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THE ROLE OF LITHIUM IN MODERN TECHNOLOGY

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ABSTRACT

Lithium ("Li") is the third element in the periodic table and is a very soft alkali metal that does not occur in elemental form in nature due to its high reactivity. It is the lightest and least dense element at a temperature of 20° C. It's sourced from pegmatites, sedimentary rocks, and brines. The most common types of minerals bearing lithium of economic interest are Spodumene, Amblygonite, Lepidolite, Petalite, Eucryptite, Polylithionite, Jadarite, Lithiophyllite, Triphyllite, Cookeite. Lithium is in high demand because of its applicability in various industries such as batteries, ceramics and glass, pharmaceuticals, and lubricating greases. It's used in battery production owing to its excellent electrical conductivity and electronegativity. Ceramics and glass made of lithium are more resistant to thermal expansion and chemical reactions. Lithium compounds, such as lithium carbonate, are used in making drugs for the treatment of psychiatric and mood disorders because of their therapeutic efficacy. Lithium is used in the production of lubricating grease because of its excellent structural stability. The demand for batteries is expected to rise as the United Nations drives towards achieving net-zero greenhouse gas emissions, which can be achieved through Introduction of electrically powered vehicles (EPV) and grid battery storage systems.

Keywords: Lithium, batteries, pegmatite, greenhouse gas emissions, electrically powered vehicles.

I. INTRODUCTION

Lithium ("Li") is the third element in the periodic table and is a very soft alkali metal that does not occur in elemental form in nature due to its high reactivity. It is the lightest and least dense element at a temperature of 20° C (68° F). The crystal structure of lithium is body-centered cubic, and it is strongly basic, considering the acid-base properties of higher oxides.

Currently, lithium is in high demand because of its applicability in various industries such as batteries, ceramics and glass, pharmaceuticals, and lubricating greases.

This research aims to comprehensively examine the diverse roles of lithium in modern technology and its impact on various industries by examining lithium in energy storage, assessing its impact on sustainable transportation, exploring its applications in electronics and consumer goods, investigating its role in healthcare and pharmaceuticals, and analyzing its contribution to the sustainable energy transition.

II. GEOLOGY OF LITHIUM DEPOSITS

Lithium is sourced from hard rocks (pegmatites), soft rocks (sedimentary rocks), and brines.

HARD ROCKS LITHIUM

Hard rock lithium deposits are found in pegmatites, which is a coarse-grained granitic igneous rock that is formed at the final stage of magmatic crystallization in Bowens reaction series.

Lithium in pegmatites is found along with other rare earth elements and alkali metals, such as beryllium (Be), lanthanum (La), neodymium (Nd), rubidium (Rb), cerium (Ce), and yttrium (Y), which are found in minerals like lepidolite, spodumene, ambligonite, and petallite.

In pegmatites, lithium is extracted using open mines or underground mines, depending on the geological conditions.

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Fig. 2: Lithium bearing mineral Spodumene

SEDIMENTARY ROCK LITHIUM

Sediments which are made up of rocks, minerals, and organic material fragments that have been carried by water, wind or ice. Sedimentary rocks are created by the accumulation of these fragments over time. Lithium can be found in sedimentary rocks in various ways such as in clay deposits and lacustrine evaporates.

Fig. 3: Sedimentary rocks lithium (Source: www.http://shutterstock.com)

FORMATIONAL BRINE

Formational brines are saline groundwater enriched with dissolved lithium. They develop in enclosed basins where evaporation concentrates the dissolved minerals in the water. Brine has a tendency to concentrate lithium, an element is moderately soluble. Following regions have the most significant lithium brine deposits: Bolivia, Argentina, Chile, China, the United States, and Western Australia.

Extracting lithium from brines requires pumping the brine to the surface and then evaporating it to concentrate lithium.

Fig. 4: Brines lithium (Source: Kent, 2021)

LITHIUM BEARING MINERAL

Lithium does not exist in its elemental form because of its reactivity. However, more than 100 known minerals may contain lithium, although only a few of these are currently economically viable (BGS, 2016). The most common types of minerals bearing lithium are listed in the table below:

Table 1: Lithium-bearing minerals

Mineral	Formula
Spodumene	$LiAl\ Si_2O_6$
Amblygonite	$(LiNa)Al(PO_4)(F,OH)$
Lepidolite	$K(Li,Al)_3(Si,Al)_4O_{10}(F,OH)_2$
Petalite	$LiAlSi_4O_{10}$
Eucryptite	$Li(AlSiO_4)$
Polylithionite	$KLi_2AlSi_4O_{10}(F,OH)_2$
Jadarite	$NaSiB_3O_7OH$
Lithiophyllite	$LiMn(PO_4)$
Triphyllite	$LiFe(PO_4)$
Cookeite	$(LiAl_2)Al_2(AlSi_3O_{10})(OH)_8$

III. APPLICATIONS OF LITHIUM

1. **Batteries:** Lithium is used in making batteries (both rechargeable and non-rechargeable), which are used for numerous applications, including mobile phones, laptop computers, camera video recorders, MP3 players, and many other consumer electronics. Lithium is used in battery production owing to its excellent electrical conductivity and electronegativity.
   The high demand for portable electronic devices and the gradual switch from ordinary mobile phones to smartphones are among the factors that have triggered the increase in lithium-ion battery demand.
2. **Ceramics and glass:** Lithium oxide is used as a flux in the ceramic and glass industries because it reduces the melting point and viscosity of silica-based compounds (BGS, 2016). Therefore, ceramics and glass made of lithium are more resistant to thermal expansion and chemical reactions.
3. **Pharmaceutical:** Lithium compounds, such as lithium carbonate, are used in making drugs for the treatment of psychiatric and mood disorders because of their therapeutic efficacy.
4. **Lubricating grease:** Lithium is used in the production of lubricating grease because of its excellent structural stability.

IV. DISCUSSION

Li plays a vital role in modern technology, particularly in the production of batteries. The demand for batteries is expected to rise as the United Nations drives towards achieving net-zero greenhouse gas emissions, which can be achieved through the Introduction of electrically powered vehicles (EPV) and grid battery storage systems.

ELECTRICALLY POWERED VEHICLES (EPV)

Electrically powered vehicles are powered by electricity instead of fossil fuels (coal, gas, and oil). They were introduced to reduce greenhouse gas emissions. There are three types of electric vehicles: hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV), and battery electric vehicles (BEV).

- Hybrid electric vehicles (HEVs) possess both internal combustion engines and electric motors. They are propelled by an internal combustion engine, while the electric motor provides assistance and efficiency improvements. The battery in a HEV with a 3kWh capacity and LCE content of about 1.6kg (John, 2019) is essential for absorbing and storing energy during regenerative breaking and for giving electric assistance to the internal combustion engine, which helps increase fuel economy and lower emissions.
- Plug-in hybrid electric vehicles (PHEV) are similar to hybrid electric vehicles, but they can also be charged externally by plugging them into an external power source. With a battery capacity of up to 15kWh and a

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total LCE content of about 12kg (John, 2019), PHEVs can typically travel a certain distance on electric power alone before the gasoline engine needs to engage. Therefore, the emission will be lower than that of HEV.

- Battery electric vehicle (BEV): This is also known as an all-electric vehicle because it is 100% powered by electricity through charging using standard household outlets or specific home chargers. This significantly demands a higher quantity of LCE content, and is more eco-friendly due to the fact that they have no tailpipe emissions. Their overall environmental effect is influenced by the electricity source utilized for charging; cleaner energy sources produce less carbon emissions. Image in fig. 5 shows the three types of EPV.

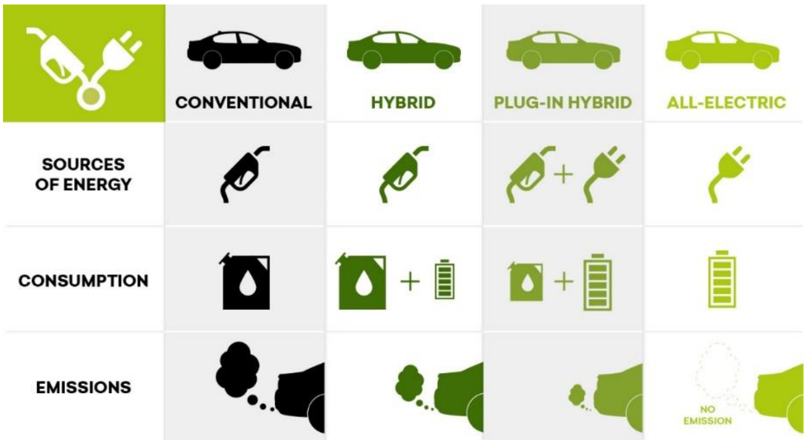

Fig. 5: Electrically – powered vehicles (Source: https://cdn.skoda-storyboard.com)

GRID BATTERY STORAGE SYSTEM

It is a large-scale battery connected to an electrical grid. It can be used to store energy from renewable sources, such as solar and wind energy, and then release it when required (Fig. 3).

Grid battery storage systems play a vital role in the modern world by helping:

1. Backup Power: During outages, battery systems offer backup power, ensuring that important infrastructure, companies, and residences can continue to operate. This was particularly significant in disaster-prone areas.

2. Reduced Greenhouse Gas Emissions: Battery storage makes it feasible to store the extra electricity produced by sustainable energy sources and use it later, which reduces greenhouse gas emissions. Consequently, there is less dependence on fossil fuels, which helps mitigate global warming.

3. Address renewable energy intermittency: Renewable energy sources such as solar and wind are intermittent, which means they do not provide electricity all of the time. When these sources provide more energy than required, grid battery storage devices may store the excess energy and then release it when there is a high demand. This contributed to a consistent and dependable electrical supply.

4. Improve grid stability: by acting as a buffer against changes in demand and supply, grid battery storage devices can contribute to an improvement in grid stability. By doing this, brownouts and blackouts may be reduced.

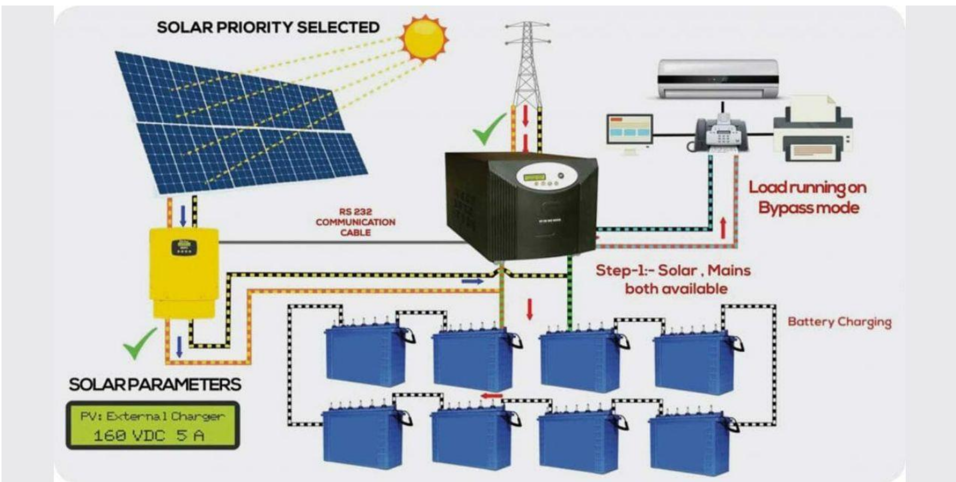

Fig. 6: Grid battery storage system (Source: http://textilevaluechain.in)

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V. CONCLUSION

Lithium has contributed to the Sustainable Energy Transition by combating climate change through the introduction of electrically powered vehicles and grid battery storage systems. However, the demand for lithium-ion batteries has drastically increased due to the high demand for portable electronic devices.

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