Chapter 2
Reliability Study of Polymers

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ABSTRACT

The chapter deals with brief introduction to polymers, composites, and nanocomposites along with their reliability. When we talk about polymeric composites, the terms crystallinity and amorphicity play a very important role, and both of these properties are highly affected by variation in temperature condition. On increasing temperature, the crystalline domains of polymers tend to become amorphous, and as we reduce the temperature, crystalline domains tend to increase. So the reliability of a particular polymer is widely dependent on temperature conditions.

INTRODUCTION

Polymers-An Introduction

Polymers are defined as a combination of small repeated structural unit known as monomers. Two monomers combine to form dimer, three combine to form trimer, four combine to form tetramer and so on to form a polymer. So the term polymer is derived from combination of two terms poly+mer that explains that it is formed by combination of ‘n; number of monomers. Polymers can also be a combination of different molecules with variable molecular weight. Variation in molecular weight may be fine or a large difference may exist. Today we have enough evidence to prove that polymers are mixtures of molecules having long chain of atoms. But it was not accepted up to 1930s. Hermann Staudinger was awarded noble prize in chemistry in 1953 on his study on macromolecules/polymers. Before 1953 polymers were regarded as a colloidal aggregate of tiny molecules having an irregular and nonspecific organization (Peacock and Calhoun, 2012; Termonia and Smith, 1988).

DOI: 10.4018/978-1-7998-1464-1.ch002
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Polymers are classified into various types based on:

1. Source
2. Type of backbone
3. Structure
4. Composition
5. Mode of polymerization
6. Molecular force

Source

1. **Natural Polymer**: Polymers like rubber, cellulose, proteins, starch etc that are mainly found in animals and plants are known as natural polymers.
2. **Semi-Synthetic Polymer**: These polymers includes all the derivatives from cellulose like cellulose nitrate and cellulose acetate (rayon).
3. **Synthetic Polymer**: They include all the artificial or man made polymers like polyethene, nylon, synthetic rubber

Backbone of the Polymer Chain:

1. **Organic Polymers**: In these type of polymers backbone of polymer chain is made up of carbon atoms. Vacancies on the side of these carbon atoms is made up of low molecular weight atoms like H, O and N.
2. **Inorganic Polymers**: Such polymers like silicon rubber and glass do not have any carbon atom in their backbone.

Structure of Polymers

1. **Linear Polymers**: They are elongated straight chain polymers that are generally soft rubbery materials. On heating, linear polymers either become soft or are melted. Examples of such polymers include PVC, Polyethylene etc.
2. ** Branched Polymers**: As compared to linear polymers, branched polymers have certain groups attached on their side chains. Examples of such polymers are low density polyethylene.
3. **Cross Linked Polymers**: These polymers are very hard and usually does not get dissolved in any solvent. As compared to linear polymers, cross linked polymers consists of covalently bonded linear polymer chains. Monomers used in polymeric chains can be trifunctional or bifunctional. Examples include urea-formaldehyde resins, vulcanised rubber etc.

Composition of Polymeric Chain

1. **Homopolymers**: Polymers that are synthesised by polymerisation of same type of monomer throughout its chain are known as homopolymers as shown in figure 1.
2. **Heteropolymers or Copolymers**: Polymers that consists of two unlike monomers joined together repeatedly to form a chain like structure are known as copolymers.