

Discipline: Actual problems of chemistry of polymer composites

Lecture 6.

Theme: Additives for Polymer Composites

Objective:

To understand the **types, roles, and effects of additives** in polymer composites, and how they **modify mechanical, thermal, and functional properties** of the final material.

Key Questions:

1. What are additives in polymer composites?
 2. What types of additives are commonly used?
 3. How do additives influence the processing and properties of composites?
 4. What are the main considerations when selecting additives for a composite system?
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Lecture Content:

- **Definition:**
 - Additives are **non-reinforcing substances** incorporated into polymer composites to **enhance or modify properties**, improve processability, or reduce cost.
 - They do not primarily carry load like fibers or particles but **influence performance, durability, and functionality**.
- **Main Types of Additives:**
 1. **Plasticizers:**
 - Increase polymer flexibility, toughness, and processability.
 - Reduce glass transition temperature (T_g) and viscosity during processing.
 - Examples: phthalates, adipates.
 2. **Stabilizers:**
 - Prevent **degradation due to heat, light, or oxidation**.
 - Include **antioxidants, UV stabilizers, thermal stabilizers**.
 - Essential for long-term performance and stability of composites.
 3. **Flame Retardants:**
 - Reduce flammability and slow down combustion.

- Types: halogenated, phosphorus-based, mineral (e.g., aluminum hydroxide).
- 4. **Fillers:**
 - Non-reinforcing fillers can **reduce cost, improve dimensional stability, and modify thermal or electrical properties.**
 - Examples: talc, calcium carbonate, silica.
- 5. **Coupling Agents / Compatibilizers:**
 - Improve **adhesion between matrix and reinforcement**, enhancing mechanical performance.
 - Examples: silanes, maleic anhydride-grafted polymers.
- 6. **Colorants / Pigments:**
 - Provide color or opacity to composites.
 - Can also offer UV protection and aesthetic appeal.
- 7. **Processing Aids:**
 - Reduce **melt viscosity, prevent sticking, and improve flow** during molding or extrusion.
 - Examples: lubricants, surfactants.
- 8. **Antimicrobial and Functional Additives:**
 - Provide **antibacterial, antifungal, or self-cleaning properties.**
 - Used in medical, food, and hygiene applications.
- **Effects on Composite Properties:**
 - Additives can **enhance mechanical, thermal, chemical, and barrier properties.**
 - Influence **processability, durability, cost, and safety** of composites.
 - Selection depends on **matrix type, reinforcement type, processing method, and application requirements.**
- **Applications:**
 - Automotive: flame retardants, fillers, stabilizers.
 - Electronics: thermal stabilizers, conductive fillers.
 - Construction: UV stabilizers, flame retardants, fillers.
 - Medical and packaging: antimicrobial additives, plasticizers.

Key Short Theses:

1. Additives are **non-reinforcing substances** used to modify or enhance composite properties.
2. Main types: **plasticizers, stabilizers, flame retardants, fillers, coupling agents, colorants, processing aids, and functional additives.**
3. Additives influence **mechanical, thermal, chemical, barrier, and aesthetic properties.**
4. Proper selection of additives improves **processability, durability, safety, and functionality** of composites.

5. Additives are critical for tailoring composites to **specific applications and performance requirements**.
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Control Questions:

1. What is the role of additives in polymer composites?
 2. Name and describe the main types of additives used in composites.
 3. How do plasticizers affect polymer properties?
 4. Why are stabilizers important in polymer composites?
 5. What is the function of coupling agents or compatibilizers?
 6. Give examples of functional additives and their applications.
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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).