# लेपिडोलाइट अयस्क से लिथियम का उपयोग - एक स्वच्छ ऊर्जा भविष्य के लिए भाभा परमाणु अनुसंधान केंद्र की स्वदेशी प्रक्रिया

# Harnessing Lithium from Lepidolite Ores - BARC's Indigenous Process for a Clean Energy Future

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### Applications of Lithium

Lithium (Li) has become one of the world's most important elements because it powers almost everything - from mobile phones and laptops to electric vehicles and renewable-energy storage systems. Global demand is rising rapidly, and India, too, aims to build a strong battery manufacturing ecosystem for clean mobility and green energy missions. An equally important use of lithium, especially for the Department of Atomic Energy, is its application in nuclear technology viz. lithium compounds are used as reactor coolants, in fusion-related research and other strategic usages. Although India does not have large lithium deposits like South America or Australia, it does possess significant lithium-bearing pegmatites in the forms of mineral spodumene in Karnataka, as lepidolite in the mica belts of Bihar and Rajasthan. Lepidolite is a lilac-coloured mica mineral that contains Li along with other valuable alkali metals such as rubidium and caesium (Fig.1). To utilise these resources effectively, BARC has successfully developed an indigenous process flowsheet for recovery of lithium compounds of high purity.

### A Closer Look at the Rock That Holds India's Lithium

The first step towards lithium extraction is to understand the nature of the ore. Ore Samples from Bihar mica belt was studied using instrumental and chemical methods. The characterisation information confirmed that the ore contains about 3.15% $Li_2O$, mainly hosted in lepidolite. Quartz and feldspar are the major gangue. Photomicrographs showed that the lepidolite occurs as fine lilac coloured flakes, while XRD patterns clearly identified lepidolite, muscovite, K-feldspar, albite and quartz (Fig.2). Presence of rubidium, caesium and potassium which are valuable by-products were identified in the chemical analysis of the sample that can be recovered later in the process. The characterisation studies helped in design and development of recovery flowsheet.

### Exploring Multiple Metallurgical Routes to Unlock Lithium from the Ore

To identify a robust method for recovery of lithium values from lepidolite, three alternating processing routes were examined in detail. The comparative plot on the leachability of Li by the three alternative routes are shown in Fig.3. The first approach, whole ore direct acid roasting, involved heating the ore with sulfuric acid, but this proved ineffective for the Bihar lepidolite. Even with fine grinding and high acid consumption, only about 36% of the lithium could be extracted, as the mineral structure restricted the reaction. A second route combined high-temperature calcination at 1000°C with subsequent acid roasting. Breaking of the mineral structure before acid treatment improved leaching of Li significantly, about 94%. However, this method created challenges during removal of impurity, leading to loss of Li values in the sludge thereby reducing the overall recovery. A third approach involving salt roasting -aqueous leaching, provided the most effective recovery (97%). In this method, the ore was mixed with $Na_2SO_4$ and $CaSO_4$ and roasted at 1000°C to convert Li into water-soluble $Li_2SO_4$ with simultaneous dissolution of Rb, Cs and K in the aqueous phase. This process gives the advantage of stabilization of fluorine as $CaF_2$ which is otherwise release as a toxic gas during roasting, thus enhancing the environmental safety. In view of the high leachability of Li values with relatively purer leach liquor quality this salt roasting route was selected for further optimisation of downstream process.

### A Clean Route to High-Purity Lithium Hydroxide Monohydrate ($LiOH.H_2O$)

After selecting the salt-roasting method, the next step was to convert the lithium extracted from the ore into high-grade $LiOH.H_2O$. Once the roasted material was leached with water, the lithium-rich solution was treated with soda ash to remove calcium and other impurities without losing Li. This produced a cleaner solution which was further concentrated through

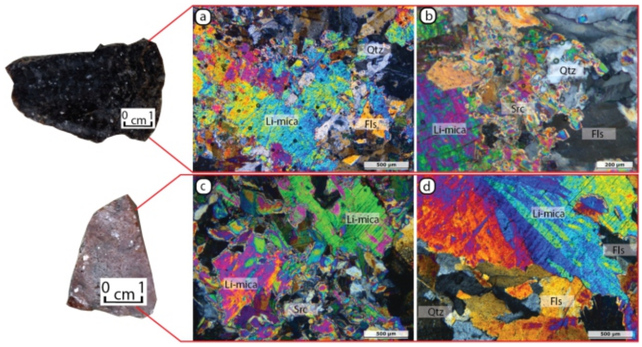


Fig.1: Photomicrographs of lepidolite showing pink/lilac mica flakes.

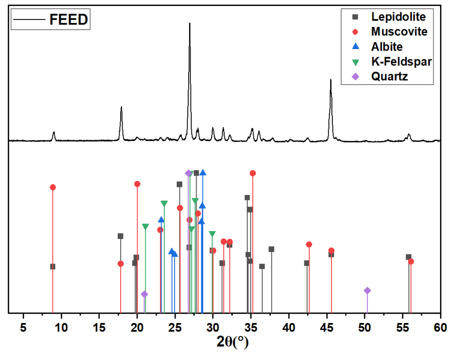


Fig.2: XRD pattern of the feed ore.

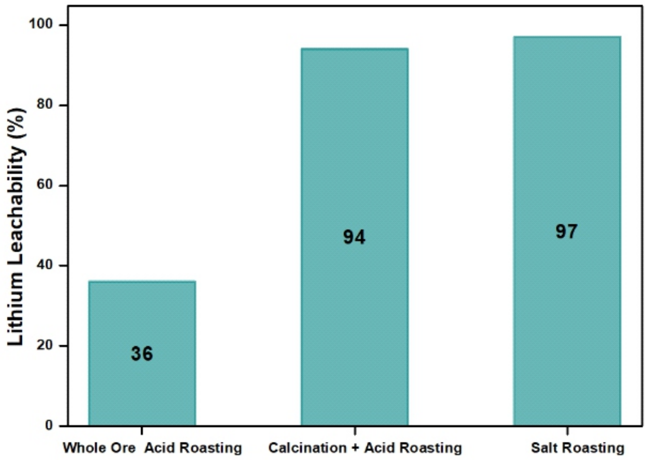


Fig.3: Comparison of leachability of lithium from lepidolite.

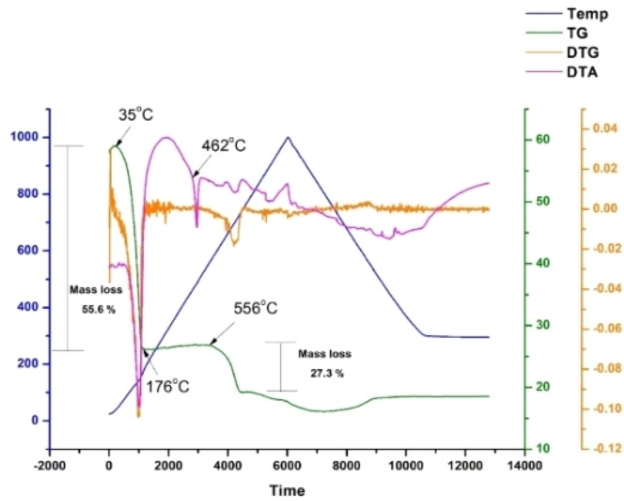


Fig.4: TG-DTA curve of $LiOH{\cdot}H_2O$.

controlled evaporation. The Li values in the concentrated solution after evaporation were precipitated as $Li_2CO_3$ by adding sodium carbonate. The soluble impurities (Na, K) in crude $Li_2CO_3$ were minimised by multiple washing of the crude precipitate. The purity of the washed precipitate was about 93%. The purified $Li_2CO_3$ was reacted with lime slurry at elevated temperature to produce a solution of LiOH free from major impurities. To obtain high-purity $LiOH.H_2O$, this solution was further concentrated under vacuum, which prevented carbon dioxide from entering and ensured that only lithium hydroxide monohydrate crystallized out. The thermal behaviour of the final crystals is illustrated in Fig.4, confirmed the quality of the product, $LiOH.H_2O$. The final crystals were of purity >99%. The product achieved through this flowsheet meets the purity requirements for nuclear applications.

## Significance and Way Forward

The work demonstrates that high-purity lithium compounds can be produced from Indian lepidolite while safely stabilizing fluorine and allowing recovery of other alkali metals. The next phase will focus on pilot-scale validation and further refinement of process steps, including improved by-product recovery and extension to other lithium-bearing deposits. Overall, this work strengthens the country's progress toward long-term self-reliance in critical minerals and clean-energy materials.

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