Super PVC and Enriched Polystyrene

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Introduction

PVC, Polystyrene are now mature polymers and still being used in wide variety of applications. These materials have been surpassed by olefinic polymers. However, they have maintained their place and serving human race even today. Their history goes back to 1930 & 1940s.

PVC

PVC today is called as polymer for infrastructure and finds maximum usage in Pipes, Profiles and cables. The most popular method of manufacturing PVC is by suspension polymerization. In this technique the additive amount is less than one percent and most of them leave with water when the polymer slurry is centrifuged. The suspension polymer is a pure polymer. Chlorinated PVC and copolymers of PVC were further developments.

Polystyrene

Clarity, transparency of polystyrenes attracted everybody when they first came in the market, It was often called as crystal polystyrene. Many other polymers such as PMMA, SAN and Polycarbonate emerged. However, polystyrene still is produced in the world and finds applications based on its clarity and transparency at the lowest cost.

Polyethylene

Prior to 1933, high molecular weight polymers from ethylene did not exist. Respected Professor N. R. Kamat used to say that he used to teach his chemical engineering students that ethylene cannot be polymerized. From those yester years to today, we find totally different scenario in the world of polyethylenes or more broadly polyolefins.

Ziegler – Natta Catalyst to Metallocene based catalyst

Metallocene based caralyst technology has revolutionized polyolefin Industry. It is considered as single most important development in catalyst technology since the discovery of Ziegler-Natta Catalysts.

We see today many new polymers introduced by major polyolefin producers which are penetrating broad array of polymer markets. They first penetrated the specialty markets followed by high volume and commodity markets. New markets are also expected to be created with development of new classes of polymers that are not possible with conventional Ziegler-Natta catalyst technologies. The frenzy of activity in this area is due to metallocene catalysts, which offer some significant process advantages and produce polymers with very favorable properties.

PVC and Polystyrene

There have been lot of process improvements in the polymerization of PVC and Polystyrene. There have been productivity gains in both manufacturing processes. However, there have been no radical or game changing developments like in the case of polyolefins. The resultant has been polymers with same or similar properties for decades.

The change is now seen at the horizon and may be that we will have "Super PVC" and "Enriched Polystrene" in the near future. What will bring this change? Will it be the process improvement? The Change will be by additivation during polymerization.

Nanotechnology

Nano size minerals are set to bring new revolution in plastic materials. What is nano size is explained below,

1000 mm make 1 meter

1000 microns make 1 mm

1000 nanometer make 1 microns

Nanometer is hence 10-9 of meter

These minerals in polymers such as PVC and polystyrene will take them into diiferent domain. These minerals in nano size will also influence the properties of all other polymers.

Super PVC and Enriched Polystyrene

Nano size is normally considered as 1 nanometer to 100 nano meter which is smaller than wavelength of light. Their incorporation in polymers will not change the clarity and transparency of polymers, however they will have significant impact on mechanical properties, thermal properties, apart from improving gas barrier and electrical & fire resistance. The claims are 30 to 50 % improvement in mechanical properties and 20 to 40% improvement in thermal properties. However, their incorporation in polymers has become a challenge. Therefore attempts are made to add them during polymerization. Few companies in the world are practicing it. Compounding of nano minerals is a subject by itself and falls outside the scope of current article on "Super PVC & Enriched Polystyrene". However, it is worthwhile to talk little more on nanoclays.

Nanoclays

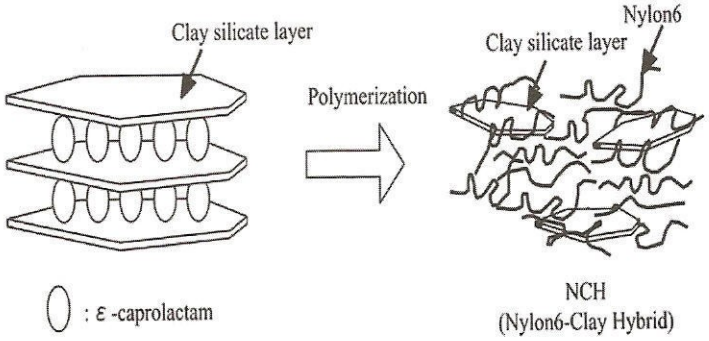
Polymer / Clay nanocomposite development began in 1930, with latex systems. During the 1980s work on development of polymer / clay nanocomposite by Toyota Central laboratories in Japan caught everybody's attention. Thereafter, world-over it became a fashion to talk about nanoclays. Though improvement in mechanical strength, barrier properties and flame retardancy was demonstrated by researchers, with very few exceptions, processing industry could not master the art of using nanoclays in commodity products. Many companies tried, spent lot of money but the results were not forthcoming. The industry got tired and retired and exited from developing these nanocomposites.

It has been approximately 30 years, clay / polymer nanocomposites were of interest yet commercial use of these materials remain to the niche markets and have not percolated in commodity markets. There are reasons for the same in the scientific domain which are again ouside the domain of this article. Therefore we can say compounding nano size fillers into polymers is still young industry and it is steadily making progress towards overcoming the challenges of commercialization. It is now said "Hype has subsided and companies are focusing on developing real products".

Nano fillers in in-site polymerization

Compounding of nanoclay was a challenge which could not be overcome. Hence there were attempts to introduce nanoclays while polymerization. Polymerization of nylons in presence of nanoclays was one of the success stories. It was observed that exfoliation and intercalation of nanoclays was possible during polymerization. However, it did not yield good results in suspension or bulk polymerization. Researchers then thought of using other minerals which started appearing in laboratory quantities due to the development happening in electronic and optical fields. Nano fillers with very high surface area are now being investigated for in-site polymerization.

Known Example of Nylon



Nanofillers and Commodity Plastics

PVC, polystyrene are commodity plastics which have now attracted attention. Incorporation of nano minerals improve mechanical, thermal properties apart from fire retardancy. Presence of nano minerals in polymer nano composites also provide barrier to gases as well as to the electric current, thereby improving electrical performance. PVC, Polystyrene,PET and cross linked polyethylene becomes a strong candidate for Nano mineral composites.

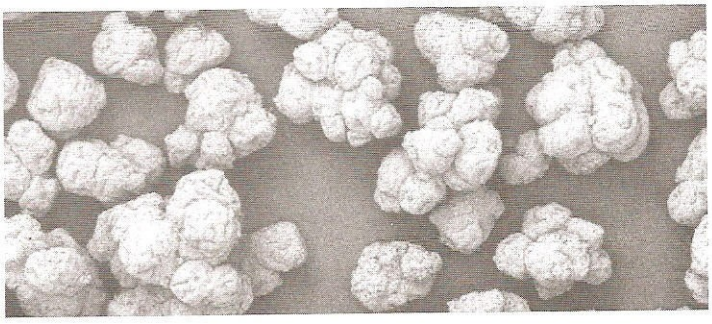
The radical, game changing development round the corner is to have transparent polymers such as PVC, Polystyrene, PET with enhanced stiffness, toughness at the same with higher thermal properties such heat distortion temperature.

Super PVC

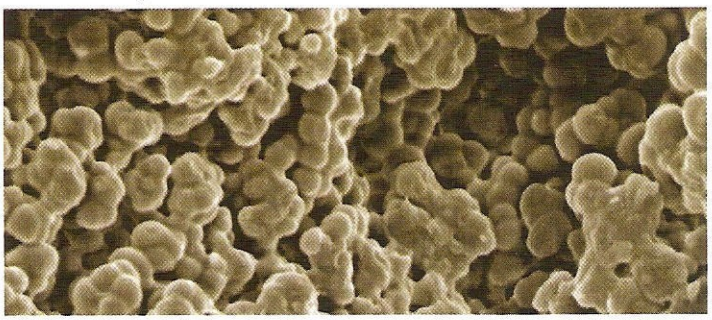
Incorporation of nano minerals during PVC polymerization has been attempted by PVC manufacturers. Nanominerals when added during polymerization would give uniform dispersion throughout resin matrix.

Morphology of PVC Grains

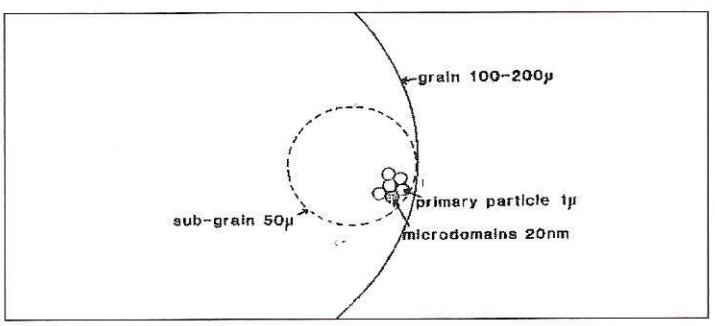
PVC Grains



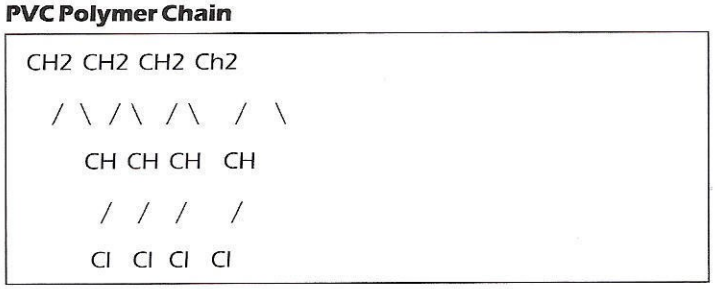
PVC Primary Particles



PVC Grain Schematic view



PVC Polymer Chain



8 Carbons in PVC = 1 nano meter 10^{-9}

PVC grain is of 100-200 microns and primary particles in the grain is of one micron with micro domain of 20 nanometres. Nanominerals with equivalent size would be suitable for the formation of as polymerization taken place in the reactor. First eight carbon atom length in PVC is around one nanometer and therefore individual nano particle from one nanometer size or more would form the nucleus as polymerization starts happening. Researchers have demonstrated that such PVC / mineral nano composites have higher mechanical and thermal properties making it "Super PVC".

This will make stronger pipes & profiles, heat resistant cables, autoclavable medical products, cheaper tea sets, dinnerware, flame retardant low smoke appliances etc. etc.

Enriched Polystyrene

Polystyrene / mineral nano composites are expected to have similar performance to PVC. Nano Minerals have been introduced during polymerization, to achieve higher mechanical and thermal properties while retaining the transparency of crystal polystyrene. This will make crystal polystyrene, nano mineral "Enriched Polystyrene" impact resistant with higher heat distortion temperature.

Commodity plastics like polystyrene will be then suitable for impact resistant, thermally stable electrical accessories, appliances, covers and large closures, thermoformed micro ovenable containers, packaging films including biaxially oriented polystyrene, BOPS, etc..... etc.....

"Super PVC and Enriched Polystyrene" will thus play vital role in improving living standards in India.

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