South Valley University

Faculty of Science

Chemistry Department

INDUSTRIAL CHEMISTRY

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Content

Sugar & sugar manufacturing

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Topics

Intro to sugar

Types of sugar

Extraction sugar process from sugar cane

What is sugar?

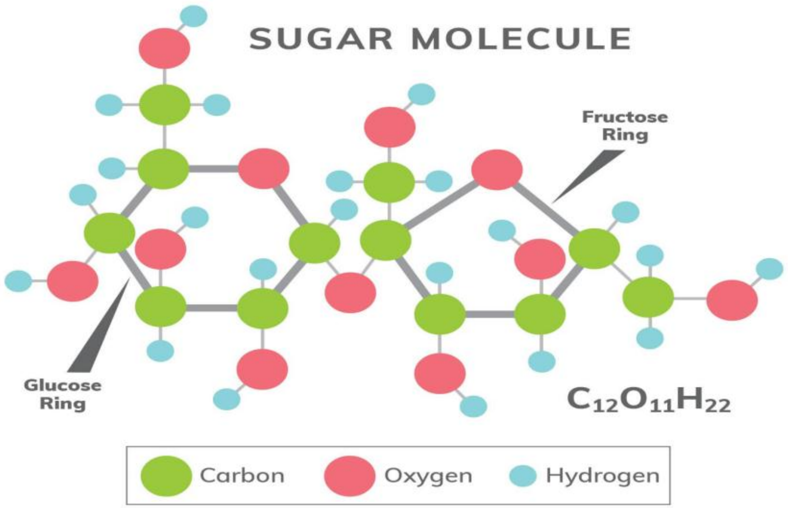
Sugar: is the name for a group of carbohydrates which have a short chain, generally cyclic structure, and are sweet tasting. However, there are several other substances that can also be used to sweeten foods.

-It has three type :

- **Monosaccharides:** The simplest of all the sugars

these form the building blocks of the other types of carbohydrates they are more commonly found bonded in pairs to form the rest of the range of sugars.

- **Disaccharides:** they are a mixture of two of the monosaccharides .
- **Polysaccharides** .



SUGARS, BROKEN DOWN

MONOSACCHARIDES
(one-molecule sugars)

Glucose (dextrose)

Fructose (levulose or fruit sugar)

Galactose (occurs in milk)

DISACCHARIDES
(two monosaccharides linked together)

Sucrose (table sugar) = glucose + fructose

Lactose (milk sugar) = glucose + galactose

Maltose (malt sugar) = glucose + glucose

POLYSACCHARIDES
(more than 10 monosaccharides linked together)

Starch (glucose polymer)

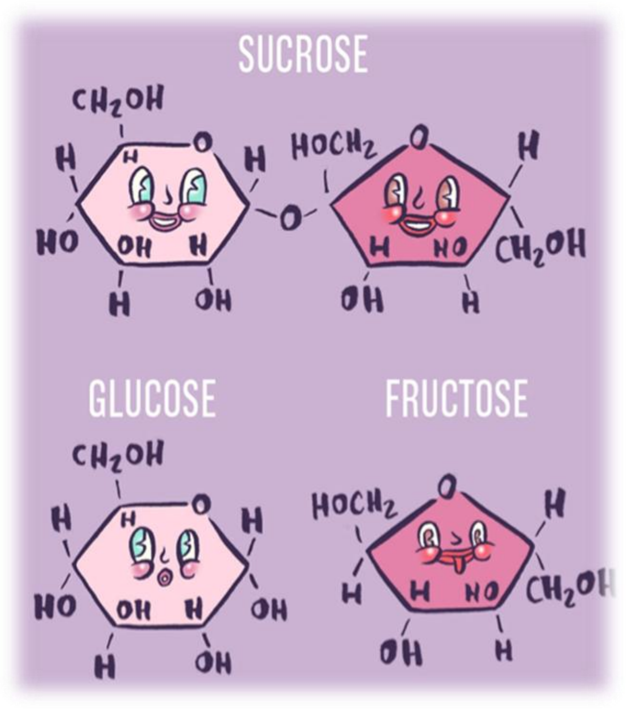
Sucrose (Table sugar)

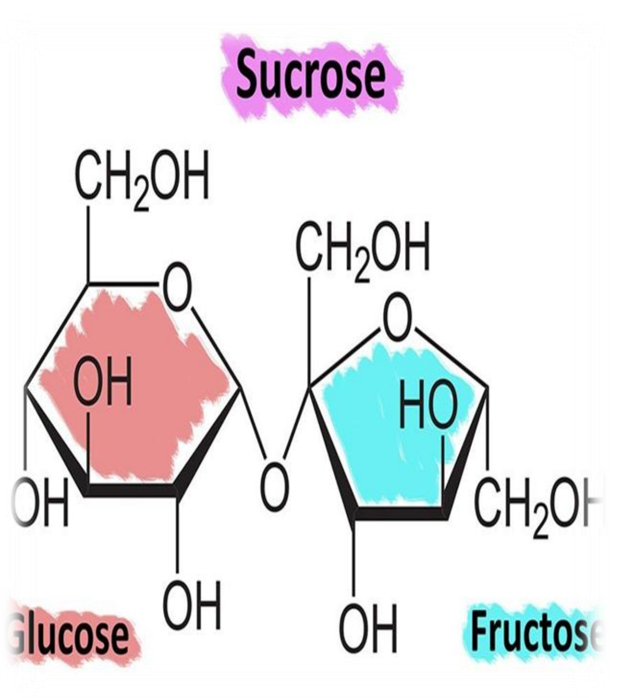
- **Common name** : Table sugar , sucrose , saccharose
- **Iupac name** : β-d-fructofuranosyl α-d glucopyranoside
- **The chemical or molecular formula :**

is **$C_{12}H_{22}O_{11}$**, which means each molecule of sugar contains 12 carbon atoms, 22 hydrogen atoms and 11 oxygen atoms.

- **Source :**

It is a saccharide that is made in many different plants. Most table sugar comes from sugar beets or sugarcane. The purification process involves bleaching and crystallization to produce a sweet, odorless powder.





Types of sugar

White sugar

Also known as granulated sugar, table sugar or refined sugar. Is one of the world’s purest foods. It’s 99.9% sucrose, is essentially the naturally occurring sugar from the sugar cane but with all ‘impurities’ such as mineral ash and polyphenols completely removed. Quite a multipurpose sugar used for baking, sprinkling, creaming and adding to hot drinks.

Icing sugar

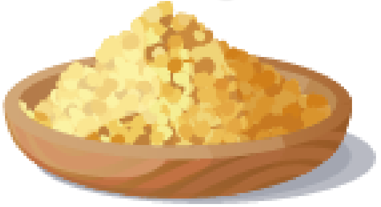
You may have noticed that icing sugar is either called 'pure' or 'soft'. Both are finely ground, and sifted sugar made from sugarcane, the difference is the soft version will often be mixed with corn starch to prevent it clumping التكتل. As the name might suggest, it is used for icing, but also buttercream and dusting cakes.

Sugar caster

This really has the same make up as table sugar, just a lot finer. Because of this you might also see it being called superfine sugar. Caster sugar is generally used in meringues or pavlovas where a smooth texture is needed.

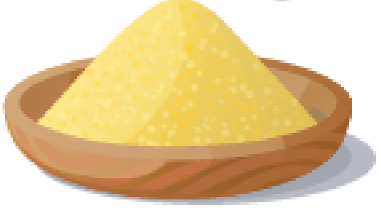
Types of sugar

Raw sugar



Raw sugar has a slightly darker color compared to white sugar. This comes from the molasses that is left on the sugar crystals. It is usually partially refined, retaining 4% molasses. Because of this it has a slightly different flavor as well. Most commonly, it is used in coffee, baking, chutneys or relishes. The only difference between this and coffee crystals is the size.

Brown sugar



Brown sugar can come in many different names and varieties. It can therefore come by many different names such as light brown, dark brown, golden brown or golden yellow sugar. They are all just blends of white sugar with different amounts of molasses added. It can therefore have quite a different taste compared to white sugar. The uses of brown sugar range from biscuits, gingerbread, carrot cakes and mince tarts.

Glucose sugar

Not commonly found in the home cooks kitchen, glucose powder is a white crystalline powder with a GI at the maximum of 100. It is the standard by which other carbohydrates are ranked. At 100, this means that glucose is rapidly absorbed into the bloodstream and stimulates a fast insulin response.

Extraction sugar process from sugar cane

1.Cleaning &Washing

2. Juice Extraction

3.Raw juice

4.Juice Purification

5. Clarified Juice Purification

6.Multiple Effect Evaporation

7.Crystallization & centrifugation

8.White sugar

Steps in producing raw sugar from cane

- Cane receiving and unloading (receive the cane at the factory and unload it from the transport vehicles)
- Cane preparation (cutting and shredding cane to prepare it for juice extraction)
- Juice extraction (two technologies are in common use; milling or diffusion)
- Juice clarification (remove suspended solids from the juice, typically mud, waxes, fibers)
- Juice evaporation (to concentrate the juice to a thick syrup of about 65°brix)
- Syrup clarification (remove suspended solids from the syrup, typically colloid size of mud, waxes, fibers, etc.)

Crystallization

- Centrifugation (Separation of the sugar crystals from the mother liquor, done by centrifugal machines)

Sugar drying

- Packaging and delivery

✓ **These processing steps will produce a brown or raw sugar**. Mill white sugar also known as plantation white sugar can be produced by introducing some form of color removal process (often solicitation) between the juice clarification and the juice evaporation stages mentioned above.

➢ The raw sugar produced is often refined to produce white sugar.

➢ This sugar refining can be done either at a separate factory or at a back-end refinery which is attached to the raw sugar factory.

Juice extraction

There are two processes for extracting juice from cane :Milling & Diffusion.

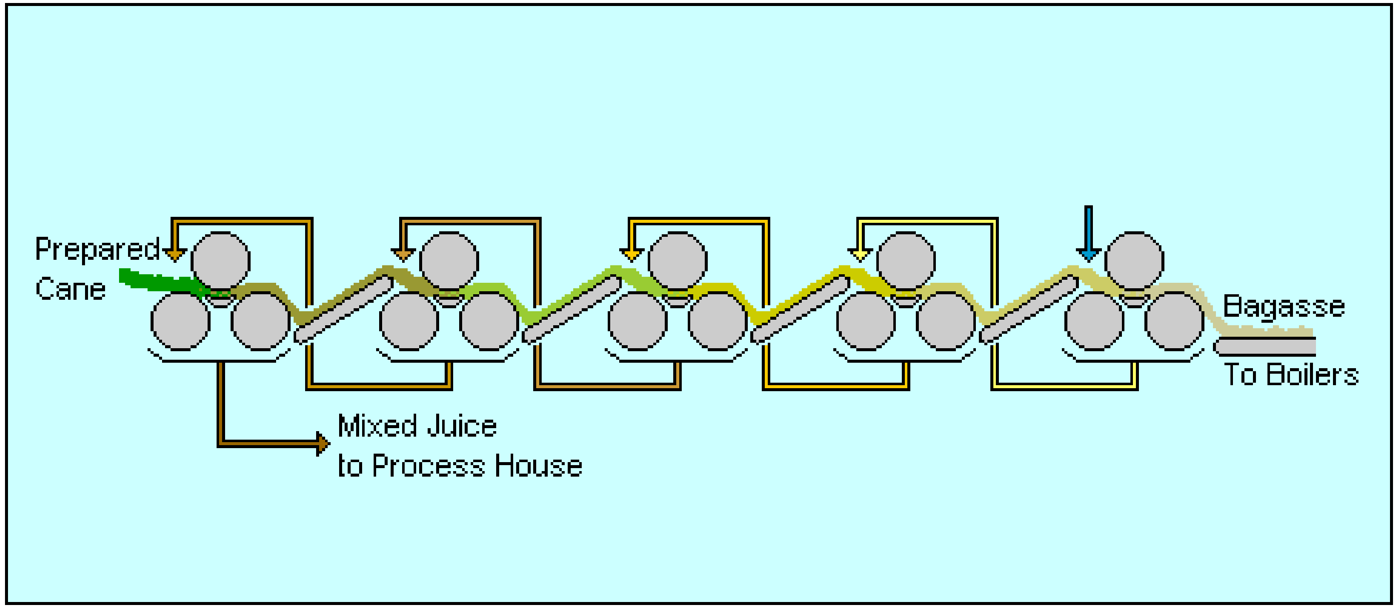
1.Milling

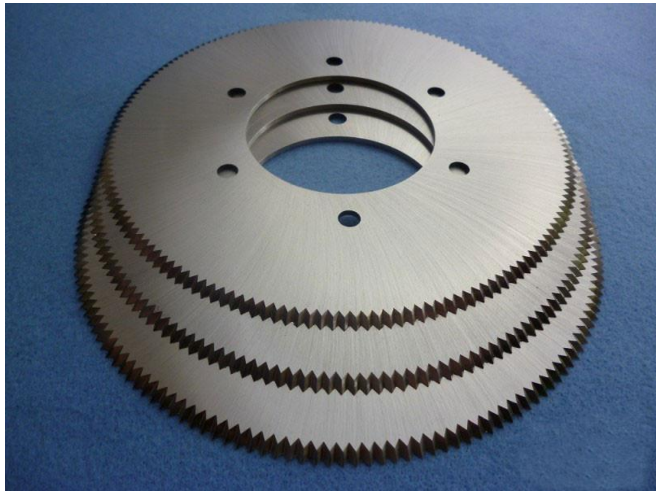
- Juice extraction by milling is the process of squeezing عصر the juice from the cane under a set mills using high pressure between heavy iron rollers.
- Those mills can have from **3 up to 6 rolls**; every set of mills is called a tandem mill or mill train.
- **To improve the milling extraction efficiency**, imbibition water مياه الشرب is added at each mill. Hot water is poured over the cane just before it enters the last mill in the milling train and is recirculated up to reach the first mill.
- The juice squeezed from this cane is low in sugar concentration and is pumped to the preceding mill and poured onto the cane just before it enters the rollers, the juice from this mill is the same way pumped back up the milling train.
- Mixed juice (that is to say cane juice mixed with the water introduced at the last mill) is withdrawn from the first and second mills and is sent for further processing.
- **Milling trains typically have four, five or six mills in the tandem:**

To improve the milling extraction performance before the cane reaches the first mill, knife and shredder preparation equipment is normally used

2. Diffusion

- **Sugarcane diffusion** is the process of extracting the sucrose from the cane with the use of imbibition water but without the squeezing by mills.
- يتم تحقيق ذلك باستخدام سكاكين دوارة وأحيانًا مطاحن مطرقية تسمى "آلة تمزيق الورق".
- Shredded cane is introduced into the diffuser at the feed end, Hot water is poured over the shredded cane just before the discharge end of the diffuser.
- The hot water percolates through the bed of cane and removes sucrose from the cane.





- This dilute juice is then collected in a compartment under the bed of cane and is pumped to a point a little closer to the feed end of the diffuser and this dilute juice is allowed to percolate through the bed of cane.
- At this point the concentration of sucrose in the cane is higher than the concentration of sucrose in the dilute juice just mentioned and so sucrose diffuses from the cane to the juice.
- this now slightly richer juice is pumped back up the diffuser and the process is repeated, typically, 12 to 15 times (compared with the four to six times for the milling process)

Juice clarification

- Sugar cane juice has a pH of about 4.0 to 4.5 which is quite acidic.
- Calcium hydroxide, also known as milk of lime or limewater, is added to the cane juice to adjust its pH to 7.
- The lime helps to prevent sucrose's decay into glucose and fructose.
- The limed juice is then heated to a temperature above its boiling point.
- The superheated limed juice is then allowed to flash to its saturation temperature: this process precipitates impurities which get held up in the calcium carbonate crystals.
- The flashed juice is then transferred to a clarification tank which allows the suspended solids to settle.
- The supernatant, known as clear juice is drawn off the clarifier and sent to the evaporators.

Juice evaporating

- The clarified juice is concentrated in a multiple-effect evaporator to make a syrup of about 50 percent sucrose by weight

Crystallization and centrifuging

- **This syrup is further concentrated under vacuum in a vacuum boiling pan until it becomes** supersaturated, finely ground sugar crystals suspended in alcohol are introduced into the vacuum pan as seed crystals around which sucrose is deposited and these crystals then grow in size until they are ready to be discharged (typically about 1 millimeter (0.039 in))
- Several boiling schemes are possible, the most commonly used boiling scheme is the three-boiling scheme. This method boils the sugar liquors in three stages, called A-, B- and C-.

- A batch type sugar centrifuge separates the sugar crystals from the mother liquor. These centrifuges have a capacity of up to 2,200 kilograms (4,900 lb) per cycle. The sugar from the centrifuges is dried and cooled and then stored in a silo or directly packed into bags for shipment.
- The mother liquor from the first crystallization step (A-product) is again crystallized in vacuum pans and then passed through continuous sugar centrifuges. The mother-liquor is again crystallized in vacuum pans. Due to the low purity the evapo-crystallization alone is not sufficient to exhaust molasses, and so the so-called **massecuite** (French for “boiled mass”) is passed through cooling crystallizers until a temperature of approx. 45 °C (113 °F) is reached.
- Then the massecuite is re-heated in order to reduce its viscosity and then purged in the C-produced centrifugals. The run-off from the C- centrifugal is called molasses.
- The spun-off sugar from the B-product and C-product centrifuges is re-melted, filtered, and added to the syrup coming from the evaporator station.

- Some sugar cane mills have so-called back-end refineries.
- In back-end refineries, raw sugar produced in the mill is converted to refined sugar with a higher purity for local consumption, export, or bottling companies.
- Wastage is used for heat generation in the sugar mills.
- The remaining fibrous solids, called Bagasse مصاص القصب, are burned for fuel in the mill's steam boilers.
- These boilers produce high-pressure steam, which is passed through a turbine to generate electrical energy (cogeneration).
- The exhaust steam from the turbine is passed through the multiple effect evaporator station and used to heat vacuum pans in the crystallization stage as well as for other heating purposes in the sugar mill.
- **Bagasse makes a sugar mill more than energy self-sufficient; surplus bagasse goes in animal feed, in paper manufacture, or to generate electricity for sale.**

References

- *Rein, P.W. (1995). "A Comparison of Cane Diffusion and Milling". Proceedings of the South African Sugar Technologists' Association.*
- *Kelly, P. S.; Porter, R. G. (1978), "Operation of the Inkerman Diffuser", Proceedings of the Forty-Fifth Conference of the Australian Society of Sugar Cane Technologists*
- *Oates, J. A. H. (2008). Lime and Limestone: Chemistry and Technology, Production and Uses*. John Wiley & Sons. *ISBN 978-3-527-61201-7*.
- *White- sugarcane-production by Peter Rein l ResearchGate*

Soap Industry

Content

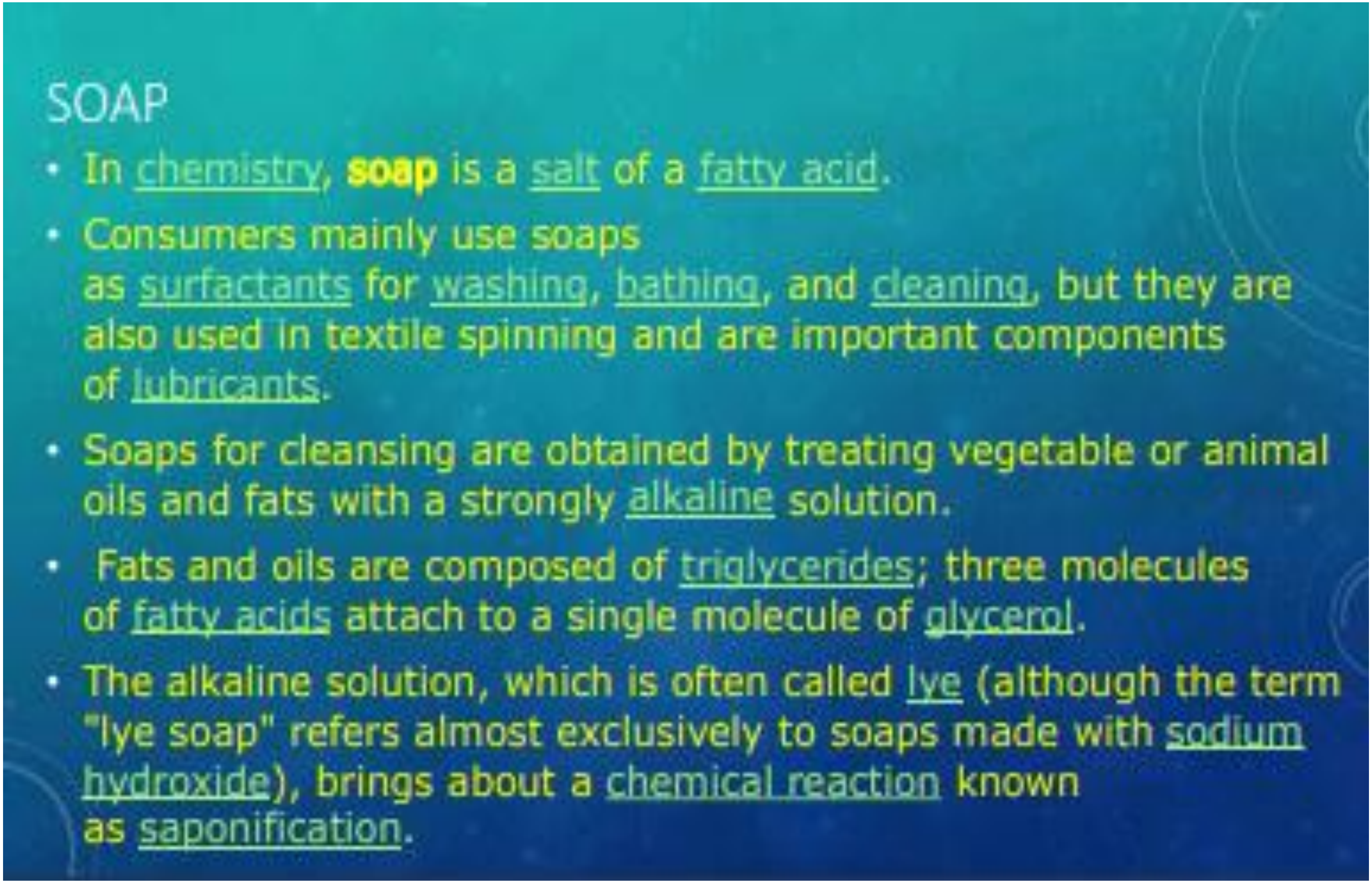
1- What is Soap ?
2- Composition of Soap
3- Mechanism of Action
4- Examples
5- Saponification

What is SOAP?

- Soap is a cleansing agent created by the chemical reaction of a fatty acid with an alkali metal hydroxide.
- Raw materials mostly obtained from animal kingdom (fat) and plant kingdom (oils).
- Soap is of natural origin, so it is biodegradable and eco friendly.

Raw Materials:

- Traditionally, soap has been manufactured from alkali (lye) and animal fats (tallow),
- Although vegetable products such as palm oil, coconut oil, almonds oil are used nowadays.



SOAP

- In chemistry, **soap** is a salt of a fatty acid.
- Consumers mainly use soaps as surfactants for washing, bathing, and cleaning, but they are also used in textile spinning and are important components of lubricants.
- Soaps for cleansing are obtained by treating vegetable or animal oils and fats with a strongly alkaline solution.
- Fats and oils are composed of triglycerides; three molecules of fatty acids attach to a single molecule of glycerol.
- The alkaline solution, which is often called lye (although the term "lye soap" refers almost exclusively to soaps made with sodium hydroxide), brings about a chemical reaction known as saponification.

Composition Of Soap

- **AlKali Material**

(50%of fats)

- **Fat**

(Tallow with 20% Grease)

- **Oil**

(Coconut 15%)

Alkali Material:

- The Alkali most commonly used today is NaOH.
- KOH can also be used. Potassium based soap creates a more water soluble product than sodium based soap, and so it is called “Soft soap”. Soft soap, alone or in combination with sodium based soap in commonly used in Shaving products.

Fat or Tallow :

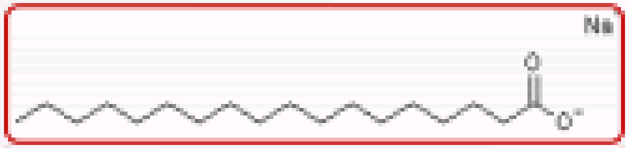
- Tallow is obtained from suet and used in making soap.
- Tallow is the fat obtained by rendering beef or mutton.
- Tallow is the harder and less fusible fat in animals and vegetables.
- Tallow is the white (nearly tasteless) solid rendered fat of cattle and sheep used for making candles, soap, and pet foods.

Oil:

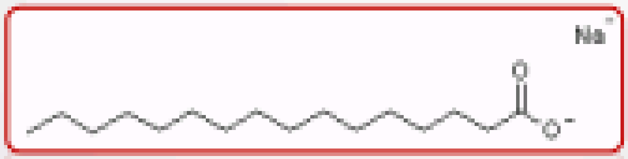
- Almond Oil , extracted from the seeds of sweet almonds is used as an emollient in high quality soap.
- Almond oil prevents dehydration of skin.
- Palm oil, coconut oil, produced by processing of palm fruit and coconut can be used in soap.
- Soap from coconut frim and lather well ,
- Coconut reduce hardness to increase solubility
- Coconut contain large proportion of lauric and myristic acid as well as small quantity of oleic, stearic, palmitic etc .
- Fish oil can also be used and better in processing of soap

EXAMPLES OF SOAPS

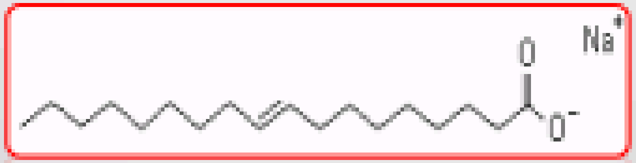
- ***Sodium stearate*** (Chemical formula: $C_{17}H_{35}COO^{-}Na^{+}$)



- ***Sodium palmitate*** (Chemical formula: $C_{15}H_{31}COO^{-}Na^{+}$)

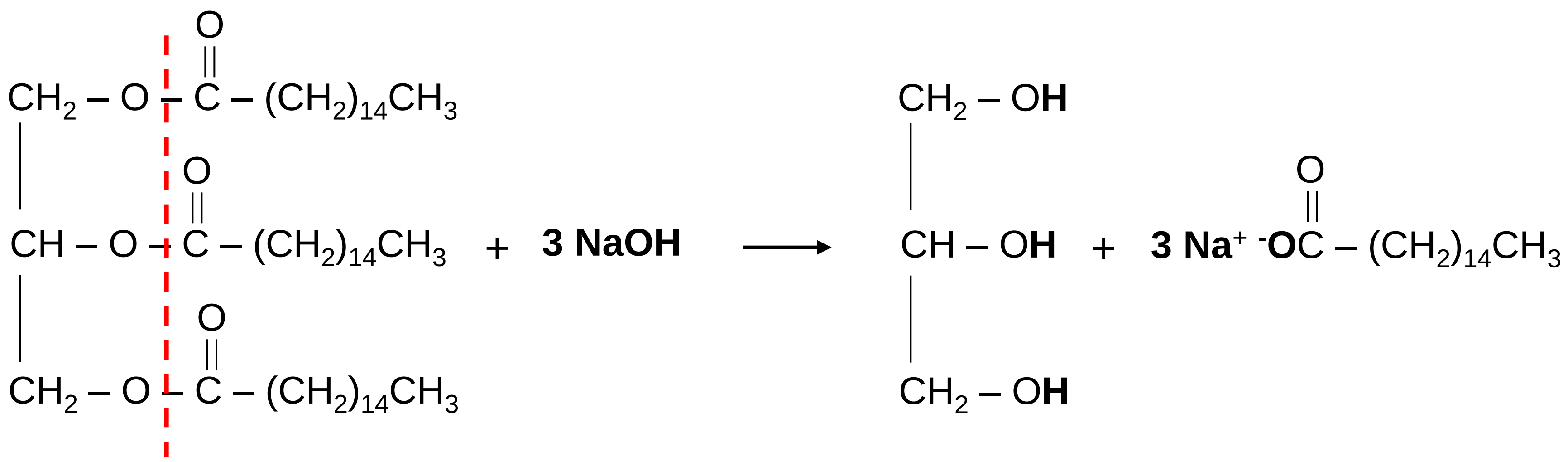


- ***Sodium oleate*** (Chemical formula: $C_{17}H_{33}COO^{-}Na^{+}$)



Saponification

Process of making soap from animal fat or vegetable oil using a base.



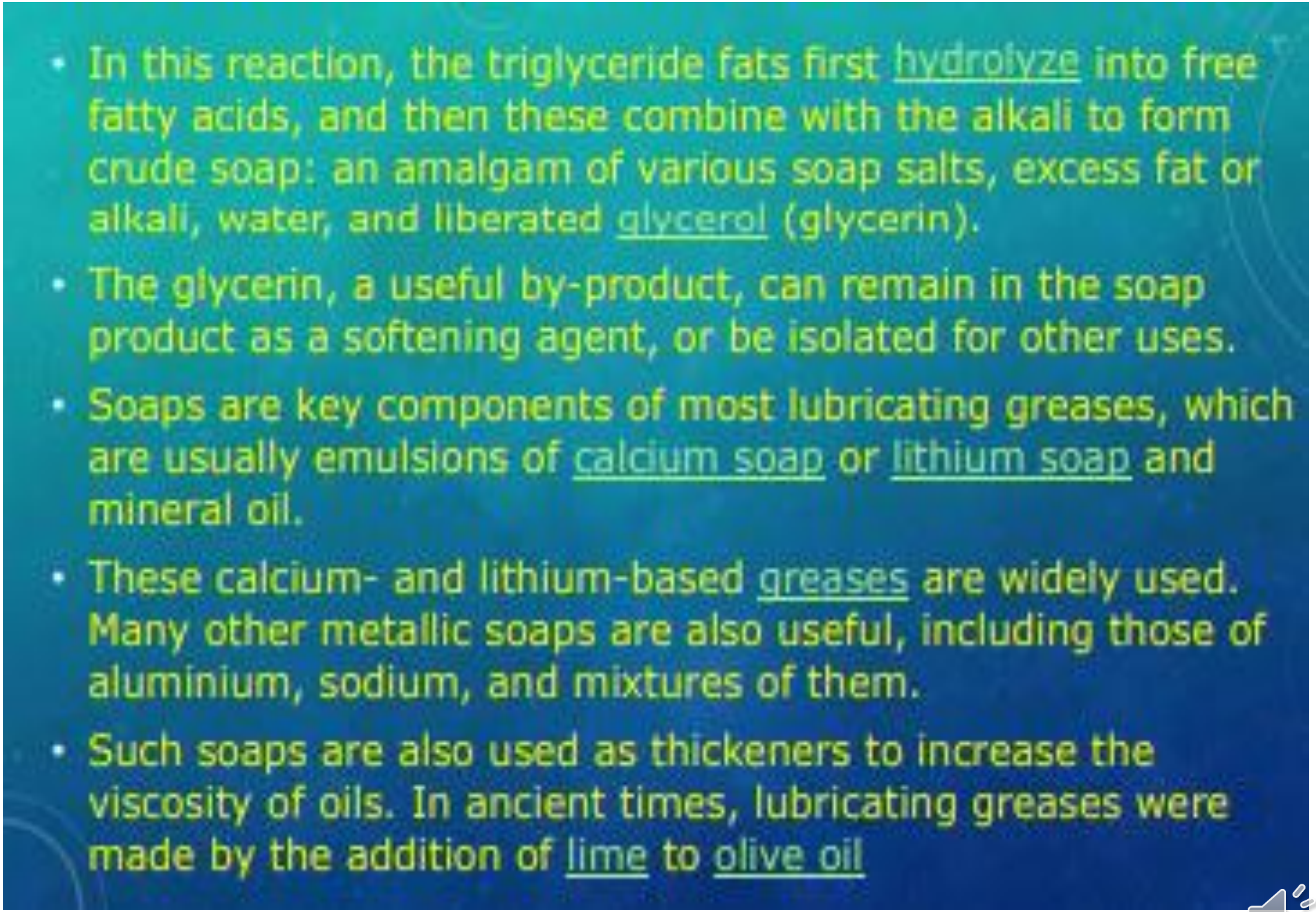
$$\begin{array}{l} CH_2-O-\overset{O}{\overset{\|}{C}}-(CH_2)_{14}CH_3 \\ | \\ CH-O-\overset{O}{\overset{\|}{C}}-(CH_2)_{14}CH_3 \\ | \\ CH_2-O-\overset{O}{\overset{\|}{C}}-(CH_2)_{14}CH_3 \end{array} + \mathbf{3\ NaOH} \longrightarrow \begin{array}{l} CH_2-O\mathbf{H} \\ | \\ CH-O\mathbf{H} \\ | \\ CH_2-O\mathbf{H} \end{array} + \mathbf{3\ Na^+}\ {}^{-}\mathbf{O}\overset{O}{\overset{\|}{C}}-(CH_2)_{14}CH_3$$

glyceryl tripalmitate
(tripalmitin)

sodium
hydroxide

glycerol

3 sodium palmitate
(soap)

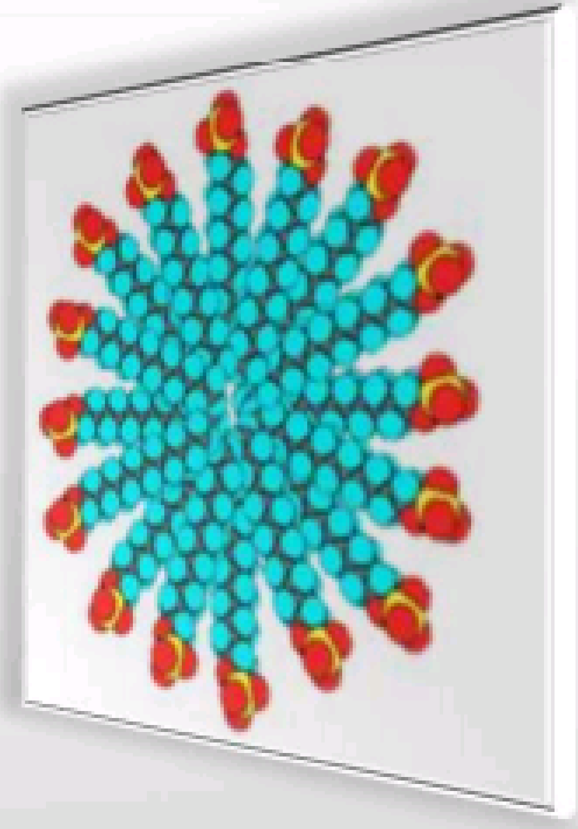


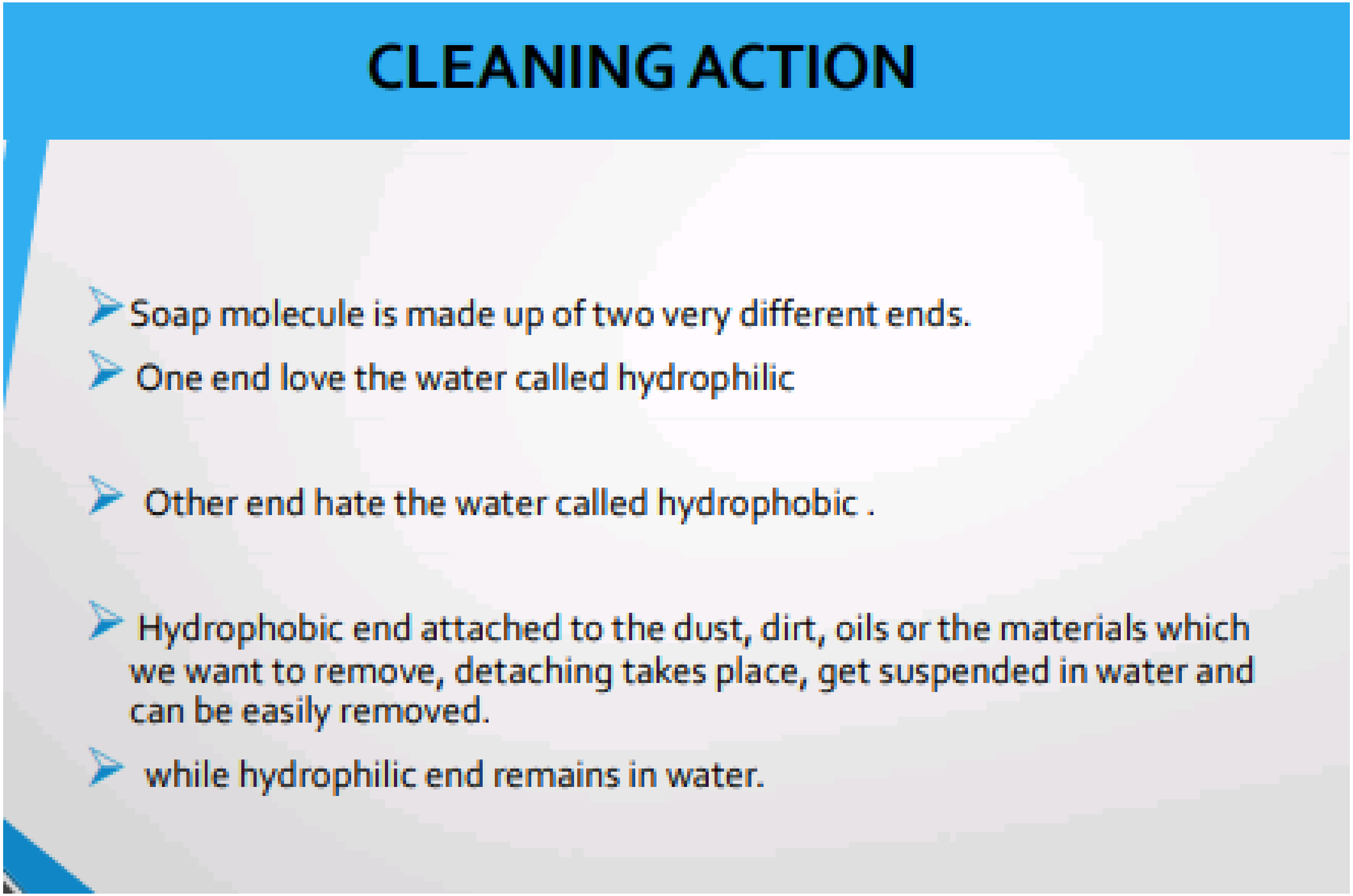
- In this reaction, the triglyceride fats first hydrolyze into free fatty acids, and then these combine with the alkali to form crude soap: an amalgam of various soap salts, excess fat or alkali, water, and liberated glycerol (glycerin).
- The glycerin, a useful by-product, can remain in the soap product as a softening agent, or be isolated for other uses.
- Soaps are key components of most lubricating greases, which are usually emulsions of calcium soap or lithium soap and mineral oil.
- These calcium- and lithium-based greases are widely used. Many other metallic soaps are also useful, including those of aluminium, sodium, and mixtures of them.
- Such soaps are also used as thickeners to increase the viscosity of oils. In ancient times, lubricating greases were made by the addition of lime to olive oil

MICELLES – SOAP MOLECULES

- A soap molecule has two ends with different properties:

1. A long hydrocarbon part which is hydrophobic (i.e. it dissolves in hydrocarbon).
2. A short ionic part containing COO-Na+ which is hydrophilic (i.e. it dissolves in water).





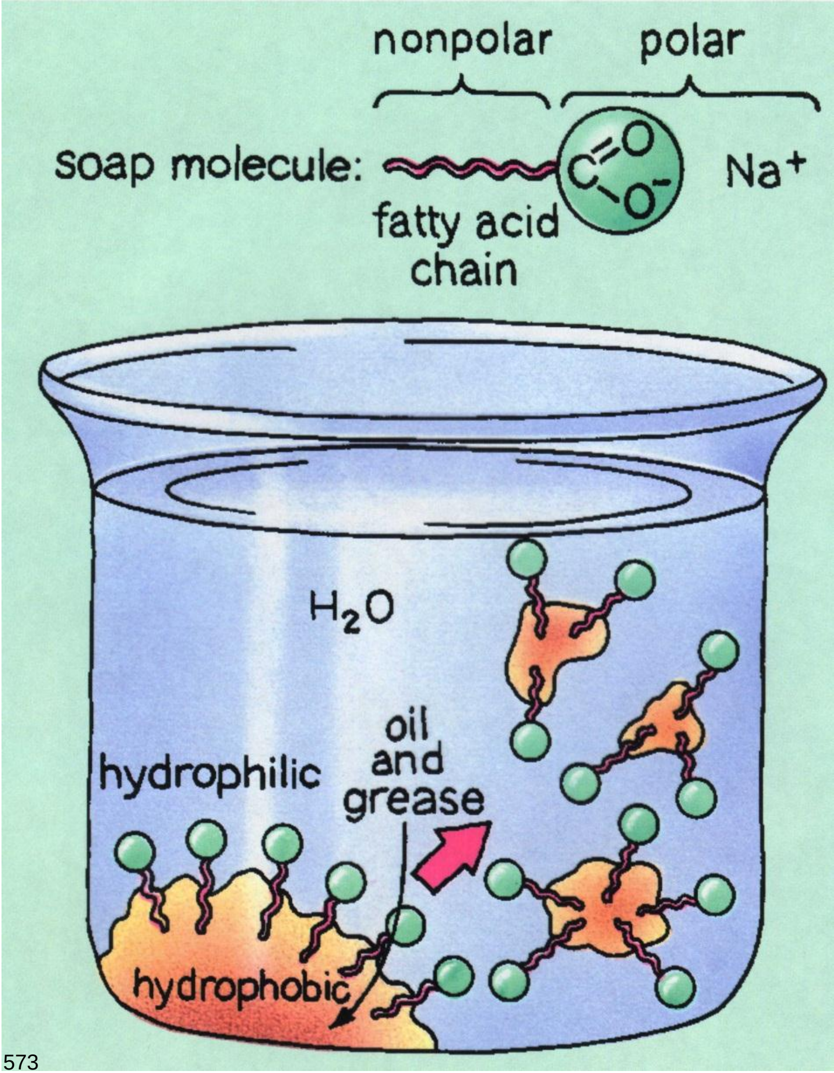
CLEANING ACTION

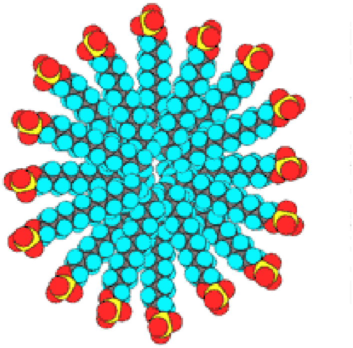
- Soap molecule is made up of two very different ends.
- One end love the water called hydrophilic

- Other end hate the water called hydrophobic .

- Hydrophobic end attached to the dust, dirt, oils or the materials which we want to remove, detaching takes place, get suspended in water and can be easily removed.
- while hydrophilic end remains in water.

Cleaning Action of Soap



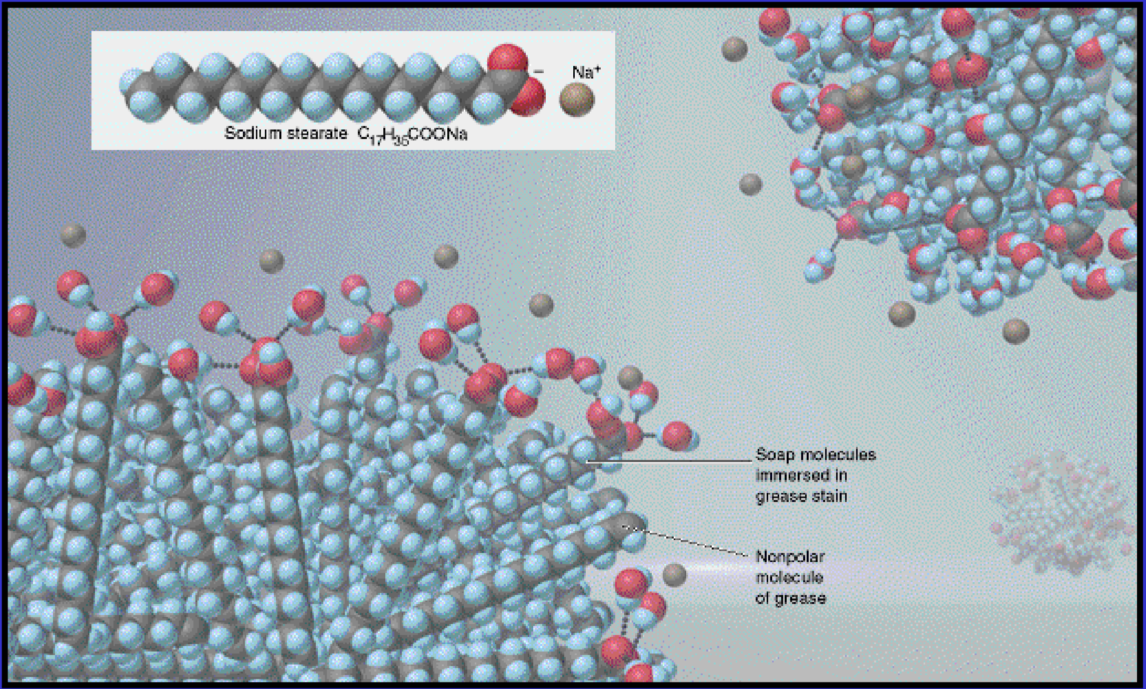


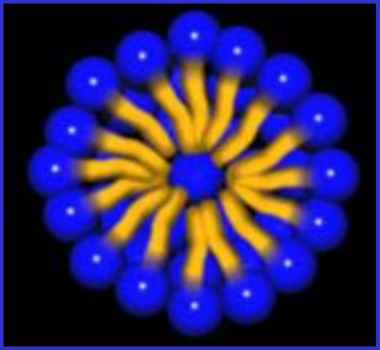
Micelle

Timberlake, Chemistry 7th Edition, page 573

Solvation

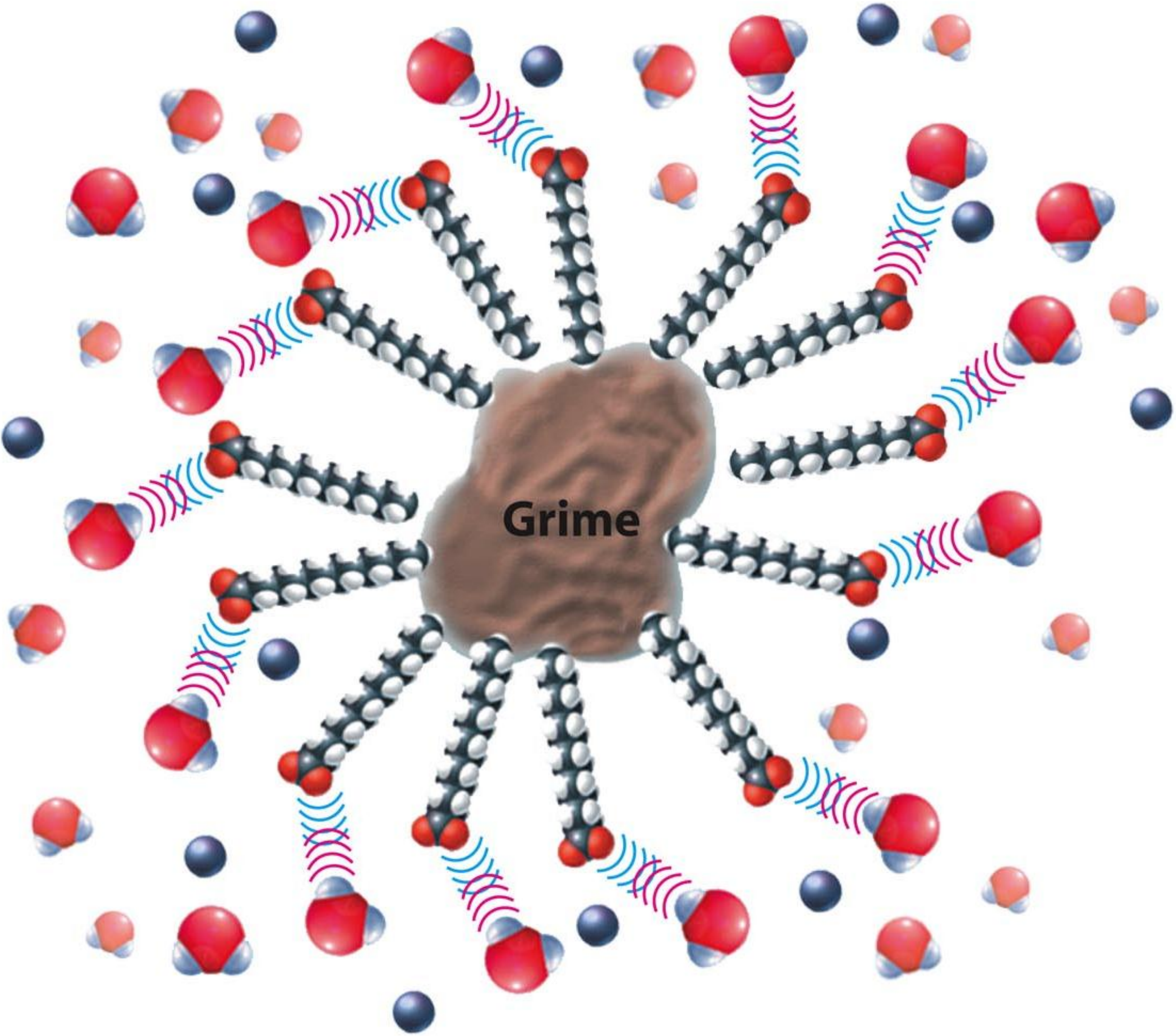
- **Soap / Detergent**
  - *polar* "head" with long *nonpolar* "tail"
  - dissolves nonpolar grease in polar water





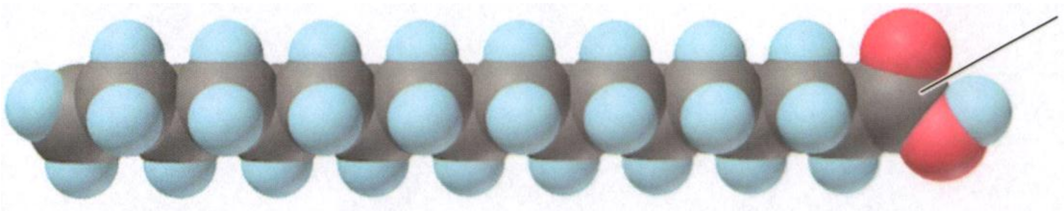
micelle

Micelle



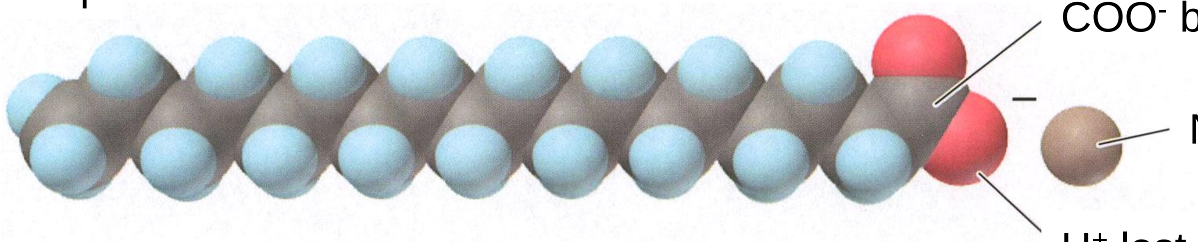
Stearic Acid

Fatty acid



Carboxylic acid group

Soap

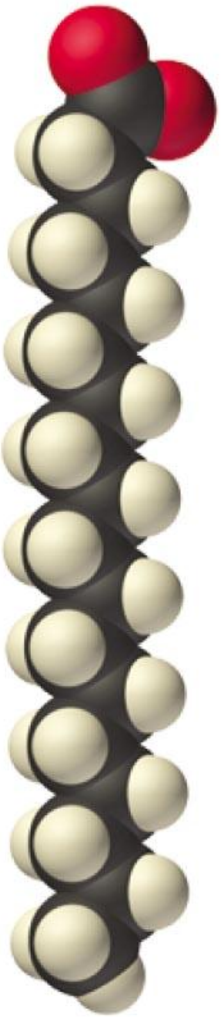


COO^- bonds to a metal ion (Na^+)

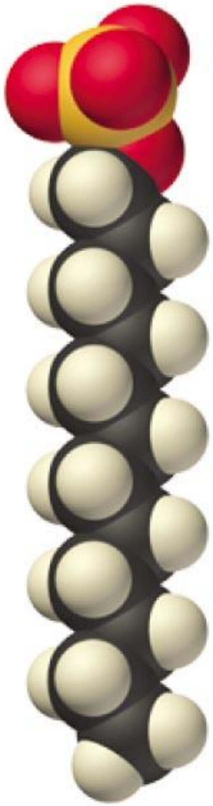
Na^+

H^+ lost from —COOH

Kelter, Carr, Scott, Chemistry A Wolrd of Choices 1999, page 257

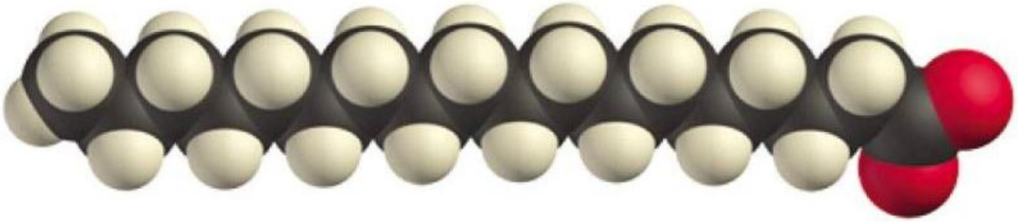


Sodium stearate: a soap



Sodium dodecyl sulfate: a detergent

Sodium stearate: a soap

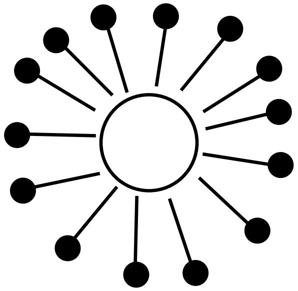


Sodium dodecyl sulfate: a detergent

SOAP	vs.	DETERGENT
-- made from animal and vegetable fats		-- made from petroleum
		-- works better in hard water

Hard water contains minerals ^{w}/ions like Ca^{2+}, Mg^{2+}, and Fe^{3+} that replace Na^{1+} at polar end of soap molecule. Soap is changed into an insoluble precipitate (i.e., soap scum).

micelle: a liquid droplet covered ^{w}/soap or detergent molecules



-:POLYMER:-

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CONTENT:-

1. INTRODUCTION
2. CLASSIFICATION OF POLYMER
3. TYPES OF POLYMERIZATION
4. CHARACTERISTICS OF POLYMERS
5. APPLICATION OF POLYMERS

INTRODUCTION

- A WORD POLYMER IS A COMBINATION OF TWO GREEK WORDS, “POLY” MEANS “MANY” AND “MEROS” MEANING “PARTS OR UNITS”.

  A POLYMER IS A LARGE MOLECULE OF WHICH IS FORMED BY REPEATED LINKING OF THE SMALL MOLECULES CALLED “MONOMERS”.

  MORE MONOMER MOLECULES JOINED IN UNITS OF LONG POLYMER.

$$\underset{\text{ETHYLENE}}{N(CH_2\text{-}CH_2)} \longrightarrow \underset{\text{POLYETHYLENE}}{(\text{-}CH_2\text{-}CH_2\text{-})_N}$$

CLASSIFICATION OF POLYMER

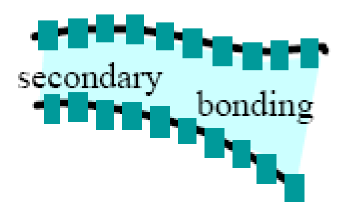
- CLASSIFICATION BASED ON SOURCE
- CLASSIFICATION BASED ONSTRUCTURE
- CLASSIFICATION BASED ON POLYMERISATION
- CLASSIFICATION BASED ON MOLECULER FORCE

CLASSIFICATION BASED ON SOURCE

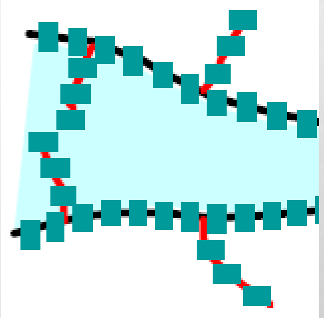
1. **NATURAL POLYMERS**:- THE DEFINITION OF A NATURAL POLYMER IS A POLYMER THAT RESULTS FROM ONLY RAW MATERIALS THAT ARE FOUND IN NATURE. EXAMPLE:- PROTEINS, CELLULOSE, STARCH, RUBBER.
2. **SEMI-SYNTHESIS POLYMERS**:- CELLULOSE DERIVATIVES - CELLULOSE ACETATE (RAYON).
3. **SYNTHESIS POLYMERS**:- BUNA-S, BUNA-R, NYLON, POLYTHENE, POLYESTER.

CLASSIFICATION BASED ON STRUCTURE

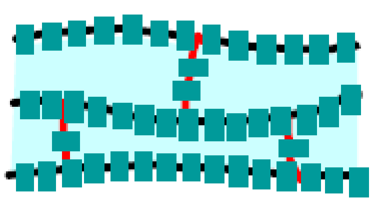
1. **LINEAR POLYMERS:-** CONSIST OF LONG AND STRAIGHT CHAINS. EXAMPLE:- PVC
2. **BRANCHED CHAIN POLYMERS:-** CONTAIN LINEAR CHAINS HAVING SOME BRANCHES, E.G., LOW DENSITY POLYMER.
3. **CROSS LINKED CHAIN POLYMERS:-** FORMED FROM BI-FUNCTIONAL AND TRI-FUNCTIONAL MONOMERS AND CONTAIN STRONG COVALENT BONDS E.G. BAKELITE, MELAMINE.



LINEAR



BRANCHED



CROSS-LINKED

CLASSIFICATION BASED ON POLYMERIZATION

1. ADDITION POLYMERS

FORMED BY THE REPEATED ADDITION OF MONOMER MOLECULES POSSESSING DOUBLE OR TRIPLE BONDS

$$N(CH_2{=}CH_2) \longrightarrow -(CH_2-CH_2)-$$

ETHYLENE POLYETHYLENE

2. CONDENSATION POLYMERS

FORMED BY REPEATED CONDENSATION REACTION BETWEEN TWO DIFFERENT BI-FUNCTIONAL OR TRI-FUNCTIONAL MONOMERIC UNITS.

EG. TERYLENE (DACRON), NYLON 6, 6, NYLON 6.

$$N(H_2N(CH_2)_6NH_2) + N(HOOC(CH_2)_4COOH) \longrightarrow [-NH(CH_2)_6NHCO(CH_2)_4CO-]_N + NH_2O$$

(NYLON 6:6)

CLASSIFICATION BASED ON MOLECULER FORCE

1. **NYLON**:- NYLON IS USED AS GENERAL NAME FOR ALL SYNTHETIC FIBER FORMING POLYAMIDES,I.E., HAVING A PROTEIN LIKE STRUCTURE. THESE ARE THE CONDENSATION POLYMERS OF DIAMINES AND DIBASIC ACIDS A NUMBER IS USUALLY SUFFIXED WITH THE NYLON WHICH REFERS TO THE NUMBER OF CARBON ATOMS PRESENT IN THE DIAMINE AND THE DIBASIC ACIDS RESPECTIVELY.

   EXAMPLE: NYLON 6,6

   NYLON-6,6: NYLON-6,6 IS OBTAINED BY THE POLYMERISATION OF ADIPIC ACID WITH HEXAMETHYLENE DIAMINE.

$$nHOOC(CH_2)_4COOH + nH_2N(CH_2)_6\ NH_2 \xrightarrow[\text{High pressure}]{553K} [-\underset{\underset{H}{|}}{N}-(CH_2)_6-N-\ \underset{\underset{O}{\|}}{C}(CH_2)_4-\underset{\underset{O}{\|}}{C}-]_n$$

2. THERMOPLASTIC POLYMERS:-

THESE ARE LINEAR OR SLIGHTLY BRANCHED LONG CHAIN POLYMERS, WHICH CAN BE SOFTENED ON HEATING & REVERSIBLY HARDENED ON COOLING REPEATEDLY. THEIR HARDNESS IS A TEMPORARY PROPERTY & VARIES WITH TEMPERATURE.

EXAMPLE:- POLYVINYL CHLORIDE.

POLYVINYL CHLORIDE:- IT IS A VINYL POLYMER CONSTRUCTED OF REPEATING VINYL GROUPS (ETHENYLS) HAVING ONE OF THEIR HYDROGENS REPLACED WITH A CHLORIDE GROUP.

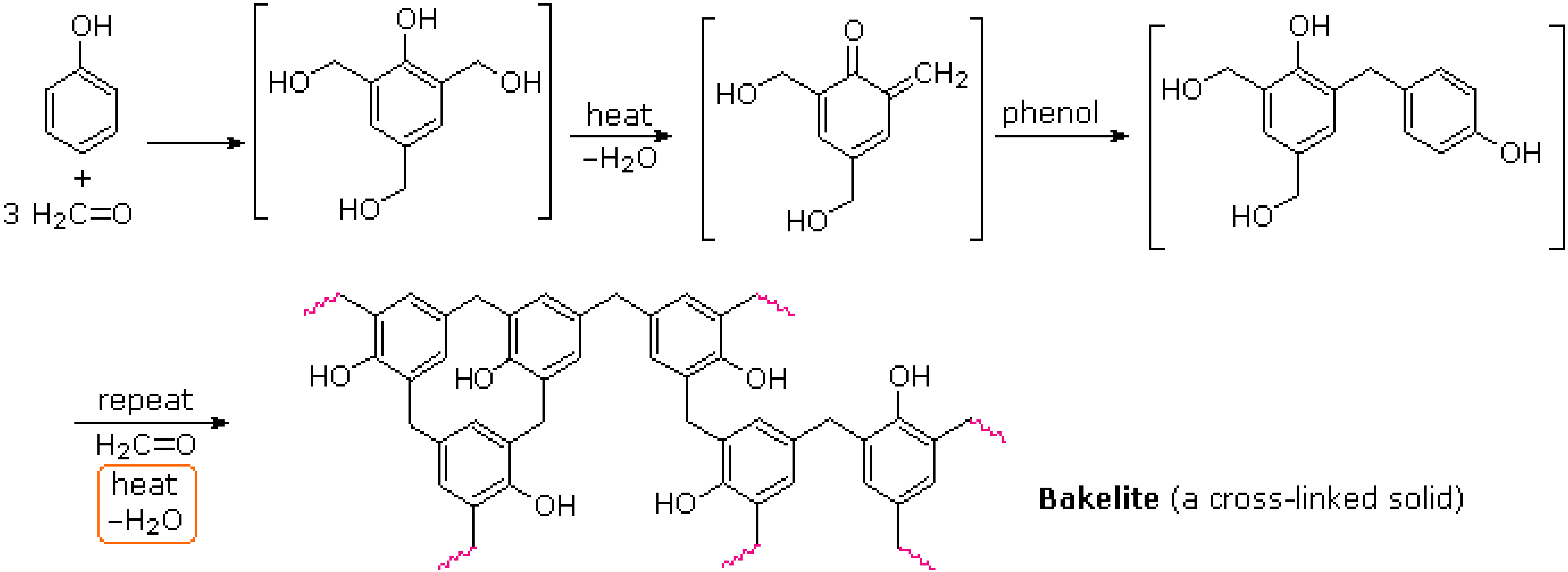
3. THERMOSETTING POLYMERS:-

INITIAL MIXTURE OF REACTIVE, LOW MOLAR MASS COMPOUNDS REACTS UPON HEATING IN THE MOLD TO FORM AN INSOLUBLE, INFUSIBLE NETWORK.

EXAMPLE: BAKELITE

BAKELITE: BAKELITE IS FORMED OF PHENOL AND FORM-ALDEHYDE POLYMERIZATION.

Phenol-Formaldehyde Resin



Bakelite (a cross-linked solid)

TYPES OF POLYMERIZATION

1. ADDITION POLYMERIZATION
2. CONDENSATION POLYMERIZATION
3. ADDITION POLYMERIZATION:-

- ❑ THE POLYMER IS FORMED FROM THE MONOMER, WITHOUT THE LOSS OF ANY MATERIAL, AND THE PRODUCT IS THE EXACT MULTIPLE OF THE ORIGINAL MONOMERIC MOLECULE.
- ❑ ADDITION POLYMERIZATION PROCEEDS BY THE INITIAL FORMATION OF SOME REACTIVE SPECIES SUCH AS FREE RADICALS OR IONS AND BY THE ADDITION OF THE REACTIVE SPECIES TO THE OTHER MOLECULE, WITH THE REGENERATION OF THE REACTIVE FEATURE.

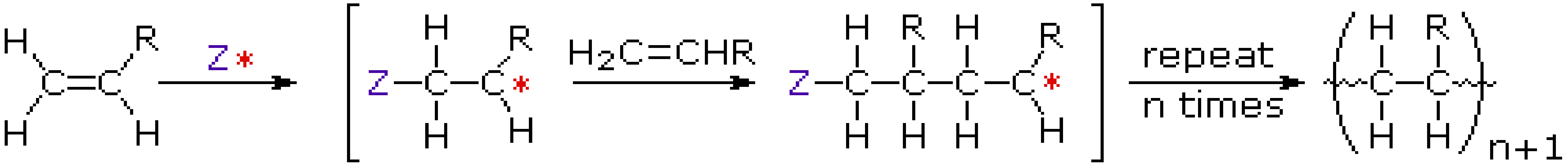
1. FREE RADICAL MECHANISM:- ALKENES OR DIENES AND THEIR DERIVATIVES ARE POLYMERIZED IN THE PRESENE OF A FREE RADICAL GENERATING INITIATOR (CATALYST) LIKE BENZOYL PEROXIDE, ACETYL PEROXIDE, T-BU PEROXIDE, ETC.

THIS PROCESS INVOLVES THREE STEPS:-

A) CHAIN INITIATION STEP - ADDITION OF PHENYL FREE RADICAL FORMED BY THE PEROXIDE TO THE ETHENE DOUBLE BOND ,THEREBY FORMING A LARGER RADICAL.

B) CHAIN PROPAGATION STEP - REPETITION OF THIS SEQUENCE WITH NEW AND BIGGER RADICALS.

C) CHAIN TERMINATING STEP - THE PRODUCT RADICAL THUS FORMED REACTS WITH ANOTHER RADICAL TO FORM THE POLYMERIZED PRODUCT.



Z* is an initiating species

* may be a radical, a cation or an anion

EXAMPLE: POLYTETRAFLOUROETHYLENE(TEFLON)

TEFLON:-

IT IS OBTAINED BY POLYMERIZATION OF WATER-EMULSION OF TETRAFLUORO ETHYLENE, UNDER PRESSURE AND IN THE PRESENCE OF BENZOYL PEROXIDE AS A CATALYST.

$$n(CF_2 = CF_2) \xrightarrow{\text{Polymerize}} \left[-\overset{F}{\underset{F}{C}}-\overset{F}{\underset{F}{C}}- \right]_n$$

2. CONDENSATION POLYMERIZATION:-

PROCESS IN WHICH TWO MONOMERS REACT TO FORM A LARGER MOLECULE AND **ELIMINATE A SMALLER MOLECULE** (USUALLY WATER, AMMONIA, METHANOL OR HYDROGEN CHLORIDE).

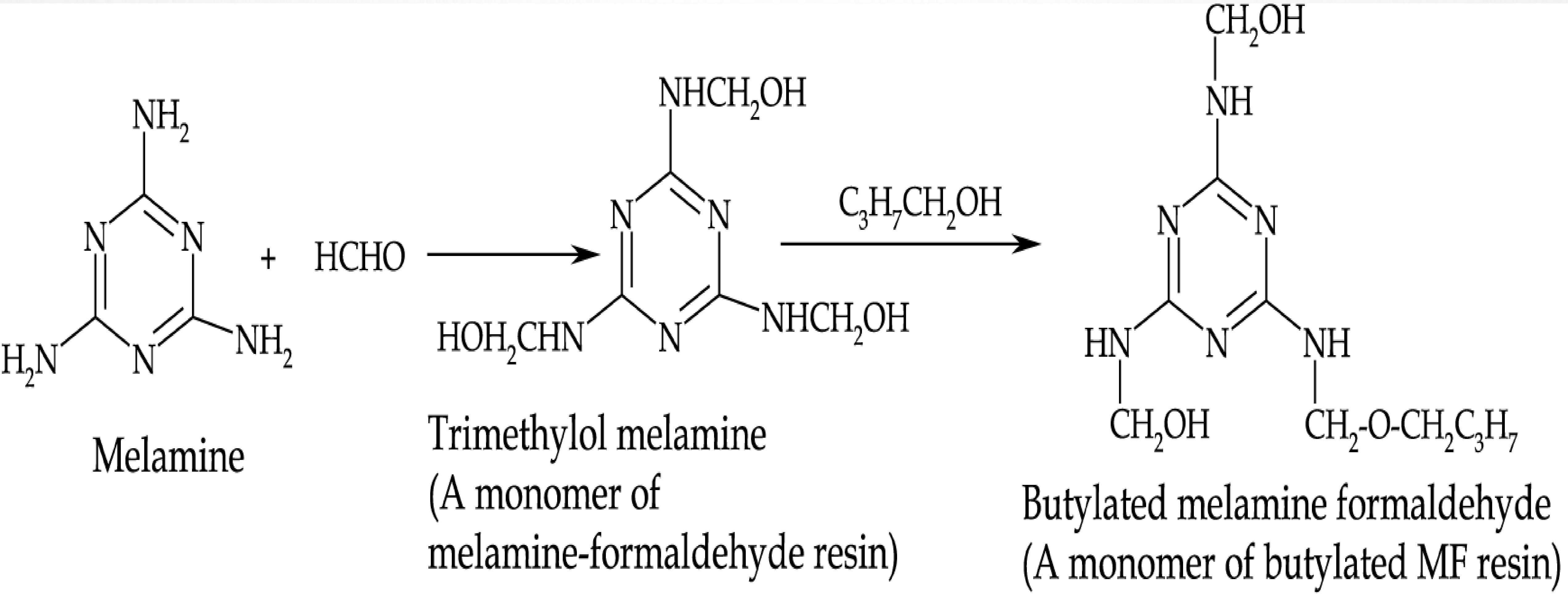
IT ALSO CALLED AS STEP-GROWTH POLYMERIZATION.

EXAMPLE:-

1. POLYAMIDE:- NYLON 6-6, NYLON 6.
2. POLYESTER:- TERILIN
3. BAKELITE POLYMER
4. MALEMIN POLYMER

MALEMIN POLYMER

THE RESIN IS FORMED BY CONDENSATION CO-POLYMERISATION OF MELAMINE AND FORMALDEHYDE.



Melamine

Trimethylol melamine
(A monomer of
melamine-formaldehyde resin)

Butylated melamine formaldehyde
(A monomer of butylated MF resin)

CHARACTERISTICS OF POLYMER

- LOW DENSITY.
- LOW COEFFICIENT OF FRICTION.
- GOOD CORROSION RESISTANCE.
- GOOD MOULD ABILITY.
- EXCELLENT SURFACE FINISH CAN BE OBTAINED.
- CAN BE PRODUCED WITH CLOSE DIMENSIONAL TOLERANCES.
- ECONOMICAL.
- POOR TENSILE STRENGTH.
- LOW MECHANICAL PROPERTIES.
- POOR TEMPERATURE RESISTANCE.
- CAN BE PRODUCED TRANSPARENT OR IN DIFFERENT COLOURS

APPLICATION OF POLYMERS

1. **MEDICINE:-** MANY BIOMATERIALS, ESPECIALLY HEART VALVE REPLACEMENTS AND BLOOD VESSELS, ARE MADE OF POLYMERS LIKE DACRON, TEFLON AND POLYURETHANE.
2. **CONSUMER SCIENCE** :- PLASTIC CONTAINERS OF ALL SHAPES AND SIZES ARE LIGHT WEIGHT AND ECONOMICALLY LESS EXPENSIVE THAN THE MORE TRADITIONAL CONTAINERS. CLOTHING, FLOOR COVERINGS, GARBAGE DISPOSAL BAGS, AND PACKAGING ARE OTHER POLYMER APPLICATIONS.
3. **INDUSTRY**:- AUTOMOBILE PARTS, WINDSHIELDS FOR FIGHTER PLANES, PIPES, TANKS, PACKING MATERIALS, INSULATION, WOOD SUBSTITUTES, ADHESIVES, MATRIX FOR COMPOSITES, AND ELASTOMERS ARE ALL POLYMER APPLICATIONS USED IN THE INDUSTRIAL MARKET.
4. **SPORTS:-** PLAYGROUND EQUIPMENT, VARIOUS BALLS, GOLF CLUBS, SWIMMING POOLS, AND PROTECTIVE HELMETS ARE OFTEN PRODUCED FROM POLYMERS.

THANK YOU

Pharmaceutical Industry (companies)

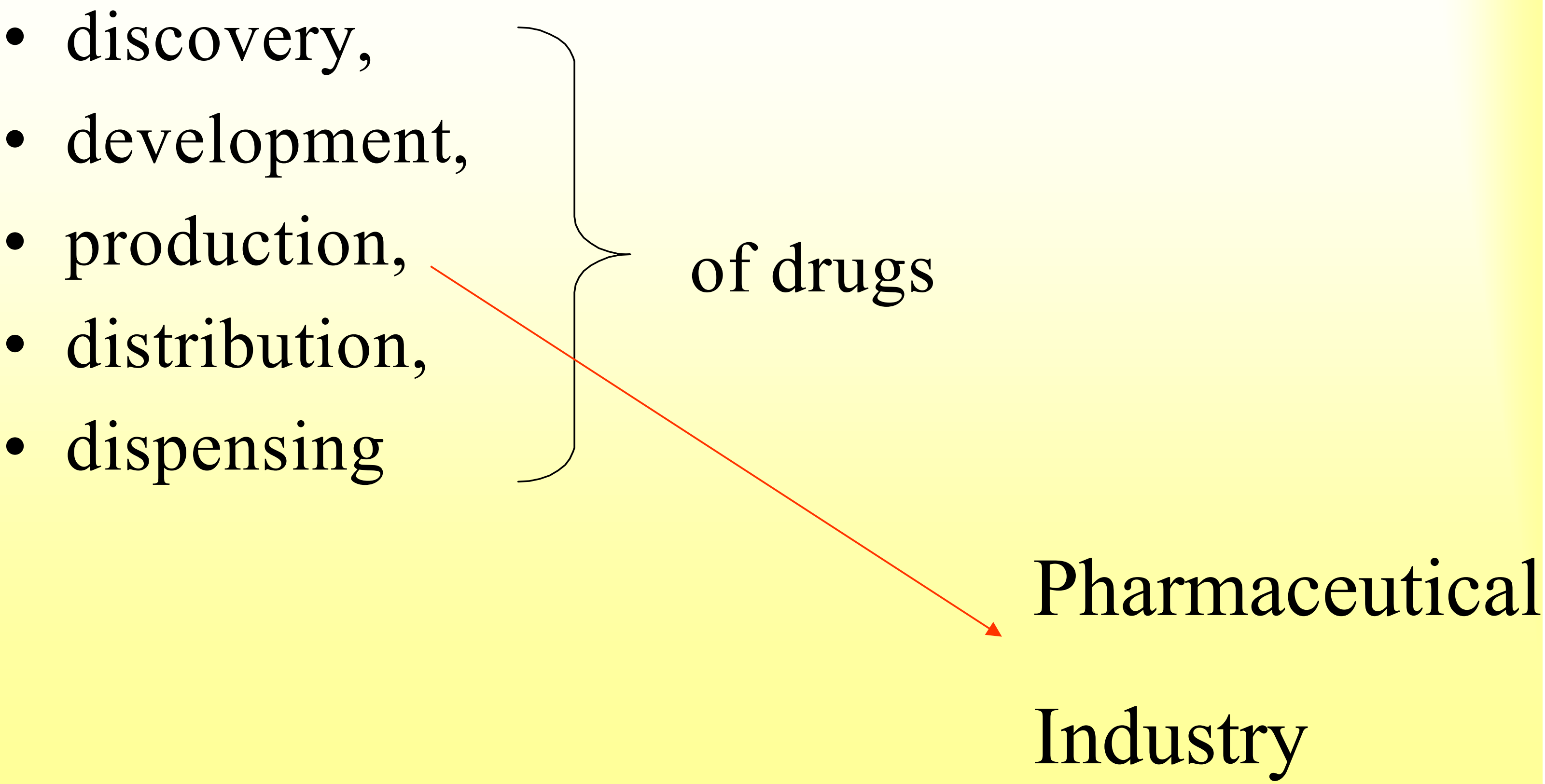
also called

Pharmaceutical Manufacturing Industry,

or Drug Production Sphere

„Pharmacy“

is a **health profession** concerned with:



- discovery,
- development,
- production,
- distribution,
- dispensing

of drugs

Pharmaceutical

Industry

The Pharmaceutical Industry

undertakes

the research, development, **production**

and supply of

pharmaceutical products

needed to save lives,

prevent disease,

and otherwise assist in maintaining

quality of life.

The Pharmaceutical Industry

notable contributes to human progress, including the development of miracle drugs for treating diseases.

By the 19th century,

many of the public (hospital) pharmacies
(drug stores)
in Europe and North America
have eventually developed into larger pharmaceutical companies.

The modern era of the pharmaceutical industry

of isolation and purification of compounds, chemical synthesis, and computer-aided drug design

is considered to have begun in the 19th century,

thousands of years after intuition and trial and error

led humans to believe that plants, animals, and minerals contained medicinal properties.

Most of today's major pharmaceutical companies were founded in the late 19th and early 20th centuries.

Key discoveries of the 1920s and 1930s, became mass-manufactured and distributed.

Switzerland, Germany and Italy had particularly strong industries, with the UK, US, Belgium and the Netherlands following suit.

The Pharmaceutical Industry
spans a spectrum of activities

- from the ultra-high research and development segment associated with human-use **prescription medicines**

through

- to the production of the **generic over the counter medicines.**

There are **3 main types** of pharmaceutical companies:

1. **Large pharmaceutical companies.**
2. **Smaller pharmaceutical companies.**
3. **Generic pharmaceutical companies**

Large, or mainline, pharmaceutical companies

are established firms that **have many approved drugs already on the market**.

These companies often have significant numbers of R&D (research and development) laboratories

throughout around the world.

Many of the largest pharmaceutical companies

are **multinational**,

having research, manufacturing, and sales taking place in multiple countries.

The phrase **Big Pharma**

is often used to refer to companies with revenue in excess of $ 3 billion

In contrast, smaller pharmaceutical companies are usually newer firms that often do **not have any approved drugs on the market.**

As a result, these firms almost exclusively perform R&D. In addition to developing their own drugs, some small pharmaceutical companies perform contract research for other pharmaceutical companies.

Finally, **generic pharmaceutical companies**

manufacture drugs that are no longer protected by patents.

Because their products are all established drugs, they devote fewer resources to R&D

and more to manufacturing.

„mass-produced medicines“

MPM

(mass-produced drugs MPD)

They are manufactured in large quantities often by or as if by assembly-line techniques (batches).

Petrochemicals

د. ابوبكر هريدي حجاب

What are petrochemicals?

Classifications of petrochemicals.

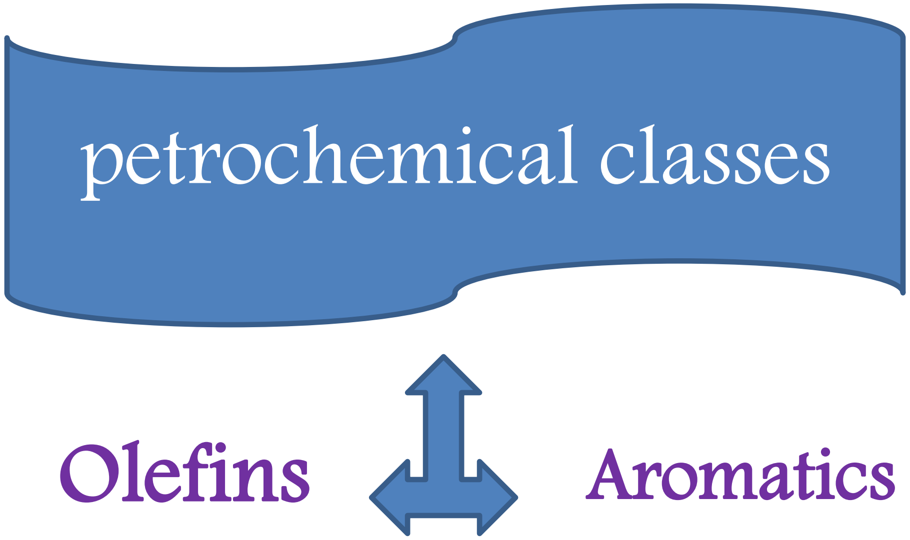
Requirements for petrochemicals industry

Uses of Petrochemicals

Petrochemicals

* Petrochemicals (also known as petroleum distillates) are the chemical products obtained from petroleum by refining.

* Some chemical compounds made from petroleum are also obtained from other fossil fuels, such as coal or natural gas, or renewable sources .

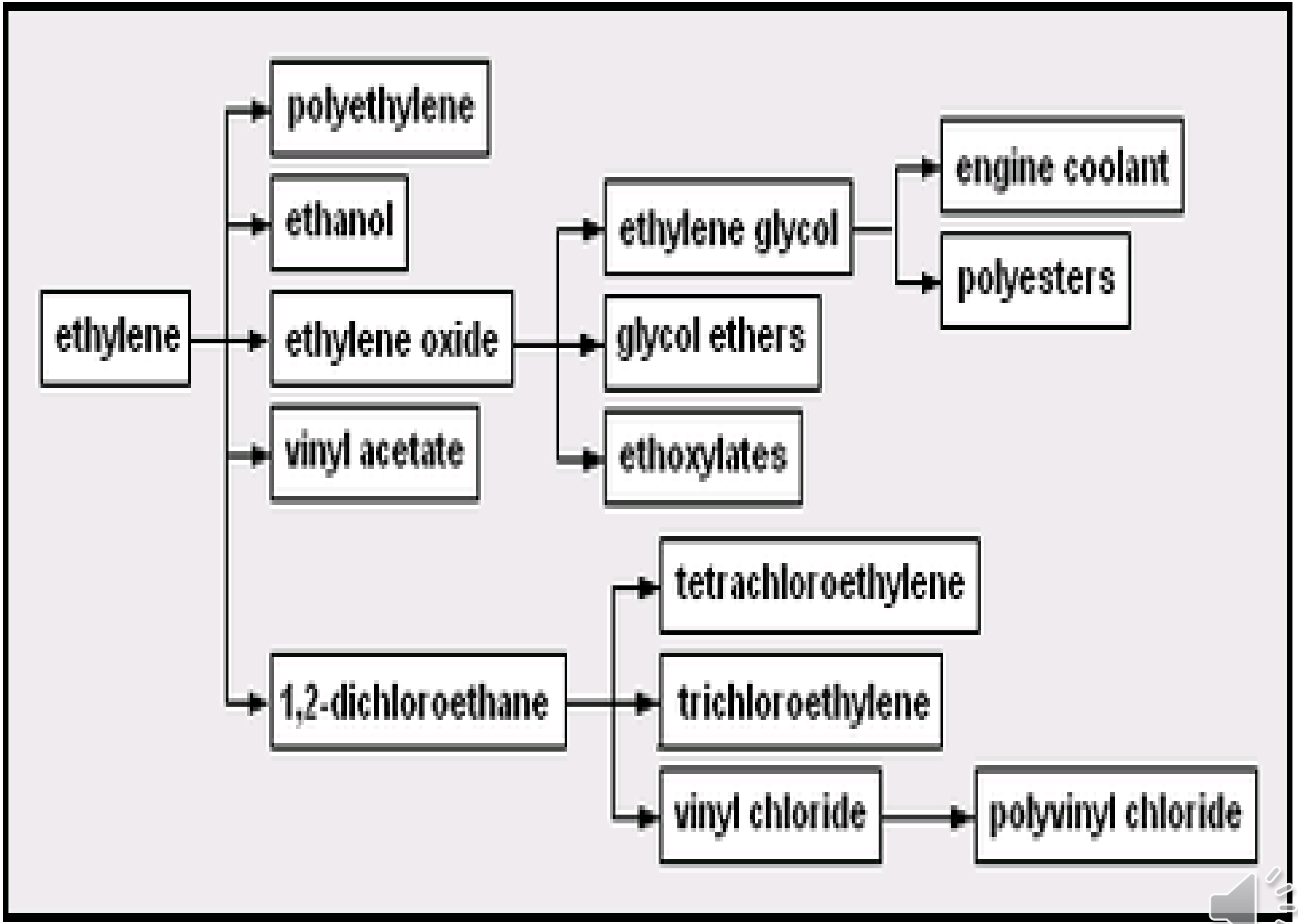


petrochemical classes

Olefins

Aromatics

The following is a partial list of the major commercial petrochemicals and their derivatives:



ethylene

polyethylene

ethanol

ethylene oxide

vinyl acetate

1,2-dichloroethane

ethylene glycol

glycol ethers

ethoxylates

engine coolant

polyesters

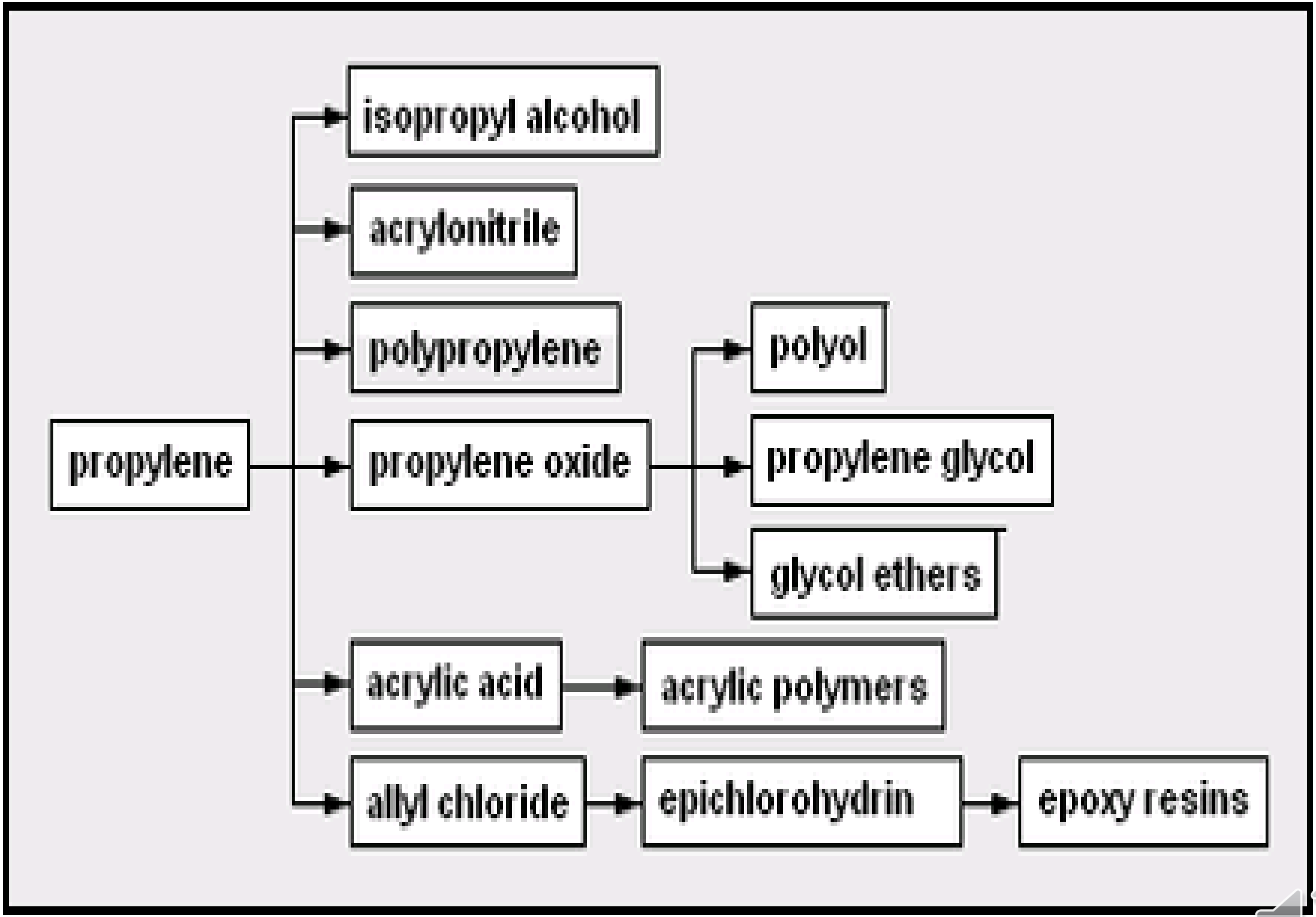
tetrachloroethylene

trichloroethylene

vinyl chloride

polyvinyl chloride

- ethylene – the simplest olefin; used as a chemical feedstock and ripening stimulant.
- Polyethylene polymerized ethylene; LDPE, HDPE,
- ethanol – via ethylene hydration (chemical reaction adding water) of ethylene.
- ethylene oxide – via ethylene oxidation.
- ethylene glycol – via ethylene oxide hydration.
- polyesters – any of several polymers with ester linkages in the main chain.
- glycol ethers – via glycol condescension.



propylene

isopropyl alcohol

acrylonitrile

polypropylene

propylene oxide

polyol

propylene glycol

glycol ethers

acrylic acid

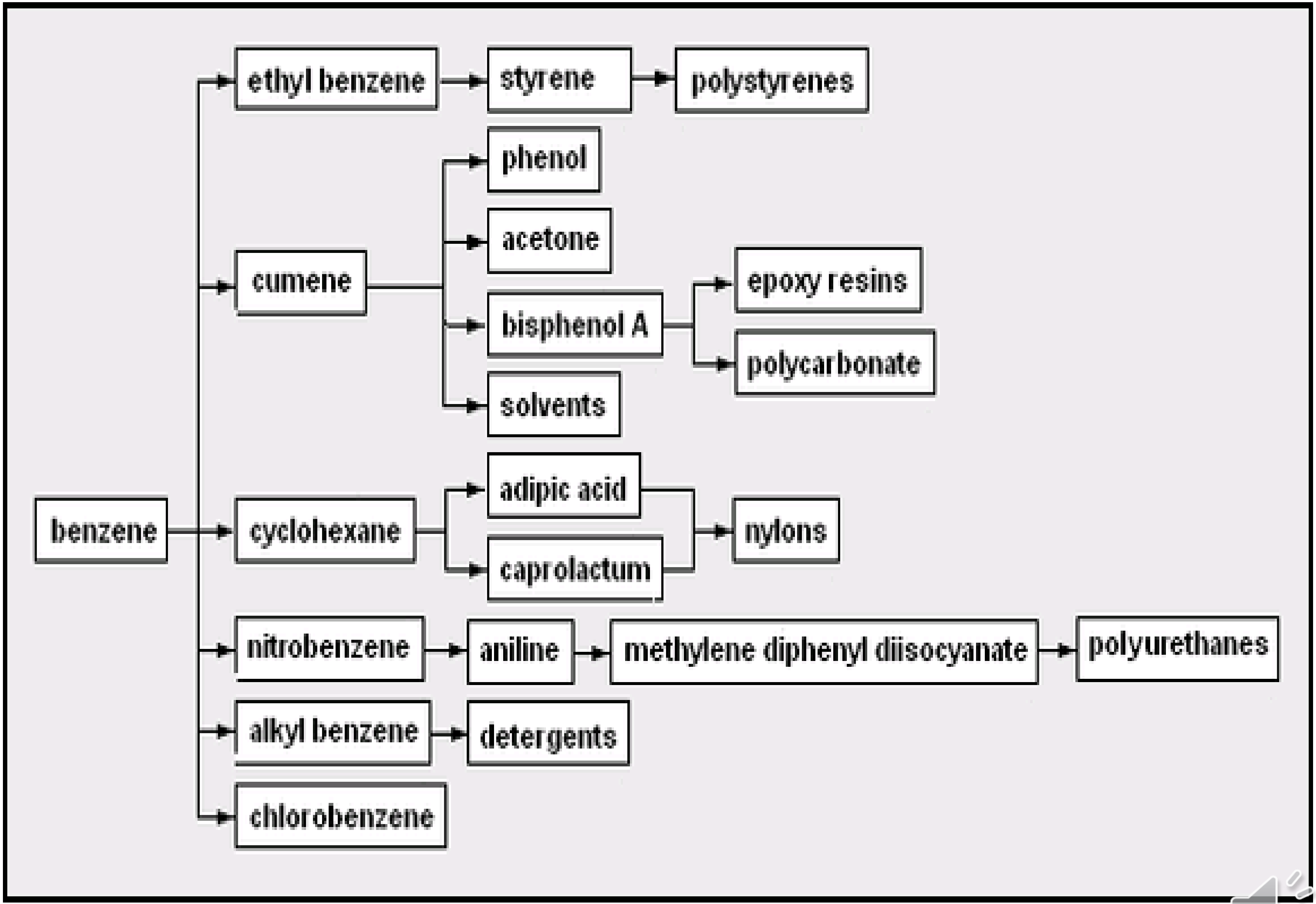
acrylic polymers

allyl chloride

epichlorolydrin

epoxy resins

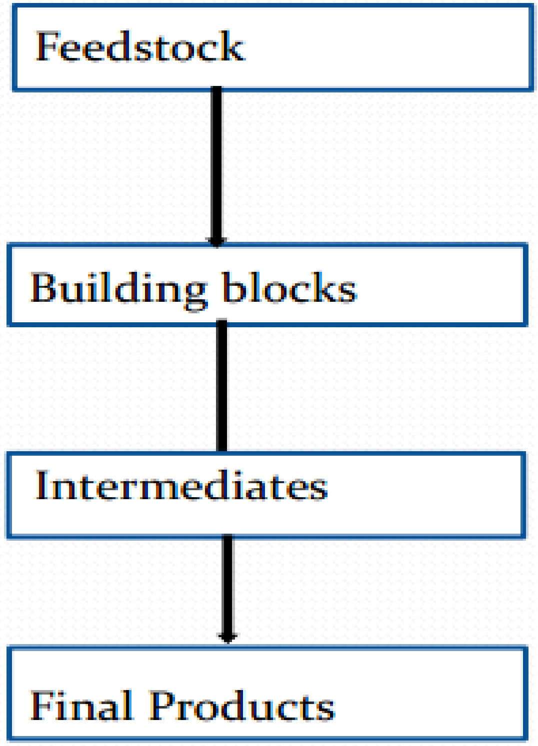
- propylene – used as a monomer and a chemical feedstock
- isopropyl alcohol – 2-propanol; often used as a solvent or rubbing alcohol
- acrylonitrile – useful as a monomer in forming acrylic fibers.
- polypropylene – polymerized propylene
- propylene oxide
  - propylene glycol – used in engine coolant and aircraft deicer fluid
  - glycol ethers – from condensation of glycols



Requirements of Petrochemical Industry

- To meet the increasing demand.
- Vital for economic growth.
- Self-sufficiency by decreasing imports.

Structure of Petrochemical industry:



Feedstock

Building blocks

Intermediates

Final Products

The Many Uses of Petrochemicals

The Primary Hydrocarbons

Raw crude oil and natural gas are purified into a relatively small number of hydrocarbons. These are used directly in manufacturing and transportation or act as feedstock to make other chemicals.

- Ethylene: used to make plastics and films, as well as detergents, synthetic lubricants, and styrenes (used to make protective packaging)
- Propylene: a colorless, odorless gas used for fuel and to make polypropylene, a versatile plastic polymer used to make products ranging from carpets to structural foam
- Butanes: hydrocarbon gases that are generally used for fuel and in industry.
- Butadiene: used in the manufacture of synthetic rubbers.

Medicine

Petrochemicals play many roles in medicine because they are used to create resins, films, and plastics. Here are just a few examples:

Phenol and Cumene are used to create a substance that is essential for manufacturing penicillin (an extremely important antibiotic) and aspirin.

Petrochemical resins are used to purify drugs, thus cutting costs and speeding the manufacturing process.

Resins made from petrochemicals are used in the manufacture of drugs including treatments for AIDS, arthritis, and cancer.

Plastics and resins made with petrochemicals are used to make devices such as artificial limbs and skin.

Plastics are used to make a huge range of medical equipment including bottles, disposable syringes, and much more.

Food

Petrochemicals are used to make most food preservatives that keep food fresh on the shelf or in a can. In addition, you'll find petrochemicals listed as ingredients in many chocolates and candies. Food colorings made with petrochemicals are used in a surprising number of products including chips, packaged foods, and canned or jarred foods.

Agriculture

More than a billion pounds of plastic, all made with petrochemicals, find use annually in U.S. agriculture. The chemicals are used to make everything from plastic to pesticides and fertilizers. Plastics are also used to make twine, and tubing. Petroleum fuels are also used to transport foods (which are, of course, stored in plastic containers).

Household Products

Because it is used to make plastics, fibers, synthetic rubber, and films, petrochemicals are used in a bewildering array of household products. Carpeting

Detergents
Dyes
Fertilizers
Perfume
Safety glass
Shampoo
Soft contact lenses

Using of Petrochemicals:-

Paint Industry

Paint is a term used to describe a number of substances that consist of a pigment suspended in a liquid or paste vehicle such as oil or water. With a brush, a roller, or a spray gun, paint is applied in a thin coat to various surfaces such as wood, metal, or stone. Although its primary purpose is to protect the surface to which it is applied, paint also provides decoration.

Samples of the first known paintings, made between 20,000 and 25,000 years ago, survive in caves in France and Spain. Primitive paintings tended to depict humans and animals, and diagrams have also been found. Early artists relied on easily available natural substances to make paint, such as natural earth pigments, charcoal, berry juice, lard, blood, and milkweed sap. Later, the ancient Chinese, Egyptians, Hebrews, Greeks, and Romans used more sophisticated materials to produce paints for limited decoration, such as painting walls. Oils were used as varnishes, and pigments such as yellow and red ochres, **chalk,** arsenic sulfide yellow, and malachite green were mixed with binders such as gum arabic, lime, egg albumen, and beeswax.

Paint was first used as a protective coating by the Egyptians and Hebrews, who applied pitches and balsams to the exposed wood of their ships. During the Middle Ages, some inland wood also received protective coatings of paint, but due to the scarcity of paint, this practice was generally limited to store fronts and signs. Around the same time, artists began to boil resin with oil to obtain highly miscible (mixable) paints, and artists of the fifteenth century were the first to add drying oils to paint, thereby hastening evaporation. They also adopted a new solvent, linseed oil, which remained the most commonly used solvent until synthetics replaced it during the twentieth century.

In Boston around 1700, Thomas Child built the earliest American paint mill, a granite trough within which a 1.6 foot (.5 meter) granite ball rolled, grinding the pigment. The first paint patent was issued for a product that improved whitewash, a water-slaked lime often used during the early days of the United States. In 1865 D. P. Flinn obtained a patent for a water-based paint that also contained zinc oxide, potassium hydroxide, resin, milk, and lin-seed oil. The first commercial paint mills replaced Child's granite ball with a buhrstone wheel, but these mills continued the practice of grinding only pigment (individual customers would then blend it with a vehicle at home). It wasn't until 1867 that manufacturers began mixing the vehicle and the pigment for consumers.

The twentieth century has seen the most changes in paint composition and manufacture. Today, synthetic pigments and stabilizers are commonly used to mass produce uniform batches of paint. New synthetic vehicles developed from polymers such as polyurethane and styrene-butadene emerged during the 1940s. Alkyd resins were synthesized, and they have dominated production since. Before 1930, pigment was ground with stone mills, and these were later replaced by steel balls. Today, sand mills and high-speed dispersion mixers are used to grind easily dispersible pigments.

Perhaps the greatest paint-related advancement has been its proliferation. While some wooden houses, stores, bridges, and signs were painted as early as the eighteenth century, it wasn't until recently that mass production rendered a wide variety of paints universally indispensable. Today, paints are used for interior and exterior housepainting, boats, **automobiles,** planes, appliances, furniture, and many other places where protection and appeal are desired.


← WHITE LATEX
BROWN LATEX ↑
WHITE ↑
White
PRE-MIXED PAINT
SILVER ↑
SUN-PROOF
Exterior House & Trim
Flat Latex
Pearl Finish
1-2-3 PRIMER
rosco
IDDINGS DEEP COLORS SCENIC PAINT
RED
5560
RAW SIENNA
5555
MINWAX
PRE-STAIN WOOD CONDITIONER
KRYLON
ULTRA FLAT BLACK
Folgers
LATEX FLAT
PRIMER/SEALER

Raw Materials

A paint is composed of pigments, solvents, resins, and various additives. The pigments give the paint color; solvents make it easier to apply; resins help it dry; and additives serve as everything from fillers to antifungicidal agents. Hundreds of different pigments, both natural and synthetic, exist. The basic white pigment is titanium dioxide, selected for its excellent concealing properties, and black pigment is commonly made from carbon black. Other pigments used to make paint include iron oxide and cadmium sulfide for reds, metallic salts for yellows and oranges, and iron blue and chrome yellows for blues and greens.

Solvents are various low viscosity, volatile liquids. They include petroleum mineral spirits and aromatic solvents such as benzol, alcohols, esters, ketones, and acetone. The natural resins most commonly used are lin-seed, coconut, and soybean oil, while alkyds, acrylics, epoxies, and polyurethanes number among the most popular synthetic resins. Additives serve many purposes. Some, like calcium carbonate and aluminum silicate, are simply fillers that give the paint body and substance without changing its properties. Other additives produce certain desired characteristics

in paint, such as the thixotropic agents that give paint its smooth texture, driers, anti-settling agents, anti-skinning agents, defoamers, and a host of others that enable paint to cover well and last long.

Design

Paint is generally custom-made to fit the needs of industrial customers. For example, one might be especially interested in a fast-drying paint, while another might desire a paint that supplies good coverage over a long lifetime. Paint intended for the consumer can also be custom-made. Paint manufacturers provide such a wide range of colors that it is impossible to keep large quantities of each on hand. To meet a request for "aquamarine," "canary yellow," or "maroon," the manufacturer will select a base that is appropriate for the deepness of color required. (Pastel paint bases will have high amounts of titanium dioxide, the white pigment, while darker tones will have less.) Then, according to a predetermined formula, the manufacturer can introduce various pigments from calibrated cylinders to obtain the proper color.

The Manufacturing Process

Making the paste

- 1 Pigment manufacturers send bags of fine grain pigments to paint plants. There, the pigment is premixed with resin (a wetting agent that assists in moistening the pigment), one or more solvents, and additives to form a paste.

Dispersing the pigment

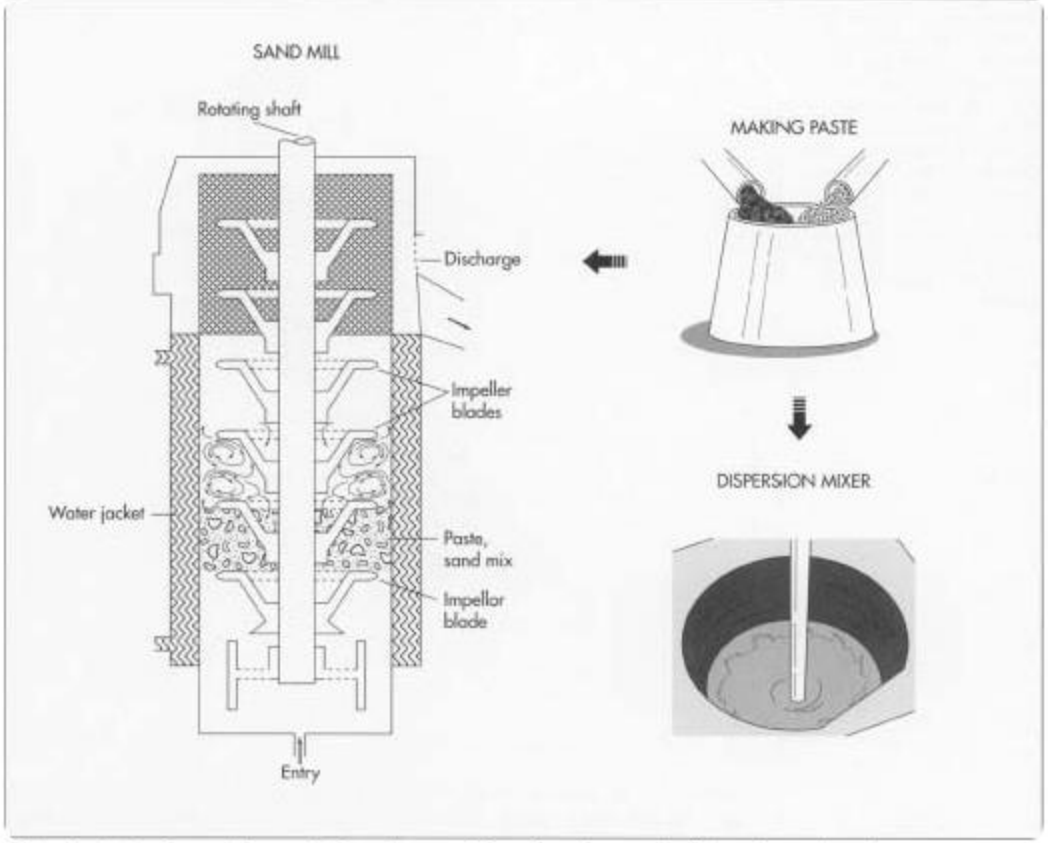
- 2 The paste mixture for most industrial and some consumer paints is now routed into a sand mill, a large cylinder that agitates tiny particles of sand or silica to grind the pigment particles, making them smaller and dispersing them throughout the mixture. The mixture is then filtered to remove the sand particles.
- 3 Instead of being processed in sand mills, up to 90 percent of the water-based latex paints designed for use by individual homeowners are instead processed in a high-speed dispersion tank. There, the premixed paste is subjected to high-speed agitation by a circular, toothed blade attached to a rotating shaft. This process blends the pigment into the solvent.

Thinning the paste

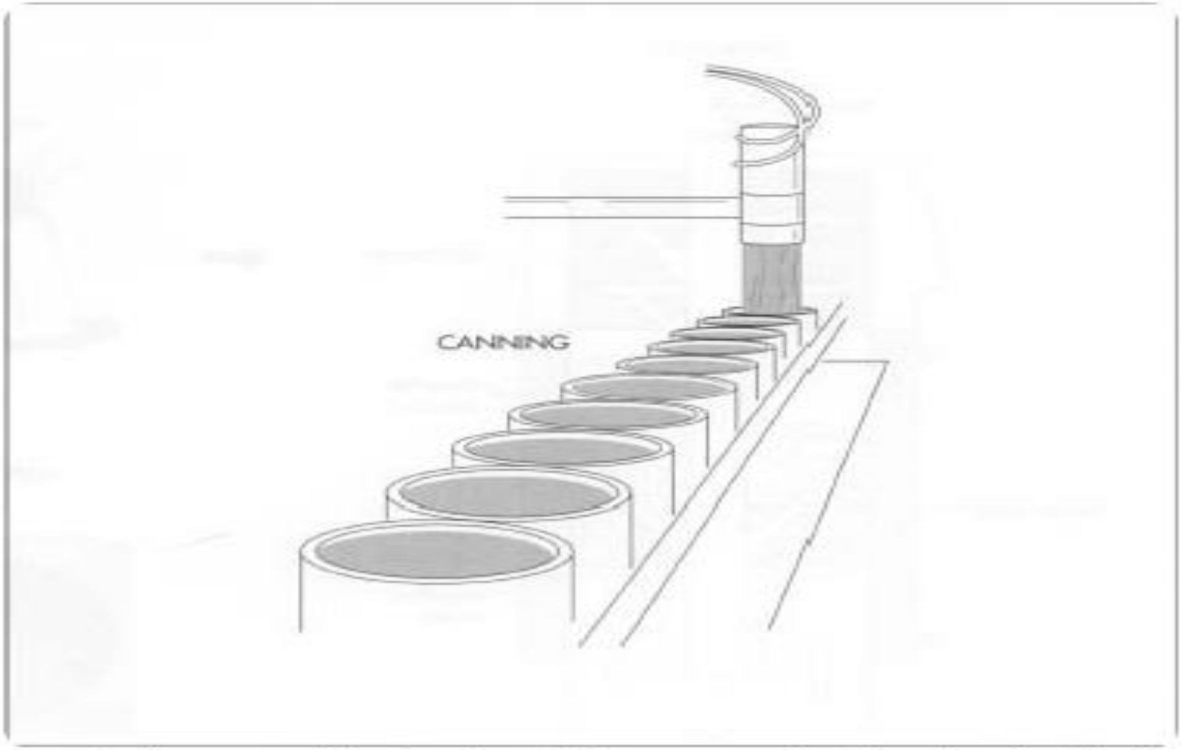
- 4 Whether created by a sand mill or a dispersion tank, the paste must now be thinned to produce the final product. Transferred to large kettles, it is agitated with the proper amount of solvent for the type of paint desired.

Canning the paint

- 5 The finished paint product is then pumped into the canning room. For the standard 8 pint (3.78 liter) paint can available to consumers, empty cans are first rolled horizontally onto labels, then set upright so that the paint can be pumped into them. A machine places lids onto the filled cans, and a second machine presses on the lids to seal them. From wire that is fed into it from coils, a bailometer cuts and shapes the handles before hooking them into holes precut in the cans. A certain number of cans (usually four) are then boxed and stacked before being sent to the warehouse.



The first step in making paint involves mixing the pigment with resin, solvents, and additives to form a paste. If the paint is to be for industrial use, it usually is then routed into a sand mill, a large cylinder that agitates tiny particles of sand or silica to grind the pigment particles, making them smaller and dispersing them throughout the mixture. In contrast, most commercial-use point is processed in a high-speed dispersion tank, in which a circular, toothed blade attached to a rotating shaft agitates the mixture and blends the pigment into the solvent.



Paint canning is a completely automated process. For the standard 8 pint paint can available to consumers, empty cans are first rolled horizontally onto labels, then set upright so that the point can be pumped into them. One machine places lids onto the filled cans while a second machine presses on the lids to seal the cons. From wire that is fed into it from coils, a bailometer cuts and shapes the handles before hooking them into holes precut in the cans.

Quality Control

Paint manufacturers utilize an extensive array of quality control measures. The ingredients and the manufacturing process undergo stringent tests, and the finished product is checked to insure that it is of high quality. A finished paint is inspected for its density, fineness of grind, dispersion, and viscosity. Paint is then applied to a surface and studied for bleed resistance, rate of drying, and texture.

In terms of the paint's aesthetic components, color is checked by an experienced observer and by spectral analysis to see if it matches a standard desired color. Resistance of the color to fading caused by the elements is determined by exposing a portion of a painted surface to an arc light and comparing the amount of fading to a painted surface that was not so exposed. The paint's hiding power is measured by painting it over a black surface and a white surface. The ratio of coverage on the black surface to coverage on the white surface is then determined, with .98 being high-quality paint. Gloss is measured by determining the amount of reflected light given off a painted surface.

Tests to measure the paint's more functional qualities include one for mar resistance, which entails scratching or abrading a dried coat of paint. Adhesion is tested by making a crosshatch, calibrated to .07 inch (2 millimeters), on a dried paint surface. A piece of tape is applied to the crosshatch, then pulled off; good paint will remain on the surface. Scrubbability is tested by a machine that rubs a soapy brush over the paint's surface. A system also exists to rate settling. An excellent paint can sit for six months with no settling and rate a ten. Poor paint, however, will settle into an immiscible lump of pigment on the bottom of the can and rate a zero. Weathering is tested by exposing the paint to outdoor conditions. Artificial weathering exposes a painted surface to sun, water, extreme temperature, humidity, or sulfuric gases. Fire retardancy is checked by burning the paint and determining its weight loss. If the amount lost is more than 10 percent, the paint is not considered fire-resistant.

Byproducts/Waste

A recent regulation (California Rule 66) concerning the emission of volatile organic compounds (VOCs) affects the paint industry, especially manufacturers of industrial oil-based paints. It is estimated that all coatings, including stains and varnishes, are responsible for 1.8 percent of the 2.3 million metric tons of VOCs released per year. The new regulation permits each liter of paint to contain no more than 250 grams (8.75 ounces) of solvent. Paint manufacturers can replace the solvents with pigment, fillers, or other solids inherent to the basic paint formula. This method produces thicker paints that are harder to apply, and it is not yet known if such paints are long lasting. Other solutions include using paint powder coatings that use no solvents, applying paint in closed systems from which VOCs can be retrieved, using water as a solvent, or using acrylics that dry under ultraviolet light or heat. A consumer with some unused paint on hand can return it to the point of purchase for proper treatment.

A large paint manufacturer will have an in-house wastewater treatment facility that treats all liquids generated on-site, even storm water run-off. The facility is monitored 24 hours a day, and the Environmental Protection Agency (EPA) does a periodic records and systems check of all paint facilities. The liquid portion of the waste is treated on-site to the standards of the local publicly owned wastewater treatment facility; it can be used to make low-quality paint. Latex sludge can be retrieved and used as fillers in other industrial products. Waste solvents can be recovered and used as fuels for other industries. A clean paint container can be reused or sent to the local landfill.

CHROMATOGRAPHY

د. احمد محمد مسلم

CHROMATOGRAPHY

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- Principle of chromatography
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- Theoretical plates and column efficiency
- Theory, Principle, technique and applications of-
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    b. Ion exchange Chromatography
    c. Thin layer Chromatography
    d. Paper Chromatography
- Numerical Problems

Introduction

- Chromatography (from Greek chroma "color and graphein "to write") is the collective term for a set of laboratory techniques for the separation of mixtures.

- The mixture is dissolved in a fluid called the mobile phase, which carries it through a structure holding another material called the stationary phase.

- The various constituents of the mixture travel at different speeds, causing them to separate.

- The separation is based on differential partitioning between the mobile and stationary phases.

- It is an important biophysical technique that enables the separation, identification, and purification of the components of a mixture for qualitative and quantitative analysis.
- It is a separation technique in which a mobile phase carrying a mixture is caused to move in contact with a selectively absorbent stationary phase.
- There are a number of different kinds of chromatography, which differ in the mobile and the stationary phase used.

- Chromatographic techniques are mostly useful for separation of components of mixture, purification of compounds, and isolation of natural products.

- It is the most powerful, fast, versatile instrumental technique available today for chemical analysis of complex mixtures.

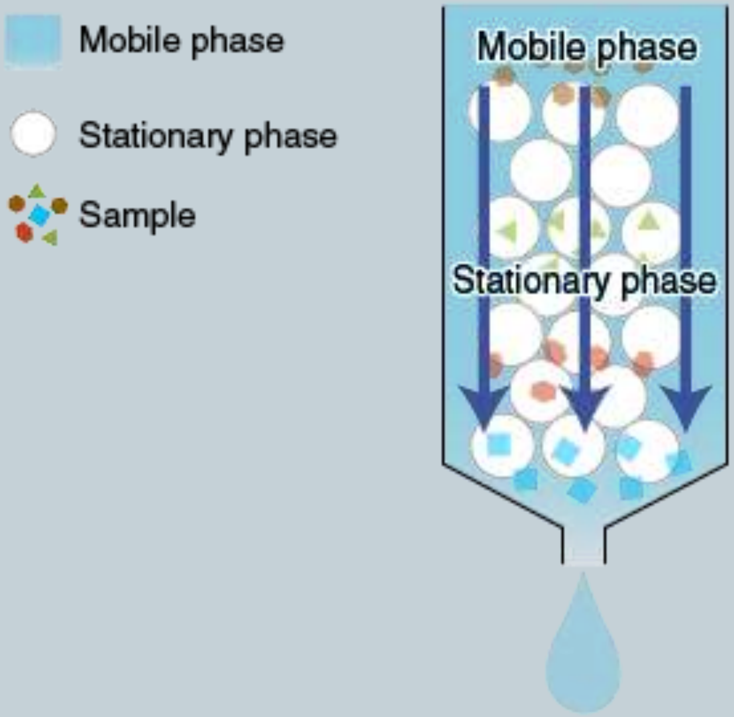
Definition

- Chromatography is a separation process in which separation of compounds from mixture is achieved by use of two phases, one of this is called as stationary phase and another is mobile phase.

- Stationary phase is either solid or liquid, acts as retardant (slows down movement of solute molecule in forward direction) for solute molecule.

- Mobile phase is liquid or gas, acts as a solvent for solute molecules.

- These two phases are immiscible with each other.



- When a solute in a solvent (or a mobile phase) is passed through or around the outside of a matrix (or a stationary phase), interactions occur between the solute and the stationary phase.

- Solutes with different properties are separated based on differences in these interactions.

Classification of chromatographic methods

General Classification	Specific Method Name	Stationary Phase	Type of Equilibrium
Liquid Chromatography (LC) **Mobile Phase = liquid**	Liquid-liquid or partition	Liquid adsorbed on a solid	Partition between immiscible liquids
	Liquid-bonded phase	Organic species bonded to a solid surface	Partition between liquid and a bonded surface
	Liquid-solid or adsorption	Solid	Adsorption
	Ion exchange	Ion-exchange resin	Ion exchange
	Size exclusion	Liquid in interstices of a polymeric solid	Partition/sieving
Gas Chromatography (GC) **Mobile Phase = gas**	Gas-liquid	Liquid adsorbed on a solid	Partition between gas and liquid
	Gas-bonded phase	Organic species bonded to a solid surface	Partition between liquid and bonded surface
	Gas-solid	Solid	Adsorption

Types of Chromatography…

Paper

Thin layer

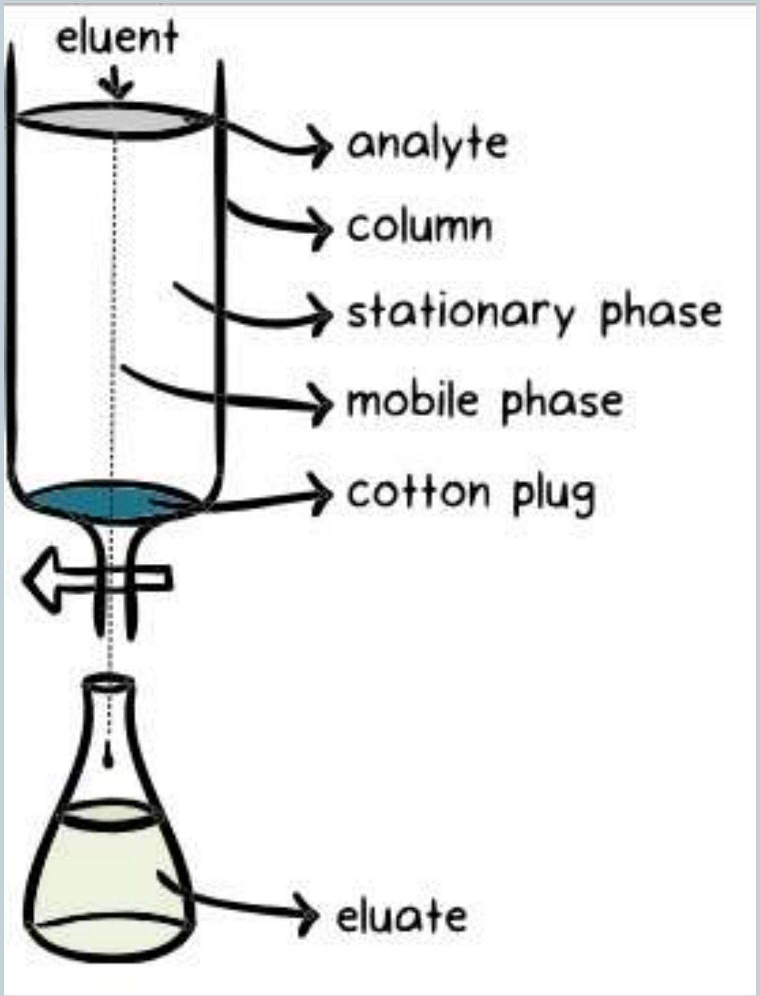
HPLC

Gas

Column

Principle of chromatography

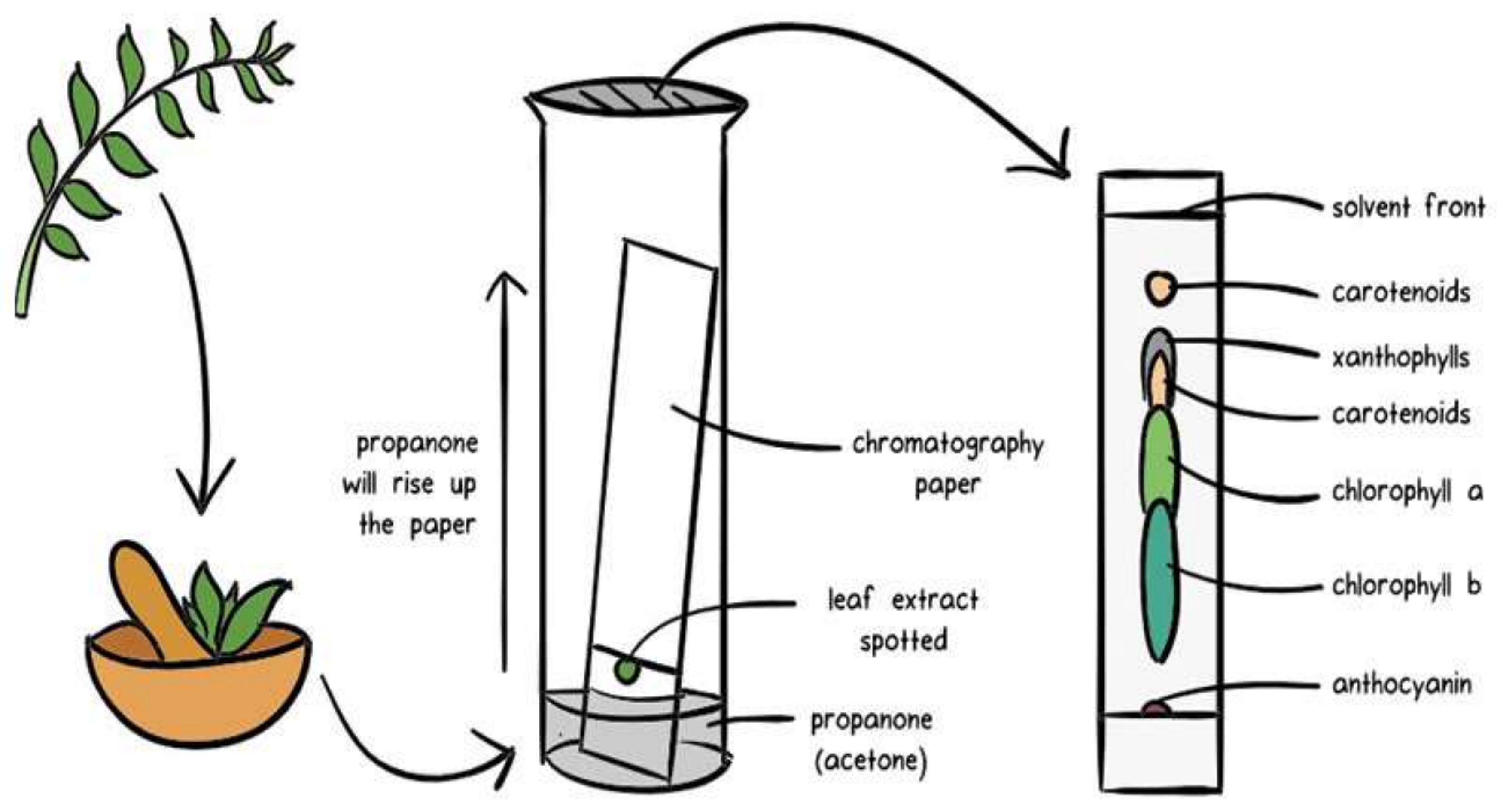
Chromatography is based on the principle where molecules in mixture applied onto the surface or into the solid, and fluid stationary phase (stable phase) is separating from each other while moving with the aid of a mobile phase



Principle of chromatography

- The factors effective on this separation process include molecular characteristics related to adsorption (liquid-solid), partition (liquid-solid), and affinity or differences among their molecular weights.

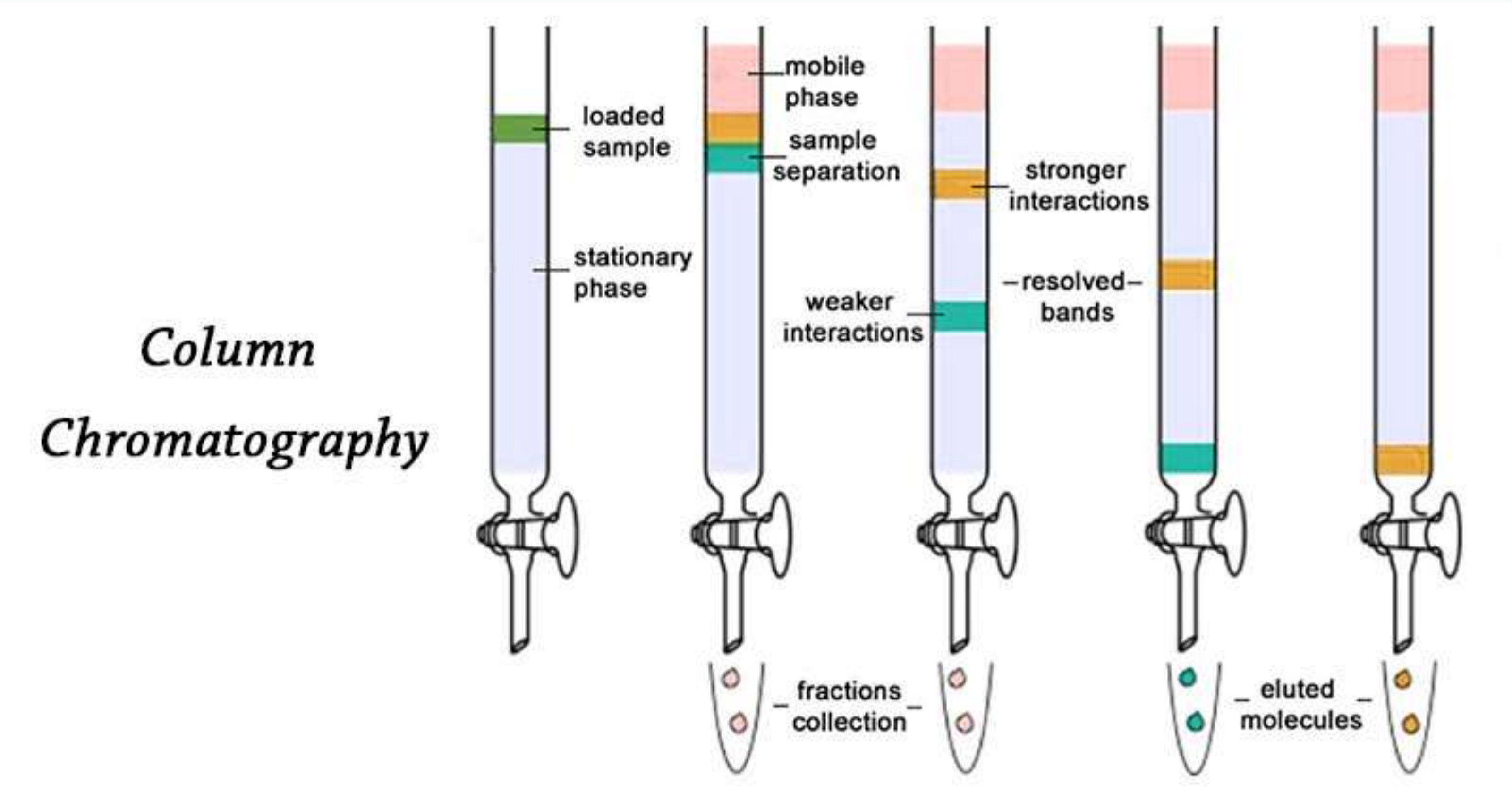
- Because of these differences, some components of the mixture stay longer in the stationary phase, and they move slowly in the chromatography system, while others pass rapidly into the mobile phase, and leave the system faster.


propanone will rise up the paper
chromatography paper
leaf extract spotted
propanone (acetone)
solvent front
carotenoids
xanthophylls
carotenoids
chlorophyll a
chlorophyll b
anthocyanin

Column Chromatography

- Column chromatography is a technique in which the substances to be separated are introduced onto the top of a column packed with an adsorbent, passed through the column at different rates that depend on the affinity of each substance for the adsorbent and for the solvent or solvent mixture, and are usually collected in solution as they pass from the column at different times.
- It is a **solid – liquid technique** in which the stationary phase is a solid & mobile phase is a liquid or gas.
- It was developed by the American chemist D.T Day in 1900 while M.S. Tswett, the Polish botanist, in 1906 used adsorption columns in his investigations of plant pigments.

Instrumentation



Instrumentation

1. A stationary phase:

- **A column**:

  In liquid chromatography these are generally 25- 50 cm long and 4mm internal diameter and made of stainless steel whereas in gas chromatography they are 1-3m long and 2-4mm internal diameter and made of either glass or stainless steel.

- They may be either of the conventional type filled with the stationary phase, or of the microbore type in which the stationary phase is coated directly on the inside wall of the column.

2. A mobile phase and delivery system:

- **An injector system**
- **A detector and chart recorder**
- **A fraction collector**

Forms of Column Chromatography

There are two forms of column chromatography.

- Liquid chromatography (LC)
- Gas chromatography (GC)

The most widely used forms of column chromatography are:

- Adsorption chromatography
- Partition chromatography
- Ion exchange chromatography
- Gel chromatography

Principle of Column Chromatography

- In column chromatography the stationary phase is packed into a glass or metal column.
- The mixture of analytes is then applied and the mobile phase, commonly referred to as the eluent, is passed through the column either by use of a pumping system or applied gas pressure.
- The stationary phase is either coated onto discrete small particles (the matrix) and packed into the column or applied as a thin film to the inside wall of the column.
- As the eluent flows through the column the analytes separate on the basis of their distribution coefficients and emerge individually in the eluate as it leaves the column.

Applications

Column chromatography is one of the most useful methods for the separation and purification of both solids and liquids.

- Separation of mixture of compounds.
- Removal of impurities or purification process.
- Isolation of active constituents.
- Isolation of metabolites from biological fluids.
- Estimation of drugs in formulation or crude extracts.

Advantages

- Any type of mixture can be separated by column chromatography.
- Any quantity of the mixture can also be separated.
- Wider choice of mobile phase.
- In preparative type, the sample can be separated and reused.
- Automation is possible.

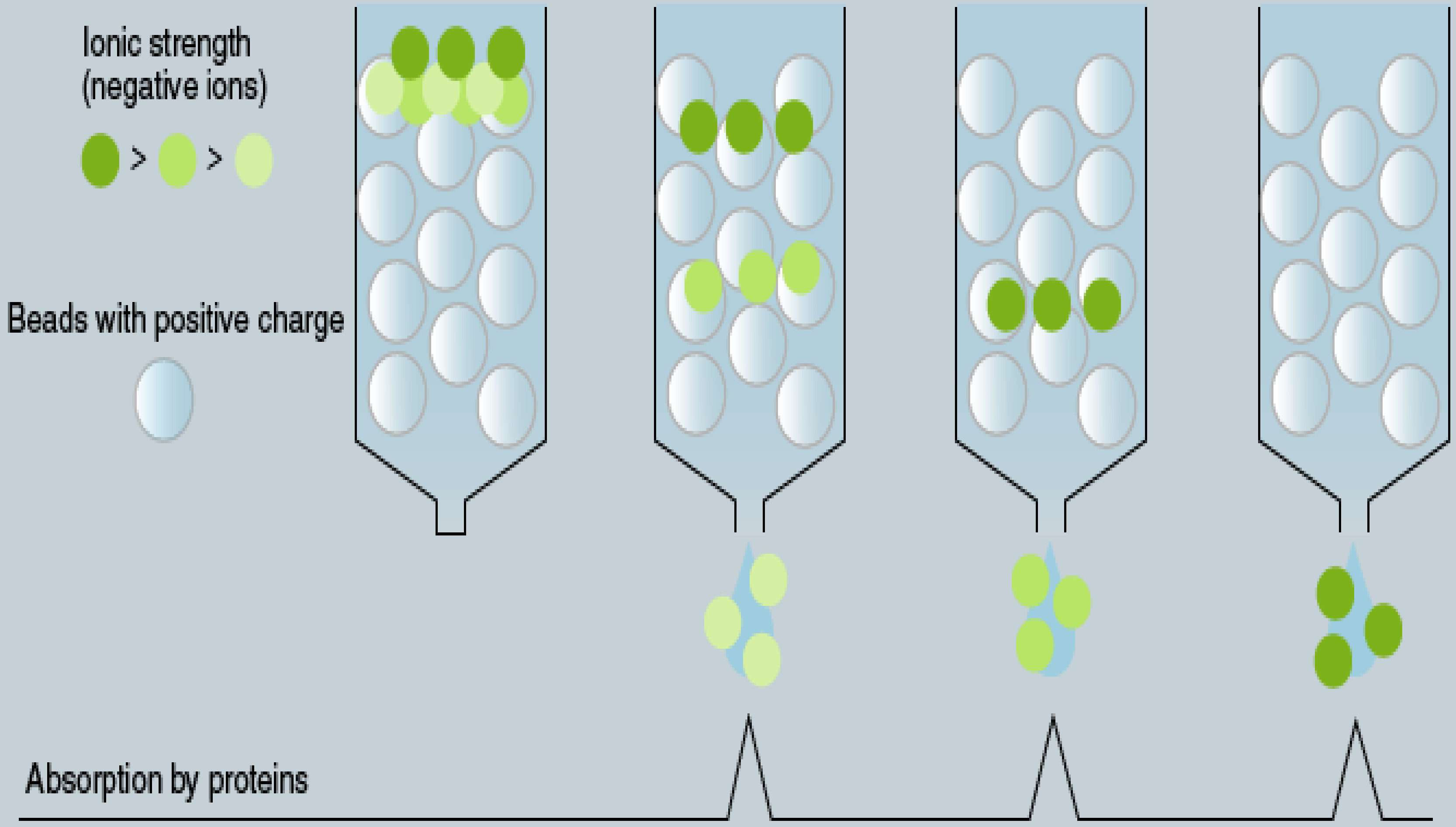
Limitations

- Time consuming method.
- More amounts of solvents are required which may be expensive.
- Automation makes the technique more complicated and costly.

Ion exchange Chromatography

- In ion-exchange chromatography, proteins are separated according to differences in their charge.
- Proteins have a net charge, which is the basis for protein interaction with ion-exchange media.
- Basic proteins with a positive charge bind ionically to a negatively charged matrix (cation exchanger), and acidic proteins with a negative charge bind ionically to a positively charged matrix (anion exchanger).
- Samples are applied to a column packed with an ion exchange resin. The elution of proteins in these samples from the column depends on gradually increasing the salt concentration of the mobile phase, which weakens the ionic interactions and facilitates their downward movement.
- Consequently, proteins that interact weakly with the resin elute first and the elution order and resolution of the separated proteins depends on their charge.

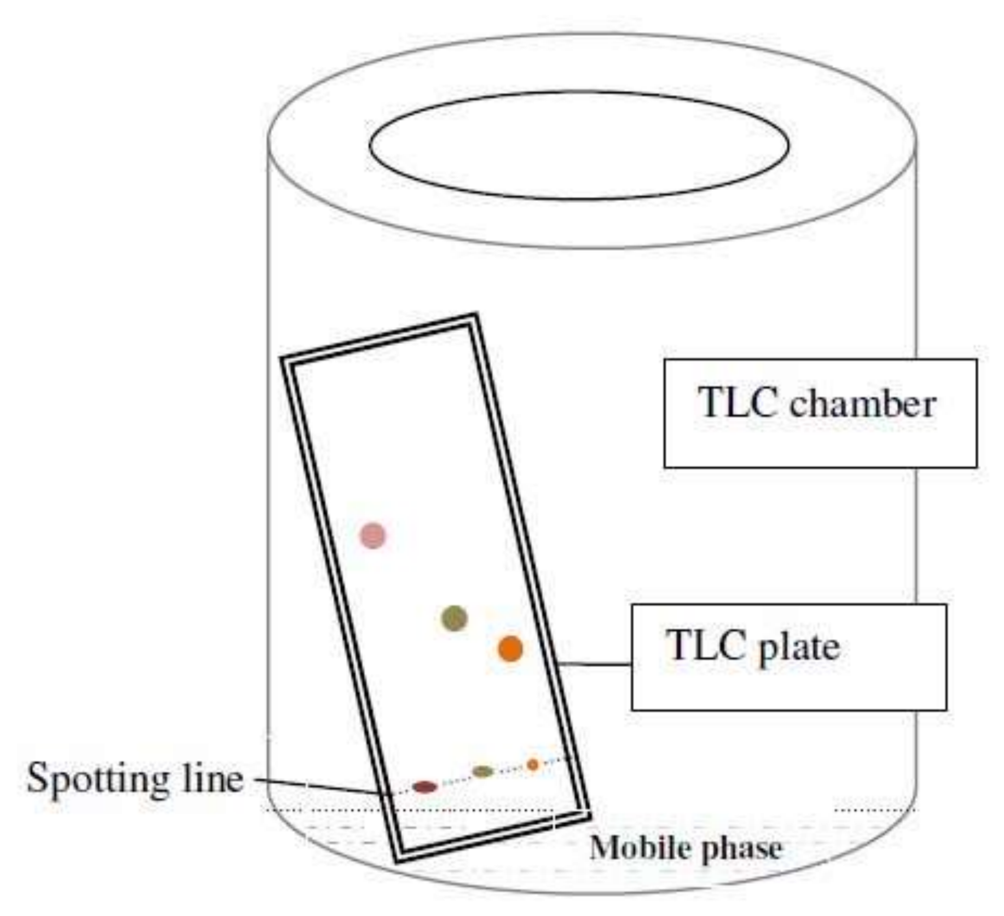
Ion exchange Chromatography



Thin layer Chromatography

Thin Layer Chromatography can be defined as a method of separation or identification of a mixture of components into individual components by using finely divided adsorbent solid / (liquid) spread over a plate and liquid as a mobile phase.

Instrumentation



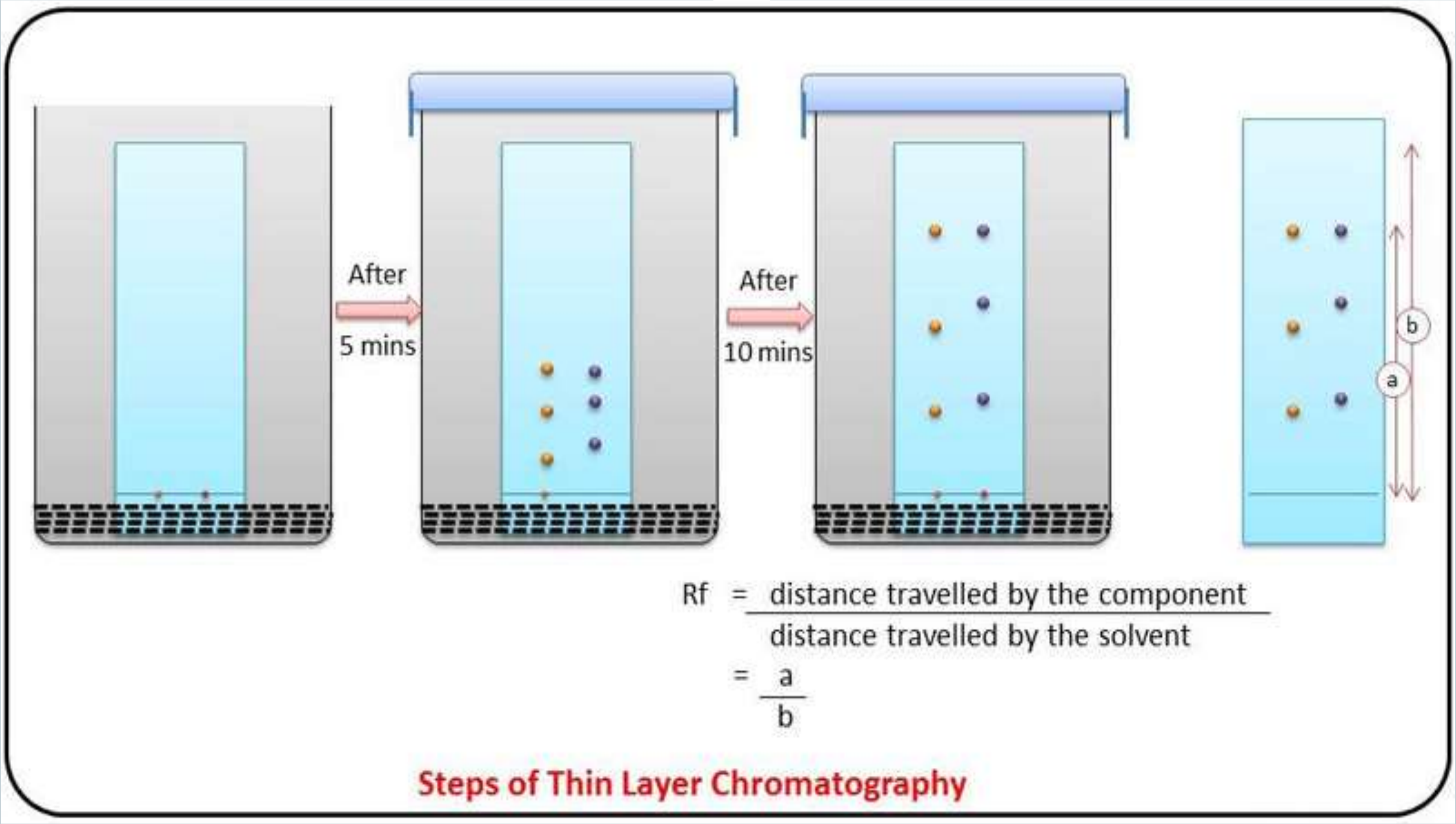
Principle of Thin Layer Chromatography (TLC)

- Thin-layer chromatography is performed on a sheet of glass, plastic, or aluminium foil, which is coated with a thin layer of adsorbent material, usually silica gel, aluminium oxide (alumina), or cellulose. This layer of adsorbent is known as the stationary phase.
- After the sample has been applied on the plate, a solvent or solvent mixture (known as the mobile phase) is drawn up the plate via capillary action. Because different analytes ascend the TLC plate at different rates, separation is achieved.
- It is thus based on the principle of adsorption chromatography or partition chromatography or combination of both, depending on adsorbent, its treatment and nature of solvents employed. The components with more affinity towards stationary phase travels slower. Components with less affinity towards stationary phase travels faster.
- Once separation occurs, the individual components are visualized as spots at a respective level of travel on the plate. Their nature or character is identified by means of suitable detection techniques.

Components of Thin Layer Chromatography (TLC)

- **TLC plates,** preferably ready made with a stationary phase: These are stable and chemically inert plates, where a thin layer of stationary phase is applied on its whole surface layer. The stationary phase on the plates is of uniform thickness and is in a fine particle size.
- **TLC chamber-** This is used for the development of TLC plate. The chamber maintains a uniform environment inside for proper development of spots. It also prevents the evaporation of solvents, and keeps the process dust free.
- **Mobile phase-** This comprises of a solvent or solvent mixture The mobile phase used should be particulate-free and of the highest purity for proper development of TLC spots. The solvents recommended are chemically inert with the sample, a stationary phase.
- **A filter paper-** This is moistened in the mobile phase, to be placed inside the chamber. This helps develop a uniform rise in a mobile phase over the length of the stationary phase.

Procedure of Thin Layer Chromatography (TLC)



$$Rf = \frac{\text{distance travelled by the component}}{\text{distance travelled by the solvent}} = \frac{a}{b}$$

Steps of Thin Layer Chromatography

Applications of Thin Layer Chromatography (TLC)

- In monitoring the progress of reactions
- Identify compounds present in a given mixture
- Determine the purity of a substance.
- Analyzing ceramides and fatty acids
- Detection of pesticides or insecticides in food and water
- Analyzing the dye composition of fibers in forensics
- Assaying the radiochemical purity of radiopharmaceuticals
- Identification of medicinal plants and their constituents

Advantages of Thin Layer Chromatography (TLC)

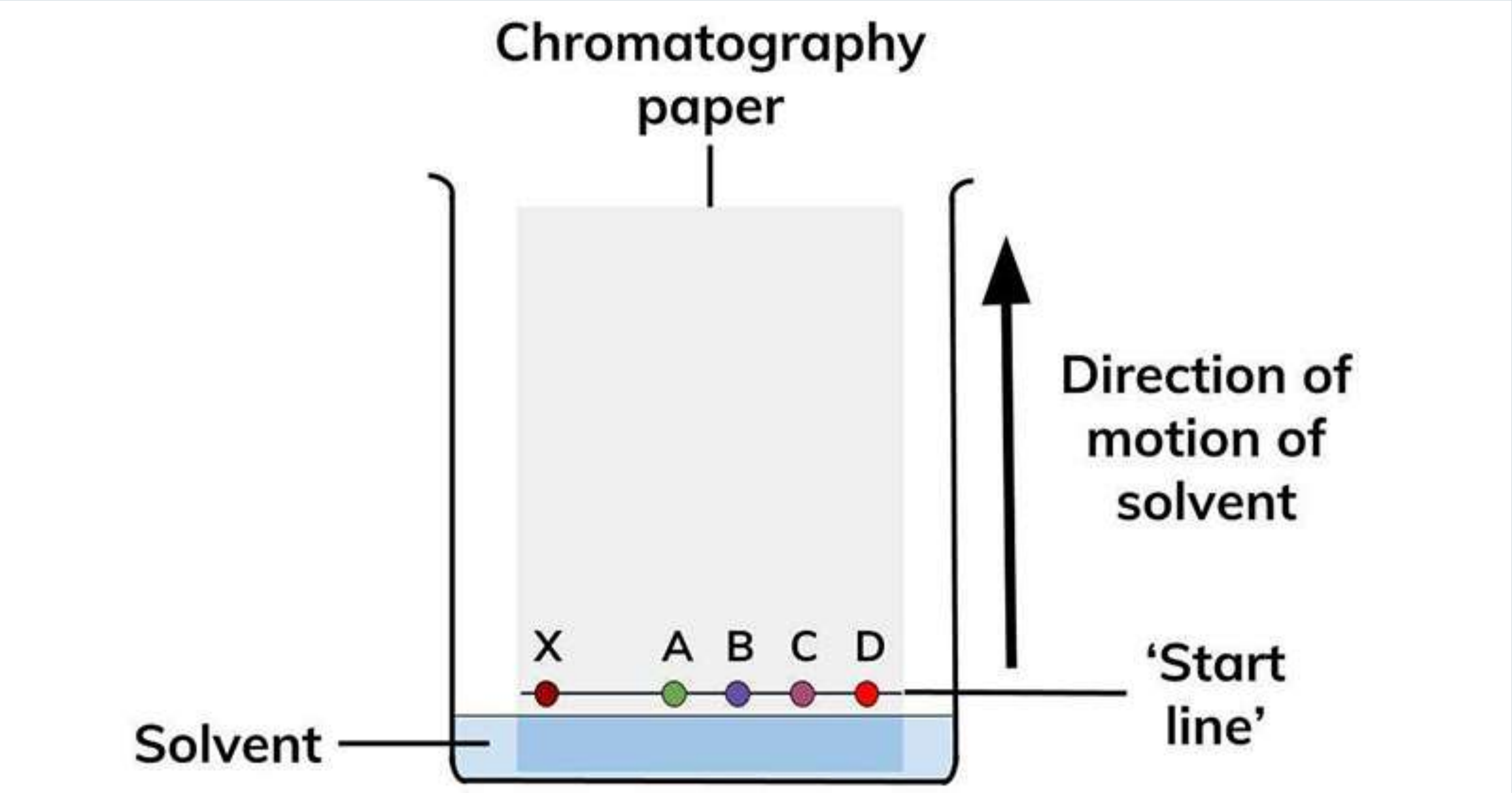
- It is a simple process with a short development time.
- It helps with the visualization of separated compound spots easily.
- It helps in isolating of most of the compounds.
- The separation process is faster and the selectivity for compounds is higher (even small differences in chemistry is enough for clear separation).
- The purity standards of the given sample can be assessed easily.
- It is a cheaper chromatographic technique.

Limitations of Thin Layer Chromatography (TLC)

- It cannot tell the difference between enantiomers and some isomers.
- In order to identify specific compounds, the Rf values for the compounds of interest must be known beforehand.
- TLC plates do not have long stationary phases. Therefore, the length of separation is limited compared to other chromatographic techniques.

Paper Chromatography

- Paper chromatography (PC) is a type of a planar chromatography whereby chromatography procedures are run on a specialized paper.
- PC is considered to be the simplest and most widely used of the chromatographic techniques because of its applicability to isolation, identification and quantitative determination of organic and inorganic compounds.
- It was first introduced by German scientist Christian Friedrich Schonbein (1865).


Chromatography paper
Direction of motion of solvent
X
A
B
C
D
'Start line'
Solvent

Types of Paper chromatography

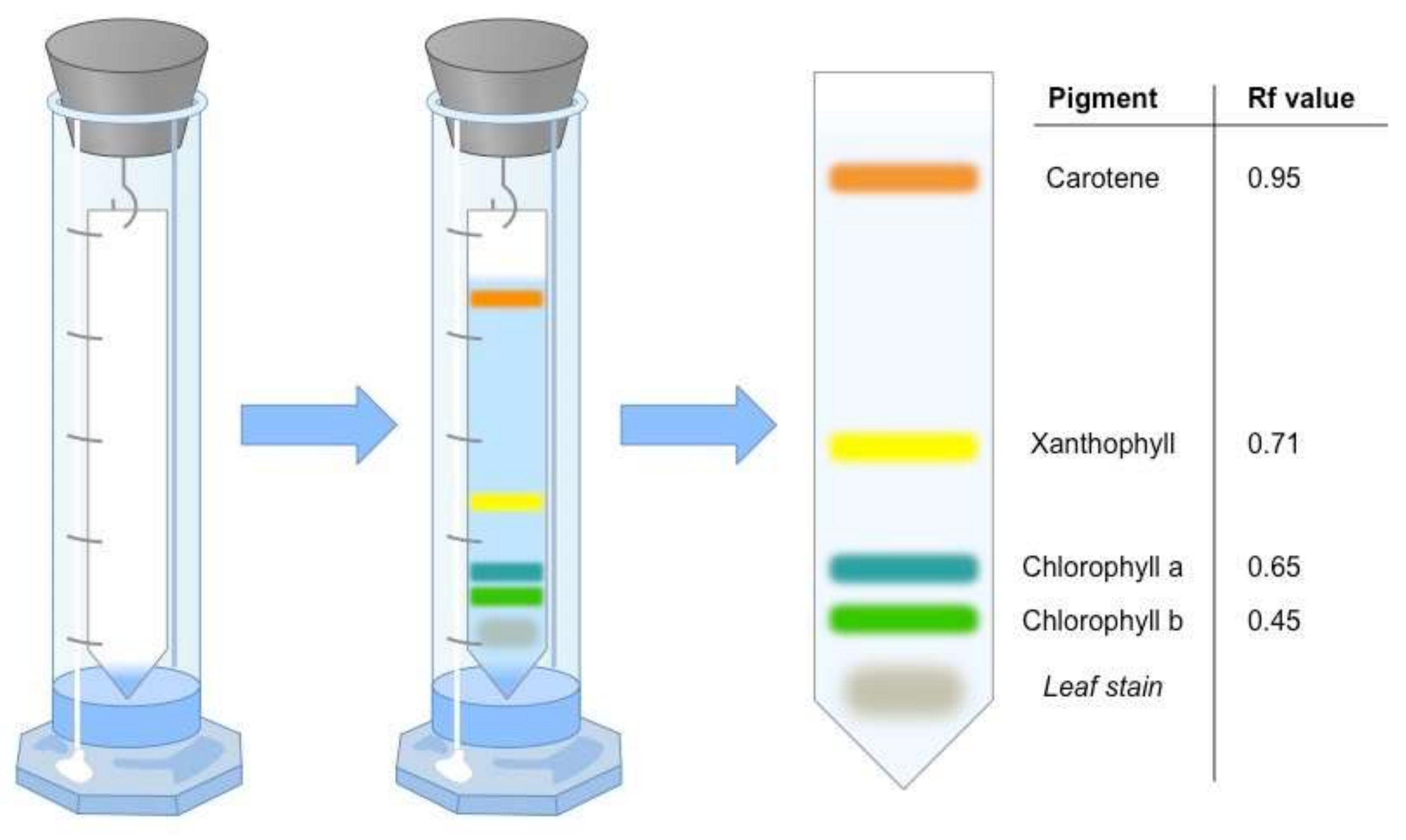
Paper Adsorption Chromatography

- Paper impregnated with silica or alumina acts as adsorbent (stationary phase) and solvent as mobile phase.

Paper Partition Chromatography

- Moisture / Water present in the pores of cellulose fibers present in filter paper acts as stationary phase & another mobile phase is used as solvent In general paper chromatography mostly refers to paper partition chromatography.

Principle of Paper chromatography



Pigment	Rf value
Carotene	0.95
Xanthophyll	0.71
Chlorophyll a	0.65
Chlorophyll b	0.45
Leaf stain	

- The principle of separation is mainly partition rather than adsorption.
- Substances are distributed between a stationary phase and mobile phase.
- Cellulose layers in filter paper contain moisture which acts as stationary phase.
- Organic solvents/buffers are used as mobile phase.
- The developing solution travels up the stationary phase carrying the sample with it.
- Components of the sample will separate readily according to how strongly they adsorb onto the stationary phase versus how readily they dissolve in the mobile phase.

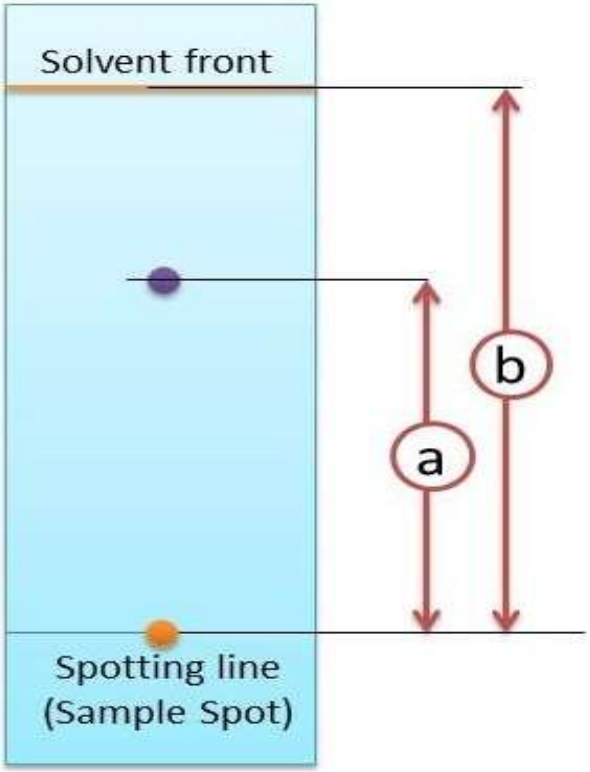
Instrumentation of Paper chromatography

- Stationary phase & papers used
- Mobile phase
- Developing Chamber
- Detecting or Visualizing agents

Steps in Paper Chromatography

- Selection of Solid Support
- Selection of Mobile Phase
- Saturation of Tank
- Sample Preparation and Loading
- Development of the Chromatogram
- Drying of Chromatogram
- Detection

R_f values



$$Rf = \frac{\text{distance travelled by the component}}{\text{distance travelled by the solvent}}$$

$$= \frac{a}{b}$$

Calculating the Retention Factor Value

Applications of Paper Chromatography

- To check the control of purity of pharmaceuticals,
- For detection of adulterants,
- Detect the contaminants in foods and drinks,
- In the study of ripening and fermentation,
- For the detection of drugs and dopes in animals & humans
- In analysis of cosmetics
- Analysis of the reaction mixtures in biochemical labs

Advantages of Paper Chromatography

- Simple
- Rapid
- Paper Chromatography requires very less quantitative material.
- Paper Chromatography is cheaper compared to other chromatography methods.
- Both unknown inorganic as well as organic compounds can be identified by paper chromatography method.
- Paper chromatography does not occupy much space compared to other analytical methods or equipments.
- Excellent resolving power

Limitations of Paper Chromatography

- Large quantity of sample cannot be applied on paper chromatography.
- In quantitative analysis paper chromatography is not effective.
- Complex mixture cannot be separated by paper chromatography.
- Less Accurate compared to HPLC or HPTLC

Applications of Chromatography

Pharmaceutical sector

- To identify and analyze samples for the presence of trace elements or chemicals.
- Separation of compounds based on their molecular weight and element composition.
- Detects the unknown compounds and purity of mixture.
- In drug development.

Food Industry

- In food spoilage and additive detection
- Determining the nutritional quality of food

Applications of Chromatography

Chemical industry

- In testing water samples and also checks air quality.
- HPLC and GC are very much used for detecting various contaminants such as polychlorinated biphenyl (PCBs) in pesticides and oils.
- In various life sciences applications

Forensic Science

- In forensic pathology and crime scene testing like analyzing blood and hair samples of crime place.

Applications of Chromatography

Molecular Biology Studies

- Various hyphenated techniques in chromatography such as EC-LC-MS are applied in the study of metabolomics and proteomics along with nucleic acid research.

- HPLC is used in Protein Separation like Insulin Purification, Plasma Fractionation, and Enzyme Purification and also in various departments like Fuel Industry, biotechnology, and biochemical processes.