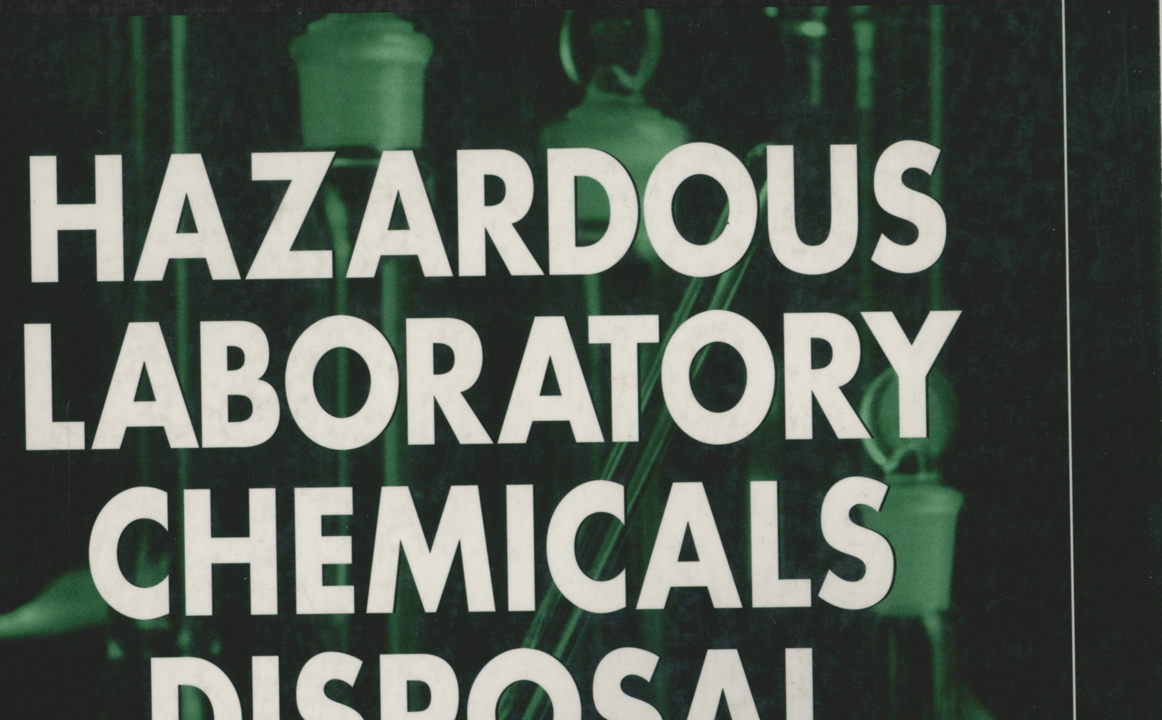
Third Edition



HAZARDOUS LABORATORY CHEMICALS DISPOSAL GUIDE

Margaret-Ann Armour

LEWIS PUBLISHERS

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PREFACE TO THE THIRD EDITION

The information contained in this guide has been compiled from sources believed to be reliable, accurate, and representative of the best opinion on the subject as of 2002. While every reasonable effort has been made to provide dependable information, I cannot assume responsibility for the validity or completeness of all chemical references given or for the consequences of their use.

The first three editions of this book were printed at the University of Alberta. In 1990, the book was published by Lewis Publishers/CRC Press. This is the third edition from the current publisher. The information contained in the first University of Alberta edition was compiled from published material. The second and third University of Alberta editions incorporated new or modified methods for spillage and waste disposal developed in my laboratory. The development and testing of procedures for disposal of small waste or surplus quantities of hazardous chemicals in my laboratory is ongoing. Thus, the previous CRC Press edition included 50 additional entries of chemicals that are animal carcinogens. This edition incorporates 15 chemicals used as pesticides.

I express my gratitude to two colleagues who collaborated in the initiation and early stages of this project. They are Dr. Lois Browne of the Department of Chemistry, University of Alberta, and Gordon Weir of Environmental Health and Safety at the University of Alberta. Without their help and support, this book would not have been possible. Rosemary Bacovsky, a pharmacist especially interested in the disposal of chemotherapeutic drugs, was instrumental in encouraging us to work in this area. The work of developing and testing the disposal methods was undertaken by a team of researchers who also contributed many excellent suggestions and discussions. They include Katherine Ayer, Yvgenia Briker, Hu-Mui Chang, John Crerar, Paul Cumming, William Hunter, Roger Klemm, Jonathan Konrad, Daria Kotovych, Asya Linetsky, Shiraz Merali, Carmen Miller, Carolyn Nelson, Sabina Qureshi, Patricia Rose, Gerard Spytkowski, and Richard Young. I am particularly grateful to Donna Ashick, now at the University of British Columbia, who was involved in the project for over 8 years, both in the practical aspects and in the preparation of the early editions of the guide. Much of the editing work for the second CRC Press edition was done by Sara Salmon; Dr. William Hunter has assisted with the updating of references for this edition. I thank the Chemistry Department at the University of Alberta for infrastructure support and many helpful discussions with its members.

The manuscript was originally entered into a database by Lu Ziola. Diane Dowhaniuk edited the previous editions. The changes to this edition have been entered by Annabelle Wiseman, and her efficiency and willingness to work long hours to meet deadlines are much appreciated. Dr. Kay Simpson, formerly of the Northern Alberta Institute of Technology, directed the checking of several of the waste disposal procedures.

The project has been funded by research grants from the Heritage Grant Program of Alberta Occupational Health and Safety, the Alberta Environmental Research Trust, and the Environmental Partners Program of Environment Canada. Funds have also been received from the Waste Management Branch of Alberta Environmental Protection, and summer students were supported by the Alberta and federal governments through their summer employment programs.

Finally, I have appreciated reactions from readers of the previous editions of this guide. Many of the suggestions have been incorporated into this edition. Comments are solicited on any aspect of the book, and suggestions for chemicals that might be included in future editions are welcome.

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INTRODUCTION

Laboratory workers generate waste chemicals. Increasingly during the past 15 years, it has been recognized that the ideal solution to the disposal of such wastes is to eliminate their generation at source. Much progress has been made and continues to be made in this direction. Chemical users are minimizing waste in several ways. These include scrutinizing procedures to determine whether chemical usage can be modified so that waste is reduced; recovering, recycling and reusing waste where possible; and, especially in academic teaching laboratories, reducing the scale of experiments.

However, the disposal of small quantities of a large variety of chemical wastes that are generated, for example, in school, college, and university laboratories, hospital pharmacies and research, and analytical and quality control laboratories, can be both difficult and expensive. Where the waste cannot be further reduced at the source, there remains the possibility of on-site conversion of at least some of the waste to nontoxic and environmentally acceptable products. This reduces the quantity of material that has to be transported off-site for disposal. On-site conversion has the added advantage that the worker who has been handling or using a chemical may also be the one eliminating or reducing the resulting waste. This worker has access to information about the chemical and would be expected to be knowledgeable in its safe handling. Sources of information about the properties of chemicals such as Material Safety Data Sheets are available in the workplace. However, to be able to convert waste and surplus chemicals to safe products, a detailed practical procedure that can be performed safely and with reproducible and reliable results is required. In school and college laboratories, it is often possible for such procedures to be the last step of an experiment so that students learn the importance of considering the waste generated by a process. It must be noted that the disposal of any toxic or hazardous material must be in accord with current federal, provincial or state, and local regulations. On-site disposal may require licensing as a treatment center unless the procedure can be considered part of the reaction being performed at the bench.

The chemical treatment of wastes can result in the material being converted to products that are nontoxic and environmentally acceptable. The methods fall into several categories that include acid/base neutralization, oxidation or reduction, and precipitation of toxic ions as insoluble solids. Many of the disposal procedures suggested in this book fall into these categories.

Physical, chemical, and physiological properties, hazardous reactions, and spill and waste disposal procedures are listed for each chemical included in this handbook. The data about properties and hazardous reactions are intended to provide the user with sufficient information to handle the chemicals safely with appropriate precautions and personal protection.

Two important factors are included in the spill and waste disposal procedures. First, procedures are listed for individual chemicals. In this way, it is possible to detail precise conditions and exact quantities of reagents for each chemical to be destroyed. Second, the majority of the procedures were tested in the laboratory for safety to the operator, reliability, and to check that they met the desired criteria for conversion of the hazardous material to nonhazardous products. Thus, to be chosen as an acceptable disposal procedure, more than 99% of the starting material had to be destroyed under the conditions and length of time given. As far as possible, the products have been identified and, in these cases, equations for the reaction taking place are included. Where it was not possible to identify all of the fragments produced, and especially when the chemical to be destroyed was a suspect carcinogen, the reaction mixture was submitted for an Ames test, which detects whether the material formed has excess mutagenicity over the background.

The disposal procedures presented are written for relatively small quantities. Laboratory testing has shown them to be safe on this scale. The methods should not be used for larger quantities unless a qualified chemist has shown that it is safe to increase the scale.

The book is intended to provide helpful information for bench workers to dispose of small amounts of waste and surplus chemicals at their bench, and for those charged with the responsibility for the management and disposal of hazardous waste. For both groups of readers, this book should facilitate complying with both legal and moral obligations in the routine treatment of waste, as well as allowing them to develop a plan of action for emergencies, such as spills of any of the chemicals listed.

INDEX OF COMPOUNDS

In the compound list, numbers in parentheses following the names of chemicals refer to hazard ratings as described in NFPA 704–11.

First Number — HEALTH HAZARD

4 Materials that on very short exposure could cause death or major residual injury.
3 Materials that on short exposure could cause serious temporary or residual injury.
2 Materials that on intense or continued but not chronic exposure could cause temporary incapacitation or possible residual injury.
1 Materials that on exposure would cause irritation but only minor residual injury.
0 Materials that on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material.

Second Number — FLAMMABILITY

4 Materials that will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature, or that are readily dispersed in air and that will burn readily.
3 Liquids and solids that can be ignited under almost all ambient temperature conditions.
2 Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.
1 Materials that must be preheated before ignition can occur.
0 Materials that will not burn.

Third Number — REACTIVITY/STABILITY

4 Materials that in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures.
3 Materials that in themselves are capable of detonation or explosive decomposition or reaction but require a strong initiating source or which must be heated under confinement before initiation or which react explosively with water.
2 Materials that readily undergo violent chemical change at elevated temperatures and pressures or which react violently with water or which may form explosive mixtures with water.
1 Materials that in themselves are normally stable, but which can become unstable at elevated temperatures and pressures.
0 Materials that in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.

DEFINITIONS OF ABBREVIATIONS

TLV-TWA: Threshold Limit Value — Time-Weighted Average. These are the time-weighted average concentrations for a normal 8-hour workday and a 40-hour work week to which nearly all workers may be repeatedly exposed, day after day, without adverse effects.

TLV-STEL: Threshold Limit Value — Short-Term Exposure Limit. These are the concentrations to which workers can be exposed continuously for a short period of time without suffering (1) irritation, (2) chronic or irreversible tissue damage, or (3) narcosis of sufficient degree to increase the likelihood of accidental injury, or materially reduce work efficiency, and, provided that the daily TLV-TWA is not exceeded. A STEL is defined as a 15-minute TWA exposure that should not be exceeded at any time during a workday even if the 8-hour TWA is within the TLV-TWA. Exposure above the TLV-TWA up to the STEL should not be longer than 15 minutes and should not occur more than four times a day. There should be at least 60 minutes between successive exposures in this range.

TLV-STEL-C: Threshold Limit Value — Short-Term Exposure Limit — Ceiling. The concentration that should not be exceeded during any part of the working exposure.

LD_{50}: Lethal Dose to 50% of specified population.

REFERENCE ABBREVIATIONS

In the references section for each entry, the following abbreviations are used.

Abbreviation	Literature Reference
ACGIH	American Conference of Government Industrial Hygienists, 2002 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, ACGIH, Cincinnati, OH, 2002.
Agro. Desk Ref.	Montgomery, J.A., *The Agrochemicals Desk Reference*, Lewis Publishers, Boca Raton, FL, 1993.
Agro. Handbook	*The Agrochemicals Handbook*, 3rd ed., Royal Society of Chemistry Information Services, Cambridge, 1992.
Ald	Lenga, R.E., ed., *The Sigma-Aldrich Library of Chemical Safety Data*, 2nd ed., Aldrich Chemical Company, Milwaukee, WI, 1988.
Aldrich	2000–01 *Aldrich Handbook of Fine Chemicals and Laboratory Equipment*, Aldrich Chemical Company, Milwaukee, WI, 2001.
B	Bretherick, L., *Handbook of Reactive Chemical Hazards*, 4th ed., Butterworths-Heinnemann, London, 1990.
Beilstein	*Beilstein's Handbuch der Organischen Chemie*, Springer-Verlag, Berlin, 1928–present.
Cas 43	Castegnaro, M. et al., *Laboratory Decontamination and Destruction of Carcinogens in Laboratory Wastes: Some N-Nitrosamines*, No. 43, IARC Scientific Publications, Lyon, 1982.
Cas 49	Castegnaro, M. et al., *Laboratory Decontamination and Destruction of Carcinogens in Laboratory Wastes: Some Polycyclic Aromatic Hydrocarbons,* No. 49, IARC Scientific Publications, Lyon, 1983.
Cas 54	Castegnaro, M. et al., *Laboratory Decontamination and Destruction of Carcinogens in Laboratory Wastes: Some Hydrazines*, No. 54, IARC Scientific Publications, Lyon, 1983.
Cas 64	Castegnaro, M. et al., *Laboratory Decontamination and Destruction of Carcinogens in Laboratory Wastes: Some Aromatic Amines and 4-Nitrobiphenyl*, No. 64, IARC Scientific Publications, Lyon, 1985.
CRC	Lide, David R., ed., *Handbook of Chemistry and Physics*, 75th ed., CRC Press, Boca Raton, FL, 1994–1995.
DOC	Buckingham, J., ed., *Dictionary of Organic Compounds*, 5th ed., Chapman & Hall, Cambridge, 1982.
F & F	Fieser, L.F. and Fieser, M.A., *Reagents for Organic Synthesis*, Wiley, New York.
Haz. Mat. Spills Tec.	Fingas, M., ed., *The Handbook of Hazardous Materials Spills Technology*, McGraw-Hill, New York, 2001.
IARC	International Agency for Research on Cancer Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans.
ITI	The International Technical Information Institute, *Toxic and Hazardous Industrial Chemicals Safety Manual for Handling and Disposal with Toxicity and Hazard Data*, ITI, Tokyo, 1981.
LSS	Lab Safety Supply, September 1994, General Safety Catalogue, Lab Safety Supply, P.O. Box 1368, Janesville, WI, 2002.

Lux	Luxon, S.G., ed., *Hazards in the Chemical Laboratory*, 5th ed., Royal Society of Chemistry, London, 1992.
Mellor	Mellor, J.W., *A Comprehensive Treatise on Inorganic and Theoretical Chemistry*, Longmans, London.
Merck	Budavari, S. et al., *The Merck Index*, 13th ed., Merck and Co., Whitehouse Station, NJ, 2001.
NFPA	National Fire Protection Association, *Fire Protection Guide on Hazardous Materials*, 12th ed., NFPA, Boston, MA, 1997.
NIEHS	Ninth Report on Carcinogens —— U.S. Department of Health and Human Services, Public Health Service. National Toxicology Program, Rockville, MD, 2001. Available at: http://ehp.nichs.nih.gov.roc/toc9.html.
PP	*Prudent Practices for Disposal of Chemicals from Laboratories*, National Research Council, National Academy Press, Washington, D.C., 1983.
PPL	*Prudent Practices in the Laboratory, Handling and Disposal of Chemicals*, National Academy Press, Washington, D.C., 1995.
Sax	Lewis, R.J., *Sax's Dangerous Properties of Industrial Materials*, Vols. I, II, and III, 8th ed., Van Nostrand Reinhold, New York, 1992
Sax5	Sax, N.I., *Dangerous Properties of Industrial Materials*, 5th ed., Van Nostrand Reinhold, New York, 1979.
Vogel	Vogel, A.I., *Vogel's Textbook of Practical Organic Chemistry*, 5th ed., revised by Furniss, B.S. et al., Addison-Wesley, 1989.

INCOMPATIBILITY TABLE

Compound/Class	Avoid Storage Near or Contact With
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetone	Conc. nitric acid and sulfuric acid mixtures
Acetylene	Fluorine, chlorine, bromine, copper, silver, mercury
Alkaline metals (e.g., Na, K, Mg, Ca, Al)	Carbon dioxide, carbon tetrachloride or other chlorinated hydrocarbons, halogens, water
Ammonia (anhydrous)	Mercury, chlorine, bromine, iodine, hydrofluoric acid, calcium hypochlorite
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Arsenicals	Reducing agents (or will generate arsine)
Azides	Acids (or will generate hydrogen azide)
Bromine	Ammonia, acetylene, butadiene, methane, propane, butane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Calcium oxide	Water
Carbon, activated	Calcium hypochlorite, oxidizing agents
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible materials
Chromic acid, chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, turpentine, alcohol or other flammable liquids
Chlorine	Ammonia, acetylene, butadiene, methane, propane, butane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Organic or inorganic acids
Cyanides	Acids (or will generate hydrogen cyanide)
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	Isolate from everything
Hydrazine	Hydrogen peroxide, nitric acid, other oxidants
Hydrocarbons (propane, butane, benzene, gasoline, turpentine, etc.)	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic acid	Nitric acid, alkalies
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous)
Hydrogen peroxide	Copper, chromium, iron, most other metals or their salts, alcohols, acetone, or other flammable liquids, aniline, nitromethane, or other organic or combustible materials
Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Hypochlorites	Acids (or will generate chlorine or hypochlorous acid)

Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, ammonia, fulminic acid (produced in nitric acid–ethanol mixtures)
Nitrates	Sulfuric acid (or will generate nitrogen dioxide)
Nitric acid (conc.)	Acetic acid, aniline, chromic acid, acetone, alcohol, or other flammable liquids, hydrocyanic acid, hydrogen sulfide, or other flammable gases, nitratable substances; copper, brass, or any heavy metals (or will generate nitrogen dioxide/nitrous fumes)
Nitrites	Acids (or will generate nitrous fumes)
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Silver, mercury
Oxygen	Oils, grease, hydrogen, other flammable gases, liquids, or solids
Perchloric acid	Acetic acid, bismuth and its alloys, alcohol, paper, wood, grease oils
Peroxides (organic)	Organic or inorganic acids. Also: avoid friction and store cold
Phosphorus (white)	Air, oxygen, caustic alkalies as reducing agents (or will generate phosphine)
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate	Acids, especially sulfuric acid
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Selenides	Reducing agents (or will generate hydrogen selenide)
Silver	Acetylene, oxalic acid, tartaric acid, fulminic acid (produced in nitric acid–ethanol mixtures), ammonium compounds
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium nitrite	Ammonium nitrate and other ammonium salts
Sodium peroxide	Any oxidizable substance such as methanol, ethanol, glycerol, ethylene glycol, glacial acetic acid, acetic anhydride, benzaldehyde, furfural, methyl acetate, ethyl acetate, carbon disulfide
Sulfides	Acids (or will generate hydrogen sulfide)
Sulfuric acid	Light metals (lithium, sodium, potassium), chlorates, perchlorates, permanganates
Tellurides	Reducing agents (or will generate hydrogen telluride)

COMPOUND

COMPOUND **PAGE**