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THE USE OF ETHYLENE OXIDE FOR STERILIZATION: A PARTIALLY ANNOTATED BIBLIOGRAPHY

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Compiled by
CHARLIE M. PIERCE

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SEPTEMBER 1962

Lockheed

MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

SUNNYVALE, CALIFORNIA

ABSTRACT

Ethylene oxide has proven to be one of the better agents for the sterilization of spacecraft. The scope of this search involves the chemical reactions involved in the destruction of microorganisms and their spores.

The 39 references which were selected are alphabetically arranged according to the first author. The resources of the LMSC Technical Information Center were utilized in this search.

The period of coverage dates from 1950 to June 1962.

Search Completed July 1962.

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References 1

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Formation of new cross-linking bridges in
fibers and possible physiological effects of
some chemicals used for this purpose.
MELLIAND TEXTILBER v. 35, p. 3-9, 1954.

Discusses ethylene oxide along with a number of other alkylating compounds in relation to their effects on wool. The author links the chemical activity of ethylene oxide to its growth retarding action.

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Ethylene glycol produced by ethylene oxide
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STERILIZING AGENTS ON MICROORGANISMS.
Jet Propulsion Lab., Calif. Inst. of Tech.,
Pasadena. Literature search no. 260, Aug 61,
55p. (Contract NASw-6) ASTIA AD-264 023.

Material has been collected on the effect of sterilizing agents on bacteria, spores, and viruses, and on the production and maintenance of sterile environments in the laboratory. There is a section for each type of sterilizing agent: radiation, temperature, ultrasonics, and vacuum. Radiation is divided into gamma-, ultraviolet-, and X-radiation, and the section on vacuum contains material on the effects of drying. An author index is included. In each section, the material is divided into books, reports, and periodicals. Books are arranged in alphabetical order by author, and reports by source. Periodicals are arranged by year with most recent material first, and within each year in alphabetical order by journal name. Abstracts found in the reference source are published here in whole or in part, and the source is noted whenever possible.

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External publication 698. Presented at the Tenth
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The sterilizing action of gaseous ethylene oxide.
III. The effect of ethylene oxide and related com-
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Describes the experimental procedures and results. Ethylene oxide and its deriva-
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IV. The effect of moisture. AM. J. HYGIENE
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The coefficient of dilution of ethylene oxide is close to unity. The temperature coefficient is 2.74 for each 10° C rise. Other compounds containing the same epoxy groupings have also been shown to possess bactericidal properties as do compounds containing the 3-membered ethylene sulfide or ethylene imine rings. The effects of ethylene oxide are considered to be related to its alkylating effects.

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Sterilization of interplanetary vehicles was investigated to find out primarily whether: (1) contamination should be avoided; (2) if all life forms would be automatically killed in passage because of the rigor of interplanetary space; and (3) if sterilization can be accomplished without adding crippling restrictions to the space exploration program. Results were as follows: (1) contamination should be avoided to enable man to examine habitat life forms other than those which arose on earth; (2) since microorganisms could probably well withstand space flights, space vehicles should be sterilized before leaving the earth to avoid living earth forms from being transported to other celestial bodies; and (3) design consideration and laboratory experiments indicated that chemical sterilization with ethylene oxide promises a good solution because it's easily stored with fluorohydracarbons in lightweight containers, and the fact that fewer types of materials are damaged by this technique than any known sterilization method. Should, however, some component prove sensitive to ethylene oxide, it could be sterilized prior to assembly by another technique and shielded from further exposure by building a gas-tight barrier around it. This method also adopts itself to simple exposure chambers; for example, a simple polyethylene bag tightly closed at the neck would serve adequately as a device to contain the gas. Objects of any size could be sterilized by building about them a bag or tent of heat-sealed plastic sheeting and admitting the sterilized mixture into this container. A hypothetical case is given of a space vehicle atop a third-stage rocket with both of them covered by a nose cone or fairing, wherein ethylene oxide provides sterilization for both the vehicle and each rocket stage.

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National Aeronautics and Space Administration,
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A meeting was held of representatives of agencies concerned with the development of space vehicles and those investigating decontamination and sterilization procedures. Recommendations resulting from the deliberations include: (1) a body of related information be accumulated, (2) standard operating procedures be established, (3) acceptable limits of contamination be determined, (4) NASA policy be clarified, (5) new sterilizing agents be developed, (6) compatibility studies be pursued, (7) sterile manufacture of parts be investigated, and (8) a working level group should be formed to implement recommendations and procedures.

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Dried foot-and-mouth disease virus (FMDV) was inactivated under definite minimal conditions of relative humidity and temperature when exposed to the action of gaseous ethylene oxide (ETO) mixed with trichloromonofluoromethane (TMM) and dichlorodifluoromethane (DDM). After the FMDV was subjected to a 40% relative humidity (RH) for 30 minutes and then exposed to ETO at 90° or 78° F and 40% RH for 5 hours, the virus was inactivated as shown by tests in mice or tissue culture. Virus was not inactivated in 2 out of 3 trials after exposure to ETO for 5 hours at 40% RH and 98° F without prior humidification. The gases TMM and DDM did not inactivate the dried virus in the absence of ETO.

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A METHOD FOR DETERMINING RELATIVE
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Ethylene oxide reacts with aqueous nicotinamide at 25° to give, after treatment with HCl, N¹ - (2-hydroxyethyl) nicotinamide chloride. This has no nicotinic acid activity for Lactobacillus arabinosus or for chicks, and it is not a nicotinic acid antagonist. Nicotinic acid is similarly converted into the betaine of N¹- (2-hydroxyethyl) nicotinic acid. The rate of reaction increases with increasing pH and temp. At higher pH values the products are unstable. The nicotinamide of DPN is unaffected. Under most conditions the acid is more reactive than the amide towards ethylene oxide. The bearing of the results on commercial ethylene oxide fumigation and other vitamin-ethylene oxide reactions is discussed.

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Reaction of ethylene oxide with histidine, methionine,
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CHEM. v. 234, p. 895-899, 1959.

The decreased microbiological availability of histidine and methionine when proteins are treated with ethylene oxide appears to be due to hydroxy-ethylation of N and S atoms. Ethylene oxide reacts readily with histidine and imidazole in aq. soln. at room temperature to give the corresponding 1:3-bis- (2-hydroxyethyl) imidazolium deriv. With methionine or N-acetylmethionine, ethylene oxide hydroxyethylates the S to give the corresponding sulphonium derivative. Similarly the thiol group of cysteine is double-alkylated to give a sulphonium group. The primary amino groups of the amino acids are also alkylated, but the carboxyl groups are not attacked.