ADDITIVES FOR POLYMER'S PROPERTIES ENHANCEMENT

[1]Mr. N. L. Phadke, [2]Mr. A. M. Vibhute
LPT, G..P. Miraj / DTE Mumbai, India,[1] LME, G.R.W.P. Tasgaon / DTE Mumbai, India[2]
phadken005@gmail.com[1], amvibhute@rediffmail.com[2]

ABSTRACT

Incorporation of additives in the polymer can often be used to alter the bulk properties of polymer. It is also possible to achieve variations in the properties of the polymeric products. Additives may be divided into four groups such as solids, liquids, rubbers and gases. The important additives for polymers are fillers, plasticizers, lubricants, anti-aging additives, flame retardants, colourants, blowing agents, ultraviolet degradable additives, cross-linking agents, etc. Filler is a solid additive incorporated into the polymer to modify its physical i.e. mechanical properties, plasticizers can be used in plastics to improve flexibility, resiliency, and melt flow. Lubricants are used to improve the processibility of resin and appearance of the end product, anti-aging additives are used in plastics to avoid the change of properties of polymeric materials with time and an adverse conditions, flame retardants are used to delay ignition and reduces flame spread of the material when polymer is exposed to flame. Blowing agent is used to produce a cellular structure in a polymeric material. Colourants are used to impart a specific colour to the polymeric material. Crosslinking agents are used in polymer to produce a thermoset plastics. The additives used in polymer should be stable under processing conditions of polymers, service conditions. They should not bloom, should be efficient in their function, should be non-toxic and cheap.

Index terms – Polymer, Fillers, plasticizers, lubricants, anti-aging additives, flame retardants, colourants, blowing agents, ultraviolet degradable additives, cross-linking agents, properties.

INTRODUCTION

Incorporation of additives in the polymer can often be used to alter the bulk properties of polymer. It is also possible to achieve variations in the properties of the polymer products. For example, in case of PVC from which rigid rain water piping, baby pants, conveyor belting, footballs can also be prepared.

Physically, additives may be divided into four groups such as solids, liquids, rubbers, and gases. The important additives for polymer are follows,

1) Fillers, 2) Plasticizers , 3) Lubricants and flow promoters,4) Anti-aging additives, 5) Flame retardants, 6) Colourants, 7) Blowing agents, 8) Cross-linking agents, 9) Ultraviolet degradable additives.

FEATURES OF ADITIVES FOR POLYMERS :-

The additives should have following features,

i) They should be stable under processing conditions of polymers,

ii) They should be stable under service conditions,

iii) They should not bleed or bloom,

iv) They should be efficient in their function,

v) They should be non-toxic,

vi) They should not impart taste or odour,

vii) They should be cheap,

viii) They should not adversely affect the properties of the polymer.

STUDY OF DIFFERENT ADITIVES FOR POLMERS:

1) **Fillers :-** Filler is a solid additive incorporated into the polymer to modify its physical (i.e. mechanical) properties. There are a number of fillers that are generally recognized in the polymer technology. These fillers are of following types,-

   Particulate fillers :- These fillers are of two types, inert fillers and reinforcing fillers.

   Inert fillers increase the modulus and hardness, may provide a white base for colouring, improve electrical properties, reduce tackiness and also reduce the cost of the compound. For example, calcium carbonates, china clay, talc, and barium sulphate are inert fillers. The fillers should be quite insoluble in any liquids, the liquids which come into contact with polymer. The finer the size of fillers, higher the values of properties such as tensile strength, modulus, and hardness. If the filler particles are coarser, they will tend to give compounds less strong than the compounds which are absent with fillers. Mineral fillers are often treated to improve the wetting of the polymers to fillers. For example, calcium carbonate may be treated with stearic acid. The acid group will attach to the filler particles while the aliphatic chain will attach to the polymer. Mineral fillers must be free from the impurities like traces of copper, manganese, iron and lead, etc. These impurities can affect the oxidative stability of the compound or may give a discoloured product.

   Reinforcing particulate fillers will increase the tensile strength, modulus, tear strength and abrasion resistance of the polymer. Reinforcing carbon black, fine silicas, aluminium hydroxide, zinc oxide, and calcium silicate are the examples of reinforcing fillers.

   Rubbery filler materials are used into rigid amorphous thermoplastics to improve the toughness of the polymeric material. SBR and polybutadiene in polystyrene, butadiene-acrylonitrile rubbers in PVC and ethylene-propylene rubbers in polypropylene are the examples of rubbery fillers. Synthetic resins or plastics can also be used as a filler into rubber. For example, phenolic resins shows low viscosity at processing temperatures. These resins improve the flow and hence processability of rubber compounds.

   Fibrous fillers are also used in the polymeric materials. They improve the toughness, rigidity, heat resistance and strength of the compound. They are used in both thermoplastics and thermosetting materials. Wood flour, cotton flocks, macerated fabric, macerated paper, nylon fibres, asbestos, and glass fibres are the examples of fibrous fillers.

2) **Plasticizers:-** Plasticizers can be used in polymers to improve flexibility, resiliency, and melt flow. With the addition of plasticizers it is possible to make plastic films, sheets, tubings and other flexible products. A plasticizer act as an internal lubricant . It overcomes attractive forces between the chains and separate them. As the temperature increases, there will be greater penetration of plasticizer with the plastic improving the melt of plasticizer with the polymer improving the melt flow and mouldability. The plasticizers are used in polymer materials such as polyvinyl chloride, cellulosics, nylon, ABS, and polystyrene, etc. Most of the plasticizers are liquid in nature. However, some solid forms are also available. The plasticizers must exhibit good compabiliity with the resin. They usually are colourless, and odourless materials show vapour pressure and good thermal stability. However, they decrease the strength, heat resistance, dimensional stability and chemical resistance of polymer. The choice of plasticizer affect the physical properties of the product and the processability of polymer. The ratio of the plasticizer to resin affects the flexibility required in the end product.

The most popular general purpose plasticizers are phthalates, epoxies, phosphates, sebasates, adipate diesters or polyesters.

3) **Lubricants :-** Lubricants are used to improve the processability of resin and the appearance of the end product. The lubricants must be compatible with the resins in which they are used. They should not adversely affect the properties of the end products. They should combine easily with the resin system. Also they should have FDA approval, where applicable. There are different types of lubricants with different functions. It is important to distinguish between them. The three main types are,

   i) Materials which reduce the friction of the mouldings or other products with other adjascent materials which may or may not be of the same composition. The most well known examples are graphite and molybdenum disulphide.

   ii) External lubricants :- These materials during processing exude from the polymer composition to interface between the molten polymer and the metal surfaces of the processing equipment. The resultant thin film layer then avoid the sticking of the polymer compositions to the machinery and helps to facilitate processing. These lubricants have a low compatibility with the polymer. They also possesses polar groups which increase the affinity towards the metal surface of the equipment . The most well-known examples are stearic acid, its calcium, lead, cadmium and barium salts, paraffin wax, low molecular weight polyethylene and ethyl palmitate.

   iii) Internal lubricants :-These materials are incorporated into the polymer compositions. They are low molecular weight materials which promote the flow of the polymer in the melt. The examples are amine waxes, glyceryl esters like glyceryl monostearate, etc. Other internal lubricants are ethylene-vinyl acetate copolymers, styrene-acrylonitrile copolymers, styrene-methyl methacrylate copolymers, etc.

   Unlubrication may cause degradation and frequently higher melt viscosities. However, overlubrication can cause too much slippage and low output rates.

4) **Anti-aging additives:-** The properties of the polymeric materials change with the time and an adverse conditions. These property changes are due to the structural changes in the polymeric materials. The changes are of four main types,-

   a) Random chain scission
   b) Crosslinking
   c) Development of chromophoric groups
   d) Development of polar groups

   These structural changes may be due to the oxidation, ozone attack, dehydrochlorination and ultraviolet attack. So antioxidants, antiozonants, dehydrochlorination stabilizers and ultraviolet absorbers are the materials used to overcome these structural changes.

   Antioxidants :- Antioxidants are used to protect the polymeric materials from deterioration through oxidation. The oxidation can be brought on by heat, light or chemically induced mechanisms. Deterioration causes embrittlement, melt flow instability, loss of tensile strength or discolouration. There are three classes generally recognized as antioxidants such as,--

   a) Peroxide decomposers
   b) Metal deactivators

c) Ultraviolet absorbers

The examples of antioxidants are acetone-diphenylamine, aldol-naphtylamines, substituted phenols, phosphates, phenylalkanes, etc.

Ultraviolet light absorbers :- Every polymer degrades in sunlight in a number of ways due to UV absorbtion. The result may be discolouration or the loss of physical properties. Carbon black or black paint or black die are the most effective UV absorbers. However, they cannot be used universally. Hence, a variety of chemicals are used to protect the polymer from UV degradation. Examples are benzo-phenones used in polyolefin materials. Benzotriazoles are used in polystyrene, polyesters. The UV absorbers are used in concentrations of the order of 0.25 to 1 %. The choice of UV absorbers rely upon the particular application, the resin system, the final effect on colour, the anticipated durability of the end product. The UV absorbers are mainly used in polyolefins, polyesters, PVC, ABS, and polyurethane polymer, because these polymers are more susceptible to UV degradation.

5) **Antistatic agents (destaticizers) :-** These materials are used in polymers to minimize the build-up of static electricity or electrostatic charge on the surface of polymeric materials. Building up static electricity on the surface of polymer affects the processing procedures. It can be an issue for hygiene and aesthetics. Antistatic agents can be external or internal. The polymeric materials that are susceptible to the accumulation of electrostatic charge are polyolefins, polystyrene, nylon, polyesters, polyurethanes, cellulosics, acrylics, and acrylonitriles. The most common antistatic agents for polymers include fatty acid esters, phosphate esters, amines, quaternary ammonium compounds, alkylsulfonates and alkylphophates, etc.

6) **Heat stabilizers :-** Heat stabilizers are used in polymeric materials to prevent the degradation of polymeric during processing, when the polymeric melts are subjected to high temperatures. These materials can also be added to the polymeric to extend the life of the end products. PVC is the major consumer of heat stabilizer. Other polymers who require stabilization are chlorinated polyethylene, blends of ABS and PVC. Examples of stabilizers are organometallic compounds, nonmetallic organic stabilizers, organophosphates, and epoxies, etc. The choice of a heat stabilizer depend on the required final desired physical properties and the processing method used to form the product.

7) **Flame retardants :-** Flame retardants are used in polymers to affect the combustion in polymeric materials. There are number of flame retardants. The choice of a particular flame retardants depends primarily on the resin in which they are added. It is a chemical which when added to a material, delays ignition and reduces flame spread of the resulting material when plastic is exposed to flame. The flame retardants can also act as a heat absorbers and create steam. It also suppress the combustion by forming a char layer on the burning material. Examples of flame retardants are alumina trihydrate, antimony oxide or zinc borate, phosphate esters, halogenated compounds of various types, magnesium hydroxide, magnesium carbonate, etc.

8) **Blowing agents :-** A blowing agent (foaming agent) is used to produce a cellular structure in a polymeric material. It is used alone or in combination with other substances. Generally chemical blowing agents are added to the polymeric mass which decompose or react under the influence of heat to form a gas. The examples of chemical blowing agents range from ammonium salts or sodium bicarbonate to complex nitrogen-releasing agents. The nitrogen releasing compounds are the

compounds majorly used as chemical blowing agents. Examples are azo compounds or N-nitroso compounds or sulfonyl hydrazides, etc.

9) **Colourants :-** There are four basic methods for colouring plastic materials. These are surface coating i.e. painting, surface dying, incorporation of colour forming groups into the polymer molecules and mass colouration. Among these four methods mass colouration approach is most favourable. There are two types of colourants used in plastics, such as pigments (insoluble colourants) and dyestuffs (soluble colourants). However, many colourants have finite solubility due to which in certain situations blooming may cause. One can use higher molecular weight colourants in order to reduce the problem of blooming. The choice of colourants i.e. either dyestuff or pigments, depends on the resin compability and the need for solubility. The dyestuff or pigment must be stable at moulding temperatures and on exposure to the light, moisture, and air. Colourants also are chosen for the purpose of strength, electrical properties, specific gravity, clarity and bleeding.

10) **Crosslinking agents :-** In order to produce thermoset plastics, the process of cross-linking has to occur. Prior to cross-linking, the polymer may be linear, but contain active sites for cross-linking. Such a situation occurs with diene polymers or natural rubber where double bond and adjuscent alpha-methylene groups provide cross-linking sites. In some cases the polymer may be a branched polymer which undergo cross-linking by intermolecular combination at the chain ends. Examples of the cross-linking agents are sulfur, selenium, sulfur monochloride, peroxides, etc.

RESULT

- Additives for polymers are used to modify the properties of polymers.
- During the compounding process filler is incorporated into the polymer to modify its physical (i.e. mechanical) properties and to reduce the cost of ultimate end product.
- Plasticizers can be used in polymers to improve flexibility, resiliency, and melt flow.
- Lubricants are used to improve the processibility of resin and appearance of the end product,
- Anti-aging additives are used in polymers to avoid the change of properties of polymeric material with time and an adverse conditions.
- Flame retardants are used to delay ignition and reduces flame spread of the material when polymers is exposed to flame.
- Blowing agent is used to produce a cellular structure in a polymer material.
- Colourants are used to impart a specific colour to the polymer material.
- Crosslinking agents are used in polymers to produce a thermoset plastics.

CONCLUSIONS

Inclusion of different additives in polymer alter and modify the different properties .Variation in properties of polymers is achieved by adding additives as per requirement of desirable properties required for application . Property enhancement of polymer is achieved by adding different additives in desired quantity as per need of application. The additives used in polymers should be stable under processing conditions of polymers, service conditions. They should not bloom, should be efficient in their function, should be non-toxic and cheap.

REFRENCES

[1] J. A. Brydson, 'Plastics Materials', (sixth edition) , Butterworth-Heinemann Ltd., Oxford, Page no. 120 to151.

[2] Michael L. Berins, 'SPI Plastics Engineering Handbook of the Society of the Plastics Industry, Inc'., (fifth edition), Chapman & Hall International Thomson Publishing; New York, Page no. 635 to 653.

[3] W.J. Grigsby, J.H. Bridson, C. Schrade Modifying biodegradable plastics with additives based on condensed tannin esters J. Appl. Polym. Sci., 132 (2015)

[4] A.A. Koelmans, T. Gouin, R. Thompson, N. Wallace, C. Arthur,Plastics in the marine environment Environ. Toxicol. Chem., 33 (2014), pp. 5-10

[5] A.M. El-Hadi, The effect of additives interaction on the miscibility and crystal structure of two immiscible biodegradable polymers Polímeros, 24 (2014), pp. 9-16

[6] L. Kattas, F. Gastrock, A. Cacciatore Plastic additives C.A. Harper (Ed.), Modern Plastics, McGraw-Hill, New York, NY (2000) 4.1–4.66

[7] https://www.bpf.co.uk/plastipedia/additives/default.aspx

[8] https://www.spg-pack.com/blog/en/plastics-additives-what-do-they-do/

[9] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1475198/

[10] https://www.azom.com/article.aspx?ArticleID=17479

[11] https://polymerdatabase.com/Additives/Polymer%20Additives.html

[12] https://bitmesra.ac.in/UploadedDocuments/admince/files/PSE_Module%201.pdf

[13] https://amcorplastics.com/blog/what-are-polymer-additives/

[14] https://revpart.com/what-can-additives-do-for-plastics/

[15] Literature survey of various internet resources. .

E-ISSN NO:2349-0721