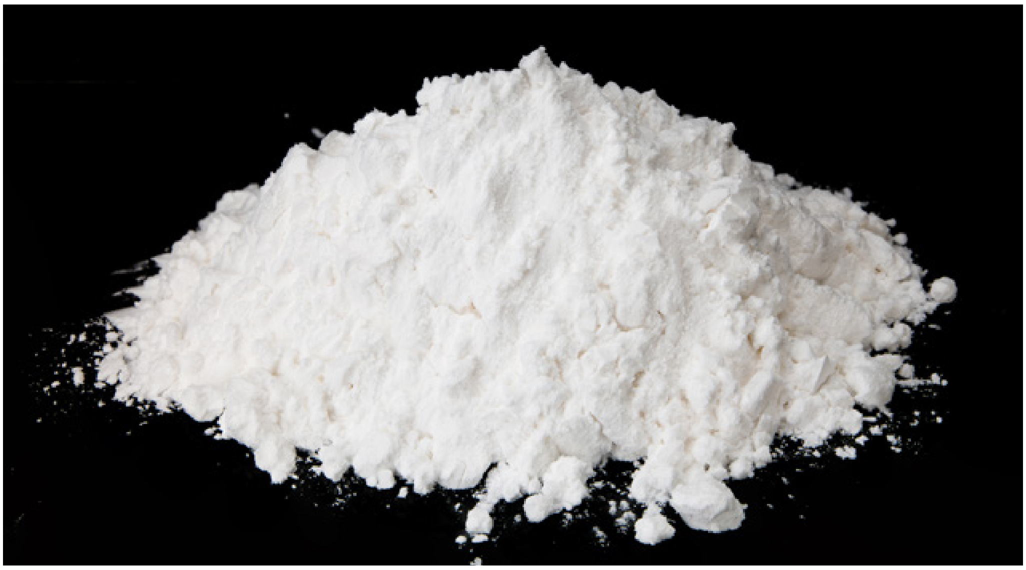
Application Note

Pure Production of Aluminum Fluoride

with In-line pH Measurement



Background

In the production of aluminum metal, aluminum fluoride (AlF_3) is one of the key components in the electrolysis cell. It is required for bath electrolyte stability as it reduces sodium impurities found in the alumina feed. As it is consumed in the reaction, 15 – 20 kg of aluminum fluoride is included in the production of every tonne of aluminum. Thus the demand of aluminum fluoride is directly dependent on the production and demand of aluminum. For use in this process there must be less than 0.2 % SiO_2 and less than 0.025 % P_2O_5 impurities in the finished aluminum fluoride.

Process

Historically, aluminum fluoride was produced from the direct reaction of hydrofluoric acid and alumina trihydrate; however, there is a shift in trend to using fluosilicic acid – a by-product from phosphoric acid-based fertilizer processes. Production begins with dissolving alumina tri-hydrate with 15 wt% fluosilicic acid at 60 °C. An exothermic reaction occurs bringing the temperature up the 90 – 100 °C according to equation (1), and comes to completion within 30 minutes.

$$H_2SiF_6 + Al_2O_3 \cdot H_2O \rightarrow AlF_3 + SiO_2 + H_2O \qquad (1)$$

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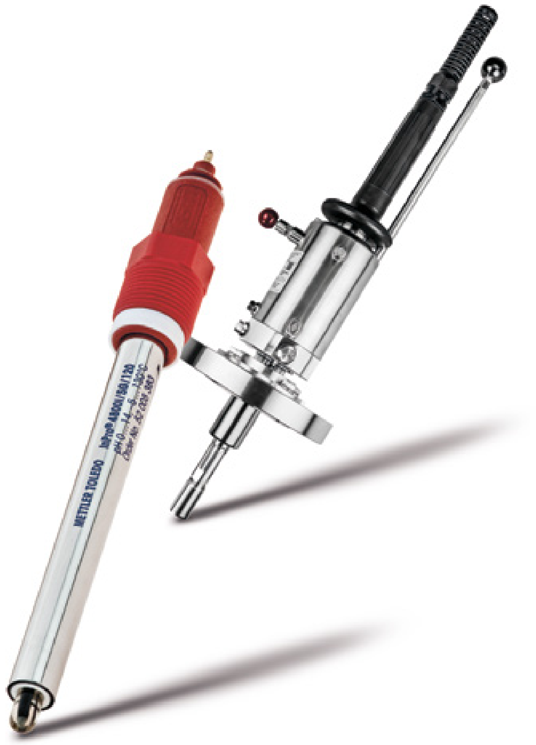
At reaction completion, the batch undergoes filtration to remove all silica species that have precipitated out of solution. Filtered silica undergoes further washing and filtration or centrifugation steps. The super-saturated AlF_3 mixture is then held at 80–90 °C for 5 to 8 hours. Within this time, crystallization of AlF_3 will occur which can be induced by seeding. This produces β–$AlF_3 \bullet H_2O$ crystals that are removed by rotary or belt filtration.

A high quality AlF_3 product requires no residual silica in the end-product as this will affect the aluminum metal quality when used. Particle size of the precipitated silica is strongly dependent on pH. At pH <3, larger particles are easily filtered and removed from the solution. However, at higher pH values, fine and colloidal silica content increases, limiting the filtering ability to remove such species. Ideal conditions usually lie within pH 3–4 depending on the filtration method used.



InPro 4802i pH sensor
- HF-resistant glass formulation
- Long helical diffusion pathway
- Fully digital sensor

InTrac 777e
- Tri-Lock™ safety system
- Flushing chamber for automatic cleaning and calibration
- Pneumatic or manual operation

METTLER TOLEDO solution

Silica contamination is the main risk in the aluminum fluoride production, thus in-line monitoring of pH is a vital tool to ensure the product is of acceptable quality. Glass-based sensors used in such applications traditionally have a short lifetime due to hydrofluoric acid (HF) species in the process. This acid rapidly dissolves many types of glass and minerals, limiting lifetime of traditional glass electrodes to a matter of hours. As even small amounts of silica can ruin a batch, sampling is required periodically for monitoring.

The InPro® 4802i pH sensor from METTLER TOLEDO overcomes this issue by using a specially formulated glass that resists HF. This sensor can measure in the presence of HF without experiencing rapid disintegration and destruction. Used in conjunction with an InTrac® 777 retractable housing, the sensor can be introduced into the measurement fluid and retracted without exposing the process to the environment. Additional, automatic cleaning and calibration can limit staff exposure to HF, as gas levels of even 2 ppm hydrogen fluoride gas is toxic, and even milliliters of the acid can be fatal.

For more information, visit:
- **www.mt.com/InPro4802**
- **www.mt.com/InTrac777e**

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