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INTRODUCTION

The use of liquid metals, especially lithium, for a heat transfer medium (because of its very attractive heat transfer properties) shows great possibilities in various high temperature nuclear reactors. Lithium has many attractive properties; however, its application in nuclear power plants is limited because of the high-absorption cross section of the Li^6 isotope for thermal neutrons. An isotopic separation of the Li^7 (which has a very low absorption cross section) from the Li^6 isotope would be necessary before lithium could be considered as a primary coolant for a nuclear reactor.

This report contains a literature survey of the properties and general information of Lithium. This information is presented in the hope that others may find information on the subject more readily. The information given is not all inclusive and may contain some errors, since the author was dependent upon the accuracy of the literature.

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LITHIUM
(Li)

3.

<u>Chemical & Physical Properties</u>	<u>Value</u>	<u>Reference</u>
1. Atomic Number	3	2
2. Atomic Weight	6.94	2
3. Valence	1	8
4. Boiling Point ($^{\circ}\text{F}$)	2403-2500	2,3
5. Atomic Volume (cc/g-atom)	13.1	9
6. Isotopes	6,7,8	1,2
7. Density	See Fig. 1	
8. Specific Gravity at 68°F	0.534	9
9. Melting Point ($^{\circ}\text{F}$)	354-376	2,3
10. Expansion of Melting (%)	1.5	1,2
11. Heat of Fusion BTU/lb	286	3
12. Heat of Hydration (kilo. cal/gm ion)	210	9
13. Heat of Ionization (cal/mole)	62.9	9
14. Specific Heat	See Fig. 2	
15. Latent Heat of Vaporization (cal/gm)	4650-4680	1,2
16. Heat of Formation (kilo-cal/equiv.mole)		
a. Hydride	21.3	12
b. Oxide	71.5	12
c. Nitride	16.5	12
d. Sulfide	57.5	12
e. Fluoride	144.7	12
f. Chloride	98.7	12
g. Bromide	87.1	12
h. Iodide	71.2	12
17. Thermal Conductivity	See Fig. 3	
18. Entropy at 0°C (cal/mole $^{\circ}\text{C}$)	6.64-6.76	
19. Enthalpy	See Fig. 4	5

<u>Chemical & Physical Properties (Con't.)</u>	<u>Value</u>	<u>Reference</u>
20. Vapor Pressure	See Fig. 5	
21. Viscosity	See Fig. 6	
22. Characteristic Spectrum Lines ($\text{\AA}$)		
a. Red	6,708	12
b. Orange	6,103	12
23. Flame Spectrum in mg.	1/660,000	9
24. Spark Spectrum in mg.	1/40,000,000	9
25. Crystal Structure	Cubic, Body Centered	12
26. Allotropic Transformation ($^{\circ}\text{C}$)		
a. Body centered cubic to face centered cubic	-196	9
- 27. Lattice Constant at 68°F ($\text{\AA}$) BCC	3.502	1,3,7
at -320°F ($\text{\AA}$) FCC	4.14	9
28. Diameter of Atoms (cm)	2.01×10^{-8}	9
29. Radius of Ions (cm)	5.0×10^{-8}	9
30. Diameter of Ions (cm)		
a. In aqueous solution	4.52×10^{-8}	9
b. In methyl alcohol	9.40×10^{-8}	9
31. Goldschmidt Atomic Radius ($\text{\AA}$)	1.57	6
32. Typical Commercial Chemical Analysis (%)		
a. Li	99.80 ⁺	
b. Na	0.05	
c. K	0.01	
d. Ca	0.01	11
e. N	0.02	
f. Fe	0.001	

<u>Electrical Properties</u>		<u>Value</u>	<u>Reference</u>
1. Electric Conductivity (recip.ohms/cc)			
(1/5 that of silver)	at 32°F	11.7×10^4	12
	at 446°F (solid)	7.88×10^4	9
	at 446°F (liquid)	2.21×10^4	9
2. Electrical Resistivity	at 230°C (micro-ohms)	42.25	2
3. Magnetic Susceptibility	at 60°F	0.38×10^{-6}	9
(cgs. electromagnetic units/unit mass)	at 367°F (solid)	2.57×10^{-6}	9
	at 367°F (liquid)	2.42×10^{-6}	9

4. Variation of Electrical Resistivity with Pressure

(kg/cm ²)	<u>0</u>	<u>1000</u>	<u>3000</u>	<u>5000</u>	<u>7000</u>	<u>9000</u>	<u>12,000</u>	
0°C	1.000	1.0069	1.0212	1.0360	1.0511	1.0675	1.0927	
50°C	1.2122	1.2206	1.2379	1.2558	1.2745	1.2940	1.3246	Ref. 9
100°C	1.4580	1.4681	1.4889	1.5105	1.5329	1.5564	1.5932	

<u>Mechanical Properties</u>	<u>Value</u>	<u>Reference</u>
1. Coefficient of linear thermal expansion at 68°F (in/°F)	56×10^{-6}	6
2. Hardness, Moh's Scale (softer than lead, harder than sodium)	0.6	9
3. Young's Modulus (lbs/sq. inch)	7.1×10^5	11
4. Coefficient of Thermal Expansion (cubic) 64°-356°F V = 1, 64°F.	1.801×10^{-4}	12

<u>Nuclear Properties</u>		<u>Value</u>	<u>Reference</u>	
1. Isotopic Neutron-Absorption				
Cross Section				
a. Mass	6.01697	7.01822	8.02502	2
b. Abundance (%)	7.5	92.5		2
c. Cross Section (Barns)	870	0.033		2
d. Half Life (sec)	-	-	0.089	2
2. Thermal Neutron Absorption				
Cross Section (Barns)		65-69		6,7
3. Thermal Neutron Scattering				
Cross Section (Barns)		1.5		2

<u>Miscellaneous Properties</u>		<u>Value</u>	<u>Reference</u>
1.	Cost (\$/lb) 1957 (500 lbs and over) 99.8% pure	9	10
2.	Corrosion Resistance of Various Metals and Alloys in Lithium	See Fig. 7	4
3.	Mean Lithium Content of the Earths Crust (%)	4×10^{-5}	9
4.	Health Hazard	None Known	9
5.	Color	Silvery White	9
6.	Ionization Potential (volts)	5.37	9
7.	EMF (volts)	2.9595	9
8.	Transport Number at 64°F	33.4	9
	a. Temperature Coefficient	0.0265	9
	b. Absolute Velocity (cm/sec) (emf = 1v/cm)	0.000346	9
9.	Electrolytic Potential (volts)	- 2.7	9
	a. Li/calamel (volts)	3.305	9
10.	Photoelectric Effect	$\gamma = 280 \mu\mu$	9
11.	Mass Effect	$\mu = 0.135$	9
12.	Principal Ores		
	a. Spodumene($\text{LiAl}(\text{SiO}_3)_2$)		9
	b. Amblygonite($\text{LiAl}(\text{F},\text{OH})\text{PO}_4$)		9
	c. Lepidolite		9
	d. Dilithium Sodium Phosphate(Li_2NaPO_4)		9
13.	Fabrication Methods		
	a. Casting		9
	b. Machining		9
	c. Extruding		9
	d. Welding		9
	e. Rolling		9
14.	Lithium oxidizes slowly in air, and a lump of the metal can be heated even above its melting point without deformation or incandescence because of the formation of an oxide shell (containing a trace of peroxide).		
15.	Lithium reacts slowly with water to form the hydroxide. It does not fuse upon contact with water as does sodium.		
16.	Lithium nitrides in air quite readily.		

<u>Miscellaneous Properties (Con't.)</u>	<u>Value</u>	<u>Reference</u>
17. At a red heat hydrogen combines with lithium to form the hydride.		9
18. Lithium reacts with carbon dioxide to form the oxide, the carbonate, and carbon.		9
19. Lithium reacts with gaseous ammonia to form the amide.		9
20. Unlike sodium and potassium, lithium burns in excess oxygen to form chiefly Li_2O , with only traces of peroxide. The burning is similar to that of magnesium, giving an intense white light.		11
21. Lithium alloys readily with Ag, Al, Cd, Bi, Hg, Mg, Pb, Ca, Sn, Tl, Zn and others, forming numerous intermetallic compounds. It has only limited solubility in Cu at room temperature and very low or no solubility in iron and nickel.		11
22. Lithium metal is available in large commercial quantities, in the following physical forms:		11
a. Ingots	4 inch dia. x 5 in. high. 4 3/8 inch dia. x 7 1/4 in. high.	
b. Cups	2 1/4 in. dia. x 2 in. high	
c. Rod	1/2 in and 3/8 in. dia.	
d. Wire	1/8 in dia. (1 lb and 2 lb spools)	
e. Ribbon	1/2 in. x 1/32 in. 1/4 in. x 1/32 in.	
f. Shot	-6 + 16 mesh	
g. Cartridges	2.25, 4.5, 9.0 and 108 grams net in copper cups	
23. Wire and ribbon are packed in petrolatum. All other forms are packed under oil. Cartridges are hermetically-sealed copper tubes or cups.		
24. Supplier - Lithium Corporation of America, Minneapolis 2, Minnesota.		

Moving and Storage

References 2, 7 and 9

Less reactive in air or water than sodium, potassium, rubidium, or cesium. Can be handled in air and stored in dry kerosene or light mineral oil. Some authorities consider that a violent reaction with halogenated hydrocarbons is likely, therefore only clean, pure kerosene or oil should be used. The mineral oil is normally washed off with petroleum ether in an argon or helium atmosphere prior to charging a tank with lithium pigs. Argon is preferred because it has a density greater than air.

Lithium of commercial purity tarnishes in moist air in a matter of seconds and even quite rapidly in dry air. Lithium reacts with water to release hydrogen. The reaction is not as violent as that between sodium and water, and the heat released is not sufficient to melt the lithium.

Lithium can be handled safely in an inert atmosphere to approximately 400°F, since it reacts slowly with oxygen and nitrogen and does not fuse on the surface of water with subsequent hydrogen explosion as does sodium. It dissolves readily in dilute HCl and H₂SO₄, slowly in concentrated H₂SO₄, and with explosive violence in HNO₃.

Molten lithium also reacts with explosive violence in contact with concrete. Rather rapid reactions are experienced when lithium at elevated temperature comes in contact with common insulating materials, such as magnesia, asbestos, mica and Marinite.

Although it is much less reactive to air than sodium, care should be taken to prevent bodily contact with lithium metal by the use of metal tongs or gloves of rubber or plastic. (Reference 11).

For handling molten lithium, workers should be protected with flame-proof clothing, foundry-type shoes, asbestos gloves, and a head shield, (Reference 11).

Fire Control

Lithium fires can be controlled by dry powders such as graphite (100 mesh), potassium chloride and Pyrene G-1. In no case should carbon tetrachloride, carbon dioxide, or acid-soda extinguishers be used on lithium fires because of violent reactions resulting. (Reference 2).

Pre-cleaning of Lithium Circulating System

During the assembly of any lithium-circulating system, care should be taken to ensure that all internal surfaces are free from welding scale and free from dust that can be mechanically removed. Upon completion of the assembly, all components should be thoroughly degreased by pumping trichloroethylene or carbon tetrachloride through the entire system. After the system has been degreased and drained, it should be flushed with acetone and drained. Following the cleaning process, the system should be evacuated and purged with argon or helium several times prior to final evacuation and charging with lithium. (Reference 2).

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13.

LITHIUM
SPECIFIC HEAT

NASA Report 1191-SC2-63
Fairchild Engine and Airplane Corp. (1949)

Liquid Metals Handbook
Atomic Energy Commission (1952)

Specific Heat

TEMPERATURE OF

Figure 2
dx 121057

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Fig. 4. Enthalpy-Temperature Curve for Lithium

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LITHIUM
VAPOR PRESSURE

NBS Report
1193-508-53
(Oct. 1969)

Figure 5
NBS 22057

CONFIDENTIAL-27527
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27.

ORNL-R-DMC-27528
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Figure 6

Oct 1957

BARS INDICATE APPROXIMATE TEMPERATURES BELOW WHICH A SYSTEM MIGHT BE OPERATED FOR 1000 HOURS WITH LESS THAN 0.005 in. OF ATTACK OR CONTAINER SURFACE REMOVAL.

FIGURE 7

REFERENCES

1. Hutchinson, R. O., Lambert, F. J., and Graham, C. B., Summary of the Properties of Lithium, Y-12 Document Y-129, pp. 5,6 (1948).
2. "Physical Properties of Liquid Metals", Liquid Metals Handbook, Atomic Energy Commission, pp. 40, 41, 57 (1952).
3. "Physical Properties of the Elements", Metals Handbook, The American Society of Metals, pp. 20, 21 (1948).
4. Hoffman, E. E., Manly, W. D., Corrosion Resistance of Metals and Alloys to Sodium and Lithium, p. 9, ORNL-2271 (1957).
5. Redmond, R. F., Lones, J., Enthalpies and Heat Capacities of Stainless Steel (316), Zirconium and Lithium at Elevated Temperatures, ORNL-1342, p. 16 (1952).
6. The Reactor Handbook, Volume 2, The Atomic Energy Commission, p. 1044 (1955).
7. "General Properties of Materials", Reactor Handbook, Atomic Energy Commission, Volume 3, Section 1, pp. 171, 172 (1955).
8. Handbook of Chemistry and Physics, Chemical Rubber Publishing Co., 30th Edition (1947).
9. Jesseman, D. S., Report on Lithium, NEPA Report 1193-SCR-53, Fairchild Engine and Airplane Corporation (1949).
10. Price List, Lithium Corporation of America, Inc. (1957).
11. Product Data Sheet, Lithium Corporation of America, Inc. No. 201-656.
12. Hampel, C. A., Lithium, Rare Metals Handbook, Reinhold Publishing Corp., Chapter 12, pp. 215-254 (1956).