Comparative Studies of Epoxy Resin with Different Curing Agents

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DOI: 10.5185/amp.2019.0012
www.vbripress.com/amp

Abstract

A polymer is a giant molecule, made of many repeated subunits. Titled material Epoxy resin is a polymer. Films of epoxy resin with curing agents are prepared by wt/wt ratio. The concentrations of both the polymer and curing agents are varied. Organic solvents - Triethylenetetramine and Diethylenetriamine are curing agents used in this study. Films are casted by solvent evaporation technique. Films of epoxy resin with different curing agents are subjected to spectroscopic, mechanical and dielectric studies. From the studies better curing agent is traced out. Copyright © VBRI Press.

Keywords: Epoxy resin, curing agent, triethylenetetramine, diethylenetriamine, solvent evaporation technique.

Introduction

Epoxy resins are extensively used for variety of applications from microelectronics to space vessels, aerospace in modern technology because of excellent mechanical and electrical properties, easily processed, and low cost. In the view of using variety of areas in technology, the epoxy resins are the major polymer group [**1**]. Epoxies are adaptable in the view of chemical structure, physical and mechanical properties [**2**].

Material

Epoxy

Epoxy resins are low molecular weight pre-polymers, having two epoxide groups. Epoxy resin exhibit exemplary mechanical properties, chemical resistance, electrical properties hence it is employed in electronics, construction, machinery and other industries [**3**]. Epoxy resin is made of two epoxy groups per molecule, is a thermosetting polymer exhibiting good performance. Two carbon atoms bonded to an oxygen atom makes up an epoxy group. The epoxide group is also called as glycidyl or oxirane group.

Curing agent

A thermosetting plastic or thermosetting resin is a polymer which becomes irreversibly hardened when cured. Curing process can be carried out by the action of heat or exposing to radiation, by using high pressure or the use of a catalyst. It results in huge cross-linking between polymer chains to give an infusible and insoluble polymer network [**4**]. Excellent adhesive properties, leads to the usage of many modifiers as dopant to the resins [**1**]. The most equivalent curing agent must be selected according to the use conditions, application, utility, and other factors [**5**]. Amines are classified as aliphatic, aromatic (Three Bond 2106), and alicyclic amines according to the types of hydrocarbons involved, and all are important curing agents for epoxy resin. Aliphatic amine is vital curing agent for epoxy, to cure at room temperature [**5**]. Curing Agents used in this study are aliphatic amines - Triethylenetetramine and Diethylenetriamine

Triethylenetetramine (TETA)

Triethylenetetramine, is known as TETA. Its chemical formula is $[CH_2NHCH_2CH_2NH_2]_2$. It is colourless oily liquid but, assumes a yellowish color due to impurities emerging from oxidation of air.

Diethylenetriamine (DETA)

Diethylenetriamine is a cross linker for epoxy resins, building block to modify epoxy resins. Diethylenetriamine is as abbreviated as DETA. It is an organic compound with the molecular formula $HN(CH_2CH_2NH_2)_2$. DETA is colourless, hygroscopic oily liquid, soluble in water and polar organic solvents.

Epoxy resin was procured from Roto Polymers, Chennai. Magnetic stirrer Remi model is used to cast homogeneous mixture of epoxy resin with different curing agents - Triethylenetetraamine and Diethylenetriamine. To cast the film concentrations of both the polymer (resin) and curing agent are varied. Casted films are of concentration - 2%, 6%, 16% of both the curing agents.

Characteristic studies

Spectral studies

FTIR spectroscopy has been proved to be an equivalent nondestructive method to explore cured epoxy resins [**6**]. FTIR spectrum of pure epoxy resin, TETA, epoxy resin with 2% of TETA is shown in **Fig 1.** FTIR spectrum of pure epoxy resin, DETA, epoxy resin with 2% of DETA is shown in **Fig. 2**. Films of epoxy resin with varying concentration of both curing agents undergo vibration of C-C aromatic ring stretching occurs at 1506 cm^{-1} - 1507 cm^{-1}. Peak at 1180 cm^{-1} - 1181 cm^{-1} reveals the stretching of C-O for all concentrations of both curing agents with epoxy resin. Vibration of C-O-C ethers occurs at 1010 cm^{-1} - 1011 cm^{-1} for all concentrations of both the curing agents with epoxy resin.

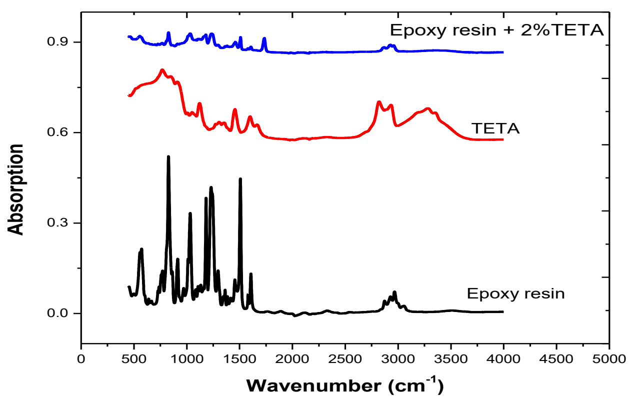

Fig. 1. FTIR Spectra of Epoxy resin, TETA, Epoxy resin with 2% of TETA.

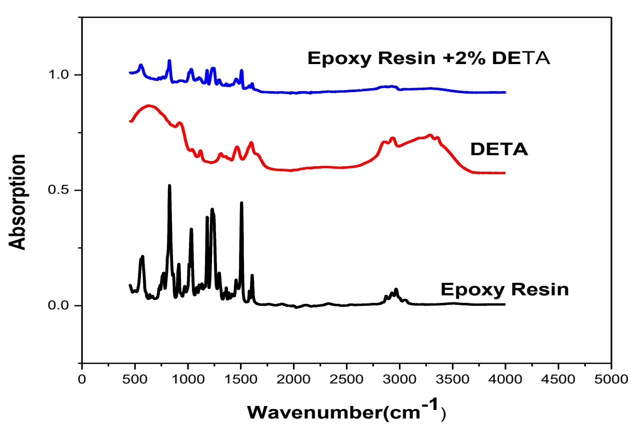

Fig. 2. FTIR Spectra of Epoxy resin, DETA, Epoxy resin with 2% of DETA.

Mechanical studies

Casted films are imposed to mechanical studies by varying the applied force. **Fig. 3** shows the typical variation of stroke with stress for film of epoxy resin with 2%, of TETA and DETA respectively. **Fig. 4** shows the typical variation of stroke with stress for film of epoxy resin with 6%, of TETA and DETA respectively. **Fig. 5** shows the typical variation of stroke with stress for film of epoxy resin with 16%, of TETA and DETA respectively. Various mechanical parameters are found and tabulated. It is revealed that as percentage of concentration of curing agents is increased the tensile strength, flexural strength, toughness also increases affirmed from the **Fig. 6, Fig. 7** & **Fig. 8** and **Table 1**. Mechanical studies also reveal the fact curing agent is used to enhance the hardness of films. Tensile strength is more for the film of epoxy resin with DETA. Hence of the two, better curing agent is Diethylenetriamine.

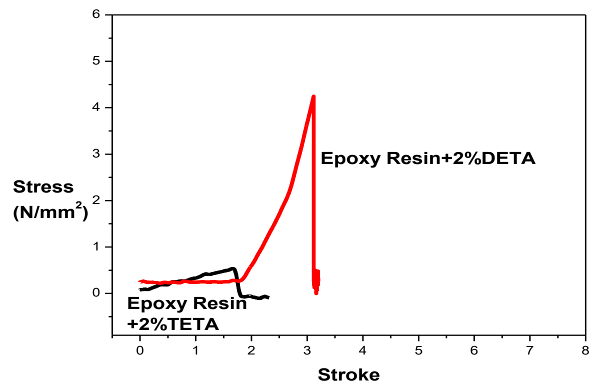

Fig. 3. Shows the typical variation of stroke with stress for film of epoxy resin with 2%, of TETA and DETA respectively.

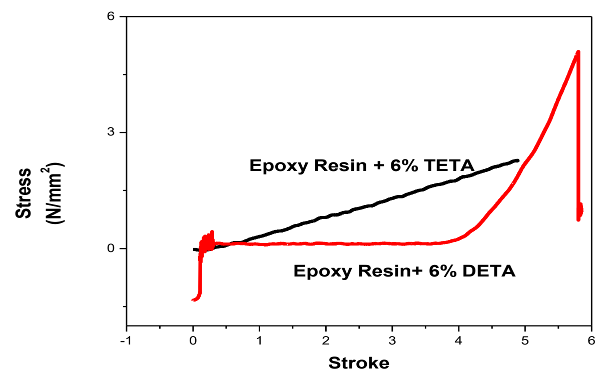

Fig. 4. Shows the typical variation of stroke with stress for film of epoxy resin with 6 %, of TETA and DETA respectively.

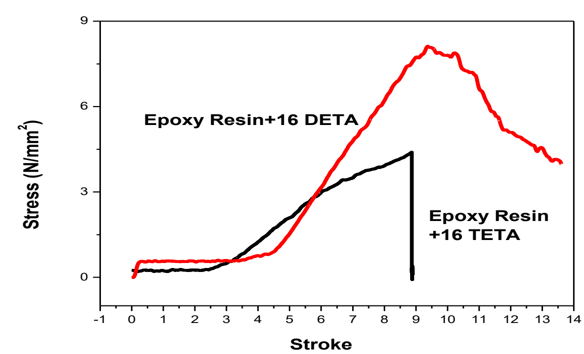

Fig. 5. Shows the typical variation of stroke with stress for film of epoxy resin with 16 %, of TETA and DETA respectively.

Table 1. Variation of Mechanical Parameters with varying Concentration of TETA & DETA.

Con-centration of curing agent in %	Tensile Strength		Flexural Strength		Toughness	
	TETA	DETA	TETA	DETA	TETA	DETA
2	**0.5316**	**4.19**	**0.25**	**0.3409**	**0.2625**	**0.3580**
6	**2.2493**	**5.0032**	**0.744**	**2.222**	**0.7812**	**2.3331**
16	**4.3664**	**8.0057**	**2.8333**	**4.0202**	**2.9715**	**4.2214**

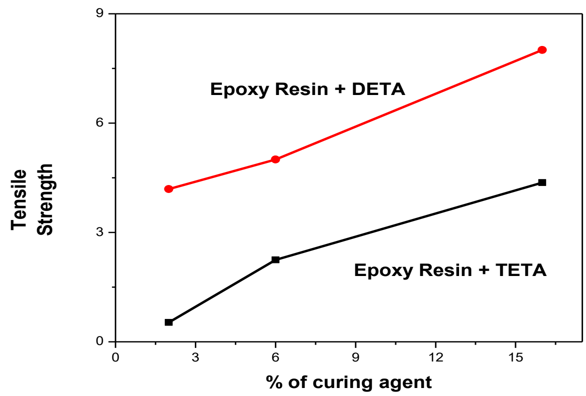

Fig. 6. Variation of Tensile strength with concentration of TETA DETA.

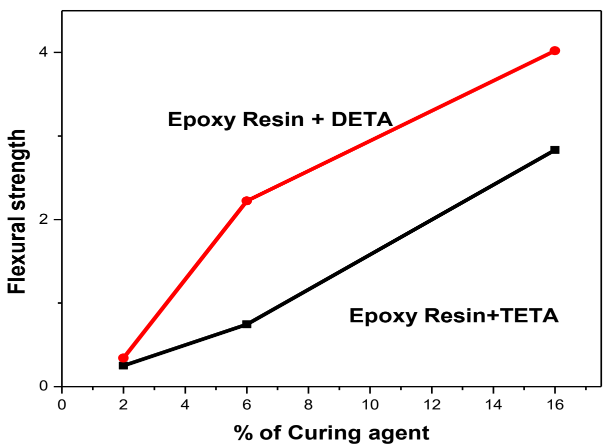

Fig. 7. Variation of Flexural Strength with concentration of TETA DETA

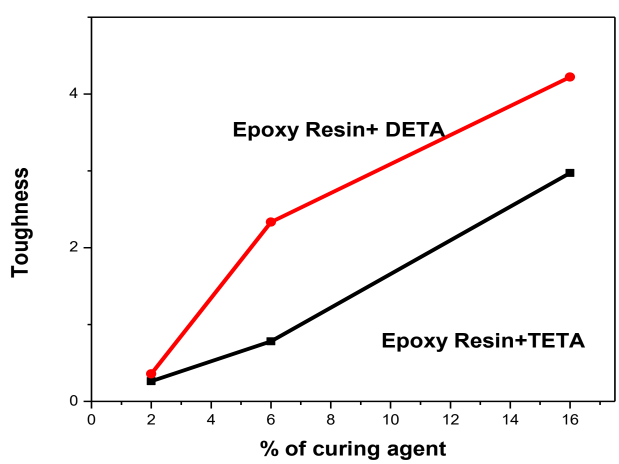

Fig.8. Variation of Toughness with concentration of TETA DETA.

Dielectric studies

Each material has some unique set of electrical features depending on thermal and dielectric properties [**1**]. Dielectric spectroscopy is one of the important methods to explore valuable information about the thermal and frequency behavior of polymers [**1**]. Casted films are imposed to dielectric studies at temperature 150°C. It is depicted from **Fig. 9, Fig. 10** dielectric constant increases frequency decreases for all concentrations for both the curing agents.

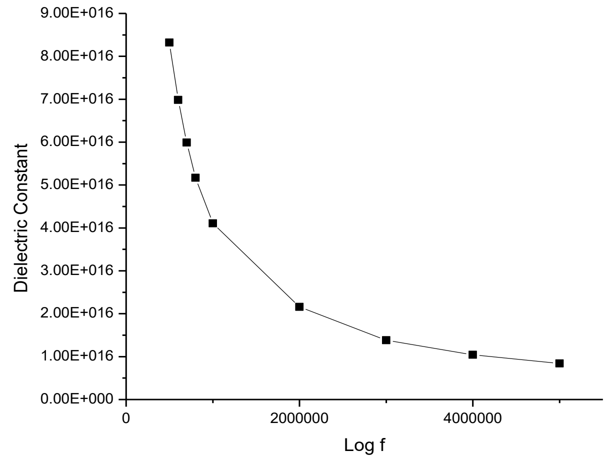

Fig. 9. Typical plot of divergence of Dielectric constant with Log f at 150° C for 16% TETA.

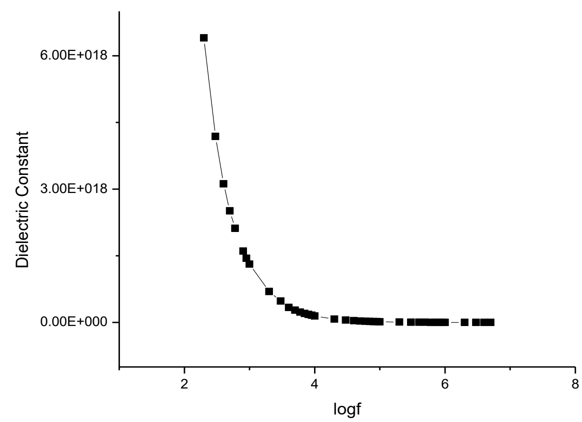

Fig. 10. Typical plot of divergence of Dielectric constant with log f at temperature 150 C for 16% of DETA.

Conclusion

Spectral studies helps to identify the functional groups. Mechanical studies plays a key role in identifying the importance of concentration of curing agent to increases the value of tensile strength, flexural strength and toughness. Dielectric studies play a vital role in confirming the fact of enhancement of frequency leads to decreases in dielectric constant.

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