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Effect of Filler Parameter on Microstructure and Mechanical Properties of Titanium Dioxide Reinforced Epoxy Composites

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Abstract

Titanium dioxide reinforced epoxy composites are developed by simple mechanical stirring and compression molding technique respectively. Investigation on mechanical and morphological characteristics of titanium dioxide reinforced epoxy composite is presented. The effect of titanium dioxide taken as different weight fractions and their interactive influences on the mechanical and morphological characteristics of these composites has been studied. X-Ray diffraction observation indicates that the composite changes its state from amorphous to crystalline behavior with increasing the filler loading. The study revealed that titanium dioxide particle addition in epoxy composite has dramatic effect on mechanical properties i.e. tensile, flexural, impact. The composite exhibit improved mechanical property with the increase of filler loading as the property of the composite mainly depends on dispersion condition of filler particles.

Keywords: *Epoxy resin; Titanium dioxid; Hardener; Impact test; Tensile test; Flexural test.*

1. INTRODUCTION

Composite are engineering materials made from two or more constituents with significantly different physical or chemical properties which remain separate and distinct on a macroscopic level within the finished structure. Most of composites are made up of just two materials. One material (the matrix or binder) surrounds and binds together a cluster of fibres or fragments of a much stronger material (the reinforcement). For the matrix, many modern composites use thermosetting or thermoplastic polymers (also called resins). (Boczkowska et al. 2003) The plastics hold the reinforcement together and help to determine the physical properties of the end product (Rothon et al., 2003; Delhaes et al. 2001).

Epoxy resin are considered as the most important thermosetting resin with many desirable properties and is, therefore widely used in various composites as matrix, coating, adhesives and many engineering material application. Epoxy resin once cured with aliphatic amine is characterized by good thermal property and mechanical property (Peters, 1998).

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Curing agent sometimes called hardener, are added in significant amount to the epoxide and react with it to become a part of the cross linked network. Curing agent speed up the gel time rate of cure and cure time of the reaction. The curing agent can be aliphatic amine, aromatic amine, anhydrides. Aliphatic amine, which rapidly reacts with epoxy resin, is a representative room-temperature curing agent. However, it generates a large quantity of heat and has a short pot life (usable time). Loading of amines containing no tertiary amine is made at the exact or much closed amount that is said in stoichiometry, and use amount of amines containing tertiary amine is made less than that. If latter curing is performed at high temperature, properties of curing agents that cure at room temperature are improved. Resins that have been cured using aliphatic amines are strong, and are excellent in bonding properties. They have resistance to alkalis and some inorganic acids, and have good resistance to water and solvents, but they are not so good to many organic solvents. Aliphatic amine irritates the skin and possesses toxicity. Although those that havehigh molecular weight and low vapour pressure are less toxic, good cares for handling are required (Subramaniam et al., 1986).

2. EXPERIMENTAL

2.1 Materials Used

For the present study, a commercial available epoxy resin procured from Ciba Geigy India Ltd was used as the polymer matrix. Aliphatic amine (HY-951) was used as the hardener for epoxy resin. The titanium dioxide powder with a particle size (<50 micron meter) minimum 99.5% was obtained from S.D. Fine-Chemical Ltd. Mumbai-400025

2.2 Preparation of Composite Sheets

A weighed amount of epoxy resin and titanium dioxide powder were taken and mixed properly. When the mixture was thoroughly mixed, the hardener, aliphatic amine (HY-951) 1% (by wt. of resin) was added after 5 minute difference to initiate the reaction and act as a cross linking agent. Direct contact of the curing agent was avoided due to the explosive nature of their mixture. Approximately 5 min. was an average mixing cycle. Over mixing adversely affected the flow characteristics and final properties of the composite sheets. When efficient mixing was achieved the mixture was cast into the steel mold.

Different sheets of epoxy resin reinforced with varying amounts of titanium dioxide filler i.e.5%, 10 %, 15%, 20%, (by wt. of resin) used aliphatic amine 1% total wt. of resin were prepared and tested.

3.RESULTS AND DISCUSSIONS

3.1 X-Ray Diffraction

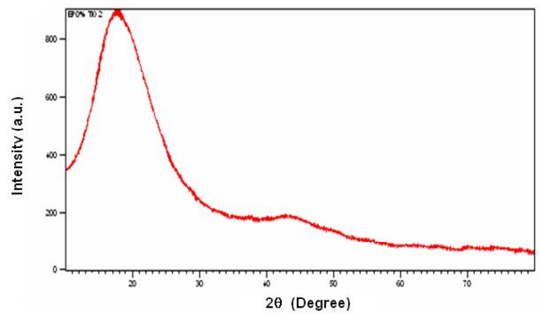

Fig. 3.1.1 Diffraction pattern of pure epoxy resin

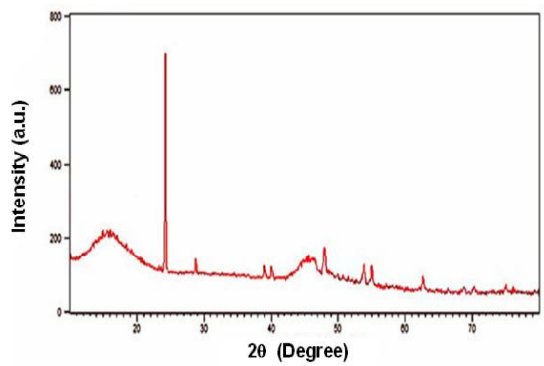

Fig. 3.1.2 Diffraction pattern of epoxy titanium dioxide composites containing 5% filler

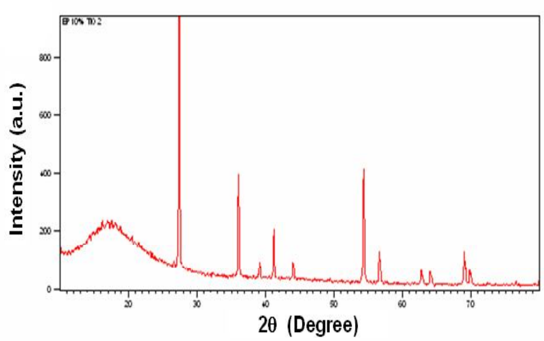

Fig. 3.1.3 Diffraction pattern of epoxy titanium dioxide containing 10% filler

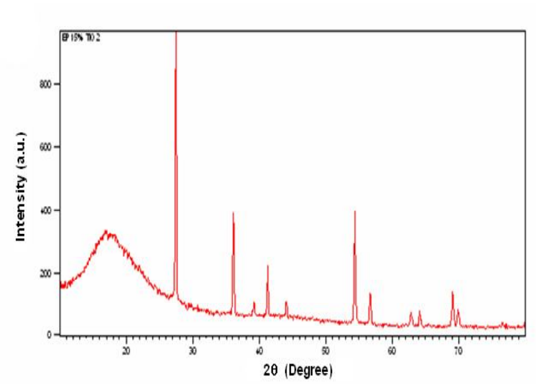

Fig. 3.1.4: Diffraction pattern of epoxy titanium dioxide composites containing 15% filler

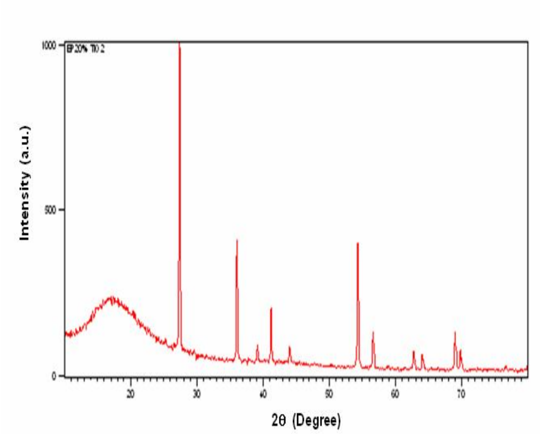

Fig. 3.1.5: Diffraction pattern of epoxy titanium dioxide composites containing 20% filler

XRD micrographs were obtained for epoxy graphite composites with variation in filler concentration. An attempt was made to explain the affect of filler content in the composites. The XRD pattern shows that epoxy epoxy exhibits highly amorphous behaviour and shows highest amorphous peak. It is clear from XRD that the amorphosity decreases and crystallinity increases with increase in the filler content as the highest peak are observes at various angle. In other words intensity increases with increases in filler concentration which shows higher crystallinity.

3.2 Tensile Properties

Table 3.2.1 depicts data for ultimate stress, % elongation, and tensile modulus of epoxy titanium dioxide composites

Sample Identification	%age filler	Ultimate Stress (MPa)	Elongation (%)	Tensile Modulus (MPa)
E-1	0	40.00	4.0	1000.00
E-2	5	50.00	2.5	2000.00
E-3	10	52.92	2.3	2300.00
E-4	15	54.09	2.2	2458.63
E-5	20	56.04	2.0	2802.00

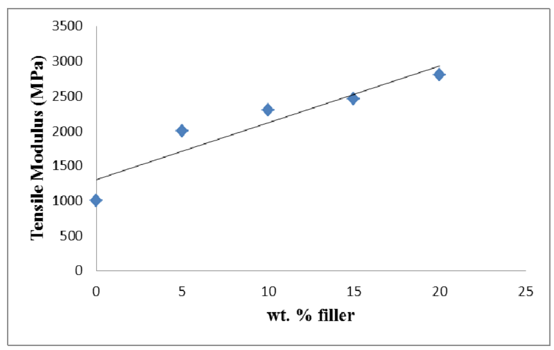

Fig. 3.2.1: Variation of tensile modulus of epoxy titanium dioxide composite

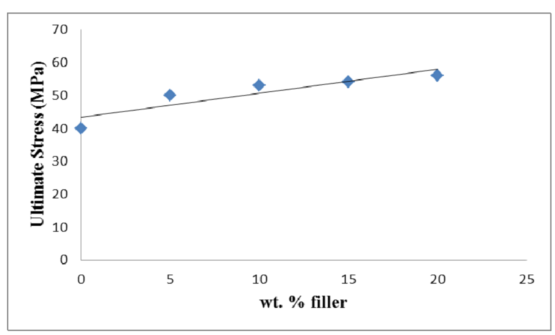

Fig. 3.2.2: Variation of ultimate stress of epoxy titanium dioxide composite

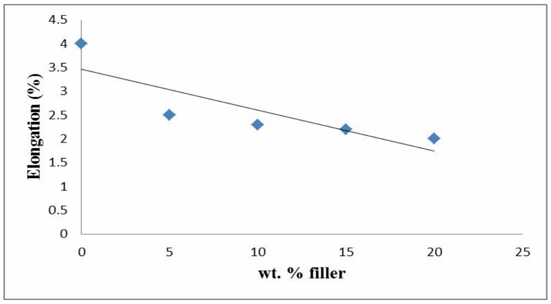

Fig. 3.2.3: Variation of elongation (%) of epoxy titanium dioxide composite

It is noticed that there is significant improvement in tensile strength with increase in filler content. From study it is observe that as the tensile modulus increases, the ultimate stress and % elongation decreases. This may be due to increase of filler content porosity increased and porosity increases due to increase in surface contact area.

3.3 Flexural Properties

The results indicated that the flexural strength increases with increase the filler content. Some important characteristic of composites have to be considered in order to explain this phenomenon. The quality of the interface in composites, i.e. the static adhesion strength as well as the interfacial stiffness, usually plays a very important role in the materials' capability to transfer stresses and elastic deformation from the matrix to the fillers. It is concluded that if interfacial bonding between the fillers and matrix is strong than the yield strength of a particulate composite can be higher than that of the matrix polymer

Table 3.3.1 Data for flexural strength in epoxy titanium dioxide composites

Sample Identification	% age filler	Flexural strength (MPa)
E-1	0	180.64
E-2	5	214.50
E-3	10	248.36
E-4	15	289.01
E-5	20	302.55

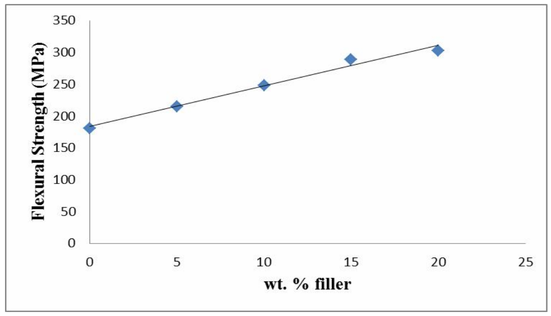

Fig. 3.3.1: Variation of flexural strength of composite of epoxy titanium dioxide composite

3.4 Impact Properties

Table 3.4 depicts the values showing decrease in impact strength of different samples and the results are plotted accordingly, as shown in Figure 3.4.1

Sample Identification	% age filler	Impact strength(J/m)
E-1	0	1.96
E-2	5	1.47
E-3	10	1.37
E-4	15	1.20
E-5	20	1.05

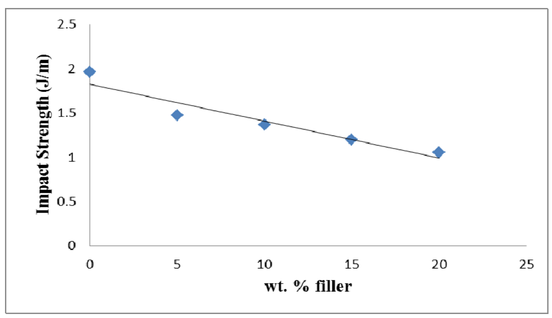

Fig. 3.4.1: Variation of impact strength of composite of epoxy titanium dioxide composite

The impact strength of composite decreases with increases the filler content. The decrease in impact strength is due to decrease availability of epoxy material to bond all the titanium dioxide particles in the matrix. It is examined that the impact property of polymeric material are directly related to the toughness of the material. The impact energy is a measure of toughness .The higher the impact energy of material, the higher the toughness of material and vice versa.

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