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from CELarson to AHHolland

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Subject Electromagnetic Enrichment of Lithium Isotopes

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C. E. Larson

By C. E. Larson

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June 30, 1950

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ELECTROMAGNETIC ENRICHMENT OF LITHIUM ISOTOPES

Introduction

Since January 1950 the Isotope Production and Development Group (Building 9731 calutrons) and the Isotope Chemistry Group (Building 9211 laboratory) have made concerted investigations to determine just what can ultimately be expected from the electromagnetic process in producing enriched lithium-7. Results have been increasingly better and the experiments can now become production type experiments so that pound quantities of enriched lithium-7 can be obtained for important reactor tests.

The enrichment of lithium isotopes electromagnetically involves two major problems, (1) Calutron Operations, and (2) Chemistry Operations. These problems will be reviewed separately.

Calutron Operations

Since 1946 lithium-7 has been successfully enriched electromagnetically from its natural abundance of 92.5 per cent to at least 99.9 per cent on a readily reproducible basis. A final isotopic purity of 99.9 per cent Li^7 requires an enhancement of 81 which is not difficult to attain in the calutrons.

In collecting the Li^7 isotope it has been found that the Li^+ ion is most abundant in the ion beam. From the well-known laws on electrochemical equivalents it can be shown that one ampere of Li^+ in the collector for one hour at 100 per cent retention efficiency will deposit 0.28 gram of Li^7.

It is apparent then that the successful electromagnetic enrichment of Li^7 in quantities at an acceptable cost depends on (a) the amperes of Li^7 ion beam which can be maintained in a calutron and (b) the cost per hour of operating a calutron. Since large quantities of Li^7 are needed the calutron hourly cost will be derived from the cost of operating a track of 96, or a building of 192 calutrons. From the experience of the past four years Alpha II calutron bins have been found to be best for Li^7. Two Alpha II buildings are available, or a total of 384 Alpha calutron bins. The source and collector units cannot be standard Alpha II units because lithium requirements are different than uranium.

Lithium collections in Building 9731, using a twin-Beta source unit in an Alpha bin on a 12" ion beam radius, have exceeded one ampere per unit. When the number of arcs per bin is increased, as is to be expected in the normal development of this program, the current per bin will be between five and ten amperes of Li^+ to the collector. 5-10 amperes will deposit 1.4-2.8 gram of Li^7 per hour per calutron. At an estimated operating cost of $4 per hour per calutron Li^7 would cost $650-$1300 per pound. The purity as stated before would be at least 99.9 per cent Li^7 and would probably approach 99.95 per cent.

The twin-Beta source unit in the Alpha bin shows the most promise for lowest costs although very satisfactory operations have been obtained with the standard Beta source in both the Beta and Alpha bins. Experiments are being continued as rapidly as possible on several phases:

(1) Twin-Beta Source and Collector
(2) Standard Alpha II Source and Collector
(3) Standard Beta Source and Collector
(4) Special Beta-Alpha Type Source and Collector
(5) Comparisons of 12" Radius Ion Beam, 24" Radius Ion Beam, and 48" Radius Ion Beam Source to Collector
(6) Deceleration of Ion Beam at Collector
(7) Diffused Reception of Beam in Collector
(8) Reduced Source Voltages and Consequent Reduced Ion Beam Energies
(9) Substitution of Lithium-Resistant Materials in Calutron, Like Stainless Steel for Copper.
(10) Experiments Such as Possible Li^7 Enrichment by Arc Diffusion or Similar Processes in the Source
(11) Experiments on Grid Type Arcs in Source
(12) Evaluation of Li Metal vs LiI Charge Material

Many of the above experiments can be carried out with collections going on at the same time, thus making it possible to accumulate Li^7 while continuing to further develop the process.

Chemistry Operations

Investigations are being carried out on the chemistry problems of Li^7 enrichment in the calutrons. A source of lithium metal will be necessary; this metal will have to be freed from its sodium impurity and loaded into charge bottles. The collected isotope Li^7 will be retained in the collector as the metal from which it will be recovered either as the metal or a salt, chemically purified, assayed both chemically and isotopically, and the enriched Li^7 put in metallic form for reactor use. None of these problems are insurmountable and the one receiving the most attention is that of getting the Li^7 from the collector into a pure metallic form for reactor application.

Conclusions

Li^7, 99.9 per cent pure or better, can be produced electromagnetically with existing facilities at Y-12 with some modification due to the mass differences of lithium and uranium and due to chemical differences. Mole for mole Li^7 is far less expensive to enrich than U^{235}; pound for pound Li^7 can be supplied at a lower price than the present going price for U^{235} from the gaseous diffusion plant, perhaps by a factor of ten. Just what design of equipment should be used if Li^7 in quantities is produced, has not at the present been determined although the choice has fortunately resolved itself to those few which would permit Li^7 production while final decisions were being made.

The greatest progress could be made to get the final rock-bottom figure on Li^7 by going to an Alpha track (96 calutrons) and gradually expand to full-track operations. One-half of a track (48 calutrons) would be the initial unit to go into operations because the magnetic field can be supplied to half-track sections. Gradually increased operations would make it possible to reach full-track production in twelve to fifteen months. During this period of twelve to fifteen months of swinging into full-scale production 1000-1500 pounds of Li^7 would be produced. After full-scale operations were reached at least 2000-4000 pounds of Li^7 per year would be produced at a probable cost of $500-$1000 per pound of Li^7.

The production of Li^7 electromagnetically has developed so successfully that full-scale track operations would enable us to more accurately determine what can ultimately be obtained from the electromagnetic process and at the same time produce Li^7 at a reasonable cost.

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In Reply Refer To:
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Oak Ridge, Tennessee
March 2, 1950
(orig. 3 copies)

Carbide and Carbon Chemicals Division
Union Carbide and Carbon Corporation
Post Office Box P
Oak Ridge, Tennessee

Attention: Dr. C. E. Larson, Director
Oak Ridge National Laboratory

Subject: LITHIUM ISOTOPE CONCENTRATE IN COMMERCIAL ELECTROLYSIS

Gentlemen:

Thank you for your letter of January 25, subject as above, in which reference was made to the possible enrichment of the Li^7 isotope in the electrolyte of the electrolysis process for the commercial production of Li metal, and in which you recommend a study of samples from Li electrolyte residues for possible enrichment effect.

We concur in the significance of this proposal and suggest that Carbide undertake the work as part of the current Lithium program. It is understood that security clearance procedures were recently initiated for Dr. Leonard W. Stager of the Maywood Chemical Company, and Dr. R. E. Ellstad of the Metalloy Corporation. These individuals may be used to assist in the work. However, you may proceed with the work at an earlier date if you so desire. In any case, the specific use of the separated isotopes should not be revealed.

Sincerely yours,

Albert H. Holland, Jr., M.D.
Director of Research and Medicine

CC: Mr. C. E. Center
Mr. R. W. Cook

Roth:my

T.D.
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