CH0204 Organic Chemical Technology

Lecture 10

Chapter 3 Plastics

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Overview of topics

Chapter 3 Plastics

1. Polymers, Plastics, and Resins
2. Production of Polyethylene
3. Production Polypropylene

Overview of topics

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1. Polymers, Plastics, and Resins
2. Production of Polyethylene
3. Production Polypropylene

Polymers, Plastics and Resins

A **monomer** (from Greek *mono* "one" and *meros* "part") is an atom or a small molecule that may bind chemically to other monomers to form a polymer.[1]

A **polymer** is a large molecule (compound) of repeated structural units. These units or sub units are typically connected by covalent (sharing pair of electrons between atoms) chemical bonds.

Although the term polymer is sometimes taken to refer plastics it actually encompasses a large class of natural and synthetic materials with a wide variety of properties.

Polymers, Plastics and Resins

Polymers usually posses a certain amount of crystallinity, and their tensile strength increases with molecular weight.

Also greater the crystallinity, the greater is tensile strength, lower is the solubility and higher is the melting point.

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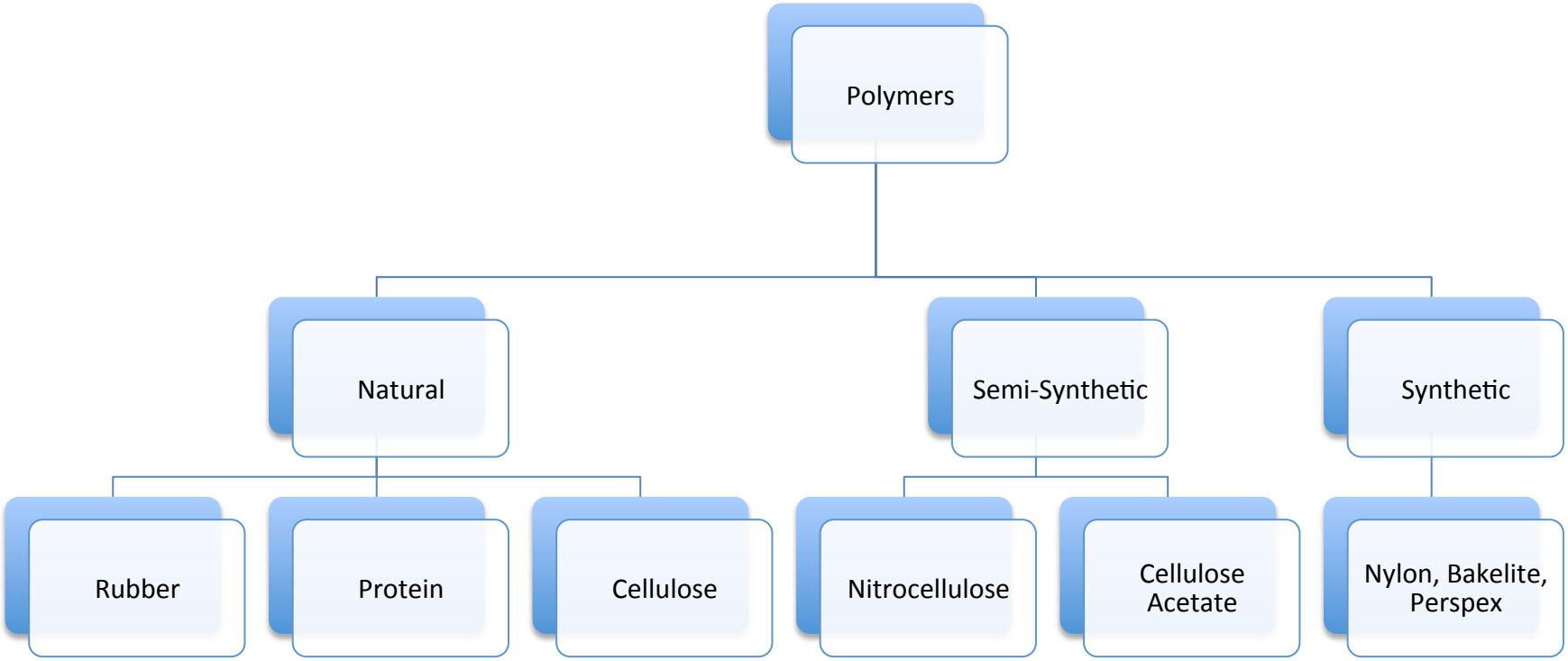
Polymers, Plastics and Resins



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Polymers, Plastics and Resins

Plastic

A **plastic** may be defined as material that contains a polymerized organic substance of large molecular weight as an essential ingredient, is solid in its finished state, and at some stage in its manufacture or its processing into finished articles can be shaped by flow.

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Polymers, Plastics and Resins

Resin is also hydrocarbon secretion of many plants, particularly coniferous trees. It is valued for its chemical properties and associated uses, such as the production of varnishes, adhesives, and food glazing agents; as an important source of raw materials for organic synthesis.

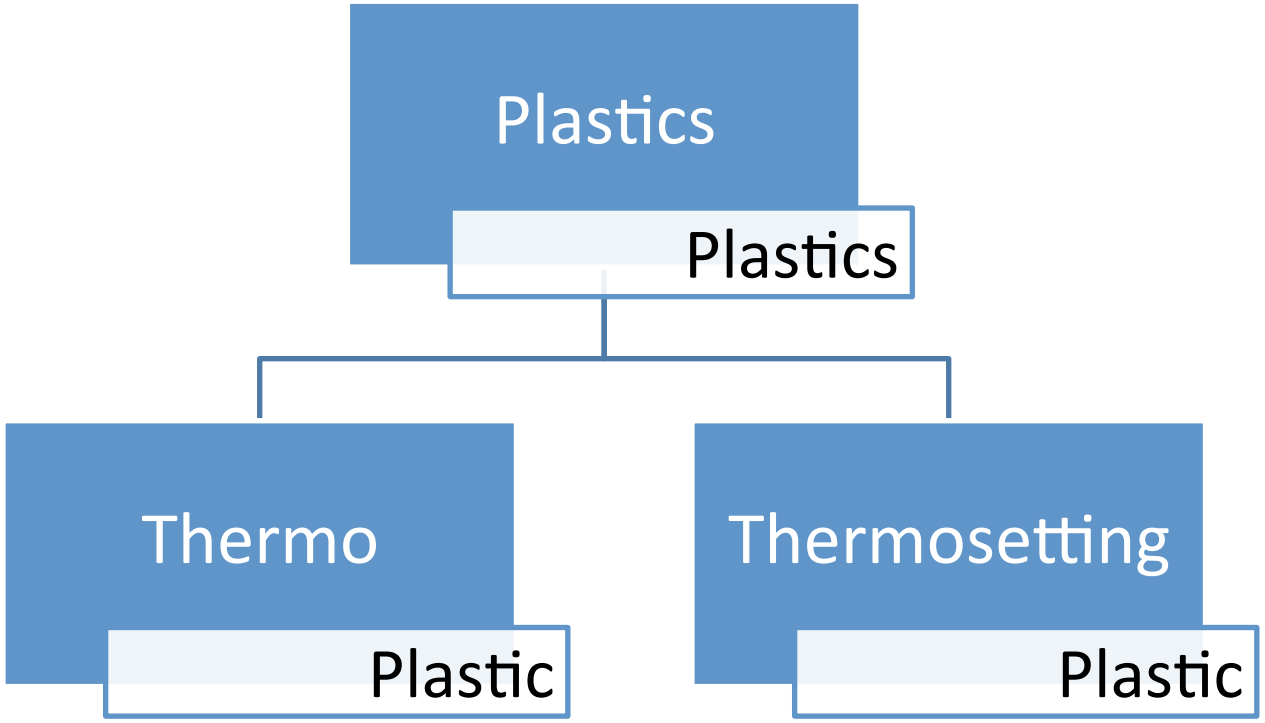
Polymers, Plastics and Resins

Resins

On the basis of derivation, plastics can also be grouped as

1. Natural resins
2. Synthetic resins
3. Cellulose derivatives
4. Protein products

Polymers, Plastics and Resins



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Polymers, Plastics and Resins

Plastic

Thermoplastic

Synthetic resins formed by addition polymerization are thermoplastic (heating softens and cooling hardens).

Thermosetting

Synthetic resins formed by condensation polymerization are thermosetting (heat curing produces an infusible or insoluble product).

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Polymers, Plastics and Resins

Thermo plastics	Thermosetting plastics
Linear polymers which are soluble in many organic solvents	Three-dimensional polymers which are insoluble in any kind of solvent
The process of heat-softening, molding and cooling can be repeated as often as desired and hardly affects of the properties of plastics.	Heat treated only once before their formation, after which heating results in chemical decomposition, and hence they cannot be "reworked".
e.g. Cellulose acetate, nitrocellulose and vinyl polymers such as polyethylene and prespex etc.,	e.g. Phenol formaldehyde, urea formaldehyde, melamine formaldehyde, silicones etc.,

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Polymers, Plastics and Resins

Polymerization (Simple molecules reacts together to form polymer)

Polymerization is carried out with the objective of building up compounds with predicted properties and since the properties of a plastic depend on the degree of polymerization it is necessary to stop the polymerization when the desired average molecular weight is reached.

This may be done by various means e.g variation of concentration of the catalyst. The average molecular weight of plastics varies from about 20,000 (e.g nylon) to several hundred thousand (e.g. Polyvinyl Chlorides 2, 50, 000).

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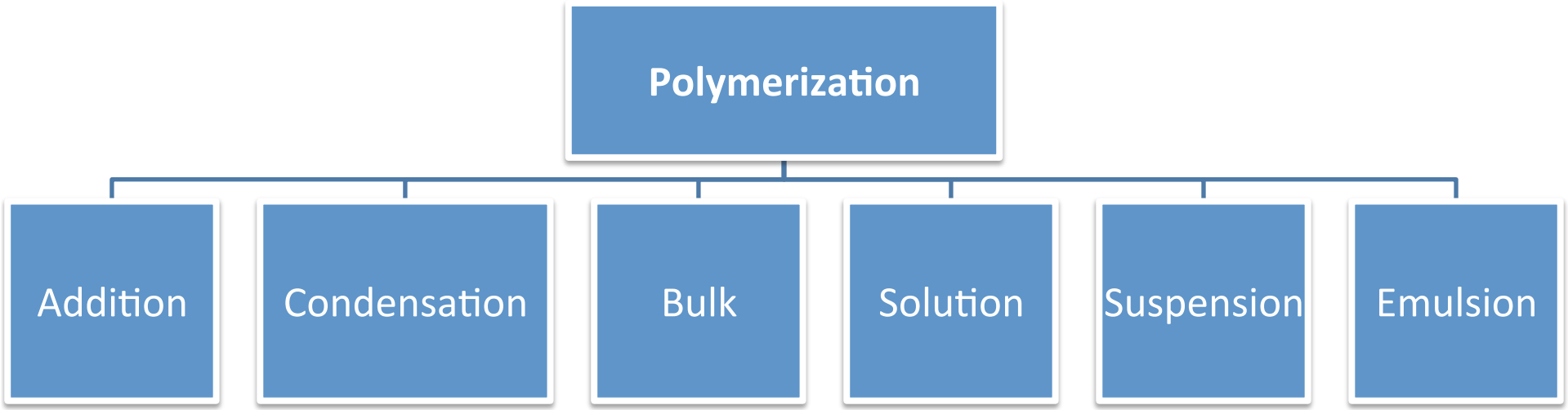
Polymers, Plastics and Resins - Polymerization



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Polymers, Plastics and Resins

Addition Polymerization

Involves a series of conversions which produce a polymer having a repeated structural unit identical with that of monomer from which it is formed.

Condensation Polymerization

It yields polymers whose repeated units lack certain atoms present in the original monomer. The reaction takes place by the combination of two or more units and the elimination of a small molecule such as water methanol or hydrogen chloride.

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Polymers, Plastics and Resins

Bulk polymerization

Involves polymerization of the monomer in bulk and it may be carried out in liquid or vapor state. The monomers and activators are mixed in reactor and heated or cooled as needed.

In some cases, the polymers are soluble in their liquid monomers causing the viscosity of the solution to increase greatly.

In other cases, the polymer is not soluble in the monomer and it precipitates out after a small amount of polymerization occurs.

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Polymers, Plastics and Resins

Solution polymerization

This method is often used when the exothermic heat is too great to be controlled in the bulk polymerization.

The monomer and initiator are dissolved in non reactive solvent. The polymer concentration usually maintained low to avoid too high viscosity.

This method produces polymers of low to medium molecular weight.

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Polymers, Plastics and Resins

Suspension polymerization

In this process the monomer is suspended in water by agitation. The stabilizers such as talc, fuller's earth and bentonite are added to stabilize the suspension and prevent polymer globules from adhering to each other.

Normally the initiator is soluble in the monomer. Each monomer globule polymerizes as a spherical pearl of high molecular weight. The heat of polymerization is removed by the water. The stabilizer must be separated from the polymer, and sometimes, because of partial miscibility of the monomer and water subsidiary polymerization may occurs in aqueous phase, producing a lower molecular weight polymer.

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Polymers, Plastics and Resins

Emulsion polymerization

This is similar to suspension polymerization but the monomer is broken up into droplets that form aggregates called miscelles.

The monomer is on the interior of the miscelles, and the initiator is in the water. Soap or emulsifying agents, is used to stabilize the miscelles.

Emulsion polymerization are rapid and can be carried out at relatively low temperatures.

The aqueous phase absorbs the heat evolved by the reaction. Polymers of very high molecular weight can be prepared by this process

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Polymers, Plastics and Resins

Polymerization type	Products Obtained
Addition polymerization	**Polyolefins (Poly ethylene and Polypropylene)**
	Vinyl resins (Poly vinyl resins)
	Vinyl alcohol resins
	Styrene resins
	Acrylic resins and plastics
Condensation polymerization	**Phenolics - Phenol formaldehyde**
	Amino resins – Urea formaldehyde
	Alkyd resins
	Epoxy resins
	Poly carbonates
	Polyimides
	Polysulfonates

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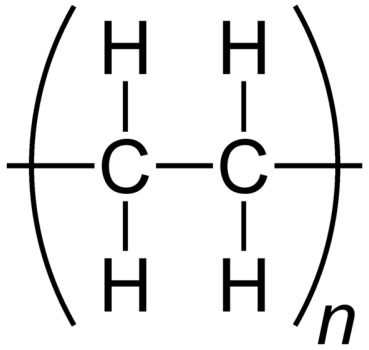
Polyethylene Production

Raw materials used

Ethylene(C_2H_4)
Water
Peroxide catalyst

Polyethylene Structure

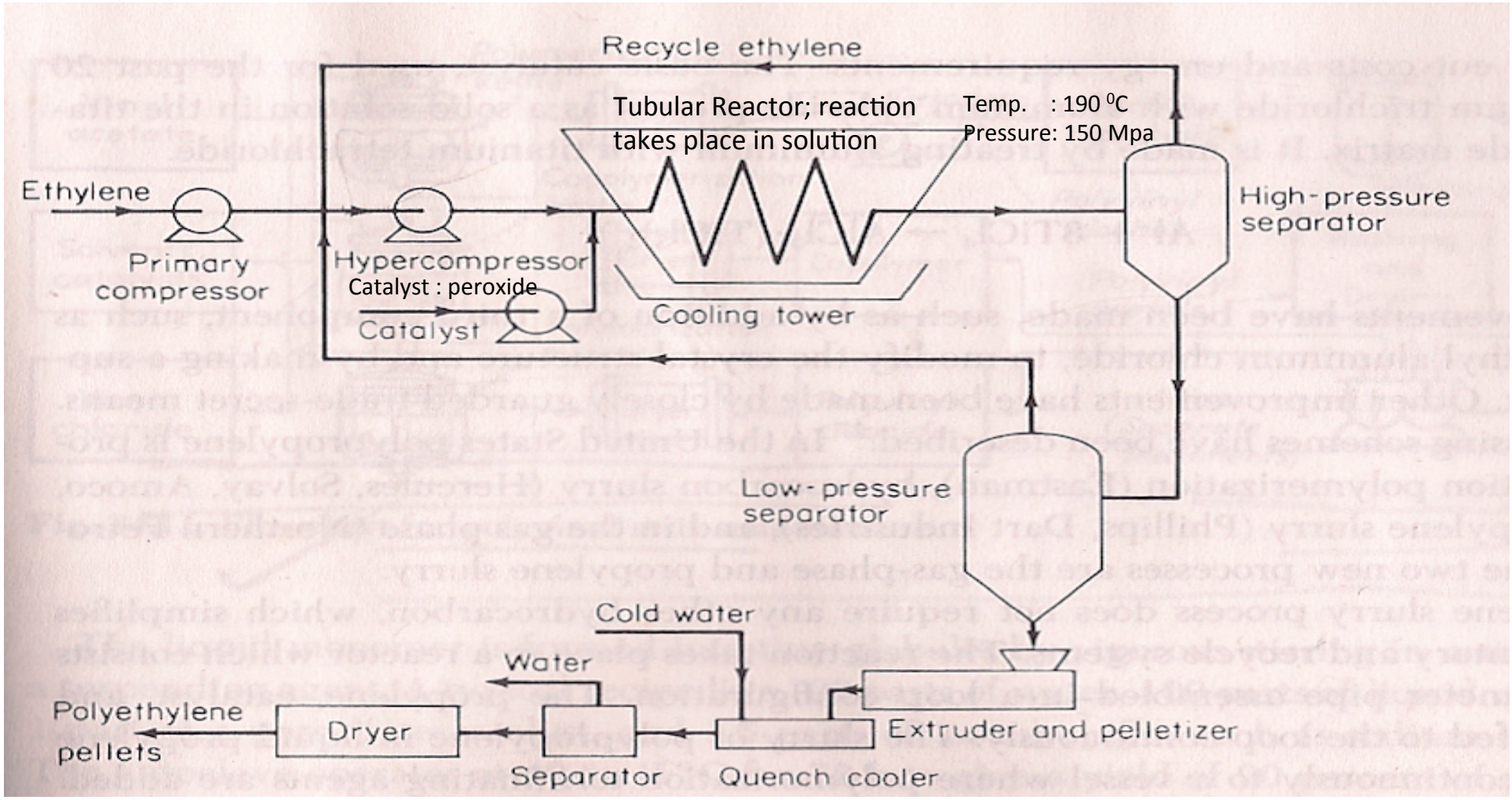


Methods of production

Low Density Polyethylene (LDPE) by high pressure processing

Low Density Polyethylene (LDPE) by low pressure processing

Production of polyethylene by high pressure process



Production of polyethylene by low pressure process

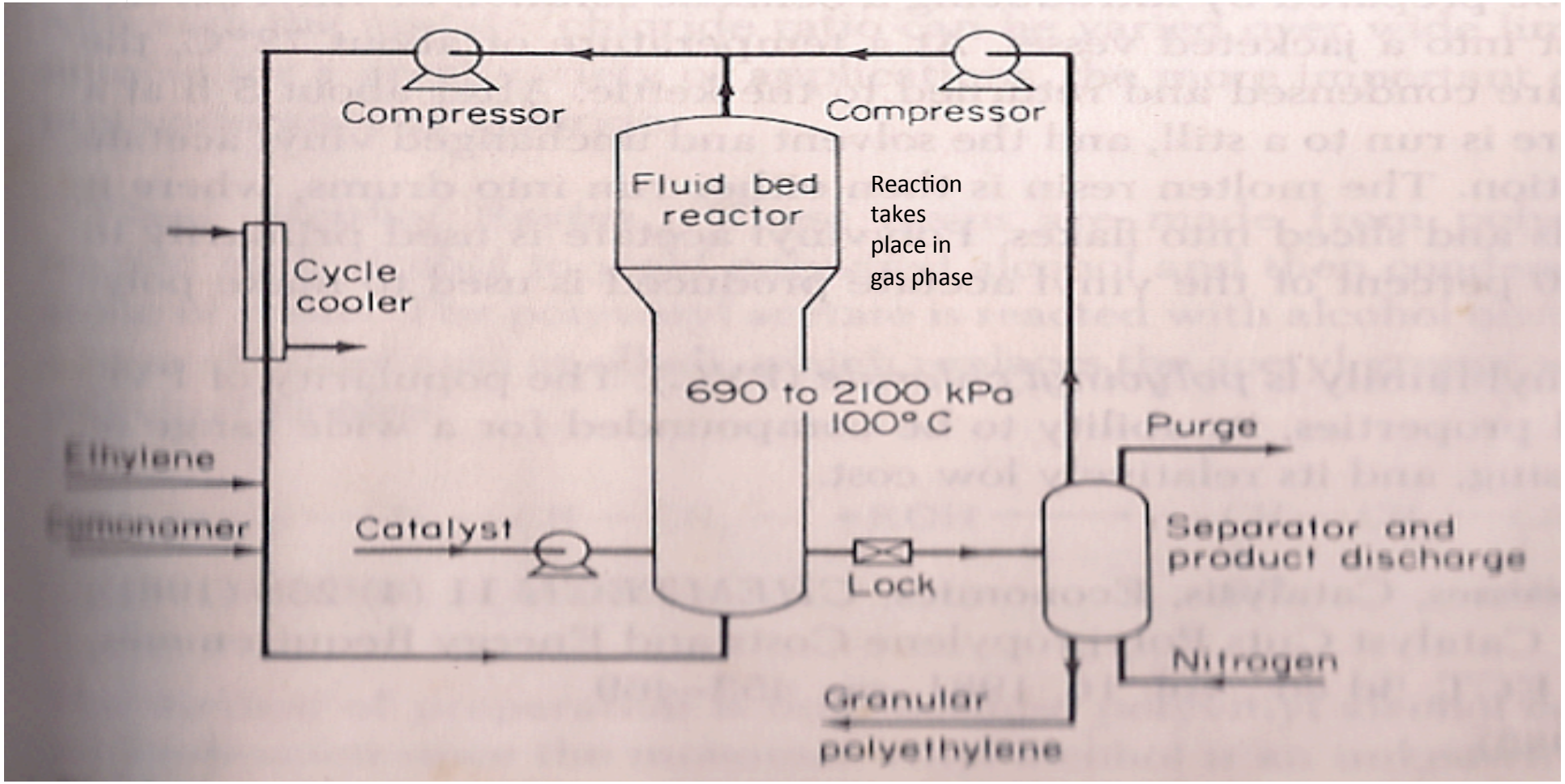
Raw materials used

Ethylene(C_2H_4)
1- butene (copolymer)
Water
Nitrogen used for purging

Methods of production

Low Density Polyethylene (LDPE) by low pressure processing

Production of polyethylene by low pressure process



Uses

Polyethylene

1. House wares
2. Medical equipment's
3. Electronic components
4. Toys
5. Automobile parts and appliances

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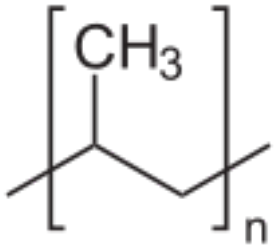
Polypropylene Production

Raw materials used

Propylene(C_3H_6)
Water
Aluminum chloride and
Titanium chloride catalyst

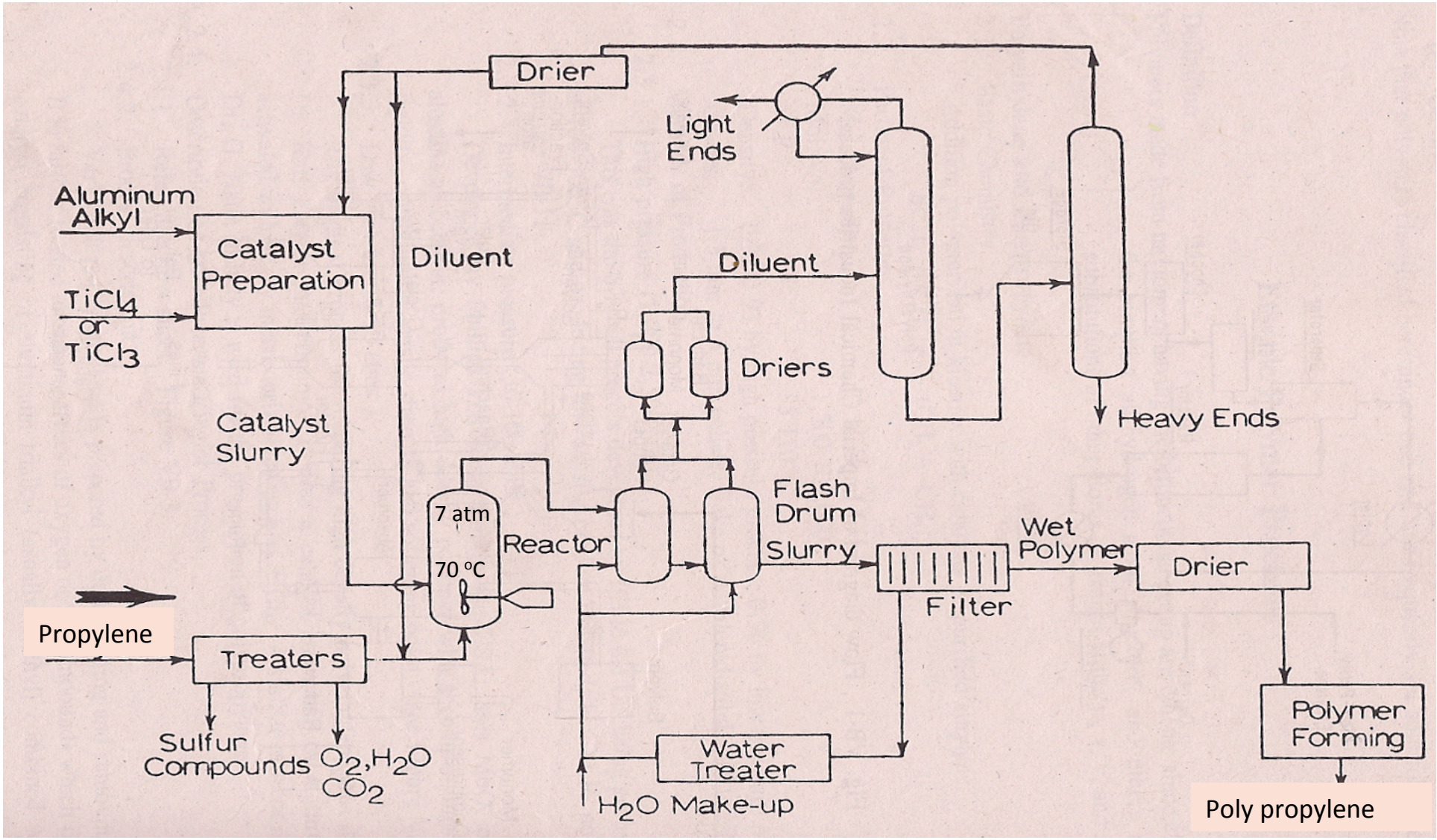
Structure of polypropylene



Methods of production

Polypropylene by low pressure process (Ziegler Process)

Polypropylene Production



Uses

Polypropylene

1. Very thin sheets of polypropylene are used as a dielectric within certain high-performance pulse and low-loss RF capacitors.
2. Polypropylene is used in the manufacturing piping systems; both ones concerned with high-purity and ones designed for strength and rigidity (eg. those intended for use in potable plumbing, heating and cooling, and reclaimed water).
3. Used in manufacturing carpets, rugs and mats to be used at home.

References

1. Dryden C. E, *Outlines of Chemical technology – for the 21st Century*, 3rd edition, East-West Press (2004)

2. Austin G. T, *Shreve's Chemical Process Industries*, 5th edition, Mc Graw Hill International editions (1984)

3. Finar IL, Organic Chemistry Vol. 1 6th Edition Pearson Education 2009 pp.116-117

Thank you