A.D.M. COLLEGE FOR WOMEN (AUTONOMOUS)
(Nationally Accredited with ‘A’ grade by NAAC – 4th Cycle)
NAGAPATTINAM

PG & RESEARCH DEPARTMENT OF CHEMISTRY
II M.Sc CHEMISTRY
SEMESTER VI
APPLIED CHEMISTRY

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ASSISTANT PROFESSOR OF CHEMISTRY

SYLLABUS : ELECTIVE COURSE -IV APPLIED CHEMISTRY

Internal	*: 25*	*Semester*	*IV*
External	*: 75*	*No. of Hours/ Week*	*6*
Exam Hours	*: 3*	*Credit*	*5*

COURSE OUTCOME:

1.To study about quality control measurements in industries.
2.To understand the textile processing and dyeing.
3.To learn the classification and application of paint.
4.To understand the importance of wealth from waste.
5.To know the mechanism of drug action and metabolism of drugs.

UNIT I : QUALITY CONTROL MEASUREMENTS

Moisture, ash, crude protein, fat, crude fibre, carbohydrates, calcium, potassium, sodium and phosphate – Food adulteration – common adulterants in food, contamination of food stuffs – Microscopic examination of foods for adulterants – Pesticides analysis in food products – analysis of toxic metals in food (Hg, Cd, Co, Sn and Cr)- Determination of iodine, Saponification and acidvalue of an oil- Food standards- ISI and Agmark. Content- 15 Hrs, Assesment- 3Hrs (18Hrs)

UNIT II : TEXTILE PROCESSING

Pretreatment: Sizing, Desizing- acid method, Scouring- kier boiling method, Bleaching – hypochlorite method, Mercerization, fastness properties – washing, rubbing and lightfastness
Dyeing: Dye fibre bond, % of shade, M:L ratio, % 0f exhaustion, equilibrium absorption, effect of electrolyte.
Reactive dye - principles of dyeing,Polyester dyes - carrier dyeing - mechanism and high temperature dyeing. Mordant dyes – principles – specific examples. Acid dyes-dyeing mechanism – role of electrolyte and dye bath assistants. Vat dyes – vatting – dyeing – oxidation and aftertreatment. Content- 15 Hrs, Assesment- 3Hrs (18Hrs)

UNIT III : PAINT

Paint – definitions – ingredients and their role – terminology – emulsion, lacquer. Enamel – pot life, shelf life –varnish – thixotropy –classification of paints based on drying mechanism - under coats – Pigments – classification (organic & inorganic) – functions – properties such as hiding power, light fastness, particle size and shape Solvents used for paints – flash point.**Vehicles:** Oil – drying mechanism, Description of Alkyd, Epoxy, Polymetyl methacrylate, Urea formaldehyde, Melamine formaldehyde, urethane resins.Additives – Anti skinning agents,Powder coating, Solvent less finish Content- 15 Hrs, Assesment- 3Hrs (18Hrs)

UNIT IV: WEALTH FROM WASTE (Recycling)

Introduction – Recycling Technique – Construction materials from waste – Medicines from agricultural waste – liquid fuels from agricultural – Urban waste and bagasse for electricity – Agricultural waste for biomass into cheap and efficient fuel – Bacteria for paper making – Waste into objects of daily use – Garbage into fuel – How to use garbage to generate power.

Content- 15 Hrs, Assesment- 3Hrs (18Hrs)

UNIT V: MEDICINAL CHEMISTRY

Mechanism of drug action and Metabolism of Drugs: Mechanism of action – Drug Receptors and Biological responses – Mechanism of different types of drug action – Metabolism of drugs – Chemical pathway of drug metabolism absorption of drugs – Routes of administration - factors affect absorption – Digestion and absorption of protein – Digestion of fat.

Content- 15 Hrs, Assesment- 3Hrs (18Hrs)

TEXTBOOKS:

1. **B. K. Sharma, H. Karur** , Environmental chemistry **–-** Goel publishing House, Meerut.
2. **B. K. Sharma –** Industrial chemistry - Goel publishing House,Meerut**.**
3. **Gareth Thomas**, Medicinal Chemistry: An Introduction, Wiley-Interscience, 2ndedition, 2008.

REFERENCES :

1.B. K. Sharma – Instrumental methods of chemical Analysis,Goel publishing House, Meerut

2.G.P.A. Turner –Principles of Paint Chemistry and Introduction to paint Technology Oxford & IBH Publishing &CoPaint Film Defects.

3. **Wilson and Giswald's**Textbook of Organic Medicinal and Pharmaceutical Chemistry by John Blockand John M Beale (Eds), Lippincott Williams & Wilkins, 11th edition, 2003.

4. **Richard B. Silverman**,The Organic Chemistry of Drug Design and Drug Action, Academic press,2nd edition,2004

WEB RESOURCES:

1. https://pubs.acs.org
2. https://www.iiserbpr.ac.in

UNIT I – FOOD CHEMISTRY

Food is the basic necessity of life. The food we eat is absorbed by our body and is used to run metabolic processes and sustain life. Food is essential for growth and various life processes. An array of food in our daily diet includes, vegetables, fruits, legumes, pulses, grains etc. All of these either consumed raw or made into delicacies and savored. But nowadays, we have seen very thin milk due to mixing with water, white, yellow or black pebbles in raw pulses, white tiny stones mixed with rice, and so on. This mixing of elements with food items is adulteration.

QUALITY CONTROL MEASUREMENT:

1.MOISTURE CONTENT:

Moisture content influences the taste, texture, weight, appearance, and shelf life of foodstuffs. For example, substances which are too dry could affect the consistency of the end product. Conversely, excess moisture may cause food material to agglomerate or become trapped in the piping systems during production. Also, the rate of microbial growth increases with total water content, possibly resulting in spoiled batches that need to be disposed of. However, water is also an inexpensive ingredient adding to the weight of the final product. Hence, obtaining an optimal analytical value for moisture is of great economic importance to a food manufacturer. For these reasons, food analysts engage in the delicate balancing of moisture and total solids to ensure consistent product quality, safety and profitability.

Determination of Moisture Content:

Air-Oven Method : Moisture content of oils and fats is the loss in mass of the sample on heating at 105 ± 1^0C under operating conditions specified.

Apparatus -Metal dishes 7 – 8 cm diameter and 2 - 3 cm deep provided with tight fitting slip on covers.

Procedure: Weigh in a previously dried and tared dish about 5 - 10g of oil or fat which has been thoroughly mixed by stirring. Loosen the lid of the dish and heat, in an oven at 105 ± 1^0C for 1 hour. Remove the dish from the oven and close the lid. Cool in a desiccator containing phosphorus pentoxide or equivalent desiccant and weigh. Heat in the oven for a further period of 1 hour, cool and weigh. Repeat this process until change in weight between two successive observations does notexceed 1 mg.

Carry out the determination in duplicate

$$\text{Moisture and volatile matter, Percent by weight} == \frac{W1 \times 100}{W}$$

Where, W1 = Loss in gm of the material on drying & W = Weight in gm of the material taken for test.

2. ASH CONTENT:

Ash content is a measure of the total amount of minerals present within a food.

Determination of Ash Content:

The three main types of analytical procedure used to determine the ash content of foods are based on this principle: *dry* ashing, *wet* ashing and *low temperature plasma dry* ashing.

i.) Sample Preparation: Samples of 1-10g are used in the analysis of ash content. Solid foods are finely ground and then carefully mixed to facilitate the choice of a representative sample. Before carrying out an ash analysis, samples that are high in moisture are often dried to prevent spattering during ashing. High fat samples are usually defatted by solvent extraction, as this facilitates the release of the moisture and prevents spattering. Other possible problems include contamination of samples by minerals in grinders, glassware or crucibles which come into contact with the sample during the analysis. For the same reason, it is recommended to use deionized water when preparing samples.

ii.) Dry Ashing Method: Dry ashing procedures use a high temperature muffle furnace capable of maintaining temperatures of between 500 and 600 ^{o}C. Water and other volatile materials are vaporized and organic substances are burned in the presence of the oxygen in air to CO_2, H_2O and

N_2. Most minerals are converted to oxides, sulfates, phosphates, chlorides or silicates. Although most minerals have fairly low volatility at these high temperatures, some are volatile and may be partially lost, *e.g.,* iron, lead and mercury. If an analysis is being carried out to determine the concentration of one of these substances then it is advisable to use an alternative ashing method that uses lower temperatures. The food sample is weighed before and after ashing to determine the concentration of ash present. The ash content can be expressed on either a *dry* or *wet* basis:

$$\%\ \text{Ash (dry basis)} = \frac{M_{ASH}}{M_{DRY}} \times 100$$

where M_{ASH} refers to the mass of the ashed sample, and M_{DRY} refer to the original masses of the dried samples.

- *Advantages:* Safe, few reagents are required, many samples can be analyzed simultaneously, not labor intensive, and ash can be analyzed for specific mineral content.
- *Disadvantages:* Long time required (12-24 hours), muffle furnaces are quite costly to run due to electrical costs, loss of volatile minerals at high temperatures, *e.g.,* Cu, Fe, Pb, Hg, Ni, Zn.

Recently, analytical instruments have been developed to dry ash samples based on microwave heating. Microwave instruments greatly reduce the time required to carry out an ash analysis, with the analysis time often being less than an hour. The major disadvantage is that it is not possible to simultaneously analyze as many samples as in a muffle furnace.

iii.) Wet Ashing Method: Wet ashing is primarily used in the preparation of samples for subsequent analysis of specific minerals. It breaks down and removes the organic matrix surrounding the minerals so that they are left in an aqueous solution. A dried ground food sample is usually weighed into a flask containing strong acids and oxidizing agents (*e.g.,* nitric, perchloric and/or sulfuric acids) and then heated. Heating is continued until the organic matter is completely digested, leaving only the mineral oxides in solution. The temperature and time used depends on the type of acids and oxidizing agents used. Typically, a digestion takes from 10 minutes to a few hours at temperatures of about 350°C. The resulting solution can then be analyzed for specific minerals.

$$\% \text{ Ash (wet basis)} = \frac{M_{ASH}}{M_{WET}} \times 100$$

where M_{ASH} refers to the mass of the ashed sample, and M_{ASH} refer to the original masses of the wet samples.

- *Advantages:* Little loss of volatile minerals occurs because of the lower temperatures used, more rapid than dry ashing.
- *Disadvantages* Labor intensive, requires a special fume-cupboard if perchloric acid is used because of its hazardous nature, low sample throughput.

iv.) Low Temperature Plasma Ashing Method: A sample is placed into a glass chamber which is evacuated using a vacuum pump. A small amount of oxygen is pumped into the chamber and broken down to nascent oxygen (O_2 , $2O^{\cdot}$) by application of an electromagnetic radio frequency field. The organic matter in the sample is rapidly oxidized by the nascent oxygen and the moisture is evaporated because of the elevated temperatures. The relatively cool temperatures (< 150°C) used in low-temperature plasma ashing cause less loss of volatile minerals than other methods.

- *Advantages:* Less chance of losing trace elements by volatilization
- *Disadvantages:* Relatively expensive equipment and small sample throughput.

3. CRUDE PROTEIN:

Crude protein is a measure of how much protein is in food, based on laboratory tests studying the food's chemical composition.

Determination of Crude Protein:

Crude Protein is determined by Enhanced Dumas Method. In this method, sample of known mass is combusted in a high temperature (about 900 °C) chamber in the presence of oxygen. This leads to the release of CO_2, H_2O and N_2. The CO_2 and H_2O are removed by passing the gasses over special columns that absorb them. The nitrogen content is then measured by passing the remaining gasses through a column that has a thermal conductivity detector at the end. The column helps separate the nitrogen from any residual CO_2 and H_2O that may have remained in the gas stream. The instrument is calibrated by analyzing a material that is pure and has a known nitrogen concentration, such as EDTA (= 9.59%N). Thus the signal from the thermal conductivity detector can be converted into a nitrogen content. Using suitable conversion factors which depend on the precise amino acid sequence of the protein.

Advantages: It is much faster than the Kjeldahl method (under 4 minutes per measurement, compared to 1-2 hours for Kjeldahl). It doesn't need toxic chemicals or catalysts. Many samples can be measured automatically. It is easy to use.

Disadvantages: High initial cost. It does not give a measure of the true protein, since all nitrogen in foods is not in the form of protein. Different proteins need different correction factors because they have different amino acid sequences. The small sample size makes it difficult to obtain a representative sample.

4. CRUDE FIBRE:

Crude fiber is a measure of the quantity of indigestible cellulose, pentosans, lignin, and other components of this type in present foods. It is the residue of plant materials remaining after solvent extraction followed by digestion with dilute acid and alkali. These components have little food value but provide the bulk necessary for proper peristaltic action in the intestinal tract.

Determination of Crude Fibre:

Crude fiber method is one of the gravimetric method that measures the organic food residue remaining after sequential digestion with 0.255N sulphuric acid and 0.313N sodium hydroxide solutions, followed by oven-drying at 104ºC overnight and ignition in muffle furnace at 600ºC for 3 hours. The compounds removed are predominantly protein, sugar, starch, lipids and portions of both the structural carbohydrates and lignin. Crude fiber method measures variable amounts of the cellulose and lignin in the sample, but hemicelluloses, pectins, and added gums or hydrocolloids are solubilised and removed. Therefore, crude fibre measurement drastically underestimates dietary fibre in foods since it measures only cellulose and lignin. As a result, crude fiber method is only adequate for determination of fiber in animal feed product, but not suitable for human food analysis as lignin is significant to human health.

5. CARBOHYDRATE:

Carbohydrates are one of the most important components in many foods. Carbohydrates are important in food because carbohydrates provide energy, enhance immune function and support cellular communications. Carbohydrates are converted into energy to allow our cells to function. There are two major types of carbohydrates such as complex carbohydrates and simple carbohydrates. Complex carbohydrates are glycogen in human tissue and cellulose in plant tissues.

Determination of Carbohydrate:

The determination of carbohydrates are several methods of carbohydrate analysis and can be divided into physical methods and chemical method. Physical methods generally determined some overall features of the sugars in food such as total carbohydrates. The physical methods include refractometry, polarimetry and hydrometry. Unlike physical methods, chemical methods are able to determined more specific features, for example, reducing sugar. In this experiment, carbohydrates in foods were determined by difference after knowing the content of other food components. The accuracy of the Method depends on the determination of other food components and does not make any distinction between the available and nonavailable carbohydrates. The advantage of this method is carbohydrates content can be calculated without carry out an experiment.

6. MINERAL CONTENT: (Ca, K, Na and P)

Mineral content is a measure of the amount of specific inorganic components present within a food, such as Ca, Na,K and P.

Determination of Mineral Content:

i.) Sample Preparation: Many of the analytical methods used to determine the specific mineral content of foods require that the minerals be dissolved in an aqueous solution. For this reason, it is often necessary to isolate the minerals from the organic matrix surrounding them prior to the analysis. This is usually carried out by ashing a sample using one of the methods described in the previous section. It is important that the ashing procedure does not alter the mineral concentration in the food due to volatilization. Another potential source of error in mineral analysis is the presence of contaminants in the water, reagents or glassware. For this reason, ultrapure water or reagents should be used, and/or a blank should be run at the same time as the sample being analyzed. A blank uses the same glassware and reagents as the sample being analyzed and therefore should contain the same concentration of any contaminants. The concentration of minerals in the blank is then subtracted from the value determined for the sample. Some substances can interfere with analysis of certain minerals.

ii.) Gravimetric Analysis: The element to be analyzed is precipitated from solution by adding a reagent that reacts with it to form an insoluble complex with a known chemical formula. The precipitate is separated from the solution by filtration, rinsed, dried and weighed. The amount of mineral present in the original sample is determined from a knowledge of the chemical formula of the precipitate. For example, the amount of chloride in a solution can be determined by adding excess silver ions to form an insoluble silver chloride precipitate, because it is known that Cl is 24.74% of AgCl. Gravimetric procedures are only suitable for large food samples, which have relatively high concentrations of the mineral being analyzed. They are not suitable for analysis of trace elements because balances are not sensitive enough to accurately weigh the small amount of precipitate formed.

iii.) Colorimetric Methods: These methods rely on a change in color of a reagent when it reacts with a specific mineral in solution which can be quantified by measuring the absorbance of the solution at a specific wavelength using a spectrophotometer. Colorimetric methods are used to determine the concentration of a wide variety of different minerals. Vandate is often used as a colorimetric reagent because it changes color when it reacts with minerals. For example, the phosphorous content of a sample can be determined by adding a vandate-molybdate reagent to the sample. This forms a colored complex (yellow-orange) with the phosphorous which can be quantified by measuring the absorbance of the solution at 420nm, and comparing with a calibration curve. Different reagents are also available to colorimetrically determine the concentration of other minerals.

iv.) EDTA Complexometric Titration: EDTA is a chemical reagent that forms strong complexes with multivalent metallic ions. The disodium salt of EDTA is usually used because it is available in high purity: Na_2H_2Y. The complexes formed by metal ions and EDTA can be represented by the following equations:

$$m^{2+} + H_2Y^{2-} \longrightarrow mY^{2-} + 2H^+$$

$$m^{3+} + H_2Y^{2-} \longrightarrow mY^{-} + 2H^+$$

$$m^{4+} + H_2Y^{2-} \longrightarrow mY + 2H^+$$

The calcium content of foods is often determined by this method. An ashed food sample is diluted in water and then made alkaline (pH 12.5 to 13). An indicator that can form a colored complex with EDTA is then added to the solution, and the solution is titrated with EDTA. The EDTA-indicator complex is chosen to be much weaker than the EDTA-mineral complex. Consequently, as long as multivalent ions remain in the solution the EDTA forms a strong complex with them and does not react with the indicator. However, once all the mineral ions have been complexed, any additional EDTA reacts with the indicator and forms a colored complex that is used to determine the end-point of the reaction. The calcium content of a food sample is determined by comparing the volume of EDTA required to titrate it to the end-point with a calibration curve prepared for a series of solutions of known calcium concentration.

ADULTERATION:

Adulteration is a substance detected in other products, such as food, meat, cosmetics, medicines, petrol or other chemicals, which affects the quality or effectiveness of that product. Food adulteration is very usual in developing countries.

FOOD ADULTERATION:

Food adulteration is a process usually refers to the adding of any chemical or unwanted substances to the food that lowers the quality of food. Adulterants are mainly added to increase the quantity of food. This is performed to increase profit but there are severe risks to human life caused by adulterated food. Some of the toxic substances are added to the food during the adulteration to increase the texture and color of the food. Some of the adulterants are extremely poisonous to the body resulting in kidney disorders, heart failure, and liver disorders, etc.

CAUSES OF FOOD ADULTERATION:

- Food insecurity: To increase the quantity of food and distribution of nutrition.
- Traders’ profit motivation: made a portion of the business strategy.
- Illiteracy of the general public: lack of awareness of sufficient food consumption.
- There is no efficient food law.
- Lack of government initiatives.
- High population demands Increased food demand of the population and its changing trends.

TYPES OF FOOD ADULTERATION:

Intentional adulteration: Adding adulterants intentionally with the purpose of increasing profit.

Incidental adulteration: due to negligence, absence of sufficient facilities, adulterants are discovered in food.

Metallic adulteration: purposely or accidentally adding metallic materials such as lead from water and mercury from effluents.

METHODS OF FOOD ADULTERATION:

Mixing: Mixing of clay, stones, pebbles, sand, marble chips, etc.

Substitution: Cheaper and lower materials are replaced with healthy ones completely or temporarily.

Decomposed food: The decomposed ones are mixed with healthy food mainly the vegetables and fruits.

Addition of toxicants: Adding non-edible materials such as mustard oil argemone, preservatives of poor value, coloring agents, etc.

False labels or misbranding: Changing the manufacture and expiry dates, includes duplicate foodstuff.

Concealing quality: Trying to hide the food standard. E.G. adds quality food captions to lower value for sale.

COMMONLY ADULTERATED FOOD:

Some of the most common adulterated foods in India are milk and milk products, oils, sugars, food grains, and its products, spices and condiments, fruits and vegetables, atta, pulses, coffee, tea, confectionery, non-alcoholic beverages, vinegar, besan, and curry powder.

S.No.	Name of the Food Material	Adulterant	Method of Detection
1.	Ghee or Butter	Vanaspathi	Take about one teaspoonful of melted ghee or butter with equal quantity concentrated. Hydrochloric Acid in a test tube and add to it a pinch of cane sugar. Shake well for one minute and test it after 5 minutes. Appearance of crimson colour in lower (acidic) layer shows the presence of ‘vanaspathi’.

2.	Milk	Water	1. The Lactometer reading should not ordinarily be less than 1.026. 2. The presence of water can be detected by putting a drop of milk on a polished vertical surface. The drops of pure milk either stops or flows slowly leaving a white trail behind it. Whereas milk adulterated with water will flow immediately without leaving a mark.
3.	Sweet meat, ice cream, sherbhat	Metanil yellow (a non permitted coal tar dye)	Extract colour with Luke warm water from food article. Add few drops of conc. Hydrochloric Acid. If magenta red colour develops the presence of metanil yellow is indicated.
4.	Dhals	Kesari dhal	Add 50 ml of dilute Hydrochloric acid to dal and keep on simmering water for about 15 minutes. The pink colour if developed indicates the presence of kesari dhal.
		Clay, stones, gravels, lead chromate (yellow)	Visual examination will detect these adulterants. Shake five grams of dal with 5 ml of water and add a few drops of Hydrochloric Acid. A pink colour shows the presence of colour.
5.	Tea leaves	Exhausted tea or black or Bengal gram dal husk with colour	1. Tea leaves sprinkled on wet filter paper would immediately release added colour. 2. Spread a little slaked lime on white porcelain tile or glass plate. Sprinkle a little tea dust on the lime. Red orange or other shades of colour spreading on

			the lime will show the presence of coal tar dye. In the case of genuine tea, there will be only a slight greenish yellow colour due to chlorophyll, which appears after sometime.
6.	Wheat, bajra and other food grains	Ergot (a fungus containing a poisonous substance)	a. Purple black longer size grains in bajra show the presence of ergots. b. Put some grains in a glass containing 20% salt solution. Ergot floats over the surface while sound grains settle down.
7.	Sugar	Chalk powder	Dissolve in a glass of water, chalk will settle down at the bottom.
8.	Turmeric	Coloured saw dust metanil yellow.	Take a teaspoon full of turmeric powder in a test tube. Add a few drops of conc. Hydrochloric Acid. Instant appearance of violet colour which disappears on dilution with water. If the colour persists metanil yellow (an artificial dye) non-permitted coal tar dye is indicated.
9.	Chilli powder	Stones	Any grittiness that may be felt on tapping the sediment at the bottom of glass confirms the presence of brick powder or sand. Smooth white residue at the bottom indicates the presence of soapstone.
		Artificial colour	Water soluble artificial dye can be detected by sprinkling a small quantity of chilli or turmeric powder on the surface of water contained in a glass tumbler. The soluble dye will

			immediately start descending in colour streaks.
10.	Jaggery powder	Chalk powder	Add few drops of HCl. Effervescence indicate adulteration. Stir a spoonful sample of sugar in a glass of water. The chalks settle down.
11.	Wheat flour (maida)	Atta from which maida suji has been extracted	When dough is prepared from resultant wheat flour, more water has to be used and chapaties prepared out of this will blow out. The normal taste of chapaties prepared out of wheat is some what sweetish whereas those prepared out of adulterated wheat flour will taste insipid.
12	Common salt	White powdered stone, chalk	Stir a spoonful of simple of salt in a glass of water. The presence of chalk will make the solution white and other insoluble impurities will settle down.
13.	Mustard seeds	Argemone seeds	Mustard seeds have a smooth surface. The argemone seed have grainy and rough surface and are blacker hence can be separated out by close examination.
14.	Honey	Molasses (sugar and water)	A cotton wick dipped in pure honey when lighted with a match stick burns. If adulterate the presence of water will not allow the honey to burn. If it does it will produce a crackling sound.
15.	Cinnamon	Cassia bark	Cinnamon barks are very thin. Cassia barks are thick and stiff. Cinnamon barks can be rolled.
16.	Coffee	Chicory	Gently sprinkle the coffee powder

			sample on the surface of water in a glass. The coffee floats over the water but chicory begins to sink down within a few seconds. The falling chicory powder particles leave behind them a trail of colour due to large amount of caramel they contain.

BORNE DISEASES CAUSED BY SOME PATHOGENIC ORGANISMS:

Pathogenic Organisms	Food Commonly involved	III effects and diseases
• **BACTERIAL**		
Bacillus cereus	Cereal Products	Nausea, vomiting, abdominal pain.
Clostridium botulinum toxins	Defectively processed meat and fish.	Botulism (muscular) paralysis, death due to respiratory failure.
Clostridium perfringens (welchii)	Defectively processed meat and fish.	Nausea, abdominal pain and diarrhoea.
Salmonella	Defectively processed meat, fish and egg products, raw vegetables grown on sewage.	Salmonellosis (vomiting diarrhoea and fever)
Shigella sonnei	Foods kept exposed or sale in unhygienic surroundings.	Bacillary dysentery
Staphylococcus aureus	Foods kept exposed or sale in unhygienic	Increased salivation, vomiting, abdominal pain

	surroundings.	and diarrhoea.
Streptococcus pyogenes	Foods kept exposed or sale in unhygienic surroundings.	Scarlet fever, septic sores throat.
- **FUNGAL**		
Aspergillus flavus (aflatoxin)	Corn and groundnut	Liver damage and cancer
Claviceps purpurea (Ergot)	Rye and pearl millet infested with ergot. Peripheral gangrene	Ergotism (burning sensation in extremities)
Fusarium sporotrichiodies	Cereals and millets infected with fusarium.	Alimentary toxic aleukia.
Penicillium islandicum	Rice	Liver damage
- **PARASITIC**		
Trichinella spiralis	Pork and pork products	Nausea,vomiting,diarrhoea, Colic and muscular pains(trichionosis)
Ascaris lumbricoides	Raw vegetables grown on sewage farm.	Ascariasis
Entamoeba histolytica	Raw vegetables grown on sewage farm.	Amoebic dysentery
Ancylostoma duodenale (hookworm)	Raw vegetables grown on sewage farm.	Epigastric pain, loss of blood, anaemia.

TOXIC EFFECTS OF SOME METALS AND CHEMICALS

Name	**Foods commonly involved**	**Toxic effects**

Arsenic	Fruits sprayed by lead arsenate.	Dizziness, chills, cramps paralysis leading to death.
Barium	Foods contaminated by rat poison (barium carbonate)	Violent peristalsis, muscular twitching and convulsions.
Cadmium	Fruit juices and soft drinks that come in contact with cadmium and plated vessels.	Excessive sallvation, liver, kidney damage, prostate cancer, multiple fractures (painful '**Itai-Itai**' disease reported from Japan due to cadmium poisoning)
Cobalt	Water, beer	Cardiac failure
Copper	Acid foods in contact with tranished copper ware.	Vomiting, diarrnoea, abdominal pain.
Lead	Some processed foods Lead water pipes.	Paralysis, brain damage.
Mercury	Mercury fungicide treated seed grains or mercury contaminated fish.	Paralysis, brain damage and blindness.
Tin	Canned foods	Colic, vomiting, photophobia.
Zinc	Foods stored in galvanised iron ware.	Dizziness, vomiting
pesticides	All types of foods	Acute or chronic poisoning causing damage to liver, kidney, brain and nerves leading to

		death.
Diethyl stilbestrol	Present in meat of stilbestrol fed animals and birds.	Teratogenesis, carcinogenesis.
antibiotics	Meat from animals fed antibiotics.	Drug resistance, hardening of arteries, heart disease.

SAPONIFICATION VALUE:

The saponification value is the number of mg of potassium hydroxide required to saponify 1 gram of oil/fat.

Determination of Saponification Value:

Principle: The oil sample is saponified by refluxing with a known excess of alcoholic potassium hydroxide solution. The alkali required for saponification is determined by titration of the excess potassium hydroxide with standard hydrochloric acid.

Analytical importance: The saponification value is an index of mean molecular weight of the fatty acids of glycerides comprising a fat. Lower the saponification value, larger the molecular weight of fatty acids in the glycerides and vice-versa.

Apparatus:

a. 250 ml capacity conical flask with ground glass joints.

b. 1 m long air condenser, or reflux condenser (65 cm minimum in length) to fit theflask (a).

c. Hot water bath or electric hot plate fitted with thermostat.

Reagents:

(i) Alcoholic potassium hydroxide solution - Reflux 1.2 litre alcohol 30 minutes with 10 gm KOH and 6 gm granulated Aluminium or Al foil. Distill and collect 1 litre after discarding first 50 ml.

Dissolve 40 g of potassium hydroxide in this 1 litre alcohol keeping temperature below 15 0 C while dissolving alkali. Allow to stand overnight, decant the clear liquid and keep in a bottle closed tightly with a cork or rubber stopper.

ii) Phenolphthalein indicator solution - Dissolve 1.0 g of phenolphthalein in 100 ml rectified spirit.

iii) Standard hydrochloric acid: approximately 0.5N

Procedure: Melt the sample if it is not already liquid and filter through a filter paper to remove any impurities and the last traces of moisture. Make sure that the sample is completely dry. Mix the sample thoroughly and weigh about 1.5 to 2.0 g of dry sample into a 250 ml Erlenmeyer flask. Pipette 25 ml of the alcoholic potassium hydroxide solution into the flask. Conduct a blank determination along with the sample. Connect the sample flasks and the blank flask with air condensers, keep on the water bath, boil gently but steadily until saponification is complete, as indicated by absence of any oily matter and appearance of clear solution. Clarity may be achieved within one hour of boiling. After the flask and condenser have cooled somewhat wash down the inside of the condenser with about 10 ml of hot ethyl alcohol neutral to phenolphthalein. Titrate the excess potassium hydroxide with 0.5N hydrochloric acid, using about 1.0 ml phenolphthalein indicator.

Calculation:

$$\text{Saponification Value} = \frac{56.1\,(B-S)N}{W}$$

Where,

B = Volume in ml of standard hydrochloric acid required for the blank.

S = Volume in ml of standard hydrochloric acid required for the sample

N = Normality of the standard hydrochloric acid and
W = Weight in gm of the oil/fat taken for the test.

ACID VALUE:

The acid value is defined as the number of milligrams of potassium hydroxide required to neutralize the free fatty acids present in one gram of fat. It is a relative measure of rancidity as free fatty acids are normally formed during decomposition of oil glycerides. The value is also expressed as per cent of free fatty acids calculated as oleic acid.

Determination of Acid Value

Principle: The acid value is determined by directly titrating the oil/fat in an alcoholic medium against standard potassium hydroxide/sodium hydroxide solution.

Analytical Importance: The value is a measure of the amount of fatty acids which have been liberated by hydrolysis from the glycerides due to the action of moisture, temperature and/or lypolytic enzyme lipase.

Apparatus: 250 ml conical flasks.

Reagents: a.)Ethyl alcohol: - Ninety-five per cent alcohol or rectified spirit neutral tophenolphthalein indicator.

b.) Phenolphthalein indicator solution: - Dissolve one gram of phenolphthalein in 100 ml of ethyl alcohol. When testing rice bran oil based blended oils or oils or fats which give dark colored soap solution, the observation of the end point of the titration may be facilitated, by using Alkali blue 6B in place of phenolphthalein.

c.) Standard aqueous potassium hydroxide or sodium hydroxide solution 0.1 or 0.5 N. The solution should be colourless and stored in a brown glass bottle. For refined oils, the strength of the alkali should be fixed to 0.1 N.

Procedure: Mix the oil or melted fat thoroughly before weighing. The mass of the test sample shall be taken based on the colour and expected acid value**.**

Expected AcidValue	**Mass of Test Portion**	**Accuracy of weighing of test portion**
<1	20 g	0.05 g
1 to 4	10 g	0.02 g
4 to 15	2.5 g	0.01 g
15 to 75	0.5 g	0.001 g
>75	0.1 g	0.0002 g

Weigh accurately appropriate amount of the cooled oil sample in a 250 ml conical flask and add 50 ml to 100 ml of freshly neutralised hot ethyl alcohol and about one ml of phenolphthalein indicator solution. Boil the mixture for about five minutes and titrate while hot against standard alkali solution shaking vigorously during the titration. The weight of the oil/fat taken for the estimation and the strength of the alkali used for titration shall be such that the volume of alkali required for the titration does not exceed 10 ml.

Calculation:

$$\text{Acid value} = \frac{56.1VN}{W}$$

Where,

V = Volume in ml of standard potassium hydroxide or sodium hydroxide used

N = Normality of the potassium hydroxide solution or Sodium hydroxide solution; and

W = Weight in g of the sample

IODINE VALUE:

The iodine value of an oil/fat is the number of grams of iodine absorbed by 100g of the oil/fat, when determined by using Wijs solution.

Determination of Iodine Value

Principle: The oil/fat sample taken in carbon-tetrachloride is treated with a known excess of iodine monochloride solution in glacial acetic (Wijs solution). The excessof iodine monochloride is treated with potassium iodide and the liberated iodine estimated by titration with sodium thiosulfate solution.

Analytical importance: The iodine value is a measure of the amount of unsaturation (number ofdouble bonds) in a fat.

Apparatus: 500 ml Erlenmeyer flask.

Reagents:

i) Potassium dichromate AR

ii) Concentrated hydrochloric acid AR

iii) Glacial acetic acid, free from ethanol

iv) Carbon tetrachloride, analytical reagent grade

v) Iodine mono-chloride (ICl)

vi) 10% Potassium iodide (free from potassium iodate) -

vii) Starch solution .

viii) Wij's Iodine monochloride solution

ix) Standard sodium thiosulphate solution (0.1N)

Procedure: Weigh accurately an appropriate quantity of the dry oil/fat as indicated in the Table above, into a 500 ml conical flask with glass stopper, to which 25 ml of carbon tetrachloride have been added. Mix the content well. The weight of the sample shall be such that there is an excess of 50 to 60 percent of Wij's solution over that actually needed. Pipette 25 ml of Wij's solution and replace the glass stopper after wetting with potassium iodine solution. Swirl for proper mixing and keep the flasks in dark for half an hour for non-drying and semi-drying oils and one hour for drying oils. Carry out a blank simultaneously. After standing, add 15 ml of potassium iodide solution, followed by 100 ml of recently boiled and cooled water, rinsing in the stopper also. Titrate liberated iodine with standardized sodium thiosulphate solution, using starch as indicator at the end until the blue colour formed disappears after thorough shaking with the stopper on.

Conduct blank determinations in the same manner as test sample but without oil/fat. Slight variations in temperature appreciably affect titre of I_2 solution as chloroform has a high coefficient of expansion. It is thus necessary that blanks and determinations are made at the same time.

Calculation:

$$\text{Iodine value} = \frac{12.69\,(B - S)\,N}{W}$$

Where, B = volume in ml of standard sodium thiosulphate solution required for the blank.

S = volume in ml of standard sodium thiosulphate solution required for the sample. N = normality of the standard sodium thiosulphate solution.
W= weight in g of the sample.

FOOD ADULTERATION ACT:

A food adulteration act is crucial to stop the practice of food adulteration. Such laws help in taking strict action for the prevention of food adulteration. The prevention of food adulteration act 1954 is one of such acts to stop the adulteration in any food or drink.

The act extending to the whole country defines adulterant as any material or substance used for adulteration. The food adulteration definition remains the same for any kind of added substance that is of cheaper quality and could harm the consumer.

The act ensures there are no false claims made upon the label and the article is not made to appear better by false means. Any kind of artificial flavoring, coloring, or preserving method should contain a label stating the fact.

The Prevention of food adulteration act, 1954 also prohibits the import of food articles that are adulterated or misbranded. The food inspectors for the local areas can take the food sample and send it for analysis. The food inspector has the power to enter the place where the food article is being manufactured and check for adulteration.

Food adulteration is an objectionable practice and consumers should not ignore it if they find any additional substance in the food article. Complaining about it to the concerned authorities will help the government to take strong action against the culprits.

Acts like the Prevention of food adulteration act are in the public interest that makes sure no vendor, manufacturer, or the buyer is involved in adulterated food articles as they are toxic to society.

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UNIT II – DYE CHEMISTRY

Dyes definition: Dyes are colored organic compounds that are use to color various substances like fabrics, paper, food, hair and drugs etc.

With regard to their solubility, organic colorants fall into two classes, *viz.* dyes and pigments. The key distinction is that dyes are soluble in water and/or an organic solvent, while pigments are insoluble in both types of liquid media. Dyes are used to colorsubstrates to which they have affinity. Pigments can be used to color any polymeric substrate but by a mechanism quite different fromthat of dyes, in that surface only coloration is involved unless the pigment is mixed with the polymer before fiber or molded article formation.

Dye possess four properties.

1. Color
2. Solubility in water and/or an organic solvent.
3. Ability to be absorbed and retained by fiber (substantivity) or to be chemically combined with it (reactivity).
4. Ability to withstand washing, dry cleaning and exposure to light.

CLASSIFICATION OF DYES

1. On the basis of source:

(a) **Natural dyes**: Natural dyes are dyes or colorants derived from plants, invertebrates, or minerals. The majority of natural dyes are vegetable dyes from plant sources—roots, berries, bark, leaves, and wood—and other biological sources such as fungi and lichens.

There are two types of natural dyes. **Additive dyes (non-substantive)** such as madder must use a mordant (a chemical that fixes a dye) to bond with fibers. These are the most common type and have been used for at least 2,000 years. **Substantive dyes** require no pretreatment to the fabric (e.g., indigo, orchil and turmeric) and there are three types: **direct dye** (for cotton, e.g., turmeric, safflower); **acid dye** (for silk and wool, e.g., saffron, lac) or **basic dye** (for silk and wool, e.g., berberine). **Mordants** are chemical compounds that combine with the fiber and the dye forming a chemical bridge between the two. Common mordants are weak organic acids, such as acetic or tannic acid, and metal salts including aluminum ammonium or potassium sulfate, ferrous sulfate, and copper sulfate. Usually, the textile to be dyed is simmered in a mordant solution before dyeing (pre-mordanting). Other options include adding the mordant to the dye bath or treating with another mordant after dyeing to shift the color.

Natural mordant dyes are either monogenetic or polygenetic; monogenetic dyes produce only one colour irrespective of mordant, whereas polygenetic dyes produce different colours according to the mordant employed (e.g., logwood, alizarin, fustic and cochineal).

Disadvantages of Natural Dyes

Before the advent of synthetic dyes, natural dyes were widely used, often together with mordants such as alum, to dye natural fibres including wool, linen, cotton and silk, but their use declined after the discovery of synthetic dyes. However, interest in natural dyes has been revived owing to increasing demands on manufacturers to produce more environmentally friendly alternatives to petrochemical-derived dyes. One main issue associated with the use of natural dyes in the coloring of textiles is their poor to moderate light-fastness, and despite their long tradition, not all natural dyes are especially environmentally friendly. Some natural dyes have no or littleaffinity for the textile materials and they require heavy-metal salts as mordants for fixation and color-fastness. Natural dyes may be sustainable but they need water and land to produce and there is insufficient dye yield per acre of plant material to sustain industrial-scale production.

b.) Synthetic Dyes: Synthetic dyes are manufactured from organic molecules. Before synthetic dyes were discovered in 1856, dyestuffs were manufactured from natural products but batches of natural dye were never exactly alike in hue and intensity, whereas synthetic dyestuffs can be manufactured consistently. The use of computers and computer color matching (CCM) produces color that is identical from batch to batch.

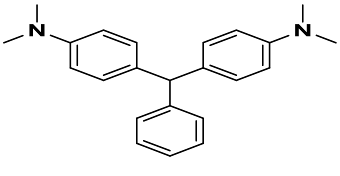
2. On the basis of chromophore: Dyes may be classified according to chromophore present in their structures.

a.) Azo dyes: Azo dyes are characterised by presence in the molecule of one or more azo groups —N = N—, which form bridges between organic residues, of which at least one is usually an aromatic nucleus. Many methods are available for preparing azo compounds, but manufacture of azo dyes is always based on the coupling of diazonium compounds with phenols, naphthols, arylamines, pyrazolones or other suitable components to give hydroxyazo or aminoazo compounds or their tautomeric equivalents. In the resulting dyes the azo group is the chromophore and the hydroxyl or amino group is an auxochrome. The importance of azo dyes is shown by the fact that they account for over 60% of the total number of dye structures known to be manufactured. A full range of shades is available, but on hydrophilic fibres the blues and greens lack fastness to light unless they are metallised; the metallised derivatives have dull shades. The chemistry of these dyes ranges from simple monoazo compounds to complex polyazo structures with a molecular weight of 1800 or more, and their properties vary accordingly.

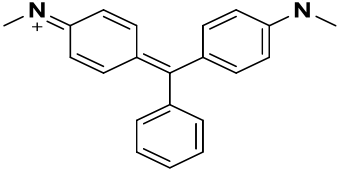
b.)Triphenylmethane Dyes: Synthetic organic dyes having molecular structures based upon that of the hydrocarbon triphenylmethane. They havepoor resistance to light and to chemical bleaches and are used chiefly in copying papers, in hectograph and printing inks, and in textile applications for which lightfastness is not an important requirement.

The triphenylmethane derivatives are among the oldest man-made dyes, a practical process for the manufacture of fuchsine having been developed in 1859. Several other members of the class were discovered before their chemical constitutions were fully understood. Crystal violet, the most important of the group, was introduced in 1883.

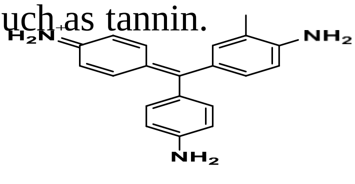
The range of colours is not complete but includes reds, violets, blues, and greens. They are applied by various techniques, but most belong to the basic class, which are adsorbed from solution by silk or wool, but have little affinity for cotton unless it has been treated with a mordant such as tannin.



Leucomalachite Green



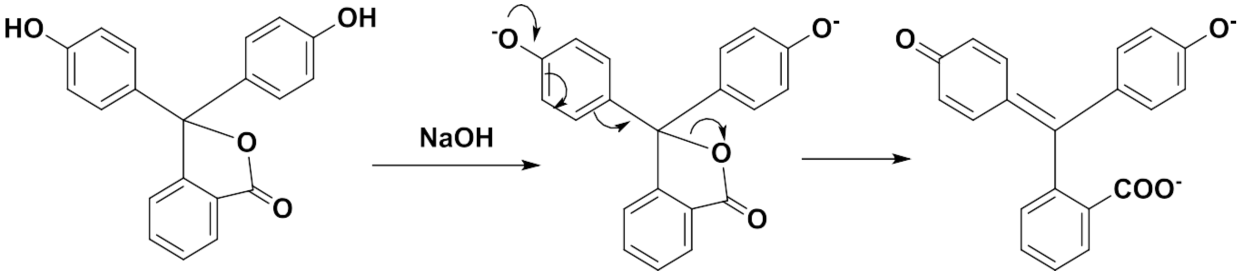
Malachite Green Dye



Rosaniline Dye
(Fuchsine Dye)

c.) Phthalein dyes are a class of dyes mainly used as pH indicators, due totheir ability to change colors depending on pH. They are formed by the reaction of phthalic anhydride with various phenols. They are a subclass of triarylmethane dyes.

- Common phthalein dyes include:
- *o*-Cresolphthalein
- Dixylenolphthalein
- Guaiacolphthalein
- α-Naphtholphthalein
- Phenolphthalein
- Tetrabromophenolphthalein
- Thymolphthalein
- Xylenolphthalein



Phenolphthalein Dye

3.On the basis of method of application:

Reactive Dyes, Acid Dyes, Premetallized Dyes, Direct Dyes, Azoic (Napthol) Dyes, Disperse Dyes, Vat Dyes, Sulfur Dyes, Basic Dyes.

a.) Reactive dyes are the most recent of dyes. These are the most popular in the world among fibre and fabric artists, used at first only by surface designers, but recently by weavers as well. There are now reactive dyes for a wide range of fibres, e.g. cotton (PROCION), silk and wool (PROCILAN). The dye actually reacts with the fibre molecules to form colour and is, as a result, extremely fast to both light and washing. There are hot and cold water reactive dyes, in fact there is a dye for almost every need. They can be most successfully used for silk painting, with a much better colour fastness than the traditional basic dyes, and are already used by batik artists. we can identify a reactive dye by the alkaliused to set off the fixation process, which requires time to take place (silk and wool reactives uses acetic acid). Assistants used are salt, soda ash and resist salt, and sometimes bicarbonate of soda and urea. Reactive dyes are equally suited to screen printing polychromatic printing, fabric painting yarn and piece dyeing.

b.) Acid Dyes are acidified basic dyes, intended for use on protein fibres but can be used on nylon and acrylics. They have a fair light fastness but poor wash fastness.

c.) Premetallized Dyes are an acid dyes with the addition of one or two molecules of chromium. The dyes give mute tonings, not unlike those of natural dyes. They are the synthetic dyes mostly used by weavers who dye their own yarns.

d.) Direct Dyes are **substantive dyes** colour cellulose fibres directly in a hot dyebath without a mordant, to give bright colours. They are not very fast to light or to washing. Direct dyes are generally any dyes which use salt as their only fixative, e.g. Dylon dyes (not to be confused with reactive dyes, which use salt plus other chemicals).

e.) Azoic Dyes are another sort of direct dye, but ones that are extremely fast towashing, bleach and light. They are intended for cellulose fibres and can beused successfully on protein fibres, although the colours are different. These dyes are widely used all over Asia and Australia for batik and direct application. They can be used to give interesting texture colour effects on fabric, thread or paper. Their use for straight silk painting is minimal because of the difficulty in achieving evenness of painted colour.

f.) Disperse Dyes originally developed for acetate fibres, these are now the major dyes for synthetics. They are not soluble in water, but in the actual fibres themselves. They require a carrier to swell the fibres so that the finely ground particles can penetrate. They are dyed hot, like direct dyes, but do not use salt. Disperse dyes are widely used for heat transfer printing (Polysol). Dye isprinted or painted onto paper and heat pressed onto fabric. Prints have excellentlight and wash fastness and strong bright colours. Their major disadvantage is that only synthetic fabrics can be used.

g.) Vat dyes are water insoluble dyes Vat dyes are insoluble in water and have to be dissolved in water by using sodium hydroxide and sodium hydrogen sulphite usually at 50 degrees for 15- 20 minutes. Vat dyes are most important dyes for dyeing and printing on cotton and cellulosic fibres They have excellent all round fastness, which includes- washing, light, perspiration, chlorine and rubbing fastnesses. Vat dyes are especially fast to light and washing. Brilliant colors can be obtained in most shades. Originated in medieval Europe, vat dyes were so named because of the vats used in the reduction of indigo plants through fermentation.

h.) Basic Dyes are very bright, but not very fast to light, washing, perspiration. Fastness is improved if they are given an after-treatment or steaming, e.g. French Silk dyes are basic dyes and should be steamed to fix.

CHEMISTRY OF DYEING

The process of applying color to fiber stock, yarn or fabric is called dyeing. There may or may not be thorough penetration of the colorant into the fibers or yarns. The dyeing of a textile fibre is carried out in a solution, generally aqueous, known as the dye liquor or dye bath. For true dyeing to have taken place, coloration of fabric and absorption are important determinants.

Coloration: The coloration must be relatively permanent: that is not readily removed by rinsing in water or by normal washing procedures. Moreover, the dyeing must not fade rapidly on exposure to light.

Absorption: The process of attachment of the dye molecule to the fiber isone of absorption: that is the dye molecules concentrate on the fibre surface. There are four kinds of forces by which dye molecules are bound to the fiber:

1) Ionic forces 2) Hydrogen bonding 3) Vander Wals' forces and 4) Covalent chemical linkages.

Exhaustion: In any dyeing process, whatever the chemical class of dye being used, heat must be supplied to the dye bath; energy is used in transferringdye molecules from the solution to the fiber as well as in swelling the fiber to render it more receptive. The technical term for this process is exhaustion.

Levelness: An Important Quality, evenness of dyeing, known as levelness is an important quality in the dyeing of all forms of natural and synthetic fibers. It may be attained by the control of dyeing conditions.

Conditions to attain Levelness:

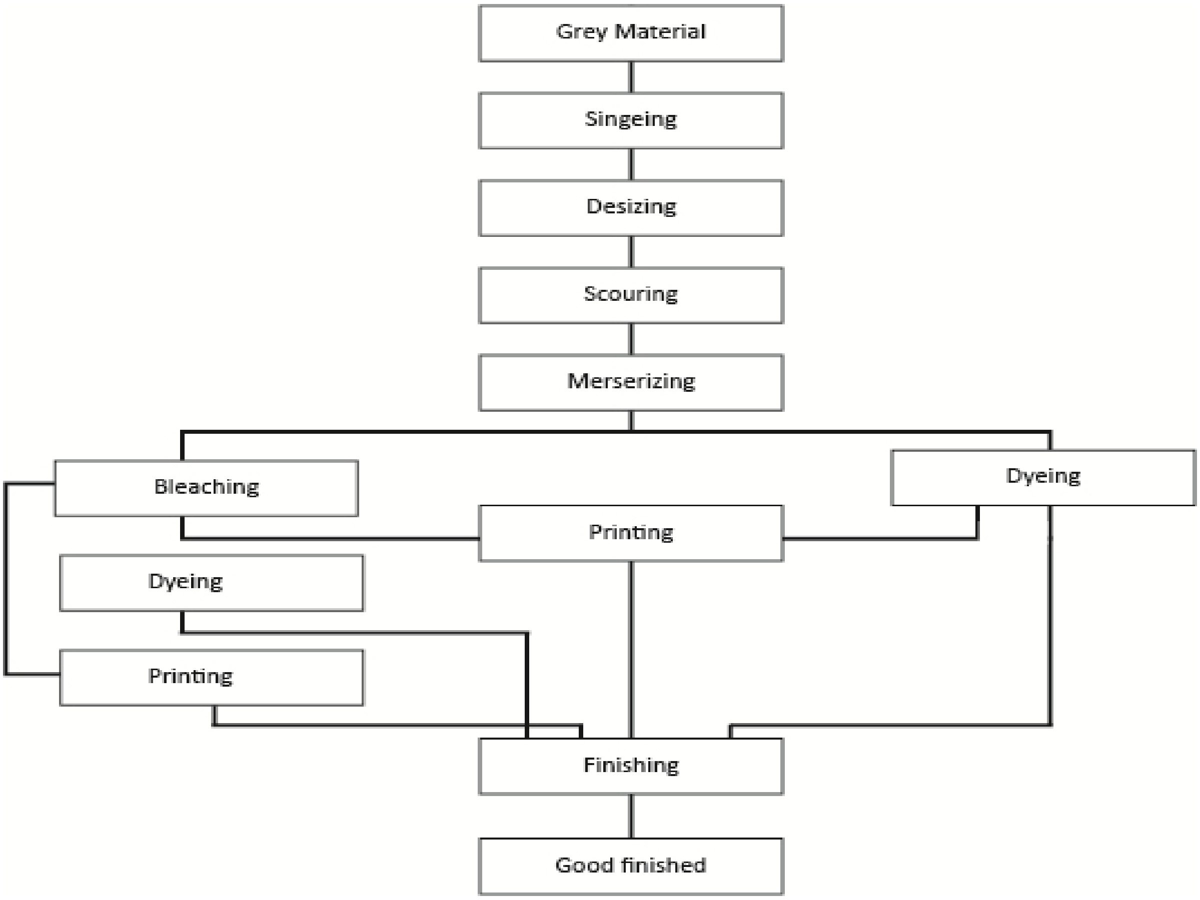
By agitation to ensure proper contact between dye liquor and substance being dyed and by use of restraining agents to control rate of dyeing or strike. Solvent Dyeing Serious consideration has recently been given to the methods of dyeing in which water as the medium is replaced by solvents such as the chlorinated hydrocarbons used in dry cleaning. The technological advantages in solvent dyeing are:

1. Rapid wetting of textiles
2. Less swelling
3. Increased speed of dyeing per given amount of material
4. Savings in energy, as less heat is required to heat or evaporate per-chloro-ethylene. Thus it eliminates the effluent (pollution) problems associated with the conventional methods of dyeing and finishing.

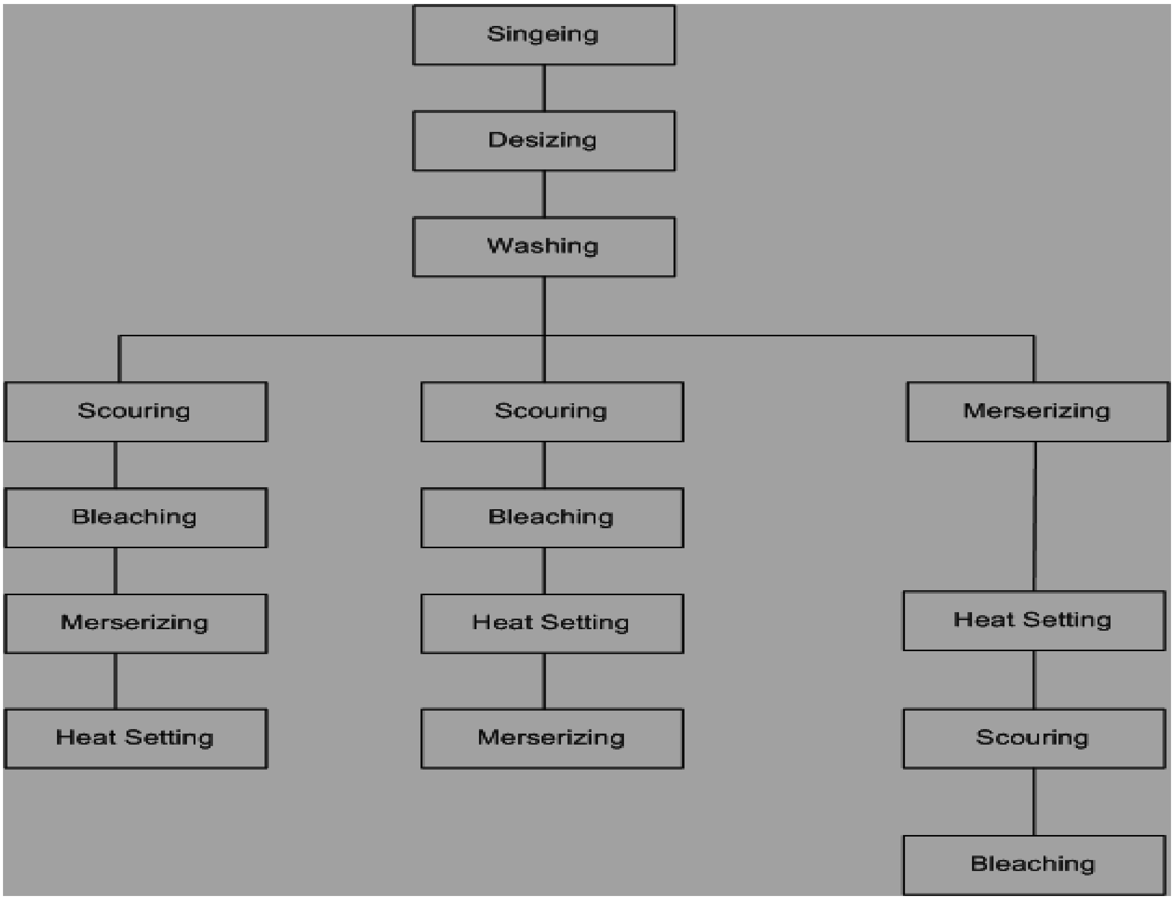
PRETREATMENT:

As a whole this process consist of desizing process, scouring and bleaching. Pretreatment process basically aim to removal all impurities found on fiber (especiallycellulose) so that materials have i) degree of white and
ii) absorbent to dyestuff.

FLOW CHART ON PROCESS TEXTILE



FLOW CHART OF PRE TREATMENT OF COTTON FABRIC



TYPICAL PRETREATMENT OF COTTON INVOLVES

1. Singeing
2. Desizing by conventional /enzymatic process
3. Scouring by conventional /enzymatic process
4. Bleaching
5. Neutralization
6. Peroxide removal
7. Bio- polishing
8. Mercerizing
9. Optical Brightening

OBJECTIVES OF THE PRETREATMENT:

1. Removal of seed husks
2. Removal of foreign substances from the fibre
3. Low possible fibre damage
4. High degree of whiteness
5. Good physical/ technological ratings
6. High color yield
7. Levelness of the effect
8. High and even hydrophilicity/ rewettability.

SINGEING : It is the process of burning out projecting hairy fibres from surface of the grey fabric by assigns the fabricthrough a gas flame. Both sides of the fabric are burnt out by the flame. It helps in subsequent chemical process of the fabric. After dyeing or printing of singed fabric, brightness and luster of color and fabric becomes better. Singeing is a process applied to both yarns and fabrics to produce an even surface by burning off projecting fibres, yarn ends, and fuzz. This is accomplished by passing the fibre or yarn over agas flame or heated copper plates at a speed sufficient to burn away the protruding material without scorching or burning the yarn or fabric.

DESIZING: The processes by which we remove sizes are known as desizing. Sizing is the need for the weaving but isan obstacle for the dyeing. It can be done by many ways such as acid steep, rot steep, enzymatic etc. inall these enzymatic desizing is dominating because of its eco- friendliness and also because of its characteristics that is it acts at specific sites only at definite pH, temperature and concentration. Mainlystarch is used as the ingredient in sizing.

Chemically starch is poly- α- glucopyranose in which straight chain (amylase) and branched chain (amylopectin) polymers are present. Both constituents of starch are insoluble in water, but they can be solubilised by hydrolysis of these long chain compounds to shorter ones. Thus under suitable conditions starch can be progressively hydrolyzed to the following stages. In desizing the hydrolysis reaction is carried out up to the stage of soluble dextrin only and not further to a-glucose.

SCOURING : It is the process of removing natural impurities present in the cotton fibre. The natural impurities are pectin’s, pectos, ash, wax, mineral compounds, etc. if those impurities present in the cotton fibres arenot removed, then it will be difficult to dye or print the fabric uniformly. Normally caustic soda ash is used as main reagent from scouring of cotton fabric.

BLEACHING: It is the process of removing natural coloring matters present in the cotton fibre. For his purpose, hydrogen peroxide, bleaching powder or other bleaching agents are used. Hydrogen peroxide is the best and most commonly used bleaching agent. If this bleaching treatment is not carried out before dyeing or printing hen the color yield and shade matching may be a great problem.

MERCERIZATION: Mercerization is a process that makes cotton take dye better and increases its luster. It was originally developed and patented by a man named John Mercer in 1844. The cotton is treated with Sodium Hydroxide (Caustic Soda) to swell the fibers and increase the fiber's luster as well as its affinity for dye by increasing the surface area of the fiber. Afterwards, the fabric is soaked in an acidic bath to neutralize the base. Also, by swelling the fibers in this highly alkaline bath, it makes the cotton fibers stronger and "pre- shrunk" because the they don't retract, so the woven fabric will shrink less later. The fabric also has a smoother and more lustrous look when mercerized under tension.

ACID DYE

The acid dyes are large dyes containing one or more sulfonic or carboxylic acid salt functional groups.

These dyes are dyed onto fibers from acid solution, since positive charge development within the fiber in acid solutions acts as a driving force for dye diffusion and migration into the fiber.

Only fibers which develop a positive charge in the presence of acid, such as wool, silk, and other protein fibers, nylon, and certain modified synthetics, are readily dyed by acid dyes,

Acid dyes on fibers are reasonably colorfast to light and laundering but moderating will improve the overall fastnessproperties of the dye.

The color of the dye may be affected somewhat by mordanting; however, pre-metallized acid dyes are a specialclass of acid dyes which have been reacted with a mordant prior to dyeing and which have sufficient solubility to be dyed under conditions normally used for acid dyes.

PROPERTIES OF ACID DYE:

- Most of the acid dye are sodium salt of sulphuric acid and carboxylic acid and anion group is the active colored component.
- Water soluble.
- Acid dye have direct affinity towards protein fiber and polyamide fibers.
- Maximum cellulose fiber can not absorb acid dye.
- Many bright shades are found.

CLASSIFICATION OF ACID DYE:

1. Classification according to affinity.
2. Classification according to dyeing characteristic.
3. Classification according to chemical constitutions.

1. Classifications of according to affinity:

I. Levelling dyes from a salt-like bond with the protein fiber and are relatively small molecules.

II. Milling dyes for which salt formation with the fiber and abosorbtion forces between the hydrophobic regions of the dye molecules.

III. Dyes which not only form a salt-like bond with the wool fiber but also bonded to the fiber by intermolecular forces. They have properties lying in an intermediate position between those of the levelling and milling dyes with intermediate molecular size.

2. Classification according to Dyeing Characteristics:

I. Level dyeing or equalizing dyes.
II. Fast acid dyes.
III. Milling acid dyes.
IV. Super-milling acid dyes.

3. Classification according to Chemical Constitution:

I. Sulphonated azo dyes.

II. Anthraquinone dyes.
III. Nitrodiphenylamine dyes.
IV. Triphenylmethane and xanthenes dyes.

Anthraquinone dyes:

Anthraquinone acid dyes are rich in violet through blue to green complementing the azo dyes. They have very good light fastness.

Properties of anthraquinone acid dyes:

- ❖ Anthraquinone acid dyes offer bright blue shades not obtainable in azo dyes.
- ❖ The red and yellow anthraquinone dyes are little importance.
- ❖ Green dyes obtained by the combination of yellow and blue dyes have mostly inferior wash fastness.
- ❖ The uniformly dyeing green dyes of the anthraquinone series have proved their special value in this context.
- ❖ Synthesis polyamides were known some selected dyes from this series were used. Special acid dyes of this class have been recently developed for this purpose.

WATER-REPELLENT DYES

Water repellence is an important property required for comfort wear. For comfort wear it is necessary for the fabric to be sufficiently porous to allow moist air to circulate. Water-repellent finish is given to fabric by way of finishes which form a water-repellent layer on the surface of the material without filling up the interstices. Several fluorine containing acid dyes are known in the literature(chao et al. 1993; hamada et al., 1989, 1990, 1991, 1993) and recently dyes having inherent water-repellent characteristics have been prepared (chao et al., 1998; Sekar and Rajule, 2004;Teli et al 2007).

DYEING OF WOOL FIBER WITH ACID DYE:

Dyestuff = 2% owf

H_2SO_4 = 2g/I

Salt ($Na_2SO_{4.}10H_2O$) =10g/I

Wetting agent =1g/I

Sequestering agent =1g/I

M:L =1:20

Time =1hr

Temp =100c

pH =4.5 to 5.5

DYEING PROCESSES:

- Dyeing
- Washing
- Neutralisation
- Soap wash & boiling
- Cold wash

AFTER TREATMENT :

- For increasing fastness properties of silk by using
  4% tannic acid
  1% tartar emetic acid
- For improving lusture by treatment with 4% acetic acid
- For increasing smoothness ,treatment with 1%t.r oil.

VAT DYE

- Dyeing produced with the vat dyes have the highest overall fastness properties.
- All of these dyes have good fastness against
  - Wet treatment
  - Crocking
  - Light fastness in the region of 6 to 7.

The vat dyes can also withstand oxidizing agent like

- Hydrogen peroxide
- Sodium chloride
- Hypochlorite

The vat dyes are extensively used for dyeing yarn. This cloth can undergo the pretreatment processes like

- Alkaline
- Bleaching
- Mercerizing
- Yarn dyeing has been taken over by the reactive dyes.
- Because reactive dyes less expensive, easier to apply.
- Superior quality shirting material
- Military uniforms
- Furnishing , curtain, towelling.

VAT DYES ARE ESSENTIALLY INSOLUBLE POLYCYCLIC AROMATIC COMPOUND:

- Vat pigments are made water soluble by reducing to HYDROQUINONE forms in an alkaline media. This process known as vatting.
- Vatting term referring to a historical link with the vegetable indigo dye that used to reduced in wooden vats with natural reducing agents like sugar.

PRESENT VATTING/ REDUCING CHEMICALS:

- Quality of reducing agent depend upon Number of ketone groups present in the dye molecules
- To the extent /amount of exposure or the dye bath to AIR
- Change in colour that is due to alternative in the conjugation of DOUBLE BONDS.

- The reduced indigo has a PALE SHADE and so it was called the LEUCO(white)dye.

DYEING STRUCTURE OF VAT DYES

Sodium salts (NaCl) of the reduced or Leuco vat dyes behave like:

- Direct dyes
- As of as adsorption on the cellulose fibers is concerned
- High intrinsic substantivity
- In spite of lack of linearity
- Hydrogen bonding groups attributed
- To the molecular complexity
- Co-planarity of the VAT dyes.

As a High concentration of sodium ion from caustic soda and sodium dithionate

- Already exist in the reduced bath
- The VAT dye tend to have HIGH RATE of adsorption
- EXHAUSTION in the initial stage of application.

The RAPID ADSORPTION of dye in the first few minute:

- Technically termed as "HIGH STRIKE" value.
- This tendency require carefully attention as well as ADDITION of retarding agents to obtained level dyeing.
- After the adsorption of the LEUCO DYES
- An oxidizing agents is added o the bath.
- That regenerates the VAT PIGMENTS insides the fibres.
- Finally to achieves full fastness properties and to develop the proper shade, the dyed goods.
- Thoroughly soaped at boil.
- VAT dyes three main classes for application purposes.

1. CLASS I or IN; 2. CLASS II or IW; 3.CLASS III or IK

i) CLASS I or IN:

- where I stands for Indanthrene and N for normal.
- In their Leuco forms have high substantively for the cellulosic fibres.
- These needs high alkalinity for dissolution and are dyed at about 75^0 c

ii) CLASS I or IW:

- Where I stands for indanthrene and W for Warm.
- In their MODERATE substantivity for cellulosic fibres.
- And are dyed at about 45^0c to 75^0
- Needs electrolytes for complete EXHAUSTION of the dye.

iii) CLASS III or IK:

- Where I stands for indanthrene and K for KALT / COLD
- Have LOW substantivity for the cellulosic fibres.
- These needs moderate Alkalinity for Dissolution
- And are dyed at low temperature about 20^0c to $30^{0.}$
- Needs in a higher concentration Electrolytes than class II for complete EXHAUSTION of the dye.
- Dyes of the IK Group other than the indigo , are not into the above mentioned three groups and are dyed by a special method.

METHOD DYEING:

- In batch dyeing of fabric, VAT dyes are normally applied in the reduced in a JIGGER.
- Continuous Processes are,

Fabric is PADDED in stable dispersion of very finely divided vat pigments often termed as MICRO-DISPERSSION. After drying the dye padded fabric, it is reacted with an ALKALINE REDUCING SOLUTION in a padder to VAT PIGMENT into water-soluble LEUCO FORM. LEUCO FORM diffuses into the fibre. Reduce vat dyeing. Batch wise dyeing woven and knit fabrics. Also for yarn in hank or package form. Reduction of the dye is faster in the stoke vat. Concentration of the dye and reducing chemicals is higher than long bath. This dispersion at optimum temperature. Stirred for 10 minute. When reduction is complete. Soft water must for dissolving and as for as dyeing. Dyeing in hard water causes precipitation counter this problem by use of sequestering agent.

TREATMENT AFTER EXHAUSTION OF DYES:

After exhaustion, the class I &II dyes are rinsed with cold water. To remove chemicals and surface dye from the fibres. But the low affinity class III dyes are not rinsed prior to their oxidation to avoid their bleeding. Rinsing also oxidizes part of the dye but except for the class III dyes. Complete regeneration or the vat pigment is done with the oxidizing agents. H_2O_2 , $NaCO_3$, Sodium meta-nitro -benzene sulphonate or Dichromate- Concentration of the oxidizing agent depend on depth of shade.Liquor ratio 1-4 g/ I perborate, Oxidation time20 minutes at 40-60°c. The class III dyes are oxidized by exposure to air.

APPLICATION :

1. PADDING: Padder should be mechanically perfect and extract even pressure through the width of the fabric.

The Pigment dispersion normally contains a migration inhibitor, Wetting agent and the later is added for quick wetting of the fabric.

2. DRYING: It is not necessary for light shades. But is HELP IN LEVELING and improving colour yield.

3. DEVELOPMENT: Method are used for both development of the DYE PIGMENT. The following process are carried out,

- Both the batch and continuous
- In the batch process - Reduction - Adsorption of the dye can be carried out on a jigger - Done is the reduced dyeing method after adding - Alkali and reducing agent - If variation is shade due to bleeding is not totally eliminated - In the chemical padder 4-10% of the bath is made with the pad liquor.

CORRECTION OF FAULTY DYEING: Levelling out and partial stripping or cross dyeing - however kept in mind LUECO VATS have a very high affinity with cotton fibers and so difficult to strip off the dyed goods.

- **LEVELLING OUT -** Defective material treated in blank bath containing 10- 20%mI / I caustic soda - 50 – 100 G / L dithionate -1 – 2 g / I wetting and dispersing agent - at 70 – 80^0 C for about 30 minutes -after this color removal treatment (15% of the original dye is used is ADDED) and the normal dyeing and oxidation is carried out.

- **PARTIAL STRIPING -** Similar to the levelling out but addition of dye complexing agent-2-2 G / L Poly Vinyl Pyrolidine(PVP) - Compounds forms a stable complex with the reduced dye - Does not allow to exhaustion on the fibers.

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UNIT -III - PAINT CHEMISTRY

PAINT

Paint is any pigmented liquid, liquefiable or solid mastic composition that after application to a substrate in a thin layer converts to a solid film. It is most commonly used to protect, color or provide texture to objects. Paint can be made or purchased in many colors and in many different types such as watercolor or synthetic. Paint is typically stored, sold and applied as a liquid but most types dry into a solid. Most paints are either oil-based or water-based and each have distinct characteristics. For one, it is illegal in most municipalities to discard oil based paint down household drains or sewers. Solvents for clean up are also different for water based paint than they are for oil based paint. Water-based paints and oil-based paints will cure differently based on the outside ambient temperature of the object being painted (such as a house.)

INGREDIENTS

All paints generally have four main ingredients pigments, binders, solvents (liquids) and additives. Pigments provide color and hide while binders work to bind the pigment together and create the paint film. Solvents are the liquids that suspend the ingredients and allow you to place the paint on the surfaces and additives are ingredients that provide specific paint properties such as mildew resistance. All four ingredients combine to provide paint that meets your specific design needs.

PIGMENTS - PROVIDE COLOR, HIDE AND BULK

Pigments are finely ground particles that are dispensed into paint and provide color and hiding properties. There are two primary types of pigment - prime pigments and extender pigments.

Prime pigments are those that contribute to both wet and dry hide in paint. Titanium dioxide (TiO_2) is the most costly pigment and it contributes directly to a paints wet hide while providing whiteness Colorants are prime pigments that provide the actual color within the can. There are two main types - organic and inorganic.

1) Organic colorants provide the brighter colors, and examples of these pigments include hansa yellow and phthalo blue. These are not very durable for exterior paint application.

2) Inorganic colorants are the duller, earthy colors and are more durable for exterior paint application. Examples of these kinds of pigments include red oxide, yellow ochre and umber

Extender pigments are lower cost pigments that give extra weight or bulk to the paint. These types of pigments contribute only to a paints dry hide but are necessary in order to control gloss. Some extender pigments also provide additional film performance in the areas of scrub or abrasion resistance. Commonly used extenders include clay, silica, diatomaceous silica, calcium carbonate, talc and zinc oxide.

Clay: Used mainly in interior paints, clay provides hiding power.

Silica: Provides enhanced durability in exterior paints as well as scrub and abrasion resistance.

Diatomaceous silica: Consisting of fossilized organisms this form of silica is used to control sheen levels.

Calcium Carbonate: Used in both interior and exterior paints, calcium carbonate, also called chalk, is a general purpose, low cost, low hide pigment.

Talc: Also called magnesium silicate, talc is a soft, general purpose extender pigment.

Zinc oxide: Used primarily in primers and exterior paints, zinc oxide provides mildew resistance, corrosion inhibition and stain blocking support.

BINDERS - PROVIDE PERFORMANCE AND SUPPORT FOR DRY PAINT FILM

Binders are ingredients that provide a binding effect that holds the pigments together to create a dry film on the surface. A paints binder is the key ingredient that directly relates to a paints performance, including adhesion, washability, scrub resistance, fade resistance or gloss retention.

Alkyd (oil) based binders are made from various oil derivatives such as linseed oil, tung oil, and soya oil. Traditional alkyd paints dry to a very hard finish and provide superior adhesion and flow and leveling. However, they will yellow in light colors and are prone to oxidation and chalking when used on exterior surfaces. As technology and VOC restrictions have changed over the years fewer paints today are made with traditional alkyd binders. A newer technology based on modified oil binders is available alkyd emulsion. This type of hybrid binder gives you oil-like performance with the ease of soap and water clean-up. Alkyd-emulsion paints dry harder, flow more smoothly than typical latex paints. However, they may still yellow in lighter colors. If used on exterior surfaces subjected to UV exposure alkyd-emulsion paints may eventually oxidize and chalk over time.

LATEX PAINT AND INGREDIENTS

Latex binders are used in water-based paints. There are various types of latex binders available such as 100% acrylic, styrene acrylic or vinyl acrylic each providing specific performance characteristics

ACRYLIC PAINT AND INGREDIENTS

- 100% Acrylic binders: often used in exterior paints as the benefits include adhesion (both wet and dry), fade resistance, alkali and efflorescence resistance. 100% acrylic binders are typically regarded as the best overall performing.
- Adhesion under wet conditions allow for greater performance in blister, cracking and peeling resistance.
- UV fade resistance allows the painted surface to retain its color and sheen longer.
- Alkali resistance means the paint is less likely to “burn" over fresh concrete or masonry.
- Vinyl acrylic, also called PVA, binders: often used in interior paints as the benefits include scrub resistance and washability.
- Styrenated acrylic binders: often used in masonry primer/sealers and top coats due to its resistance to alkali burn and efflorescence.

Solvents (liquids) Provides a vehicle for the pigment and binder to get from the can onto the surface

Solvents, or liquids, are the vehicle for allowing paint to get from the can to the surfaces and these types of liquids differ depending on the type of paint. Combining the pigments and binders considered solids with the liquids creates the paint coating you see in the paint can.

- Oil-based and alkyd paints: the liquid is typically paint thinner or other type of solvent.
- Latex paints: the liquid is primarily water.

Higher-quality paints allow for more solids typically 35-40% depending on gloss level. Solids by volume indicate how much paint will remain on the surface after the liquids have evaporated. The overall paint performance is directly attributable to the make-up of the solids. Just because a paint has high solids by volume does not always translate to a high quality product.

ADDITIVES - PROVIDES ADDITIONAL PROPERTY ENHANCEMENTS

Additives are used in paints to create additional performance properties and the most commonly used are:

- Thickening agents: provides viscosity or additional thickness so the paint can be applied properly also allows for better flow and leveling and resists a splatter effect when rolling out the paint.
- Surfactants or soaps: provides paint stability so the paint won't separate; also keeps the pigments dispersed in the liquid to allow for better hiding power and additional assurance for color accuracy
- Biocides: In latex paints, there are two types of biocides used a preservative to keep bacteria from growing; and a mildewcide to discourage mildew growth
- Defoamers: Provides a way to break bubbles as they are formed during the paint manufacturing process when paint is shaken at the tint center and when paint is applied onto a surface
- Co-solvents: provides additional liquids to the water and can assist the binders in forming a good film when applied in cold temperatures and assists brushing properties so paint has time to be applied before drying.

CLASSIFICATION OF PAINT

- Solvent borne paints contain up to 80% of solid constituents (binders, pigments and additives) dispersed in the organic solvent. Solvent-borne paints dry fast and may contain a wide range of binders. The main disadvantages of the solvent-borne paints are their toxicity and combustibility.
- Water borne paints contain water as the paint solvent. Waterborne paints are non-toxic and non-combustible but they are characterized by long drying time due to slow evaporation rate of water.
- Water borne paints based on water soluble binders contain low molecular weight polymeric binders dispersed in water in form of true solutions. Water-soluble binders contain up to 15% of organic oxygen containing solvents soluble in water (alcohols, glycol ethers, etc.).
- Water borne paints based on polymer dispersions (Emulsion paints) contain 50-60% of high molecular weight polymeric binders dispersed in water in form of Colloids. Emulsion paint contain up to 5% of organic oxygen containing solvents soluble in water (alcohols, glycol ethers, etc.).
- High solids paints (Low VOC paints) contain more than 80% of solid constituents (binders, pigments) dispersed in an organic solvent. VOC - volatile organic compounds.
- Powder Coatings are obtained from powdered resin, particles of which are attracted by the electrostatic force to the substrate surface (electrodeposition). No solvent is involved in the process therefore powder coatings produce no/low toxic waste. The main disadvantage of powder coatings is high cost of equipment.
- Radiation curable coatings are formed from a mixture of

- Prepolymers monomers and additives, which is cured under ultra-violet radiation. Radiation curable coatings harden fast and contain no solvents. The main disadvantage is relatively high cost.

EMULSION PAINT

Emulsion paint is basically water based paint. It can be principally used for both internal as well as the external surfaces of the building. In Emulsion paint water is used as a solvent. Water is a medium in which the binder, pigment and additives are dispersed in molecular form. Polymers are a binder, forming a continuous film on the surface. Binder used in emulsion paint is alkyd resins, acrylic resins, epoxies, etc.

Properties of Emulsion Paint

Emulsion paints are less toxic as compared to other oil based paints and almost all manufacturer companies claim that it possesses zero volatile organic compounds. Washability of Emulsion paints is of medium to high level. Washability mainly depends upon the surface sheen. Some sheen is wipeable & some are washable depending upon the manufacturer’s guide. Emulsion Paints are available in 1 ltr, 4 ltr, 10 ltr, 20 ltr packs. Emulsion paint is available in the market with several different finishes such as matt, smooth, egg shell, semi glossy and glossy. Two coat of emulsion paints can cover up to 100 -160 sqft/lit of the area. i.e for painting 100 sqft of the area you may need 0.6 to 1.0 litre of paint for two coats.

Application

- Emulsion paints are easy to apply and they dry quicker than other water based paint and oil based paint. It can be applied by both brushes as well as a roller. If you are planning to paint your house on your own than follow the DIY instructions on the manufacturer’s brochures.
- Emulsion paints are not ready to use. You have to add thinner (water) before the application. If you don’t add thinner in the paint, there are chances of appearance of various defects on finished paint walls.
- Emulsion Paints are applied to new as well as the old plastered surface. It is also applied on metal, wooden furniture, glass, and concrete.

LACQUER

The term lacquer is used for a number of hard and potentially shiny finishes applied to materials such as wood or metal. These fall into a number of very different groups.

The term lacquer originates from the sanskrit word laksha representing the number 100,000, which was used for both the lac insect (because of their enormous number) and the scarlet resinous secretion, rich in shellac, that it produces that was used as wood finish in ancient India and neighbouring areas.

Asian lacquer ware which may be called true lacquer are objects coated with the treated dyed and dried sap of Toxicodendron vernicifluum or related trees applied in several coats to a base that is usually wood. This dries to a very hard and smooth surface layer which is durable, waterproof, and attractive in feel and look. Asian lacquer is sometimes painted with pictures inlaid with shell and other materials or carved, as well as dusted with gold and given other further decorative treatments.

In modern techniques, lacquer means a range of clear or pigmented coatings that dry by solvent evaporation to produce a hard, durable finish. The finish can be of any sheen level from ultra matte to high gloss and it can be further polished as required. Lacquer finishes are usually harder and more brittle than oil-based or latex paints and are typically used on hard and smooth surfaces.

In terms of modern finishing products, finishes based on shellac dissolved in alcohol are often called shellac or lac to distinguish them from synthetic lacquer often called simply lacquer which consists of synthetic polymers (such as nitrocellulose, cellulose acetate butyrate or acrylic resin) dissolved in lacquer thinner, a mixture of various organic solvents. Although synthetic lacquer is more durable than shellac, traditional shellac finishes are nevertheless often preferred for their aesthetic characteristics, as with French polish, as well as their all-natural and generally food-safe ingredients.

Types of Lacquer

Types of lacquer vary from place to place but they can be divided into unprocessed and processed categories.

The basic unprocessed lacquer is called raw lacquer. This is directly from the tree itself with some impurities filtered out. Raw lacquer has a water content of around 25% and appears in a light brown colour. This comes in a standard grade made from Chinese lacquer, which is generally used for ground layers by mixing with a powder, and a high-quality grade made from Japanese lacquer called kijomi-urushi which is used for the last finishing layers.

The processed form (in which the lacquer is stirred continuously until much of the water content has evaporated) is called guangqi in Chinese but comes under many different Japanese names depending on the variation, for example, kijiro-urushi is standard transparent lacquer sometimes used with pigments and roiro-urushi is the same but pre-mixed with iron hydroxide to produce a black coloured lacquer. Nashiji-urushi is the transparent lacquer but mixed with gamboge to create a yellow-tinged lacquer and is especially used for the sprinkled-gold technique. These lacquers are generally used for the middle layers. Japanese lacquers of this type are generally used for the top layers and are prefixed by the word jo- which means top (layer)

Processed lacquers can have oil added to them to make them glossy for example shuai-urushi is mixed with linseed oil. Other specialist lacquers include ikkake-urushi which is thick and used mainly for applying gold or silver leaf.

Nitrocellulose lacquers

Solvent-based lacquers that contain nitrocellulose a resin obtained from the nitration of cotton and other cellulosic materials debuted in the 19th century along with nitrocellulose's other commercial applications. They were used, for example on brass items such as musical instruments. Faster-drying and more durable versions of these lacquers were developed in the early 1920s and soon greatly displaced much use of the slower-drying paints and lacquers that preceded them they were extensively used in the automotive industry and others for the next 30 years until further chemical advancements replaced them. Prior to their introduction, mass-produced automotive finishes were limited in colour damaged easily and took a long time to dry with Japan black being the fastest drying and thus the most economical to use. In 1923 General Motors Oakland brand automobile was the first to introduce one of the new fast-drying nitrocellulose lacquers a bright blue produced by Dupont under their Duco tradename. In 1924 the other GM makes followed suit and by 1925 nitrocellulose lacquers were thoroughly disrupting the traditional paint business for automobiles, appliances, furniture, musical instruments, caskets and other products.

Nitrocellulose lacquers are also used to make firework fuses waterproof. The nitrocellulose and other resins and plasticizers are dissolved in the solvent and each coat of lacquer dissolves some of the previous coat. These lacquers were a huge improvement over earlier automobile and furniture finishes both in ease of application and in colour retention. The preferred method of applying quick-drying lacquers is by spraying and the development of nitrocellulose lacquers led to the first extensive use of spray guns. Nitrocellulose lacquers produce a hard yet flexible durable finish that can be polished to a high sheen. Drawbacks of these lacquers include the hazardous nature of the solvent which is flammable and toxic and the hazards of nitrocellulose in the manufacturing process. Lacquer grade of soluble nitrocellulose is closely related to the more highly nitrated form which is used to make explosives. They become relatively non-toxic after approximately a month since at this point the lacquer has evaporated most of the solvents used in its production.

Acrylic lacquers

Lacquers using acrylic resin a synthetic polymer were developed in the 1950s. Acrylic resin is colorless transparent thermoplastic obtained by the polymerization of derivatives of acrylic acid. Acrylic is also used in enamel paints which have the advantage of not needing to be buffed to obtain a shine. Enamels, however, are slow drying. The advantage of acrylic lacquer is its exceptionally fast drying time. The use of lacquers in automobile finishes was discontinued when tougher more durable weather and chemical-resistant two component polyurethane coatings were developed. The system usually consists of a primer, color coat and clear topcoat commonly known as clear coat finishes.

Water – based lacquers

Due to health risks and environmental considerations involved in the use of solvent-based lacquers much work has gone into the development of water-based lacquers. Such lacquers are considerably less toxic and more environmentally friendly and in many cases, produce acceptable results. While water-based lacquer's fumes are considerably less hazardous and it does not have the combustibility issues of solvent-based lacquers, the product still dries fairly quickly. Even though its odor is weaker, water-based lacquers can still produce airborne particulates that can get into the lungs, so proper protective wear still needs to be worn. More and more water-based colored lacquers are replacing solvent-based clear and colored lacquers in under-hood and interior applications in the automobile and other similar industrial applications. Water-based lacquers are used extensively in wood furniture finishing as well.

One drawback of water-based lacquer is that it has a tendency to be highly reactive to other fresh finishes such as quick-dry primer (excluding waterborne lacquer primers) caulking and even some paints that have a paint/primer aspect. Tannin bleed-through can also be an issue depending on the brand of lacquer used. Once it happens there is no easy fix as the lacquer is so reactive to other products.

Water-based lacquer used for wood finishing is also not rated for exterior wear unless otherwise specified.

Japanning

Just as china is a common name for porcelain japanning is an old name to describe the European technique to imitate Asian lacquerware. As Asian lacquer work became popular in England, France, the Netherlands and Spain in the 17th century, the Europeans developed imitation techniques. The European technique which is used on furniture and other objects uses finishes that have a resin base similar to shellac. The technique which became known as japanning involves applying several coats of varnish which are each heat-dried and polished. In the 18th century japanning gained a large popular following. Although traditionally a pottery and wood coating, japanning was the popular (mostly black) coating of the accelerating metalware industry. By the twentieth century, the term was freely applied to coatings based on various varnishes and lacquers besides the traditional shellac.

ENAMEL

Enamel paint is paint that air-dries to a hard usually glossy, finish, used for coating surfaces that are outdoors or otherwise subject to hard wear or variations in temperature It should not be confused with decorated objects in painted enamel where vitreous enamel is applied with brushes and fired in a kiln. The name is something of a misnomer as in reality most commercially available enamel paints are significantly softer than either vitreous enamel or stoved synthetic resins and are totally different in composition. vitreous enamel is applied as a powder or paste and then fired at high temperature. There is no generally accepted definition or standard for use of the term enamel paint and not all enamel-type paints may use it.

Typically, the term enamel paint is used to describe oil-based covering products usually with a significant amount of gloss in them however recently many latex or water-based paints have adopted the term as well. The term today means hard surfaced paint and usually is in reference to paint brands of higher quality floor coatings of a high gloss finish or spray paints. Most enamel paints are alkyd resin based. Some enamel paints have been made by adding varnish to oil-based paint.

Although enamels and painted enamel in art normally refer to vitreous enamel in the 20th century some artists used commercial enamel paints in art including Pablo Picasso (mixing it with oil paint) Hermann-Paul, Jackson Pollock and Sidney Nolan. The Trial (1947) is one of a number of works by Nolan to use enamel paint usually Ripolin a commercial paint not intended for art also Picasso's usual brand. Some enamel paints are now produced specifically for artists.

Enamels paints can also refer to nitro-cellulose based paints one of the first modern commercial paints of the 20th century. They have since been superseded by new synthetic coatings like alkyd, acrylic and vinyl due to toxicity, safety and conservation (tendency to age yellow) concerns. In art has been used also by Pollock with the commercial paint named Duco. The artist experimented and created with many types of commercial or house paints during his career. Other artists after discovering various types of industrial materials produced in the United States in the 1930s, Siqueiros' produced most of his easel works with uncommon materials which include Duco paint a DuPont brand name for pyroxyline paint a tough and resilient type of nitro-cellulose paint manufactured for the automotive industry. Nitro-cellulose enamels are also commonly known as modern lacquers.

USES

- Floor enamel - May be used for concrete, stairs, basements, porches, and patios.
- Fast dry enamel - Can dry within 10-15 minutes of application. Ideal for refrigerators, counters, and other industrial finishes.

- High-temp enamel – May be used for engines, brakes, exhaust, and BBQs.
- Enamel paint is also used on wood to make it resistant to the elements via the waterproofing and rotproofing properties of enamel. Generally treated surfaces last much longer and are much more resistant to wear than untreated surfaces.
- Model building – Xtracolor and Humbrol are mainstream UK brands. Colour coats model paint is a high-quality brand with authentic accurate military colours. Testors, a US company, offers the Floquil, Pactra, Model Master and Testors brands.
- Nail Enamel – to color nails is also called as enamel and it comes in many varieties for fast drying, color retention, gloss retention etc…
- Epoxy enamel, Polyurethane Enamel etc used in protective coating / industrial painting purpose in chemical and petrochemical industries for anti-corrosion purposes.

Pot Life

Pot Life is a term used for two-pack (multi-pack) coatings that cure through a chemical reaction such as epoxies and most polyurethanes. These systems consist of a base component and a catalyst or hardener component. When these components are mixed together a chemical reaction starts that leads to the curing of the paint. Pot life is the time from mixing the two packs together to the point at which the mixed paint is no longer useable. It is also known as the working time or useable life. Pot life is often thought of as the length of time that a mixed (catalysed) coating system retains a viscosity low enough to be applied to a surface. This is not strictly true. While many two-pack coatings show an increase in viscosity as they approach and pass their pot life there are also many products (typically low-solids or water-borne products) that show little or no change in viscosity even well past their pot life.

Shelf Life

All paints have a shelf life. some shorter and some longer. Waterborne paints such as household latex paints have a shelf life of six months to one year depending on ambient temperature conditions. Once you have opened the can of paint, the shelf life may be shorter. Even though the published shelf life of the paint you intend to use may have expired that does not automatically mean that you should discard it. If the paint appears to mix properly and does not show signs of livering, separation or anything else unusual, you should still be able to use it.

VARNISH

Varnish is a clear transparent hard protective finish or film. It is neither a paint nor stain. In its native state it has little or no color but may be pigmented as desired, and is sold commercially in various shades.

Varnish is primarily used to seal wood finishes where, stained or not the distinctive tones and grains in the wood are intended to be visible. Varnish finishes are naturally glossy but satin or semi-gloss sheens are available.

The term varnish refers to the finished appearance of the product. It is not a term for any single or specific chemical composition or formula. There are many different compositions that achieve a varnish effect when applied. A distinction between spirit-drying (and generally removable) lacquers and chemical-cure varnishes (generally thermosets containing drying oils) is common, but varnish is a broad term historically and the distinction is not strict.

Components of Varnish

Varnish is traditionally a combination of a drying oil, a resin, and a thinner or solvent. However, different types of varnish have different components. After being applied the film-forming substances in varnishes either harden directly as soon as the solvent has fully evaporated or harden after evaporation of the solvent through curing processes, primarily chemical reaction between oils and oxygen from the air (autoxidation) and chemical reactions between components of the varnish.

Resin varnishes dry by evaporation of the solvent and harden almost immediately upon drying. Acrylic and waterborne varnishes dry upon evaporation of the water but will experience an extended curing period for evaporation of organic solvents absorbed on the latex particles and possibly chemical curing of the particles. Oil, polyurethane and epoxy varnishes remain liquid even after evaporation of the solvent but quickly begin to cure undergoing successive stages from liquid or syrupy, to tacky or sticky, to dry gummy, to dry to the touch to hard.

Environmental factors such as heat and humidity play a very large role in the drying and curing times of varnishes. In classic varnish the cure rate depends on the type of oil used and to some extent, on the ratio of oil to resin. The drying and curing time of all varnishes may be sped up by exposure to an energy source such as sunlight, ultraviolet light or heat.

Drying oil

There are many different types of drying oils, including linseed oil, tung oil, and walnut oil. These contain high levels of polyunsaturated fatty acids. Drying oils cure through an exothermic reaction between the polyunsaturated portion of the oil and oxygen from the air. Originally, the term varnish referred to finishes that were made entirely of resin dissolved in suitable solvents, either ethanol (alcohol) or turpentine. The advantage to finishes in previous centuries was that resin varnishes had a very rapid cure rate compared to oils in most cases they are cured practically as soon as the solvent has fully evaporated. By contrast, untreated or raw oils may take weeks or months to cure depending on ambient temperature and other environmental factors. In modern terms boiled or partially polymerized drying oils with added siccative's or dryers (chemical catalysts) have cure times of less than 24 hours. However, certain non-toxic by-products of the curing process are emitted from the oil film even after it is dry to the touch and over a considerable period of time. It has long been a tradition to combine drying oils with resins to obtain favorable features of both substances.

Resin

Many different kinds of resins may be used to create a varnish. Natural resins used for varnish include amber, kauri gum, dammar, copal, rosin (colophony or pine resin), sandarac, balsam, elemi, mastic, and shellac. Varnish may also be created from synthetic resins such as acrylic, alkyd, or polyurethane. A varnish formula might not contain any added resins at all since drying oils can produce a varnish effect by themselves.

Solvent

Originally, turpentine or alcohol was used to dissolve the resin and thin the drying oils. The invention of petroleum distillates has led to turpentine substitutes such as white spirit paint thinner, and mineral spirit. Modern synthetic varnishes may be formulated with water instead of hydrocarbon solvents.

Types

Violin varnishing is a multi-step process involving some or all of the following: primer, sealer, ground, color coats, and clear topcoat. Some systems use a drying oil varnish as described below, while others use spirit (or solvent) varnish. Touchup in repair or restoration is only done with spirit varnish.

Drying oil such as walnut oil or linseed oil may be used in combination with amber, copal, rosin or other resins. Traditionally the oil is prepared by cooking or exposure to air and sunlight but modern stand oil is prepared by heating oil at high temperature without oxygen. The refined resin is sometimes available as a translucent solid and is then run by cooking or melting it in a pot over heat without solvents. The thickened oil and prepared resin are then cooked together and thinned with turpentine (away from open flame) into a brush able solution. The ingredients and processes of violin varnish are very diverse, with some highly regarded old examples showing defects (e.g cracking, crazing) associated with incompatible varnish components.

Some violin finishing systems use Vernice (egg white and gum Arabic) as a sealer or ground. There is also evidence that finely powdered minerals possibly volcanic ash were used in some grounds. Some violins made in the late 18th century used oxen's blood to create a very deep-red coloration. Today this varnish would have faded and currently be a very warm, dark orange.

RESIN

Most resin or gum varnishes consist of a natural plant or insect-derived substance dissolved in a solvent, called spirit varnish or solvent varnish. The solvent may be alcohol, turpentine, or petroleum-based. Some resins are soluble in both alcohol and turpentine. Generally, petroleum solvents i.e. mineral spirits or paint thinner, can substitute for turpentine. The resins include amber, dammar, copal, rosin, sandarac, elemi, benzoin, mastic, balsam, shellac, and a multitude of lacquers.

Synthetic resins such as phenolic resin may be employed as a secondary component in certain varnishes and paints.

Over centuries, many recipes were developed which involved the combination of resins, oils, and other ingredients such as certain waxes. These were believed to impart special tonal qualities to musical instruments and thus were sometimes carefully guarded secrets. The interaction of different ingredients is difficult to predict or reproduce so expert finishers were often prized professionals.

Shellac

Shellac is a very widely used single-component resin varnish that is alcohol-soluble. It is not used for outdoor surfaces or where it will come into repeated contact with water, such as around a sink or bathtub. The source of shellac resin is a brittle or flaky secretion of the female lac insect, Kerria lacca found in the forests of Assam and Thailand and harvested from the bark of the trees where she deposits it to provide a sticky hold on the trunk. Shellac is the basis of French polish, which for centuries has been the preferred finish for fine furniture. Specified dewaxed shellac has been processed to remove the waxy substances from original shellac and can be used as a primer and sanding-sealer substrate for other finishes such as polyurethanes, alkyds, oils, and acrylics.

Prepared shellac is typically available in clear and amber (orange) varieties, generally as three-pound cut or three pounds dry shellac to one US gallon of alcohol. Other natural color shades such as ruby and yellow are available from specialty pigment or woodworker's supply outlets. Dry shellac is available as refined flakes, sticklac, button lac or shellac. White pigmented shellac primer paint is widely available in retail outlets billed as a fast-drying interior primer problem solver, in that it adheres to a variety of surfaces and seals off odors and smoke stains. Shellac clean-up may be done either with pure alcohol or with ammonia cleansers.

Alkyd

Modern commercially produced varnishes employ some form of alkyd for producing a protective film. Alkyds have good solvent, moisture and UV light resistance. Alkyds are chemically modified vegetable oils which operate well in a wide range of conditions and can be engineered to speed up the cure rate and thus harden faster. Better (and more expensive) exterior varnishes employ alkyds made from high performance oils and contain UV-absorbers; this improves gloss-retention and extends the lifetime of the finish. Various resins may also be combined with alkyds as part of the formula for typical oil varnishes that are commercially available.

Spar varnish

Spar varnish (also called marine varnish) was originally intended for use on ship or boat spars, to protect the timber from the effects of sea and weather. Spars bend under the load of their sails. The primary requirements were water resistance and also elasticity, so as to remain adhering as the spars flexed. Elasticity was a pre-condition for weatherproofing too as a finish that cracked would then allow water through, even if the remaining film was impermeable. Appearance and gloss was of relatively low value. Modified tung oil and phenolic resins are often used.

When first developed, no varnishes had good UV-resistance. Even after more modern synthetic resins did become resistant a true spar varnish maintained its elasticity above other virtues even if this required a compromise in its UV-resistance. Spar varnishes are thus not necessarily the best choice for outdoor woodwork that does not need to bend in service.

Despite this the widespread perception of marine products as tough led to domestic outdoor varnishes being branded as Spar varnish and sold on the virtue of their weather- and UV-resistance. These claims may be more or less realistic depending on individual products. Only relatively recently have spar varnishes been available that can offer both effective elasticity and UV-resistance.

Drying oils

Arguably, drying oils, such as linseed and tung oil are not true varnishes though often in modern terms they accomplish the same thing.

Poly urethane

Polyurethane varnishes are typically hard, abrasion-resistant and durable coatings. They are popular for hardwood floors but are considered by some wood finishers to be difficult or unsuitable for finishing furniture or other detailed pieces. Polyurethanes are comparable in hardness to certain alkyds but generally form a tougher film. Compared to simple oil or shellac varnishes, polyurethane varnish forms a harder, decidedly tougher and more waterproof film. However, a thick film of ordinary polyurethane may delaminate if subjected to heat or shock fracturing the film and leaving white patches. This tendency increases with long exposure to sunlight or when it is applied over soft woods like pine. This is also in part due to polyurethane's lesser penetration into the wood. Various priming techniques are employed to overcome this problem including the use of certain oil varnishes, specified dewaxed shellac, clear penetrating epoxy sealer or oil-modified polyurethane designed for the purpose. Polyurethane varnish may also lack the hand-rubbed lustre of drying oils such as linseed or tung oil in contrast, however, it is capable of a much faster and higher build of film accomplishing in two coats what may require multiple applications of oil. Polyurethane may also be applied over a straight oil finish, but because of the relatively slow curing time of oils the emission of certain chemical byproducts, and the need for exposure to oxygen from the air care must be taken that the oils are sufficiently cured to accept the polyurethane.

Unlike drying oils and alkyds which cure after evaporation of the solvent and upon reaction with oxygen from the air true polyurethane coatings cure after evaporation of the solvent and then either by a variety of reactions of chemicals within the original mix, or by reaction with moisture from the air. Certain polyurethane products are hybrids and combine different aspects of their parent components. Oil-modified polyurethanes, whether water-borne or solvent-borne, are currently the most widely used wood floor finishes.

Exterior use of polyurethane varnish may be problematic due to its heightened susceptibility to deterioration through ultra-violet light exposure. All clear or translucent varnishes, and indeed all film-polymer coatings (e.g. paint, stain, epoxy, synthetic plastic, etc.) are susceptible to this damage in varying degrees. Pigments in paints and stains protect against UV damage. UV-absorbers are added to polyurethane and other varnishes (e.g. spar varnish) to work against UV damage but are decreasingly effective over the course of 2–4 years depending on the quantity and quality of UV-absorbers added, as well as the severity and duration of sun exposure. Water exposure, humidity, temperature extremes and other environmental factors affect all finishes. By contrast wooden items retrieved from the Egyptian pyramids have a new and fresh appearance after 4000 years of storage. Even there, however, fungal colonies were present and mildew and fungus are another category of entities which attack varnish. In other words, the only coat of varnish with near perfect durability is the one stored in a vacuum, in darkness, at a low and unvarying temperature. Otherwise, care and upkeep are required.

LACQUER

The word lacquer refers to quick-drying, solvent-based varnishes or paints. Although their names may be similarly derived, lacquer is not the same as shellac and is not dissolved in alcohol. Lacquer is dissolved in lacquer thinner which is a highly flammable solvent typically containing butyl acetate and xylene or toluene. Lacquer is typically sprayed on, within a spray booth that evacuates overspray and minimizes the risk of combustion.

The rule of thumb is that a clear wood finish formulated to be sprayed is a lacquer, but if it is formulated to be brushed on then it is a varnish. Thus, by far most pieces of wooden furniture are lacquered.

Lacquer may be considered different from varnish because it can be re-dissolved later by a solvent (such as the one it was dissolved in when it was applied) and does not chemically change to a solid like other varnishes.

Acrylic

Acrylic resin varnishes are typically water-borne varnishes with the lowest refractive index of all finishes and high transparency. They resist yellowing. Acrylics have the advantage of water clean-up and lack of solvent fumes, but typically do not penetrate into wood as well as oils. They sometimes lack the brush ability and self-leveling qualities of solvent-based varnishes. Generally, they have good UV-resistance.

In the art world, varnishes offer dust-resistance and a harder surface than bare paint they sometimes have the benefit of ultraviolet light resistors, which help protect artwork from fading in exposure to light. Acrylic varnish should be applied using an isolation coat (a permanent, protective barrier between the painting and the varnish, preferably a soft, glossy gel medium) to make varnish removal and overall conservation easier. Acrylic varnishes used for such a final removable art protection layer are typically mineral-spirit–based acrylic, rather than water-based.

PIGMENT

A pigment is a colored material that is completely or nearly insoluble in water. In contrast, dyes are typically soluble, at least at some stage in their use. Generally dyes are often organic compounds whereas pigments are often inorganic compounds. Pigments of prehistoric and historic value include ochre, charcoal, and lapis lazuli

Pigments by Elemental Composition

- Cadmium pigments: cadmium yellow, cadmium red, cadmium green, cadmium orange, cadmium sulfo selenide
- Chromium pigments: chrome yellow and chrome green (viridian)
- Cobalt pigments: cobalt violet, cobalt blue, cerulean blue, aureolin (cobalt yellow)
- Copper pigments: Azurite, Han purple, Han blue, Egyptian blue, Malachite, Paris green, Phthalocyanine Blue BN, Phthalocyanine Green G, verdigris

- Iron oxide pigments: sanguine, caput mortuum, oxide red, red ochre, yellow ochre, Venetian red, Prussian blue, raw sienna, burnt sienna, raw umber, burnt umber
- Lead pigments: lead white, cremnitz white, Naples yellow, red lead, lead-tin-yellow
- Manganese pigments: manganese violet, Y,In,Mn blue
- Mercury pigments: vermilion
- Titanium pigments: titanium yellow, titanium beige, titanium white, titanium black
- Zinc pigments: zinc white, zinc ferrite, zinc yellow
- Aluminum pigment: Aluminum powder
- Carbon pigments: carbon black (including vine black, lamp black), ivory_black (bone charcoal)
- Ultramarine pigments (based on sulfur): ultramarine, ultramarine green shade

Pigment Classification

Pigment can be classified into organic pigments and inorganic pigments, organic pigments which can be divided into azo pigments and non-azo pigments. Organic pigments can classify into azo pigments and non-azo pigments which azo pigments includes mono azo yellow, orange, diazo compounds, naphthol, naphthol AS, azo lake, benzimidazolone, Bis azo condensation, metal complexes. The non – azo pigments can further subdivide into pigments such as heterocyclic and fused ring including phthalocyanine, quinacridone, perylene and perinone, thioindigo, anthraquinone, dioxazine, isoindolinone and isoindoline, diketo-pyrrole- pyrrole (DPP), triarylcarbonium, quinophthalone.

Inorganic pigments include titanium dioxide white, carbon and plant black, iron oxide, cadmium, lead chromate, chromium oxide green, ultramarine blue, iron blue, chrome green, phthalocyanine green, mixed metal oxides, bis vanadates, Manganese oxide(MNO)

Organic Pigments:

Azo pigments, Mono azo yellow and orange, Diazo, Naphthol, Azo lakes, Benzimidazolone, Diazo condensation, Metal complex, Polycyclic pigments, Phthalocyanine, Quinacridone, Perylene and perinone, Thioindigo, Anthraquinone, Dioxazine, Isoindolinone and isoindoline, Diketo-pyrrolo-pyrrole (DPP), Triarylcarbonium, Quinophthalone.

Inorganic Pigments:

Titanium dioxide white, Carbon and vegetable black, Iron oxide, cadmium, Lead chromate, Chromium oxide green, Ultramarine blue, Iron blue, Chrome green, Phthalo chrome green, Mixed metal oxide, Bi – vanadate, Manganese oxide.

PROPERTIES

1. Particle size : Particle size also influences the color strength of a pigment. Higher color strength is obtained with smaller particles. Manufacturing conditions are the main factor that influences the particle size of pigment crystals. Pigment manufacturers play a crucial role. They can:

a. Reduce the size of the particles by preventing the growth of crystals during synthesis

b. Increase color strength by efficient dispersion

Pigment dispersion also plays a major role in the color strength of the paint. Indeed, it imparts colloidal stability to the finer particles, avoiding their flocculation and using their full intrinsic color strength.

2. Light fastness : Light fastness is evaluated in relation to the whole pigmented system, not just the pigment. The binder imparts a varying degree of protection to the pigment, so the same pigment will tend to have better light fastness in a polymer than it will in paint.

Pigments will nearly always have a much poorer light fastness in a printing ink system, where there is less resin to protect the pigment, and where there is a double effect of light passing through the pigmented layer, being reflected by the substrate and back through the pigmented layer.

Other pigments that may influence light fastness in a pigmented system. These include:

a. Titanium dioxide promotes the photodegradation of most organic pigments. Therefore, high ratios of titanium dioxide lead to poorer levels of light fastness.

b. Iron oxide can improve the light fastness of organic pigments, due to the fact that it is an effective absorber of UV light.

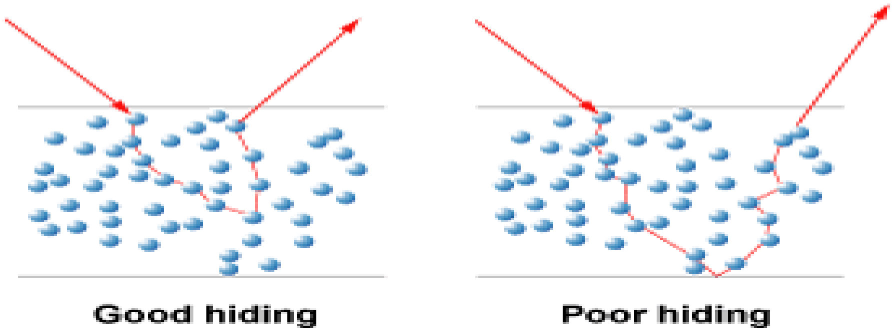
c. When the association of two pigments gives a better light fastness, it is called a synergistic effect and when the light fastness obtained is lower, it is called an antagonistic effect.

d. Some inorganic pigments are unchanged by exposure to light, but most pigments, and all organic pigments, are changed in some way: darkening or complete fading can occur.

e. A pigment's ability to resist light is influenced considerably by chemical constitution. Other less significant influences are pigment concentration, the crystal modification, and particle size distribution. Additionally, factors in the environment can dramatically affect results, such as the presence of water and chemicals in the atmosphere or in the paint system.

f. The light fastness of a pigmented system can only truly be tested in the final formulation and application. Light fastness tests must be carried out only under carefully controlled test conditions.

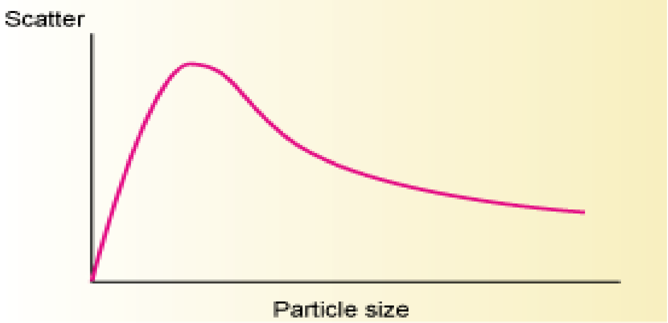
4. Hiding power : Hiding power is the ability of a pigmented coating to obliterate the surface. It is dependent on the ability of the film to absorb and scatter light. Naturally, the thickness of the film and the concentration of the pigment play a fundamental role. The color is also important.



5. Hiding power: Dark, saturated colors, such as blacks and deep blues, absorb most light falling upon them, whereas yellows do not. However, carbon black and most organic blue pigments are fairly transparent because they do not scatter the light that falls on them. In contrast, titanium dioxide absorbs almost no light, yet its capacity to scatter light ensures that at a sufficiently high concentration it will cover the substrate being coated. It is common practice to use a combination of pigments to achieve the best results.

A key factor in the opacity of a pigment is its refractive index (RI), which measures the ability of a substance to bend light. The opacifying effect is proportional to the difference between the refractive index of the pigment and that of the medium in which it is dispersed. This is one of the main reasons why titanium dioxide is now almost universally used as the white pigment in paint. Inorganic pigments have a high refractive index and organic pigments have much lower values. Consequently, most inorganic pigments are opaque, whereas organic pigments are transparent.

The particle size distribution of the pigment is another factor that also plays an important role in opacity. As the particle size increases, the ability of the particle to scatter light increases, up to a maximum. It then starts to decrease. This ability to scatter light increases the hiding power of the pigment, and therefore the hiding power also reaches a maximum and then decreases as the particle size increases.



Effect of particle size on scattering: Whereas the refractive index of a compound cannot be altered, the pigment manufacturer can influence the particle size of pigments. consequently, particle size selection has become one of the principal developments in pigment technology in recent years.

Shape solvents used for paints: In paints, solvents dissolve or disperse different components used in the paint formulation (such as pigment and resin) making paint the desired consistency for application. Once paint is applied, the solvent evaporates, allowing resin and pigment to produce a film of paint (a coat) and dry rapidly. The use of solvents in paints provides a variety of effective choices among durable and decorative coatings and glossy paints for indoor and outdoor uses.

In the production of paints and coatings, three new technologies have emerged: waterborne, powder, and high-energy. All of these technologies offer different technical and performance attributes, depending on application needs. For many applications, however, solvent-based coatings have clear performance advantages or are the only effective option. This is the primary reason why solvent-based coatings still account for approximately 65% of the industrial coatings used in the United States.

Flash point : The flash point of a volatile material is the lowest temperature at which its vapors ignite if given an ignition source.

The flash point is sometimes confused with the autoignition temperature, the temperature that causes spontaneous ignition. The fire point is the lowest temperature at which the vapors keep burning after the ignition source is removed. It is higher than the flash point, because at the flash point more vapor may not be produced fast enough to sustain combustion. Neither flash point nor fire point depends directly on the ignition source temperature, but ignition source temperature is far higher than either the flash or fire point.

VEHICLE

Oil drying:

The fluid carrier of the ink pigment that dries by oxidation (the absorption of and chemical reaction with oxygen) of the vehicle, rather than by evaporation or absorption into the substrate. Once an ink vehicle has absorbed oxygen, it hardens by a process called polymerization, or the combining of simple molecules to form a long, chain molecule called a polymer. Linseed oil is the drying oil most commonly used in inks, which must be boiled to impart the desired viscosity to the vehicle. Other oils used for drying oil vehicles include castor oil, tung oil, cottonseed oil, fish oil, petroleum drying oils, rosin oil, soybean oil, and various types of synthetic oils. Synthetic resins and other substances may be added to the vehicle to prevent absorption of the vehicle by the substrate, as high-gloss inks require a high degree of ink holdout in order to dry with the desired level of gloss. Paper that has a low degree of ink absorbency is required for these types of inks. Drying oil vehicles are commonly used in letterpress and offset lithographic inks.

Polymethylmethacrylate

PolyMethyl MethAcrylate (PMMA), also known as acrylic, acrylic glass, or plexiglass, as well as by the trade names Crylux, Plexiglas, Acrylite, Astariglas, Lucite, Perclax, and Perspex, among several others a is transparent thermoplastic often used in sheet form as a lightweight or shatter-resistant alternative to glass. The same material can be used as a casting resin or in inks and coatings, among many other uses.

Although not a type of familiar silica-based glass the substance like many thermoplastics is often technically classified as a type of glass (in that it is a non-crystalline vitreous substance) hence its occasional historic designation as acrylic glass. Chemically it is the synthetic polymer of methyl methacrylate. The material was developed in 1928 in several different laboratories by many chemists such as William Chalmers, Otto Röhm, and Walter Bauer, and was first brought to market in 1933 by German *Röhm & Haas AG* (as of January 2019, part of Evonik Industries) and its partner and former U.S. affiliate Rohm and Haas Company under the trademark Plexiglas.

PMMA is an economical alternative to polycarbonate (PC) when tensile strength, flexural strength, transparency, polish ability, and UV tolerance are more important than impact strength, chemical resistance, and heat resistance.

Additionally, PMMA does not contain the potentially harmful bisphenol-A subunits found in polycarbonate and is a far better choice for laser cutting. It is often preferred because of its moderate properties easy handling and processing, and low cost. Non-modified PMMA behaves in a brittle manner when under load especially under an impact force, and is more prone to scratching than conventional inorganic glass, but modified PMMA is sometimes able to achieve high scratch and impact resistance.

Uses

Being transparent and durable, PMMA is a versatile material and has been used in a wide range of fields and applications such as rear-lights and instrument clusters for vehicles, appliances, and lenses for glasses. PMMA in the form of sheets affords to shatter resistant panels for building windows, skylights, bulletproof security barriers, signs & displays, sanitary ware (bathtubs), LCD screens, furniture and many other applications. It is also used for coating polymers based on PMMA provides outstanding stability against environmental conditions with reduced emission of VOC. Methacrylate polymers are used extensively in medical and dental applications where purity and stability are critical to performance

Urea-formaldehyde : Urea-formaldehyde also known as urea-methanal, so named for its common synthesis pathway and overall structure, is a nontransparent thermosetting resin or polymer. It is produced from urea and formaldehyde. These resins are used in adhesives, finishes, particle board, medium-density fibreboard (MDF), and molded objects.

Urea- formaldehyde and related amino resins are a class of thermosetting resins of which urea-formaldehyde resins make up 80% produced worldwide. Examples of amino resins use include in automobile tires to improve the bonding of rubber to tire cord, in paper for improving tear strength, in molding electrical devices, jar caps, etc…

Properties: Urea-formaldehyde resin's attributes include high tensile strength, flexural modulus, high heat-distortion temperature, low water absorption, mould shrinkage, high surface hardness, elongation at break, and volume resistance. It has a refractive index.

Uses: Urea-formaldehyde is pervasive. Examples include decorative laminates, textiles, paper, foundry sand molds, wrinkle-resistant fabrics, cotton blends, rayon, corduroy, etc. It is also used as wood glue. UF was commonly used when producing electrical appliances casing (e.g. desk lamps). Foams have been used as artificial snow in movies.

Melamine formaldehyde

Melamine resin or melamine formaldehyde is a resin with melamine rings terminated with multiple hydroxyl groups derived from formaldehyde. This thermosetting plastic material is made from melamine and formaldehyde. In its butylated form, it is dissolved in *n*-butanol and xylene. It is then used to cross-link with alkyd, epoxy, acrylic, and polyester resins, used in surface coatings. There are many types, varying from very slow to very fast curing.

Applications

Construction material

The principal use of melamine resin is as the main constituent of high-pressure laminates, such as Formica and Arborite, and of laminate flooring. Melamine-resin tile wall panels can also be used as whiteboards. Melamine formaldehyde is used in plastic laminate and overlay materials. Formaldehyde is more tightly bound in melamine-formaldehyde than it is in urea-formaldehyde, reducing emissions.

Others

In the kitchen

Melamine resin is often used in kitchen utensils and plates (such as Melmac). Melamine resin utensils and bowls are not microwave safe.

During the late 1950s and 1960s melamine tableware became fashionable. Aided by the stylish modern designs of A. H. Woodfull and the Product Design Unit of British Industrial Plastics it was thought to threaten the dominant position of ceramics in the market. In the late 1960s the tendency of melamine cups and plates to stain and scratch led to a decline in sales, and eventually the material became largely restricted to the camping and nursery market.

Cabinet and furniture making

Melamine resin is often used to saturate decorative paper that is laminated under heat and pressure and then pasted onto particle board the resulting panel often called melamine is commonly used in ready-to-assemble furniture and kitchen cabinets.

Melamine is available in diverse sizes and thicknesses, as well as a large number of colors and patterns. The sheets are heavy the resin is prone to chipping when being cut with conventional table saws.

Powder coating

Powder coating is a type of coating that is applied as a free-flowing, dry powder. Unlike conventional liquid paint which is delivered via an evaporating solvent, powder coating is typically applied electrostatically and then cured under heat or with ultraviolet light. The powder may be a thermoplastic or a thermoset polymer. It is usually used to create a hard finish that is tougher than conventional paint. Powder coating is mainly used for coating of metals, such as household appliances, aluminium extrusions, drum hardware, automobiles, and bicycle frames. Advancements in powder coating technology like UV curable powder coatings allow for other materials such as plastics, composites, carbon fiber, and MDF (medium-density fibreboard) to be powder coated due to the minimum heat and oven dwell time required to process these components.

Properties

Powder coating does not have a liquid carrier, it can produce thicker coatings than conventional liquid coatings without running or sagging, and powder coating produces minimal appearance differences between horizontally coated surfaces and vertically coated surfaces. Because no carrier fluid evaporates away, the coating process emits few Volatile Organic Compounds (VOC). Finally, several powder colors can be applied before curing them all together, allowing color blending and bleed special effects in a single layer.

While it is relatively easy to apply thick coatings that cure to smooth, texture-free coating, it is not as easy to apply smooth thin films. As the film thickness is reduced, the film becomes more and more orange peeled in texture due to the particle size and glass Transition temperature (Tg) of the powder.

Most powder coatings have a particle size in the range of 2 to 50 μ (Microns), a softening temperature (Tg) around 80 °C, a melting temperature around 150 °C, and are cured at around 200 °C for a minimum of 10 minutes to 15 minutes (exact temperatures and times may depend on the thickness of the item being coated). For such powder coatings, film build-ups of greater than 50 μ (Microns) may be required to obtain an acceptably smooth film. The surface texture which is considered desirable or acceptable depends on the end product. Many manufacturers prefer to have a certain degree of orange peel since it helps to hide metal defects that have occurred during manufacture, and the resulting coating is less prone to showing fingerprints.

There are very specialized operations where powder coatings of less than 30 micro metres or with a Tg below 40 °C are used in order to produce smooth thin films. One variation of the dry powder coating process, the Powder Slurry process, combines the advantages of powder coatings and liquid coatings by dispersing very fine powders of 1–5 micro metre sized particles into water, which then allows very smooth, low film thickness coatings to be produced.

For garage-scale jobs, small "rattle can" spray paint is less expensive and complex than powder coating. At the professional scale, the capital expense and time required for a powder coat gun, booth and oven are similar to a spray gun system. Powder coatings have a major advantage in that the over spray can be recycled. However, if multiple colors are being sprayed in a single spray booth, this may limit the ability to recycle the overspray.

Types

There are three main categories of powder coatings: thermosets, thermoplastics, and UV curable powder coatings. Thermoset powder coatings incorporates a cross-linker into the formulation.

Most common cross-linkers are solid epoxy resins in so-called hybrid powders in mixing ratios of 50/50, 60/40 and 70/30 (polyester resin/ epoxy resin) for indoor applications and Tri Glycidyl Iso Cyanurate (TGIC) in a ratio of 93/7 and β-Hydroxy Aalkyl Amide (HAA) hardener in 95/5 ratio for outdoor applications. When the powder is baked, it reacts with other chemical groups in the powder to polymerize, improving the performance properties. The chemical cross-linking for hybrids and TGIC powders representing the major part of the global powder coating market is based on the reaction of organic acid groups with an epoxy functionality. This carboxy-epoxy reaction is thoroughly investigated and well understood by addition of catalysts the conversion can be accelerated and curing schedule can be triggered in time and/or temperature. In the powder coating industry it is common to use catalyst masterbatches where 10-15% of the active ingredient is introduced into a polyester carrier resin as matrix. This approach provides the best possible even dispersion of a small amount of a catalyst over the bulk of the powder.

Concerning the cross-linking of the TGIC-free alternative based on HAA hardeners there is no known catalyst available.

For special applications like coil coatings or clear coats it is common to use glycidyl esters as hardener component, their cross-linking is based on the carboxy-epoxy chemistry too. A different chemical reaction is used in so-called polyurethane powders, where the binder resin carries hydroxyl functional groups that react with isocyanate groups of the hardener component. The isocyanate group is usually introduced into the powder in blocked form where the isocyanate functionality is pre-reacted with ε-caprolactame as blocking agent or in form of uretdiones, at elevated temperatures (deblocking temperature) the free isocyanate groups are released and available for the cross-linking reaction with hydroxyl functionality.

In general, all thermosetting powder formulations contain next to the binder resin and cross-linker additives to support flow out and levelling and for degassing. Common is the use of flow promoter where the active ingredient a polyacrylate is absorbed on silica as carrier or as masterbatch dispersed in a polyester resin as matrix. Vast majority of powders contain benzoin as degassing agent to avoid pinholes in final powder coating film.

The thermoplastic variety does not undergo any additional actions during the baking process as it flows to form the final coating. UV-curable powder coatings are photo polymerizable materials containing a chemical photo initiator that instantly responds to UV light energy by initiating the reaction that leads to crosslinking or cure. The differentiating factor of this process from others is the separation of the melt stage before the cure stage. UV-cured powder will melt in 60 to 120 seconds when reaching a temperature 110 °C and 130 °C. Once the melted coating is in this temperature window it is instantly cured when exposed to UV light.

The most common polymers used are: polyester, polyurethane, polyester-epoxy (known as hybrid), straight epoxy (fusion bonded epoxy) and acrylics.

Advantages

1. Powder coatings contain no solvents and release little or no amount of Volatile Organic Compounds (VOC) into the atmosphere. Thus, there is no need for finishers to buy costly pollution control equipment. Companies can comply more easily and economically with the regulations of the U.S. Environmental Protection Agency.
2. Powder coatings can produce much thicker coatings than conventional liquid coatings without running or sagging.
3. Powder coated items generally have fewer appearance differences than liquid coated items between horizontally coated surfaces and vertically coated surfaces.
4. A wide range of speciality effects are easily accomplished using powder coatings that would be impossible to achieve with other coating processes.
5. Curing time is significantly faster with powder coatings compared to liquid coatings especially when using ultraviolet cured powder Coatings or advanced low bake thermosetting powders.

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UNIT -IV – WEALTH FOR WASTE

Wastes are unwanted or unusable objects or materials which are discarded after primary use, or declared as worthless, defective and of no use. Municipalities require these to be disposed of by the provisions of national law.

Examples include Municipal Solid waste (MSW) which is household trash/refuse, hazardous waste, wastewater, radioactive waste, e-waste and others.

TYPES OF WASTE:

Hazardous waste: It is any waste which by reason of characteristics such as physical, chemical, biological, reactive, toxic, flammable, explosive or corrosive, causes danger or is likely to cause danger to health or environment, whether alone or in contact with other wastes or substances.

Biodegradable (Bio-waste): Biodegradable materials are composed of waste from living organisms and theactual plant, animal or other organisms when its life ends.

Examples: These include human and animal waste; plant products, wood, paper, food waste, leaves, grass clippings and other horticulture waste; and remains from death of living creatures such as animal carcasses.

Hazards posed: It is usually believed that biodegradable waste does not cause environmentaldamage and is harmless. However, a quick glance at our own habitat is enough to prove that it poses health if not disposed of properly. Stagnant waste emits foul smell as it decays and becomes a breeding ground for mosquitoes and other disease causing organisms. Rotting waste emits greenhouse gases such as methane, carbon dioxide and produces chemicals like ammonia. Too much of biodegradable waste in water can deplete oxygen impacting marine life. Again, too much of cattle manure can cause health concerns.

Another major problem arises when instead of being segregated and composted, biodegradable waste ends up in large garbage dumps or landfills and gets buried under mounds of non biodegradable waste, rendering it difficult for microorganisms to break it down.

Bio-degradation or decomposition: This is the process of changing biodegradable materials into a useful resource. A quick look at any ecological system shows widespread synergy between organisms. Waste from one living entity often helps create a healthy environment for another organism, providing nourishment and conditions conducive for its survival and growth. Decayed organic material (compost) is commonly used as manure or fertilizer for growing plants. It improves soil structure and provides nutrients. The process ofcompositing requires making a heap of wet organic matter known as green waste (leaves, food waste) and waiting for the materials to break down into humus after a period of weeks or months. The decomposition can be accelerated by other living organisms such as bacteria, fungi, insects, worms, etc. and abiotic elements like temperature, moisture, oxygen, ultravioletlight, etc.

Creating sustainable wealth

Organic Agriculture: With greater sensitivity to issues related to sustainable development, agro-ecological farming methods are gaining in popularity. These rely on ecological processes to sustain the health of soil as well as treating farming as an integrated, holistic, interconnected process of food production by optimizing the farm in design and closely knit nutrient and resource recycling. Instead of synthetic fertilizers and pesticides, compost, green manure and bone meal are key ingredient in organic farming and also on non-chemical modes of pest and disease control, Consciousness towards healthy lifestyle has seen organic farm production and trade emerging as an important sector in India as in other parts of the developing world. According to business chamber ASSOCHAM, current organic food market was estimated to be about Rs.3350 crore in 2016 and predicted to treble in next four years.

Bio-fuels: Another important direction in bid for sustainability is use of bio-fuels from biomassor bio-waste. Biogas production is a clean low carbon technology for conversion of organic waste into clean renewable biogas and a source of organic fertilizer. Biogas obtained by anaerobic digestion of cattle dung and other loose and leafy organic matter/ wastes can be used as energy source for cooking, lighting, refrigeration, electricity generation and transport applications.

Biomass has always been an important source of energy in our country. According to the Ministry of New and Renewable Energy (MNRE), about 32% of the total primary energy usein the country is still derived from biomass and more than 70% of the country’s population depends upon it for its energy needs. MNRE is promoting development of efficient technologies for its use in various sectors of economy. Biomass materials used for power generation include bagasse, rice husk, straw, cotton stalk, coconut shell, soya husk, de- oiled cakes, coffee waste, jute waste, groundnut shells, saw dust etc.

Applications range from use of bio-fuel in rural/urban kitchens to grid power generation to meet varied energy demands of a sugar mill, an entire village and even a smart city. This is an industry that attracts an investment of Rs. 600 crore every year, generating more than 5000 million units of electricity and yearly employment of more than 10 million man-days inrural areas. Maharashtra leads by example generating about 1220 MW of Biomass power.

Non Biodegradable Waste: Non Biodegradable waste includes materials that do not breakdown or decay naturally, that is, cannot be decomposed by microbes and abiotic elements or dissolved bynatural agents or biological processes.

Examples: These include glass, metal, baked pottery**,** ceramics and plastic items**;** most forms of medical waste (Biomedical waste); electronic/ electrical devices (E-waste); construction and demolition waste (C&D). Most of the inorganic waste is non biodegradable in the sense that it could take from a few weeks and years to thousands of centuries to decay. In fact, our understanding of ancient civilizations rests on archeological findings of non biodegradable artifacts of that era.

Plastics: About 15,342 tonnes of plastic waste are generated in India everyday, of which 6,137 tonnes remain uncollected and littered, 9205 tonnes are recycled. Lack of awareness and absence of effective tools to collect back the discarded plastic products including the wrapping material has led to the indiscriminate littering and disposal of plastic waste.

Biomedical Waste is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biologicals. Common examples are diapers, sanitary pads, syringes, shaving blades, ear buds, finger nails, band aid, dressings, used cotton, dry cloth items, surgical waste, body parts, animal bones etc.

E-Waste: Electronic products nearing the end of their “useful life” are termed as “E-waste”. Examples include discarded computer monitors, motherboards, cathode ray tubes, televisions, VCRs, stereos, Printed Circuit Boards (PCB), mobile phones and chargers, CDs, headphones, Liquid Crystal Displays (LCDs)/ plasma televisions, air conditioners, refrigerators and so on. In India, computer equipment accounts for major fraction of e-wastematerial.

Cons*truction and Demolition Waste:* This refers to materials that are unused, damaged or unwanted during construction and the demolition debris. The list is large and includes rubble, drain silt, marble sludge, bricks, concrete, tiles, wood, nails, pipes, roofing, plaster boards, electrical wires, insulation, etc. Site preparation can involve digging and felling of trees. Construction waste may contain lead, asbestos, paint, etc. It is estimated that almost 10 to 15% of the materials that go into construction of a building are wasted.

Creating sustainable Wealth

Non-biodegradable waste disposal poses a major challenge to planet earth and civilization. Characteristics of various waste items determine the potential these have for wealth generation.

Recyclable waste: Those non biodegradable materials which can be put to use again in the same or different form – that is, reused, refurbished, or recycled – are known as "Recyclable Waste". Inorganic waste, such as PET and plastics, waste paper and tetra packs are now increasingly recycled. These are used to create innovative products through organized or unorganized sector at micro or small scale. Recycling waste of useful materials puts them back into circulation for consumers. Large amounts of functional electronic itemsare phased out or discarded in favour of new models. These can be easily put to use. This would reduce the consumption of scarce and expensive resources/raw materials. It would also reduce consumption of energy. All these interlinks have positive impact on economyand environment.

Another form of recycling is salvaging or recovering certain materials from complex products. This could be

(i) Because of their intrinsic value, such as lead from car batteries or gold from circuit boards. *Around 10% of total gold worldwide is used for their production*.

(ii) Due to the intrinsic hazardous nature, such as removal and reuse of mercury from thermometers and thermostats.

Non recyclable waste: Those non biodegradable materials which can not be put to use again are termed as "Non Recyclable Waste". Traditionally these are disposed off by (i) transporting to a distant site and dumping them in a landfill; and (ii) incineration or burning. Environmental concerns have led municipalities to develop better management of these wastes. Major initiatives have been launched to look at non recyclable waste as a resourceto make energy. As an example, base liner systems are installed in landfills to prevent escape of leachate from waste into the environment. Installation of the leachate tank and methane extraction pipe allows these to be harvested as source of energy. Municipal Solid Waste Incinerators (MSWI) transform waste into solid ash that can be recycled for various applications. Energy is extracted from the hot gasses / fumes produced by generating steamin a boiler. This is used to turn a turbine to produce electricity. Development of flue gas scrubbing technology for MSWI cleans the toxic fumes before these are released into the environment.

Waste Segregation: The treatment of waste depends upon its nature and decomposition properties. Hence handling of waste requires segregation at source. A simple practice is to identify wet and dry waste being generated in the household and discard these in separate containers. Many households and communities now convert wet kitchen waste into compost,a product used for enriching soil quality.

Waste Management:

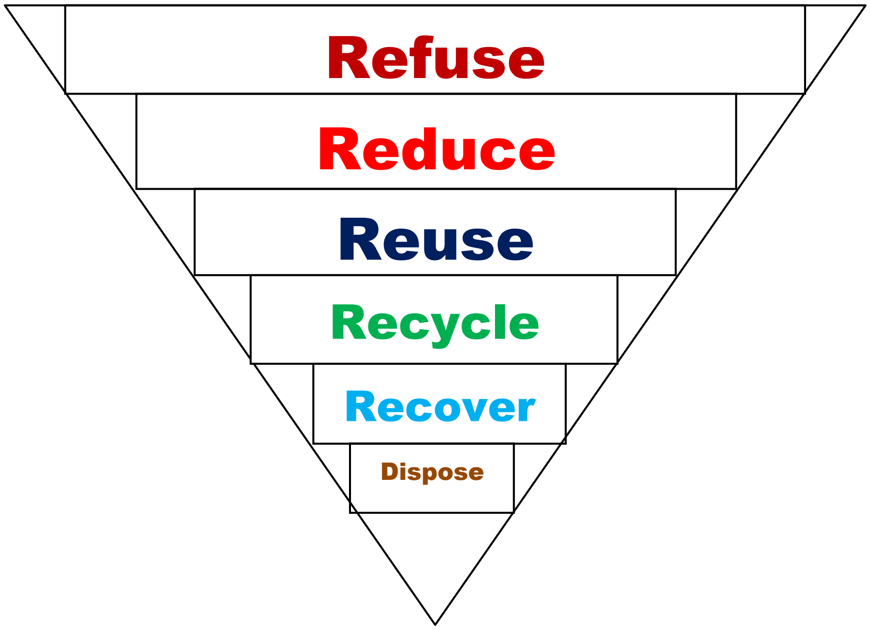
According to Central Pollution Control Board Report 2014-15, 51.4 million tonnes of solid waste was generated in the country. Of this, 91 per cent was collected, and 27 per cent was treated and remaining 73 per cent disposed of at dump sites. There is a critical need for developing sustainable wealth generating models for India's waste. The potential is immense. It is estimated that India will have a waste management market to the tune of US$ 13.62 billion by 2025. With the concerted efforts of the government, increasing interest and participation of the industry, academia, not-for-profit organizations, and communities, the nascent waste management industry in the country is poised for a major turn around.

The emphasis has to be on 100 per cent collection and scientific processing/disposal/reuse/ recycling of municipal solid waste. To ensure the success of this vision, the government is focusing on providing all support to municipal bodies to come up with design, execution and operation plans for waste disposal systems. There is also an emphasis on private-sector participation and public-private-partnership (PPP) in capital expenditure and operation and maintenance costs for sanitary facilities. Industries are also increasingly cognizant about waste management, right from the point of production. Sustainable development sets the goal of redesigning the product to use non-hazardous materials.

Waste can be recovered on-site, or at an off-site recovery facility, or through inter industry exchange. A number of physical and chemical techniques are available to reclaim a waste material such as reverse osmosis, electrolysis, condensation, electrolytic recovery, filtration, centrifugation etc. For example, a printed-circuit board manufacturer can use electrolytic recovery to reclaim metals from copper and tin-lead plating bath. However recycling of hazardous products has little environmental benefit if it simply moves the hazards into secondary products that eventually have to be disposed of. For anything to be a resource, it should be as clean and pure as possible. Therefore, to generate wealth, anything that is not useful in a particular location or for a person/s shouldbe put away without contaminating it with other ‘waste’ or useless material. This is called ‘source segregation’. For instance, to make compost from ‘wet waste’ generated in homes, markets, educational institutions, hotels and restaurants or religious places, it must be ensuredthat it is not contaminated with ‘toxic waste’ such as batteries, paints, pesticides, mercury lamps and other hazardous chemicals. The quality of the compost then is excellent and bycarrying out bio-methanation and composting, huge revenue from both the solid and liquid wastes can be realized.

Installing more efficient process equipment or modifying existing equipment to take advantage of better production techniques can significantly reduce waste generation. New or updatedequipment can use process materials more efficiently producing less waste. Modifying existing process equipment can be a very cost-effective method of reducing waste generation. In many cases the modification can just be relatively simple changes in the way the materials are handled within the process to ensure that they are not wasted.

5Rs Principle: Refuse, Reduce, Reuse, Recycle, Recover:



Problems with waste are as old as the human race. Generation of waste causes a loss of materials and energy. It increases environmental costs on society for its collection, treatment and disposal. Every stage in the life cycle of a product – from its initial creation to its final disposal – can create waste and environmental residuals. The 5Rs Principle offers a sustainable, environment friendly alternative to deal with the enormous challenge posed by waste with its obvious impact on human health, environment and natural ecosystems. It looks at waste as a resource at every stage of its life cycle. This defines waste hierarchy as a set of priorities for the efficient use of resources and underpins the objectives of waste management and wealth generation.

Refuse: It encourages the community to avoid unnecessary consumption and make informed life style choices by selecting items that use least packaging, require the least resources to produce, can be used multiple times. It promotes buying products that are recycled, recyclable,repairable, refillable, re-usable or biodegradable.

Reduce: It costs much less to make processes more efficient and prevent wastes from occurring than to later consume more energy and materials to capture the wastes and then to reuse, recycle, or dispose of them.

Reuse: It involves using resources in their existing forms without further reprocessing thereby minimizing additional labor, material, water, and energy required for recycling. For example, many household and industrial items can be repaired, re-used, sold or donated to charities, thereby keeping them in the productive economy

Recycle: It involves transforming resources into a form that can be used as an input to a new process i.e. taking a product or material at the end of its useful life and turning it into a usable raw material to make another product. (e.g., recovering aluminum or plastic from drink containers, reprocessing a by-product from a chemical process, or processing wastewater for secondary use).

Recover: Resource Recovery occurs after reduce, reuse and recycle have been attempted. It entails conversion of waste materials for the recovery of resources (such as electricity, heat, compost and fuel) or as metals, glass etc. through thermal and/ or biological means.

Disposal or treatment: Finally, the waste hierarchy recognizes that some types of waste, such as hazardous chemicals or asbestos, cannot be safely recycled and direct treatment or disposalis the most appropriate management option.

PAPER MADE USING BACTERIA

Microbial Cellulose:

- Microbial celluose, sometimes called bacterial cellulose, is a form of cellulose that is produced by bacteria.
- Bacterial cellulose is an organic compound with formula $(C_6H_{10}O_5)n$ produced from certain types of bacteria.
- The glucan chains are held together by inter- and intra-hydrogen binding.

- Inherent Purity: free of hemicelluose, lignin, pectin, wax
- **Moldable in cultivation. Carbon Sources used:**
  - Glucose, fructose, sucrose, molasses, glycerol
  - Corn steen liquor, potato effluent, grape pomace, whey lactose Tea, cola nut, Saccharified food waste
- **Natural network structure, High Crystallinity**:~85%, High DP
- High Carbon-to-Celluose Conversion Efficiency.

Sources of Cellulose:

1. Wood (40-50%)
2. Cotton (90%)
3. Dried hemp (45%)
4. Microbes (varies)

Paper from bacterial Cellulose:

- Paper from bacteria cellulose Due to microbial cellulose's higher purity and micro fibril structure, it may prove to be an excellent candidate for an electronic paper substrate. Microbial cellulose can be fashioned into sheets approximately 100 micrometers thick, about the thickness of normal paper, by wet synthesis process.
- In papermaking, it is used as an ultra-strength paper and as a reticulated fine fibre network with coating, binding, thickening and suspending characteristics.

GENERATION OF POWER USING GARBAGE

Shadnagar factility of 6MW in Andhra Pradesh is the first operational Waste-To-Energy (WTE) plant in india. Selco has a 20 year PPA with APTRANSCO at`3.48/kWh and connects to the grid through a 33/11kV substation.

All cities anywhere have garbage disposal as a major problem. It is produced in large quantities, and has nowhere to go, except mostly in landfills. This is attracting of city planners lately and measures are being considered towards making the garbage disposal fruitful and productive. One of the major areas of interest is the use of garbage for energy.

Waste generated in urban India every year

- Solid waste: 300 Million Tons
- Liquid waste: 4400 Cu. Metres.
- Municipal solid waste: 0.30-0.66 Kg/person/day
- Plus industrial waste.

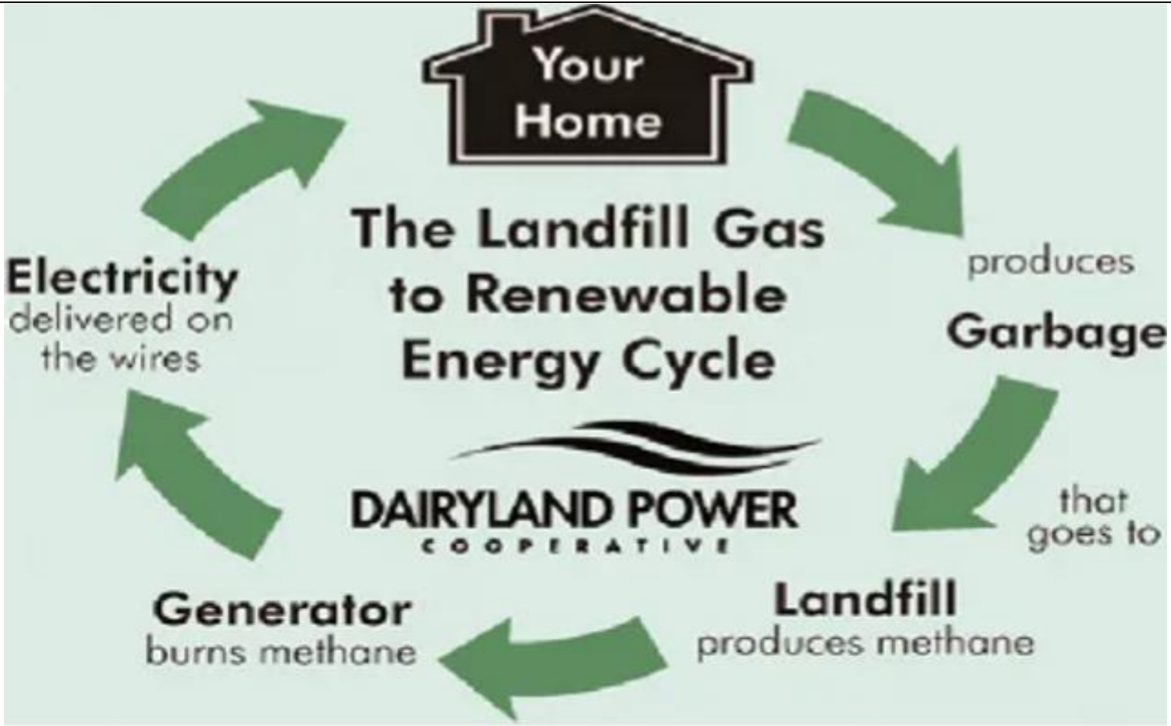
Urban Local Bodies spend around`500/-to `1500/- per ton on solid waste management, out of which 60 to 70% of the amount is on collection, 20 to 30% on transportation, while hardly any fund is spent on treatment and disposal of waste. Even after segregation of waste, about 45% goes to landfills.

Most solid waste goes to landfills/water bodies, causing serious pollution with methane and CO_2. Finding new landfill sites is no solution. Permanent and eco-friendly solution lies in gainful utilization of this garbage into energy, by processing and treating the waste before by up to 90% and at the same time, recover fuel gas for cooking and lighting and electricity.

Waste- to-energy conversion is possible in a number of ways. Refuse-Derived Fuel (RDF) facilities process the MSW prior to direct combustion processing varies among facilities, But generally involves shredding of the MSW, and removal of metals and other bulky items. Energy from municipal waste takes care of two problems- garbage and energy needs, at the same time. There is no pollutant released or carbon emissions to speed up global warming, and waste to energy plants can be very cost efficient. Municipal solid waste pays not only in collection fees but also in the production of by-products which can be sold for a profit. It will not be out of place to mention here that landfill is banned in Germany, and entire garbage is usefully employed.

Biomass is a clean source of energy in Brazil. Over 1 million people work in production of biomass, which represents 27% of the country’s energy generation. Nearly all of the biomass for power generation is based on the use of waste and residue fuels.

India is second in rank in the world in biomass utilisation (MNRE). Biomass can be tapped right at the landfill. When garbage decomposes, it gives off methane gas. Natural gas is made up of methane. Pipelines are put into the landfills and the methane gas is collected. It is then used in power plants to make electricity. This is called landfill gas.



WASTE TO ENERGY CYCLE

Landfill gas is gathered from landfills through extraction wells placed depending on the size of the landfill. Roughly one well per acre is typical. Gas is then used to produce electricity, heat, fuels and chemical compounds.

Today, more than 900 thermal WTE plants operate around the globe. These plants treat an estimated 200 million tons of Municipal Solid Waste (MSW) with an estimated output of 130 terawatt hours (TWh) of electricity. Vancouver landfill is operative since 1966, and in 2003 received 450,000 tons of MSW. The landfill serves over 900,000 residents and businesses from city and surrounding area. The landfill is part of the district’s disposal system consisting of two landfills and a WTE facility that collectively serve 2,000,000 people. The project results in the recovery of approximately 500,000 GJ/year of energy, the total energy requirements of 3,000 to 4,000 homes, and results in a reduction of more than 230,000 tons per year CO_2 (the emissions of approximately 45,000 automobiles).

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UNIT -V - MEDICINAL CHEMISTRY

MECHANISM OF ACTION

In pharmacology, the term mechanism of action (MOA) refers to the specific biochemical interaction through which a drug substance produces its pharmacological effect. A mechanism of action usually includes mention of the specific molecular targets to which the drug binds such as an enzyme or receptor. Receptor sites have specific affinities for drugs based on the chemical structure of the drug as well as the specific action that occurs there.

Drugs that do not bind to receptors produce their corresponding therapeutic effect by simply interacting with chemical or physical properties in the body. Common examples of drugs that work in this way are antacids and laxatives.

In contrast, a mode of action (MOA) describes functional or anatomical changes, at the cellular level, resulting from the exposure of a living organism to a substance.

Importants

Elucidating the mechanism of action of novel drugs and medications is important for several reasons:

- In the case of anti-infective drug development, the information permits anticipation of problems relating to clinical safety. Drugs disrupting the cytoplasmic membrane or electron transport chain, for example, are more likely to cause toxicity problems than those targeting components of the cell wall (peptidoglycan or β-glucans) or 70S ribosome, structures which are absent in human cells.
- By knowing the interaction between a certain site of a drug and a receptor, other drugs can be formulated in a way that replicates this interaction, thus producing the same therapeutic effects. Indeed, this method is used to create new drugs.
- It can help identify which patients are most likely to respond to treatment. Because the breast cancer medication trastuzumab is known to target protein HER2, for example, tumors can be screened for the presence of this molecule to determine whether or not the patient will benefit from trastuzumab therapy.
- It can enable better dosing because the drug's effects on the target pathway can be monitored in the patient. Statin dosage, for example, is usually determined by measuring the patient's blood cholesterol levels.
- It allows drugs to be combined in such a way that the likelihood of drug resistance emerging is reduced. By knowing what cellular structure an anti-infective or anticancer drug acts upon, it is possible to administer a cocktail that inhibits multiple

targets simultaneously, thereby reducing the risk that a single mutation in microbial or tumor DNA will lead to drug resistance and treatment failure.

- It may allow other indications for the drug to be identified. Discovery that sildenafil inhibits phosphodiesterase-5 (PDE-5) proteins, for example, enabled this drug to be repurposed for pulmonary arterial hypertension treatment, since PDE-5 is expressed in pulmonary hypertensive lungs

DETERMINATION OF DRUG ACTION

Microscopy-based methods

Bioactive compounds induce phenotypic changes in target cells, changes that are observable by microscopy, and which can give insight into the mechanism of action of the compound.

With antibacterial agents, the conversion of target cells to spheroplasts can be an indication that peptidoglycan synthesis is being inhibited, and filamentation of target cells can be an indication that PBP3, FtsZ, or DNA synthesis is being inhibited. Other antibacterial agent-induced changes include ovoid cell formation, pseudo multicellular forms, localized swelling, bulge formation, blebbing, and peptidoglycan thickening. In the case of anticancer agents, bleb formation can be an indication that the compound is disrupting the plasma membrane.

A current limitation of this approach is the time required to manually generate and interpret data, but advances in automated microscopy and image analysis software may help resolve this.

Direct biochemical methods

Direct biochemical methods include methods in which a protein or a small molecule, such as a drug candidate, is labeled and is traced throughout the body. This proves to be the most direct approach to find target protein that will bind to small targets of interest, such as a basic representation of a drug outline, in order to identify the pharmacophore of the drug. Due to the physical interactions between the labeled molecule and a protein, biochemical methods can be used to determine the toxicity, efficacy, and the mechanism of action of the drug.

Computation inference methods

Typically, computation inference methods are primarily used to predict protein targets for small molecule drugs based on computerbased pattern recognition. However, this method could also be used for finding new targets for existing or newly developed drugs. By identifying the pharmacophore of the drug molecule, the profiling method of pattern recognition can be carried out where a new target is identified. This provides an insight at a possible mechanism of action, as it is known what certain functional components of the drug are responsible for interacting with a certain area on a protein, thus, leading to a therapeutic effect.

Omics based methods

Omics based methods use omics technologies, such as reverse genetics and genomics, transcriptomics, and proteomics, to identify the potential targets of the compound of interest. Reverse genetics and genomics approaches, for instance, uses genetic perturbation (e.g. CRISPR-Cas9 or siRNA) in combination with the compound to identify genes whose knockdown or knockout abolishes the pharmacological effect of the compound. On the other hand, transcriptomics and proteomics profiles of the compound can be used to compare with profiles of compounds with known targets. Thanks to computation inference, it is then possible to make hypotheses about the mechanism of action of the compound, which can subsequently be tested.

METABOLISM OF DRUGS

Drug metabolism is the metabolic breakdown of drugs by living organisms, usually through specialized enzymatic systems. More generally, xenobiotic metabolism (from the Greek xenos "stranger" and biotic "related to living beings") is the set of metabolic pathways that modify the chemical structure of xenobiotics, which are compounds foreign to an organism's normal biochemistry, such as any drug or poison. These pathways are a form of biotransformation present in all major groups of organisms and are considered to be of ancient origin. These reactions often act to detoxify poisonous compounds (although in some cases the intermediates in xenobiotic metabolism can themselves cause toxic effects). The study of drug metabolism is called pharmacokinetics.

The metabolism of pharmaceutical drugs is an important aspect of pharmacology and medicine. For example, the rate of metabolism determines the duration and intensity of a drug's pharmacologic action. Drug metabolism also affects multidrug resistance in infectious diseases and in chemotherapy for cancer, and the actions of some drugs as substrates or inhibitors of enzymes involved in xenobiotic metabolism are a common reason for hazardous drug interactions. These pathways are also important in environmental science, with the xenobiotic metabolism of microorganisms determining whether a pollutant will be broken down during bioremediation, or persist in the environment. The enzymes of xenobiotic metabolism, particularly the glutathione S-transferases are also important in agriculture, since they may produce resistance to pesticides and herbicides.

FACTORS THAT AFFECT DRUG METABOLISM

The duration and intensity of pharmacological action of most lipophilic drugs are determined by the rate they are metabolized to inactive products. The Cytochrome P450 monooxygenase system is the most important pathway in this regard. In general, anything that increases the rate of metabolism (*e.g.*, enzyme induction) of a pharmacologically active metabolite will decrease the duration and intensity of the drug action. The opposite is also true (*e.g.*, enzyme inhibition). However, in cases where an enzyme is responsible for metabolizing a pro-drug into a drug, enzyme induction can speed up this conversion and increase drug levels, potentially causing toxicity.

Various physiological and pathological factors can also affect drug metabolism. Physiological factors that can influence drug metabolism include age, individual variation (*e.g.*, pharmacogenetics), enterohepatic circulation, nutrition, intestinal flora, or sex differences.

In general, drugs are metabolized more slowly in fetal, neonatal and elderly humans and animals than in adults.

Genetic variation (polymorphism) accounts for some of the variability in the effect of drugs. With N-acetyltransferases (involved in Phase II reactions), individual variation creates a group of people who acetylate slowly (slow acetylators) and those who acetylate quickly, split roughly 50:50 in the population of Canada. This variation may have dramatic consequences, as the slow acetylators are more prone to dose-dependent toxicity.

Cytochrome P450 monooxygenase system enzymes can also vary across individuals, with deficiencies occurring in 1 – 30% of people, depending on their ethnic background.

Dose, frequency, route of administration, tissue distribution and protein binding of the drug affect its metabolism.

Pathological factors can also influence drug metabolism, including liver, kidney, or heart diseases.

In silico modelling and simulation methods allow drug metabolism to be predicted in virtual patient populations prior to performing clinical studies in human subjects. This can be used to identify individuals most at risk from adverse reaction.

ROUTES OF ADMINISTRATION:

A route of administration in pharmacology and toxicology is the path by which a drug, fluid, poison, or other substance is taken into the body.

Routes of administration are generally classified by the location at which the substance is applied. Common examples include oral and intravenous administration. Routes can also be classified based on where the target of action is. Action may be topical (local), enteral (system-wide effect, but delivered through the gastrointestinal tract or parenteral (systemic action, but delivered by routes other than the GI tract). Route of administration and dosage form are aspects of drug delivery.

Classification

Routes of administration are usually classified by application location (exposition).

The route or course the active substance takes from application location to the location where it has its target effect is usually rather a matter of pharmacokinetics (concerning the processes of uptake, distribution, and elimination of drugs). Exceptions include the transdermal or transmucosal routes, which are still commonly referred to as routes of administration.

The location of the target effect of active substances are usually rather a matter of pharmacodynamics (concerning e.g the physiological effects of drugs). An exception is topical administration, which generally means that both the application location and the effect thereof is local.

Topical administration is sometimes defined as both a local application location and local pharmacodynamic effect, and sometimes merely as a local application location regardless of location of the effects.

By application location - Enteral/gastrointestinal

Administration through the gastrointestinal tract is sometimes termed enteral or enteric administration (literally meaning 'through the intestines'). Enteral/enteric administration usually includes oral (through the mouth) and rectal (into the rectum) administration, in the sense that these are taken up by the intestines. However, uptake of drugs administered orally may also occur already in the stomach, and as such gastrointestinal (along the gastrointestinal tract) may be a more fitting term for this route of administration. Furthermore, some application locations often classified as enteral, such as sublingual (under the tongue) and sublabial or buccal (between the cheek and gums/gingiva), are taken up in the proximal part of the gastrointestinal tract without reaching the intestines. Strictly enteral administration (directly into the intestines) can be used for systemic administration, as well as local (sometimes termed topical), such as in a contrast enema, whereby contrast media is infused into the intestines for imaging. However, for the purposes of classification based on location of effects, the term enteral is reserved for substances with systemic effects.

Many drugs as tablets, capsules, or drops are taken orally. Administration methods directly into the stomach include those by gastric feeding tube or gastrostomy. Substances may also be placed into the small intestines, as with a duodenal feeding tube and enteral nutrition. Enteric coated tablets are designed to dissolve in the intestine, not the stomach, because the drug present in the tablet causes irritation in the stomach.

The rectal route is an effective route of administration for many medications, especially those used at the end of life. The walls of the rectum absorb many medications quickly and effectively. Medications delivered to the distal one-third of the rectum at least partially avoid the "first pass effect" through the liver, which allows for greater bioavailability of many medications than that of the oral route. Rectal mucosa is highly vascularized tissue that allows for rapid and effective absorption of medications. A suppository is a solid dosage form that fits for rectal administration. In hospice care, a specialized rectal catheter, designed to provide comfortable and discreet administration of ongoing medications provides a practical way to deliver and retain liquid formulations in the distal rectum, giving health practitioners a way to leverage the established benefits of rectal administration.

Parenteral

The parenteral route is any route that is not enteral (Par + enteral). Parenteral administration can be performed by injection, that is, using a needle (usually a hypodermic needle) and a syringe or by the insertion of an indwelling catheter.

Locations of application of parenteral administration include:

Central nervous system:

1. Epidural (synonym: peridural) (injection or infusion into the epidural space) e.g epidural anesthesia.
2. Intracerebral (into the cerebrum) administration by direct injection into the brain. Used in experimental research of chemicals and as a treatment for malignancies of the brain. The intracerebral route can also interrupt the blood brain barrier from holding up against subsequent routes.
3. Intracerebroventricular (into the cerebral ventricles) administration into the ventricular system of the brain. One use is as a last line of opioid treatment for terminal cancer patients with intractable cancer pain.
4. Epicutaneous (application onto the skin). It can be used both for local effect as in allergy testing and typical local anesthesia as well as systemic effects when the active substance diffuses through skin in a transdermal route.

Sublingual and buccal medication administration is a way of giving someone medicine orally (mouth). Sublingual administration is when medication is placed under the tongue to be absorbed by the body. The word "sublingual" means "under the tongue." Buccal administration involves placement of the drug between the gums and the cheek. These medications can come in the form of tablets, films, or sprays. Many drugs are designed for sublingual administration, including cardiovascular drugs, steroids, barbiturates, opioid analgesics with poor gastrointestinal bioavailability, enzymes and, increasingly, vitamins and minerals.

- Extra-amniotic administration between the endometrium and fetal membranes.

- Nasal administration (through the nose) can be used for topically acting substances, as well as for insufflation of e.g. decongestant nasal sprays to be taken up along the respiratory tract. Such substances are also called inhalational e.g inhalational anesthetics.
- Intra-arterial (into an artery), e.g. vasodilator drugs in the treatment of vasospasm and thrombolytic drugs for treatment of embolism.
- Intra-articular into a joint space. It is generally performed by joint injection. It is mainly used for symptomatic relief in osteoarthritis.
- Intracardiac (into the heart), e.g. adrenaline during cardiopulmonary resuscitation (no longer commonly performed).
- Intracavernous injection, an injection into the base of the penis.
- Intradermal (into the skin itself) is used for skin testing some allergens, and also for mantoux test for tuberculosis.
- Intralesional (into a skin lesion), is used for local skin lesions, e.g. acne medication.
- Intramuscular (into a muscle) e.g many vaccines, antibiotics, and long-term psychoactive agents. Recreationally the colloquial term 'muscling' is used.

- Intraocular, into the eye, e.g., some medications for glaucoma or eye neoplasms.
- Intraosseous infusion (into the bone marrow) is, in effect, an indirect intravenous access because the bone marrow drains directly into the venous system. This route is occasionally used for drugs and fluids in emergency medicine and pediatrics when intravenous access is difficult.
- Intraperitoneal (infusion or injection into the peritoneum) e.g peritoneal dialysis.
- Intrathecal (into the spinal canal) is most commonly used for spinal anesthesia and chemotherapy.
- Intrauterine.
- Intravaginal administration in the vagina.
- Intravenous (into a vein) e.g. many drugs, total parenteral nutrition.
- Intravesical infusion is into the urinary bladder.
- Intravitreal through the eye.
- Subcutaneous (under the skin). This generally takes the form of subcutaneous injection e.g. with insulin, Skin popping is a slang term that includes subcutaneous injection, and is usually used in association with recreational drugs. In addition to injection it is also possible to slowly infuse fluids subcutaneously in the form of hypodermoclysis.
- Transdermal (diffusion through the intact skin for systemic rather than topical distribution), e.g. transdermal patches such as fentanyl in pain therapy, nicotine patches for treatment of addiction and nitroglycerine for treatment of angina pectoris.

- Perivascular administration (perivascular medical devices and perivascular drug delivery systems are conceived for local application around a blood vessel during open vascular surgery).
- Transmucosal (diffusion through a mucous membrane), e.g. insufflation (snorting) of cocaine, sublingual i.e. under the tongue, sublabial i.e. between the lips and gingiva, nitroglycerine, vaginal suppositories.

Oral

The oral route is generally the most convenient and costs the least. However, some drugs can cause gastrointestinal tract irritation. For drugs that come in delayed release or time-release formulations, breaking the tablets or capsules can lead to more rapid delivery of the drug than intended. The oral route is limited to formulations containing small molecules only while biopharmaceuticals (usually proteins) would be digested in the stomach and thereby become ineffective. Biopharmaceuticals have to be given by injection or infusion. However, recent research (2018) found an organic ionic liquid suitable for oral insulin delivery (a biopharmaceutical) into the blood stream.

Oral administration is often denoted "PO" from "per os", the Latin for "by mouth".

The bioavailability of oral administration is affected by the amount of drug that is absorbed across the intestinal epithelium and first-pass metabolism.

Local

By delivering drugs almost directly to the site of action, the risk of systemic side effects is reduced.

Skin absorption (dermal absorption), for example, is to directly deliver drug to the skin and, hopefully, to the systemic circulation. However, skin irritation may result, and for some forms such as creams or lotions, the dosage is difficult to control. Upon contact with the skin, the drug penetrates into the dead stratum corneum and can afterwards reach the viable epidermis, the dermis, and the blood vessels.

Mouth inhalation

Inhaled medications can be absorbed quickly and act both locally and systemically. Proper technique with inhaler devices is necessary to achieve the correct dose. Some medications can have an unpleasant taste or irritate the mouth.

In general, only 20–50% of the pulmonary-delivered dose rendered in powdery particles will be deposited in the lung upon mouth inhalation. The remainder of 50-70% undeposited aerosolized particles are cleared out of lung as soon as exhalation.

An inhaled powdery particle that is >8 μm is structurally predisposed to depositing in the central and conducting airways (conducting zone) by inertial impaction.

An inhaled powdery particle that is between 3 and 8 μm in diameter tend to largely deposit in the transitional zones of the lung by sedimentation.

An inhaled powdery particle that is <3 μm in diameter is structurally predisposed to depositing primarily in the respiratory regions of the peripheral lung via diffusion.

Particles that deposit in the upper and central airways are rarely absorbed systemically because they are going to be removed by mucociliary clearance in an efficient and rapid fashion.

Nasal inhalation

Inhalation by smoking a substance is likely the most rapid way to deliver drugs to the brain, as the substance travels directly to the brain without being diluted in the systemic circulation. The severity of dependence on psychoactive drugs tends to increase with more rapid drug delivery.

Parenteral

The term injection encompasses intravenous (IV), intramuscular (IM), subcutaneous (SC) and intradermal (ID) administration.

Parenteral administration generally acts more rapidly than topical or enteral administration, with onset of action often occurring in 15–30 seconds for IV, 10–20 minutes for IM and 15–30 minutes for SC. They also have essentially 100% bioavailability and can be used for drugs that are poorly absorbed or ineffective when they are given orally. Some medications, such as certain antipsychotics, can be administered as long-acting intramuscular injections. Ongoing IV infusions can be used to deliver continuous medication or fluids.

Disadvantages of injections include potential pain or discomfort for the patient and the requirement of trained staff using aseptic techniques for administration. However, in some cases, patients are taught to self-inject, such as SC injection of insulin in patients with insulin-dependent diabetes mellitus. As the drug is delivered to the site of action extremely rapidly with IV injection, there is a risk of overdose if the dose has been calculated incorrectly, and there is an increased risk of side effects if the drug is administered too rapidly.

Intranasal

Drug administration via the nasal cavity yields rapid drug absorption and therapeutic effects. This is because drug absorption through the nasal passages doesn't go through the gut before entering capillaries situated at tissue cells and then systemic circulation and such absorption route allows transport of drugs into the central nervous system via the pathways of olfactory and trigeminal nerve.

Intranasal absorption features low lipophilicity, enzymatic degradation within the nasal cavity, large molecular size, and rapid mucociliary clearance from the nasal passages, which explains the low risk of systemic exposure of the administered drug absorbed via intranasal.

DIGESTION OF FAT

Digestion is the breakdown of large insoluble food molecules into small water-soluble food molecules so that they can be absorbed into the watery blood plasma. In certain organisms, these smaller substances are absorbed through the small_intestine into the blood stream. Digestion is a form of catabolism that is often divided into two processes based on how food is broken down: mechanical and chemical digestion. The term mechanical digestion refers to the physical breakdown of large pieces of food into smaller pieces which can subsequently be accessed by digestive enzymes. In chemical digestion, enzymes break down food into the small molecules the body can use.

In the human digestive system, food enters the mouth and mechanical digestion of the food starts by the action of mastication (chewing), a form of mechanical digestion, and the wetting contact of saliva. Saliva, a liquid secreted by the salivary glands, contains salivary amylase, an enzyme which starts the digestion of starch in the food; the saliva also contains mucus, which lubricates the food, and hydrogen carbonate, which provides the ideal conditions of pH (alkaline) for amylase to work. After undergoing mastication and starch digestion, the food will be in the form of a small, round slurry mass called a bolus. It will then travel down the esophagus and into the stomach by the action of peristalsis. Gastric juice in the stomach starts protein digestion. Gastric juice mainly contains hydrochloric acid and pepsin. In infants and toddlers gastric juice also contains rennin. As the first two chemicals may damage the stomach wall, mucus is secreted by the stomach, providing a slimy layer that acts as a shield against the damaging effects of the chemicals. At the same time protein digestion is occurring, mechanical mixing occurs by peristalsis, which is waves of muscular contractions that move along the stomach wall. This allows the mass of food to further mix with the digestive enzymes. Studies suggest that increasing the number of chews per bite increases relevant gut hormones and may decrease self-reported hunger and food intake.

After some time (typically 1–2 hours in humans, 4–6 hours in dogs, 3–4 hours in house cats) the resulting thick liquid is called chyme. When the pyloric sphincter valve opens, chyme enters the duodenum where it mixes with digestive enzymes from the pancreas and bile juice from the liver and then passes through the small_intestine, in which digestion continues. When the chyme is fully digested, it is absorbed into the blood.

95% of nutrient absorption occurs in the small intestine. Water and minerals are reabsorbed back into the blood in the colon (large intestine) where the pH is slightly acidic about 5.6 ~ 6.9. Some vitamins, such as biotin and vitamin K (K_2MK7) produced by bacteria in the colon are also absorbed into the blood in the colon. Waste material is eliminated from the rectum during defecation.

SIGNIFICANCE OF FAT

Digestion is a complex process controlled by several factors. pH plays a crucial role in a normally functioning digestive tract. In the mouth, pharynx and esophagus, pH is typically about 6.8, very weakly acidic. Saliva controls pH in this region of the digestive tract. Salivary amylase is contained in saliva and starts the breakdown of carbohydrates into monosaccharides. Most digestive enzymes are sensitive to pH and will denature in a high or low pH environment.

The stomach's high acidity inhibits the breakdown of carbohydrates within it. This acidity confers two benefits: it denatures proteins for further digestion in the small intestines, and provides non-specific immunity, damaging or eliminating various pathogens.

In the small intestines, the duodenum provides critical pH balancing to activate digestive enzymes. The liver secretes bile into the duodenum to neutralize the acidic conditions from the stomach, and the pancreatic duct empties into the duodenum, adding bicarbonate to neutralize the acidic chyme, thus creating a neutral environment. The mucosal tissue of the small intestines is alkaline with a pH of about 8.5.

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