

Discipline: Actual problems of chemistry of polymer composites

Lecture 1.

Theme: Introduction to Polymer Composites: Main Definitions and Classification. Classification of Matrices in Polymer Composites. The Influence of Polymer Matrix on the Properties of Composite

Objective:

To understand the **basic definitions, types, and classification of polymer composites**, learn about different **polymer matrices**, and examine how the **matrix influences the properties of composites**.

Key Questions:

1. What is a polymer composite?
 2. How are polymer composites classified?
 3. What types of matrices are used in polymer composites?
 4. How does the type of polymer matrix affect composite properties?
 5. What are practical applications of different matrices in composites?
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Lecture Content:

- **Definition of Polymer Composites:**
 - Materials consisting of at least two distinct phases: a **matrix** (continuous phase) and a **reinforcement** (dispersed phase) to improve mechanical, thermal, or chemical properties.
 - Commonly used to enhance strength, stiffness, toughness, and environmental resistance.
- **Classification of Polymer Composites:**
 - **By matrix type:** thermoplastic, thermosetting, elastomeric.
 - **By reinforcement type:** fiber-reinforced, particle-reinforced, hybrid composites.
 - **By application:** structural, functional, or multifunctional composites.
- **Classification of Matrices:**
 - **Thermoplastic matrices:** polyethylene, polypropylene, polycarbonate – melt-processable, recyclable, good impact resistance.
 - **Thermosetting matrices:** epoxy, phenolic, polyester – high thermal and chemical stability, strong cross-linked networks.

- **Elastomeric matrices:** silicone, polyurethane – flexible, high toughness, damping properties.
 - **Influence of Polymer Matrix on Composite Properties:**
 - Determines **mechanical performance:** stiffness, strength, impact resistance.
 - Affects **thermal stability:** heat resistance, glass transition temperature.
 - Influences **chemical and environmental resistance:** resistance to solvents, UV, moisture.
 - Matrix-reinforcement interaction governs **load transfer efficiency** and overall composite behavior.
 - **Practical Examples:**
 - Thermosetting matrix composites in aerospace (epoxy-carbon fiber).
 - Thermoplastic matrix composites in automotive applications (PP-glass fiber).
 - Elastomeric composites in vibration damping and flexible components.
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Key Short Theses:

1. **Definition of polymer composites:**
 - Polymer composites are **materials composed of two or more distinct phases:** a continuous polymer matrix and a dispersed reinforcement.
 - The matrix **binds and supports the reinforcement**, transferring load and protecting it from environmental influences.
 - The reinforcement (fibers, particles, or fillers) **improves mechanical, thermal, or chemical properties** beyond those of the pure matrix.
2. **Classification of polymer composites:**
 - **By matrix type:**
 - **Thermoplastics:** melt-processable, recyclable, good impact resistance (e.g., PE, PP, PC).
 - **Thermosets:** cross-linked, high thermal and chemical stability (e.g., epoxy, polyester, phenolic).
 - **Elastomers:** flexible, tough, excellent damping properties (e.g., silicone, polyurethane).
 - **By reinforcement type:**
 - **Fiber-reinforced:** continuous or short fibers; high strength-to-weight ratio.
 - **Particle-reinforced:** small dispersed particles; improve stiffness and wear resistance.
 - **Hybrid composites:** combination of fibers and particles to balance properties.
 - **By application:** structural (load-bearing), functional (conductive, magnetic), multifunctional (simultaneously structural and functional).
3. **Role of polymer matrix in composites:**

- **Mechanical properties:** matrix stiffness and ductility influence tensile strength, modulus, and impact resistance.
 - **Thermal properties:** matrix determines heat resistance, thermal expansion, and glass transition temperature.
 - **Chemical resistance:** protects reinforcement from moisture, UV, and chemical attack.
 - **Load transfer efficiency:** strong matrix-reinforcement interaction ensures effective stress transfer, improving composite performance.
4. **Practical significance of matrix selection:**
- **Thermoplastics** allow **recycling and reshaping**, suitable for automotive and consumer products.
 - **Thermosets** provide **high strength and dimensional stability**, ideal for aerospace and electronics.
 - **Elastomers** offer **flexibility and damping**, used in vibration control, seals, and flexible components.
5. **Overall importance of polymer composites:**
- They provide a **combination of properties** unattainable by individual components.
 - Enable **lightweight, high-performance materials** for engineering, transportation, electronics, and biomedical applications.
 - Proper understanding of **matrix-reinforcement interactions** is critical for **designing composites with tailored properties**.
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Control Questions:

1. Define a polymer composite and its main components.
 2. How can polymer composites be classified?
 3. What are the main types of polymer matrices and their properties?
 4. How does the polymer matrix affect the performance of a composite?
 5. Give examples of applications for thermoplastic, thermosetting, and elastomeric matrices.
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Recommended references

Main literature:

1. Introduction to Polymer Science and Chemistry: A Problem-Solving Approach, Second Edition 2nd Edition / by Manas Chanda, CRC Press; 2nd edition (January 11, 2013)
2. Polymer Chemistry 2nd Edition / by Paul C. Hiemenz, Timothy P. Lodge, CRC Press; 2nd edition (February 15, 2007)

3. Semchikov Yu.D. High-molecular compounds: Textbook for universities. Moscow: Academy, 2003, 368.
4. S. Thomas, K. Joseph, S.K. Malhotra, K. Goda, M.S. Sreekala. Polymer composites. – Wiley-VCH, 2012. – 829 p.
5. Irmukhametova G.S. Fundamentals of polymer composite materials technology: textbook for universities; Al-Farabi Kazakh National University. - Almaty: Kazakh University, 2016. - 175 p.

Additional literature:

1. Polymer composite materials (part 1): a tutorial / L.I. Bondaletova, V.G. Bondaletov. - Tomsk: Publishing house of Tomsk Polytechnic University, 2013. - 118 p.
2. Polymer composite materials: structure, properties, technology. Edited by Berlin A.A. - St. Petersburg, Publishing house "Profession", 2008. - 560 p.
3. Polymer composite materials: structure, properties, technology: a tutorial / M.L. Kerber et al.; under the general editorship of A.A. Berlin. - St. Petersburg: Profession, 2009.- 556, [4] p.
4. Bataev, A.A. Composite materials. Structure, production, application: a tutorial. manual / A. A. Bataev, V. A. Bataev. - M.: Logos, 2006. - 397, [3] p. - (New University Library).