Chemistry for Sustainable Energies

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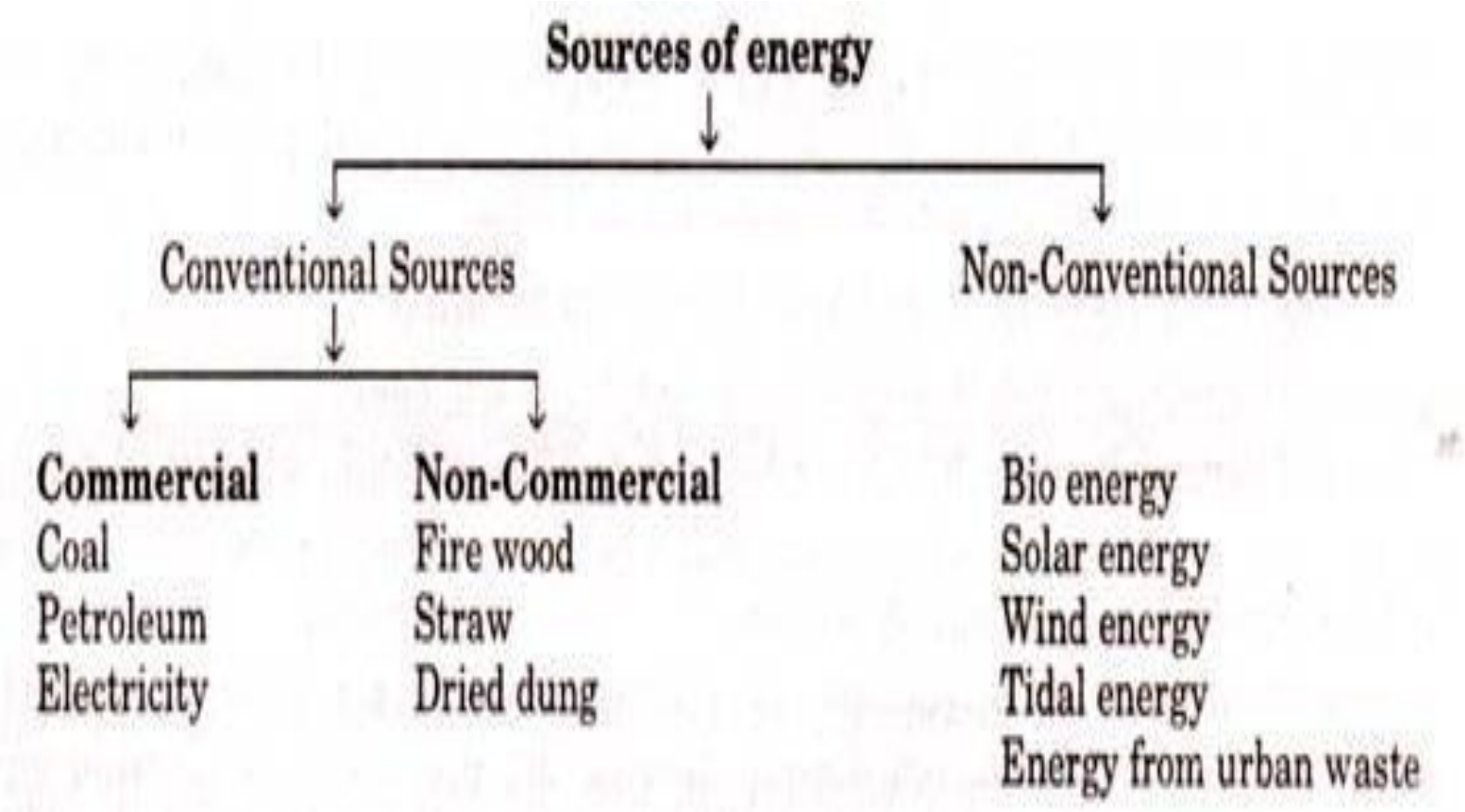
Sustainable Energy

Sustainable energy can be defined as a form of energy that can be utilized again and again without putting a source in danger of getting depleted, expired, or vanished.

Sustainable energy is power which is able to be replenished within a human lifetime and so cause no long-term damage to the environment. Sustainable energy includes all renewable energy sources, such as hydroelectricity, biomass, geothermal, wind, wave, tidal and solar energies.

Classification of Energy



- Renewable (Non-Conventional) energy: Energy obtained from sources that are essentially inexhaustible such as wind power, solar power, geothermal energy, tidal power and hydro-electric power.

- Non-renewable (conventional) energy: Is the conventional fossil fuels such as coal, oil, gas and nuclear energy. This energy is exhaustible.

Distinction: Conventional (non-renewable) and nonconventional energy (renewable) sources.

Renewable resources	Non- renewable resources
Resources which can be renewed or can be reused are renewable resources.	Resources which cannot be renewed or reused once utilized are called non-renewable resources.
These include components like air, water, wind, sunlight etc.	These include components like fossil fuels, LPG gases.
They are sustainable resources.	They are exhaustible resources.
Their rate of renewal is greater than the rate of getting exhausted.	Their rate of renewal is slower than the rate of getting exhausted.
They are mostly environmental friendly and does not cause pollution.	They are the main cause of pollution.

Solar Energy

The electromagnetic radiation from sun is commonly known as solar energy. These radiations are resulted from thermo nuclear fusion reaction on the surface of sun. All the radiation from the sun is not in the same wavelength range. Almost 92% lie in the range of 315 nm to 1400nm.

The estimated amount of solar flux reaching the atmosphere of earth is approximately 1400W/m2min.and that of heat equivalent is 2.68 X 10^{24} J/Year. The eco system of earth utilizes about 0.2-0.5 % of total amount of solar energy received. It indicates clearly that large amount solar energy get wasted, which otherwise can be immense use for satisfying needs of humans.

Advantage of solar energy:

1. It is non-polluting and non-depleting source of energy.

2. It is renewable source of energy.

3. It is available abundantly.

The solar energy has been successfully used in following purpose

i) Heating: Used for water and space heating in colder countries.

ii) Electricity: Using solar energy electric energy can be generated.

In spite of these advantages, the use of solar energy in large scale is still not in practice, due to following reasons,

1. Non availability of intense light in all areas throughout year

2. Difficulties faced in economic collection and conversion of solar energy into other forms of energy such as electricity

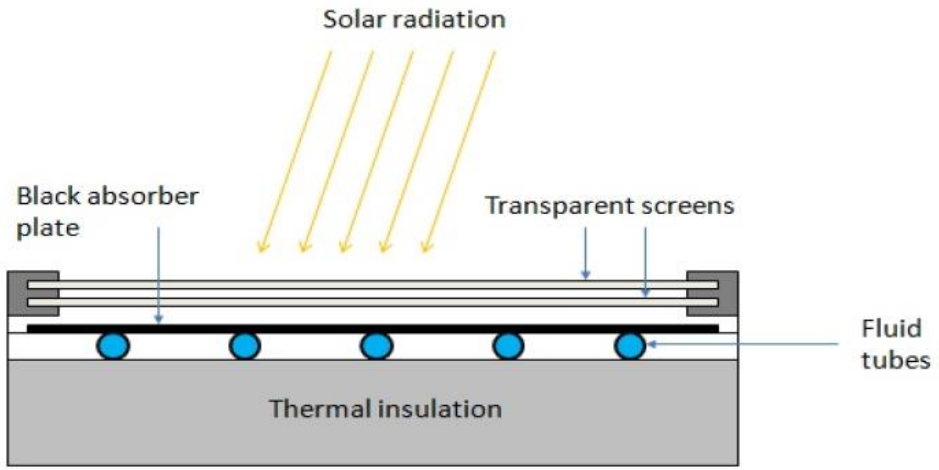
Advantages and Disadvantages

Advantages	Disadvantages
Reduces consumption of fossil fuels.*	Currently, electricity from PV systems is more expensive than electricity produced from fossil fuel or nuclear power plants.
Reduces production of greenhouse gases.*	Expensive to buy.
Reduces production of various pollutants.*	Requires engineering expertise to design and install systems.
Good for remote applications: satellites, rural hospital equipment in developing countries, telecommunication equipment, etc.	Production of PV systems from single silicon crystals is technically challenging, and energy- and time-consuming.
Reduces the loss of electricity due to power line resistance (distribution losses) because it can be sited where the electricity is used.	Sunlight is not constant, so must get electricity from other sources at night or on cloudy days or store it (such as batteries, etc.)
Reduces water consumed in electrical generation processes by displacing electrical demand.	Sunlight is diffuse; PV would take much space to produce enough electricity to meet our current needs (an area ~one sixth the size of Arizona)
Does not contribute to thermal pollution of waterways.	* Once manufactured, PV systems produce no waste products. Manufacturing of almost any device uses some nonrenewable resources, consumes energy and produces waste products. PV systems consume some nonrenewable resources if a system component needs repair or maintenance (such as batteries, inverter, etc.).
No hidden costs.	
Can provide energy independence.	
PV cells last ~ 30 years.	
Uses a renewable energy source.	

Flat Plate Collector (Solar Heater):

The device works on the principle of black body in which heat absorbing capacity and tendency of a black surface is utilized to achieve benefits for human.

Diagram:



Construction:

These are the main components of a typical flat-plate solar collector:

Black surface - absorbent of the incident solar energy

Glazing cover - a transparent layer that transmits radiation to the absorber, but prevents radiative and convective heat loss from the surface

Tubes containing heating fluid to transfer the heat from the collector

Support structure to protect the components and hold them in place

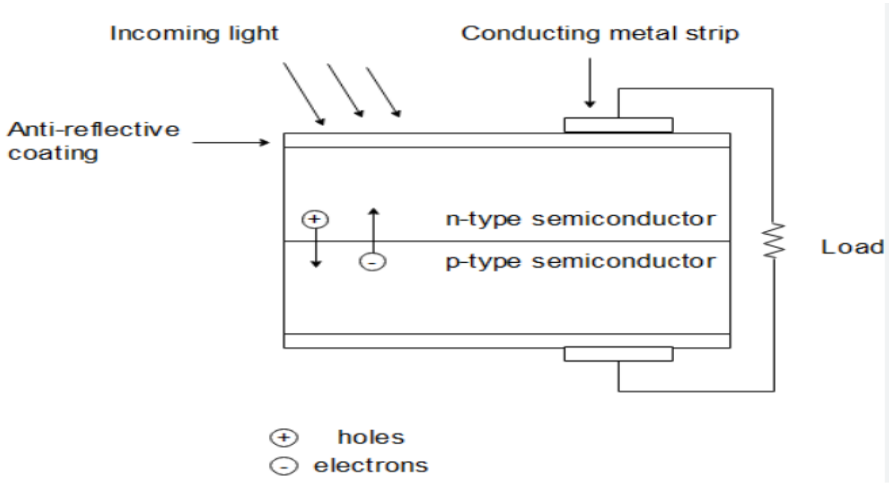
Insulation covering sides and bottom of the collector to reduce heat losses

Application

- Some advantages of the flat-plate collectors are that they are:
- Easy to manufacture
- Low cost, Collect both beam and diffuse radiation
- Permanently fixed (no sophisticated positioning or tracking equipment is required)
- Little maintenance

PHOTO VOTAIC CELL (SOLAR CELL)

A photovoltaic (PV) cell, also known as a solar cell, is a device that converts light energy directly into electrical energy through the photovoltaic effect.



Construction: The core component of a PV cell is a semiconductor material, usually silicon. Silicon is doped with elements (usually P or B) to create two distinct layers: an N-type layer (which has an excess of electrons) and a P-type layer (which has an excess of "holes" or positive charge carriers Hence these two layers form p-n junction. A metallic grid is the electrical contact of the diode and allows light to fall on the semiconductor between the grid lines. An anti-reflective layer between the grid lines increases the amount of light transmitted to semiconductor.

Working: When light radiation falls on the p-n junction diode, photons are absorbed and electron-hole pairs are generated. The electrons are diffused and collected at the n-type end and holes are diffused and collected at the p-type end. When these two ends are electrically connected through a conductor, there is a flow of current between the two ends through the external circuit. Thus photoelectric current is produced and available for use. The current output of a cell depends on its efficiency and size and is proportional to the intensity of sun light striking the surface of the cell. Therefore, photovoltaic cells are connected electrically in series or parallel circuits to produce higher voltages, currents and power levels. A number of solar cells electrically connected to each other and mounted in a support structure or frame is called a photovoltaic module. A photovoltaic array is the complete power generating unit, consisting of any number of photovoltaic modules and panels.

Advantages

- **Renewable Energy Source:** Solar energy is abundant and renewable, making PV cells an eco-friendly option for generating electricity without depleting natural resources.
- **Low Operating Costs:** Once installed, PV systems have minimal operating costs as they require little maintenance and can generate electricity for 25-30 years or more.
- **Silent and Clean Energy Production:** PV cells operate silently and produce electricity without emitting greenhouse gases or other pollutants, contributing to a cleaner environment.
- **Scalability:** PV systems come in various sizes and can be installed in different locations (rooftops, ground-mounted arrays, portable systems), making them versatile for residential, commercial, and even off-grid applications. They can be scaled up by adding more panels to meet increasing energy needs.
- **Energy Independence:** Using solar power reduces dependence on fossil fuels and centralized power grids, offering energy independence to individual households or businesses.
- **Remote Area Power Generation:** PV cells can provide electricity in remote or off-grid areas where traditional power infrastructure is unavailable or costly to install.

Limitations

- **Intermittency and Weather Dependency:** Solar power generation is dependent on sunlight availability, making it intermittent. Cloudy weather, nighttime, or shading can significantly reduce electricity output.
- **Initial Cost:** The initial installation cost of PV systems can be relatively high, although prices have been decreasing. The overall return on investment depends on factors like incentives, energy prices, and system efficiency.
- **Space Requirement:** Generating significant power may require considerable space for installing multiple solar panels, especially for large-scale applications.
- **Energy Storage Challenges:** Storing surplus energy generated by PV cells for use during low-light or nighttime hours can be challenging and might require additional equipment like batteries, adding to the overall system cost.
- **Resource Intensive Production:** The manufacturing process of PV cells involves some resource-intensive procedures, including mining and refining of materials, which can have environmental impacts.
- **Efficiency Variability:** The efficiency of PV cells can be affected by factors like temperature, shading, and dust accumulation, leading to variable energy output.

Fuels

- Fuels can be defined as substances which undergo combustion in the presence of air to produce a large amount of heat that can be used economically for domestic and industrial purpose.
- Examples, Wood, Coal, Kerosene, Petrol

Classification of chemical fuels

A) Based on the origin: i) Primary or natural fuels

ii) Secondary or artificial or derived fuels

B) Based on Physical State: i) Solid Fuels

ii) Liquid Fuels

iii) Gaseous Fuels

C) Based on Chemical Nature

i) Organic eg. Vegetable fuel, coal

ii) Inorganic eg. Iron Pyrites

iii) Nuclear Fuels eg. Uranium oxide

Characteristic Properties of Fuels

- Fuels are characterized by testing certain physical and chemical properties.

i) Calorific Value should be as high as possible.
ii) Ignition temperature-Moderate
iii) Flame temperature should be as high as possible.
iv) Flash and Fire point should be as high as possible.
v) Aniline point should be low.
vi) Cloud and Pour point should be as low as possible.
vii) Viscosity should be adequate.
viii) Coke number should be as high as possible.
ix) Moisture content-as low as possible.
x) Volatile matter as low as possible.
xi) Ash content should be absent.
xii) Easy risk free transport should be possible.
xiii) Storage space-ideally fuel should occupy small space.
xiv) Air requirement- adequate
xv) Harmless products should be produced on combustion.

Calorific Value

- Calorific value is defined as the number of parts of water which gets heated through 1°C by the heat evolved by the complete combustion of one unit weight of fuel(unit volume of gaseous fuels) under the conditions such as

i) Whole of heat evolved is absorbed by water.

ii) The products formed leave the system at atmospheric temperature and pressure.

- It is the most important property of fuel.

Units of calorific value

1) B.T.U. (British Thermal Unit)

A British thermal unit may be defined as the heat required to raise the temperature of one pound of water from 60°F to 61°F.

2) K.C.U. (Kilogram Centigrade Unit)

The calorie, a unit of heat may be defined as, the heat required to raise the temperature of one Kg of water from 15°C to 16°C.

Correlation between BTU and KCU:

1BTU = 0.252KCal =252Cal

1KCal = 3.968 BTU

3) C.H.U. (Centigrade Heat Unit)

The calorific value can also be expressed as centigrade heat unit (C.H.U.)., which is the amount of heat required to raise temperature of one pound of water through one degree centigrade.

1) High Calorific value (HCV) or Gross Calorific value (GCV):

High calorific value may be defined as the total amount of heat produced when one unit of the fuel has been burnt completely and the products of combustion have been cooled to 16°C or 60°F.

2) Low calorific value(LCV) or Net Calorific value (NCV)

Low calorific value may be defined as the net heat produced when unit mass or volume of fuel is completely burnt and products are allowed to escape.

NCV or LCV = GCV (HCV) – Latent Heat of water formed

= GCV(HCV) – Mass of hydrogen x 9 x Latent heat of steam

= GCV(HCV) – 0.09 x %H x 587

Because 1 part by weight of hydrogen produces 9 parts (1+8) by mass of water.

Dulong Formula

- The calorific value of fuels is determined theoretically by Dulong formula or I.A. Davies formula.
- It is expressed as

$Q = 1/100 [8080 \times C + 34500 \times (H - O/8) + 2240 \times S]$

Where, Q = Calorific value in KCU/Kg

C = % of carbon

H = % of hydrogen

O = % of oxygen

S = % of sulphur

Dulong formula for HCV & LCV

$HCV = 1/100 [8080 \times C + 34500 \times (H - O/8) + 2240 \times S]$

$LCV = HCV - [9/100 \times \%H \times 587]$

Experimentally calorific value of solid and liquid fuel is determined using Bomb Calorimeter.

- Numerical 1: A sample of coal contains C = 55%, O = 28%, H =7%, S = 0.7%, N =0.2%, Ash = 0.2%. Calculate the GCV and NCV.

Soln:

GCV = 1/100[8080C + 34500(H-O/8) + 2240S]

= 1/100 [8080x55 + 34500(7-28/8) + 2240 x 0.7]

= 5667 Kcal/Kg

NCV = HCV – 0.09 x % H x 587

= 5667 – 0.09 x 7 x 587

= 5297.19Kcal/Kg

Numerical 2: A sample of coal has following composition C = 70%, O = 8%, H = 10%, N =3%, S = 2%, Ash = 7%. Calculate HCV and GCV.

Numerical 3: A sample of coal contains C = 61% , O = 32%, S = 0.5%, N = 0.2% and Ash = 0.3%. If NCV of coal is 5313.02KCal/Kg. Calculate % H and GCV.

GCV =1/100[8080C + 34500(H-O/8) + 2240S]----i)

NCV = GCV -0.09x%Hx587

GCV = NCV + 0.09x%H x587-------ii)

1/100[8080C + 34500(H-O/8) + 2240S) = NCV + 0.09x%Hx587

Numerical 3: A sample of coal contains C = 61% , O = 32%, S = 0.5%, N = 0.2% and Ash = 0.3%. If NCV of coal is 5313.02KCal/Kg. Calculate % H and GCV.

GCV =1/100[8080C + 34500(H-O/8) + 2240S]----i)

NCV = GCV -0.09x%Hx587

GCV = NCV + 0.09x%H x587-------ii)

1/100[8080C + 34500(H-O/8) + 2240S) = NCV + 0.09x%Hx587

Numerical 3: A sample of coal contains C = 70% , O = 25%, S = 1%, N = 1% and Ash = 0.5%. If NCV of coal is 5200KCal/Kg. Calculate % H and GCV.

GCV =80.80x70 + 345(H-25/8) + 22.40x1]----i)

=5656+345H-1078.125+22.4

= 4600+345H

NCV = GCV - 0.09x%Hx587

GCV = 5200 + 0.09x%H x587

= 5200 + 52.83H-------ii)

4600.275+345H = 5200 + 52.83H

345H- 52.83H = 5200-4600.275

292.17H = 599.725

H = 2.05%

GCV= 5308.44Kcal/Kg

l Hydrocarbon as Fuel

- Hydrocarbons are organic compounds composed primarily of hydrogen and carbon atoms. Hydrocarbons are the primary constituents of fossil fuels, which have been the backbone of modern civilization's energy consumption for decades. They power vehicles, aircraft, ships, and provide heating and electricity for residential, commercial, and industrial purposes.
- **Characteristics of Hydrocarbons as Fuel:**
- **Energy-Dense:** Hydrocarbons are highly energy-dense compounds, making them efficient sources of fuel. When burned, they release significant amounts of energy, which can be harnessed for various purposes like transportation, electricity generation, heating, and industrial processes.
- **Various Forms:** Hydrocarbons exist in different forms, including solid (like coal), liquid (such as crude oil and its derivatives like gasoline, diesel, and kerosene), and gaseous (like natural gas). This diversity allows for flexibility in their applications.
- **Ease of Transport and Storage:** Liquid hydrocarbons, such as gasoline and diesel, are relatively easy to transport and store compared to other forms of energy. They have high energy density per unit volume, allowing for convenient storage and transportation via pipelines, tankers, and fuel storage facilities.

Environmental and Societal Impact:

- The biggest challenge modern industrial society is facing today is the decline and exhaustion of the fossil energy resources. The primary sources of energy that power our civilization are those fossil fuels.
- The combustion of hydrocarbons releases carbon dioxide (CO2), a greenhouse gas contributing to climate change. Additionally, incomplete combustion can result in emissions of harmful pollutants like carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter, which contribute to air pollution and health issues.
- Therefore continued use of hydrocarbon derived from fossils-sourced fuels is now widely recognized as unsustainable because of depleting supplies and increasing demand.

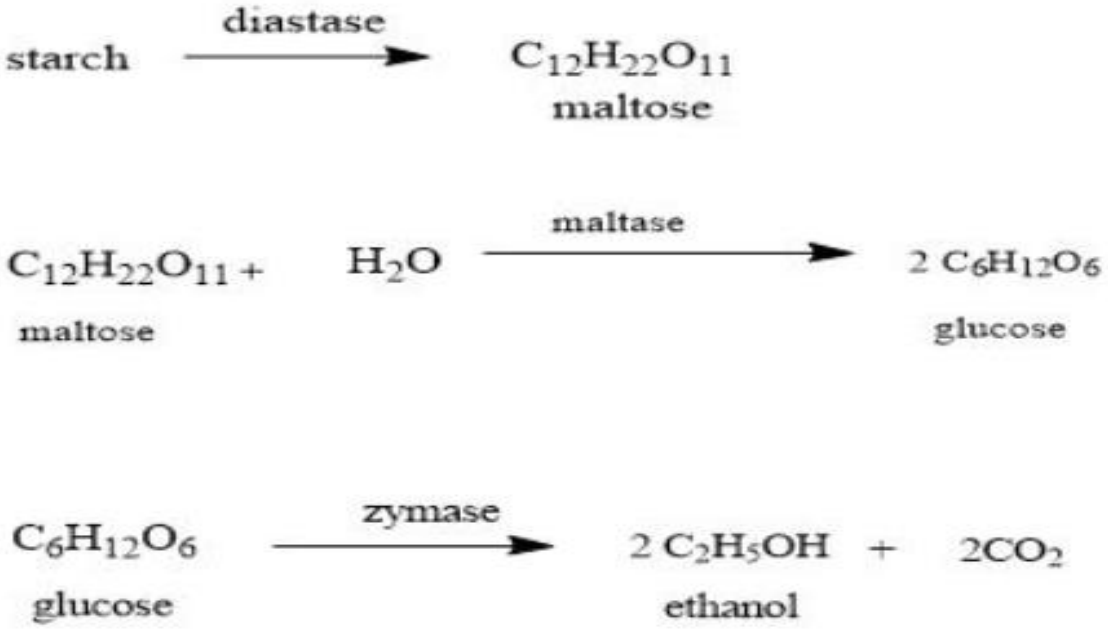
Future Trends and Alternatives:

- **Shift Towards Renewable Energy:** Increasing concerns about climate change and environmental impact are driving efforts to transition away from fossil fuels. Renewables like power alcohol and biodiesel, fuel cell are gaining prominence due to their lower environmental impact and potential for sustainable energy generation.

- **Technological Innovations:** Ongoing research and development aim to improve the efficiency of hydrocarbon-based fuel production and reduce their environmental footprint.

Power alcohol

- Power alcohol, also known as ethanol or ethyl alcohol, is a type of renewable biofuel derived from plant materials such as sugarcane, corn, barley, wheat, or cellulose-rich materials like wood chips and agricultural residues.
- **Production:**
- **Fermentation:** Power alcohol is primarily produced through a process called fermentation, where sugars present in plant materials are converted into ethanol by the action of yeast or bacteria in the absence of oxygen



Advantages

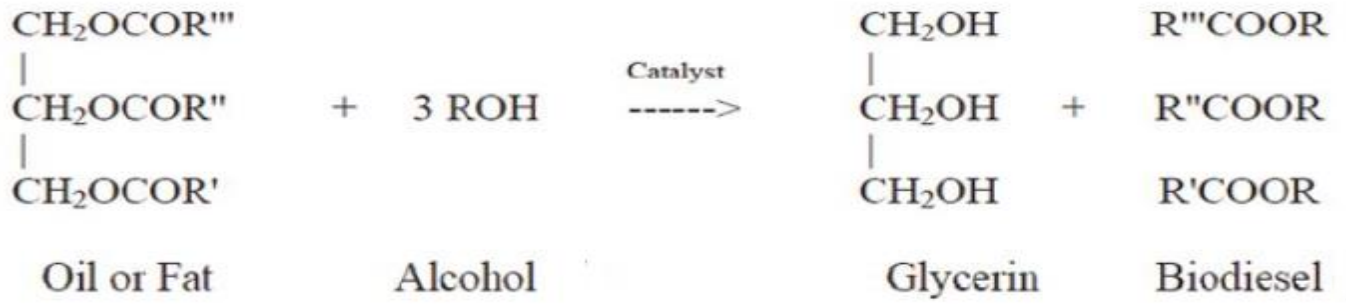
- **Reduced Greenhouse Gas Emissions:** When compared to fossil fuels, ethanol generally produces lower net carbon dioxide emissions, contributing to mitigating climate change.
- **Domestic Production:** Many countries aim to promote ethanol production from locally grown crops, reducing dependence on imported oil and enhancing energy security.
- **Fuel Properties:** Ethanol has high octane ratings and can be used as a blending component in gasoline to enhance its octane level and reduce emissions.
- **Renewable and Environmentally Friendly:** Power alcohol is considered a renewable fuel as it is derived from plant matter that can be grown and harvested repeatedly. It is also relatively cleaner burning compared to fossil fuels, emitting fewer greenhouse gases and pollutants like carbon monoxide and particulate matter.

Limitations

- **Lower Energy Density:** Ethanol has a lower energy density (calorific value 7000 Kcal/Kg as compared to gasoline (12000 Kcal /Kg), resulting in decreased fuel efficiency when used as a standalone fuel. Vehicles running on ethanol may experience reduced mileage compared to gasoline-powered vehicles.
- **Cold Weather Performance:** Ethanol has a higher water content, making it prone to issues in cold weather conditions, such as difficulties in starting engines and potential corrosion of fuel system components.
- **Infrastructure and Compatibility Issues:** While some vehicles are designed to run on ethanol (flex-fuel vehicles), the widespread use of ethanol as a fuel requires significant changes in infrastructure, including fuel distribution systems and vehicle engines, which might not be readily available or cost-effective.
- It must be noted that these disadvantages are significantly reduced when biodiesel is used in blends with petrol.

Biodiesel

- Biodiesel is a liquid biofuel obtained by chemical processes from vegetable oils or animal fats and an alcohol that can be used in diesel engines, alone or blended with diesel oil
- Biodiesel is an alternative energy source and could be a substitute for petroleum-based diesel fuel.
- The production of biodiesel chemical reaction is known as transesterification.
- Transesterification is the chemical process, which converts natural fats and oils into Biodiesel. Most of the biodiesel is produced from waste animal fats and vegetable oils obtained from restaurants, and industrial food producers.



Advantages of the Use of Biodiesel:

- Some of the advantages of using biodiesel as a replacement for diesel fuel are Renewable fuel, obtained from vegetable oils or animal fats.
- Low toxicity, in comparison with diesel fuel. Degrades more rapidly than diesel fuel, minimizing the environmental consequences of biofuel spills.
- Lower emissions of contaminants: carbon monoxide, particulate matter, polycyclic aromatic hydrocarbons, aldehydes.
- Lower health risk, due to reduced emissions of carcinogenic substances. No sulfur dioxide (SO2) emissions.
- Higher flash point (100C minimum).
- May be blended with diesel fuel at any proportion; both fuels may be mixed during the fuel supply to vehicles.
- Excellent properties as a lubricant.
- It is the only alternative fuel that can be used in a conventional diesel engine, without modifications.

Disadvantages of the Use of Biodiesel

- Slightly higher fuel consumption due to the lower calorific value of biodiesel.
- Slightly higher nitrous oxide (NOx) emissions than diesel fuel.
- Higher freezing point than diesel fuel. This may be inconvenient in cold climates.
- It is less stable than diesel fuel, and therefore long-term storage (more than six months) of biodiesel is not recommended.
- It may degrade plastic and natural rubber gaskets and hoses when used in pure form, in which case replacement with Teflon components is recommended.
- In consequence, the cleaning of tanks prior to filling with biodiesel is recommended.
- It must be noted that these disadvantages are significantly reduced when biodiesel is used in blends with diesel fuel.

Rechargeable Batteries

INTRODUCTION

- Battery: It is a device consisting of two or more galvanic cells connected in series or parallel or both

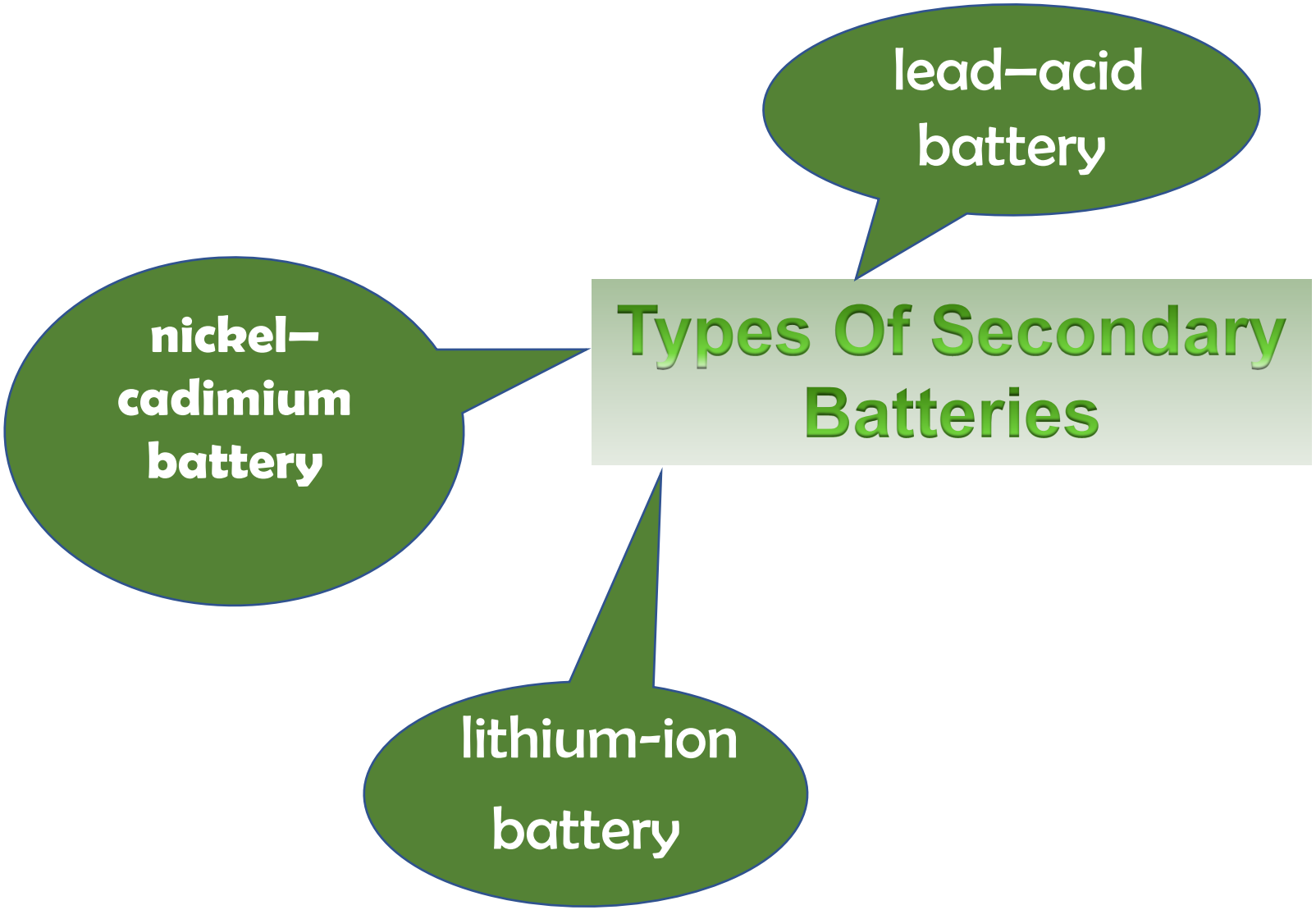
Classification of batteries:

1. Primary batteries: In these batteries the cell reaction is not reversible, after discharging cannot be rechargeable.

Ex. Zn-MnO_2 dry cell.

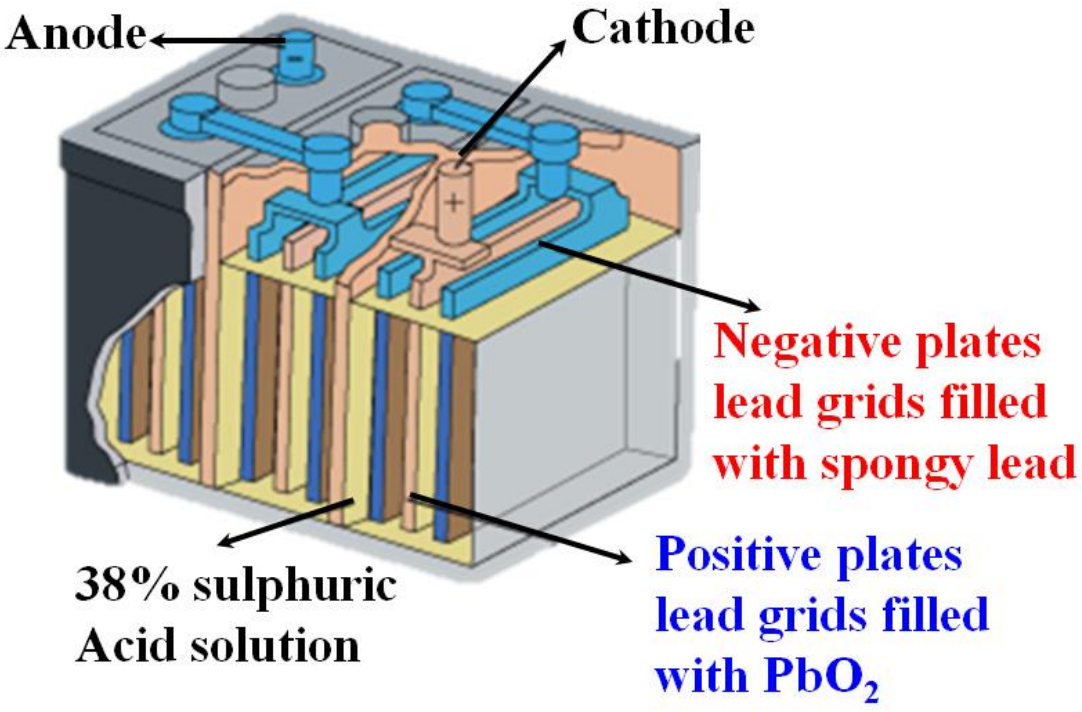
2. Secondary batteries: In these battery the cell reaction is completely reversible, after discharging can easily rechargeable.

Ex. Lead-acid battery, Ni-Cd battery.


lead–acid battery
nickel–cadimium battery
Types Of Secondary Batteries
lithium-ion battery

LEAD ACID BATTERIES

LEAD STORAGE BATTERY



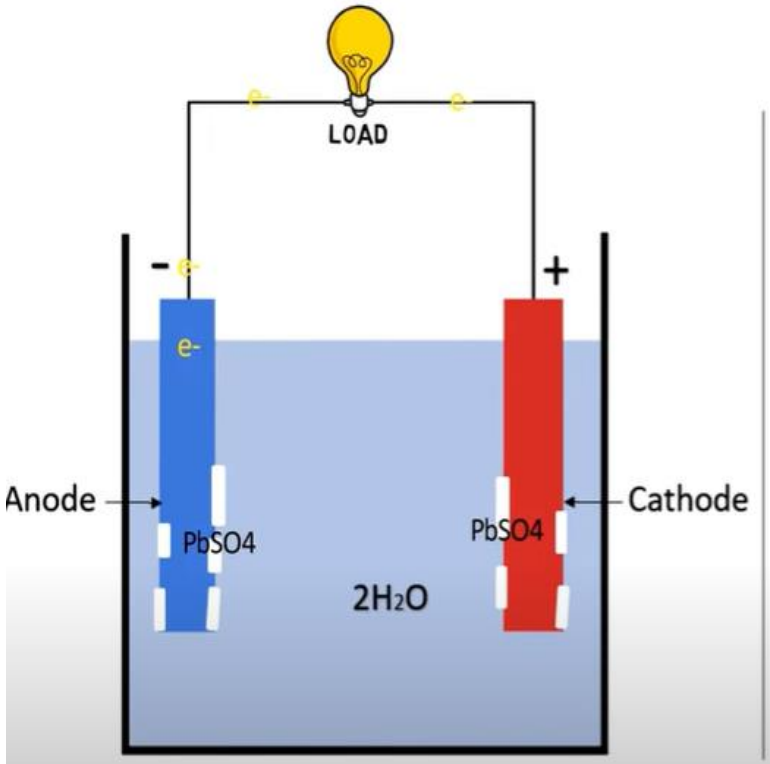
- The Lead-acid battery is one of the oldest types of rechargeable batteries. These batteries were invented in the year 1859

- Lead-acid batteries can be classified as secondary batteries. The chemical process of extracting current from a secondary battery (forward reaction) is called discharging. The method of regenerating active material is called charging.

Construction:

- Cathode: Group of lead plate bearing spongy lead
- Anode: a grid of lead bearing lead oxide
- Electrolyte: in lead acid battery dilute sulphuric acid (38%) is used as an electrolyte.
- Separator: It is most important part of lead acid battery. Which separate the positive and negative plates from each other and prevents the short circuit. The material used for separators are wood, rubber, glass wood mate, pvc.

Reaction (During Dischharging):



ELECTOLYTE:

$$2H_2SO_4 \rightarrow 4H^+ + 2SO_4^{2-}$$

AT ANODE:

$$Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$$

AT CATHODE:

$$PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O$$

CELL REACTION:

$$PbO_2 + Pb + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$$

Life

The optimum functional temperature for lead acid battery is 25^0C which means 77^0F. The increase in the range of temperature shortens longevity. A per the rule, for every 80oC increase in temperature, it reduces the half-life of the battery. While a value regulated battery that functions at 25^0C has a **lead acid battery life** of 10 years. And when this is operated at 33^0C, it has a life period of 5 years only.

Lead Acid Battery Applications

These are employed in emergency lightening to provide power for sump pumps.

Used in electric motors

Submarines

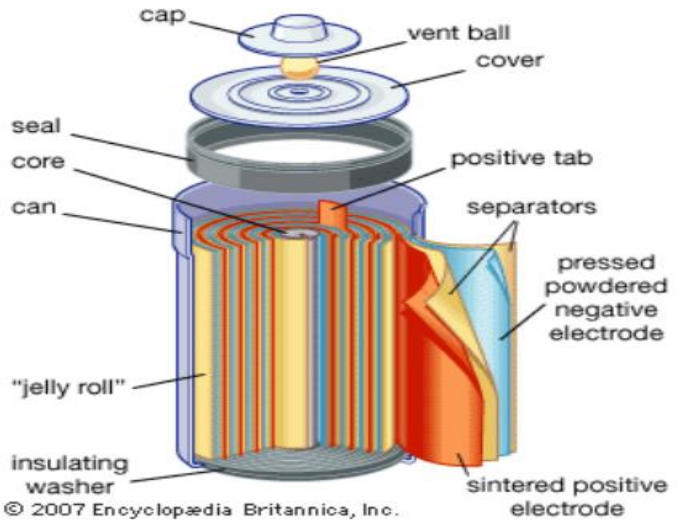
Nuclear submarines

2. NICKEL-CADMIUM BATTERY
INTRODUCTION

- The nickel-cadmium battery, often known as the ‘NiCad’ battery, is a rechargeable battery that uses metallic cadmium along with nickel oxide hydroxide as the cell’s electrodes.
- Nickel(hydroxide)–cadmium systems are the most common small rechargeable battery type for portable appliances. The sealed cells are equipped with “jelly roll” electrodes, which allow high current to be delivered in an efficient way. These batteries are capable of delivering exceptionally high currents, can be rapidly recharged hundreds of times, and are tolerant of abuse such as over discharging or overcharging.
- It produces a voltage of about 1.4 V

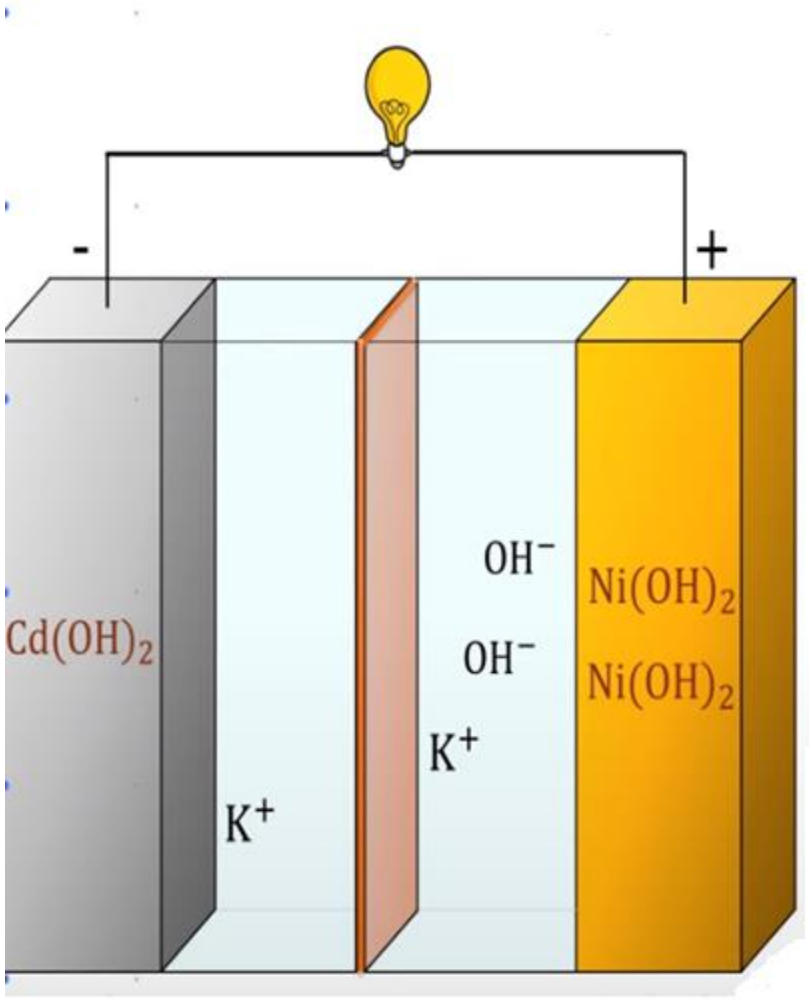
Construction:

- The nickel-cadmium battery is constructed similarly to lead-acid batteries. It is made up of three basic layers. The nickel layer is first, followed by the separator layer, and then the cadmium layer. The nickel layer functions as a positive electrode collector, while the cadmium layer functions as a negative electrode collector.
- KOH or NaOH is used as a separator layer between the two layers. Its role is to supply OH ions. A safety valve, sealing pad, insulation ring, insulation gasket, and an exterior case round out the package. The insulator ring's job is to keep the two layers apart by providing insulation



Cell Reaction during discharging:

DISCHARGING



At Negative Electrode:

$$Cd + 2OH^- \rightarrow Cd(OH)_2 + 2e^-$$

At Positive Electrode:

$$2NiO(OH) + 2H_2O + 2e^- \rightarrow 2Ni(OH)_2 + 2OH^-$$

Overall Reaction:

$$Cd + 2NiO(OH) + 2H_2O \rightarrow Cd(OH)_2 + 2Ni(OH)$$

ADVANTAGES

- Fast and simple charging process
- It is compact and lighter than traditional batteries
- It has a longer life than lead storage batteries
- Available in a wide range of sizes and performance options
- Good low-temperature performance
- Only battery that can be ultra-fast charged with little stress

LIMITATIONS

- It is rather more expensive than a lead storage battery
- It has a lower energy density value
- Cadmium is a toxic metal. Cannot be disposed of in landfills
- Memory effect; needs periodic full discharges
- High self-discharge; needs recharging after storage

APPLICATIONS

- Ni-Cd cells are popularly used in many appliances because they are available in variety of sizes and capaciities.
- Few examples are:

❖Calculators

❖Electronic flash units

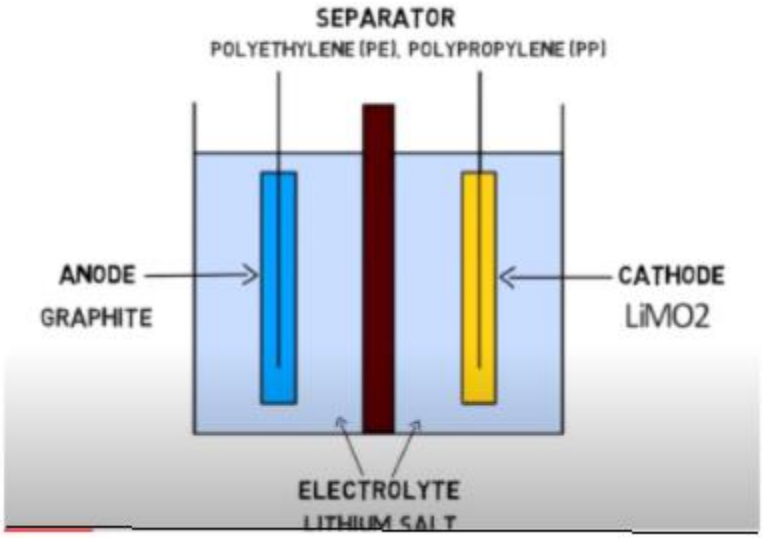
❖Transistors

❖Cordless appliances

3. RECHARGEABLE LITHIUM BATTERIES

DESCRIPTION

- Lithium ion battery is a type of rechargeable battery that uses lithium based compound as active raw material. Since lithium is very reactive compound it can not be used in pure form hence we use lithium based compound as cathode material.
- Anode: Some batteries use pure graphite as cathode while some uses lithium hexa carbide (LiC6)
- Cathode: It is an intercalated compound of
- Lithium metal oxide (LiMO2) where metal can be like Cobalt, Manganese, Titanium
- Electrolyte: It contains lithium hexa fluoro phosphate (LiPF6)
- Seperator: A non conductive polymer material is used as seperator



- During the charging and discharging process, the lithium ions move back and forth between the two electrodes of the battery, which is why the working principle of a lithium-ion battery is called the rocking chair principle.

CHARGING

DISCHARGING

AT CATHODE

$$LiMO_2 \rightarrow Li^+ + MO_2 + e^-$$

AT ANODE

$$C_6 + Li^+ + e^- \rightarrow LiC_6$$

CELL REACTION:

$$LiMO_2 + C_6 \longrightarrow LiC_6 + MO_2$$

ADVANTAGES

- 1. Lithium-ion batteries have a significantly low self-discharge rate as compared to the other type of batteries.
- 2. They have a high energy density.
- 3. There exists no memory effect in lithium-ion batteries.
- 4. The average life span of lithium-ion batteries is ten times more than the traditional lead-acid batteries.
- 5. The charging rate of lithium-ion batteries is high.
- 6. Lithium-ion batteries work efficiently under extreme conditions such as high pressure and temperature fluctuations.
- 7. Lithium-ion batteries are lightweight and compact in size. Typically, the weight of lithium-ion batteries is roughly 50-60% less than the standard lead-acid batteries.
- 8. Installation of lithium-ion batteries is comparatively easy.

APPLICATIONS

- Emergency Power Backup Or UPS
- Dependable Electric And Recreational Vehicle Power
- Solar Power Storage
- Reliable And Lightweight Marine Performance
- Solar Power Storage
- Surveillance Or Alarm Systems In Remote Locations
- Personal Freedom With Mobility Equipment
- Portable Power Packs That Eliminate Downtime