

N-Methyl-3-oxobutanamide

20306-75-6

OVERVIEW

Prepared for the National Cancer Institute (NCI) for consideration by the Chemical Selection Working Group (CSWG) by Technical Resources International, Inc. under contract no. N02-07007.

N-Methyl-3-oxobutanamide came to the attention of the National Cancer Institute (NCI) Division of Cancer Biology as the result of a review of high production chemicals in commerce that do not meet the criteria for inclusion in the United States (U.S.) Environmental Protection Agency (EPA) HPV Challenge Program. This chemical has applications in chemical synthesis, including pesticides, and as a coupling agent for pigment manufacture.

The available information on N-methyl-3-oxobutanamide is insufficient to establish a toxicological profile for this chemical. The only toxicological data identified in the available literature consisted of acute toxicity and mutagenicity studies. During the discussion of this compound at the Chemical Selection Planning Group (CSPG) meeting, the concern that this chemical may undergo metabolic transformation to more reactive species was expressed.

NOMINATION OF N-METHYL-3-OXOBUTNAMIDE TO THE NTP

Based on a review of the available literature and the recommendations of the Chemical Selection Working Group (CSWG) on December 15, 2004, NCI nominates this chemical for testing by the National Toxicology Program (NTP) and forwards the following information:

- The attached Summary of Data for Chemical Selection
- Copies of references cited in the Summary of Data for Chemical Selection
- CSWG recommendations to:
 - (1) Conduct genetic toxicology tests to examine clastogenicity and mutagenicity, e.g., Ames battery in *Salmonella typhimurium* and *in vivo* micronucleus assay

- (2) Conduct absorption, distribution, metabolism, and excretion studies with special emphasis on the possibility of nitrosation and the formation of formaldehyde as a breakdown product. Attention to possible species differences should be given.

PRIORITY

The CSWG suggested that the recommended testing be conducted with high priority.

COMMENTS

N-methyl-3-oxobutanamide is a contaminant of several pesticides widely used in the past. It is also a metabolite of these chemicals. Information from the recommended tests will assist in determining whether past exposure to N-methyl-3-oxobutanamide from pesticide use is a concern.

SUMMARY OF DATA FOR CHEMICAL SELECTION

CHEMICAL IDENTIFICATION

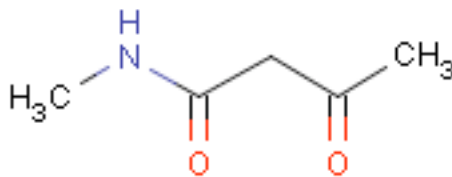
CAS Registry No: 20306-75-6

Chemical Abstracts Service Name: Butanamide, N-methyl-3-oxo- (9CI)

Synonyms and Trade Names: N-Methyl-3-oxobutanamide; acetoacetic-monomethylamide; 2-acetyl-N-methylacetamide; EINECS 243-723-9; N-methyl-acetoacetamide; N-methyl-3-oxobutayramide; MMAA; N-monomethylacetoacetamide; SD 9112 (ChemFinder, 2004; ChemIDplus, 2004; European Commission, 2000a)

Structural Class: Diketene derivative

Structure, Molecular Formula, and Molecular Weight:



Chemical and Physical Properties:

Description: Clear yellow liquid with a strong fish-like odor (European Commission, 2000a; Sigma Aldrich MSDS, 2004)

Melting Point: -3 °C (Fisher Scientific MSDS, 2003)
Boiling Point: 106 °C (Sigma Aldrich, 2004); 118 °C at 6.7 hPa (European Commission, 2004a)

| | |
|-----------------------------------|--|
| <u>Solubility:</u> | Soluble in water and in polar organic solvents; slightly soluble in nonpolar organic solvents (European Commission, 2000a) |
| <u>Density/Specific Gravity:</u> | 1.069 (Fisher Scientific MSDS, 2003) |
| <u>Flash Point:</u> | 105 °C, closed cup (Sigma Aldrich MSDS, 2004) |
| <u>Reactivity:</u> | Stable; hazardous polymerization will not occur; incompatible with strong oxidizing agents (Sigma Aldrich MSDS, 2004) |
| <u>O/W Partition Coefficient:</u> | Log P _{O/W} = -1.046 (European Commission, 2000a) |

Technical Products and Impurities:

N-Methyl-3-oxobutanamide is available from Sigma Aldrich and Fisher Scientific as a 70% aqueous solution (Fisher Scientific, 2004; Sigma Aldrich, 2004).

EXPOSURE INFORMATION

Production and Producers:

Manufacturing Process. Alkylacetoacetamides are often made by reaction of diketene and the corresponding alkylamines in aqueous solutions. They are traded mostly as aqueous solutions, which in the case of the N-monoalkyl derivatives have limited stability and require refrigeration for prolonged storage (Abaecherli & Miller, 1995).

N-methyl-3-oxobutanamide is produced from monomethylamine and diketene (Dupont, 2003).

Producers and Importers. According to Chemical Sources International, there are four U.S. suppliers of N-methyl-3-oxobutanamide (Chemical Sources International, 2004).

The following companies are manufacturers or distributors of N-methyl-3-oxobutanamide: Acros - USA; Camphor Technologies, Inc.; Daicel Chemical Industries, Ltd.; Lonza Inc.; SK Energy & Chemical; TCI; Wacker-Chemie GMBH (ChemACX, 2004; ChemBuyersGuide.com, 2004; Chemical Information Services, 2004; Tilton, 2003).

Production/Import/Export Level. The EPA's Inventory Update Rule reports the production levels of chemicals every 4 years. The production levels of N-methyl-3-oxobutanamide during the years 1986 to 2002 are listed in Table 1.

Table 1. Production Levels of N-Methyl-3-oxobutanamide

| Year | Production Range (lbs.) |
|-------------|--------------------------------|
| 1986 | > 500,000 - 1,000,000 |
| 1990 | 10,000 - 500,000 |
| 1994 | 10,000 - 500,000 |
| 1998 | > 1,000,000 - 10,000,000 |
| 2002 | No Reports |

Source: EPA, 2004

N-Methyl-3-oxobutanamide is also listed as an HPV chemical in Europe, implying that over 1,000 metric tons were produced or imported between 1990 and 1994 (ESIS, 2004).

Use Pattern:

N-Methyl-3-oxobutanamide has applications in several industries as an intermediate in the preparation of pesticides, e.g., monocrotophos, and as a coloring agent. It is used as a coupling agent for pigment manufacture, in textile processing, and in polyester curing (Abaecherli & Miller, 1995; Dupont, 2003; European Commission, 2000a).

Acetoacetamides produced from small-chain aliphatic amines are used in the manufacture of systematic insecticides such as monocrotophos (Azodrin) and dicrotophos (Bidrin), phosphamidon (Dimecron), and oxamyl (Vydate) (Abaecherli & Miller, 1995).

Monocrotophos and dicrotophos are systemic insecticides that once were used in a wide range of applications. In the United States, the Pesticide Registration Status of monocrotophos is cancelled, but dicrotophos is the active ingredient in three products, Anvac Bidrin 8 water miscible insecticide, Dupont technical Bidrin insecticide, and Mauget Inject-a-cide B. Oxamyl is the active ingredient in three pesticide products, Dupont Oxamyl Technical 42 insecticide/nematicide, Vydate C-LV insecticide/nematicide, and Vydate L insecticide/nematicide. Ciba-Geigy announced voluntary cancellation of phosphamidon in 1990 (California Environmental Protection Agency, 2004a-c, Ciba-Geigy, 1990).

N-Methyl-3-oxobutanamide can also be an impurity in pesticides prepared from this chemical. Analysis of a typical sample of technical monocrotophos found 2% N-methyl-3-oxobutanamide by weight (WHO, 1972).

N-Methyl-3-oxobutanamide is cited in three U.S. patents from 1976 to the present. N-monomethylacetoacetamide and monomethyl acetoacetamide are both cited in only one U.S. patent from 1976 to the present (United States Patent and Trademark Office, 2004).

Human Exposure:

Occupational Exposure. In Europe, worker exposure during the production of N-methyl-3-oxobutanamide is thought to be low because it is prepared in an apparent state-of-art facility (European Commission, 2000a).

N-methyl-3-oxobutanamide has other applications where processing or use is unlikely to be performed in large-scale closed systems and where lower levels of protection may be available to workers. In these situations, it is presumed that worker exposure could be more substantial.

Since N-methyl-3-oxobutanamide can be present as a contaminant in certain pesticides, occupational exposure to these pesticides through inhalation or dermal contact during or after application to foliage or at workplaces where they are produced would result in exposure to N-methyl-3-oxobutanamide. Mammalian metabolism studies have shown that two of the pesticides are metabolized, in part, to N-methyl-3-oxobutanamide, thus accounting for an additional source of exposure to this compound (Health Council of the Netherlands, 2003a,b; HSDB, 2004; WHO, 1972).

No listing was found for N-methyl-3-oxobutanamide in the National Occupational Exposure Survey (NOES), which was conducted by the National Institute for Occupational Safety and Health (NIOSH) between 1981 and 1983.

Environmental Exposure. One means of human exposure to N-methyl-3-oxobutanamide from the environment would occur in areas where monocrotophos or dicrotophos have been applied. Production and use of N-methyl-3-oxobutanamide may also result in its release to the environment through various waste streams.

In the European Union, environmental release from production is expected to be low because production occurs in an emissions-free plant and the exhaust air is incinerated (European Commission, 2000a).

Consumer Exposure. Non-occupational exposure to pesticides containing N-methyl-3-oxobutanamide as a contaminant or that produce this substance as a metabolite can occur from inhalation of ambient air or ingestion of contaminated food (HSDB, 2004), thus resulting in exposure to N-methyl-3-oxobutanamide.

Environmental Occurrence:

No information was found on the occurrence of N-methyl-3-oxobutanamide in the environment.

Only limited information on the toxicity of N-methyl-3-oxobutanamide in terrestrial or aquatic species was found. The 30 minute EC₅₀ in activated sludge was > 16,000 mg/l. The 96-hr LC₅₀ in *Salmo gairdneri* (rainbow trout) was > 1,000 mg/l (European Commission, 2000a).

Regulatory Status:

No standards or guidelines have been set by NIOSH or OSHA for occupational exposure to or workplace allowable levels of N-methyl-3-oxobutanamide. N-methyl-3-oxobutanamide was not on the American Conference of Governmental Industrial Hygienists (ACGIH) list of compounds for which recommendations for a Threshold Limit Value (TLV) or Biological Exposure Index (BEI) are made.

TOXICOLOGICAL INFORMATION

Human Data:

No epidemiological studies or case reports investigating exposure to N-methyl-3-oxobutanamide and cancer risk in humans were identified in the available literature.

Animal Data:

Acute Studies. The oral LD₅₀ for N-methyl-3-oxobutanamide in rats was reported to be > 3,200 mg/kg. The dermal LD₅₀ for N-methyl-3-oxobutanamide in guinea pigs was > 1,000 mg/kg (European Commission, 2000a).

N-Methyl-3-oxobutanamide caused a slight irritant action in the skin of guinea pigs and the eyes of rabbits. In guinea pigs, this compound produced a slight sensitization of the skin (European Commission, 2000a).

Repeated Dose Toxicity. N-methyl-3-oxobutanamide was administered to rats in the diet at 90 or 940 mg/kg/day for 10 days. Measured parameters included food intake, body weight, hematology, clinical signs and chemistry, macro- and microscopical pathology, and organ weights. The no observable adverse effect level (NOAEL) in this study was reported to be 90 mg/kg. Animals given 940 mg/kg in the diet were reported to have a slight increase in relative liver weight and relative and absolute kidney weights. No other information was reported in this industry-supplied abstract (European Commission, 2000a).

Subchronic and Chronic Studies. No chronic or carcinogenicity studies of N-methyl-3-oxobutanamide in animals were identified in the available literature.

Short-term Tests:

Reviews of the literature produced very little information on the potential genotoxicity of N-methyl-3-oxobutanamide. This chemical was described as negative in *Salmonella*

typhimurium TA98, TA100, TA1535, TA1537, and TA1538 with and without S-9 when 2-200 Φ l was applied per plate in an industry-reported abstract (European Commission, 2000a).

Metabolism:

No studies on the metabolism of N-methyl-3-oxobutanamide were found in the available literature.

In mammals, including rats, mice, dogs, rabbits, and goats, metabolites of bidrin (dicrotophos) consisted mainly of hydrolysis products, with substantial amounts of azodrin and smaller amounts of hydroxymethyl bidrin, hydroxymethyl azodrin and desmethyl azodrin. Trace amounts of N-methyl-3-oxobutanamide and 3-hydroxy-N,N-dimethylbutyramide were identified in the urine of bidrin-treated rats (HSDB, 2004).

In Wistar rats given a single oral dose of 2 mg/kg bw of monocrotophos, the main mechanism of biotransformation was hydrolysis of the P-O vinyl linkage to give dimethyl phosphate and N-methyl-3-oxobutanamide as major metabolites. The latter was further biotransformed into 3-hydroxy-N-butylamide and carbon dioxide (Health Council of the Netherlands, 2003a).

Whether the above biotransformation occurs after direct administration of N-methyl-3-oxobutanamide is unknown. Other potential metabolic pathways involve N-nitrosation of the amide moiety forming a nitrosamide or N-demethylation of N-methyl-3-oxobutanamide resulting in the release of formaldehyde, a known human carcinogen. Nitrosamides are potent carcinogens because they spontaneously decompose to a highly reactive carbonium ion (Kotsonis *et al.*, 1996).

Other Biological Effects:

Reproductive and Developmental Effects. One milligram of N-methyl-3-oxobutanamide was injected into the yolk of 30 fertile white leghorn eggs on day 4 of incubation. Ninety

percent of the eggs hatched with 15 survivors. Teratogenic effects were assessed on day 21 by measuring the embryo's body weight, body length, and length of legs. No abnormalities of the beak, leg, or feathers were observed. The authors concluded that N-methyl-3-oxobutanamide was not teratogenic to hen embryos because no treatment-related effects were found. No statistical analysis or histopathological evaluation was performed in this study (European Commission, 2000a; Roger *et al.*, 1969).

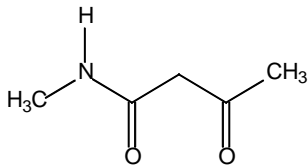
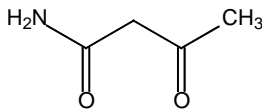
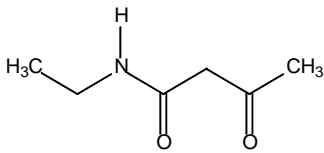
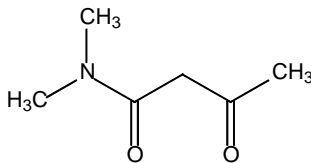
Structure/Activity Relationships:

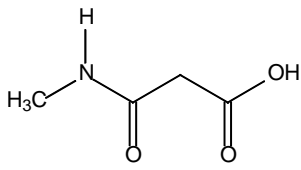
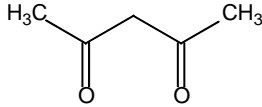
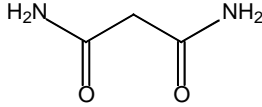
The first chemicals selected for SAR analysis were those containing the 3-oxobutanamide or 3-oxobutanoic acid moiety, resulting in the identification of four chemicals: 3-oxobutanamide, N-ethylacetoacetamide, N,N-dimethylacetoacetamide, and N-methylmalonamic acid.

No carcinogenicity or mutagenicity data were found for 3-oxobutanamide, N-ethylacetoacetamide, or N-methylmalonamic acid. N,N-dimethylacetoacetamide is sponsored by the Color Pigment Manufacturers Association in the EPA's HPV Challenge Program. Basic information is also lacking for this chemical, and the sponsor has submitted a test plan offering to test N,N-dimethylacetoacetamide in the Ames assay and for induction of chromosome aberrations in Chinese hamster lung cells (Color Pigments Manufacturers Association, Inc., 2003).

Acetylacetone and malonamide were also examined for structure activity analysis because they are beta-diketones, having the molecular formula (R-CO-CH₂-CO-R). Acetylacetone is not a strong candidate for SAR analysis because it replaces the amide group with a methyl group. Nonetheless, it does provide information on the reactivity of beta-diketone compounds and available information on the mutagenicity of acetylacetone is shown in Table 2. No carcinogenicity or genotoxicity studies were found for malonamide.

Table 2: Summary of Information on N-Methyl-3-oxobutanamide and Related Compounds

| Chemical Name | Mutagenicity Data |
|---|---|
| <p>N-Methyl-3-oxobutanamide (20306-75-6)</p>  | <p>Negative in <i>S. typhimurium</i> TA98, TA100, TA1535, TA1537, and TA1538 w/wo S-9 (European Commission, 2000a)</p> |
| <p>3-Oxobutanamide (5977-14-0)</p>  | <p>No information found in the available literature</p> |
| <p>N-Ethylacetoacetamide (10138-46-2)</p>  | <p>No information found in the available literature</p> |
| <p>N,N-Dimethylacetoacetamide (2044-64-6)</p>  | <p>No information on repeated dose toxicity, genetic toxicity, developmental or reproductive toxicity, or carcinogenicity was found by the Color Pigments Manufacturers Association. (Color Pigments Manufacturers Association, Inc., 2003)</p> |

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|--|---|
| <p>N-Methylmalonamic acid (42105-98-6)</p>  | <p>No information found in the available literature</p> |
| <p>Acetylacetone (123-54-6)</p>  | <p>Negative in <i>S. typhimurium</i> TA98, TA100, TA1535, TA1537, and TA1538 with or without S-9 (HSDB, 2003)</p> <p>Negative in <i>S. typhimurium</i> TA92 and positive in TA104 without S-9 (CCRIS, 2003)</p> <p>Positive and negative results in <i>E. coli</i> WP2uvrA w/wo S-9 (CCRIS, 2003; European Commission, 2000b)</p> <p>Positive in <i>Bacillus subtilis</i> w/ S-9 but negative w/o S-9 (European Commission, 2000b)</p> <p>Negative in inducing mutations at the HGPRT locus in CHO cells <i>in vitro</i> w/wo S-9 (CCRIS, 2003; HSDB, 2003)</p> <p>Positive for sister chromatid exchanges in CHO cells <i>in vitro</i> with and without S-9. Positive for chromosomal aberrations (CA) in CHO cells <i>in vitro</i> without S-9 and negative in the presence of S-9 (HSDB, 2003)</p> <p>Positive in an <i>in vivo</i> micronucleus (MN) test in the bone marrow cells of mice given a single i.p. injection of acetylacetone (European Commission, 2000b; HSDB, 2003)</p> <p>Negative for CA and MN in rats and for MN in mice <i>in vivo</i> when animals were exposed to acetylacetone vapor for 5 consecutive days (European Commission, 2000b)</p> |
| <p>Malonamide (108-13-4)</p>  | <p>No information found in the available literature</p> |

w/wo = with and without

References

- Abaecherli, C. & Miller, R.J. (1995) Ketenes. In: Kroschwitz, J.I. & Howe-Grant, M., eds., *Kirk-Othmer Encyclopedia of Chemical Technology*, 4th ed., Vol. 14, New York, John Wiley & Sons, Inc., p 971
- California Environmental Protection Agency (2004a) Monocrotophos [6923-22-4]. *USEPA/OPP Chemical Ingredients Database Query*. PC Code 058901. Department of Pesticide Regulation, Sacramento, CA. Accessed through [<http://www.cdpr.ca.gov/docs/epa/epachem.htm>] Searched October 20, 2004
- California Environmental Protection Agency (2004b) Dicrotophos [141-66-2]. *USEPA/OPP Chemical Ingredients Database Query*. PC Code 035201. Department of Pesticide Regulation, Sacramento, CA. Accessed through [<http://www.cdpr.ca.gov/docs/epa/epachem.htm>] Searched October 20, 2004
- California Environmental Protection Agency (2004c) Oxamyl [23135-22-0]. *USEPA/OPP Chemical Ingredients Database Query*. PC Code 103801. Department of Pesticide Regulation, Sacramento, CA. Accessed through [<http://www.cdpr.ca.gov/docs/epa/epachem.htm>] Searched November 18, 2004
- CCRIS (2003) Acetylacetone. *Chemical Carcinogenesis Research Information System*. Record no. 3466. National Library of Medicine, Bethesda, MD. Accessed through [<http://toxnet.nih.gov>] Searched November 2004
- ChemACX (2004) N-Methyl-acetoacetamide [20306-75-6]. *Search results*. [<http://chemacx.cambridgesoft.com/ChemACX/index.asp>] Searched October 19, 2004
- ChemBuyersGuide.com (2004) N-Methyl-acetoacetamide [20306-75-6]. *Search results*. [<http://www.chembuyersguide.com/index.htm>] Searched October 19, 2004
- ChemFinder.com (2004) *N-Methyl-acetoacetamide* [20306-75-6]. Cambridge Software Corporation. [<http://chemfinder.cambridgesoft.com/>] Searched October 19, 2004
- Chemical Information Services (2004) Global Info Centre for N-methylacetoacetamide [20306-75-6]. *DWCP*. [http://chemicalinfo.com/products/dwcp/dwcp_overview.htm] Searched October 19, 2004
- ChemIDplus (2004) *Chemical Identification plus*. [Record no. 020306756]. National Library of Medicine, Bethesda, MD. [<http://chem.sis.nlm.nih.gov/chemidplus>] Searched October 19, 2004
- Chemical Sources International (2004) ALL chemical suppliers for N-methylacetoacetamide. *Chem Sources - Chemical Search*. [http://db.chemsources.com/cgi-bin/foxweb.exe/validate_user@csi/login] Searched October 19, 2004

Ciba-Geigy (1990) Phosphamidon (Dimecron) Voluntary Cancellation 7/90. Letter from J.F. Ellis, Director, Biological Research, Agricultural Division, CIBA GEIGY Corporation, Greensboro, NC. [<http://pmep.cce.cornell.edu/profiles/insect-mite/mevinphos-propargite/phosphamidon/prof-phosphamidon-cancel.html>] Searched November 19, 2004

Color Pigments Manufacturers Association, Inc. (2003) Test plan for N,N-dimethylacetoacetamide. *High Production Volume (HPV) Challenge Program*. [<http://www.epa.gov/chemrtk/dmaa/c14993tp.pdf>] Searched November 4, 2004

Dupont (2003) Agricultural Chemicals. *DuPont Methylamines*. [<http://www.dupont.com/methylamines/uses.html>] Searched November 17, 2004

EPA (2004) Butanamide, N-methyl-3-oxo- [20306-75-6]. *2002 Inventory Update Rule Search Result Page*. [<http://www.epa.gov/oppt/iur/iur02/search03.htm>] Searched October 19, 2004

ESIS (2004) N-Methyl-3-oxobutyramide [20306-75-6]. *European Chemical Substances Information System*. [<http://ecb.jrc.it/esis>] Searched October 19, 2004

European Commission (2000a) N-Methyl-3-oxobutyramide 20306-75-6]. *IUCLID Dataset*. [<http://ecb.jrc.it/IUCLID-Data-Sheet/20306756.pdf>] Searched October 19, 2004

European Commission (2000b) Pentane-2,4-dione [123-54-6]. *IUCLID Dataset*. [<http://ecb.jrc.it/IUCLID-Data-Sheet/123546.pdf>] Searched November 1, 2004

Fisher Scientific (2004) N-Methylacetoacetamide. *Product Detail*. Accessed through [<https://www1.fishersci.com/>] Searched October 19, 2004

Fisher Scientific MSDS (2003) N-Methylacetoacetamide, 70 wt% aqueous solution. *Material Safety Data Sheet*. [<https://fscimage.fishersci.com/msds/25228.htm>] Searched October 19, 2004

Health Council of the Netherlands (2003a) *Monocrotophos*. [<http://www.gr.nl/pdf.php?ID=756>] Searched October 20, 2004

Health Council of the Netherlands (2003b) *Dicrotophos*. [<http://www.gr.nl/pdf.php?ID=752>] Searched October 20, 2004

HSDB (2003) *Hazardous Substances Data Bank*. [Record no. 2064]. Bethesda, MD, National Library of Medicine. Searched November 1, 2004

HSDB (2004) *Hazardous Substances Data Bank*. [Record no.1637]. Bethesda, MD, National Library of Medicine. Searched November 17, 2004

IARC (2004) Formaldehyde, 2-butoxyethanol and 1-*tert*-butoxy-2-propanol. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans*. [<http://www-cie.iarc.fr/htdocs/announcements/vol88.htm>] Searched October 26, 2004

Kotsonis, F.N., Burdock, G.A. & Flamm, W.G. (1996) Food Toxicology. In: Klaassen, C.D., Amdur, M.O. & Doull, J., eds., *Casarett and Doull's Toxicology The Basic Science of Poisons*, 5th ed., New York, McGraw-Hill, p 936

Roger, J.-C., Upshall, D.G. & Casida, J.E. (1969) Structure-activity and metabolism studies on organophosphate teratogens and their alleviating agents in developing hen eggs with special emphasis on bidrin. *Biochemical Pharmacology*, **18**, 373-392

Sigma-Aldrich (2004) N-Methylacetoacetamide solution [20306-75-6]. *Search results for 20306-75-6*. [http://www.sigmaaldrich.com/Area_of_Interest/The_Americas/United_States.html] Searched October 19, 2004

Sigma-Aldrich MSDS (2004) N-Methylacetoacetamide solution, 70% in water, Wacker quality Material Safety Data Sheet. *Search Results for 20306-75-6*. [http://www.sigmaaldrich.com/Area_of_Interest/The_Americas/United_States.html] Searched October 19, 2004

Tilton, H., ed. (2003) N-Methyl acetoacetamide and N-methylacetoacetamide 70% aqueous solution. *OPD Chemical Buyers Directory 2004*, New York, Schnell Publishing Co., p 331

United States Patent and Trademark Office (2004) Results of search (all years) of database for "N-methyl-acetoacetamide," "N-monomethylacetoacetamide," and "monomethyl acetoacetamide." *USPTO Patent Full-Text and Image Database*. [<http://patft.uspto.gov/netahtml/search-bool.html>] Searched October 20, 2004

WHO (1972) Monocrotophos. *Monocrotophos (WHO Pesticide Residues Series 2)*. [<http://www.inchem.org/documents/jmpr/jmpmono/v072pr22.htm>] Searched November 17, 2004