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ALTECH – 4N HPA'S APPLICATION IN SOLID STATE LITHIUM-ION BATTERY

Highlights

- Improved lithium-ion battery safety by moving to a solid state electrolyte
- Considerable increase in energy storage capacity
- 4N HPA is likely to play a key role in solid state lithium-ion battery
- Usages likely to be higher for future solid state batteries

Altech Chemicals Limited (Altech/the Company) (ASX: ATC) (FRA: A3Y) is pleased to provide information regarding the possible use of high purity alumina (HPA) in the manufacture of a likely next generation of lithium-ion battery (LiB) – the solid state LiB. The Company has been frequently asked if 4N HPA will be used in future solid state lithium ion batteries where there are no ceramic coated separators.

As an internal research project, Altech has reviewed and investigated more than one hundred separate research journal articles citing the use of high purity alumina in the development of solid state lithium-ion batteries. Based on this extensive research, Altech believes that 4N HPA will continue to be a key ingredient of future commercialised solid state lithium-ion batteries. Similarly, the amount of 4N HPA used is also likely to be higher than the amount used in the current ceramic coated separators.

Conventional lithium-ion battery

Lithium-ion is arguably the most advanced battery technology available today and since its initial commercialisation in 1991, the lithium-ion battery has helped facilitated the prolific growth of a vast range of portable electronic devices, electric vehicles and renewable energy storage options. LiB's are increasingly indispensable for our comfortable living today.

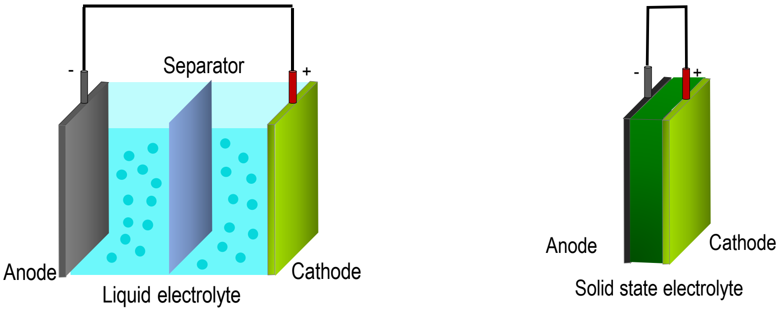
A conventional LiB cell consists of two solid electrodes (anode and cathode) that are separated by a pool of liquid electrolyte and a polymer separator sheet (see figure 1 on page 2). The electrolyte provides the pathway via which lithium ions travel from anode to cathode (and visa-versa) during battery discharge and recharge. However, the liquid electrolyte is the LiB's "Achilles' heel", as this organic substance is highly corrosive and highly combustible and has a finite operating temperature. Although low-risk, LiB's are susceptible to intense flammability (fire and/or explosion) and corrosion should battery integrity be compromised by for example, overcharging, short-circuit, overheating or mechanical abuse (e.g. bent, cut, crushed etc.).

Also, an inherent challenge of using lithium within a battery is the propensity for dendrites, or branch-like growths of lithium metal, to occur when lithium ions collect in localised areas on the electrode surface, usually the anode. During the charge cycle, lithium ions move from cathode to anode and distribute unevenly on the anode surface. With each subsequent charge cycle, ions find the path of least resistance, causing them to collect in localised areas that protrude from the anode surface. This reduces battery life (because of a reduced number of active lithium ions), but is a significant safety concern as the protrusions can grow long enough to span the distance between the electrodes, causing an internal electrical short circuit and resulting in battery failure. Furthermore, short-circuiting often causes localised heating and, because of the liquid electrolyte with low thermal stability, the battery can rapidly heat and a thermal runaway can result.

Solid State lithium-ion battery

Alternatively, a future solid-state LiB has a non-liquid "solid state" electrolyte which appreciably improves battery safety and allows for significantly higher battery operating temperatures, plus the propensity for dendrite grown across the electrolyte is reduced. However, solid-state LIB's have their own challenges, most prominent is slower ion diffusion during battery discharge and re-charge, as the lithium ions must travel through the solid state electrolyte, as compared to a liquid.

Figure 1 – Conventional lithium-ion battery (left) compared to a solid state lithium-ion battery (right)



The challenge of reduced ion conductivity in a solid state LiB is addressed by using a different material for the battery anode. The graphite anode that is used in a conventional LiB can be replaced by a lithium metal anode in a solid state LiB, as lithium metal can store 10 times more energy than graphite. Consequently the slower ion flow between anode and cathode in the solid state LiB is more than off-set by the sheer amount of energy transferred compared to a conventional LiB. This increased energy transfer results in a much higher battery operating temperature, a temperature that far exceeds what would be safe if a liquid electrolyte were used.

Replacing the liquid electrolyte with a solid one has the advantage of physically suppressing dendrite growth. Solid electrolytes also improve battery safety due to their superior mechanical and thermal stability when compared to liquid electrolytes. The ion conductivity of solid electrolytes is thermally dependent and increases with temperature, meaning they are well suited for high temperature applications. However, conductivity also decreases with temperature meaning the energy density of solid-state batteries decreases significantly in cold conditions, something that needs to be managed.

Figure 2. Typical PEO-based, HPA-added, nanocomposite membrane (Armand et al, 2011)

Among the different types of solid-state electrolytes, polyethylene oxide (PEO) solid electrolytes have been the most extensively studied. PEO solid electrolytes are blends of a lithium salt and a high molecular weight polymer containing Li+-coordinating groups. Numerous research papers have been published and numerous patents have been granted. A recognised limitation of PEO solid electrolytes is the low ion conductivity at lower temperatures due to the crystallisation of the polymer. However, it has been demonstrated that by adding 4N high purity alumina (HPA) to the polymer as a filler or active material, the crystallisation temperature is lowered and the polymer remains amorphous, enabling it to maintain its ion conductivities at lower temperatures. The typical addition of 4N HPA to the PEO is around 10 to 15% w/w (weight for weight), and it addition to maintaining polymer conductivity the HPA particles: increase mechanical strength; improve cycling performance and reduces crystallinity of the polymer host.

Based on extensive research in the field, Altech believes that 4N HPA will continue to be a key ingredient of future commercialised solid state lithium-ion battery. The demand for 4N HPA will likely increase further with the future development of solid state lithium-ion battery technology.

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For more information, please contact:

Corporate

Iggy Tan
Managing Director
Altech Chemicals Limited
Tel: +61 8 6168 1555
Email: info@altechchemicals.com

Shane Volk
Company Secretary
Altech Chemicals Limited
Tel: +61 8 6168 1555
Email: info@altechchemicals.com

Investor Relations (Europe)
Kai Hoffmann
Soar Financial Partners
Tel: +49 69 175 548320
Email: hoffmann@soarfinancial.com
Wir sprechen Deutsch.

About Altech Chemicals (ASX:ATC) (FRA:A3Y)

Altech Chemicals Limited (Altech/the Company) is aiming to become one of the world's leading suppliers of 99.99% (4N) high purity alumina (Al2O3) through the construction and operation of a 4,500tpa high purity alumina (HPA) processing plant at Johor, Malaysia. Feedstock for the plant will be sourced from the Company's 100%-owned kaolin deposit at Meckering, Western Australia and shipped to Malaysia.

HPA is a high-value, high margin and highly demanded product as it is the critical ingredient required for the production of synthetic sapphire. Synthetic sapphire is used in the manufacture of substrates for LED lights, semi-conductor wafers used in the electronics industry, and scratch-resistant sapphire glass used for wristwatch faces, optical windows and smartphone components. Increasingly HPA is used by lithium-ion battery manufacturers as the coating on the battery's separator, which improves performance, longevity and safety of the battery. With global HPA demand approximately 19,000t (2018), it is estimated that this demand will grow at a compound annual growth rate (CAGR) of 30% (2018-2028); by 2028 HPA market demand is forecast to be approximately 272,000t, driven by the increasing adoption of LEDs worldwide as well as the demand for HPA by lithium-ion battery manufacturers to serve the surging electric vehicle market.

German engineering firm SMS group GmbH (SMS) is the appointed EPC contractor for construction of Altech's Malaysian HPA plant. SMS has provided a USD280 million fixed price turnkey contract and has proposed clear and concise guarantees to Altech for plant throughput and completion. Altech has executed an off-take sales arrangement with Mitsubishi Corporation's Australian subsidiary, Mitsubishi Australia Ltd (Mitsubishi) covering the first 10-years of HPA production from the plant.

Conservative (bank case) cash flow modelling of the project shows a pre-tax net present value of USD505.6million at a discount rate of 7.5%. The Project generates annual average net free cash of ~USD76million at full production (allowing for sustaining capital and before debt servicing and tax), with an attractive margin on HPA sales of ~63%. (Refer to ASX Announcement *"Positive Final Investment Decision Study for 4,500TPA HPA project"* dated 23 October 2017 for complete details. The Company confirms that as at the date of this announcement there are no material changes to the key assumptions adopted in the study).

The Company has been successful in securing senior project debt finance of USD190 million from German government owned KfW IPEX-Bank as senior lender. Altech has also mandated Macquarie Bank (Macquarie) as the preferred mezzanine lender for the project. The indicative and non-binding mezzanine debt term sheet (progressing through due diligence) is for a facility amount of up to USD90 million. To maintain project momentum during the period leading up to financial close, Altech has raised ~A$39 million in the last 24 months to fund the commencement of Stage 1 and 2 of the plant's construction; Stage 1 construction commenced in February 2019 with Stage 2 now underway.

In July 2019 Altech announced the sale of an option to Frankfurt stock exchange listed Youbisheng Green Paper AG (since renamed Altech Advanced Materials AG (AAM)), whereby AAM can acquire up to a 49% interest in Altech's HPA project for USD100 million. AAM has commenced the process of securing the funds to enable it to exercise its option, which once complete is anticipated would be a catalyst for project financial close.

Forward-looking Statements

This announcement contains forward-looking statements which are identified by words such as 'anticipates', 'forecasts', 'may', 'will', 'could', 'believes', 'estimates', 'targets', 'expects', 'plan' or 'intends' and other similar words that involve risks and uncertainties. Indications of, and guidelines or outlook on, future earnings, distributions or financial position or performance and targets, estimates and assumptions in respect of production, prices, operating costs, results, capital expenditures, reserves and resources are also forward-looking statements. These statements are based on an assessment of present economic and operating conditions, and on a number of assumptions and estimates regarding future events and actions that, while considered reasonable as at the date of this announcement and are expected to take place, are inherently subject to significant technical, business, economic, competitive, political and social uncertainties and contingencies. Such forward-looking statements are not guarantees of future performance and involve known and unknown risks, uncertainties, assumptions and other important factors, many of which are beyond the control of the Company, the directors and management. We cannot and do not give any assurance that the results, performance or achievements expressed or implied by the forward-looking statements contained in this announcement will actually occur and readers are cautioned not to place undue reliance on these forward-looking statements. These forward-looking statements are subject to various risk factors that could cause actual events or results to differ materially from the events or results estimated, expressed or anticipated in these statements.