Title
An Isotope Effect in Photosynthesis

Permalink
https://escholarship.org/uc/item/1tm554d5

Authors
Weigl, John W
Calvin, M

Publication Date
1948-11-01

Copyright Information

UCRL - 228

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

BERKELEY, CALIFORNIA

UCRL-228

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

BERKELEY, CALIFORNIA

Copy 2-A

UCRL-228

Administrative-General

UNCLASSIFIED

UNIVERSITY OF CALIFORNIA

RADIATION LABORATORY

Contract No. W-7405-Eng-48

AN ISOTOPE EFFECT IN PHOTOSYNTHESIS

by

John W. Weigl and M. Calvin

23 November 1948

Berkeley, California

Standard Distribution	Copy Nos.
Argonne National Laboratory	1-5
Armed Forces Special Weapons Project	6
Atomic Energy Commission, Washington	7-8
Battelle Memorial Institute	9
Brookhaven National Laboratory	10-13
Bureau of Ships	14
Carbide & Carbon Chemicals Corp. (K-25 Plant)	15-18
Carbide & Carbon Chemicals Corp. (Y-12 Plant)	19-22
Chicago Operations Office	23
Columbia University (Dunning)	24
Columbia University (Failla)	25
General Electric Company, Richland	26-29
Hanford Operations Office	30
Iowa State College	31
Kellex Corporation	32-33
Knolls Atomic Power Laboratory	34-35
Los Alamos	36-38
Massachusetts Institute of Technology (Kaufman)	39
Massachusetts Institute of Technology (Gaudin)	40
Mound Laboratory	41-42
National Advisory Committee for Aeronautics	43
National Bureau of Standards	44
Naval Radiological Defense Laboratory	45
NEPA Project	46
New York Operations Office	47-48
North American Aviation, Inc.	49
Oak Ridge National Laboratory	50-53
Patent Advisory, Washington	54
Sandia Base	55-56
Technical Information Division, OROO	57-71
UCLA Medical Research Laboratory, (Warren)	72
University of California Radiation Laboratory	73-78
University of Rochester	79-80
Western Reserve University (Friedell)	81
Total	81

Information Division
Radiation Laboratory
University of California
Berkeley, California

AN ISOTOPE EFFECT IN PHOTOSYNTHESIS

by

John W. Weigl and M. Calvin

Radiation Laboratory and Department of
Chemistry, University of California,
Berkeley, California.*

23 November 1948

In the course of some kinetic studies on photosynthesis of barley seedlings, it has been found that plants utilize $C^{12}O_2$ faster than $C^{14}O_2$. The plants were placed in a closed system containing an infra-red absorption-cell for the analysis of total CO_2 and an ionization chamber for the determination of $C^{14}O_2$ in the gas phase, both instruments recording continuously.

Carbon dioxide, containing about 2% $C^{14}O_2$, was introduced in the dark, and the specific activity at this point taken as unity. After a short dark period, the lights were turned on and photosynthesis was allowed to take place. Figure 1 shows the result of a typical experiment.

---

* This paper is based on work performed under Contract No. W-7405-Eng-48 with the Atomic Energy Commission in connection with the Radiation Laboratory, University of California, Berkeley, California.

During the initial dark period the specific activity fell because of dilution by inactive respired CO_2. However, as photosynthesis proceeded, the specific activity of the residual CO_2 rose until, when only 1/6 of it remained, the specific activity reached a peak some 20% higher than it had been at the start of photosynthesis. At this point the steady respiratory dilution became an appreciable fraction of the total remaining CO_2, and the specific activity dropped rapidly.

Two other possible explanations of the rise in specific activity were:

1) a difference in the response times between the instruments of the order of a minute or two.

2) the conversion of the CO_2 into some other volatile compound.

Independent determinations of the response time to changes in the system revealed no appreciable time lags. The interpretation as an isotope effect was confirmed by removing samples of CO_2 during the course of a run and determining its specific activity by counting as $BaCO_3$, reconverting to CO_2, and measuring in a separate ionization chamber.

A similar selectivity favoring $C^{12}O_2$ over $C^{13}O_2$ has been observed by Nier (1) and Urey (2) in steady state systems, in which the net effect is considerably smaller than that reported here.

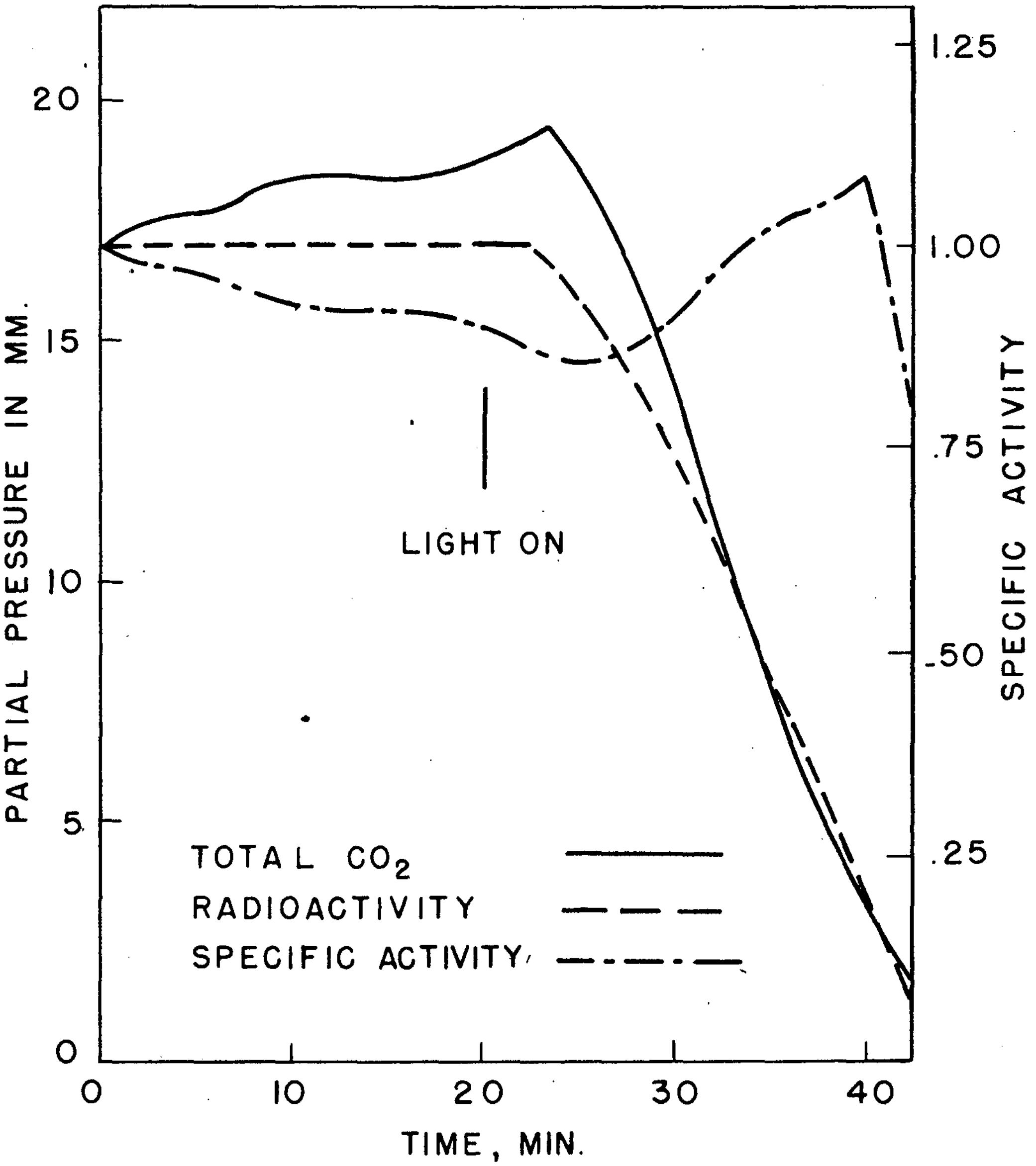
The authors wish to acknowledge the valuable aid of Mr. Paul M. Warrington in these experiments.

---

(1) A. O. Nier and E. A. Gulbransen, J. Am. Chem. Soc., 61, 697 (1939); B. F. Murphey and A. O. Nier, Phys. Rev., 59, 771 (1941).

(2) H. C. Urey, Science, 108, 489 (1948).

To be published in the Journal of Chemical Physics.



PARTIAL PRESSURE IN MM.
0
5
10
15
20
SPECIFIC ACTIVITY
.25
.50
.75
1.00
1.25
TIME, MIN.
0
10
20
30
40
LIGHT ON
TOTAL CO_2
RADIOACTIVITY
SPECIFIC ACTIVITY