusion, the use of the Mexican bentonitic earth coupled with infrared irradiation promotes the Knoevenagel condensation of diethyl malonate with aromatic aldehydes. This method proved to be an alternative to conventional and moisture-sensitive homogeneous acid catalysis, without the frequent troublesome manipulation and work-up.

## EXPERIMENTAL SECTION

Melting points were obtained on a Fisher-Johns apparatus and boiling points on a Kugelrohr apparatus; both are uncorrected. $^1$H and $^{13}$C NMR spectra were recorded on a Varian Gemini 300 spectrometer at 300 MHz and 75 MHz, respectively, in deuterochloroform with tetramethylsilane (TMS) as an internal reference. Mass spectrometric analyses were carried out on a Hewlett-Packard 5971 GC/MS instrument. Infrared spectra were recorded on a Perkin-Elmer 283B spectrophotometer. Column chromatography were performed on silica gel 60 (230-400 mesh).

**A typical procedure. Preparation of diethyl benzylidenemalonate (3a):** A mixture of **2** (1 g, 0.006 mmol), aldehyde **1** (1 g, 0.009 mmol) and Mexican bentonite[7] (3 g) was stirred in a round bottom flask equipped with a conventional condenser and irradiated for 15 min by an infrared lamp (Osram, 250 watts,127 volts) as reported by Pool and Teuben.[14] The cooled mixture was extracted with ethyl acetate (2 x 25 ml) and the clay was removed by filtration through Celite. The filtrate was concentrated *in vacuo* and then purified by column chromatography on silica gel, eluting with increasing amounts of ethyl acetate in hexane to give **3a** (32%) as an oil: bp 183-185 $^0$C/13 mmHg (lit.[13] 179 $^0$C/10 mmHg); IR (film):1729, 1630 cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.74 (s, 1H, HC=C), 7.47-7.34 (m, 5H, Ar-H), 4.33 (q, J=7.1 Hz, 2H, CH$_3$$\underline{\text{CH}_2}$O), 4.29 (q, J=7.1 Hz, 2H, CH$_3$$\underline{\text{CH}_2}$O), 1.31 (t, J=7.1 Hz, 3H, $\underline{\text{CH}_3}$CH$_2$O), 1.27 (t, J=7.1 Hz, 3H, $\underline{\text{CH}_3}$CH$_2$O); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 166.4 (C=O), 163.8 (C=O), 141.8 (HC=C), 132.6 (C$_1$, Ar), 130.3 (C$_4$, Ar), 129.1 ($C_3$ and $C_5$, Ar), 128.5 ($C_2$ and $C_6$, Ar), 126.0 (HC=$\underline{C}$), 61.4 ($2CH_3\underline{C}H_2O$), 13.8 ($\underline{C}H_3CH_2O$), 13.6 ($\underline{C}H_3CH_2O$); MS (70 eV) m/z 248 ($M^+$, 30), 203 (50), 158 (45), 130 (49), 102 (100), 77 (35).

The following substituted diethyl benzylidenemalonates were prepared by the same procedure:

**Diethyl *p*-hidroxybenzylidenemalonate (3b):** 25 % yield; mp 113 $^0$C (lit.[13] 116 $^0$C); IR (KBr): 3330, 1728, 1628 $cm^{-1}$; $^1H$ NMR (300 MHz, $CDCl_3$) $\delta$ 7.66 (s, 1H, HC=C), 7.33-6.80 (AA'BB' system, 4H, Ar-H), 6.68 (br s, 1H, O$\underline{H}$), 4.36 (q, J=7.2 Hz, 2H, $CH_3C\underline{H}_2O$), 4.29 (q, J=7.2 Hz, 2H, $CH_3C\underline{H}_2O$), 1.32 (t, J=7.2 Hz, 6H, $2C\underline{H}_3CH_2O$); $^{13}C$ NMR (75 MHz, $CDCl_3$) $\delta$ 167.9 (C=O), 164.8 (C=O), 158.8 ($C_4$, Ar), 142.4 (H$\underline{C}$=C), 131.7 ($C_2$ and $C_6$, Ar), 124.6 ($C_1$, Ar), 122.6 (HC=$\underline{C}$), 115.9 ($C_3$ and $C_5$, Ar), 61.9 ($CH_3\underline{C}H_2O$), 61.7 ($CH_3\underline{C}H_2O$), 14.0 ($\underline{C}H_3CH_2O$), 13.8 ($\underline{C}H_3CH_2O$); MS (70 eV) m/z 264 ($M^+$, 23), 219 (33), 190 (22), 146 (54); 118 (100).

**Diethyl *p*-(*N,N'*-dimethylamino)-benzylidenemalonate (3c):** 48 % yield; mp 108 $^0$C (lit.[13] 110-111 $^0$C); IR (KBr): 1717, 1594 $cm^{-1}$; $^1H$ NMR (300 MHz, $CDCl_3$) $\delta$ 7.63 (s, 1H, HC=C), 7.40-6.59 (AA'BB' system, 4H, Ar-H), 4.38 (q, J=7.1 Hz, 2H, $CH_3C\underline{H}_2O$), 4.27 (q, J=7.1 Hz, 2H, $CH_3C\underline{H}_2O$), 3.02 (s, 6H, $N(C\underline{H}_3)_2$), 1.34 (t, J=7.1 Hz, 3H, $C\underline{H}_3CH_2O$), 1.31 (t, J=7.1 Hz, 3H, $C\underline{H}_3CH_2O$); $^{13}C$ NMR (75 MHz, $CDCl_3$) $\delta$ 168.0 (C=O), 165.0 (C=O), 151.8 ($C_4$, Ar), 142.7 (H$\underline{C}$=C), 131.9 ($C_2$ and $C_6$, Ar), 120.1 ($C_1$, Ar), 119.9 (HC=$\underline{C}$), 111.5 ($C_3$ and $C_5$, Ar), 61.4 ($CH_3\underline{C}H_2O$), 61.1 ($CH_3\underline{C}H_2O$), 40.0 ($N(CH_3)_2$), 14.2 ($\underline{C}H_3CH_2O$), 14.0 ($\underline{C}H_3CH_2O$); MS (70 eV) m/z 291 ($M^+$, 85), 246 (65), 217 (26), 173 (44), 145 (100), 101 (23).

**Diethyl *p*-methoxybenzylidenemalonate (3d):** 57 % yield; bp 175-178 $^0$C/13 mmHg (lit.[13] 180 $^0$C/11 mmHg); IR (film): 1726, 1604 $cm^{-1}$; $^1H$ NMR (300 MHz, $CDCl_3$) $\delta$ 7.61 (s, 1H, HC=C), 7.36-6.69 (AA'BB' system, 4H, Ar-H), 4.43 (q, J=7.1 Hz, 2H, $CH_3C\underline{H}_2O$), 4.37 (q, J=7.1 Hz, 2H, $CH_3C\underline{H}_2O$), 3.76 (s, 3H, $C\underline{H}_3O$), 1.39 (t, J=7.1 Hz, 3H, $C\underline{H}_3CH_2O$), 1.33 (t, J=7.1 Hz, 3H,

$C\underline{H}_3CH_2O$); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 168.5 (C=O), 167.3 (C=O), 157.5 ($C_4$, Ar), 149.2 ($H\underline{C}$=C), 135.8 ($C_2$ and $C_6$, Ar), 130.8 ($C_1$, Ar), 121.1 (HC=$\underline{C}$), 115.5 ($C_3$ and $C_5$, Ar), 61.7 ($CH_3\underline{C}H_2O$), 61.4 ($CH_3\underline{C}H_2O$), 55.0 ($CH_3O$), 14.4 ($\underline{C}H_3CH_2O$), 14.2 ($\underline{C}H_3CH_2O$); MS (70 eV) m/z 278 ($M^+$, 36), 233 (26), 188 (39), 173 (100), 145 (57), 117 (15).

**Diethyl *o*-methoxybenzylidenemalonate (3e):** 38 % yield; bp 190-195 $^0$C/13 mmHg (lit.[13] 200-217 $^0$C/14 mmHg); IR (film): 1726, 1607 cm$^{-1}$; $^1$H NMR (300 MHz, $CDCl_3$) δ 8.09 (s, 1H, HC=C), 7.81-6.85 (m, 4H, Ar-H), 4.28 (q, J=7.2 Hz, 2H, $CH_3C\underline{H}_2O$), 4.27 (q, J=7.2 Hz, 2H, $CH_3C\underline{H}_2O$), 3.87 (s, 3H, $C\underline{H}_3O$), 1.31 (t, J=7.2 Hz, 3H, $C\underline{H}_3CH_2O$), 1.22 (t, J=7.2 Hz, 3H, $C\underline{H}_3CH_2O$); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 166.4 (C=O), 164.0 (C=O); 157.7 ($C_2$, Ar); 137.8 ($H\underline{C}$=C), 131.7 ($C_4$, Ar), 128.8 ($C_6$, Ar), 125.8 ($C_1$, Ar), 124.6 (HC=$\underline{C}$), 121.9 ($C_5$, Ar), 110.5 ($C_3$, Ar), 61.1 ($\underline{C}H_3O$), 55.2 ($CH_3\underline{C}H_2O$), 55.1 ($CH_3\underline{C}H_2O$), 13.8 ($\underline{C}H_3CH_2O$), 13.6 ($\underline{C}H_3CH_2O$); MS (70 eV) m/z 278 ($M^+$, 24), 233 (30), 188 (45), 173 (100), 145 (48), 117 (27).

**Diethyl *p*-bromobenzylidenemalonate (3f):** 61 % yield; bp 198-200 $^0$C/13 mmHg (lit.[13] 176 $^0$C/2 mmHg); IR (film): 1730, 1631 cm$^{-1}$; $^1$H NMR (300 MHz, $CDCl_3$) δ 7.65 (s, 1H, HC=C), 7.52-7.29 (AA'BB' system, 4H, Ar-$\underline{H}$), 4.35 (q, J=7.1 Hz, 2H, $CH_3C\underline{H}_2O$), 4.30 (q, J=7.1 Hz, 2H, $CH_3C\underline{H}_2O$), 1.31 (t, J=7.1 Hz, 3H, $C\underline{H}_3CH_2O$), 1.29 (t, J=7.1 Hz, 3H, $C\underline{H}_3CH_2O$); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 166.2 (C=O), 163.7 (C=O); 140.5 ($H\underline{C}$=C), 131.9 ($C_3$ and $C_5$, Ar), 131.6 ($C_1$, Ar), 130.6 ($C_2$ and $C_6$, Ar), 127.5 ($C_4$, Ar)*, 124.8 (HC=$\underline{C}$)*, 61.6 ($CH_3\underline{C}H_2O$), 61.3 ($CH_3\underline{C}H_2O$), 13.9 ($\underline{C}H_3CH_2O$), 13.7 ($\underline{C}H_3CH_2O$); MS (70 eV) m/z 328 ($M^+$, 17), 283 (28), 238 (10), 210 (21), 182 (86), 157 (100), 102 (88).

**Diethyl *p*-chlorobenzylidenemalonate (3g):** 67 % yield; bp 195-198 $^0$C/13 mmHg (lit.[13] 171-173 $^0$C/1 mmHg); IR (film): 1726, 1634 cm$^{-1}$; $^1$H NMR (300 MHz, $CDCl_3$) δ 7.70 (s, 1H, HC=C), 7.42-7.34 (AA'BB' system, 4H, Ar-H), 4.34 (q, J=7.2 Hz, 2H, $CH_3C\underline{H}_2O$), 4.30 (q, J=7.2 Hz, 2H, $CH_3C\underline{H}_2O$), 1.34 (t, J=7.2 Hz, 3H, $C\underline{H}_3CH_2O$), 1.31 (t, J=7.2 Hz, 3H, $C\underline{H}_3CH_2O$); MS (70 eV) m/z 282 ($M^+$, 28), 237 (66), 192 (16); 164 (46), 136 (100), 101 (37).

**Diethyl *p*-nitrobenzylidenemalonate (3h):** 73 % yield; mp 88 $^{0}$C (lit.[13] 92-92.5 $^{0}$C); IR (KBr): 1727, 1637 cm$^{-1}$; $^{1}$H NMR (300 MHz, $CDCl_3$) δ 8.26-7.60 (AA'BB' system, 4H, Ar-H), 7.76 (s, 1H, HC=C), 4.34 (q, J=7.2 Hz, 2H, $CH_3C\underline{H}_2O$), 4.33 (q, J=7.2 Hz, 2H, $CH_3C\underline{H}_2O$), 1.35 (t, J=7.2 Hz, 3H, $C\underline{H}_3CH_2O$), 1.28 (t, J=7.2 Hz, 3H, $C\underline{H}_3CH_2O$); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 165.6 (C=O), 163.3 (C=O), 148.4 (H$\underline{C}$=C), 139.2 ($C_1$, Ar), 139.1 ($C_4$, Ar), 130.0 (HC=$\underline{C}$), 129.9 ($C_3$ and $C_5$, Ar), 123.9 ($C_2$ and $C_6$, Ar), 62.1 ($CH_3\underline{C}H_2O$), 62.0 ($CH_3\underline{C}H_2O$), 14.1 ($\underline{C}H_3CH_2O$), 13.9 ($\underline{C}H_3CH_2O$); MS (70 eV) m/z 293 ($M^+$, 15), 248 (60), 203 (100), 175 (62), 147 (87), 101 (37).

**Diethyl *m*-nitrobenzylidenemalonate (3i):** 64 % yield; mp 70 $^{0}$C (lit.[13] 74.5 $^{0}$C); (KBr): 1727, 1637 cm$^{-1}$; $^{1}$H NMR (300 MHz; $CDCl_3$) δ 8.35 (t, J= 2.2 Hz, Ar-$H_2$), 8.25 (ddd, J=8.2 Hz, J=2.2 Hz, J=1.1 Hz, Ar-$H_4$), 7.78 (dd, J=8.2 Hz, J=1.1 Hz, Ar-$H_6$), 7.75 (s, 1H, HC=C), 7.62 (t, J=8.2 Hz, Ar-$H_5$), 4.39 (q, J=7.1 Hz, 2H, $CH_3C\underline{H}_2O$), 4.34 (q, J=7.1 Hz, 2H, $CH_3C\underline{H}_2O$), 1.36 (t, J=7.1 Hz, 3H, $C\underline{H}_3CH_2O$), 1.33 (t, J=7.1 Hz, 3H, $C\underline{H}_3CH_2O$); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 165.6 (C=O), 163.3 (C=O), 148.3 ($C_3$, Ar), 138.9 (H$\underline{C}$=C), 135.0 ($C_2$, Ar), 134.5 ($C_1$, Ar), 130.0 ($C_4$, Ar), 129.2 (HC=$\underline{C}$), 124.6 ($C_6$, Ar), 123.5 ($C_5$, Ar), 62.0 ($CH_3\underline{C}H_2O$), 61.9 ($CH_3\underline{C}H_2O$), 13.9 ($\underline{C}H_3CH_2O$), 13.7 ($\underline{C}H_3CH_2O$); MS (70 eV) m/z 293 ($M^+$, 21), 248 (100), 203 (98), 175 (31), 147 (72), 101 (94).

ACKNOWLEDGMENTS: This work has been supported by Dirección de Estudios de Posgrado e Investigación del Instituto Politécnico Nacional (942511). The authors are grateful to F. Labarrios for your technical assistance.

## REFERENCES AND NOTES

1. Knoevenagel, L. *Ber.*, **1898**, *31*, 2585.
2. (a) Pratt, E. F.; Werble, E. *J. Am. Chem. Soc.*, **1950**, *72*, 4638. (b) Cope, A. A. *J. Am. Chem. Soc.*, **1937**, *59*, 2327.
3. (a) Lehnert, W. *Tetrahedron*, **1973**, *29*, 635. (b) Lehnert, W. *Tetrahedron Lett.*, **1970**, *54*, 4753.

4. Chalais, S.; Laszlo, P.; Mathy, A. *Tetrahedron Lett.*, **1985**, *26*, 4453.

5. Subba, Y. V.; Choudary, S. M. *Synth. Commun.*, **1991**, *21*, 1163.

6. Texier-Boullet, F.; Foucad, A. *Tetrahedron Lett.*, **1982**, *23*, 4927.

7. *TONSIL*, at present *Actisil FF*, is a commercial Mexican Bentonitic clay available from Tonsil Mexicana S.A. Examined with X-ray flourescence, this clay proved to have the following composition %: $SiO_2$, 74.5; $Al_2O_3$, 9.3; MgO, 0.4; $Fe_2O_3$, 1.3; CaO, 0.4; $TiO_2$, 0.4; $H_2O$, 9.5 (110 $^0$C). The clay showed a specific surface area of 55.3 $m^2/g$; the interlayer distance was proved to be 15 Å, using parafine as the internal standar reference. It is worth mentioning that quartz and cristobalite are also important components.

8. (a) Alvarez, C.; Cano, A. C.; Rivera, C.; Márquez, C. *Synth. Commun.*, **1987**, *17*, 279. (b) Cano, A. C.; Delgado, F.; Córdova, A. A.; Márquez, C.; Alvarez, C. *Synth. Commun.*, **1988**, *18*, 2051.

9. Miranda, R.; Cervantes, H.; Joseph-Nathan, P. *Synth. Commun.*, **1990**, *20*, 153.

10. Cabrera, A.; Rosas, N.; Márquez, C.; Salmón, M.; Miranda, R.; Angeles, E.; Lozano, R. *Gazz. Chim. Ital.*, **1991**, *121*, 127.

11. Salmón, M.; Miranda, R.; Angeles, E. *J. Chem. Soc., Chem. Commun.*, **1990**, 1188.

12. Delgado, F.; Cano, A. C.; Rudler, H.; García, O.; Alvarado, J.; Velasco, L. ; Alvarez, C. *Synth. Commun.*, **1992**, *22*, 2123.

13. (a) Zabicky, J. *J. Chem. Soc.*, **1961**, 683. (b) Freudenberg, K., *Ber.*, **1951**, *84*, 447

14. Pool, G .C.; Teuben, J. H. *IR Radiation as a Heat Source in Vacuum Sublimation, in: Practical Organometallic Chemistry.* Wayda, A. L.; Darensbourg, M. Y. Eds., Symposium Series 357, Washington, D. C., **1987**, pp 30-33.

(Received in the USA 07 September 1994)