

SUBJECT: - ENERGY & ENVIRONMENT

SEMESTER -1 QUESTION BANK – UNIT 5

UNIT V Advanced Materials for Sustainable Development

QUE.1). What do you understand by the term "composite-material". How are they classified? State the important application of composite material. (5M)

Ans: Composite materials are made by combining two or more different types of materials with distinct physical or chemical properties, resulting in a new material with improved or unique characteristics. In other words, a composite material is a combination of at least two materials that differ in form or composition on a macroscopic level.

Composite materials can be classified based on their matrix material, reinforcing material, and structure. Based on matrix material, they can be classified as polymer matrix composites (PMCs), metal matrix composites (MMCs), and ceramic matrix composites (CMCs). Based on the reinforcing material, they can be classified as fiber-reinforced composites (FRCs), particle-reinforced composites (PRCs), and structural composites. Based on structure, they can be classified as laminates, sandwich structures, and hybrid composites.

Some important applications of composite materials are:

1. **Aerospace and Aviation:** Composite materials are widely used in aircraft and spacecraft construction due to their high strength-to-weight ratio and resistance to fatigue and corrosion. They are used in wing and fuselage structures, engine components, landing gear, and interior furnishings.
2. **Automotive:** Composite materials are increasingly being used in the automotive industry to reduce weight, improve fuel efficiency, and enhance safety. They are used in body panels, chassis components, and interior parts.
3. **Construction:** Composite materials are used in the construction industry for their high strength, durability, and fire resistance. They are used in bridges, buildings, and infrastructure components such as pipes and tanks.
4. **Sports Equipment:** Composite materials are widely used in sports equipment such as golf clubs, tennis rackets, and bicycle frames due to their high strength and light weight.
5. **Medical:** Composite materials are used in medical devices such as prosthetics, implants, and surgical instruments due to their biocompatibility and strength.

QUE.2). What are composite materials? How can you explain fibre reinforced materials? Give industrial applications of fibre reinforced composite materials. (4)

Ans: Composite materials are materials made by combining two or more different materials with different properties to create a new material that possesses superior properties to the individual components. They are widely used in various industries due to their high strength, durability, and corrosion resistance.

Fiber-reinforced composite materials are a type of composite material where the reinforcing material is composed of fibers, which are embedded in a matrix material. The fibers provide the strength and stiffness, while the matrix material provides protection against environmental factors and holds the fibers in place. The most used fibers are glass, carbon, and aramid, while the matrix materials can be polymers, ceramics, or metals.

Fiber reinforced composites are used in various industries such as:

1. **Aerospace:** The aerospace industry extensively uses fiber-reinforced composite materials in aircraft structures, due to their high strength-to-weight ratio, stiffness, and durability.

2. Automotive: Fiber-reinforced composites are used in automobile body panels, interior parts, and structural components to reduce weight, improve fuel efficiency, and enhance safety.
3. Construction: Fiber-reinforced composite materials are used in the construction of buildings, bridges, and infrastructure components due to their high strength, durability, and resistance to environmental factors.
4. Sports: Fiber-reinforced composite materials are used in the manufacturing of sports equipment such as tennis rackets, golf clubs, and skis due to their high strength and stiffness.

QUE.3). What are composite materials? How would you classify composite materials? Give their important applications. (4)

Ans: Composite materials are materials composed of two or more different materials with distinct physical or chemical properties that, when combined, create a new material with improved or unique characteristics. The individual components, known as the reinforcement and the matrix, work together to enhance the mechanical, thermal, and chemical properties of the composite.

Composite materials can be classified based on their matrix material, reinforcing material, and structure. Based on matrix material, they can be classified as polymer matrix composites (PMCs), metal matrix composites (MMCs), and ceramic matrix composites (CMCs). Based on the reinforcing material, they can be classified as fiber-reinforced composites (FRCs), particle-reinforced composites (PRCs), and structural composites. Based on structure, they can be classified as laminates, sandwich structures, and hybrid composites.

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3. Construction: Composite materials are used in the construction industry for their high strength, durability, and fire resistance. They are used in bridges, buildings, and infrastructure components such as pipes and tanks.
4. Sports Equipment: Composite materials are widely used in sports equipment such as golf clubs, tennis rackets, and bicycle frames due to their high strength and light weight.

QUE.4). What are composite materials? How are they classified? How would you use it for industrial applications explain any two applications. (4)

Ans: Composite materials are materials made by combining two or more different materials with distinct properties, resulting in a new material that possesses superior or unique properties to the individual components. The composite materials can be classified based on the type of matrix material, reinforcing material, and the structure.

Based on the matrix material, composite materials can be classified into polymer matrix composites (PMCs), metal matrix composites (MMCs), and ceramic matrix composites (CMCs). Based on the reinforcing material, composite materials can be classified into fiber-reinforced composites (FRCs), particle-reinforced composites (PRCs), and structural composites. Based on structure, composite materials can be classified into laminates, sandwich structures, and hybrid composites.

Composite materials have a wide range of industrial applications, including:

1. **Aerospace:** Composite materials are widely used in the aerospace industry for their high strength-to-weight ratio and resistance to fatigue and corrosion. They are used in aircraft structures, engine components, and interior furnishings.
2. **Automotive:** Composite materials are increasingly being used in the automotive industry to reduce weight, improve fuel efficiency, and enhance safety. They are used in body panels, chassis components, and interior parts.

For example, in the aerospace industry, composite materials are used to create the fuselage of airplanes. The fuselage is made of a combination of composite materials, including carbon fiber reinforced polymer (CFRP) and glass fiber reinforced polymer (GFRP) composites. These composites offer high strength, rigidity, and durability while keeping the weight low. This translates to improved fuel efficiency and better performance of the aircraft.

In the automotive industry, composite materials are used to create body panels, which offer a high strength-to-weight ratio and can withstand high impact forces. For instance, carbon fiber reinforced plastic (CFRP) is used to make automotive body parts, such as hoods, doors, and trunk lids, due to its high strength, light weight, and low thermal expansion coefficient. This helps to reduce the weight of the vehicle and improve fuel efficiency.

QUE.5). What are the properties and applications of Liquid Crystal Polymers? How can you sort different phases of LCP. (4)

Ans: Liquid crystal polymers (LCPs) are a unique class of thermoplastics that possess a high degree of molecular order, similar to liquid crystals. They have several unique properties that make them suitable for a wide range of applications.

Properties of Liquid Crystal Polymers:

1. **High Temperature Resistance:** LCPs have a high melting point and can withstand high-temperature environments without melting or degrading.
2. **Low Coefficient of Thermal Expansion:** LCPs have a low coefficient of thermal expansion, making them ideal for applications where dimensional stability is critical.
3. **High Strength and Stiffness:** LCPs have a high strength-to-weight ratio and are stiff, making them suitable for use in structural components.
4. **Chemical Resistance:** LCPs are highly resistant to chemicals and solvents, making them ideal for use in harsh chemical environments.

Applications of Liquid Crystal Polymers:

1. **Electronic Components:** LCPs are widely used in the electronics industry for their high-temperature resistance and low coefficient of thermal expansion. They are used in the production of printed circuit boards, connectors, and other electronic components.
2. **Automotive:** LCPs are used in the automotive industry for their high strength and stiffness. They are used in the production of engine components, fuel system components, and other structural parts.

Sorting different phases of LCP:

LCPs can exhibit different phases, depending on the temperature and the degree of molecular order. The different phases of LCPs include:

1. **Nematic Phase:** In this phase, the LCP molecules are oriented in a parallel manner but are not arranged in a specific pattern.
2. **Smectic Phase:** In this phase, the LCP molecules are arranged in a specific pattern, forming layers.
3. **Cholesteric Phase:** In this phase, the LCP molecules are arranged in a helical pattern.

QUE.6). What is the use of mesogen in the structure of liquid crystal polymers? Discuss the applications of LCP. (4)

Ans: Mesogens are the repeating units in the molecular structure of liquid crystal polymers (LCPs) that give them their unique properties. Mesogens are rigid, rod-like structures that have a high degree of molecular order, like that of liquid crystals.

The use of mesogens in the structure of LCPs is essential for controlling the orientation and ordering of the polymer chains, which is necessary for the formation of the liquid crystal phase. The mesogens also contribute to the mechanical properties of the LCPs, providing them with high stiffness and strength.

Applications of Liquid Crystal Polymers:

1. **Electronics:** LCPs are widely used in the electronics industry for their high-temperature resistance and low coefficient of thermal expansion. They are used in the production of printed circuit boards, connectors, and other electronic components.
2. **Aerospace:** LCPs are used in the aerospace industry for their high strength-to-weight ratio and resistance to high-temperature environments. They are used in the production of structural components for aircraft and spacecraft.
3. **Automotive:** LCPs are used in the automotive industry for their high stiffness and strength. They are used in the production of engine components, fuel system components, and other structural parts.
4. **Medical:** LCPs are used in the medical industry for their biocompatibility and ability to withstand sterilization processes. They are used in the production of surgical instruments, medical devices, and implants.

QUE.7). Can you give some important properties and applications of liquid crystal polymers. (3)

Ans: Yes, here are some important properties and applications of liquid crystal polymers:

Properties:

1. High temperature resistance
2. Low coefficient of thermal expansion
3. High strength and stiffness
4. Chemical resistance
5. Dimensional stability

Applications:

1. **Electronics industry:** LCPs are used in the production of printed circuit boards, connectors, and other electronic components because of their high-temperature resistance and low coefficient of thermal expansion.
2. **Aerospace industry:** LCPs are used in the production of structural components for aircraft and spacecraft because of their high strength-to-weight ratio and resistance to high-temperature environments.
3. **Automotive industry:** LCPs are used in the production of engine components, fuel system components, and other structural parts because of their high stiffness and strength.
4. **Medical industry:** LCPs are used in the production of surgical instruments, medical devices, and implants because of their biocompatibility and ability to withstand sterilization processes.
5. **Packaging industry:** LCPs are used in the production of food packaging materials because of their chemical resistance and barrier properties against gases and moisture.

QUE.8). What are conducting polymers? Give the properties and applications of polypyrrole. (4)

Ans: Conducting polymers are a class of organic polymers that can conduct electricity. They are also known as "synthetic metals" because they exhibit properties similar to metals, such as electrical conductivity, high thermal stability, and mechanical strength.

Polypyrrole is a conducting polymer that has several unique properties that make it useful for various applications. Some of its properties and applications are:

Properties:

1. High electrical conductivity
2. High thermal stability
3. High mechanical strength
4. Biocompatibility
5. Environmental stability

Applications:

1. Energy storage devices: Polypyrrole is used in the production of rechargeable batteries and supercapacitors because of its high electrical conductivity and ability to store energy.
2. Antistatic coatings: Polypyrrole is used in the production of antistatic coatings for electronic devices and other applications because of its high electrical conductivity.
3. Biomedical applications: Polypyrrole is used in biomedical applications such as tissue engineering, drug delivery, and biosensors because of its biocompatibility.
4. Corrosion protection: Polypyrrole is used as a corrosion inhibitor for metals because of its environmental stability and ability to form a protective coating on metal surfaces.
5. Sensors: Polypyrrole is used in the production of gas and humidity sensors because of its high electrical conductivity and sensitivity to changes in the environment.

In summary, polypyrrole is a conducting polymer with high electrical conductivity, thermal stability, and mechanical strength. It has various applications in energy storage, antistatic coatings, biomedical applications, corrosion protection, and sensors.

QUE.9). What are conducting polymers? Give properties and applications of polyaniline. (4)

Ans: Conducting polymers are a class of organic polymers that can conduct electricity. They have attracted significant attention due to their unique properties, including high electrical conductivity, mechanical strength, and environmental stability. One of the most widely studied conducting polymers is polyaniline.

Properties:

1. Electrical conductivity: Polyaniline exhibits high electrical conductivity, which makes it suitable for various electronic applications.
2. Environmental stability: Polyaniline is stable in different environmental conditions, including humidity and temperature changes.
3. Chemical resistance: Polyaniline is resistant to many organic solvents and can be easily processed.
4. Biocompatibility: Polyaniline is biocompatible, making it suitable for biomedical applications.

5. Optical properties: Polyaniline exhibits unique optical properties, including the ability to change color based on its oxidation state.

Applications:

1. Electronic devices: Polyaniline is used in the production of electronic devices, including transistors, sensors, and batteries, due to its high electrical conductivity.
2. Anticorrosion coatings: Polyaniline is used in the production of anticorrosion coatings due to its environmental stability and chemical resistance.
3. Biomedical applications: Polyaniline is used in biomedical applications, including tissue engineering and drug delivery, due to its biocompatibility.
4. Gas sensors: Polyaniline is used in gas sensors due to its sensitivity to various gases and humidity.
5. Textile industry: Polyaniline is used in the textile industry as a colour-changing material for smart fabrics.

QUE.10). What are conducting polymer? State the types of conducting polymer? Give an account of polyacetylene as conducting polymer. (5)

Ans: Conducting polymers are a class of organic polymers that can conduct electricity. They are also called "synthetic metals" due to their metallic-like conductivity and unique properties.

Types of Conducting Polymers:

1. Polyacetylene
2. Polypyrrole
3. Polythiophene
4. Polyaniline
5. Poly(3,4-ethylenedioxythiophene)

Polyacetylene is the first conducting polymer to be discovered and is a highly studied material. It is a conjugated polymer, which means that its repeating units contain alternating single and double bonds. The double bonds form a network of overlapping p-orbitals, which allows the polymer to conduct electricity.

Properties of Polyacetylene:

1. High electrical conductivity
2. Optical properties: Polyacetylene can change colour based on its oxidation state.
3. Flexibility: Polyacetylene is highly flexible and can be easily processed.
4. Sensitivity to environmental changes: Polyacetylene is highly sensitive to environmental changes such as temperature, humidity, and chemical exposure.

Applications of Polyacetylene:

1. Electronic devices: Polyacetylene is used in the production of electronic devices, such as organic transistors and solar cells, due to its high electrical conductivity and optical properties.
2. Gas sensors: Polyacetylene is used in gas sensors due to its sensitivity to environmental changes and ability to change colour.
3. Biomedical applications: Polyacetylene is used in biomedical applications, such as drug delivery and tissue engineering, due to its biocompatibility and flexibility.

QUE.11). What are insulators? How are they classified? Give examples. (4)

Ans: Insulators, also known as dielectrics, are materials that do not conduct electricity easily. They have high resistivity and low conductivity, which makes them useful in electrical applications that require insulation.

Insulators can be classified based on their electrical properties into two main types: organic and inorganic insulators.

1. Organic Insulators: These are insulators that are composed of carbon and other non-metallic elements. Some examples of organic insulators include:
 - Rubber
 - Paper
 - Plastics (e.g., polyethylene, PVC)
 - Glass
 - Wood
2. Inorganic Insulators: These are insulators that are composed of metals and metalloids. Some examples of inorganic insulators include:
 - Ceramics (e.g., porcelain, alumina)
 - Mica
 - Quartz
 - Diamond
 - Air

In addition to the above classification, insulators can also be classified based on their usage, such as high-voltage insulators, low-voltage insulators, and thermal insulators.

High-voltage insulators are used in high-voltage power systems to prevent electric current from flowing between two conductors. They are typically made of ceramics, glass, or composite materials.

Low-voltage insulators are used in low-voltage electrical systems, such as household appliances and electronics. They are typically made of plastics or rubber.

Thermal insulators are used to prevent heat transfer between two materials. Examples of thermal insulators include fiberglass, mineral wool, and foam insulation.

QUE.12). What are Insulating materials? Discuss thermal and Electric insulating materials. (4)

Ans: Insulating materials are materials that have low thermal and electrical conductivity and are used to prevent the flow of heat or electricity between two materials. There are two main types of insulating materials: thermal insulators and electrical insulators.

1. Thermal Insulating Materials: These materials are used to prevent heat transfer between two materials. They are typically made of materials that have low thermal conductivity, such as fiberglass, mineral wool, and foam insulation. Some common applications of thermal insulating materials include:
 - Insulating pipes and ducts in HVAC systems to prevent heat loss or gain.
 - Insulating walls and roofs in buildings to improve energy efficiency.
 - Insulating refrigerators and freezers to maintain low temperatures.

- Insulating cooking utensils and oven mitts to prevent burns.
2. **Electrical Insulating Materials:** These materials are used to prevent the flow of electric current between two conductors. They are typically made of materials that have high resistivity, such as ceramics, glass, and plastics. Some common applications of electrical insulating materials include:
- Insulating wires and cables in electrical systems to prevent short circuits and electrical shock.
 - Insulating transformers and motors to prevent electrical arcing and breakdown.
 - Insulating electronic components and printed circuit boards to prevent interference and damage.
 - Insulating electrical switches and outlets to prevent accidental contact with live wires.

QUE.13). What are Adhesives? Write applications of Adhesive materials? Evaluate and discuss Natural and Synthetic adhesives. (5)

Ans: Adhesives are materials that are used to join two or more materials together by forming a strong bond between them. They can be classified into two main types: natural adhesives and synthetic adhesives.

Applications of Adhesive Materials:

1. **Construction:** Adhesives are used in construction to bond materials such as wood, metal, and plastic together. They are commonly used in roofing, flooring, and insulation applications.
2. **Automotive:** Adhesives are used in the manufacturing of automobiles to bond various parts together, such as windshields, body panels, and interior components.
3. **Packaging:** Adhesives are used in the packaging industry to seal boxes and containers, as well as to bond labels and packaging materials.
4. **Medical:** Adhesives are used in the medical industry to close wounds and incisions, as well as to bond medical devices and implants to the body.

Natural Adhesives: Natural adhesives are made from natural materials such as plant and animal products. Some examples of natural adhesives include:

- **Animal glue:** made from animal collagen and used in woodworking and bookbinding.
- **Casein glue:** made from milk protein and used in woodworking and paperboard manufacturing.
- **Starch-based glue :** made from plant starch and used in paper and packaging applications.

Natural adhesives have the advantage of being environmentally friendly and non-toxic, but they often have lower strength and durability compared to synthetic adhesives.

Synthetic Adhesives: Synthetic adhesives are made from chemical compounds and are typically stronger and more durable than natural adhesives. Some examples of synthetic adhesives include:

- **Epoxy:** used in construction and aerospace applications.
- **Cyanoacrylate:** used in electronics and medical applications.
- **Polyurethane:** used in woodworking and automotive applications.

Synthetic adhesives have the advantage of being stronger and more durable, but they can be toxic and have a negative impact on the environment.

QUE.14). What are biodegradable polymers? Give synthesis and applications of poly lactic acid. (4)

Ans: Biodegradable polymers are a type of polymer that can be broken down by natural processes, such as microorganisms and enzymes, into simpler compounds like water, carbon dioxide, and biomass. Poly lactic acid (PLA) is one such biodegradable polymer.

Synthesis of Poly Lactic Acid: PLA is synthesized through a process called polymerization. The monomer used to produce PLA is lactic acid, which can be obtained by fermenting natural sugars. The lactic acid is then polymerized into PLA by heating it to a high temperature and pressure in the presence of a catalyst.

Applications of Poly Lactic Acid: PLA has a range of applications due to its biodegradable and renewable nature. Some of its applications include:

1. **Packaging:** PLA is used to produce packaging materials such as bags, trays, and containers, as it can be easily molded and has good barrier properties.
2. **Medical:** PLA is used in medical implants and drug delivery systems due to its biocompatibility and biodegradability.
3. **Textiles:** PLA fibers can be used to produce clothing and other textiles, as they are soft, breathable, and eco-friendly.
4. **3D printing:** PLA is a popular material for 3D printing due to its ease of use, low toxicity, and biodegradability.

QUE.15). Explain properties and applications of Polylactic acids (PLA) biodegradable polymer. (4)

Ans: Polylactic acid (PLA) is a biodegradable polymer that is produced from renewable resources, such as corn starch or sugarcane. PLA is a versatile polymer that exhibits a range of properties, including:

1. **Biodegradability:** PLA is biodegradable, which means it can be broken down by natural processes into simpler compounds like water, carbon dioxide, and biomass.
2. **Strength and stiffness:** PLA is strong and stiff, making it suitable for a range of applications.
3. **Heat resistance:** PLA has good heat resistance, which makes it suitable for use in high-temperature applications.
4. **Transparency:** PLA is transparent, which makes it suitable for packaging and other applications where a clear material is required.

Applications of PLA: PLA has a range of applications due to its biodegradable and renewable nature. Some of its applications include:

1. **Packaging:** PLA is used to produce packaging materials such as bags, trays, and containers, as it can be easily molded and has good barrier properties.
2. **Medical:** PLA is used in medical implants and drug delivery systems due to its biocompatibility and biodegradability.
3. **Textiles:** PLA fibers can be used to produce clothing and other textiles, as they are soft, breathable, and eco-friendly.
4. **3D printing:** PLA is a popular material for 3D printing due to its ease of use, low toxicity, and biodegradability.
5. **Agriculture:** PLA can be used in agriculture as a biodegradable alternative to traditional plastics for mulching, greenhouse films, and other applications.

QUE.16). Why the demand for biodegradable polymer is more as compared to ordinary polymers? Discuss the synthesis and applications of Polycaprolactone. (4)

Ans: The demand for biodegradable polymers is increasing as they offer several advantages over traditional polymers. Some of the key reasons for the increased demand for biodegradable polymers are:

1. Environmental concerns: Biodegradable polymers are eco-friendlier and more sustainable than traditional polymers. They can be broken down into simpler compounds by natural processes, reducing the environmental impact of plastic waste.
2. Government regulations: Many countries are implementing regulations and restrictions on the use of traditional plastics to reduce waste and pollution.
3. Consumer preferences: Consumers are becoming more aware of the environmental impact of plastic waste and are choosing eco-friendly alternatives.

Polycaprolactone is a biodegradable polyester that is produced from the ring-opening polymerization of ϵ -caprolactone monomer. It has a low melting point, high crystallinity, and good mechanical properties, which makes it suitable for a range of applications.

Some of the applications of Polycaprolactone are:

1. Biomedical applications: Polycaprolactone is biocompatible, and its slow biodegradation rate makes it suitable for use in medical implants and drug delivery systems.
2. Packaging materials: Polycaprolactone can be used to produce biodegradable packaging materials such as films, bags, and containers.
3. Adhesives: Polycaprolactone can be used as an adhesive in applications where a low melting point and good adhesion properties are required.
4. 3D printing: Polycaprolactone is used in 3D printing as it has a low melting point and can be easily molded into complex shapes.

QUE.17). Explain properties and applications of polycaprolactone (PLC). (3)

Ans: Polycaprolactone (PCL) is a biodegradable polyester that is produced from the ring-opening polymerization of ϵ -caprolactone monomer. Some of the key properties and applications of PCL are:

Properties:

1. Biodegradable: PCL can be broken down into simpler compounds by natural processes, making it an eco-friendly material.
2. Low melting point: PCL has a low melting point (60-65°C), which makes it easy to mold into different shapes.
3. Good mechanical properties: PCL has good tensile strength and elasticity, making it suitable for use in a range of applications.

Applications:

1. Biomedical applications: PCL is biocompatible, and its slow biodegradation rate makes it suitable for use in medical implants and drug delivery systems.
2. Packaging materials: PCL can be used to produce biodegradable packaging materials such as films, bags, and containers.
3. Adhesives: PCL can be used as an adhesive in applications where a low melting point and good adhesion properties are required.

4. 3D printing: PCL is used in 3D printing as it has a low melting point and can be easily molded into complex shapes.

QUE.18). Give an account of synthesis, properties and applications of polylactic acid, a biodegradable polymer. (4)

Ans: Polylactic acid (PLA) is a biodegradable polymer that is produced from renewable resources such as corn starch, sugarcane, and tapioca roots. PLA is synthesized through a process called condensation polymerization, which involves the reaction of lactic acid molecules.

Properties:

1. Biodegradability: PLA is biodegradable, which means it can be broken down into simpler compounds by natural processes.
2. High strength and stiffness: PLA have high tensile strength and stiffness, which makes it suitable for use in applications where strength is important.
3. Heat resistance: PLA has a high melting point, which makes it suitable for use in high-temperature applications.
4. Transparency: PLA is transparent and can be used to produce clear products such as packaging materials.

Applications:

1. Biomedical applications: PLA is used in biomedical applications such as sutures, drug delivery systems, and tissue engineering scaffolds.
2. Packaging materials: PLA is used to produce biodegradable packaging materials such as bags, containers, and films.
3. Textile industry: PLA can be used in the textile industry to produce fabrics that are biodegradable and eco-friendly.
4. 3D printing: PLA is used in 3D printing as it can be easily molded into complex shapes.

QUE.19). Explain and write applications of Nanomaterials used in photochemical devices like Lithium-ion battery. (4)

Ans: Nanomaterials have been extensively used in the field of photochemical devices such as lithium-ion batteries due to their unique properties. Lithium-ion batteries are widely used in portable electronic devices and electric vehicles, and the use of nanomaterials in their construction has resulted in significant improvements in their performance. Some of the applications of nanomaterials in lithium-ion batteries are:

1. Electrode materials: Nanomaterials such as metal oxides, sulfides, and phosphates are used as electrode materials in lithium-ion batteries. These materials have high surface area and improve electrochemical properties, resulting in enhanced battery performance.
2. Electrolytes: Nanomaterials such as ceramic nanoparticles and polymer nanofibers are used as electrolytes in lithium-ion batteries. These materials have high ionic conductivity and improved stability, resulting in longer battery life.
3. Separator membranes: Nanomaterials such as graphene and carbon nanotubes are used as separator membranes in lithium-ion batteries. These materials have high mechanical strength and thermal stability, resulting in improved safety and durability.
4. Current collectors: Nanomaterials such as metal nanoparticles and carbon nanofibers are used as current collectors in lithium-ion batteries. These materials have high conductivity and improved mechanical strength, resulting in improved battery performance.

Que.20). Discuss the role of Nanomaterials in photovoltaic cell/solar cell. (4)

Ans: Nanomaterials play a crucial role in the development of photovoltaic cells or solar cells, which are devices that convert light energy into electricity. The use of nanomaterials in photovoltaic cells offers several advantages such as improved efficiency, lower cost, and better stability. Some of the ways in which nanomaterials are utilized in photovoltaic cells are:

1. **Light absorption:** Nanomaterials such as quantum dots and nanowires are used to increase the absorption of sunlight by the solar cell. These materials have a high surface area to volume ratio, which allows for efficient absorption of photons, and their size can be tuned to absorb specific wavelengths of light, resulting in improved efficiency.
2. **Charge separation:** Nanomaterials such as nanocrystals and metal oxides are used to facilitate the separation of charges generated by the absorption of light. These materials have unique electronic properties that allow them to transport and store charges, resulting in improved efficiency and stability of the solar cell.
3. **Transparent electrodes:** Nanomaterials such as graphene and carbon nanotubes are used to make transparent electrodes in solar cells. These materials have high conductivity and transparency, resulting in improved light transmission and reduced reflection losses.
4. **Anti-reflection coatings:** Nanomaterials such as nanostructured films and coatings are used to reduce reflection losses in solar cells. These materials have a tailored surface texture that reduces the reflection of light, resulting in improved light absorption and efficiency.

QUE.21). What are Nanostructured based solar cell ? Illustrate its advantages and disadvantages (4)

Ans: Nanostructured-based solar cells are a type of photovoltaic cell that incorporates nanomaterials to improve their performance. These cells are designed to have a high surface area to volume ratio, which allows for efficient absorption of photons and separation of charges generated by the absorption of light. Some of the advantages and disadvantages of nanostructured-based solar cells are:

Advantages:

1. **Improved efficiency:** The use of nanomaterials in solar cells increases the absorption of sunlight and facilitates the separation of charges, resulting in improved efficiency.
2. **Reduced cost:** Nanostructured-based solar cells can be produced at a lower cost than traditional solar cells, as they use less material and require less energy to manufacture.
3. **Enhanced durability:** Nanomaterials can improve the durability of solar cells by increasing their resistance to environmental factors such as moisture, heat, and UV radiation.
4. **Versatility:** Nanostructured-based solar cells can be produced in a variety of shapes and sizes, allowing for greater flexibility in their application.

Disadvantages:

1. **Complexity:** The production of nanostructured-based solar cells is a complex process that requires specialized equipment and expertise.
2. **Unproven technology:** Nanostructured-based solar cells are a relatively new technology and their long-term performance and reliability have yet to be fully tested.
3. **Sensitivity to impurities:** Nanostructured-based solar cells are highly sensitive to impurities in the manufacturing process, which can impact their performance and durability.

4. Limited scalability: The production of nanostructured-based solar cells is currently limited in scale, which may hinder their widespread adoption.

QUE.22). Explain how Nanomaterials can be used for Energy Storage. (3)

Ans: Nanomaterials can be used for energy storage by enhancing the performance of energy storage devices such as batteries, supercapacitors, and fuel cells. The use of nanomaterials allows for increased surface area and improved electrical conductivity, resulting in higher energy and power density.

For example, in lithium-ion batteries, the use of nanomaterials such as nanowires, nanotubes, and nanoparticles can improve the electrode performance by increasing the surface area and shortening the diffusion path of lithium ions. This results in faster charging and discharging rates, higher capacity, and longer cycle life.

In supercapacitors, the use of nanomaterials such as carbon nanotubes and graphene can increase the surface area and electrical conductivity, resulting in higher energy and power density, faster charging and discharging rates, and longer cycle life.

QUE.23). Define carbon nanotubes. Can you distinguish between single wall and double wall carbon nanotubes? List any two applications of carbon nanotubes. (4)

Ans: Carbon nanotubes are cylindrical carbon molecules with diameters typically on the nanometer scale and lengths that can be several millimeters long. They exhibit exceptional mechanical, electrical, and thermal properties, making them attractive for various applications.

Single wall carbon nanotubes (SWCNTs) and double wall carbon nanotubes (DWCNTs) differ in the number of graphene layers that make up their cylindrical structure. SWCNTs have only one graphene layer and have a diameter of about 1 nanometer, whereas DWCNTs have two graphene layers and are slightly larger, with a diameter of about 2-3 nanometers.

Some applications of carbon nanotubes include:

1. Electronics: Carbon nanotubes have high electrical conductivity, making them ideal for use in electronic devices such as transistors, interconnects, and sensors.
2. Aerospace: Carbon nanotubes are lightweight and have high strength, making them attractive for use in aerospace applications such as composite materials for aircraft and spacecraft.
3. Energy: Carbon nanotubes have high surface area and can be used as electrodes in energy storage devices such as batteries and supercapacitors. They can also be used as catalysts in fuel cells.
4. Medical: Carbon nanotubes have potential applications in drug delivery, tissue engineering, and biosensors. However, their biocompatibility and toxicity are still being studied.

QUE.24). Write notes on (6)

Biodegradable Polymer.

Liquid crystal polymer.

Ans: Biodegradable Polymer: Biodegradable polymers are a class of polymers that are capable of being degraded by natural processes into harmless components such as water, carbon dioxide, and biomass. They are commonly made from renewable sources such as plant starch, cellulose, and lactic acid. Biodegradable polymers have a wide range of applications, including packaging, agriculture, medical implants, and drug delivery systems. One example of a biodegradable polymer is polylactic acid (PLA).

Liquid Crystal Polymer: Liquid crystal polymers (LCPs) are a class of high-performance polymers that exhibit liquid crystalline behavior. They have a unique molecular structure that allows them to form highly ordered phases with excellent mechanical, thermal, and electrical properties. LCPs are commonly used in applications that require high strength, stiffness, and temperature resistance, such as electronic components, aerospace parts, and automotive parts. LCPs can also be used as fiber-reinforced composites to provide high strength and stiffness while maintaining low weight.

The mesogenic units in the molecular structure of LCPs are responsible for their liquid crystalline behavior. The orientation of these mesogenic units gives LCPs their unique mechanical and physical properties. LCPs are classified based on the orientation of their mesogenic units, which can be smectic, nematic, or cholesteric. Smectic LCPs have a layered structure, nematic LCPs have a rod-like structure, and cholesteric LCPs have a helical structure.

QUE.25). Write short notes on any two. (6)

1)Applications of nanomaterials in Energy storage.

2)Conducting polymers

3)Carbon nanotubes

Ans: 1) Applications of Nanomaterials in Energy Storage: Nanomaterials are being widely investigated for their potential applications in energy storage devices such as batteries, supercapacitors, and fuel cells. One major advantage of using nanomaterials is their large surface area, which provides a higher electrode/electrolyte contact area, enhancing the performance of energy storage devices. Additionally, nanomaterials exhibit unique physical and chemical properties such as high conductivity, low resistance, and high stability, making them suitable for energy storage applications.

Some of the applications of nanomaterials in energy storage include:

1. Lithium-ion batteries: Nanomaterials such as silicon, graphene, and metal oxides are being used as anodes in lithium-ion batteries due to their high capacity, high cycling stability, and fast charge/discharge rates.
2. Supercapacitors: Carbon-based nanomaterials such as graphene, carbon nanotubes, and nanowires are being investigated for their use as supercapacitor electrodes due to their high surface area and high electrical conductivity.

2) Conducting Polymers: Conducting polymers are a class of polymers that exhibit high electrical conductivity, similar to that of metals, and can be used as an alternative to conventional inorganic conductors. They possess several advantages such as low weight, low cost, and flexibility.

Some important properties of conducting polymers include:

1. Electrical conductivity: Conducting polymers exhibit electrical conductivity similar to that of metals due to the presence of conjugated double bonds.
2. Optical properties: They exhibit unique optical properties such as fluorescence, which makes them useful in optoelectronic applications.
3. Electrochemical properties: Conducting polymers can be easily oxidized and reduced, allowing them to be used in batteries and supercapacitors.

Some of the applications of conducting polymers include:

1. Organic electronics: Conducting polymers are being used as active materials in organic electronic devices such as organic solar cells, organic light-emitting diodes (OLEDs), and organic field-effect transistors (OFETs).
2. Sensors: They are being used as sensing materials in gas sensors, biosensors, and chemical sensors due to their high sensitivity and selectivity.

3) Carbon Nanotubes: Carbon nanotubes (CNTs) are cylindrical structures made of carbon atoms arranged in a hexagonal lattice. They possess unique mechanical, electrical, and thermal properties, making them useful in a wide range of applications.

Some of the properties of CNTs include:

1. High mechanical strength: CNTs are extremely strong, with a tensile strength more than 100 times stronger than steel.
2. High electrical conductivity: CNTs exhibit high electrical conductivity, making them useful in electronic devices.
3. Thermal conductivity: CNTs exhibit high thermal conductivity, making them useful in thermal management applications.

Some of the applications of carbon nanotubes include:

1. Electronics: CNTs are being used in the development of high-performance electronic devices such as transistors, sensors, and memory devices.
2. Energy storage: CNTs are being investigated for their potential use in energy storage devices such as batteries and supercapacitors.
3. Biomedical applications: CNTs are being explored for their potential use in drug delivery systems, biosensors, and tissue engineering due to their unique properties.

QUE.26). Write short notes on any two. (6)

1. **Liquid crystal polymers.**
2. **Properties & applications of polyaniline**
3. **Applications of nanomaterials in Solar Cell**

Ans: 1) Liquid crystal polymers (LCPs): Liquid crystal polymers are a class of organic materials that exhibit properties of both liquids and solids. They possess an ordered molecular structure that can result in anisotropic mechanical, optical, and electrical properties. LCPs find applications in a wide range of industries including automotive, aerospace, and electronics. They are used in applications such as microelectronics, flexible displays, and medical devices.

ii) Properties and applications of polyaniline: Polyaniline is a conducting polymer that exhibits high conductivity, stability, and processability. It has been used in a variety of applications such as sensors, batteries, and capacitors. Polyaniline can be doped with different acids to tune its properties such as conductivity and solubility. The applications of polyaniline include corrosion protection, gas sensing, and electromagnetic interference shielding.

iii) Applications of nanomaterials in solar cells: Nanomaterials have been used in the development of next-generation solar cells with improved efficiency and lower cost. They have been used in various parts of solar cells including the absorber layer, electrodes, and encapsulation layers. Nanomaterials such as quantum dots, nanowires, and nanoparticles have been incorporated into solar cells to improve their light harvesting properties, charge transport, and stability. The applications of nanomaterials in solar cells include thin-film solar cells, dye-sensitized solar cells, and perovskite solar cells.