

# SINGLE COMPONENT EPOXY RESIN AND ITS APPLICATION

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## Abstract

Composite materials have been used in modifying the shortcomings of monolithic materials. They are mainly composed of two components, a matrix and reinforcement. One of the early applications of composite materials is seen in the construction of the pillars and beams which are done with a combination of steel and concrete. Concrete, the matrix of the composite, does not achieve high enough strength to take the weight of a whole building. But high strength can be achieved using steel, and this reinforcing material greatly increases the strength of these pillars and beams. Furthermore, the demands in the automotive and aerospace industries, materials with high strength or stiffness-to-weight ratio are preferred. Polymer composite materials can reduce the weight of pure metal and alloys. Advantages of composites are not only in weight reduction but also in superior excellent mechanical, thermal, and electrical properties. Hence, numerous studies have begun to focus on the characteristics of reinforcements and composite materials.

**Key Words:** Epoxy resin; modification; impact modification; toughening; bisphenol-A resins; phase morphology; elastomer modification.

## 1. Introduction

In the present study also and investigation has been made of the different characteristics of single components epoxy resin like particle size, gel time, solubility, fusion temperature, infra red spectroscopy, thermo gravimetric analysis and differential scanning calorimetry. The effect of temperature, accelerator concentration and hardener concentration on single component epoxy resin are also studied, sheets are also prepared in the hydraulic press at 1500 C by using compression molding technique.

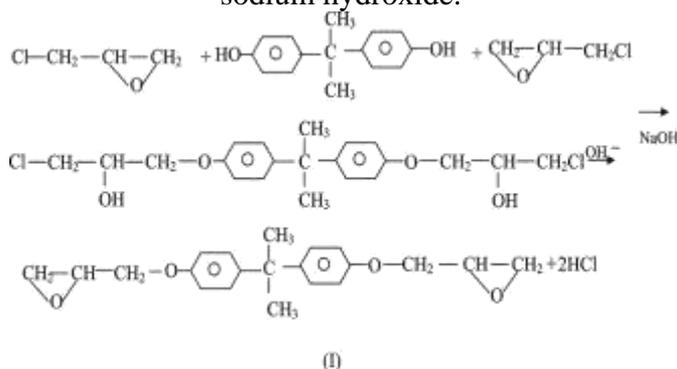
Epoxy resins are versatile from the view point of chemical structure, as well as physical and mechanical properties. They have been and will continue to be among the mainstream plastic materials for applications like coatings, adhesives, laminates and structural components. However, when the application is structural, unfortunately epoxy resins suffer other engineering polymers; they are either brittle or notch sensitive or both. As a result, considerable effort has been focused on toughness improvement of epoxy resins [1].

Epoxy resins (EPs), as typical representatives of thermosetting polymers, have found use in

numerous industrial applications since their commercialization in 1946, including surface coatings, castings, laminates, adhesives and polymer composites. They provide an exceptional balance of mechanical and chemical properties, such as high strength, toughness, chemical and electrical resistance, low shrinkage on cure and high adhesion to many substrates, combined with outstanding processing versatility [1,2,3]. Due to these properties they are also of particular interest in structural polymer composite applications, where their technical advantages balance their relatively high price level compared to other commodity thermosetting matrices. The tendency towards replacement of mineral oil based polymers and reinforcements by bio-based ones has emerged also in polymer composite industry. Depleting mineral oil sources initiated increasing environmental awareness and legislations aiming at fostering the use of renewable resources, which is reflected in rapidly increasing need for bio-based polymers and composites. By definition, bio-based composites are those composites, in which at least one of the components is originating from biological

products issued from biomass [4]. This means that polymer composites, in which either the matrix or the reinforcement is bio-based, can be already considered as bio-based, nevertheless, it is essential to distinguish these “partial bio-based” materials from the “completely bio-based” or “all-bio” composites.

Fig. 1 epichlorohydrin in the presence of sodium hydroxide.



## PROCESSING OF SINGLE COMPONENT EPOXY RESIN

The very fact that polymeric material are used in many forms such as Rods, tubers, Sheets, foams coating or adhesives and also as molded or fabricated articles implies that there must be a variety of ways in which the compounded Resin can be processed and converted into finished products. A majority of items are either molded or fabricated. The process of molding can be compared to making for instance, a toy horse out to clay fabrication process can perhaps be compared to making the toy by carving it out of a soap cake. Today there are many processes and automatic machine for this purpose, the important one being calendaring, casting, compression molding, injection molding, extrusion molding, blow molding, thermoforming, foaming, thermo foaming etc. Thermoplastic materials are molded shaped under heat and pressure. They are required to be cooled much below their softening temperature before being Released out of the mold as otherwise they may get Reshaped In the case of thermosetting materials there is no need to cool the article before releasing. It out of mold, since once set under the influence of heat and pressure, the article does not change it is shape even when handled hot.

Calendering :

The calendaring process, in it is simplest form is employed to produce continuous films and sheets. The main part of calendaring machine is a set of highly polished metals rollers rotating in opposite directions with provision for precise adjustment of the gap between them. The gap between the Rollers determines thickness of the sheet calendered out. Compounded polymeric material is fed between the rollers which are maintained at an elevated temperature (150°C for Rigid single component epoxy Resins). The Sheet finally Rolls on the Rollers. If however, thin films are required instead of sheets. A series of Rollers with a sequentially diminishing gap. Between them is employed polyvinyl chloride, rubber etc. are among the main polymers which are usually calendered into sheets.

Compression molding: -

The compression molding process is very widely used to produce articles from thermosetting materials the mold is made up of two levels the upper and lower half usually contains a cavity and upper half has a projection which fits into the cavity when the mould is closed. The gap between the projected upper half and the cavity in lower one gives the shape of mold article.

In compression molding, the thermosetting materials are subjected to heat and pressure in a single stroke. This is accomplished by using a hydraulic press with heated plattens mold temperature and pressure depends on the Plastic material to be molded as high as 2000C 870 kg / cm respectively. The compounded material is placed in the cavity of the mold so as to fully fill the cavity. As the mold closes down under pressure the material is squeezed or compressed between the two halves and compacted to shape inside the cavity. The excess material hows out of mold as a thin film. Under the influence of the heat the compacted mass gets cured and hardened to shape. The mold can be opened while it is still hot to release the mold product.

Injection molding :

The Injection molding process is best suited for producing articles made of thermoplastic material here the equipment cost is relatively high but the main attraction is the high production rate. In injection

molding a dominate quantity of molten thermoplastic material is injected under pressure into a relatively cold mold where it solidifies to the shape of the mold.

The injection molding machine process consist of feeding the compounded plastic material as granules. Pellets or Powder through the hopper at definite time interval into the hot horizontal cylinder where it gets softened pressure is applied through hydraulically driven piston to push the molten material through a cylinder into a mold fitted at the end of cylinder, while moving through the hot zone of cylinder, a device called toffee help to spread the plastic material uniformly around the inside wall of the cylinder and thus ensure uniform heat distribution. The molten plastic material from the cylinder is then injected through a nozzle into the mold cavity. The mold used in it's simplest form is a two part system one part is movable part and other stationary. The stationary part is fixed to the end of the cylinder while the movable part can be opened or locked on to the stationary part. By using a mechanical locking as molten plastic material is injected under a pressure as high as 1500 kg/cm. The locking device has to be very skillfully designed in order to filled by molten material under pressures so as to inject the molded articles.

Extrusion molding: -

Extrusion is one of the cheapest methods available for producing many common plastic products such as film, filaments, tubes, sheets, pipes, rods, hoses and strips all in continuous lengths. In this machine the compounded plastic materials is fed through the hopper as either powder or granules into a cylinder having provision for electrical heating for softening the material. The hot plastic charge is further worked through the cylinder by a helically fringed revolving screw. The temperature of the plastic material rises owing to the frictional heat produced by the compression of the charge between the rotating screw and the cylinder surface. During it's journey from the hopper to die, the plastic material passes through distinct zones namely feed zone, compression zone, metering zone, the extruded material of the required profile emerging from the die is quite hot and has to be cooled rapidly to avoid

deshaping. It is therefore that the extrudate is carried out over a conveyor belt through a tub containing cold water.

Particle size: -

Sieve Analysis

The principle of sieve analysis is generally well known. Several sieves, one on top of each other, form a set, with the size of the sieve openings decreasing from top to bottom. A representative sample of the material to be analyzed is fed to the coarsest sieve, and the sieve column is vibrated either mechanically or electro - mechanically. The particles pass through the sieve openings, and the coarser ones are retained on the sieves. As soon as the particles cease to pass through the openings, the vibration is stopped. The amount of particles on each individual sieve is weighed, and the histogram of the density distribution is obtained by weight.

Apparatus used: -

Sieves

Sieve Shaker

Sample Splitter

Balance

Procedure: -

Assemble the group of sieves selected from table 1 in order, with the sieve having the largest opening at the top and the one having the smallest opening at the bottom. Add a solid collecting pan below the bottom sieve. Weigh the test specimen to within +0.1 g and place in the topmost sieve. Complete the assembly by placing a solid cover over the top sieve. Securely fasten the sieve assembly in the mechanical sieve shaking device.

Pass the specimen through the assembled group of sieves by subjecting it to the sieve shaker for a period of 300 + 10s. Carefully remove the portion of the specimen retained on each of the sieves and on the pan, and weigh each portion to within + 0.1g.

Calculations: -

Total wt. of particle in all sieves

$$= 82.42 \text{ gm}$$

Weight of particle in 600  $\mu$  sieve

$$= 18.34 \text{ gm}$$

Weight of particle in 600  $\mu$  sieve in %

$$= (18.34 \times 100)/(82.42)$$

$$= 22.25\%$$

2. Weight of particle in 420  $\mu$  sieve  
 $= 15.8 \text{ gm}$   
 Weight of particle in 420  $\mu$  sieve in %  
 $= (15.8 \times 100) / (82.42)$

$$= 19.17\%$$

3. Weight of particle in 300  $\mu$  sieve  
 $= 9.2 \text{ gm}$   
 Weight of particle in 300  $\mu$  sieve in %  
 $= (9.2 \times 100) / (82.42) =$

$$11.16\%$$

4. Weight of particle in blind sieve  
 $= 37.3 \text{ gm}$   
 Weight of particle in blind sieve in %  
 $= (37.3 \times 100) / (82.42)$

$$= 45.25\%$$

Total weight of particle in all sieves  
 $18.34 \text{ gm} + 15.8 \text{ gm} + 9.2 \text{ gm} + 37.3 \text{ gm}$   
 $= 80.64 \text{ gm}$

Weight loss =  $82.42 \text{ gm} - 80.64 \text{ gm}$   
 $= 1.78 \text{ gm}$

#### Observations: -

S. NO.	Retained on sieve size	Passing Sieve	Percent
1	600 $\mu\text{m}$	600 $\mu\text{m}$	22.25 %
2	420 $\mu\text{m}$	420 $\mu\text{m}$	19.17 %
3	300 $\mu\text{m}$	300 $\mu\text{m}$	11.16 %
4	Blind	Blind	45.25 %

#### Estimation of Epoxy Group: Direct Titration with Hydrogen Bromide in Acetic Acid

##### 1. Reagents:

Hydrogen bromide in acetic acid, approximately 0.1 N. Pass anhydrous hydrogen bromide at a slow rate through glacial acetic acid until the desired normality is attained. Standardize daily against potassium acid phthalate, or sodium carbonate. Store the solution in a Karl Fischer type reservoir burette, fit the tip of the burette with a rubber stopper having a small hole to allow escape of the displaced air during titration. Crystal violet indicator solution, 0.1% in glacial acetic acid.

##### 2. Procedure

Weigh a sample containing 1 to 1.5 meq of epoxy groups into an Erlenmeyer flask, and add 10 ml of chlorobenzene (liquid epoxy resin) or 25 ml of chlorobenzene-chloroform mixture (solid epoxy resins). Place a magnetic stirrer bar in the flask and swirl to effect solution. Add a few drops of crystal violet indicator solution. Attach the flask to the rubber stopper on the burette tip. place the tip just above the solution, and titrate the sample with the hydrogen bromide in acetic acid to the blue green end point while stirring at a slow speed with the magnetic stirrer. Make a blank determination on the reagents in an identical manner.

##### 3. Determination of factor of HBr acetic acid solution

In a 100 ml moisture free  $\text{Na}_2\text{CO}_3$  is weighed in a Erlenmeyer flask: 30 ml glacial acetic acid is added into it and  $\text{Na}_2\text{CO}_3$  is dissolved in it two drops of 1% alcoholic solution of crystal violet indicator is added to the solution and the same is titrated with - 1 N HBr acetic acid solution till the colour change from violet to green. The factor is calculated as per equation gives below

$$F = \frac{W \times 0.1887}{V (\text{in ml})}$$

F = factor

W = Weight of  $\text{Na}_2\text{CO}_3$  (exact)

V = Vol. Consumed

= Vol. Of titre

Determination of epoxy no.:

A sufficient quantity of epoxy resin is weighed accurately in a 200 ml Erlenmeyer flask 10 ml of 1.4 dionane is added into it to get the resin dissolved in it. 20 ml of glacial acetic acid is added followed by 2 drops of crystal violet alc. Solution the mixture is titrated against 0.1 N HBr acetic acid solution till the colour change four violet to green.

#### Conclusion

On varying the temperature , we find that we increase temperature, the time curing of single component epoxy reign decrease and vice versa , we find that we vary the concentration of accelerator i.e. when we increase the concentration of accelerator and keep the concentration of hardener to be constant , in this case fusion temperature of single component epoxy decrease as the concentration of hardener increases .

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