

Discipline: Actual problems of chemistry of polymer composites

Lecture 2.

Theme: Classification of Reinforcements by Shape. Influence of the Reinforcement Shape on the Properties of Polymer Composite

Objective:

To understand the **types of reinforcements in polymer composites based on their shape**, and to learn how the **geometry and morphology of reinforcements affect the mechanical, thermal, and functional properties** of polymer composites.

Key Questions:

1. How are reinforcements in polymer composites classified by shape?
 2. What are the main types of reinforcement geometry?
 3. How does the shape of reinforcement influence mechanical properties?
 4. How does reinforcement morphology affect thermal, electrical, and chemical properties?
 5. How to choose the appropriate reinforcement shape for specific applications?
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Lecture Content:

- **Classification of Reinforcements by Shape:**
 - **Fibrous Reinforcements:** continuous fibers (long fibers) and short fibers (chopped fibers).
 - **Particle Reinforcements:** spherical, irregular, flake-like particles.
 - **Laminar or Platelet Reinforcements:** thin sheets or platelets (e.g., mica, graphene layers).
 - **Hybrid or Mixed Shapes:** combinations of fibers and particles to optimize composite performance.
- **Influence of Reinforcement Shape on Composite Properties:**
 - **Fibers:**
 - Long continuous fibers provide **maximum tensile strength and stiffness** along the fiber direction.
 - Short fibers improve **isotropic reinforcement** but less effective than continuous fibers.
 - **Particles:**

- Increase **stiffness and hardness**; depending on shape, may influence fracture toughness.
- Spherical particles distribute stress evenly; irregular particles may create stress concentrations.
- **Platelets / Laminar:**
 - Improve **barrier properties, thermal stability, and dimensional stability**.
 - Enhance **mechanical properties in specific directions**, e.g., in-plane stiffness.
- **Hybrid Reinforcements:**
 - Combine properties of different shapes for **balanced strength, toughness, and thermal behavior**.
- **Additional Considerations:**
 - Aspect ratio (length/diameter) of fibers affects stress transfer and load-bearing efficiency.
 - Particle size and distribution influence composite **viscosity, processability, and mechanical performance**.
 - Orientation of reinforcements during processing can create **anisotropic properties**.
- **Applications:**
 - Fiber-reinforced composites in aerospace and automotive structures.
 - Particle-reinforced composites in wear-resistant coatings and tooling.
 - Laminar composites in electronics, packaging, and high-barrier applications.
 - Hybrid composites in sports equipment and multifunctional materials.

Key Short Theses:

1. Reinforcements are classified by shape into **fibers, particles, platelets, and hybrids**.
2. **Fibers** provide high strength and stiffness; continuous fibers are more effective than short fibers.
3. **Particles** improve stiffness, hardness, and wear resistance; shape affects stress distribution.
4. **Platelets / laminar reinforcements** enhance barrier, thermal, and directional mechanical properties.
5. **Hybrid reinforcements** combine benefits of different shapes for optimized performance.
6. Reinforcement **aspect ratio, orientation, and distribution** are critical for composite behavior.
7. Proper selection of reinforcement shape allows **tailoring composite properties** for specific applications.

Control Questions:

1. What are the main types of reinforcement shapes in polymer composites?
 2. How does fiber length and orientation affect composite strength and stiffness?
 3. How do particle shape and size influence mechanical and processing properties?
 4. What advantages do laminar or platelet reinforcements provide?
 5. Why are hybrid reinforcements used and in which applications?
 6. How does reinforcement shape influence anisotropy in composite properties?
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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).