Project Title: To study the fire retardancy of nano-ATH in polymers (S-30).

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Name of the PI, Institution, contact details:

Dr. (Mrs.) Suchita B. Rai

Jawaharlal Nehru Aluminium Research Development and Design Centre

suchitarai@jnarddc.gov.in : 9423680346: **JNARDDC, Nagpur &**

Dr. Smita Mohanty

Senior Scientist & I/C,: **CIPET** : drsmitamohanty@gmail.com, 9338053123

Objectives:

- To investigate the effect of nano or micro-ATH particles as a fire-retardant additive in thermoplastic polymers (PP & PVC).
- Replace/substitute the existing flame retardants used in polymer composites with nano-ATH & evaluate the performance.
- To examine the mechanical, thermal, and flame-retardant properties of thermoplastic polymers (PP & PVC) /ATH composites obtained using ATH fillers of various particle sizes.
- Innovative process utilizing aluminum trihydroxide (ATH) and thermoplastic polymer matrix with value addition.

Abstract:

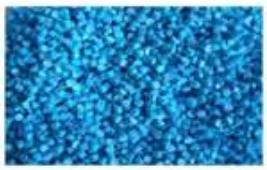
Aluminium hydroxide is a common inorganic additive used in a wide range of industrial applications. One of its applications is its use as a fire retardant. Polymer based materials are now recognized as key components in many important industries such as construction, automotive, electronics and aerospace due to their outstanding physical and electronic properties, cost-effectiveness, high versatility, and portability. However, one severe problem with many polymers is that they are highly flammable and can produce large amounts of toxic smoke during combustion, which poses a great threat to human safety. To tackle this problem, the project has been undertaken to explore the use of Nano-ATH as flame retardant fillers into polymer matrices because of its specific properties of high surface area and good dispersibility. The project aims to develop new process and product using aluminium tri-hydroxide and polymer matrix for various applications. The project is a collaborative work carried out by the Jawaharlal Aluminium Research Development and Design Centre (JNARDDC) and Central Institute of Plastic Engineering and Technology (CIPET).

Findings:

This research work is based on synthesizing and using nanoparticles of Aluminium trihydroxide (nano-ATH) as fire-retardant fillers in polymers. The goal was to modify the properties of ATH by reducing its particle size to nano size which has been achieved by reduction of the coarse size aluminium hydrate using mechanical milling through high energy planetary ball mill. As milling operation may consume a significant amount of energy, it must be done at optimized milling parameters. Through this, the desired size reduction of feed can be achieved at less energy and cost requirements. Optimization of the grinding parameters such as energy requirement, milling time, media size, and initial feed particle size was carried out in the study. Micron size and nano-ATH are reinforced into polymer composites using thermoplastic matrices like PP/PE and thermosets like epoxy and flame retardancy of the prepared composites were investigated.

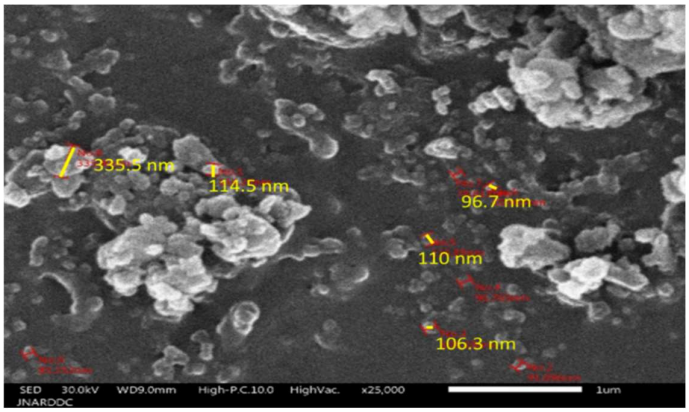
Highlights of the findings achieved in the Project

- Nano-size ATH (40-350nm) developed. Milling parameters optimized for high energy ball mill for the synthesis of nanosized ATH and properties of nanosized ATH established.
- Eventually, the utilization of nanosized ATH having a large surface area improves the fire retardancy and the mechanical properties of the polymer.
- Nano-ATH/PP composites exhibit improved performance concerning mechanical, thermal as well as fire-retardant properties.
- Polymer matrix showed better flame retardancy in the nano-ATH-based formulation which has been established from UL94 and cone calorimetry studies.
- The nano-ATH-based system with PP matrix at 2-3% loading showed improved performance for mechanical, thermal, and flammability properties.
- The existing flame retardants in polymer composites can successfully be replaced with nanosized ATH with reduced loading. The desired performance was confirmed with TGA, DSC, vertical burning test, cone calorimetry, and mechanical strength study.
- These composites can be utilized for building applications as acoustic panels.
- They can also be used in automotive/building & construction sectors wherein the light-weight, fuel-efficient parts with inherent flame retardancy & acoustic are the primary requirements.



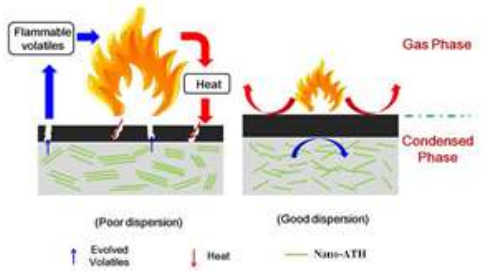
Another polymer i.e. PVC, which is used for wires & cables, tiles, pipes, and other applications also showed better fire retardancy with nanosized ATH.

- Incorporation of nano and micro ATH within PVC matrix improves the fire retardance properties in comparison to virgin PVC without affecting the base properties, which meet the requirements of wire and cable applications.



Microstructure of nano-size ATH in Scanning Electron Microscope

The final report findings showed that nanosized ATH with 40-350 nm size has reduced the loading of fire-retardant filler in the polymer (PP) from 40-60% to 2-3%. It has a large surface area and improves the fire retardancy and the mechanical properties of the polymer. PP/nano-ATH nanocomposites can be suitably validated for acoustic panels used in building and construction industries based on their mechanical & flame retardancy where lightweight is a priority. Based on the successful lab scale findings the pilot scale level can be taken up.



Dispersion of ATH

Polymer with ATH

- Cost of nano-ATH generated in a planetary ball mill is Rs. 47.5/kg which is much below the price of Rs. 65/kg of nano- ATH available in the market.
- Micron size and nano-ATH are reinforced into polymer composites using thermoplastic matrices like PP/PE and thermosets like epoxy and flame retardancy of the prepared composites were investigated.
- Using nanosized ATH has reduced the loading of fire-retardant filler in polymer (PP) from 40-60% to 2-3% while retaining the fire retardancy and improving the mechanical properties and reducing the density for applications.
- PP /Nano-ATH nanocomposites can be suitably validated for acoustic panels used in building & construction industries as well as in automobile parts based on its mechanical properties & flame retardancy wherein the light-weight, fuel efficient parts are essentially required.
- Incorporation of nano and micro ATH within PVC matrix also improves the fire retardance properties in comparison to virgin PVC without affecting the base properties, which meet the requirements of wire and cable applications.

Patent filing -under progress: Method of preparation of Flame Retardant & Acoustically Isolated - Polypropylene Composites using Nano- Alumina

Paper under revision: J. Applied Polymer Science

Polypropylene- Aluminum Tri-hydrate (PP –ATH) Composites: Effect of incorporation of micro and nanofillers on the Mechanical, Thermal as well as Fire retardant properties

Paper presented online: 'Milling route for synthesis of nano-aluminium hydroxide for development of low-density polymer composites' at the *International Conference on Energy & Advanced Materials ICEAM 2021 (*21-23 October 2021); Organized by Department of Physics and Materials Science & Engineering, Jaypee Institute of Information Technology, Noida, India.