Sustainability in ultra high pure alumina production

Richard Foster

The first steps in reducing the carbon footprint

How can the carbon footprint for High Purity Alumina be reduced or even eliminated? The conventional process for manufacturing HPA is a notorious "energy hog". The alkaloid process yields a typical carbon footprint of 12.3 tonnes of CO2 emitted per tonne of HPA(1). This is an incredibly high ratio compared to even the huge energy consumers of the cement and steel industries with their respective ratios of only 0.6 and 1.85 tonnes of CO2 emitted per tonne of cement(2,3) and steel(4,5,6) respectively. The alkaloid process for HPA relies on expensive, carbon-intensive aluminium metal as its feedstock(1), which clearly will not be acceptable in the future.
Shocked by numbers like these, consumers and investors are making decisions on the basis of sustainability. For example, the Norwegian sovereign fund, one of the largest with more than 1.1 trillion euros invested(7), now requires all 9,000+ companies it invests in to show a plan to reduce net greenhouse gas emissions to zero by 2050(8). In this light, it is clear that the alumina industry needs an alternative manufacture 99.999%-pure 5N HPA at a competitive price.

This is because HPA is valued for its excellent properties in terms of chemical stability; very high melting point; and high mechanical strength and hardness, particularly as sapphire. It has good thermal conductivity but high electrical insulation. It takes on several crystalline structures, such as alpha (α), beta (β) and gamma (γ). α-HPA has a low specific surface area and is very resistant to high temperature. Inert, it has almost no catalytic activity. γ-alumina has excellent dispersion and a higher specific surface area, but it is inert and provides high activity(9).

The first step in reducing the carbon footprint and environmental effects is to reduce the power requirement for the manufacturing processes. This starts with the design of the processes and the manufacturing plant to implement them. As a basis to reduce power consumption: hydro metallurgy processes use much less power than thermal process steps.

With AEM's proven chlorine leach – crystalline purification (CLCP) process, for example, the carbon footprint for HPA is currently less than 12% of that from the alkaloid process and can potentially be reduced to zero in Q3 2023. Close cooperation with the laboratory is the basis for continuous improvement in the plant. This is the plan for eliminating the Scope 1 category of emissions.
The CLCP process produces almost zero waste. Hydrochloric acid, an important input, is recycled many times within the process before being discharged, predominantly in the form of aluminium chloride, which is sold as a by-product for use in water treatment. The water from our processes that we do not recycle is treated and released under strict guidelines.
The next step is to source the required power from green sources. A location rich in hydro power and wind farms is of the essence. This leads to both predictable pricing and fulfilment of environmental criteria. By-products are produced with hydro power. As a result, there are no Scope 2 emissions.

Manufacturing HPA does not occur in a vacuum. Reducing Scope 3 emissions means paying attention to inputs and outputs of production. The feedstock must arrive bringing with it a carbon footprint of zero. This can be achieved if the supplier uses hydro or wind power exclusively, ideally within the company from its own dams or wind installations. It is of course simplest if the supply is from a secured source located nearby. An alternative feedstock is aluminium from decommissioned factories.

The product going out must match the customers' requirements exactly so that they can minimise their own process steps and maximise their own productivity.

This means that HPA cannot be seen as a commodity product where the customisation is left to the customer; a wide and versatile product portfolio is needed. Powder particle size can be controlled both at the crystal-growing stage and via subsequent milling (although the latter requires careful control to avoid contamination by the grinding media). Powder must be tailored to a customer's specific requirements for particle size, densification, and doping. Pellets (compacted powder in a 'puck' shape) must also meet exacting specifications to fulfil their applications(9).
Customisation to meet special requirements involves simulation, development in the laboratory and transfer to production. Quality controls after manufacturing complete the technical involvement to the benefit of the customer. A location convenient to North American and European markets simplifies shipping.

Even if the site is not in a location where every turn of a spade is audited and certified, transparency must be maintained for internal and external purposes. All systems are running to clearly identify where things come from and where they are going. Logging of operations is ongoing in preparation for internal and external audits.

As we have seen, sustainability depends on many factors large and small. Process design, reduction of power requirements, an advantageous site, green energy sources, clean feedstocks, and customised products are all important to sustainably produce and deliver ultra high pure alumina.

Emissions Scopes according to the Greenhouse Gas Protocol[10,11]

Scope 1 – emissions from sources that a company owns or controls directly

Scope 2 – emissions that a company causes indirectly when the energy it purchases and uses is produced

Scope 3 – emissions not produced by the company itself, and not the result of activities from assets owned or controlled by them, but by those that it's indirectly responsible for, up and down its value chain.

Scope 3 emissions include all sources not within the boundaries of Scopes 1 and 2.

References

1. Cicero Shades of Green report "Altech Chemicals Limited"
2. https://news.wttw.com/2022/06/22/cement-carbon-dioxide-emissions-quietly-double-20-years
3.https://essd.copernicus.org/articles/13/1667/2021"CDIAC-FF: global and national CO2emissions from fossil fuel combustion and cement manufacture: 1751–2017"
4.https://www.recyclingtoday.com/news/worldsteel-co2-report/
5. https://www.iea.org/reports/iron-and-steel
6. https://www.mckinsey.com/industries/metals-and-mining/our-insights/decarbonization-challenge-for-steel
7. https://www.reuters.com/business/sustainable-business/norways-sovereign-wealth-fund-tells-companies-set-zero-emission-goals-2022-09-20/
8.https://www.weforum.org/agenda/2022/09/norways-massive-sovereign-wealth-fund-sets-net-zero-goal/
9.https://www.innovationnewsnetwork.com/ultra-high-purity-alumina-sustainably-manufactured-canada/20960/
10. https://www.nationalgrid.com/stories/energy-explained/what-are-scope-1-2-3-carbon-emissions
https://ghgprotocol.org/