New Products from RUSAL's Super-Fine Precipitated Aluminum Hydroxide

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Abstract

UC RUSAL is currently developing production of aluminum hydroxide products for non-metallurgical applications. One of the prospective products is super-fine precipitated aluminum trihydroxide VOGA, which is used as a halogen-free fire retardant, smoke suppressant and filler for cable insulation and other polymeric materials. RUSAL produces VOGA using its own proprietary process. The product is characterized by narrow particle size distribution; the average grain size is 2 µm and can be adjusted depending on the customers' requirements. The production process is truly promising and allows obtaining aluminum hydroxide that can be used as a raw material for catalyst carriers in oil industry, as well as for some other applications, i.e. synthetic floor coatings, artificial stone, mechanical rubber goods, fire-retarding compositions.

Keywords: Super-fine precipitated aluminum trihydroxide, Special aluminum hydroxide, Fire retardant, Functional filler.

1. General Remarks

Super-fine precipitated aluminum trihydroxide (SF ATH – VOGA) is one of the most promising and effective halogen-free mineral fire retardant and filler to reduce the fire hazard rating of polymeric materials [1–7]. Primarily, it can be applied for non-combustible halogen-free cable insulation based on polyethene, ethylene-vinyl acetate or polyvinylchloride. In the polymer matrix, having the loading efficiency of 30–70 %, said fire retardant acts by thermal decomposition reaction to separate water (in form of steam):

$$2Al(OH)_3 \rightarrow Al_2O_3 + 3H_2O \tag{1}$$

Aluminium hydroxide is characterized by the following fire-retardant properties:

- early thermal dehydration (at 190–225 °C);
- significant heat absorption (1051 J/g);
- high oxygen index;
- effective smoke suppression;
- reduction of the toxic properties of the flue gases.

Electrical cables insulated using fire-retardant aluminium hydroxide must or should be used under the most stringent requirements for the fire safety, i.e. critical industries, aircraft- and shipbuilding, in premises and facilities with mass presence of people (schools, hospitals, malls, etc.)

For this purpose, in 2022 RUSAL launched the production of super-fine precipitated aluminum trihydroxide with average particle size (D50) of 1.5–3.5 µm for cable compounds using the proprietary sol-gel process.

Furthermore, the process proved to be flexible in terms of controlling the phase composition and particle size distribution by changing the temperature and fluid dynamics of solution mixing process. Bayerite content in the product can vary within 50–95 %, and the average particle size (D50) can range within 1.2–20 µm. It allowed expanding the use of aluminium hydroxide produced by the sol-gel process; namely, it can be applied in the products used for the following:

- fillers in the composites based on the epoxy, polyester, polyisocyanate and other polymer resins to be used in transportation, insulators, etc. (GAM – fine aluminium hydroxide);
- floorings;
- fire retardants for construction;
- paints and varnishes;
- bayerite precursors for catalyst carriers and adsorbing agents (GAK – catalytic aluminium hydroxide).

However, use of aluminium hydroxide instead of magnesium hydroxide, which decomposes at a temperature of 320 °C, can be quite challenging for producing compounds, as a higher temperature of polymer blend processing enables to improve the efficiency of extrusion equipment. Thus, one should find a good balance between the early thermal dehydration and processing properties of aluminium hydroxide.

Leading European and American manufacturers of aluminium hydroxide adopt various approaches to this issue. Some of them improve thermal stability by controlling the crystalline structure and increasing the size of the particles, and others enhance rheology by mixing aluminium hydroxides of different particle size distribution. Nevertheless, all manufacturers provide their customers with specific compound blends to ensure proper processing and preserving the best fire-resistant properties of the cables.

It should be noted that the admissible temperature of obtaining and further processing of the compounds results from both properties of the source polymers and the viscosity of the material. In actual production, this temperature is maintained by controlled heating of the polymer, but additional self-heating occurs due to mechanical friction during the stirring of the compound with the fire-retardant filler in the screw extruder. In this case, the rheology of the powder is important attributed to its particle size distribution, shape of the particles, and the presence of special coupling agents, compatibilizers and coating components on the surface, included into the compound blend. The mechanical self-heating increases the temperature of the mix and the thermal dehydration of the fire retardant begins thus resulting in formation of the pores due to boiling the free water.

Particle size distribution and particle shape of the filler characterize the viscosity of the compound and the intensity of the internal friction during the passing of the screw extruder, thus producing significant influence on the self-heating of the compound. It is known that the higher particle size distribution of the filler (mineral fire retardant) increases the viscosity of the blend. Besides, the viscosity of the compound increases due to the use of aluminium hydroxide obtained by grinding a larger product (smelter grade hydrate). Such grinded aluminium hydroxide is characterized by the particles of irregular shattered shape [8] (see Figure 1 (a)) that increases the internal friction.

4. Conclusions

Sol-gel process, which is implemented at RUSAL's Achinsk refinery, enables to obtain powders of super-fine precipitated aluminum trihydroxide using one process stage; said powders having good fire-retardant properties that can be used in cable insulation of low fire hazard based on halogen-free and PVC compounds.

The new process allows controlling phase composition and particle size distribution by varying the temperature and hydrodynamics of the mixing of the solutions. Bayrite content in the product can range within 50–95 % and the average particle size (D50) can vary within 1.2–20 µm that provide for new applications of the product: floorings, solid surfacing, rubber goods, paints and varnishes, fire-retardant construction materials, composites, etc.

Temperature limitations for producing halogen-free cable compounds with low fire hazard can be avoided by improving thermal stability of the mineral fire retardant and enhancing the rheology of the powder due to the roundness of its particles. Additionally, it reduces the viscosity of the polymer compounds, which can be used for other applications.

RUSAL's process enables to obtain round fine particles of fire retardant using easy and effective method by the specific hydrodynamic conditions of mixing the solutions.

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5. References

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