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Flame Retardant Polymeric Materials And Composites

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ABSTRACT

The major overview of this work is to make attention in the field of the fire retardant materials, biomaterials and Nano composites as a great demand in the fire safety of the domestic, public and industrial situation required by fire safety standard .Here we are mainly focusing on the discussion of various kind of properties, manufacturing processes and applicability of the materials which satisfies the behaviour of fire retardancy and also found that some of the specific doped polymer composite having the flame retardancy behaviour for different materials are different .The experimental facts such as Limited oxygen index (LIO), UL94V, cone calorimeter study of the polymer composite materials indicates the extend of flame retardancy of the materials, The physical behaviour and chemical action along with its oxidising property shows the behaviour of the polymer composite materials towards the action of the heat .It is found that generally the use of polymeric composite materials are flammable in nature but if some additives like nitrogen based or phosphorous based or silicon based compounds, halogen based compounds are added in the polymeric composite materials as filler , it shows higher flame retardancy property. Wood -plastic composite and poly - vinyl acetate composite are also shows better fire retardancy which is fit for industry ,household and construction materials. Addition of Nano clays,Nano fibres, and carbon Nano materials such as nanotubes, Nano buds,fullerenes and graphenes enhances the flame tetardancy of the polymeric composite materials and composites.

KEYWORDS: fire retardants, polymer Nano composites, flame retardacny, carbon Nano tube, Nano clays.

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INTRODUCTION

Flame causes a significant hazard to the society including living and non-living beings. According to the flame safety engineering point of view, mostly the flame hazards can be measured when all influencing features like ignitability, flame velocity, ignition point of the specific doped polymeric composite materials, biomaterials and the composites are studied in a proper way. The polymeric doped composite materials are mostly used because of their useful properties such as low molecular weight, light weight, easy fabric ability, goodfinishness property and durability .However the polymeric composite materials and composites are of greater flammability property which is the main disadvantages of its use in different fields of engineering, industry and construction materials. This is mainly complemented by the simultaneous release of many poisonous gases and smokes during the process of combustion and is one of a major source of the inbalance of our air quality. The use of the plastic materials and composites increases very rapidly because of low cost ,light weight durability and some useful required essential property but the major disadvantages is the flammability[1.] Hence by developing the flame retardant property of the polymeric materials and composite is the main challenge for expanding their uses in most of applications both in industry and domestic. The technical and practical literature covers very important and effective approaches for refining the flame retardant doping polymeric materials, which mostly depends upon the nature, structure and the chemical composition of materials. The decomposition method along with a required level of flame safety and also globally better used polymeric materials and composites having good performance which makes it better use in different field of applications. To develop the technology and mechanism for manufacturing of the materials having fire retardancy property[2].The bio-degradation polymeric material Nano composites and its stability is now a great challenge to us to protect our society from fire hazards. Some additives are combined with the polymeric matrixes to rise during the period of ignition, maximize self- quenching property, reducing the amount of the heat radiation rate and check the fabric ability of highly flammable droplets[3,4].Although flame retardants property can varies in-between one to other, flame retardant property can be explained mainly by three kinds of mechanism which are normally considered as:-

1. Gas phase flame retardants
2. Endothermic flame retardant
3. Char-forming flame retardants

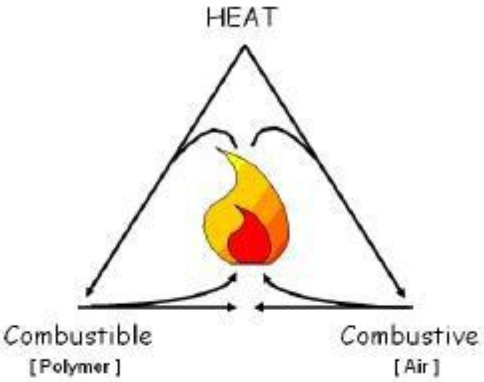
(i). *Gas phase flame retardancy* (i.e. the halogen and phosphorus): It is a chemical mechanistic property. These essential materials decrease the heat evolved during the gaseous phase due to the controlled combustion by sifting the free radicals.

(ii). ***The Endothermic flame retardancy*** (i.e. the metal hydroxides and also carbonates): These are major mechanism in this gaseous phase. These ingredients releases a very huge quantity of non- flammable gases is like H_2O, CO_2 etc. which diluted the flammable gases and minimizes the ignition temperature.

(iii) ***The Char-forming flame retardants*** (i.e., intumescent, Nano composites): These are a condensed type of phase mechanism. Polymer materials, which can be operate by avoiding the fuel discharged over by binding up the fuel as the non- pyrolyzable type of carbon (char),can also provide the thermal insulation of the polymers with the manufacture of the char safety coatings. The best influencing flame retardant compounds for the poly vinyl acetate (PVAc) can reacts with the substrate and shows a type of condensed phase. Compounds that forms a part of the composite should ideally exhibited much functional ability. The magnesium hydroxide [$Mg(OH)_2$] and the zinc borate ($2 ZnO. 3 B_2O_3. 3 H_2O$) causes the change in functional ability of the polymer material and reduces the fire catching capacity. Fire retardant changes the decomposition root of the polymeric materials during heating, which causes the reduction of the amount of the combustible volatile materials and facillates the char soformed resulting the increase in flame retardancy. The char so formed tumescent, and causes heat having fire resistance characteristics until thistouches a critical temperature above which it burns. The formationof intumescent char isan improvement for protection of the materials used in building infrastructure where emulsion polymer has been applied in coating, paints, dyes and the sealants. On heating,these types of constituent materials causeactivation and production of an in tumescent char. This provides a shielding barrier between the underlying substrate andflame produced. Chars normally cause the productionof maximum insignificant volume or thickness of foam, like layer. Fire protection by coating via intumescences increase the path for heat transfer and increase the thermal gradient from the charred surface to the materials and composites. Wood – plastic composite (WPC) are a recent advanced type of biomaterial and also sustainable composite which can be used as the best piece of wood or plastic, Good reactor to flame properties are essential for many possible applications of WPC. These characteristic of WPC is especially usable for application to residential construction, transportation and wood industries. For much application in various fields, theproperties of fire retardant of the polymeric doping materials prepared have to be known. In this review, the main purpose isthe vital keys for understanding the fire retardant characteristics of the new specifically designed polymeric materials and composites.

Mechanism of Combustion ofthe Polymeric materials

Taking into account, the chemical composition and structures it was observed that thespecifically manufactured polymeric materials are mainly made up from carbon along with hydrogen for which the materials are highly combustible. This combustion reaction includes two major factors among which one is combustible (reducing agent) and another one is combustive agent (oxidizing agent). The whole procedure mainly originates with arise in temperature of the so prepared polymeric materials because of the heat sources to such as an extent that it reduces polymer bond scission. The volatile component of the polymeric fragment diffuses into the air and creates a flammable gaseous mixture. The gaseous combination ignites when auto ignition with this temperature is reached[4, 5]. The life period of the required combustion cycle mainly depend upon theheat released because of fuel combustion. The amount of heat releasedwhen touches to a certain minimum level, then a complete new decomposition type of reactions are produced in its solid phase and therefore more combustible materials are produced. This typeof combustionalso called as fire triangle.



(Figure:-1 principles of combustion cycle with polymer and air)

The decomposition of the so specifically prepared polymeric materials thermally is an endothermicprocess that involves in a definite amount of energy. That fundamental energy of this system given here should be larger than that much amount of binding energy in between this covalently related atoms like (200 to 400 KJ for normally C-C bond of polymer). This type of decomposition mechanisms are extremely depends on the weak bond and also the presence or may be the absence ofthe oxygen in the solid and also in the gaseous phases. Hence the decomposition occurs thermally is the suitable arrangement which has an influence on anoxygenand heat. Hence these materials may be distinguished as oxidising or non-oxidising method ofdegradation thermally.

Non-oxidizing

The thermal degradations are mainly introduced by using the process of incineration and Pyrolysis by the chain scissions. This chain scission involves different degree of material polymerization. The chain initiation processdepends upon different factors.

I. This occurrence of the oxygen atoms inside the chain with catalyst residue.
II. The first residue of oxidation.
III. The chemical defect in between the polymeric chain segment and with the presence weakest bond along with chain, which instatesthe opening of reactions. Again the chain scission which can occurs in two ways.

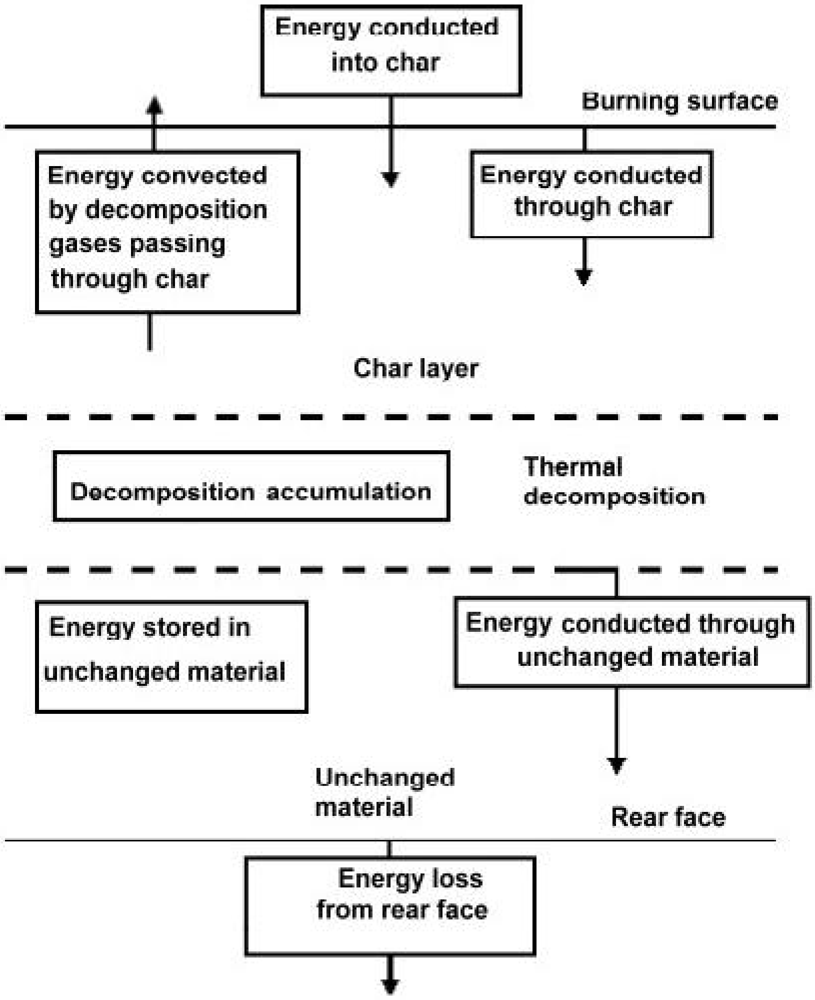
Theformationof free radicals are oflike below

$$\mathbf{R_1\text{-}CH_2\text{-}CH_2\text{-}R_2 \rightarrow R_1\text{-}CH_2^{o} + R_2\text{-}CH_2^{o}}$$

This type of reactions never stop sat this stage because of these free radicals stand with the chain thatfound both in the oxidizing and also in the non-oxidizing condition. The shifting of hydrogen atom and alsothe formation of two most stable molecules forms a reactive carbon-carbon double bond.

$$\mathbf{R_1\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}R_2 \rightarrow R\ _1\text{-}CH_2{=}CH_2 + R_2\text{-}CH_3}$$

In the oxidizing thermal degradation, the polymer chain molecule reacts with oxygen or air and able to produce a number of the low molecular weight different kinds of products (thecarboxylic acid, alcohol, ketene, aldehyde etc.). The degradation emitted among these reactive species some specieslike, $-H^+$,$-OH^-$mainly frompolyolefin[6]. The Oxidation, which can proceed to the cross linking through there combination in the reaction along with the production of micro molecular free radicals. In thistransmission, the degradation process rate is organisedby twistingthe reaction withthe hydrogen atoms or moleculesfrom the polymeric chain. The stability of the oxidation of the given polymeric materials dependsupon the C-C bond energy. Some of the researchers recommended that at the combustion temperature above 300°C, the polymer degradation can be able to takes place via the non-oxidisingdecomposition thermally. Under suchconditions, the rate of pyrolysis and incineration is muchgreater than the diffusion of the molecules of the oxygen moleculewithin the solid phase. In the gaseous phase the oxidation takes place because of the formation of a number of low molecular weight compounds due to the process of pyrolysis and incineration[6, 7]. This decomposition causes the production of several harmfulgases which can be obtained by the pyrolysis and incinerationofthe first mixed with the oxygen by both convention and also in the diffusion process into the layer very close to thatsurface, which will be able to create the free radicals and then ignites the materials. The ignition may be generally activatedthrough an exterior flame (called as flash-ignition) or may be the self- induced (called as self-ignition), when thistemperature given issignificantly higher, then combustion of this gas rises the temperature of the specific polymeric materials which supports the process of pyrolysis and the creation of new combustible gas. The Combustion may continue even with the absence of an external heat source. The flame propagation is also exaggerated by the physical factor much more exactly with the thermal transfers. The Conductive transfer is vitalpoint in the primary phase of the flame improvement when the properties of this flame remainrestricted to a few terms of centimetre during several stages of reaction. With the significant development of the materials, the heterogeneity property can bemostlyemphasizedduring his combustion process. Therefore, a rising structure leads to the material arising from the interaction with the oxygen present in atmospherejoined with its outward diffusion of the reactive species andalso associatedwith the polymer chain break down inside this special material. Numerouskinds of zones which are present inside the materials can be interfiled. The process of decomposition ofgaseousproduct first leads to be placed in this cavity of the layer under it and after that it travels through surface when combustion of gases takes place. The lower layer is in the direct interaction with thethermal decomposition of the polymers and present at the upper part of the layer in which this polymers stay intact even if it may undergoes the phase transitions. In addition, there is energy balance established between the heat transitions occurring in the homogeneous structure.



(Figure:-2 Identification of thermal transfers during the process of combustion)

Fire Retardant Methods

The most important mode of action of fire retardant system reported is mainly classified of two categories. Fire retardant system can act withthis physically by covering the development of protecting layer or fuel dilution. Theymay influence with the various processes which may involve in polymer materials combustion (i.e. heating, pyrolysis, ignition, propagation of the thermal decomposition)

Physical action

The physical methods are based upon reducing thetemperature induction by some flame retardant additives through heat consumption (process of endothermic reaction). In this method the reaction medium is cooled below theignitiontemperature of the polymer. Hence we can take hydrated trialuminium or magnesium hydroxide as suitable flame retardant, because it startsby liberating the water vapour atapproximately about200^{o}C and 300° C respectively. When the flame retardant material decomposes, it produces gasses (CO_2, H_2O, NH_3 etc.), which mixed with combustible gasses, it is diluted so as to limitthe possibility of ignitionand the concentration or theamount of reagents. In addition to this effect, some of the materials which act asflame retardant additives and these additives have a capacity of creating aprotecting solids or gaseous phase layers in-between different gaseous phases, wherever the combustion take place and the solid phase type where the degradation of substances takes placethermally and such type of protective layer will cause the interchange of material particles, combustible gases and oxygen[8]. As a result of which the amount of the decomposition of the gases decreases significantly causing the physical separation of the gases which are flammable from oxygen and prevent the combustion process.

Chemical action

This type of methods are normally shows free radicalmechanism reaction which happens mainly during the burning of gaseous phases and protect the inside materials from the char creation (in the solid phase). This process occurs either in gaseous phase or in the condensed type phases.Thegiven type of free radical reaction mechanism involves this combustion process, which can be checked by the combination of the flame retardant additive (especially release of radicals ($Cl^{\cdot}$,$Br^{\cdot}$) in this given gaseous phase. This free radicals react with the reactive species like (H^+ andOH^-) and forms less reactive or even inert molecules This alteration of this combustion reaction gives the pathway which is the cause of decrease in temperature and therefore a reduction of fuel is caused. In this condensed phase areof mainly two different types of chemical reactions and areactivated withprobably by the flame retardants properties of the materials. These flame retardantsaccelerate theseparation of the polymer chain and inthese cases the polymeric materials are changes away from this flame active level. In the second case this flame retardant forms a carbonized (expanded) transparentlayer of the polymer chains at its surface. The char or the same vitrified layer shows as a physical layer with insulating area amongthe gaseous phase and condensed typephase. Depending upon its mode of function flame retardants are categorised into following two types.

(a)Additive Flame retardants

That are normally combined throughout the procedure of transformation and which will not shows any reactionat this phase with in the polymer matrix but then at a high temperature with the starting of fire they frequently act as mineral fuels , the hybrids materials on the organic compounds that can be included in the macromolecule.

(b)Reactive flame retardant

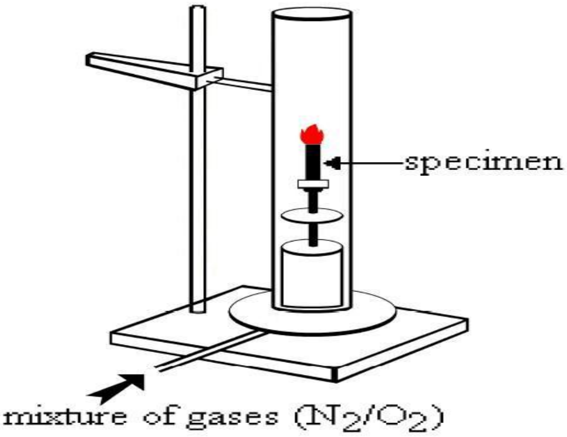
Like other additives of flame retardants, these are alsofrequentlybring together in the polymeric chain throughthe synthesis or it may be in the major reactive process (i.e. via the chemical grafting process). Now Such types of flame retardants that are normally incorporated in polymeric chain. The Laboratory Method of Testing of flammability of polymer can must be characterized along with the ignitability, the flame spreading rate along with theheat release mode. Depending on its targeted applicability of the given polymer material, one or many more of its flammability criteria needed to be calculated by its appropriate test of flammability. There are a numerous number of small, intermediate or full-scale flammability tests are now adopted in industrial scale or academic laboratory for either of the screening material during product development or testing manufactured product. The most commonly used flammability laboratory testing methods are as follows.

Limited oxygen index (LIO)

This test was first of all suggested in 1966 by Fermions and Manton and is basically used to specify the comparative flammability of the materials. The LIO test at the present aresubjected to an international standard test (ISO 4589). That rate of the LIO isbasically distinct as the mineral oxygen concentrated [O_2] in oxygen-nitrogen mixture ratio (O_2/N_2) that both maintains the flame combustion with thephysical substance for 3 minutes or the consume a length of 5cm, with the sample which is placed in a vertical position (two of the test sample is inflamed with a burner).

The LIO is represented as LIO =100[O_2]/{[O_2]+[N_2]}

In accordance with its measurement along with the TSO 4589, the LIO is calculated on (80 x 10 x 4 mm) specimens are placed perpendicularly at the certain type of chimney made up of glass(fig-3). The mixture of thesegaseswill flows up to the stream through the chimney andwhich is homogenized by beingseated through layer of a glass beads. After 30 seconds of purge of the column, its top of spectrum is ignited like the candle.



(Figure: - 3 Image showing the experimental arrangementfor theLOI measurement)

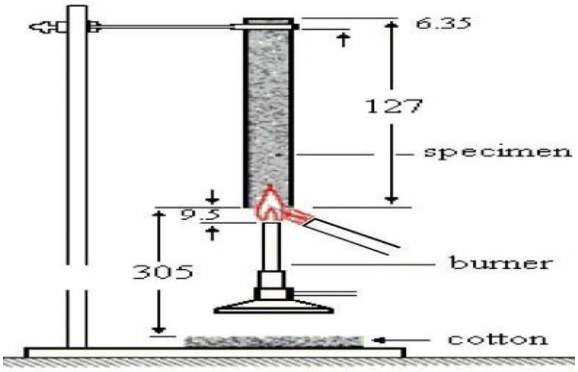
The air which contains 21% oxygen, material with an LIO below 21% are generally classified as combustible, while those with an LIO above this 21% are classified as a selfextinguishing combustion continued at ambient temperature in the absence of an external type of energy contribution. The higher is the LIO; the better is the propertyof the flame retardancy. Nowa days this test is considered to be relatively not acceptable because of the development and more standardization.

(Table:-1) lash-ignition temperature, self-ignition temperature and correlated LOI values for selected representative polymers

Sl. No	Polymer	Flash- ignition Temperature (^{o}c)	Self- ignition Temperature (^{o}c)	LOI (%)
1	**Polyethylene**	**340**	**350**	**18**
2	**Polypropylene**	**320**	**350**	**18**
3	**Polystyrene**	**350**	**490**	**18**
4	**Poly (vinyl chloride)**	**390**	**450**	**42**
5	**Poly (tetra fluoroethylene)**	**560**	**580**	**95**
6	**Acrylonitrile- butadiene- Styrene polymer**	**390**	**480**	**19**
7	**Poly (methyl methacrylate)**	**300**	**430**	**18**
8	**Poly (Acrylonitrile)**	**480**	**560**	**27**
9	**Polyamide 6**	**420**	**450**	**25**
10	**Polyamide 66**	**490**	**530**	**24**

UL94V

This test has been appeared by the laboratory for the flammability of the plastic material for painting in various devices and appliances, it included a range of flammability test(small and large flame vertical test, horizontal test for bulk and foamed material, radical panel flame spread test).The most normally usedto test the UL94V for bulk calculating this ignitability and the flame spread of the perpendicular bulk material which is exposed to the small flame.



(Figure 4: Experimental set-up showing UL94V flammability test)

The burner is organized to produce with the blue light flame in a 20m high cone and a power of about 50W was supplied to it. Theflameis useful to the lowestpart of the spectrum at the top of the burner which has to be located at 10 mm distance from the lowest edge of that specimen and the flame is laid for 10seconds and then removed. The after flame time i.e. the time essential for this flame to extinguish (t_1) is noted. After elimination, the flame is seeing for extra10 seconds and then after flame time (t_2) is noted. Together with that heating time (t_3) i.e. the time required for fire glow to disappear is noted. During the application with the flame time, the main distance in between the burner and thespecimen must remain constant. If the drops fall, thatburner must be flitted through extreme angle of 45°c which is slightly isolated apart from that specimen flame. During the conduct of test, presence of the burning drops, which causing a quantity of cotton located under the sample to ignite must be noted. The specimen V_0, V_1, V_2 classified listed in (Table- 2).

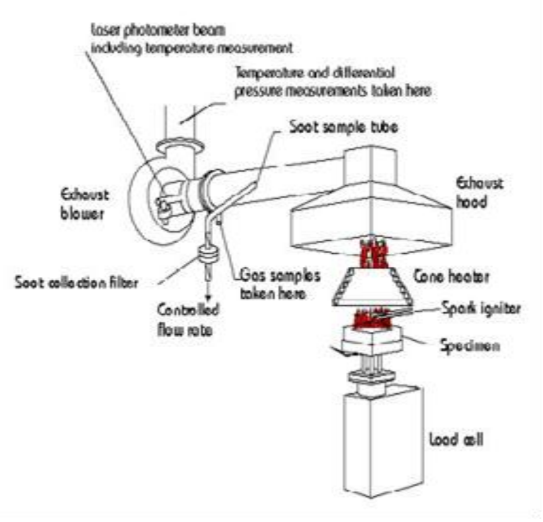
Fire classification

(Table 2: Classification of biomaterials of the UL 94 V flammability test Cone Calorimeter The cone calorimeter, which is one of the greatest effective polymer flame behaviour test)

1	**UL94V_0**	**t1 and t2 less than 10sec for each specimen t1+t2 less than 50secfor the 5 specimen No after flame or afterglow up to the holdings No burning drops**
2	**UL94V_1**	**t 1 and t 2 less than 30 sec for each specimen t1+t2 less than 250 sec for each of the 5 specimen t2+t3 less than 60 sec for each specimen No after flame or afterglow up to the holdings No burning drops**
3	**UL94V_2**	**t 1 and t 2 less than 30 sec for each specimen t1+t2 less than 250 sec for each of the 5 specimen t2+t3 less than 60 sec for each specimen No after flame or afterglow up to the holdings Burning drops allowed**

Cone calorimeter

The standard of this cone calorimeter experiment is created on the quantity of the reductionof oxygen. The concentration in that combustion type gasses of that sample of the particles aresubjected to the heating flux (generally 10 to 100 Kw/m^2). The experimentalinstrument establish with the cone calorimeter standardized in the United States. Experimental set-up for a cone calorimetry measurement are shown in Fig-5



(Figure 5: Experimental set-up for a cone calorimetry measurement)

A sample (100 x 100 x 4 mm) is located in a way to calculate the development of mass which will loss during the experimental process. A special type of conical radiant electrical heater is used which is uniformly irradiatedin the sample with abeam from the above.An electrical sparkis triggered at the time of combustion. The combustion of gasesthat can be evolved through the process of heating cone and capturedgenerally througha special type of an exhaust dust system having a centrifugal fan and a definite hood. The gas flow, O_2, CO and CO_2 concentrations and the density of that smoke is measured in the exhaust dust. The measurement of the gas flows, O_2 concentration are used to calculate the quantity of heat released per unit of time and surface area. The HRR (heat release rate) is expressed with Kw/m^2. The evaluation of the HRR over time, in particular with the value of its peak or maximum HRR is usually taken into account in order to evaluate the flame properties. The calculation is generally based upon Huggett ’s observation, that most of the organic material releases the quantity of heat practically proportional to that amount ofthe required quantity of oxygen consumed during burning. The proportionality feature is a constant term and varies fromone to other material and is equal to 13.1KJ/g consumed oxygen.Integration of this HRR vs. time curve shows that the total amount of heat released (THR) which is expressed in KJ/m^2. In addition to that the cone calorimeter testing also example the characterization of the time to time to ignite (TTI) , the time of combustion or extinction (TOE), mass loss during combustion, quantities of CO and CO_2 and total amount of smoke released (TSR). Certainly, that cone calorimeter testing delivers more complete flame characteristics. The heat released rate (HRR) is certainly the most widely used parameters for calculating the properties of the polymeric materials and polymer composites. In many cases, this flame retardant preparation tends to the significant value of reduction in the HRR values and with an increase in that combustion time but must offer without any change within that total heat released. This can more the less considered with an enhancement of polymer flame retardant behaviour, since it enables the same quantity of heat to be released over a longer period of time. Consequently it limits the improvement of fire and the risk of flash-over i.e. an extremely, even with the explosive, rate of the fire spreading over that entire area.

Wood-plastic composites

These are the composite materials which are the combination of the best properties of wood and plastic and also exhibits high cost effective. The components of WPCs are naturalfibre and a filler such as wood flour fibre,kenaffiber, hemp fibre, sisal fibre etc. and thermoplastic materials like PE,PP,and PVC. The natural fibres are generally light weight, less abrasiveness, lesscost, and also these are renewable and biodegradable in comparison with common synthetic fibres. WPCs can be fabricated in different colours,shapesand sizes, and they can have different surface textures. WPCs can also be fabricated intoanydesired shape and are therefore used in a large number of applications, such as doors, window frames, interior panels in cars, railings, fences, landscaping timbers, cladding and siding, park benches, moulding, and furniture [9]. WPCs arealso resistance to moisture, insects, decay,and warpin[10, 11, 12] .WPCs can be melted and also recycled in some other shape of materials but the utilization and cost of the materials can also be reduced by further manufacture of composites with desired shapes and size.

Fire retardancy of wood-plastic composites

The improved properties of wood-plastic composites are the cause of its use extensively in different applications. WPCs have many advantages over metal and metal alloys, such as low density and thermal expansion, high specific stiffness and specific strength, good fatigue and corrosion resistance, as well as excellent thermal insulation properties[13]. On theother hand, there are some disadvantages which can restrict the value of these compositesin markets. These disadvantages are poor mechanical properties, low impact strength and anisotropic in nature[14].The major drawbackof these composites is less fire performance characteristics. At temperature of usually above 300-4000C, the organic matrix present in it usually destroyswith the release of huge amounts of heat, smoke, soot and toxic volatile substances. The release of smoke and toxic gases makes fire fighting very hazardous and enhances the possibility of serious injury or even death. Improvement of the reaction-to-fire properties of wood-plastic composites has become a very important area of research responding to safety requirements[14]. The fire retardancyproperties of natural fibre-containing composites can be enhanced by several methods. The most commonly used method for the improvement of the fire resistance of combustiblematerials is the addition of fire retardants. Fire retardants can be added to the composite either by mass treatment, where the fire retardants are added to the mass during the production process, or by surface protection, where the fire retardants are added onto the surface of the compositein the final stage of manufacturing.Fire retardant systems can work either chemically or physically in the solid, liquid or gas phase. These methods depend on the nature of the fire retardant system. Chemical action is based on thereaction in the gaseous phase (free radical reactions) and reaction in condensed phases (char formation). Physical action is based on the cooling effect (endothermic reaction), formation of a protective layer or fuel dilution on its surface .The reaction in the gaseous phase is carried out in the radical reactions of the flame, causing the cooling down of the system and decreasing thesupply of flammable gases. However, interfering with the flame reactions always causes highly toxic and unpleasant partially burnt products, including -CO, which generally increasesthe toxicity of the fire gases resulting the reduction of fire growth.

ii. In the condensed phase reaction the fire retardants can causes the formation of a carbonaceous char layer which impedes the liberation of volatile gases and preventing oxygen from the substrate there by protecting the material surface from the influence of veryhigh temperatures. Char formation usually decreases the formation of smoke and other by products of incomplete combustion.

iii. The in tumescent systems swell when it is subjected to heat or fire and create porous carbonaceous foam and that foam produces a barrier and that barrier protects from air, heat and pyrolysis products. Intumescent systems mainly consist of three components: a carbonization agent, an acidic source and a blowing agent. The carbonization agent is usually a char-creating organic compound[14].

Flame Retardant Additives

1. Phosphorous based Fame additive:

The existence of the polymeric materials is much essential in our day to day life. To manufacture a wide range of flame retardant polymeric materials usually phosphorousbased flame retardant additives including phosphorous, phosphate, phosphonite, phosphine oxide, phosphate, red phosphorous are used. These additives are incorporated into the layers of the polymer chain segment during the synthesis and are active in the condensed or vapour phase of the reaction. The incorporation of that phosphorous based additive material into organic polymer enhancessignificantly the flame retardant properties.

The main component of the flame retardant is the formation of an intumescent char. Intumescence char is the swelling of a material into thick, robust, multi cellular foam upon exposure to heat. The char produced is a function of physical barrier properties, the underlying material from further degradation. Poly (vinyl alcohol) PVA on treatment with phosphoric acid generates phosphoesters and that compound when heated undergoes degradation with subsequent cross linking of the polymeric materials leading to the formation of intumescence char.The study of PVA with or without the addition of phosphorous based additive causes improvement in the LIO (limiting oxygen index) of the phosphorylated sample. This result means that higher levels of oxygen are required to support that combustion of PVA with the occurrence of those phosphorous based additives.

Thermo gravimetric analysis (TGA) showed the formation of a residue whose mass generally increases with the increase in phosphorous content. In the condensed phase, the phosphorous based flame retardant additives are particularly effective with the polymer containing oxygen. (Polyester, polyamides cellulose etc.) .In most of these during thermal decomposition phosphoric acid is produced which condensed readily and forms pyrophosphatewith liberate ofwater.

2. Nitrogen-based flame retardants

Melamine is a special type of thermally stable crystalline product and are characterized by the melting point as high as 345 °C and contains 67 weight% nitrogen and Melamine,also sublimates at about 350 °C and during sublimation, a major quantity of energy is absorbed resulting the reduction of temperature. At a higher temperature, the melaminedecomposes along with the liberation of ammonia gas causing the dilution of oxygen and other combustible gases and also the production of the thermally stable condensates which are commonly known as melam ormelem or melon. This molecular reactions contest with the melamine volatilization and that are extra noticeable if its melamine volatilization is inhibited, along with the development of a protective type of layers. The formation of thatmelam, melem and melon produces the condensed phase as aendothermic processes, which are also muchmore effective for the flame retardancy. In addition to that melamine can form thermally stable salts with strong acids such as melamine cyanurate, melamine phosphate, and melamine pyrophosphate. Melamine and melamine salts are normally characterized by various types of flame retardant mechanisms.

The phosphoric acid evolved is known to phosphorylate .Many polymeric materials create flame retardant properties equivalent to phosphorus-based flame retardant additives. The thermal decomposition of melamine polyphosphate tends to synthesisemelamultraphosphate and ammonium polyphosphate, with the release of melamine but however, the melamine in the gaseous phase enters with the production of its condensation products, such as melamultraphosphate. The condensation ofthe melamine is thus accompanied by the formation of polyphosphoric structures. Ammonium polyphosphate can also be formed from melamine polyphosphate. The ammonium polyphosphate dissociates and evolve ammonia above the temperature of 300°C and the free end condensed hydroxyl (-OH) groups give cross linked structures (ultra phosphate) with elimination of water. That hydrolysis of the melamultraphosphate generates a melam phosphate derivative ormelam polyphosphate. The formation of carbonaceous structures is more significant here and its action mode is similar to that of ammonium polyphosphate.

3. Silicon-based flame retardants

Normal the addition of an even lessquantity of silicon-based complexes (silicones, silica, organosilanes, silsesquioxanes and silicates) to polymeric materials causes increase in flame retardancy behaviour. These are mainly used as fillers and incorporated in the gap between the polymerchain, as copolymers or as the main form of polymer matrix. This should be called as that of the flame retardancy of silicones.

4. Fire-Retardant Mechanism for Clay-Based Nanocomposites

Montmorillonite (MMT) is one of the most commonly used clay because it is naturally obtained at high purity and low cost, and exhibits very high intercalation chemistry i.e. it can be easily organically modified. The surface of natural clay is hydrophilic in nature,so that the claycan easily disperses in aqueous medium butnot in polymerssamples. Natural clays are often modified using organic cationssuch asasalkylammonium and alkylphosphoniumcations, forming hydrophobic organ modifiedclays and that clay can be readily dispersed in polymers. Clay-based Nano compositesare usually classified into three categories because clay properties are unique:

1. Immiscible (also known as micro composites)
2. Intercalated
3. exfoliated (also known as delaminated).

The exfoliated Nano composites are usually desired because they exhibit enhanced mechanicalproperties. The fire-retardancy mechanisms for clay-based andcarbon-based Nano compositesare almost identical. One fire-retardancy mechanism is the reduction in PHRR due to the production of a protective surface barrier or insulation layer consisting of clay platelets accumulated with a less amounts of carbonaceous char . The clay platelets can accumulate because the clay remaining on the surface from polymer decomposition and clay migration was pushed by numerous rising bubbles of degradation products. The surface quality appears to determine the flame-retardant efficiency. There is also another mechanism which suggested that the paramagnetic iron in the matrix traps radicals and thus increases the thermal stability. In fact, adding only 0.1 wt% iron containing clay decreases the polystyrene (PS) PHRR by 60 %. This effect wasnot observed for carbon-based Nano composites because most of their iron is not onthe surface becauseof their contact with the polymeric material is minimum.

CONCLUSIONS

These review work includes wide variety of flame retardantproperties which have been studied either by or the presently under the improvement to confirm larger security in the world where the plastic materials are being gradually are used in transferenceof particles and in the buildings, and normally anywherein the fire prevention which remains as a main issue. While some systems, such as halogenated compounds, are in the method of being excluded due to the health and with the environmental concerns, other types of systems are such as the basic use of comparatively lessquantities of nanoparticles of bio composites or the synergistic effects of the flame retardants from various families show very promising results. Amongst the non-halogenated fire retardant additives like the phosphorus based and the nitrogen-based compounds have showed to be very much powerful solutions, which are especially in the matrices that containing the oxygen or with the nitrogen atoms in their different types of backbone structure , while the silicon-based additives which are also appear to be responsible for the efficient solutions. Wood fibre plastics are also a good and stable fire retardant materials .The fire retardency properties are confirmedby the various flammability tests of the plastic materials or the substances which remains as a very complex type of scientific problem for which there is no single solution can be establish, specifically with respect to the widespreaddiversification of the polymeric matrices are available.Finally to save our society from fire hazards more research work has to be done for manufacturing of fire retardant materials having low cost and easy process ability.

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