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ER ID NO. 59377 *Date Received:* 9/28/98 *Processor:* YCA *Page Count:* 7

Privileged: (Y/N) N *Record Category:* P *Record Package No:* 0

FileFolder: N/A

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Administrative Record: (Y/N) Y

Refilmed: (Y/N) N *Old ER ID Number:* 0 *New ER ID Number:* 0

Miscellaneous Comments:

REFERENCE CITED

14030

THIS FORM IS SUBJECT TO CHANGE. CONTACT THE RPF FOR LATEST VERSION. (JUNE 1997)

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Toxicological Chemistry

TOXICOLOGICAL CHEMISTRY

A GUIDE TO TOXIC SUBSTANCES IN CHEMISTRY

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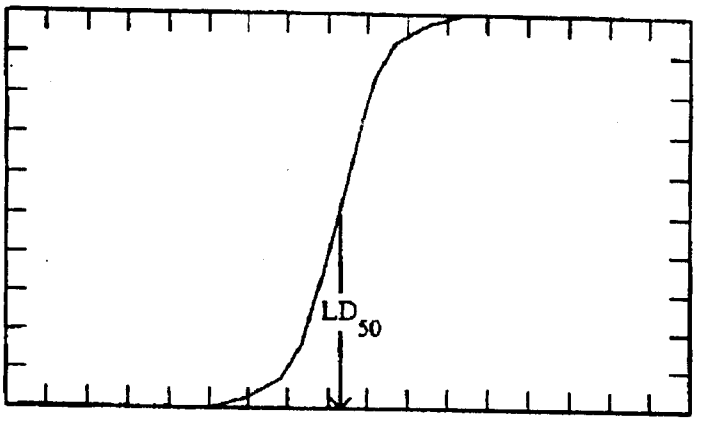

TOXICOLOGICAL CHEMISTRY

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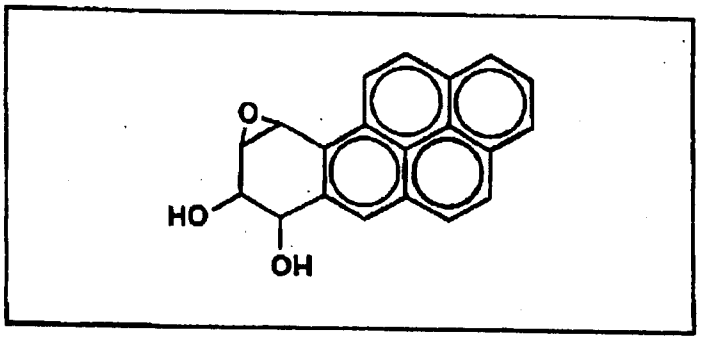

STANLEY E. MANAHAN

Library of Congress Cataloging-in-Publication Data

Manahan, Stanley E.
Toxicological chemistry

Bibliography: p.
Includes index.
1. Toxicological chemistry I. Title.
RA1219.3.M36 1988 615.9'00154 88-25552
ISBN 0-87371-149-1

Third Printing 1990

Second Printing 1989

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121 South Main Street, Chelsea, Michigan 48118

PRINTED IN THE UNITED STATES OF AMERICA

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faculty since 1965. He receive
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Stanley E. Manahan is a Professor of Chemistry at the University of Missouri – Columbia, where he has been on the faculty since 1965. He received his A.B. in chemistry from Emporia State University in 1960 and his Ph.D. in analytical chemistry from the University of Kansas in 1965. Since 1968 his primary research and professional activities have been in environmental chemistry and have included development of methods for the chemical analysis of pollutant species, environmental aspects of coal conversion processes, development of coal products useful for pollutant control, hazardous waste treatment, and toxicological chemistry. He teaches courses on environmental chemistry, hazardous wastes, and toxicological chemistry and has lectured on these topics throughout the United States as an American Chemical Society Local Section tour speaker.

Professor Manahan has written books on environmental chemistry, applied chemistry and quantitative chemical analysis. He has been the author or co-author of approximately 70 research articles.

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Minimata Bay

The most notorious incident of widespread mercury poisoning in modern times occurred in the Minimata Bay region of Japan during the period 1953-1960. Mercury waste from a chemical plant draining into the bay contaminated seafood consumed regularly by people in the area. Overall, 111 cases of poisoning with 43 deaths and 19 congenital birth defects were documented. The seafood was found to contain 5-20 parts per million of mercury.

Lead

Lead (Pb) ranks fifth behind iron, copper, aluminum, and zinc in industrial production of metals.[8] About half of the lead used in the United States goes for the manufacture of lead storage batteries. Other uses include solders, bearings, cable covers, ammunition, plumbing, pigments, and caulking.

Metals commonly alloyed with lead are antimony (in storage batteries), calcium and tin (in maintenance-free storage batteries), silver (for solder and anodes), strontium and tin (as anodes in electrowinning processes), tellurium (pipe and sheet in chemical installations and nuclear shielding), tin (solders), and antimony and tin (sleeve bearings, printing, high-detail castings).

The electron configuration of lead is $\{Xe\}4f^{14}5d^{10}6s^{2}6p^{2}$ and it has four valence electrons. Lead is one of a small group of "p-block" metals that are representative elements with partially filled *p* orbitals. Inorganic lead exists in chemical compounds in both the +2 and +4 oxidation states. Lead(II) compounds are predominantly ionic (e.g., $Pb^{2+}SO_4^{2-}$), whereas lead(IV) compounds tend to be covalent (e.g., tetraethyllead, $Pb(C_2H_5)_4$). Some lead(IV) compounds, such as PbO_2, are strong oxidants. Lead forms several basic lead salts, such as $Pb(OH)_2{\cdot}2PbCO_3$, which was once the most widely used white paint pigment and the source of considerable chronic lead poisoning to the children who ate peeling white paint. Many compounds of lead in the +2 oxidation state (lead(II)) and a few in the +4 oxidation state

effective against syphilis and they are still used to treat amebic dysentery. Arsobal, or Mel B, an organoarsenical, is the most effective drug for the treatment of the neurological stage of African trypanosomiasis for which the infectious agents are *Trypanosoma gambiense* or *T. rhodesiense*.

Exposure and Absorption of Arsenic

Arsenic can be absorbed through both the gastrointestinal and pulmonary routes. Although the major concern with arsenic is its effect as a systemic poison, arsenic trichloride ($AsCl_3$) and the organic arsenic compound, Lewisite (used as a poison gas in World War I) can penetrate skin; both of these compounds are very damaging at the point of exposure and are strong vesicants (causes of blisters).[11] The common arsenic compound As_2O_3 is absorbed through the lungs and intestines. The degree of coarseness of the solid is a major factor in how well it is absorbed. Coarse particles of this compound tend to pass through the gastrointestinal tract and to be eliminated with the feces.

Arsenic occurs in the +3 and +5 oxidation states, and inorganic compounds in the +3 oxidation state are generally more toxic. The conversion to arsenic(V) is normally favored in the environment, which somewhat reduces the overall hazard of this element.

Arsenic is a natural constituent of most soils. It is found in a number of foods, particularly shellfish. The average adult ingests somewhat less than 1 milligram of arsenic per day through natural sources.

Metabolism, Transport, and Toxic Effects of Arsenic

Biochemically, arsenic acts to coagulate proteins, forms complexes with coenzymes, and inhibits the production of ATP. Like cadmium and mercury, arsenic is a sulfur-seeking element. Arsenic has some chemical similarities to phosphorus,[12] and it substitutes for phosphorus in some biochemical processes, with adverse metabolic effects. Figure 5.7 summarizes one such effect. The top reaction in the figure illustrates the enzyme-catalyzed synthesis of 1,3-diphosphoglycerate from glyceraldehyde 3-phosphate. The product undergoes additional reactions to produce adenosine triphosphate (ATP),

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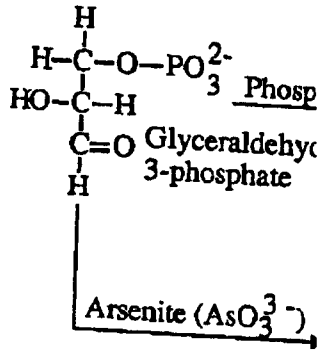

1-Arseno-3-
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Figure 5.7. Interference of arse

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5.6. NONMETALS

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