8 June 2018

# FORECAST SURGE IN HPA DEMAND DRIVEN BY LITHIUM-ION BATTERY SECTOR

**Highlights**

- HPA joins lithium, cobalt, nickel and copper as a recognised key input to lithium-ion batteries
- Higher battery energy density is driving migration to HPA coated battery separators
- Adoption of nickel based battery cathodes underpinning transition to HPA coated separators
- Significant increase in forecast HPA powder demand to 2025 – a 9 fold increase on 2017
- Altech ideally positioned to capitalise on forecast increase in HPA demand

Altech Chemicals Limited (Altech/the Company) (ASX: ATC) (FRA: A3Y) is pleased to provide information on the faster than expected migration by lithium-ion battery manufacturers to the use of high purity alumina (HPA) coated battery separators. Recent independent forecasts of HPA demand for the lithium-ion battery sector by various groups are extremely bullish and exceed earlier demand projections.

**HPA Critical to the Lithium-ion Battery Sector**

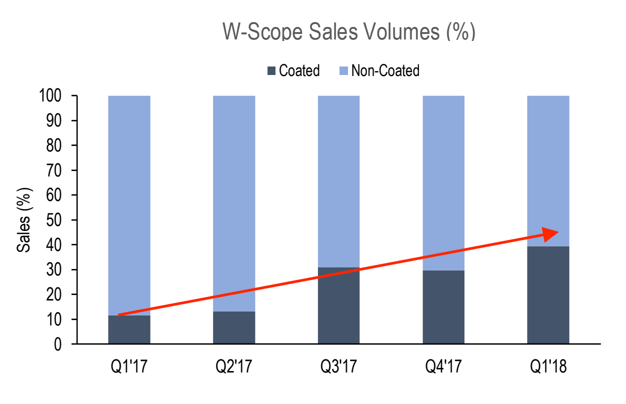
Of late, there has been considerable media coverage of presentations at natural resources industry conferences that have forecast unprecedented demand for lithium-ion battery materials and the ensuing predictions of materials shortages. Lithium, cobalt, nickel and copper have attracted much of the attention, as these are four of the key raw materials used in lithium-ion batteries. Most recently however conference speakers have for the first time added HPA to the list of critical lithium-ion battery materials. As an example, at the May 2018 Resource Stocks Sydney conference, CRU senior consultant Mr Toby Green told delegates in his presentation on lithium-ion battery (LiB) growth commodities that *"it's not cobalt, lithium or even nickel sulphate, it's high-purity alumina (HPA)"*. Mr Green went on to say that *"HPA is a huge growth story, albeit one emerging off a low base in the form of the estimated US$1.1 billion HPA market"*. Mr Green said that *"HPA ran a close second to lithium in terms of the projected scale of the impact of LiB demand on an existing battery mineral commodity up to 2025, with a plus 60% growth forecast". "The eyes of the car companies turn from time to time and they've landed at the moment on HPA*," Mr Green said. A detailed report of Mr. Green's address is available on the Company's web site (www.altechchemicals.com).

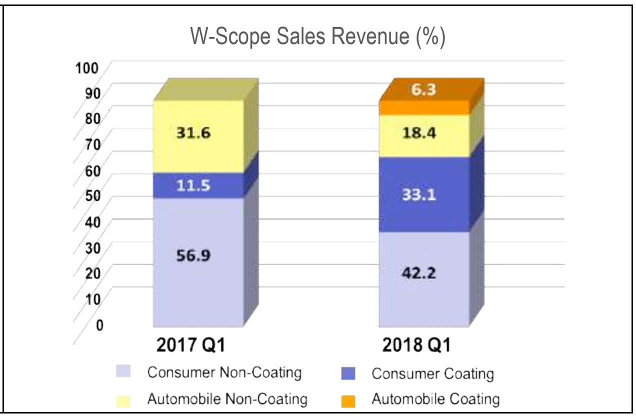
This trend toward HPA coated lithium-ion battery separators was also evident when Altech attended Battery Show Europe in Hanover, Germany on 15 May 2018; the show is Europe's largest trade fair for advanced battery technology. It was evident from discussions with exhibitors that the market share of ceramic coated battery separators is growing fast and that HPA coated separators dominate the market segment. Many coating technology and equipment suppliers exhibiting at the show reported excellent sales growth to battery makers. It was also reported that some lithium-ion battery manufacturers have been purchasing un-coated battery separator sheets and coating equipment, then applying HPA to separators in-house.

The apparent trend towards the use of HPA coated lithium-ion battery separator sheets has been recognised previously and was reflected in early HPA demand forecasts. However recent information suggests that the transition to these separators is occurring at a rate surpassing the earlier predictions. A HPA demand inflection point may be fast approaching, as the penetration rates of HPA coated lithium-ion battery separators accelerate.

A current example of the penetration and take-up rate of HPA coated separators is from the Japanese publicly listed (Tokyo) battery separator sheet manufacturer, W-Scope. W-Scope, in its Q1-2018 results reported that HPA coated battery separator sheet sales made up of 39% of all coated separator sheet sales; a ~350% increase from the same quarter in 2017. In addition, the revenue from automotive industry coated sheets accounted for 6.3% (Q1-2017 <0.5%) and revenue from consumer coated separators (electronic) was 33.1% (Q1-2017 11.5%).

**Figure 1 – W-Scope sales of HPA coated battery separator sheets by volume (%) and value (%)**




The superior safety characteristics of HPA coated battery separators, especially in larger batteries such as those in EV's, but also in consumer electronics such as laptop computers, tablets and hand-held battery packs, will likely attract the attention of regulators, especially as battery energy density continues to increase. As a consequence, it is not inconceivable that HPA coated battery separators will be broadly adopted across all lithium-ion battery categories and/or potentially mandated.

## Updated HPA Demand Outlook

In June 2016 Altech announced its in-house forecast for HPA demand of 15,102 tpa from the lithium-ion battery sector by 2025 (refer ASX Announcement dated 21 June 2016). A research report released by Sydney based Petra Capital Pty Ltd on 19 March 2018, titled "HPA Critical to Lithium-ion Battery Market" (available on the Company's web site), independently forecast that the lithium-ion battery manufacturing sector would consume ~23,000 tpa of HPA by 2025 (mid case), with a bull case of ~37,500 tpa demand for 2025.

Most recently (May 2018), London based global commodity consulting and analysis firm CRU Consulting (CRU), applying its robust "bottom-up" analysis and using its rich electric vehicle industry data base, forecast HPA demand of 76,000 tpa from the lithium-ion battery sector in 2025, close to 3 times the demand forecast of Petra Capital. The CRU forecast represents a 9-fold increase in HPA demand from the lithium-ion battery sector compared to 2017.

Based on these three separate forecasts, the average estimated demand for HPA from the lithium-ion battery sector is 42,867 tpa in 2025, which is roughly equivalent to nine and a half (9.5) of Altech's proposed HPA plants at 4,500 tpa (see Table 1).

**Table 1 –HPA demand forecast from lithium-ion battery sector (2025)**

| Organisation | Separator HPA Demand Forecast 2025 (tpa) | Equivalent Number of Altech HPA Plants |
|---|---|---|
| Altech Chemicals | 15,102 (est. June 2016) | 3.4 x |
| Petra Capital | 37,500 (est. March 2018) | 8.3 x |
| CRU Consulting | 76,000 (est. May 2018) | 16.9 x |
| Average | 42,867 | 9.5 x |

Whilst the forecast growth in HPA demand from the lithium-ion battery sector is exciting, established core HPA demand growth is strong due to HPA's position as the un-substitutable material required for the production of synthetic sapphire for use in the manufacture of Light Emitting Diodes (LEDs), in semiconductor manufacturing and the fabrication of speciality glass. Currently, around 56% of HPA use is from this sector, which is growing at an unchanged 15%-16% compound annual growth rate (CAGR).

Total HPA demand by 2025 (including from HPA coated separator sheets) is estimated by Persistence (KfW IPEX-Bank market consultant) at 62,519 tpa. Petra Capital and CRU have HPA demand estimates of 122,000 tpa and 92,900 tpa respectively (see Table 2). The average estimate of total HPA demand is 92,473 tpa by 2025, which is roughly equivalent to twenty (20) of Altech's proposed HPA plants at 4,500 tpa.

**Table 2 – Total HPA demand forecast (2025)**

| Organisation | Total HPA Demand tpa 2025 | Equivalent Number of Altech Plants |
|---|---|---|
| Persistence | 62,519 tpa | 14 x |
| Petra Capital | 122,000 tpa | 27 x |
| CRU Consulting | 92,900 tpa | 20 x |
| Average | 92,473 tpa | 20 x |

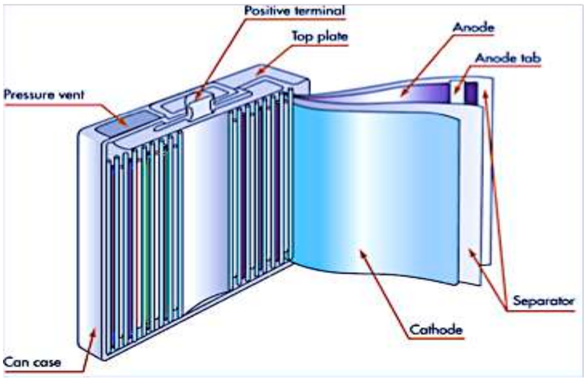
Altech managing director Mr Iggy Tan said, *"HPA demand growth in the LED sector has long been acknowledged and understood; it is now apparent that this growth will be complemented by stronger than forecast HPA demand growth from the lithium-ion battery industry, specifically from battery separator sheet manufacturers.*

*Most battery separator sheet manufacturers are based in Japan, where our off-take partner Mitsubishi Corporation is based, or in South Korea. Altech, together with Mitsubishi is well positioned to meet this rapidly expanding demand sector for HPA. The timing for construction of Altech's proposed HPA plant in Malaysia appears perfect, with two parallel streams of near-term HPA demand growth now apparent".* Mr Tan concluded

### HPA Coated Lithium-ion Battery Separators

The major application of HPA in a lithium-ion battery is as a sub-micron particle size (fine powder) coating on separator sheets that divide the cathode and anode electrodes within the battery (figure 2).

**Figure 2 – Lithium-ion battery illustration**




The anode/cathode separator sheet is a critical component within a lithium-ion battery. If the battery's cathode and anode make direct contact a highly exothermic reaction called a thermal runaway will commence and result in an extremely intense combustion event – a volatile and uncontrolled battery fire.

### HPA Coated Battery Separators Uptake

Traditionally, the majority of lithium-ion battery separators are based on polyethylene (PE) or polypropylene (PP), which have been adequate for incumbent cathodes such as lithium iron phosphate (LFP), lithium manganese oxide (LMO) and lithium cobalt oxides (LCO). However, with electronic devices and electric vehicles demanding ever-smaller batteries and increased energy density, the trend is towards nickel manganese cobalt (NMC) and nickel cobalt aluminium (NCA) cathodes to accommodate the higher energy density. One of the trade-offs for a smaller, compact and more energy intense battery is higher battery operating temperature, and this is where HPA becomes extremely important.

The use of HPA coated battery separators was commercialised in around 2008 and the technology has been adopted in line with increased demand from EVs and energy storage applications. HPA coated battery separators withstand unusually high temperature incursions, increase the battery separator's shrinkage temperatures, reduce flammability during thermal runaways, and thus make lithium-ion batteries much safer. HPA coated battery separators also increase a battery's discharge rate; lowers self-discharge; and lengthen battery life cycles.

# HPA AND ITS ROLE IN THE LITHIUM-ION BATTERY SECTOR

The following report describes in more detail the role and technological evolution of the lithium-ion battery separator and its importance in the safety and integrity of the lithium-ion battery.

## 1. Lithium-ion Battery

A lithium-ion battery is a rechargeable battery in which lithium ions travel from the negative electrode to the positive electrode during discharge and back again when charging. The battery consists of three main components;

- Electrodes – one negative and one positive. When discharging the positive electrode is the cathode and is typically lithium based, the negative electrode is the anode and is typically graphite based.
- Separator – is a thin, porous sheet, which prevents the electrodes from touching, but allows lithium ions to pass through.
- Electrolyte – the electrolyte or electrolytic solution provides for the movement of lithium ions, it typically consists of a lithium salt in an organic solvent. (see figure 3).

A battery is unique in that it contains an oxidiser (cathode) and fuel (anode/electrolyte) in a sealed container. In most other applications this combination has the risk of explosion, but in a battery, under normal operation, the anode and cathode are kept apart by a separator and convert this energy electrochemically. However, if the anode and cathode make contact, a short circuit occurs and this energy is converted directly into heat and gas. Once started, this chemical reaction will proceed to completion because of the intimate contact of fuel and oxidiser, becoming a thermal runaway. Once the thermal runaway has begun, the ability to stop it is impossible and only ceases once the fuel has expired.

**Figure 3 – Lithium-ion battery cross section showing separator**

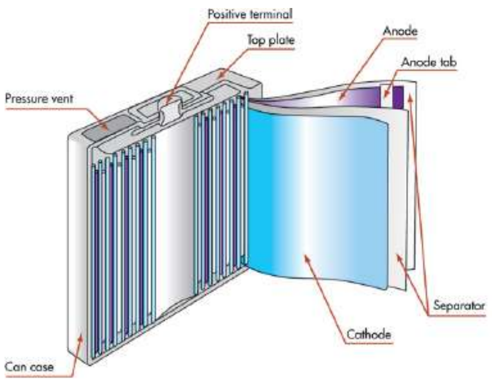



**Figure 4 – Lithium-ion battery separator sheet rolls**

## 2. Importance of Separators in EVs

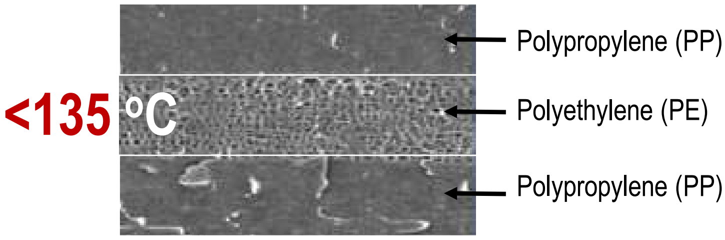
Lithium-ion batteries in EV applications are fundamentally different to those developed for other applications;

- Scale – orders of magnitude larger than those in consumer electronics.
- Environmental conditions – exposed to a wide range of temperatures, short circuits, crushing, fire exposure, mechanical shock, and vibration.
- Performance demands – overcharge/undercharge, high rates of discharging/charging, requirements for high voltage demanding long strings of cells, long life, and high energy.
- These requirements place strain on all components particularly the separator, which is required to maintain its integrity to prevent catastrophic failure of the lithium-ion battery.

## 3. Separators Types

Separators are polymer membranes consisting of either polypropylene (PP) (melting temp of 155ºC) and polyethylene (PE) (melting temperature of 135ºC) are used widely as lithium-ion battery separators. These are referred to as monolayer membranes. Monolayer polymers are simple and low cost but often struggle to achieve mechanical strength, thermal resistance, and electrochemical performance simultaneously. This has led to the development of multilayer membranes (combination of PP and PE) which can combine the characteristics of different polymers (see figure 5). These multilayer membranes combines good puncture resistance with shutdown and thermal stability. In scenarios where the cell begins to experience higher temperatures the two PP layers provide dimensional structure and mechanical strength whilst the PE layer acts as a thermal fuse. As the PE layer reaches its melting point (135ºC) the PE layer melts and closes its pore network, this blocks the pathway of ions and shuts down the battery whilst maintaining the separators integrity, preventing a thermal runaway but rendering the battery useless.

**Figure 5 – Example of multilayer membrane PP/PE/PP**




## 4. Separator Manufacturing Methods

Lithium-ion battery separators are polymer based porous sheets, which are manufactured using one of two processing methods;

- Dry Process – The cheaper, simpler manufacturing method. The polymer, either polypropylene (PP) or polyethylene (PE) is extruded into a thin sheet, this precursor film is then annealed (cooled slowly) to improve its crystalline structure. The film is then stretched in a single direction when cold, and then stretched again when hot. The cold stretch creates pore structure whilst the hot stretch increases pore size. A porosity of 35-45% can be achieved using this method. This process can also produce a trilayer PP/PE/PP separator.
- Wet Process – The more expensive manufacturing method but typically produces stronger and thinner separators. Polyethylene (PE) is the polymer usually used, which is mixed with other additives to make a homogenous solution, which is extruded into a thin, gel like sheet and then annealed. The sheet is stretched in two directions and exposed to a volatile solvent to remove the additives leaving a porous sheet. A porosity of 40-50% can be achieved using this method.

## 5. HPA Coated Membrane Separators

Coated membranes were commercialised in around 2008 in response to demand for separators that could provide safer batteries with greater short protection and better structural integrity at higher temperatures for applications in EVs and energy storage. In general, any polymer-based membrane can be coated and benefit from the improved characteristics (see figure 6). These HPA coated membranes provides enhanced short prevention and excellent structural integrity at high temperatures. Nano sized inorganic particles of high purity alumina ($Al_2O_3$) can significantly improve the mechanical strength, thermal stability and ionic conductivity of polymer membranes. Coating the separator also increases its wettability (how easily it can be soaked by a liquid) and surface area which improves the effectiveness of the liquid electrolyte.

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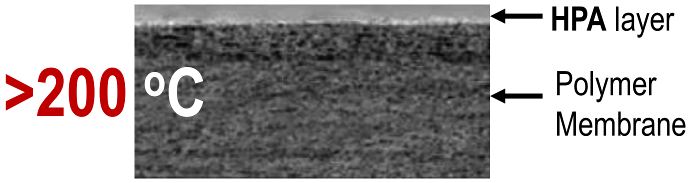
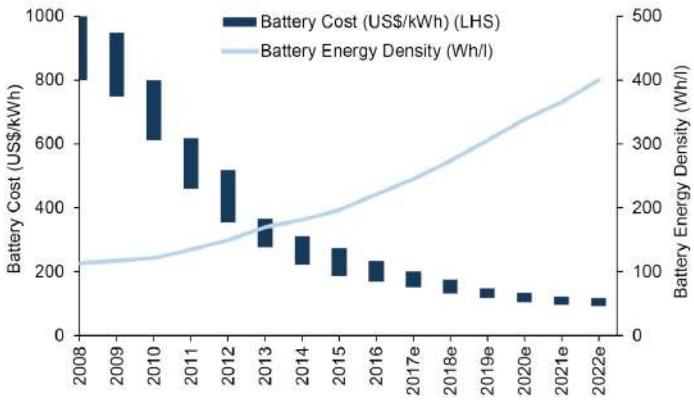
Figure 6 – HPA coated separators




## 6. Higher Energy Density, Higher Temperatures

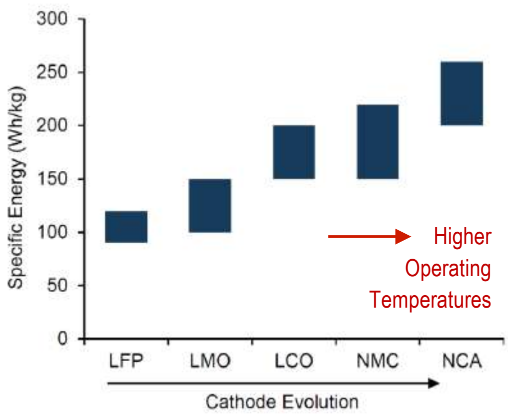
Evolution of cathode materials - The increased adoption of electric vehicles has had a profound effect on battery costs and energy density. Battery costs are falling through the economies of scale that larger battery manufacturing facilities bring to the industry, and energy density is improving as research and development continues to improve key properties of the battery. In the future, there will be a continuous focus to improve both battery costs and energy density. Figure 7 shows this relationship where in order to reduce the battery costs, the energy density of each battery needs to be increased.

Figure 7 – Battery costs vs battery energy density




The improvements to energy density are likely to be achieved through changes to the battery chemistry, and particularly the cathode. Recent improvements to energy density have been achieved by increasing the nickel content of the cathode. Figure 8 shows the evolution of cathode with increasing nickel and cobalt content allowing the specific energy of a lithium-ion battery to increase. The increased energy density higher nickel content batteries result in higher operating temperatures and more chances of overheating. Overheating can cause the separator membranes to shrink allowing contact of the positive and negative terminals, creating battery fires. The increased energy density increases the consequences of thermal runaway and places greater importance of the separator to keep the two electrodes apart.

Figure 8 – Specific energy by cathode type




LFP – Lithium Iron Phosphate
LMO – Lithium Manganese Oxide
LCO – Lithium Cobalt Oxide
NMC – Nickel Manganese Cobalt
NCA – Nickel Cobalt Aluminium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## 7. Why HPA is critical?

It is clear that the integration of inorganic particles into polymer membranes improves the characteristics (shrinkage temperature) of the separator, and that HPA is the dominant inorganic particle. HPA is the incumbent and dominant inorganic coating utilised in lithium ion battery separators. It has very favourable characteristics to improve thermal stability and wettability, and does not electrochemically react with the battery (lithium) components. In addition, the particle morphology and slurry consistencies are well understood for applying the HPA to polymer based separators. As an example, a polypropylene (PP) membrane shrinks by around 18% at 130 ºC whilst a HPA coated membrane has a very low shrinkage rate of 4% (See figure 9). Figure 10 shows how overheating can cause the separator membranes to shrink allowing contact of the positive and negative terminals, creating battery fires and thermal runaways. Enhancing the physical and chemical properties of the LiBS further, HPA particles are being introduced to create a composite separator that can withstand temperatures of >200ºC.

**Figure 9 – Shrinkage rate of PP vs HPACS**

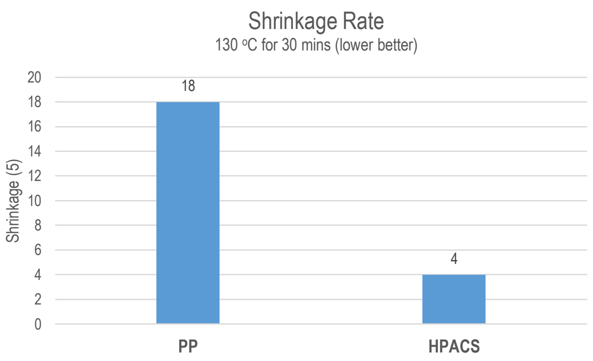
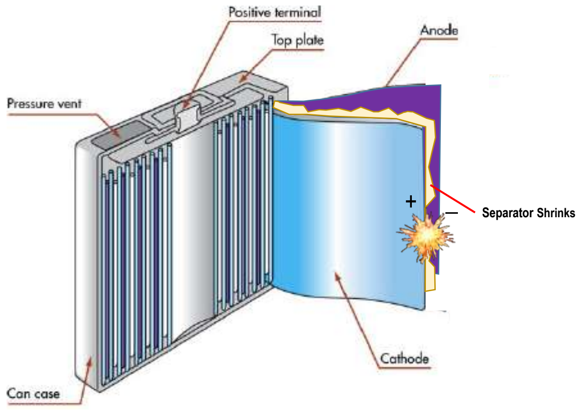



**Figure 10 - Separator shrinkage and thermal runaway**




## 8. Manufacturers producing HPA Separators

Ceramic coated separators utilising HPA have been commercially adopted in both consumer electronic and EV applications. The following leading separator manufacturers produce ceramic coated separators.

- **AsahiKasei** – 25% Mkt Share
  AsahiKasei is a Japanese chemical conglomerate and became the world's largest LiBS producer following the acquisition of Polypore International in 2015. The group produce a range of wet (PE) and dry (PP) separators through the brands Hipore (wet) and Celgard (dry). Celgard produce several dry HPA coated separator products.

- **Toray** – 15% Mkt Share
  Toray Industries is a Japanese chemical conglomerate. The group recently announced a US$1.1b capital plan to establish a European LiBS facility with capacity of 80msqm and establish a similar plant in the US. The group aims to have a global production capacity of 1.95bn sqm per year by ~2020. The group produce a range of wet and dry separators through the Setela brand, which can be coated following the acquisition of LG Chem's South Korean LiBS HPA coating facilities in 2016.

- **SK Innovation** – 9% Mkt Share
  SK Innovation is South Korea's largest energy chemical company. The group have invested heavily in lithium-ion battery production capabilities and are suppliers to major automakers Hyundai Motor Group, BAIC Group and Daimler AG. In Dec-17 the group announced a US$920m expansion of LiBS and battery manufacturing capabilities in Europe and South Korea. In Feb-18 SK Innovation signed a 7 year offtake deal for 60ktpa $NiSO_4$ and 12ktpa $CoSO_4$ with Australian Mines (AUZ.ASX) and acquired

19.9% of the company for A$80m. The group produce a HPA coated PE separator under the brand Enpass.

- **Sumitomo Chemical** – 6% Mkt Share
  Sumitomo Chemicals is a Japanese chemical conglomerate. The group produce both high purity alumina in the Inorganic Materials Division and LiBS in the Battery Materials Division. The group produce a coated separator under the brand Pervio. Following a patent dispute settled with Polypore in 2014 (subsequently acquired by AsahiKasei) the company utilises aramid as the inorganic particle rather than high purity alumina. Pervio separators are utilised by Panasonic and car manufacturer Tesla.

- **Entek** – 4% Mkt Share
  Entek is a US based battery separator manufacturer. The group produce a range of wet process PE separators including ceramic coated and PVDF coated PE separators for use in EV applications and large format polymer cells respectively.

- **Ube Industries** – 6% Mkt Share
  Ube Industries is a Japanese chemical conglomerate. In 2011, Ube Industries formed a JV with Hitachi Maxell to produce a ceramic coated separator under the business name Ube Maxell. In 2014 Ube Maxell licenced LG Chem's Safety Reinforced Separator (SRS) technology for ceramic coated separators. Ube Industries has 200msqm of dry separator production capacity for the UPORE brand whilst UbeMaxell produces ceramic coated separators.

- **W-Scope** – 6% Mkt Share
  W-Scope is a Japanese plastic film producer. The company has been investing heavily in coating facilities to meet growing demand from high end applications in consumer electronics and EVs. W-Scope produce wet separator products. In Q1'18 39% of the company's separator sales were from coated separators.

- **Oxyphen AG**
  Oxyphen is the leading German manufacturer of microporous track-etched membranes. Oxyphen's products are manufactured at two production facilities (Germany and Switzerland). The membranes produced from the company are traditionally used, as filtration materials, in the automotive and life science sectors. However, they are seeking at the applications in lithium-ion battery separator industry.

- **Targray Technology**
  A lithium-ion battery material distributor located in Canada. They distributed ceramic coated separators. Their partner includes separator manufacturer, Litarion GmbH.

- **Jiangxi Advanced Nanofiber**
  Jiangxi Advanced Nanofiter Co is a manufacturer of battery separator. The material of their separator is not typical PE and PP, instead, they are producing Polyimide nano coating separators. The separator can stand a higher temperature. However, they are still coating the separator with HPA.

*Source: Petra Capital Pty Ltd, Research Report titled "HPA Critical to Lithium-ion Battery Market", dated 19 March 2018; and Altech Chemicals Limited.*

– End –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***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** (**HPA**) ($Al_2O_3$).

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, semiconductor wafers used in the electronics industry, and scratch-resistant sapphire glass used for wristwatch faces, optical windows and smartphone components. There is no substitute for HPA in the manufacture of synthetic sapphire.

Global HPA demand is approximately 25,315tpa (2016) and demand is growing at a compound annual growth rate (CAGR) of 16.7% (2016-2024), primarily driven by the growth in worldwide adoption of LEDs. As an energy efficient, longer lasting and lower operating cost form of lighting, LED lighting is replacing the traditional incandescent bulbs.

Current HPA producers use expensive and highly processed feedstock materials such as aluminium metal to produce HPA. Altech has completed a Final Investment Decision Study (FIDS) for the construction and operation of a 4,500tpa HPA plant at the Tanjung Langsat Industrial Complex, Johor, Malaysia. The plant will produce HPA directly from kaolin clay, which will be sourced from the Company's 100%-owned kaolin deposit at Meckering, Western Australia. Altech's production process will employ conventional "off-the-shelf" plant and equipment to extract HPA using a hydrochloric (HCl) acid-based process. Production costs are anticipated to be considerably lower than established HPA producers.

The Company is currently in the process of securing project financing with the aim of commencing project development in 2018.

**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.