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SUMMARY OF AVAILABLE LITERATURE ON TRITIUM

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by

Eloise Newcomb

February 3, 1950

Biology Division
HEALTH INSTRUMENT DIVISIONS

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ABSTRACT

This report abstracts available literature on tritium in respect to instrumentation, physics, and biological effects. It includes a bibliography of work summarized here, and a bibliography of other literature on tritium which either duplicates the efforts of the authors reviewed, or does not appear to have bearing on the problems at hand, or was not available in the Technical Library at the time this report was prepared.

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SUMMARY OF AVAILABLE LITERATURE ON TRITIUM (CLASSIFIED AND UNCLASSIFIED)

INSTRUMENTATION

Determination of Free Hydrogen-Tritium Gas

The tritium may be determined as a free hydrogen-tritium gas. Table 1 gives the gas mixtures used when tritium is so counted in a Geiger Mueller tube.

The authors whose works are reported in Table 1 obtained their tritium-hydrogen mixtures as radioactive water, either from combustion of organic materials using standard combustion methods, or as a product of other chemical reactions. The water was trapped by freezing it out of a gas mixture. It was then reduced to hydrogen by heating it over magnesium turnings. The resulting tritium-hydrogen mixtures were then introduced into a G.M. tube together with other gases and vapors used in the counting mixture. Free hydrogen-tritium alone does not make a suitable counting gas.

Determination as Tritium Oxide or HTO

Pace, et al. (8) counted HTO vapor at pressures of 0.4 mm. to 2.2 mm. Hg in a mixture containing 25 mm. Hg ethyl alcohol vapor and 20 mm. Hg Argon. The paper includes diagrams of the apparatus used. Joris and Taylor (9) used a mixture of tritium oxide, ethanol vapor, and argon at a total pressure of 20 mm. Hg. The paper includes diagrams of apparatus and specifications of the G.M. Tube. Fontana (10) used water vapor at a pressure of 10 mm. Hg and propane at 20 mm. pressure as a counting gas.

Brown (23) absorbed tritium water on a counting plate which was coated with sublimed phosphorus pentoxide. The plate was inserted into a modified G.M. tube through which helium was flowing at a pressure slightly greater than one atmosphere. The paper includes a diagram of the tube.

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Watts and Williams (30) in determining the energy of beta rays from tritium used a special counter containing argon at atmospheric pressure saturated with ethanol vapor. The counter window consisted of several very thin layers of collodion supported on a perforated copper disk. The source was an aluminum disk with a layer of aluminum oxide on the surface which was hydrated by exposure to tritium oxide vapor. A diagram of the counter is given in the paper.

Other Methods

Powell and Reid (11) counted tritium incorpor... into butane which was used as the counter gas at a pressure of 40 mm. Hg in a G.M. tube.

Henriques and Margnotti (13) used an ionization chamber attached to a Lauritzen electroscope for counting free tritium. They report a sensitivity of about 10^{-4} microcuries per 10 millimoles hydrogen. Paper includes a diagram.

Healy (.4) gives a method for the determination of tritium in urine now in use at the Hanford Works.

Taschek and Gittings (15) report the scintillations from naphthalene in contact with tritium are proportional to the concentration, but give no actual method of determining concentration.

PHYSICAL PROPERTIES

Half-life

Jenks, et al. (16, 17) determined the half-life by measuring the rate of He^3 evolution to be 12.5 yrs. Novick (18) used a similar method. Goldblatt, et al.(19) used an ionization chamber, and obtained a value of 10.7 ± 2 years. See Table 3.

These are in marked disagreement with the results of O'Neal and Goldhaber (20) who obtained a value of 31 years. They used a G.M. tube and assumed that

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every tritium nucleus decaying in the counter was detected. However, this does not seem a valid assumption.

Energy of Radiation

Table 2 summarizes the values found for the maximum energy of beta radiation for tritium. Curran, Angus, and Cockcroft (21) give the complete spectrum of the energies from 1 to 16.9 kev. Manning (22) and Jenks (16, 17) using calorimetric methods found the average energy to be 5.66 kev./disintegration.

Table 3 gives the summary of the physical properties of H^3.

Physical Effects of Beta Radiation from Tritium

Under the radiation from tritium, water decomposes to hydrogen and hydrogen peroxide, the latter decomposing to oxygen and water. Approximately one molecule of electrolytic gas (hydrogen or oxygen) is formed per kev of radiant energy. The yield of gas is influenced by temperature and impurities present (24).

The radiation also catalyzes breakdown of silicates. Glass fluoresces with a visible glow. Tritium and tritium water are strongly adsorbed on glass and other surfaces.

The reaction constant for the reaction $T_2 + H_2 = 2HT$ has been reported as 2.58 at 25° C. (25)

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TABLE 1

Composition of counter gas mixtures using free tritium-hydrogen

Author	Pressure* hydrogen-tritium	Pressure rare gas	Ethanol vapor pressure	Other gases pressure	Total Pressure
Libby & Barter (1)	15	--	203	--	238
Harmon, Stewart & Rubin (2)	200	--	15	--	215
Norris. Allen & Rubin (3)	656	--	104	--	760
Allen & Rubin (4)	760	--	150	--	910
Guria & Deliuva (5)	10	Ne, 60	10	--	80
Black & Taylor (6)	8-20	Argon 20	25	Water 2	55-67
Melander (7) **	?	--	--	methane ?	?
Eidenoff (12)	25	Argon 20-25	20-25	--	65-75

* All gas pressures are in mm. Hg
Numbers in parentheses indicate paper in bibliography

** Paper is unavailable, data taken from Chem. Abstracts

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Table 2

Maximum energy values (kev) for tritium beta radiation

Author	Method of determination	Maximum value
Alvarez and Cornog (31)	Ion pairs/unit volume gas	Approx. 18
O'Neal and Goldhaber (20)	Range in Argon-alcohol mixture	15 ± 3
Brown (23)	Range in helium	11 ± 2
Nielsen (32)	Droplets in cloud chamber	14.5 ± 1
Watts and Williams (30)	Electron acceleration	11.2
Curran et al. (21)		16.9
Byatt et al. (33)	Cloud chamber	11.1

Numbers in parentheses are journal references.

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Table 3

Summary of Physical Proportion of Tritium

Half-life	Energy/disintegration	Radiation absorbed by
12.5 yrs. (16, 17)	Maximum 16.9 kev (21)	0.1 mm Li (20)
11.8-12.4 yrs. (18)	Average 5.6 kev (21,17)	0.5 mgm/cm Al (23)
31 yrs. (20)		13.1 mm He at one atm. (23)

Numbers in parentheses indicate journal references.

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TRITIUM IN BIOLOGICAL SYSTEMS

Tracer Applications

Norris, et al. (3) studied photosynthesis of Chlorella in water containing tritium oxide. No tritium was incorporated into chlorophyll in a period of three hours. No quantitative data were given on dosages.

Gurin and Delluva (5) fed "tritiophenylalanine" to rats. Total amount was about 0.1 microcurie fed over a period of ten days to a 150 gram rat. The rats were sacrificed at the end of the ten days. Approximately 3 per cent of the tritium was recovered from the body water and 0.17 per cent recovered as adrenaline. The fate of the rest of the tritium was not reported.

Pace, et al. (8) injected water containing HTO into rabbits and man. Amounts were approximately 0.18 microcuries per 3 kg. rabbit, and 2.6 microcuries per 70 kg. man. The rabbits were sacrificed during the experiments, but no unfavorable effects were reported on the man.

Standard Permissible Concentrations

H. M. Parker (26) reports that the Chalk River Conference established the following permissible limits on tritium concentration:

Permissible body content	1 mc.	
Permissible concentration, air	10^{-6} uc/cc	(assumed as oxides)
Permissible concentration, water	10^{-2} uc/cc	(assumed as oxides)

No permissible air concentration for tritium gas established.

Toxicity

Brues, et al. (27) reports the mortality from tritium water injected into mice. The tabulated results indicate a 20-day LD_{50} of about 1 mc. per gram body weight.

On the basis of the rate of body water turnover in mice and the percentage of water in the body, and assuming a mean beta ray energy of 5.7 kev, the

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calculated total accumulated dose to mice receiving 1 mc. per gram is about 1000 rep the first five days, about 200 rep the second five days, and essentially negligible thereafter.

It should be recognized that the relatively slower water turnover of the human being would result in a greater retention of the isotope and an increased toxicity, perhaps by a factor of three or four.

Results indicate clearly that no serious or unexpected correction factor needs to be introduced in calculating short-term tritium water toxicity on physical grounds, i.e., no remarkable factor of biological effectiveness exists for tritium beta rays as compared with X or gamma rays.

Methods for calculating the Maximum Permissible Limits of tritium and tritium oxide are set forth in a memorandum by H.A. Kornberg (30).

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HW-12250	"	"
HW-12256	"	"
HW-12287	"	"
HW-12290	"	"
HW-12354	"	"
HW-12447	"	"
HW-12508	"	"
HW-12463	"	"
HW-12529	"	"
HW-12551	"	"
HW-12558	(1949)	(SECRET)
HW-12558A	"	"
HW-12588	"	"
HW-12709	"	"
HW-12753	"	"
HW-12795	"	"
HW-12830	"	"
HW-13019	"	"
HW-13070	"	"
HW-13093	"	"
HW-13099	"	"
HW-13100	"	"
HW-13143	"	"
HW-13157	"	"
HW-13448	"	"
HW-13525	"	"
HW-13[illegible]5	"	"
HW-13567	"	"
HW-13585	"	"
HW-13627	"	"
HW-13680	"	"
HW-13838	"	"
HW-13927	"	"
HW-13932	"	"
HW-14003	"	"
HW-14007	"	"
HW-14022	"	"
HW-14037	"	"
HW-14120	"	"
HW-14178	"	"
HW-14185	"	"
HW-14369	"	"
HW-14421	"	"
HW-14433	"	"
HW-14441	"	"
HW-14450	"	"
HW-14512	"	"
HW-14533	"	"
HW-14595	"	"
HW-14735	"	"
HW-14890	"	"
HW-14920-A	"	"
HW-14936	"	"
HW-14947	"	"
HW-14956 (Determination of Tritium Purity)	"	"
HW-14971	(1949)	(SECRET)
HW-15012	"	"
HW-15054	"	"
HW-15153	"	"
HW-15210	"	"

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[redacted]

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[redacted]

HW-15281 (1949) (SECRET)
HW-15287 " "
HW-15288 " "
HW-15364 " "
HW-15373 " "
HW-15387 " "
HW-15402 " "
HW-15429 " "
HW-15513 " "
HW-15531 " "
HW-15634 " "
HW-15557 " "
HW-11305 (1948) (SECRET) - H.I. Recommendations on all Stages of the P-10 Project
HW-11206 (1948) (SECRET) - Facilities at ANL for Production

Work Duplicated in papers reviewed in this report

LA-632 (1947) (SECRET) Same as AECD-2190

LA-656 (1948) (SECRET) Same as LADC-493, AECD-1863

LAMS-654 (1947) (SECRET) Same as AECD-2190, LADC-462

LAMS-683 (1948) (SECRET) Same as AECD-2273 or LADC-552

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