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PUERTO RICO NUCLEAR CENTER

RESONANCE IN RADIATION EFFECTS

Progress Summary Report No. 1

foreaaTco BY UNIVERSITY OF PUERTO ICO UNDER CONTRACT

UPL? no. AT W0-1-1833 FOR U. §. ATOMIC ENERGY COMMISSION

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Progress Summary Peport #1

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?operated by che

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?To answer the question "what are the vaique effects of tonizing radiation on matter?, our research program continues a study started at the University of Michigan under the principal investigator. The Michigan progran is nov under the direction of Prof. Hoyt ?ihipple, while in Puerto Rico @ new project has beca created.

The firse objective of the Puerto Rico Progr:

is to provide an independent test of the original results reported from Ann Arbor. The second is the extension of the investigation to new problems in bio-

Aogical, chemical and physical effects produced by monochromatic X-rays

in the

jess than 20 kilovolt? energy range

Below is a summary of the results obteined during the first year

of operation of the Puerto Rico project.

Section 1. Resonance Radiation Effects of Lov-Energy Monochromatic

rays on Catali

(by R.A. Lose)

Dilute solutions of the iron metalloenzyne catalase were irradiated

with a beam of monochromatic {-rays having photon energies in the 6-9 jion and with @ high purity (4 50 ev). Irradiation wae earri

out in a sample holder constructed of eethactylate plastic with a thin

Mylar file window. Approxinately 0.2 al of sample could be irradiated

in the chamber (6 x 9 x 4 om #0)

a chanber of similar size, shielded

from radiation, contained control solution. Masking of solution under

the conditions of complete absorption was avoided by mechanical stirring

with a fine glass rod. To minimize evaporation and inactivation of the

jase, solutions were covered and aaintained at 5*C by pt

ing water

from a constant tonperature, refrigerated bath through the sample holder.

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In conjunction with this Irradiation system, # ferroue-ferric micro-dosinetry technique was developed. The prine requirenent

specified for the dosimeter systen was the ability of direct su

eitution for the sample, to ensure that values of cadiation intensity measured with the dosineter correspond directly to those absorbed by

the biological sample. Other considerations were simplicity of use

and reliability in the low dose ranges involved in this work, The Fricke ferrous-ferric dosimeter vas chosen, since it is the best characterized secondary standard available, It relies on the oxidation, by Sonizing radiation, of ferrous ion to ferric ion, and on determination of the concentration of ferric ion forved by its Light absorption at 304 ?mu (cf. Schuler and Allen). Application of this dosineter is primarily Limited by the methods for ferric ion analysis.

?A considerably wore sensttive assay of ferric {on concentration {8 measurement of the absorption of the red-orange ferric-thtocyanate complex; the solar absorptivity of thie complex is 10,000 - 14,000 liter mole"! ca'l at 480 mu, Pribicevic, Gal, and Draganic have characterized this complex formation and proposed its use as a dosimetry aystem in the 300 - 100 rad dose range. Not all their results could be confirmed, so chat further characterization and sodification of the eysten were under-

taken; these chenges were incorporated in the procedure developed. To

avoid dilution of the irradiated solution, optical measurements were taken with the Beckman DU spectrophotometer in cuvettes of 3 mm x 10 ax x 25 am chanber dimensions; as Little as 0.22 ml of solution may be

jayed in such cuvettes, X-radiation intensities of 2 x 10" photons Per hour in the sample holder have been determined by thie method (6-hour

irradiation periods vere required), The results of this cheaical dosimetry

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ety x 10"

Beam intensity absorbed in sapple

?as (photons

Photon energy,

Figure 1. Monochromatic X-ray beam intensity

a6 a function of photon eneray

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Percent catalase inactivation

20

-6e

65 70 75 8.0 85

Photon energy, Kev

Figure 2. Resonance radiation effect of sonochromatic

Xerays on catalase

Total dose absorbed by sauple = 1.4 x 10!3 phovons.

(except for starred point, where dose = 0.2% 10!

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im the photon energy range of current interest are given in Figure 1.

There 16 no resonance radiation effect in the ferrous dosimeter at the

K-absorption edge of iron; this is

sxpected, since the ferrous to

ferric oxidation is due to ?indirect? effects.

?The extent of enzyme inactivation was determined using essentially

the standard assay for catalase developed by Beers and Sizer in which trate hydrogen peroxide is folloved

spectrophotometrically at 212 au.

The results of such irradiation experiments using monochromatic x-rays in the energy range 6.4 - 8.3 Kev are given in Figure 2. Here

ed inactivation of the iron enzyne at or near the K-absorption ?edge of iron (7-11 Kev) 4 obvious. This de taken to confirm the res0-hance radiation hypothesis of Gosberg and previous experimental work of

Benons and Paraskevoudakis.

Section II, Characterization of a High Intensity Monochromatic X-Irradiation System in the 5-20 Kev. Region (by F. Vasquez Martinez)

?The x-ray emission system utilized for the present resonance radiation

studi

was characterized quantitatively as to intensity and photon energy distribution, and second harmonic contamination.

The sonochromatic x-ray bean resulting from crystal diffraction and collimation was analyzed horizontally across its front for (a) intensity distribution, utilizing @ special moving slit device; and (b) photon energy distribution, using double diffraction by a second analyzer crystal.

?The results of this work are shown ac Figures 3 and 4,

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DISTRIBUTION WITH[oz* SLIT | DISTRIBUTION WITH [oz? SLT

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mnergy distribution of photons

in the whole beaw

Figure & 10

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Estination of the extent of second harmonic energies vas made on

the basis of (a) absorption seasurenents relying on the different mass

absorption coefficients at the first and second harsontc wavelengths and

(b) double diffraction weasurenents in which photons vith second harsonic

energies were analyzed

sparately. Correction for percentage of reflection

by second harsonie energies also vas determined by the double diffracto-

nneter wethod, Contamination by higher harsonics was shown to be considerable at higher operating voltages (see Pigure 5); monochromatic beans can

be obtained only by proper selection of tube potential.

The effects on the beam of positioning the various components of the

aeray ayoten (tube, diffraction crystal, two soller slits) vere determined

land the systen was selected which provides high uniformity of photon energy

aseeributton.

As a result, a diffraction 5)

was developed which permits irradi-

ation with photons of uniform energy distribution (+ 50 ev in 6000-9000 ev),

4 selectivity of photon energice not possible with fluorescent entesion

aystens.

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