India

Underweight *(no change)*

Highlighted Companies

Ami Organics

REDUCE, TP Rs714, Rs1170 close

The much-vaunted vinylene carbonate will hardly add Rs0.4-0.6bn in EBITDA while operating full capacity (i.e., 800t sales). All the hopes are pinned on darulatamide, which suffers from heavy competition. Its fate can be akin to dolutegravir.

Gujarat Fluorochemicals

REDUCE, TP Rs1946, Rs2774 close

With the collapse in HFC prices and the continued headwinds on the demand for fluoropolymers, the near-term as well as long-term earnings of Gujarat Fluorochemicals are at risk. Consensus estimates need a massive cut and 2QFY24F EPS is likely to well below Rs10.

Summary Valuation Metrics

P/E (x)	Mar22-A	Mar23-A	Mar24-F
Ami Organics	58.53	50.56	47.92
Gujarat Fluorochemicals	39.32	23.03	36.34

P/BV (x)	Mar22-A	Mar23-A	Mar24-F
Ami Organics	8.13	7.09	6.46
Gujarat Fluorochemicals	7.16	5.52	4.79

Dividend Yield	Mar22-A	Mar23-A	Mar24-F
Ami Organics	0%	0%	0%
Gujarat Fluorochemicals	0%	0%	0%

Chemicals - Overall

Battery chemicals- LiPF6 hey days are over

- Indian companies are expanding their capacities to make $LiPF_6$, but the world has moved to a better electrolyte “LiFSi”.
- LiFSi has better thermal stability, hydrolysis resistance, and conductivity. It has higher power capacity, longer life, and performance at extreme temperatures.
- LG, Tesla, Volkswagen, etc. are using LiFSi. LiPF6 rules the market for now but with the mass production of 4680 & Qilin batteries, the trend will change.

LiPF6 rules the battery chemical market but has a huge overcapacity

There are eight kinds of lithium salts. Out of these, LiPF6 is the most widely used salt commercially. LiPF6 stands for lithium hexafluorophosphate, made up of a lithium cation and hexafluorophosphate anion. It accounts for 43% of the total electrolyte costs and is manufactured by reacting phosphorus pentachloride with hydrogen fluoride and lithium fluoride. In comparison to the older electrolyte salts like LiBF4, LiAsF6 and LiClO4, LiPF6 has a better performance with respect to solubility, conductivity, safety, and environmental friendliness in organic solvents. Hence, it became widely popular among battery electrolytes. Even though some of the newer salts like LiFSi have better properties, LiPF6 still dominates the market because standardized processes exist for it, enabling the refinement of the manufacturing process, thus lowering the costs. However, the trend is likely to change in the future. Currently, the global demand for $LiPF_6$ stands at 67kt and Chinese capacity now is 2x of this, with another 100kt capacity in the pipeline. Overcapacity led to the collapse of $LiPF_6$ spreads over the raw material.

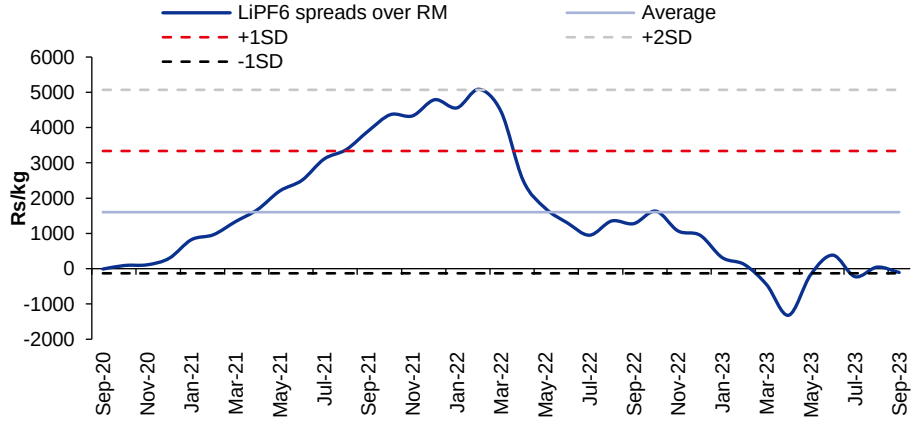
LiFSi is far better than $LiPF_6$ and is getting wider acceptance

LiFSi stands for lithium bis(trifluoromethanesulfonyl)imide. The fluorine atom in LiFSi has strong electron absorption ability, because of which it has a high conductivity. FSi- anion in LiFSi has better hydrolysis resistance compared to PF_6. LiFSi has a lower crystallization point than $LiPF_6$ and hence, it is more stable at lower temperatures. Overall, in comparison to $LiPF_6$, LiFSi has the plus side of better thermal stability, strong hydrolysis resistance, and high conductivity. Owing to its superior properties, LiFSi can significantly improve a battery’s life, its range, and charge and discharge power in the summer and winter seasons. Because of these reasons, LG, Tesla, Volkswagen, etc. are using LiFSi. Big capacities are being set up in China (LiFSi capacity in China is ~100kt and more is in the pipeline)

$LiPF_6$ investments are ill-timed; REDUCE Gujarat Fluorochemicals

In our coverage universe, Ami Organics is making the additive for $LiPF_6$ (vinylene carbonate). Please click our earlier report: IN: Ami Organics Ltd - Earnings volatility to kick in - REDUCE (REDUCE - Initiate).. GFL (Gujarat Fluorochemicals) is setting up LiPF6 production capacity. However, multiple headwinds are there for both these companies like:
1) Demand for LiPF6 will decline as it gets replaced with a better electrolyte called LiFSi.
2) LiPF6 suffers from a huge overcapacity, which is already squeezing the margins.
3) Even vinylene carbonate’s spreads over the raw material has collapsed to an all-time low.

Figure 1: $LiPF_6$ spreads over raw material are already declining



SOURCE: INCRED RESEARCH, COMPANY REPORTS

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Battery chemicals- $LiPF_6$ hey days are over

Indian companies are expanding their capacity to make $LiPF_6$ but the world has moved to a better electrolyte called LiFSi. LiFSi has better thermal stability, hydrolysis resistance, and conductivity. It has higher capacity, longer life, and performance even at extreme temperatures. LG, Tesla, Volkswagen, etc. are using LiFSi. LiPF6 dominates the market for now but with the mass production of 4680 & Qilin batteries, the trend will change.

The basics of lithium-ion batteries

What is the hype behind lithium-ion batteries? ➤

1. With the shift towards a green economy and efforts to reduce fossil fuel emissions, lithium-ion batteries have come into focus. The technological advances in the field and a reduction in prices have propelled the growth of this business.
2. In the early 1990s, storage capacity to power an US household would have cost US$75,000 and the battery pack would have weighed 111kg. The same capacity can now be obtained at a cost of US$2,000 from a 40kg cell. **There has been an 87% decline in lithium-ion prices per kilowatt hour or KWh** (see Fig. 2).
3. These batteries are primarily used in electric vehicles and stationary energy solutions. The demand for automotive lithium-ion (li-ion) battery **rose to 500 GWh (~55%) in 2022, relative to the 333GWh demand in 2021**. This growth was mostly driven by an increase in electric passenger car sales. There was a 55% increase in new vehicle registrations in 2022 when compared with 2021 (see Fig. 3).

Figure 2: The price of lithium-ion battery declined by 87% over 2010-19

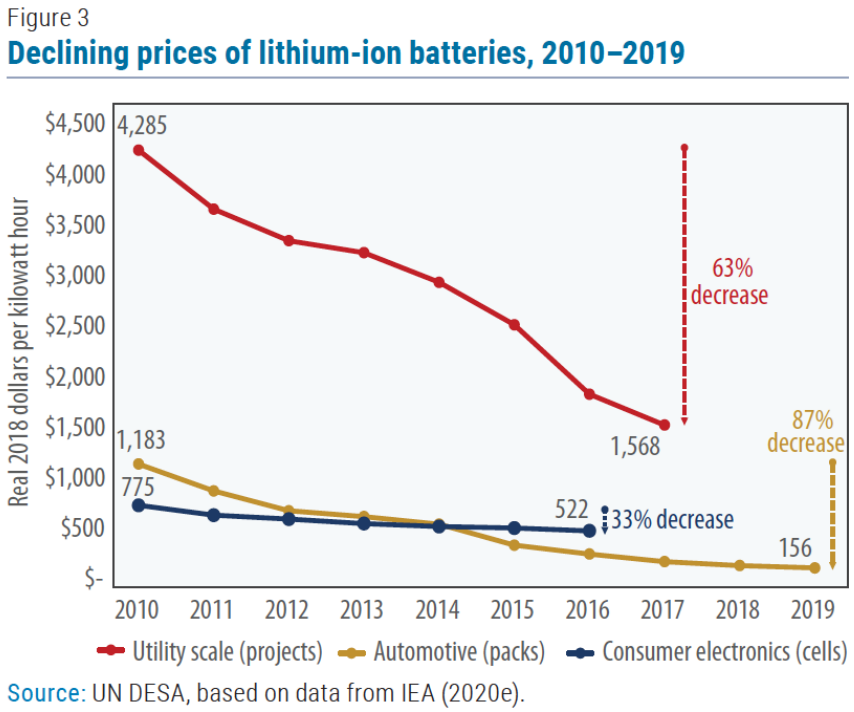

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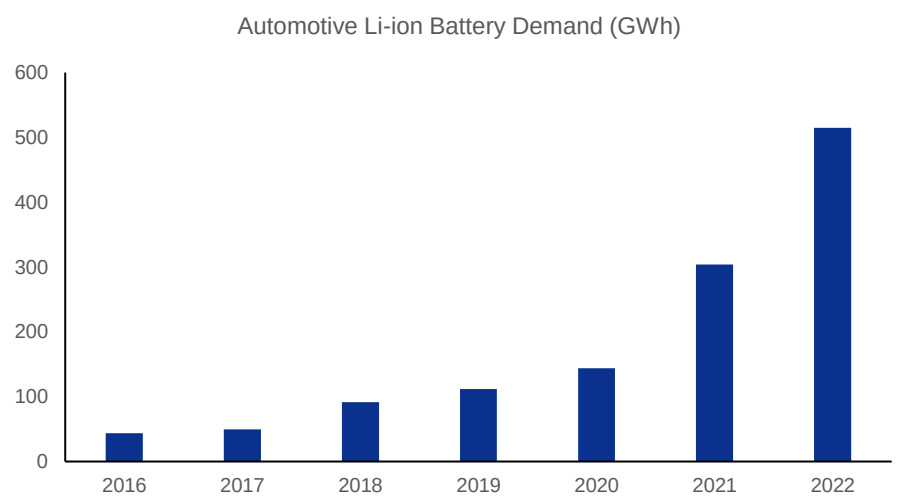
Figure 3: Demand for automotive lithium-ion battery grew by 55% from 2021 to 2022



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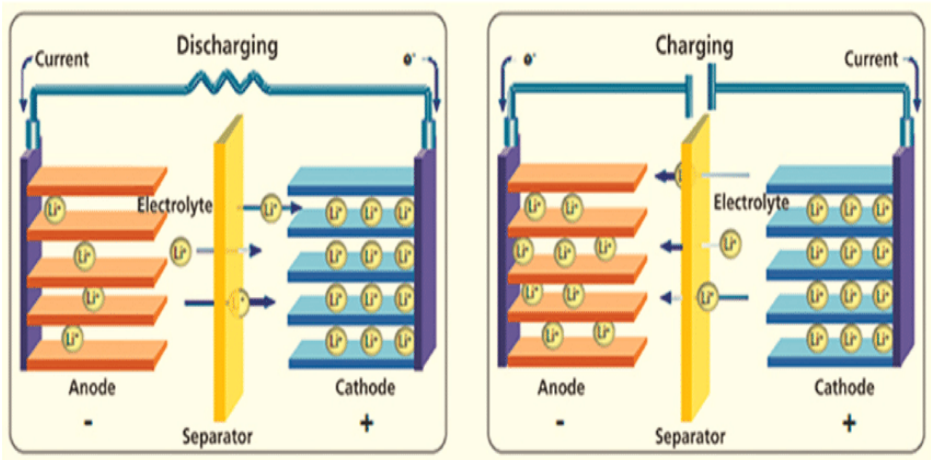
How does a lithium-ion battery work? ➤

1. A lithium-ion battery has one of more power-generating compartments called cells. A cell is primarily made of four things: positive electrode corrected to the battery's positive terminal, negative electrode connected to the battery's negative terminal, separator, and an electrolyte in between both.
2. During the charging process, the positive electrode, lithium cobalt, gives up some of its lithium ions. These ions move through the electrolyte to the negative graphite electrode and stay there. The battery takes in the energy and stores it in this process.
3. When the battery is discharging, the lithium ions move back via the electrolyte to the positive electrode. This produces the energy that powers the battery.
4. Electrons do not flow through the electrolyte. It acts like an insulting barrier for the electrons.

Figure 4: The mechanism of a lithium-ion battery



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Electrolyte and lithium-ion battery

- Electrolyte makes up 7% of a lithium-ion battery's manufacturing costs. The lithium-ion battery electrolyte market is expected to touch US$15.2bn. China dominates this market.
- Electrolyte facilitates the movement of lithium ions between the electrodes.
- Electrolyte comprises lithium salt, organic solvent, and additives.

Market landscape and growth prospects for electrolyte

1. Electrolyte is one of the four important components of a lithium-ion battery. The choice of an electrolyte can affect several components of the battery like heat resistance, battery life, performance, etc.
2. Electrolyte makes up 5% of a LMO battery pack's mass**. 7% of a lithium-ion battery's cost can be attributed to the electrolyte (see Fig. 5)**.
3. With an increase in market revenue of lithium-ion batteries, the market for electrolytes is also bound to witness a growth. **It is expected to touch US$15.2bn, growing at a CAGR of 16% over 2022-23 (see Fig. 6)**.
4. Asian suppliers dominate the market. **China leads it with 60% by weight, followed by Japan and Korea (see Fig. 7).**

Figure 5: Cost break-up of a lithium-ion battery

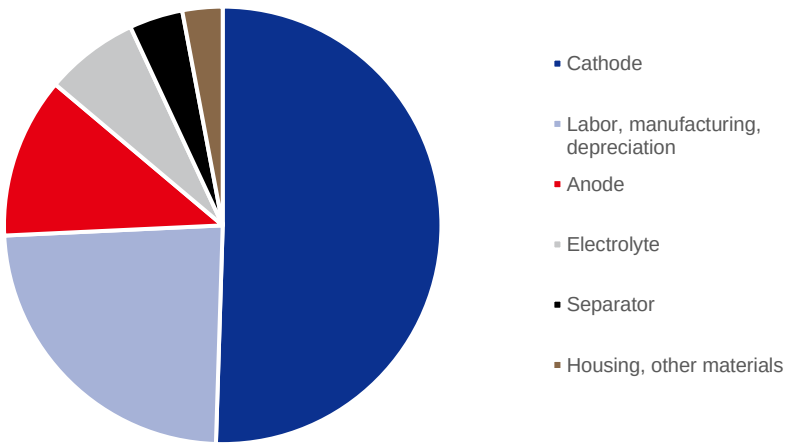

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Figure 6: Lithium-ion battery electrolyte market is expected to grow to a size of US$15.2bn by 2032F

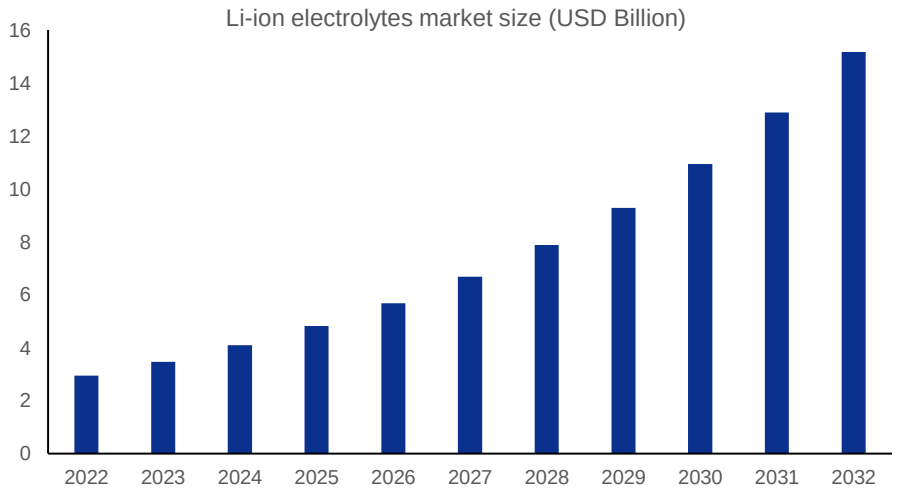

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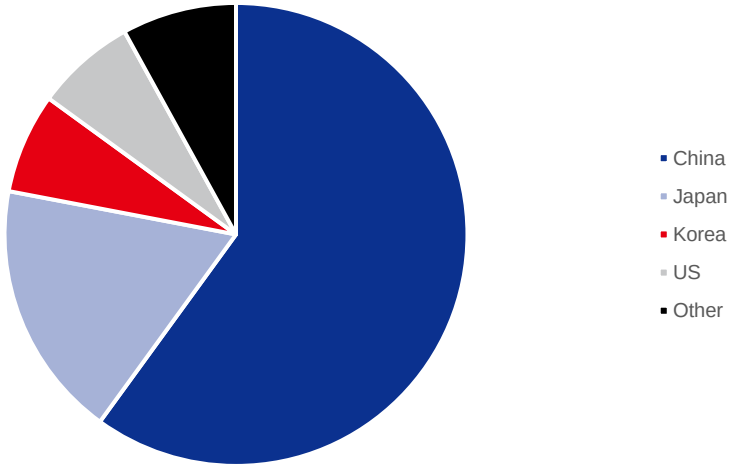
Figure 7: Regional distribution of electrolyte producers



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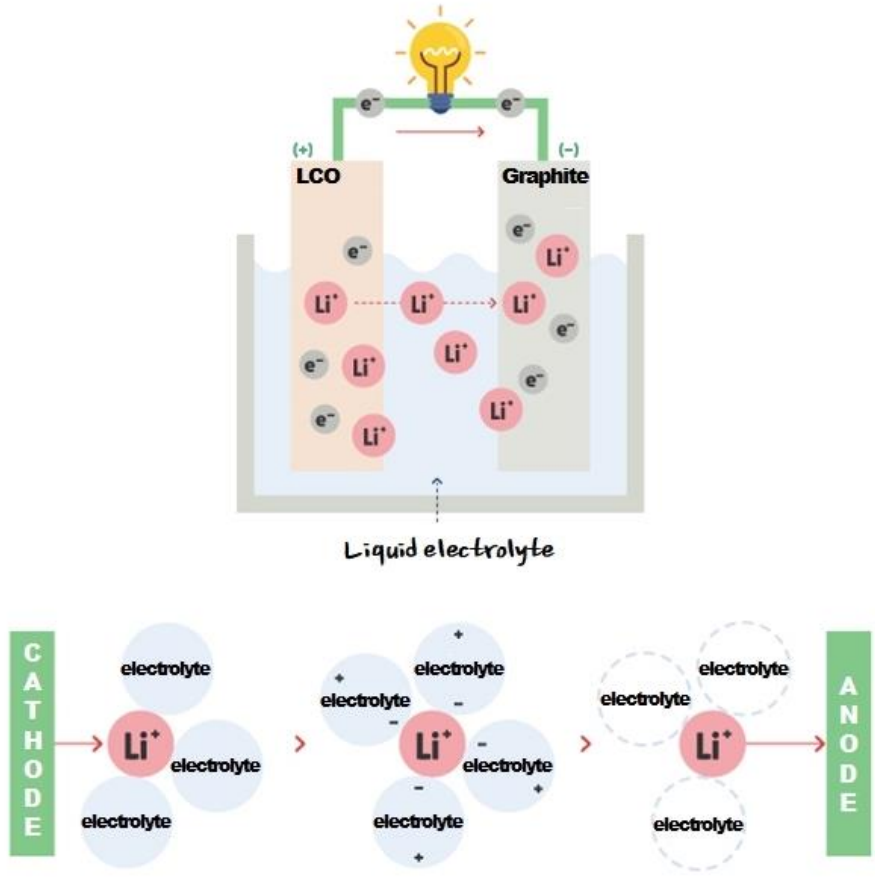
What exactly is an electrolyte? ➤

1. Batteries can have a liquid or solid electrolyte. Lithium-ion batteries have a liquid electrolyte.
2. The electrolyte facilitates the movement of lithium ions (Li+) between the cathode and the anode. In simple terms, you can think of it as a driver driving across the lithium ion (see Fig. 4).
3. It also stabilizes cathode and another surface, extends the battery life, and improves the performance of the cell.

Figure 8: The liquid electrolyte drives lithium ions from the cathode to the anode and vice-versa



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A closer look at different parts of the lithium-ion battery electrolyte ➤

1. **The electrolyte for a lithium-ion battery generally consists of an organic solvent, salt, and additives.**
2. Lithium salt acts as a carrier of lithium ions and hence, it is crucial for the lithium ions to dissolve and dissociate in a solvent, and the dissociated ions should be able to move smoothly. (Dissociation: Compounds break into ions).
3. **LiPF6 is the most-used lithium salt** as it provides better ion movement, dissolution, and more chemical stability. It is made up of lithium, fluorine, and phosphate. LiFSi is a new lithium salt that is gaining popularity - it has better dissociation and dissolution than LiPF6.
4. Organic solvent aids the dissolution of lithium salts and eases the conveyance of lithium ions. The solvent needs to have a high solubility for lithium salts to aid the separation of ions and a low viscosity for the smooth movement of lithium ions. It also needs to have a low chemical reactivity. Lithium reacts with water, and so the solvents should be non-reactive to it.
5. Additives are used in small quantities. They form a protective layer on anode and cathode surfaces. They also avert battery degradation and facilitate the smooth movement of lithium ions between the anode and the cathode.

Figure 9: Electrolyte composition

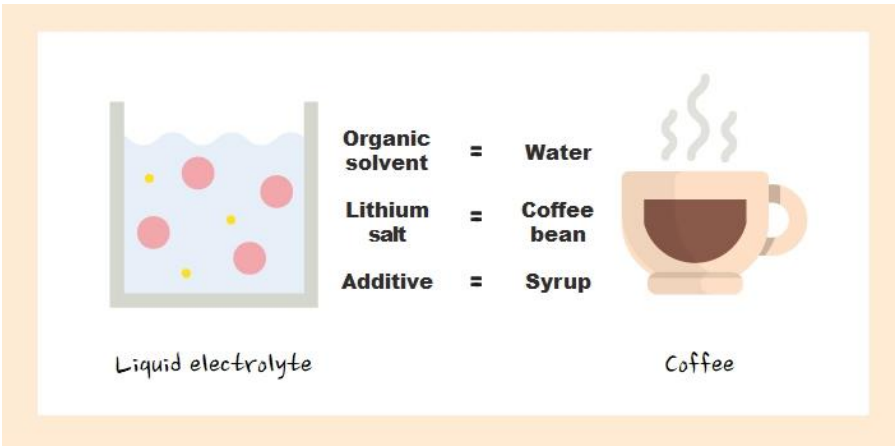

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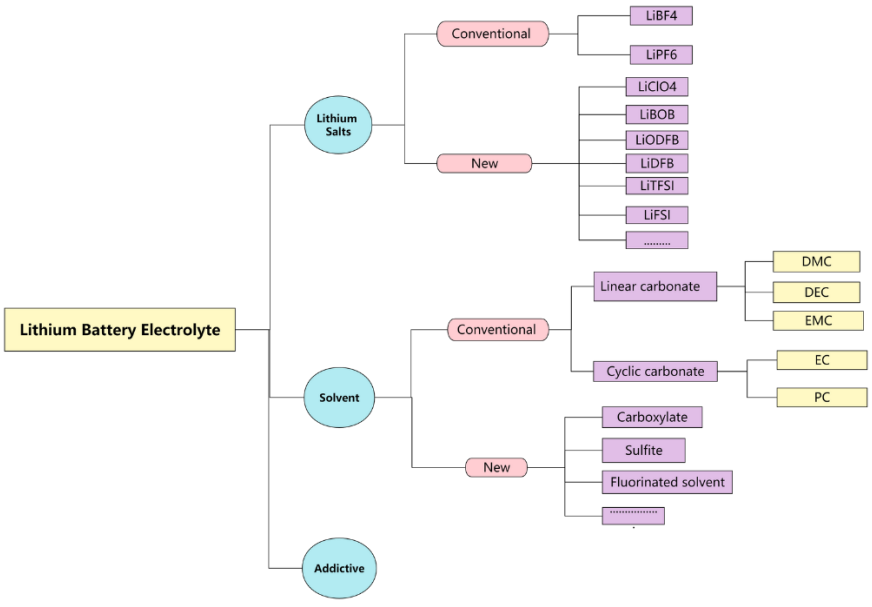
Figure 10: Different components and compounds used in a electrolyte



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As Indian players enter the market, a closer look at LiPF6

1. Multiple Indian players like GFL, Neogen, and Ami Organics are working towards or have announced plans to make LiPF6.
2. LiPF6 is the most widely used lithium salt in electrolytes due to its lower costs and superior properties like solubility, conductivity and safety. However, LiFSi, a newer lithium salt with superior qualities compared to LiPF6, will take over the market soon.
3. Lithium fluoride is reacted with phosphorous pentachloride to make LiPF6. It is a multi-step reaction. The three primary raw materials involved in this process are as follows: lithium chloride, phosphorous pentachloride, and anhydrous hydrofluoric acid.
4. Even though LiPF6 is the most prominently used lithium salt for electrolytes, it is sub-optimal because of poor performance at extreme temperatures and high humidity.

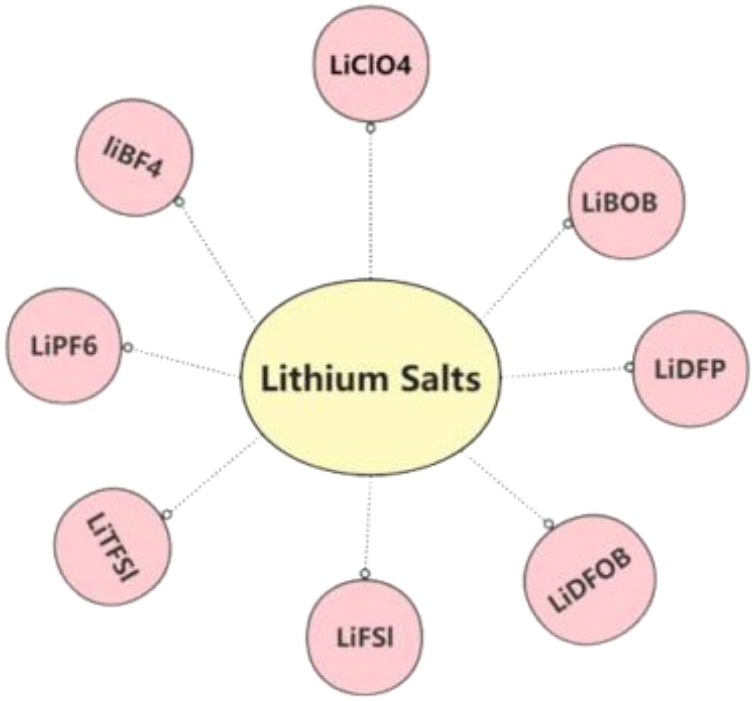
Multiple Indian players are dabbling with LiPF6 ➤

1. GFL has invested over Rs25bn in its integrated battery chemicals complex at Dahej. This plant is intended for the production of LiPF6. It is expected to be completed in FY23-24F. The plant is estimated to have an initial capacity of 1800tpa in the first phase and it is likely to be expanded in two phases over the next three-to-four years. The sample distribution phase has started, and this will be followed with a validation period of approximately three months before the commercialization of LiPF6.
2. Some other companies active in this area are Neogen and Ami Organics. Neogen has stated that it will be building capacity to commercially produce LiPF6, and Ami Organics is looking at vinylene carbonate and fluoroethylene carbonate.
3. However, we believe the **LiPF6 opportunity is not lucrative for Indian players due to the China factor and the adaptation of LiFSi, a more suitable electrolyte salt by leading electric vehicle or EV makers**. We will be looking at these aspects in more detail in the sections below.

Why is LiPF6 so popular? ➤

1. There are eight kinds of lithium salts. Out of these**, LiPF6 is the most widely used salt commercially.**
2. LiPF6 stands for lithium hexafluorophosphate, made up of a lithium cation and hexafluorophosphate anion. It is an inorganic white crystalline powder and is primarily used as an electrolyte salt in lithium-ion batteries. It accounts for **43% of the total electrolyte cost** and is manufactured by reacting phosphorus pentachloride with hydrogen fluoride and lithium fluoride.
3. In comparison to the older electrolyte salts like LiBF4, LiAsF6 and LiClO4, LiPF6 has a better performance with respect to solubility, conductivity, safety, and environmental friendliness in organic solvents. Hence, it became widely popular as a battery electrolyte.
4. Even though some of the newer salts like LiFSi have better properties, LiPF6 still dominates the market because standardized processes exist for it, the manufacturing process is refined, and the costs are lower. However, the trend is likely to change in the future.

Figure 11: Eight different lithium salts



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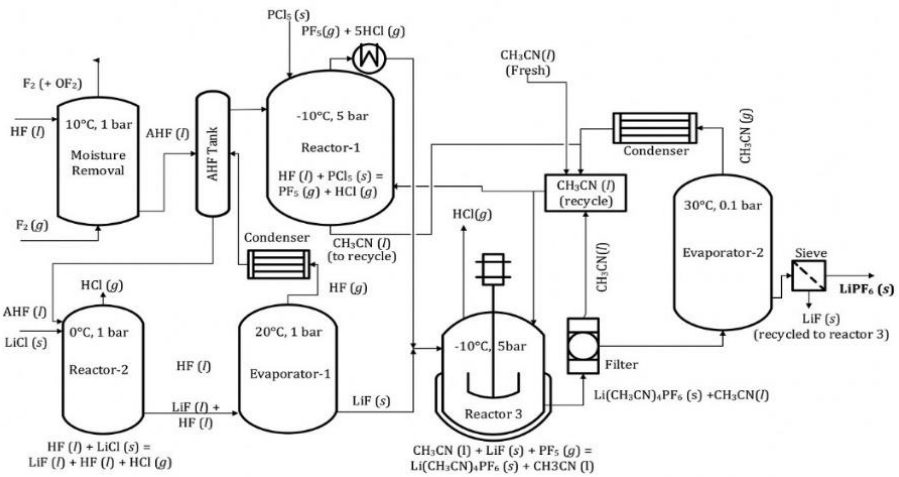
How is LiPF6 made? ➤

1. Lithium chloride, phosphorous pentachloride, and anhydrous hydrofluoric acid are the three critical raw materials used in the manufacturing process of lithium hexafluorophosphate.
2. Below is a brief overview of the manufacturing process of LiPF6:
   a. Lithium chloride (LiCl) and hydrogen fluoride (HF) are mixed to make lithium fluoride.
   b. Phosphorous pentachloride (PCL5) is reacted with HF to make phosphorus pentafluoride (PF5).
   c. An organic solvent is used to mix LiF and PF5 to make LiPF6 in a solution form.
   d. The solution is then evaporated to leave LiPF6 crystals, which are packaged and sent to the electrolyte manufacturer.
   e. The LiPF6 crystals are then dissolved into organic solvents to form the final battery electrolyte.

Figure 12: Production process of LiPF6



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Why LiPF6 is not the optimal salt despite its popularity? ➤

1. Even though LiPF6 is the mainstream lithium solute salt, it has several drawbacks. It decomposes easily in heat, has hydrolysis resistance, and crystalizes easily at low temperatures.
2. LiPF6 electrolyte's performance is not optimal at high and low temperatures, and humidity because LiPF6 is unstable and sensitive to humidity and temperature. It is susceptible to decomposition when the temperature and humidity are high. Hydrogen fluoride is produced under these conditions, and it severely affects the battery life. LiPF6 also crystalizes under low temperature, thereby decreasing the electrical conductivity of the electrolyte.

LiFSi – the nextgen threat to $LiPF_6$

1. LiFSi has better thermal stability, hydrolysis resistance, and conductivity when compared to LiPF6.
2. Owing to its superior qualities, batteries with LiFSi have higher capacity, longer battery life, age, and performance at extreme temperatures.
3. China is rapidly expanding its LiFSi capacity. A lot of downstream players like LG, Tesla, Volkswagen, etc. are starting to use LiFSi. Even though LiPF6 dominates the market now, with the mass production of 4680 batteries and Qilin batteries, the trend is likely to change.

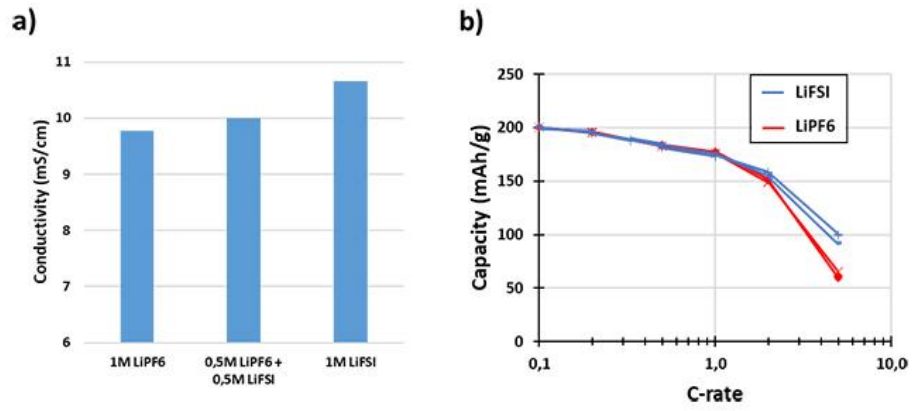
What is LiFSi➤

1. LiFSi stands for lithium bis(trifluoromethanesulfonyl)imide. It is a hydrophyphic lithium salt that is used to make electrolytes for lithium-ion batteries as a safer alternative to the conventionally used LiPF6. It is made up of one li cation and a bistriflimide anion.
2. The fluorine atom in LiFSi has strong electron absorption ability, because of which it has high conductivity. FSI- anion in LiFSi has better hydrolysis resistance. LiFSi has a lower crystallization point than LiPF6 and hence, it is more stable at lower temperatures. **Overall, in comparison to LiPF6, LiFSi has the plus side of better thermal stability, strong hydrolysis resistance, and high conductivity.**
3. Owing to its superior properties, LiFSi can significantly improve a battery's life, their range, and charge and discharge power in the summer and winter seasons. **Due to these reasons, it is expected to become the next-generation mainstream lithium salt.**

LiFSi trumps over LiPF6➤

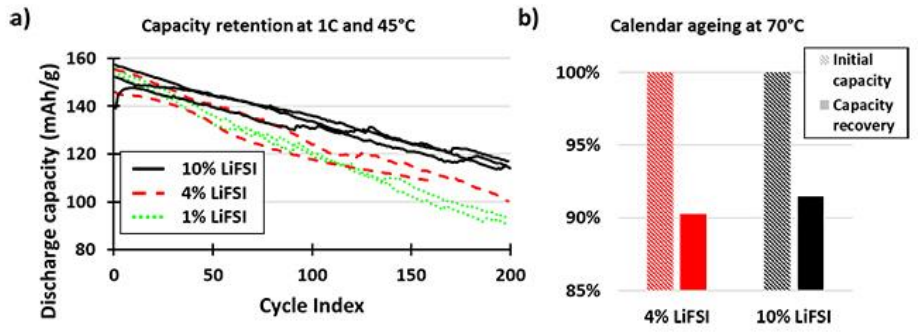
1. Ionic conductivity is the ability of the ions to move across the electrodes. In comparison to LiPF6, LiFSi drives higher ionic conductivity. This means that the battery that has **LiFSi** will have higher capacity and will be able to travel a longer distance in a single charge when compared to a battery with LiPF6 (see Fig. 13a).
2. **LiFSi**-based electrolytes have improved rate performance in NMC811/graphite cells compared to LiPF6-based electrolytes. Rate performance affects the power and charge capabilities of lithium-ion batteries. High rates are crucial for fast charging and high-power delivery (see Fig. 13 b).
3. We already know that batteries with LiPF6 have a low tolerance to high and low temperatures. Batteries with more LiFSi have a **longer life and capacity** at 45°C and 1°C. Batteries with more LiFSi have a longer life at 70C (see Figs. 14a and 14b).

Figure 13: a) Batteries with LiFSi have a higher capacity than batteries with LiPF6; b) LiFSi batteries have improved fast-charging and high-power delivery



SOURCE: INCRED RESEARCH, COMPANY REPORTS

Figure 14: a) Capacity retention of NMC532/graphite cells cycled at 1C (charge & discharge) at 45°C; b) Initial capacity and capacity recovery at C/10 after two weeks of calendar ageing at 100% SOC at 70°C



SOURCE: INCRED RESEARCH, COMPANY REPORTS

The trend is moving towards LiFSi »

1. LiFSi mass production technology using proprietary synthesis and purification techniques was first developed by Nippon Shokubai in 2013. After Nippon, European and American companies such as Arkema stepped into the development of LiFSi synthesis process.
2. Nippon has a production capacity of 300t/year in Japan. The company has also made an investment in Hunan Fluopont New Materials Co. Ltd (capacity of 1,200t/year in 2022 to be increased to 12,000t/year in 2025F). Toyata Tsusho has agreed to a joint capital participation with Nippon Shokubai for this project. Through this capital participation, Toyota Tsusho will commit to sales of LiFSi produced at Hunan Fluopont to electrolytic solution makers not only in China but also in Japan, other Asian countries and Europe, leveraging its global sales network.
3. Tianci Materials, Shanghai Chemspec Corporation, and DFD Chem are some of the leading LiFSi manufacturers. 98% of the planned new LiFSi production capacity worldwide will be found in China. The top three brands will have a production capacity of 60,000mt, 20,000mt, and 10,000mt, respectively.
4. Power battery plants and new vehicle enterprises are the present customers of LiFSi. Some of companies that use LiFSi include LG, Samsun, Panasonic and other well-known new energy battery manufacturers like Volkswagen, Toyota, etc.
5. Tesla's 4680 battery uses LiFSi, and it has started mass production. The usage of LiFSi in the Tesla battery will further accelerate the introduction of LiFSi in the industry chain.

6. As the most important component of the electrolyte, the choice of lithium salt largely affects the battery's performance. Even though LiPF6 dominates the market due to its low costs, it is failing to keep up with the needs of innovative batteries due to chemical instability and poor performance at low and high temperatures. LiFSi will be used more often in these innovative batteries and will ultimately become the primary replacement for LiPF6 with the mass production of Qilin and 4680 batteries.

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