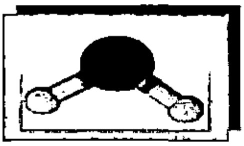
CHAPTER-III

EXPERIMENTAL SECTION

III. 1 NAME, STRUCTURE, PHYSICAL AND CHEMICAL PROPERTIES, PURIFICATION AND APPLICATIONS OF THE CHEMICALS USED IN THE RESEARCH WORK

III.1.1 SOLVENTS

The details of the aqueous and non-aqueous solvents used in the research work are given below:

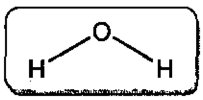
Water (H_2O): 

Water is an omnipresent chemical substance is composed of hydrogen and oxygen and is essential for all known forms of life. In typical usage, water refers only to its liquid form or state, but the substance also exists as solid state, ice, and a gaseous state, water vapour or steam. Water is a good solvent and is often referred to as the universal solvent.

Source: Distilled water, distilled from fractional distillation method in Lab.

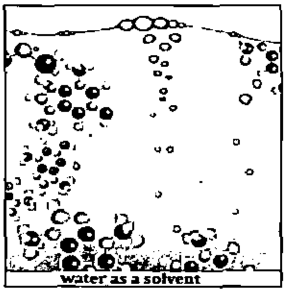
Purification: Water was first deionised and then distilled in an all glass distilling set along with alkaline $KMnO_4$ solution to remove any organic matter therein. The doubly distilled water was finally distilled

WATER



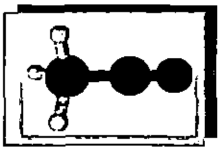
Appearance	*:Liquid*
Molecular Formula	*:H_2O*
Molecular Weight	*:18.02 $g \cdot mol^{-1}$*
Density	*:0.99713 $g \cdot cm^3$*
Viscosity	*:0.891 $mP \cdot s$*
Refractive Index	*: 1.3333*
Ultrasonic Speed	*:1500.0 $m \cdot s^{-1}$*
Dielectric Constant	*:78.35 at 298.15K*

using an all glass distilling set. Precautions were taken to prevent contamination from CO_2 and other impurities. The triply distilled water had specific conductance less than 1×10^{-6} S·cm^{-1}.


water as a solvent

Application: Water is widely used in chemical reactions as a solvent or reactant and less commonly as a solute or catalyst. In inorganic reactions, water is a common solvent, dissolving many ionic compounds. Supercritical water has recently been a topic of research. Oxygen saturated supercritical water combusts organic pollutants efficiently. It is also use in various industries. It is a superb solvent, generally taken as the universal solvent, due to the marked polarity of the water molecule and its tendency to form hydrogen bonds with other molecules. Life on earth totally depends on water. Not only a high percentage of living things, both plants and animals are found in water, all life on earth is thought to have arisen from water and the bodies of all living organisms are composed largely of water. About 70 to 90 percent of all organic matter is water. The chemical reactions in all plants and animals that support life take place in a water medium. Water not only provides the medium to make these life sustaining reactions possible, but water itself is often an important reactant or product of these reactions. In short, the chemistry of life is water chemistry.

Acetonitrile (ACN):



Acetonitrile is the colourless liquid and of the simplest organic nitrile. It is produced mainly as a byproduct of acrylonitrile manufacture.

Source: Merck, India.

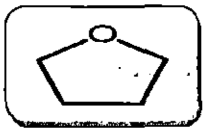
Purification: Acetonitrile (ACN) obtained from Merck, India was used after further purification. It was distilled from P_2O_5 and then from CaH_2 in an all-

Acetonitrile $H_3C\equiv N$	
Appearance	*:Colourless Liquid*
Molecular Formula	*:CH_3CN*
Molecular Weight	*:41.05 g·mol^{-1}*
Density	*:0.77668 g·cm^{3}*
Viscosity	*:0.344 mP·s*
Refractive Index	*: 1.3418*
Ultrasonic Speed	*:1282.6 m·s^{-1}*
Dielectric Constant	*:35.95 at 298.15 K*

glass distillation apparatus.[III.1] The middle fraction was collected. About 99% purified acetonitrile with specific conductivity $0.8 - 1.0\times10^{-8}$ S cm^{-3} was obtained. The purity of the liquid was checked by measuring it's density and viscosity which were in good agreement with the literature values[III.1, III.2] as shown in Table IV.1.

Application: It is widely used in battery applications because of its relatively high dielectric constant and ability to dissolve electrolytes. For similar reasons it is a popular solvent in cyclic voltammetry. Its low viscosity and low chemical reactivity make it a popular choice for liquid chromatography. Acetonitrile plays a significant role as the dominant solvent used in the manufacture of DNA oligonuleotides from monomers. Industrially, it is used as a solvent in the purification of butadiene and in the manufacture of pharmaceuticals and photographic film. Acetonitrile is a common two-carbon building block in organic synthesis as in the production of pesticides to perfumes.

Tetrahydrofuran (THF): 

Tetrahydrofuran	
	
Appearance	*:Colourless Liquid*
Molecular Formula	*:C_4H_8O*
Molecular Weight	*:72.11 g·mol^{-1}*
Density	*:0.88074 g·cm^3*
Viscosity	*:0.463 mP·s*
Refractive Index	*: 1.4072*
Ultrasonic Speed	*:1279.0 m·s^{-1}*
Dielectric Constant	*:7.58 at 298.15 K*

Tetrahydrofuran (THF) is an organic compound with the formula $(CH_2)_4O$. The compound is classified as heterocyclic compound, specifically a cyclic ether. It is a colorless, water-miscible organic liquid with low viscosity. THF has an odor similar to acetone. It is mainly used as a precursor to polymers. Being polar and having a wide liquid range, THF is a versatile solvent.

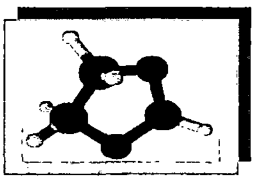
Source: Merck, Indian.

Purification: Tetrahydrofuran (THF), Merck, Indian was kept several days over potassium hydroxide (KOH), refluxed for 24 h and distilled over lithium aluminium hydride ($LiAlH_4$) described earlier.[IV.3] The purified solvent had a boiling point of 339 K and a specific conductance of 0.81×10^{-6} S cm^{-3}. The density and viscosity of the purified solvent were in good agreement with

the literature data[III.4, III.5] as shown in Table IV.1. The purity of the solvent was ≥98.9%.

Application: The main application of THF is as an industrial solvent for PVC and in varnishes. It is an aprotic solvent with a moderately polar solvent and can dissolve a wide range of non-polar and polar chemical compounds. THF is a popular solvent in the laboratory when a moderately higher-boiling ethereal solvent is required and its water miscibility is not an issue. Hence, like diethyl ether, THF can be used in hydroboration reactions to synthesize primary alcohols, and as a solvent for organometallic compounds such as organolithium and Grignard reagents. THF is often used in polymer science as dissolve polymers prior to determining their molecular mass using gel permeation chromatography, to PVC as well and thus it is the main ingredient in PVC adhesives. It can be used to liquefy old PVC cement, and is often used industrially to degrease metal parts. THF is also used as a component in mobile phases for reversed-phase liquid chromatography.

1,3-Dioxolane (1,3-DO):

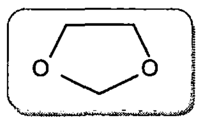


Dioxolane or 1,3-dioxolane is a heterocyclic acetal. No unusual toxic effects have been associated with the use of 1,3-dioxolane. The product is not explosive, not spontaneously flammable and has no disagreeable odour. Dioxolanes are a group of organic compounds sharing the dioxolane ring structure.

Source: Merck, India.

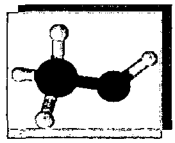
Purification: It is dried with KOH and then distilled from sodium.[III.6]

1,3-Dioxolane



Appearance	*:Colourless Liquid*
Molecular Formula	*:C_3H_6O*
Molecular Weight	*:74.08 $g{\cdot}mol^{-1}$*
Density	*:1.05873 $g{\cdot}cm^{3}$*
Viscosity	*:0.589 mP·s*
Refractive Index	*: 1.3980*
Ultrasonic Speed	*:1338.8 $m{\cdot}s^{-1}$*
Dielectric Constant	*:7.34 at 298.15 K*

Application: It is a very good solvent for pharmaceutical manufacturing, it is used as a replacement for many chlorinated solvents, in lithium battery electrolyte solvent component, as a copolymerization agent with trioxane and formaldehyde for manufacturing polyacetal resins, paint stripper, glue stabilizer, water solubilizing agent for pesticides, herbicides and wood preservatives.

Methanol (MeOH): 

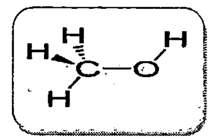
Methanol, also known as methyl alcohol, wood alcohol, wood naphtha or wood spirits, is the simplest alcohol, and is a light, volatile, colourless, flammable, liquid with a distinctive odour that is very similar to but slightly sweeter than ethanol (drinking alcohol).

Source: Merck, India.

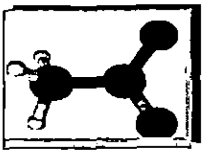
Purification: It was passed through Linde Å molecular sieves and then distilled.[III.6]

Application: The largest use of methyl alcohol by far is in making other chemicals. About 40% of methanol is converted to formaldehyde, and from there into products as diverse as plastics, plywood, paints, explosives, and permanent press textiles. Methanol is a traditional denaturant for ethanol, thus giving the term methylated spirit. Methanol is also used as a solvent, and as an antifreeze in pipelines. In some waste water treatment plants, a small amount of methanol is added to waste water to provide a food source of carbon for the denitrifying bacteria, which converts nitrates to nitrogen to reduce the denitrification of sensitive aquifers. Methanol is used on a limited basis to fuel internal combustion engines. Methanol is also useful as an energy carrier. It is easier to store than hydrogen, burns cleaner than fossil fuels, and is biodegradable.

Methanol



Appearance	*:Colourless Liquid*
Molecular Formula	*:CH_4O*
Molecular Weight	*:32.04 $g{\cdot}mol^{-1}$*
Density	*:0.7866 $g{\cdot}cm^3$*
Viscosity	*:0.5445 $mP{\cdot}s$*
Refractive Index	*: 1.3284*
Ultrasonic Speed	*:1103.0 $m{\cdot}s^{-1}$*
Dielectric Constant	*:32.6 at 298.15 K*

Nitromethane (NM): 

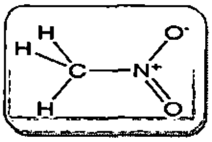
Nitromethane is one of the simplest organic nitro compounds. It is a slightly viscous, highly polar liquid.

Source: S.D. Fine Chemicals Ltd., Mumbai, India.

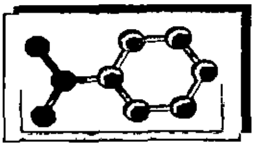
Purification: It is dried with $CaSO_4$ and then distilled.[III.6]

Application: The principle use of nitromethane is as a stabilizer for chlorinated solvents, which are used in dry cleaning, semiconductor processing, and degreasing. It is also used most effectively as a solvent or dissolving agent for acrylate monomers, such as cyanoacrylates. In more specialized organic synthesis, nitromethane serves as a Michael donor, adding to α, β-unsaturated carbonyl compounds via 1,4-addition in the Michael reaction. Its acidicity allows it to undergo deprotonation, enabling condensation reactions analogous to those of carbonyl compounds.

Nitromethane



Appearance	*:Colourless Liquid*
Molecular Formula	*:CH_3NO_2*
Molecular Weight	*:61.04 $g{\cdot}mol^{-1}$*
Density	*:1.13045 $g{\cdot}cm^3$*
Viscosity	*:0.614 mP·s*
Refractive Index	*: 1.3260*
Ultrasonic Speed	*:1317.0 $m{\cdot}s^{-1}$*
Dielectric Constant	*:35.87 at 298.15 K*

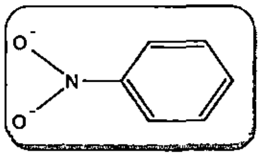
Nitrobenzene (NB): 

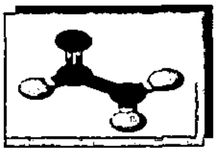
Nitrobenzene is a colorless to pale yellow oily liquid with an odour resembling that of bitter almonds or "shoe polish." It represents a fire hazard, with a flash point (closed cup method) of 88 °C and an explosive limit (lower) of 1.8% by volume in air. Nitrobenzene can undergo degradation by both photolysis and microbial biodegradation.

Source: Sd. Fine Chemicals, India

Purification: It is distilled in presence of dil. H_2SO_4 then dried with $CaCl_2$ followed by distillation from P_2O_5.[III.6]

Application: Nitrobenzene, one of the major uses for nitrobenzene is for the production of aniline,[III.7] which is a chemical intermediate used during the manufacture of polyurethane. Nitrobenzene is also used industrially in the manufacture of some pharmaceuticals, dyes and rubbers, as a constituent in some polishes and paint solvents and as a solvent in the refining of petroleum. More specialized applications include the use of nitrobenzene as a precursor to rubber chemicals, pesticides, dyes, explosives, and pharmaceuticals. Nitrobenzene is also used in shoe and floor polishes, leather dressings, paint solvents, and other materials to mask unpleasant odors. Redistilled, as oil of mirbane, nitrobenzene has been used as an inexpensive perfume for soaps. A significant merchant market for nitrobenzene is its use in the production of the analgesic paracetamol.[III.8]

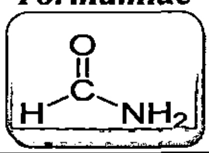
Nitrobenzene	
	
Appearance	*:Pale Yellow Liquid*
Molecular Formula	*:$C_6H_5NO_2$*
Molecular Weight	*:123.06 $g\cdot mol^{-1}$*
Density	*:1.19836 $g\cdot cm^3$*
Viscosity	*:1.815 mP·s*
Refractive Index	*: 1.5474*
Ultrasonic Speed	*:1460.8 $m\cdot s^{-1}$*
Dielectric Constant	*:34.82 at 298.15 K*

Formamide (F): 

Formamide, also known as **methanamide**, is an amide derived from formic acid. It is a clear liquid which is miscible with water and has an ammonia like odor. It is chemical feedstock for the manufacture of sulfa drugs, other pharmaceuticals, herbicides, pesticides and the manufacture of hydrocyanic acid.

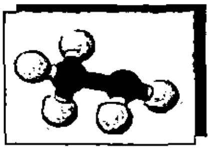
Source: Sigma Adrich, Germany

Purification: The Spectrographic grade formamide used as procured, without further purification. The purity of the solvent is 99.5%.

Formamide	
	
Appearance	*:Colourless Liquid*
Molecular Formula	*:$HCONH_2$*
Molecular Weight	*:45.04 $g\cdot mol^{-1}$*
Density	*:1.13300 $g\cdot cm^3$*
Viscosity	*:3.304 mP·s*
Refractive Index	*: 1.4475*
Ultrasonic Speed	*:1626.3 $m\cdot s^{-1}$*
Dielectric Constant	*:109.5 at 298.15 K*

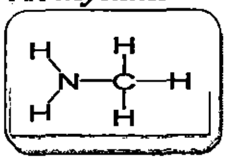
Application: It has been used as a softener for paper and fiber. It is a solvent for many ionic compounds. It has also been used as a solvent for resins and plasticizers. Formamide will begin to partially decompose into carbon monoxide and ammonia at 180°C. When heated strongly, formamide decomposes to hydrogen cyanide (HCN) and water vapor. It is also a constituent of cryoprotectant vitrification mixtures used for cryopreservation of tissues and organs. Formamide is also used as an RNA stabiliser in gel electrophoresis by deionizing RNA. In capillary electrophoresis, it is used for stabilizing (single) strands of denatured DNA. Another use is to add it in sol-gel solutions in order to avoid cracking during sintering. Formamide, in its pure state, has been used as an alternative solvent for the electrostatic self-assembly of polymer nano-films. It is used to prepare primary amines directly from ketones via their N-formyl derivatives, using the Leuckart reaction.

Methylamine (CH_3NH_2):



Methylamine is the organic compound with a formula of CH_3NH_2. This colourless gas is a derivative of ammonia, but with one H atom replaced by a methyl group. It is the simplest primary amine. It is sold as a solution in methanol, ethanol, THF, and water, or as the anhydrous gas in pressurized metal containers. Industrially, methylamine is transported in its anhydrous form in pressurized railcars and tank trailers. It has a strong odour similar to fish.

Methylamine



Appearance	*:Colourless Liquid*
Molecular Formula	*:CH_3NH_2*
Molecular Weight	*:31.06 g·mol^{-1}*
Boiling Point	*:266.5-267.1 K*
Melting Point	*:180.05 K*
Density	*:0.89703 g·cm^{-3}*
Viscosity	*:0.178 mP·s*
Dielectric Constant	*:9.10 at 298.15 K*

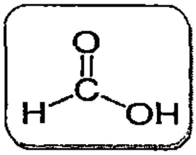
Source: Sigma Aldrich, Germany

Purification: The solvent was used as purchased without further purification.

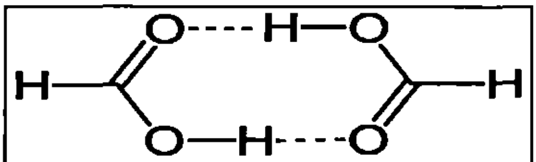
Application: Methylamine is used as a building block for the synthesis of many other commercially available compounds. Methylamine is a good nucleophile as it is highly basic and unhindered, although, as an amine it is considered a weak base. Its use inorganic chemistry is pervasive.

Methanoic Acid (Formic Acid): 

Formic Acid

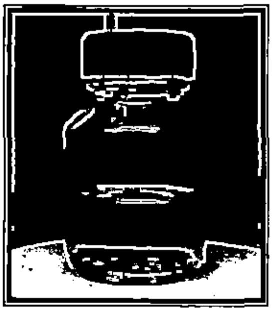


Appearance	*:Colourless Liquid*
Molecular Formula	*:HCOOH*
Molecular Weight	*:46.03 g·mol⁻¹*
Density	*:1.21405 g·cm³*
Viscosity	*:1.532 mP·s*
Refractive Index	*: 1.3694*
Ultrasonic Speed	*:1283.0 m·s⁻¹*
pKa	*:3.77*



Cyclic dimer of formic acid; dashed green lines represent hydrogen bonds

Formic acid (systematically called **methanoic acid**) is the simplest carboxylic acid. Its chemical formula is HCOOH or HCO_2H. It is an important intermediate in chemical synthesis and occurs naturally, most notably in ant venom. Its name comes from the Latin word for ant, *formica*, referring to its early isolation by the distillation of ant bodies. Esters, salts, and the anions derived from formic acid are referred to as formates. Formic acid is a colorless liquid having a highly pungent, penetrating odour at room temperature. It is miscible with water and most polar organic solvents, and is somewhat soluble in hydrocarbons. In hydrocarbons and in the vapor phase, it consists of H-bonded dimers rather than individual molecules. Solid formic acid (two polymorphs) consists of an effectively endless network of hydrogen-bonded formic acid molecules. This relatively complicated compound also forms a low-boiling azeotrope with water (22.4%) and liquid formic acid also tends to supercool.



Source: Sigma Aldrich, Germany

Purification: Used as parched without further purification. The purity is >98.9%.

Application: A major use of formic acid is as a preservative and antibacterial agent in livestock feed. Formic acid is also significantly used in the production of leather, experimental data is known, the apparent molal property at infinite dilution can also be found out. Theoretically, as the concentration approaches zero, the apparent molal property approaches the partial molal property of the solute at infinite dilution, because by definition the solvent is already assumed to be in its pure form. If the apparent molal property is assumed to reflect the apparent molal property of the solute only and not the solute-solvent complex, then the apparent molal property at infinite dilution, $\phi^{\infty}_{2,Y}$, would be equal to the standard state molal property of the solute, as defined by Henry's law. Ignoring the previous equality, equation of state developed for standard state partial molal variables have been used successfully to describe partial molal quantities at infinite dilution.

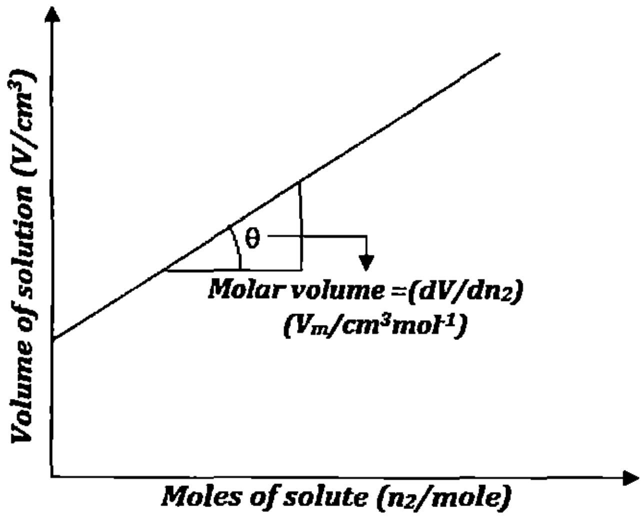


Figure II.9a: A diagram for the explanation of molal volume

The easiest way to explain this is in terms of the molal volume, V_m, shown in the Figure II.9a, where the volume increases with respect to the amount of solute added. A dissolved solute has its own property, referred to as partial molal property. Figure II.9b shows an extremely large tank containing 1 mol·L^{-1} solution of a solute with a certain volume, shown at position (a). If 1mole of solute is added to the solution in the tank, the volume will increase to (b); however the concentration of the other species of the solution will not change by any detectable amount.

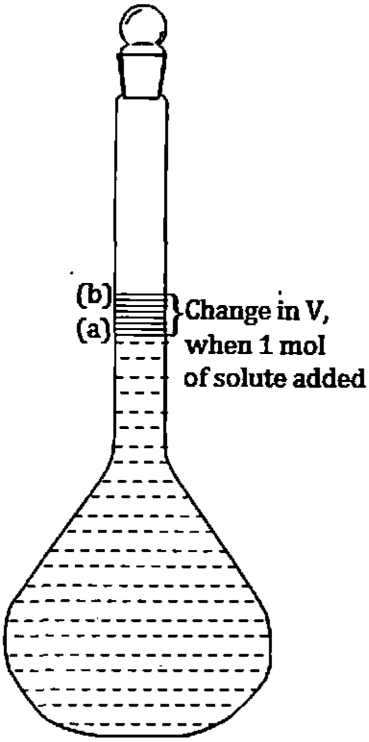


Figure II.9b: A diagram to assist in the explanation of a partial molal volume

Therefore for a two component system, where one component is the solvent and the other is solute, the total volume of the system can be represented as the sum of the partial molal volumes of the solvent, $\overline{V}_1$, and the solute, $\overline{V}_2$:

$$V = n_1\overline{V_1} + n_2\overline{V_2} \tag{II. 1c}$$

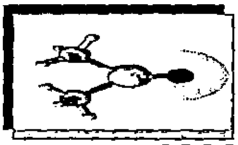
Dividing Eq. (II. 1c) by $n_1 + n_2$, the molal volume of the solution is obtained as:

$$V_m = x_1\overline{V_1} + x_2\overline{V_2} \tag{II. 1d}$$

where, x_1 and x_2 represent the mole fraction of the solvent and the solute, respectively. The partial molal property of a solute is defined as the change in the total property of the system with respect to the change in the number of moles of solute added, with all other variables (*T*, *P*, and the amount of the solvent) are held constant. An alternative, widely used property of the solute is the apparent molal property. The apparent molal volume is the volume that should be attributed to the solute in solution if it is assumed that the solvent contributes the exact volume it would if it was in its pure state.

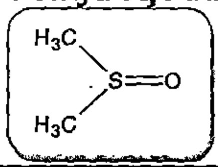
Under this assumption, the apparent molal volume of the solute, $\phi_{2,V}$, as defined by

Application: DMA is useful solvent for reactions involving strong bases such as sodium hydroxide. Dimethylacetamide is commonly used as a solvent for fibers (e.g., polyacrylonitrile, spandex) or in the adhesive industry.[III.11] It is also employed in the production of pharmaceuticals and plasticizers as a reaction medium.

Dimethylsulfoxide (DMSO): 

Dimethyl sulfoxide (DMSO) is an organosulfar compound with the formula $(CH_3)_2SO$. This colorless liquid is an important polar aprotic solvent that dissolves both polar and non-polar compounds and is miscible in a wide range of organic solvents as well as water. It penetrates the skin very readily, giving it the unusual property for many individuals of being secreted onto the surface of the tongue after contact with the skin and causing a garlic-like taste in the mouth. Although it has some niche medicinal uses it also has significant known side effects. It has been promoted as a fake cure for cancer and other conditions.

Dimethylsulfoxide

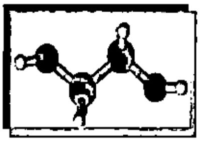


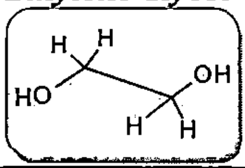
Appearance	*:Colourless Liquid*
Molecular Formula	*:$(CH_3)_2SO$*
Molecular Weight	*:78.13 g·mol^{-1}*
Density	*:1.09602 g·cm^3*
Viscosity	*:1.946 mP·s*
Refractive Index	*: 1.4783*
Ultrasonic Speed	*:1490.4 m·s^{-1}*
Dielectric Constant	*:46.7 at 298.15 K*

Source: Thomas Baker, India

Purification: It was dried by passing through Linde 4Å molecular sieves.

Application: DMSO is frequently used as a solvent for chemical reactions involving salts, most notably Finkelstein reactions and other nucleophilic substitutions. It is also extensively used as an extractant in biochemistry and cell biology. Because of its ability to dissolve many kinds of compounds, DMSO plays a role in sample management and high-throughput screening operations in drug design. DMSO is used in PCR to inhibit secondary structures in the DNA template or the DNA primers. It is added to the PCR mix before reacting, where it interferes with the self-complementarity of the DNA, minimizing interfering reactions. In medicine, DMSO is predominantly used as a topical analgesic, a vehicle for topical application of pharmaceuticals, as an anti-inflammatory, and an antioxidant.[III.12] Because DMSO increases the rate of absorption of some compounds through organic tissues, including skin, it can be used as a drug delivery system. It is frequently compounded with antifungal medications, enabling them to penetrate not just skin but also toe and fingernails. It is also used as veterinary medicines.

Ethylene Glycol (EG): 

Ethylene Glycol 	
Appearance	*:Colourless Liquid*
Molecular Formula	:$C_2H_6O_2$
Molecular Weight	:$62.07\ g{\cdot}mol^{-1}$
Density	:$1.10980\ g{\cdot}cm^3$
Viscosity	:$16.9\ mP{\cdot}s$
Refractive Index	*:1.4002*
Ultrasonic speed	:$1660.0\ m{\cdot}s^{-1}$
Dielectric Constant	*:40.7 at 298.15 K*

Ethylene glycol is a colourless, practically odourless, low-volatility, low-viscosity, hygroscopic liquid. It is completely miscible with water and many organic liquids. The hydroxyl groups on glycols undergo the usual alcohol chemistry, giving a wide variety of possible derivatives.

Source: Merck, India.

Purification: It was dried with anhydrous $CaSO_4$ and distilled under vacuum. The distillate was passed through Linde type 4 Å molecular sieves.[III.6]

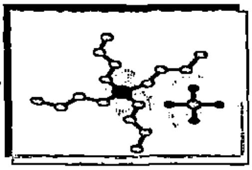
Application: The major uses of ethylene glycol are as antifreeze, which accounts for over 50% of ethylene glycol's commercial uses, and as raw material in the production of polyester fibers, mainly PET, which accounts for 40% of total ethylene glycol consumption. Because this material is cheaply available, it finds many niche applications.[III.13] It is widely used as an intermediate in the synthesis of many varieties of organic chemical compounds. Industrially it is employed in the manufacture of synthetic drugs and dyes.

III.1.2 ELECTROLYTES AND NON-ELECTROLYTES

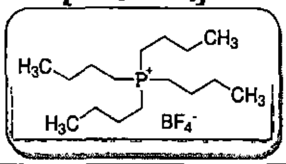
The electrolytes ionic liquids, and non-electrolytes amino acids, respectively, and other chemicals than these two categories that are used in the research work have been describing follow:

III.1.2.1 Ionic Liquids

Tetrabutylphosphonium tetrafluorobotrate $[Bu_4PBF_4]$:



Tetrabutylphosphonium tetrafluorobotrate is the phosphonium based ionic liquid, containing bulky alkyl (n-butyl) group of molecular formula $[(C_4H_9)_4PBF_4]$, exists as a molten solid phase (white crystalline) with the melting point 96-99°C.

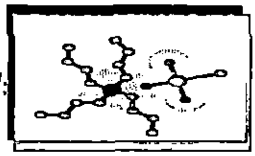
$[Bu_4PBF_4]$	
	
Appearance	*:White Crystalline*
Molecular Formula	*:$C_{16}H_{36}BF_4P$*
Molecular Weight	*:346.24 g·mol^{-1}*
Melting Point	*:369-372 K*
Relative Density	*:No data available*
Ionic radii	*: 4.42 (Å) of Bu_4P^+* *2.78 (Å) of BF_4^-*

Source: Sigma Aldrich, Germany

Purification: Used as purchased. The purity of the chemical is >99.0%

Application: Tetrabutylphosphonium tetrafluoroborate is widely used as electrolytes in electrochemical windows when control of electrode potentials is required source. The ionic liquid may be used in organic synthesis and bio-catalysis, dye sensitized-cells, batteries, electrochemical application and phase transfer catalyst, etc.

Tetrabutylphosphonium methanesulfonate $[Bu_4PCH_3SO_3]$:



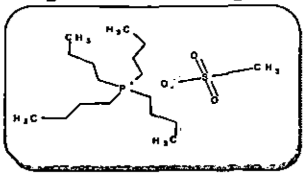
Tetrabutylphosphonium methanesulfonate is the also phosphonium based ionic liquid, containing bulky alkyl (n-butyl) group of molecular formula $[(C_4H_9)_4PCH_3SO_3]$, exists as a molten solid phase (white crystalline) with the melting point 96-99°C.

Source: Sigma Aldrich, Germany

Purification: Used as purchased. The purity of the chemical is >99.0%

Application: Tetrabutylphosphonium methanesulfonate is perhaps used as same as tetrabutylphosphonium tetrafluoroborate as electrolytes in electrochemical windows when control of electrode potentials is required source. The ionic liquid may be used in organic synthesis and bio-catalysis, dye sensitized-cells, batteries, electrochemical application and phase transfer catalyst, etc

[$Bu_4PCH_3SO_3$]



Appearance	*:White Crystalline*
Molecular Formula	*:$C_{17}H_{39}PSO_3$*
Molecular Weight	*:354.53 g·mol^{-1}*
Melting Point	*:369-372 K*
Relative Density	*:No data available*
Ionic radii	*:4.42 (Å) of Bu_4P^+* *2.83(Å) of $CH_3SO_3^-$*

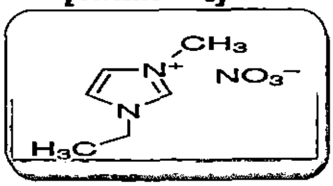
1-ethyl-3-methylimidazolium nitrate [$emimNO_3$]:

1-ethyl-3-methylimidazolium nitrate is the imidazolium based ionic liquid, of molecular formula $C_6H_{11}N_3O_3$, containing methyl, ethyl group with two active nitrogen atoms in the imidazole or five member ring, exist as a molten liquid phase with the melting point ≥ 40°C.

Source: Sigma Aldrich, Germany

Purification: Used as purchased. The purity of the chemical is >98.0%

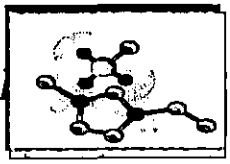
[$emimNO_3$]



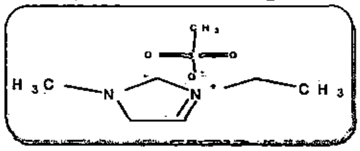
Appearance	*: Beige Crystalline*
Molecular Formula	*:$C_6H_{11}N_3O_3$*
Molecular Weight	*:173.17 g·mol^{-1}*
Melting Point	*: ≥313.15 K*
Relative Density	*: No data avilable*
Ionic radii	*:1.33(Å)of [emim]$^+$* *1.99 (Å) of NO_3^-*

Application: The ionic liquid are good examples of neoteric solvents, new types of solvents, or older materials that are finding new applications as solvents, which is environmentally friendly (or eco-friendly) because they are less hazardous for human body as well as less toxic for living organisms, used as recyclable solvents for organic reactions and separation processes, lubricating fluids, heat transfer fluids for processing biomass and electrically conductive liquids as electrochemical device in the field of electrochemistry (batteries and solar cells).

1-ethyl-3-methylimidazolium methanesulfonate [emimCH_3SO_3]



1-ethyl-3-methylimidazolium methanesulfonate is the also imidazolium based ionic liquid, of molecular formula $C_6H_{11}N_3O_3$, containing methyl, ethyl group with two active nitrogen atoms in the imidazole or five member ring, exists as a molten liquid phase with the melting point ≥ 30°C.

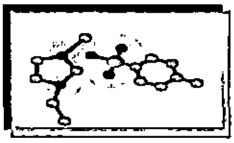
[emimCH_3SO_3]	
	
Appearance	*:Odourless solid*
Molecular Formula	*:$C_7H_{14}N_2O_3S$*
Molecular Weight	*:206.26 $g{\cdot}mol^{-1}$*
Melting Point	*:303.15 K*
Relative Density	*:1.247 $g{\cdot}cm^{-3}$*
Ionic radii	*:1.33(Å) of [emim]$^+$* *2.83(Å) of $CH_3SO_3^-$*

Source: Sigma Aldrich, Germany

Purification: Used as purchased. The purity of the chemical is >95.0%

Application: The ionic liquid are new types of solvents, or older materials that are finding new applications as solvents, which is environmentally friendly (or eco-friendly) because they are less hazardous for human body as well as less toxic for living organisms, used as recyclable solvents for organic reactions and separation processes, lubricating fluids, heat transfer fluids for processing biomass and electrically conductive liquids as electrochemical device in the field of electrochemistry (batteries and solar cells) and so forth.

1-ethyl-3-methylimidazolium tosylate [emimTos]:

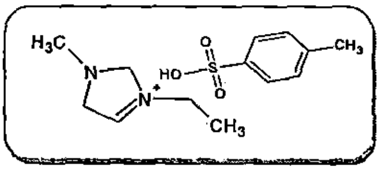


1-ethyl-3-methylimidazolium tosylate is also the imidazolium based ionic liquid, of molecular formula $C_{13}H_{11}N_3O_3$, containing methyl, ethyl group with two active nitrogen atoms in the imidazole or five member ring, exist as a molten liquid phase with the melting point ≥ 25-30°C.

Source: Sigma Aldrich, Germany

Purification: Used as purchased. The purity of the chemical is >98.0%

Application: The ionic liquid are good examples of neoteric solvents, new types of solvents, or older materials that are finding new applications as solvents, which is environmentally friendly (or eco-friendly) because they are less hazardous for human body as well as less toxic for living organisms, used as recyclable solvents for organic reactions and separation processes, lubricating fluids, heat transfer fluids for processing biomass and electrically conductive liquids as electrochemical device in the field of electrochemistry (batteries and solar cells) and so forth. In the modern technology, industry, and also in academic research field, the vast application is frequently increases.

[emimTos] 	
Appearance	*:Crystalline*
Molecular Formula	*:$C_{13}H_{18}N_2O_3S$*
Molecular Weight	*:282.36 g·mol^{-1}*
Melting Point	*: 298.15-303.15 K*
Relative Density	*:1.231 g·cm^{-3}*
Ionic radii	*:1.33(Å) of [emim]$^+$* *3.16 (Å) of Tos$^-$*

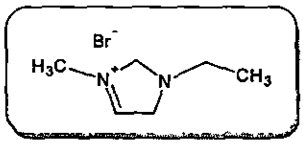
1-ethyl 3-methylimidazolium bromide [emimBr]:

1-ethyl 3-methylimidazolium bromide is an ionic liquid. The cation consists of a five-membered ring with two nitrogen and three carbon atoms, i.e. a derivative of imidazole, with ethyl and methyl groups substituted at the two nitrogen atoms.

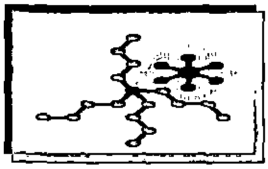
Source: Sigma Aldrich, Germany

Purification: Used as purchased. The purity of the electrolyte is 99.8%.

Application: 1-ethyl-3-methylimidazolium salts are used in cellulose processing. They are also used as use as non-aqueous electrolytes in electrochemical applications.

[emimBr] 	
Appearance	*:Light yellow Cryst*
Molecular Formula	*:$C_6H_{11}BrN_2$*
Molecular Weight	*:191.07 g·mol^{-1}*
Melting Point	*:< 373.15 K*
Relative Density	*: No data available*
Ionic radii	*:1.33(Å) of [emim]$^+$* *1.95 (Å) of Br$^-$*

Tetrabutylammonium Hexafluorophosphate [Bu_4NPF_6]:



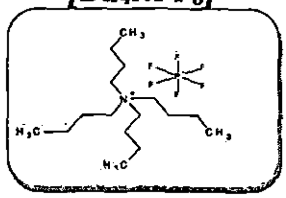
Tetrabutylammonium hexaflurophosphate is also the ammonium based ionic liquid, of molecular formula $C_{16}H_{36}NPF_6$, exist as a molten solid phase.

Source: Sigma Aldrich, Germany

Purification: Used as purchased. The mass fraction purity of Bu4NPF6 was ≥0.99.

Application: It is used as reference electrolyte because both ions have about the same volume and half the limiting conductance is assumed to give the single ion conductances of Bu_4N^+ and PF_6^-.

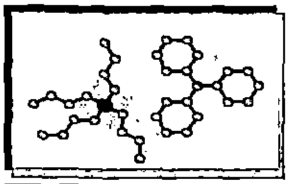
[Bu_4NPF_6]



Appearance	*:Off-white Power*
Molecular Formula	*:$C_{16}H_{36}NPF_6$*
Molecular Weight	*:387.43 g·mol^{-1}*
Melting Point	*:517.15 - 519.15 K*
Relative Density	*:No data available*
Ionic radii	*:5.00(Å) of [Bu_4N]$^+$ 1.95 (Å) of PF_6^-*

III.1.2.2 Electrolytes other than Ionic Liquids

Tetrabutylammonium tetraphenylborate [Bu_4NBPh_4]:



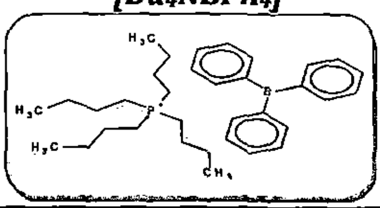
Tetrabutylammonium tetraphenylborate is the most popular electrolyte, containing the approximately same ionic radii of cation (Bu_4N^+) and anion (Ph_4B^-) as well as same ionic conductance; for the reason the electrolyte commonly used as *'reference electrolyte'* method.

Source: Sigma Aldrich, Germany

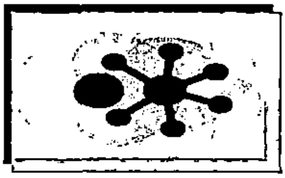
Purification: Used as purchased.

Application: It is widely used as supporting electrolytes in electrochemical measurements when control of electrode potentials is required.

[Bu_4NBPh_4]



Appearance	*:White Power*
Molecular Formula	*:$C_{40}H_{56}BN$*
Molecular Weight	*:561.69 g·mol^{-1}*
Melting Point	*:506.15-510.15 K*
Relative Density	*:No data available*
Ionic radii	*:5.00 (Å) of [Bu_4N]$^+$ 5.33 (Å) of [BPh_4]$^-$*

Lithium Hexafluoroarsenate [$LiAsF_6$]: 

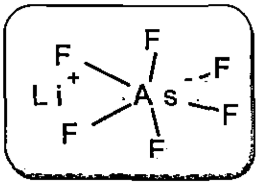
Lithium hexafluoroarsenate is the most prominent lithium-ion battery is a member of a family of rechargeable battery in which lithium ions moves from the negative electrode to the positive electrode during discharge and back when charging. Chemistry, performance, cost and safety characteristics vary across lithium-ion battery (LIB) type. Handheld electronics mostly use LIBs based on the electrolyte, which offers high energy density, but presents safety risks, especially when damaged.

Source: Sigma Aldrich, Germany

Purification: Used as purchased. The mass fraction purity of the salt is 0.98.

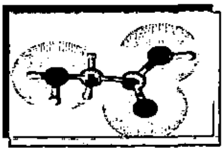
Application: Used as electrolytes in lithium-ion batteries. It is used an intercalated lithium compound as the electrode material, compared to the metallic lithium used in non-rechargeable lithium battery. Such batteries provide lightweight, high energy density power sources for a variety of devices, are widely used for electric tools, medical equipment and other roles.

[$LiAsF_6$]

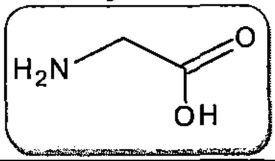


Appearance	*:White Power*
Molecular Formula	*:$LiAsF_6$*
Molecular Weight	*:195.85 $g{\cdot}mol^{-1}$*
Purity	*: ≥ 99.0%*
Melting Point	*:622.15 K*
Relative Density	*:No data available*
Ionic radii	*:1.33 (Å) of Li^+* *1.95 (Å) of AsF_6^-*

III.1.2.3 Amino Acids

Glycine (gly): 

Glycine



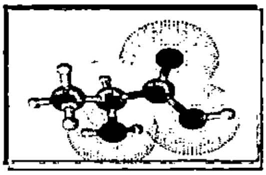
Appearance	*:White Solid .*
Molecular Formula	*:$C_2H_5NO_2$*
Molecular Weight	*:75.07 g·mol^{-1}*
Melting Point	*:506.15 K*
Relative Density	*:1.607 g·cm^{-3}*
pKa	*:2.34 (carboxyl); 9.6 (amino)*

Glycine (abbreviated as Gly or G) is an organic compound with the formula NH_2CH_2COOH. Having a hydrogen substituent as its side-chain, glycine is the smallest of the 20 amino acids commonly found in proteins. Its codons are GGU, GGC, GGA, GGG of the genetic code. Glycine is a colourless, sweet-tasting crystalline solid. It is unique among the proteinogenic amino acids in that it is not chiral. It can fit into hydrophilic or hydrophobic environments, due to its minimal side chain of only one hydrogen atom.

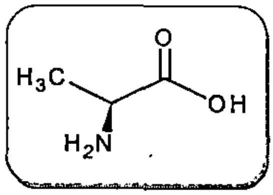
Source: Sigma Aldrich, Germany

Purification: Used as parched without further purification. The purity is 99.99%.

Application: Pharmaceutical grade glycine is produced for or some pharmaceutical applications, as intravenous injections. Technical grade glycine is solid for use in industrial applications, e.g. as an agent in metal complexing and finishing. For humans, glycine is solid as a sweetner/taste enhancer. Certain food supplements and protein drinks containing glycine, for drug formulations it used to improve gastic absoption. Glycine serves as a buffering agent in antacids, analgesics, antiperspirants, cosmetics, and toiletries. Many miscellaneous products use glycine or its derivatives, such as the production of rubber sponge products, fertilizers, metal complexants.

L-Alanine (Ala): 

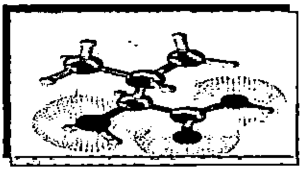
Alanine



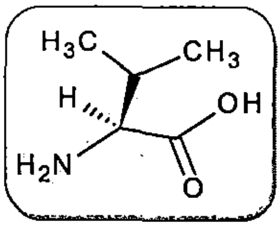
Appearance	*:White Powder*
Molecular Formula	*: $C_3H_7NO_2$*
Molecular Weight	*:89.09 $g{\cdot}mol^{-1}$*
Melting Point	*: 531.15 K*
Relative Density	*:1.424 $g{\cdot}cm^{-3}$*
pKa	*:2.35 (carboxyl); 9.69 (amino)*

Alanine (abbreviated as Ala or A) is an α-amino acid with the chemical formula $CH_3CH(NH_2)COOH$. The L-isomer is one of the 20 amino acids encoded by the genetic code. Its codons are GCU, GCC, GCA, and GCG. It is classified as a nonpolar amino acid. L-Alanine is second only to leucine in rate of occurrence, accounting for 7.8% of the primary structure in a sample of 1,150 proteins.[III.3] D-Alanine occurs in bacterial cell walls and in some peptide antibiotics.

Application: alanine is used in dosimetric measurements in radiotherapy. Alanine plays a key role in glucose–alanine cycle between tissues and liver. In muscle and other tissues that degrade amino acids for fuel, amino groups are collected in the form of glutamate by transamination.

L-Valine (Val): 

L-Valine



Appearance	*:White Solid*
Molecular Formula	*:$C_5H_{11}NO_2$*
Molecular Weight	*:117.15 $g{\cdot}mol^{-1}$*
Melting Point	*:506.15 K*
Relative Density	*:1.316 $g{\cdot}cm^{-3}$*
pKa	*:2.32 (carboxyl); 9.62 (amino)*

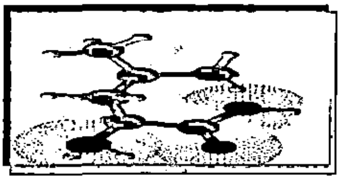
Valine is an α-amino acid with the chemical formula $HO_2CCHCH(CH_3)_2$. L-valine is one of 20 proteinogenic amino acids. Its codons are GUU, GUC, GUA, and GUG. This essential amino acid is classified as nonpolar. Human dietary sources are any proteinaceous foods such as meats, dairy products, soy products, beans and legumes. Along with leucine and isoleucine, valine is a branched-chain amino acid. It is named after the plant valerian. In sickle-cell disease, valine substitutes for the hydrophilic amino acid glutamic acid in hemoglobin. Because valine is hydrophobic, the hemoglobin is prone to abnormal aggregation.

Source: Sigma Aldrich, Germany

Purification: Used as parched without further purification. The purity is 99.99%.

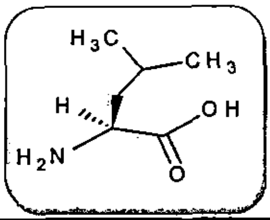
Application: Valine is an essential amino acid; hence it must be ingested, usually as a component of proteins. It is used for some pharmaceutical applications, industrial applications, food supplements and protein drinks, give out as a buffering agent in antacids, analgesics, antiperspirants, cosmetics, toiletries, production of rubber sponge products, fertilizers, metal complexants etc.

L-Leucine (Leu):



Leucine (abbreviated as Leu or L) is a branched-chain α-amino acid with the Chemical formula $HO_2CCH(NH_2)CH_2CH(CH_3)_2$. Leucine is classified as a hydrophobic amino acid due to its aliphatic isobutyl side chain. It is encoded by six codons (UUA, UUG, CUU, CUC, CUA, and CUG) and is a major component of the subunits in ferritin, astacin and other 'buffer' proteins. Leucine is an essential amino acid, meaning that the human body cannot synthesize it, and it therefore must be ingested.

L-Leucine



Appearance	*:White Solid*
Molecular Formula	*:$C_6H_{13}NO_2$*
Molecular Weight	*:131.17 g·mol^{-1}*
Melting Point	*: >573.15 K*
Relative Density	*:1.167 g·cm^{-3}*
pKa	*:2.36 (carboxyl); 9.60 (amino)*

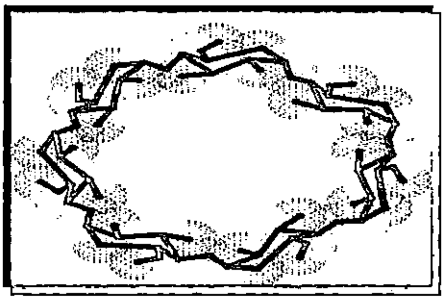
Source: Sigma Aldrich, Germany

Purification: Used as parched without further purification. The purity is 99.99%.

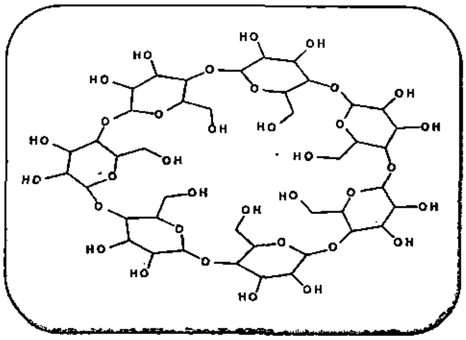
Application: Leucine is utilized in the liver, adipose tissue, and muscle tissue, for formation of sterols. Leucine is the only dietary amino acid that has the capacity to stimulate muscle protein synthesis. Leucine potently activates the mammalian target of rapamycin kinase that regulates cell growth. In yeast genetics, mutants with a defective gene for leucine synthesis (leu2) are transformed with a plasmid that contains a working leucine synthesis gene (LEU2) and grown on minimal media. Leucine synthesis then becomes a useful selectable marker.

III.1.2.3 Non-electrolytes other than amino acids

β-Cyclodextrin (β-CD):



β-Cyclodextrin



Appearance	*:Crystalline Powder*
Molecular Formula	$C_{42}H_{70}O_{35}$
Molecular Weight	*:1134.98 g·mol*$^{-1}$
Melting Point	*:563.15-573.15 K*
Boiling Point	*:1814.33 K*
Relative Density	*:1.44 g·cm*$^{-3}$ *at 20°C*
Refractive Index	*:1.59* (n_D^{20})

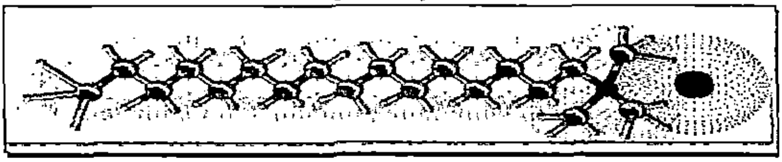
β-Cyclodextrin is finely made from pure provision material-starch and translate enzyme, which is white powder and whose molecule structure is like a cylinder compounded from 7 glucose group with a key of 2-1.4. The function of β-Cyclodextrin depends on its cylinder molecule structure which can be easy to integrate other materials. That feature is applied widely in industry.

Source: Sigma Aldrich, Germany

Purification: Used as parched. The purity is 99.98%.

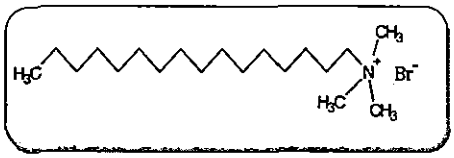
Application: β-Cyclodextrin is a new stuff which can be widely applied in production of medicine and food. It can be applied widely in production of medicine, food and cosmetics, whose function is improved stability, solubility and good smelled. In the production of medicine, it can strengthen the stability of medicine without being oxidized and resolving. On the other hand, it can improve the solubility. And the effect on living of medicine, lower the toxic and side-effect of medicine and cover the strange and bad smell. In the production of food, it can mainly cover strange and bad smell of food, improve the stability of perfume and condiment and keep food dry or wet at will. *β*-CD with a cavity diameter of 6.4-7.5 Å, is the most interest because its cavity size allows for the best special fit for many common guest moieties. For this reason, β-cyclodextrin is most commonly used as a complexing agent in hormones, vitamins, and many compounds frequently used in tissue and cell culture applications. This capability has also been of assistance for different applications in medicines, cosmetics, food technology, pharmaceutical, and chemical industries as well as in agriculture and environmental engineering as an encapsulating agent to protect sensitive molecules in hostile environment.

N-cetyl-N,N,N-trimethylammonium bromide (CTAB) or :



Cetrimonium bromide ($(C_{16}H_{33})N(CH_3)_3Br$, cetyltrimethylammonium bromide, hexadecyltrimethylammonium bromide, CTAB) is one of the components of the topical antiseptic cetrimide. The cetrimonium (or hexadecyltrimethyl-ammonium) cation is an effective antiseptic agent against bacteria and fungi. It is a cationic surfactant. Its uses include providing a buffer solution for the extraction of DNA. It has been widely used in synthesis of gold nanoparticles (e.g., spheres, rods, bipyramids). It is also widely used in hair conditioning products. As any surfactant, it forms micelles in aqueous solutions. At 303 K (30 °C) it forms micelles with aggregation number 75-120 (depending on method of determination, usually average ~95) and degree of ionization α (fractional charge) 0.2–0.1 (from low to high concentration). The standard constant of Br- counterion binding to the micelle at 303 K (30 °C) is $K° \approx 400$. This value is calculated from Br- and CTA+ ion selective electrode measurements and conductometry data by using literature data for micelle size (r = ~3 nm), extrapolated to the critical micelle concentration of 1 mM. However, it varies with total surfactant concentration so it is extrapolated to the

Cetrimonium bromide



Appearance	*:White powder*
Molecular Formula	*:$C_{19}H_{42}NBr$*
Molecular Weight	*:364.45 g·mol^{-1}*
Melting Point	*:521.15-524.15K*
pH	*:5.0-7.0 at 298.15K*

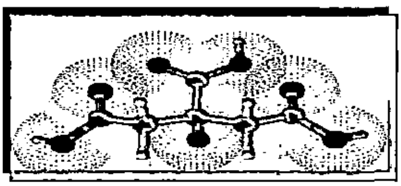
point at which the concentration of micelles is zero) The closely related compounds cetrimonium chloride and cetrimonium stearate are also used as topic antiseptics, and may be found in many household products such as shampoos and cosmetics, while cetrimonium bromide, due to its high cost, is only found in select cosmetics.

Source: Thomas Baker, India.

Purification: Used as without further purification. The mass fraction purity is 0.99.

Application: Cetrimonium bromide is one of the components of the topical antiseptic cetrimide. It is also widely used as an active ingredient for hair conditioners, etergent sanitizers, disinfection agents, and softener for textiles and paper products. Understanding the behavior of citric acid in cetrimonium bromide solution will be of the utmost importance in the biological and pharmaceutical science (e.g., advanced lice treatment, etc.). Cetrimonium bromide forms micelles in water. Depending on the temperature and concentration of the cetrimonium bromide, water is forced to attain a specific structural form. Because of the broad distribution of negative charges in glycoproteins, these form broad, fuzzy bands in SDSPAGE (Laemmli-electrophoresis). This can be avoided by using positively charged detergents like CTAB instead of the negatively charged SDS. Proteins can be blotted from CTAB-gels in analogy to western blots ("eastern blot"), and CTAB-PAGE can be used as second dimension after IEF. Myelin-associated high hydrophobic protein can be analyzed using CTAB 2-DE.

Citric Acid (CA):



Citric acid, ($C_6H_8O_7 \cdot 3H_2O$), that is, 2-hydroxypropane-1,2,3-tricarboxylic acid, is a tribasic, environmentally acceptable, and versatile chemical. It is a natural preservative/conservative and is also used to add an acidic or sour taste to foods and drinks. In biochemistry, the conjugate base of citric acid, citrate, is important as an intermediate in the citric acid cycle, which occurs in the metabolism of all aerobic organisms. It consists of 3 carboxyl (R-COOH) groups. Citric acid is a commodity chemical, and more than a million tonnes are produced every year by fermentation.

It is used mainly as an acidifier, as a flavoring, and as a chelating agent.

Citric Acid

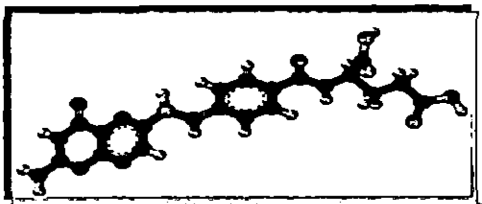
Appearance	*:Crytalline*
Molecular Formula	*: $C_6H_8O_7$*
Molecular Weight	*:192.124 g·mol^{-1}*
Melting Point	*:523.15 K*
Relative Density	*:1.66 g·cm^{-3}*
Boiling Point	*: 448.15 K*
Solubility	*: Water soluble*

Source: Citric acid monohydrate (CA) was purchased from HiMedia.

Purification: Its mass purity as supplied is 0.99. The reagent was always placed in the desiccator over P_2O_5 to keep them in dry atmosphere.

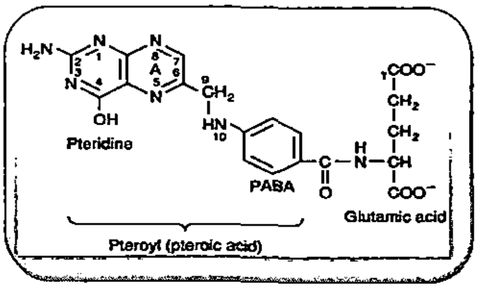
Application: The dominant use of citric acid is as a flavoring and preservative in food and beverages, especially soft drinks. Citric acid can be added to ice cream as an emulsifying agent to keep fats from separating, to caramel to prevent sucrose crystallization, or to recipes in place of fresh lemon juice. Citric acid is used with sodium bicarbonate in a wide range of effervescent formulae. Citric acid is also often used in cleaning products and sodas or fizzy drinks. Citric acid is an excellent chelating agent, binding metals. It is used to remove limescale from boilers and evaporators. Citric acid can be used in shampoo to wash out wax and coloring from the hair. It can be used to soften water, which makes it useful in soaps and laundry detergents. Citric acid is widely used as a pH adjusting agent in creams and gels of all kinds. Citric acid is an alpha hydroxy acid and used as an active ingredient in chemical peels. Citric acid is commonly used as a buffer to increase the solubility of brown heroin. Citric acid is used as one of the active ingredients in the production of antiviral tissues. Citric acid can be used in food coloring to balance the pH level of a normally basic dye. It is used as an odourless alternative to white vinegar for home dyeing with acid dyes. Citric acid can be used as a successful alternative to nitric acid in passivation of stainless steel. Citric acid can be used as a lower-odor stop bath as part of the process for developing photographic film. As it occurs in metabolism of almost all living beings, its interactions in an aqueous solution is of great value to the biological scientists. In the pharmaceutical industry, citric acid is used as a stabilizer in various formulations, as a drug component and as an anticoagulant in blood for transfusions and also used as an acidifier in many pharmaceuticals. Citric acid can be used in food colouring to balance the pH level of the normally basic dye. Citric acid's ability to chelate metals makes it useful in soaps and laundry detergents, as well as water softening.

Folic Acid (FA):



Folic acid (also known as folate, vitamin M, vitamin B9, vitamin B_c (or folacin), pteroyl-L-glutamic acid, pteroyl-L-glutamate, and pteroylmonoglutamic acid) are the water-soluble vitamin B9. Folic acid (FA) is composed of three components: an aromatic pteridine ring system (Pteridine), a *p*-amino benzoic acid (PABA) portion and the amino acid glutamic acid (Glu). It is an essential vitamin that is yellow-orange in color, is reported to be present in photosensitive organs, various mammalian metabolic pathways, and possibly involved in photosynthesis. The electrochemical behavior of folic acid has been well studied. Folic acid is itself not biologically active, but its biological importance is due to tetrahydrofolate and other derivatives after its conversion to dihydrofolic acid in the liver.

Folic Acid



Appearance	*:Yellow-orange Crytalline*
Molecular Formula	*:$C_{19}H_{19}N_7O_6$*
Molecular Weight	*:441.40 g·mol^{-1}*
Melting Point	*:523.15 K*
Relative Density	*:1.66 g·cm^{-3}*
Solubility	*:Water soluble*

Resource of the folic acid: The best natural sources of folic acid are: Leafy vegetables such as spinach, asparagus, turnip greens, lettuce, peas, whole grains, nuts; Legumes such as dried or fresh beans, peas and lentils egg yolk; liver, kidneys, yeast, sunflower seeds, certain fruits (orange juice, canned pineapple juice, cantaloupe, honeydew melon, grapefruit juice, banana, raspberry, grapefruit and strawberry). Folate is also necessary for the production and maintenance of new cells, for DNA synthesis and RNA synthesis, and for preventing changes to DNA, and, thus, for preventing cancer.

Source: Sigma-Aldrich, Germany.

Purification: The mass purity as supplied is 0.99. The salts were dried from moisture at 353K for 24 h, and then they were cooled and store in a desiccator prior to use.

Application: Vitamin B9 (folic acid and folate) is essential for numerous bodily functions. Humans cannot synthesize folate de novo; therefore, folate has to be supplied through the diet to meet their daily requirements. The human body needs folate to synthesize DNA, repair DNA, and methylate DNA as well as to act as a cofactor in certain biological reactions. It is especially important in aiding rapid cell division and growth, such as in infancy and pregnancy, and reproduction of cells, particularly red blood cells. Children and adults both require folic acid to produce healthy red blood cells and prevent anemia.

III. 2 EXPERIMENTAL METHODS

III.2.1 PREPARATION OF SOLUTIONS

A sock solution for each salt was prepared by mass (digital electronic analytical balance, Mettler Toledo, AG 285, Switzerland), and the working solutions were obtained by mass dilution of the stock solution. The uncertainty of concentration (molarity or molality) of different working solutions was evaluated to be ±0.0002.

III.2.2. PREPARATION OF MULTICOMPONENT LIQUID MIXTURES

The binary and multicomponent liquid mixtures can be prepared by any one of the methods discussed below:

(a) Mole fraction

(b) Weight fraction

(c) Volume fraction

(a) Mole fraction: The mole fraction (x_i) of the multicomponent liquid mixtures can be prepared using the following relation:

$$x_i = \frac{(w_i / M_i)}{\sum_{i=1}^{n} (w_i / M_i)}$$

where w_i, and M_i are weight and molecular weight of i^{th} component, respectively. The values of *i* depends on the number of components involved in the formation of a mixture.

(b) Weight fraction: The mole fraction (w_i) of the multicomponent liquid mixtures can be prepared using the following relation:

$$w_i = \frac{(x_i / M_i)}{\sum_{i=1}^{n} (x_i M_i)}$$

(c) Volume fraction: The volume fraction (ϕ_i) of the multicomponent liquid mixtures can be prepared by following employing three methods:

i. ***Using volume:*** The volume fraction (ϕ_i) of the multicomponent liquid mixtures can be prepared by following relation

$$\phi_i = \frac{V_i}{\sum_{i=1}^{n} V_i}$$

where V_i, is the volume of pure liquid *i*.

ii. ***Using molar volume:*** The volume fraction (ϕ_i^l) of the multicomponent liquid mixtures can be prepared by following relation

$$\phi_i^l = \frac{x_i V_{mi}}{\sum_{i=1}^{n} (x_i V_{mi})}$$

where V_{mi} is the molar volume of pure liquid *i*.

iii. ***Using excess volume:*** The volume fraction (ϕ_i^{ex}) of the multicomponent liquid mixtures can be prepared by following relation

$$\phi_i^{ex} = \frac{x_i V_i}{\sum_{i=1}^{n} (x_i V_i) + V^E}$$

where V^E is the excess volume of the liquid mixture.

III.2.3. PREPARATION OF SOLVENT MIXTURES (MIXED SOLVENTS)

The research work has been carried out with binary or ternary solvent systems with acrylonitrile, tetrahydrofuran, methanol, ethylene glycol, 1,3-dioxolane etc. as primary solvents with some polar, weakly polar and non-polar solvents as well as with some electrolytes (ionic liquids & other electroluytes) and non-electrolytes (amino acids and other solutes).

For the preparation of solvent mixture, pure components were taken separately in glass stoppered bottles and thermostated at the desired temperature for sufficient time. When the thermal equilibrium was ensured, the required volumes of each component were transferred in a different bottle which was already cleaned and dried thoroughly. Conversion of required mass of the respective solvents to volume was accomplished by using experimental densities of the solvents at experimental temperature. It was then stoppered and the mixed contents were shaken well before use. While preparing different solvent mixtures care was taken to ensure that the same procedure was adopted throughout the entire work. The physical properties of different pure and mixed solvents have been presented in the respective chapters.

The following different binary and ternary solutions have been prepared and used for my research studies.

Binary Solutions:

Formic acid + Glycine

Formic acid + L-Alanine

Formic acid + L-Valine

Formic acid + L-Leucine

Tetrabutylphosphonium methanesulfonate + Acetonitrile

Tetrabutylphosphonium methanesulfonate + Methanol

Tetrabutylphosphonium methanesulfonate + Nitromethane

Tetrabutylphosphonium methanesulfonate + Water

Tetrabutylphosphonium methanesulfonate + Formamide

1-ethyl-3-methylimidazolium nitrate + Acetonitrile

1-ethyl-3-methylimidazolium nitrate + methanol

1-ethyl-3-methylimidazolium nitrate + nitromethane

1-ethyl-3-methylimidazolium nitrate + methylamine

1-ethyl-3-methylimidazolium methanesulfonate + Acetonitrile

1-ethyl-3-methylimidazolium methanesulfonate + methanol

1-ethyl-3-methylimidazolium methanesulfonate + nitromethane

1-ethyl-3-methylimidazolium methanesulfonate + methylamine

1-ethyl-3-methylimidazolium tosylate + Acetonitrile

1-ethyl-3-methylimidazolium tosylate + methanol

1-ethyl-3-methylimidazolium tosylate + nitromethane

1-ethyl-3-methylimidazolium tosylate + methylamine

Ternary Solutions:

Tetrabutylphosphoniumtetrafluoroborate + Acetonitrile(w_1=1.00) + Tetrahydrofuran(w_1=0.00)

Tetrabutylphosphoniumtetrafluoroborate + Acetonitrile(w_1=0.75) + Tetrahydrofuran(w_1=0.25)

Tetrabutylphosphoniumtetrafluoroborate + Acetonitrile(w_1=0.50) + Tetrahydrofuran (w_1=0.50)

Tetrabutylphosphoniumtetrafluoroborate + Acetonitrile(w_1=0.25) + Tetrahydrofuran (w_1=0.75)

Tetrabutylphosphoniumtetrafluoroborate + Acetonitrile(w_1=0.00) + Tetrahydrofuran (w_1=1.00)

Tetrabutylphosphoniumtetrafluoroborate + Acetonitrile(w_1=1.00) + 1,3-Dioxolane (w_1=0.00)

Tetrabutylphosphoniumtetrafluoroborate + Acetonitrile(w_1=0.75) + 1,3-Dioxolane (w_1=0.25)

Tetrabutylphosphoniumtetrafluoroborate + Acetonitrile(w_1=0.50) + 1,3-Dioxolane (w_1=0.50)

Tetrabutylphosphoniumtetrafluoroborate + Acetonitrile(w_1=0.25) + 1,3-Dioxolane (w_1=0.75)

Tetrabutylphosphoniumtetrafluoroborate + Acetonitrile(w_1=0.00) + 1,3-Dioxolane (w_1=1.00)

Tetrabutylphosphoniumtetrafluoroborate+ Tetrahydrofuran(w_1=1.00)+ 1,3-Dioxolane(w_1=0.00)

Tetrabutylphosphoniumtetrafluoroborate+ Tetrahydrofuran(w_1=0.75)+ 1,3-Dioxolane(w_1=0.25)

Tetrabutylphosphoniumtetrafluoroborate+ Tetrahydrofuran(w_1=0.50)+ 1,3-Dioxolane(w_1=0.50)

Tetrabutylphosphoniumtetrafluoroborate+ Tetrahydrofuran(w_1=0.25)+ 1,3-Dioxolane(w_1=0.75)

Tetrabutylphosphoniumtetrafluoroborate+ Tetrahydrofuran(w_1=0.00)+ 1,3-Dioxolane(w_1=1.00)

Cetrimonium bromide + 0.001 (M) aqueous mixture of Citric acid

Cetrimonium bromide + 0.003 (M) aqueous mixture of Citric acid

Cetrimonium bromide + 0.005 (M) aqueous mixture of Citric acid

Lithium chloride + Acetonitrile(w_1=1.00) + 1,3-Dioxolane (w_1=0.00)

Lithium chloride + Acetonitrile(w_1=0.75) + 1,3-Dioxolane (w_1=0.25)

Lithium chloride + Acetonitrile(w_1=0.50) + 1,3-Dioxolane (w_1=0.50)

Lithium chloride + Acetonitrile(w_1=0.25) + 1,3-Dioxolane (w_1=0.75)

Lithium chloride + Acetonitrile(w_1=0.00) + 1,3-Dioxolane (w_1=1.00)

Lithium bromide + Acetonitrile(w_1=1.00) + 1,3-Dioxolane (w_1=0.00)

Lithium bromide + Acetonitrile(w_1=0.75) + 1,3-Dioxolane (w_1=0.25)

Lithium bromide + Acetonitrile(w_1=0.50) + 1,3-Dioxolane (w_1=0.50)

Lithium bromide + Acetonitrile(w_1=0.25) + 1,3-Dioxolane (w_1=0.75)

Lithium bromide + Acetonitrile(w_1=0.00) + 1,3-Dioxolane (w_1=1.00)

Lithium iodide + Acetonitrile(w_1=1.00) + 1,3-Dioxolane (w_1=0.00)

Lithium iodide + Acetonitrile(w_1=0.75) + 1,3-Dioxolane (w_1=0.25)

Lithium iodide + Acetonitrile(w_1=0.50) + 1,3-Dioxolane (w_1=0.50)

Lithium iodide + Acetonitrile(w_1=0.25) + 1,3-Dioxolane (w_1=0.75)

Lithium iodide + Acetonitrile(w_1=0.00) + 1,3-Dioxolane (w_1=1.00)

w_1=0.005 mass fraction of aqueous β-cyclodextrin mixtures + Glycine

w_1=0.005 mass fraction of aqueous β-cyclodextrin mixtures + L-Alanine

w_1=0.005 mass fraction of aqueous β-cyclodextrin mixtures + L-Valine

w_1=0.075 mass fraction of aqueous β-cyclodextrin mixtures + Glycine

w_1=0.075 mass fraction of aqueous β-cyclodextrin mixtures + L-Alanine

w_1=0.075 mass fraction of aqueous β-cyclodextrin mixtures + L-Valine

w_1=0.01 mass fraction of aqueous β-cyclodextrin mixtures + Glycine

w_1=0.01mass fraction of aqueous β-cyclodextrin mixtures + L-Alanine

w_1=0.01 mass fraction of aqueous β-cyclodextrin mixtures + L-Valine

w_1=0.0001 mass fraction of aqueous folic acid mixtures + Glycine

w_1=0.0001 mass fraction of aqueous folic acid mixtures + L-Alanine

w_1=0.0001 mass fraction of aqueous folic acid mixtures + L-Valine

w_1=0.0003 mass fraction of aqueous folic acid mixtures + Glycine

w_1=0.0003 mass fraction of aqueous folic acid mixtures + L-Alanine

w_1=0.0003 mass fraction of aqueous folic acid mixtures + L-Valine

w_1=0.0005 mass fraction of aqueous folic acid mixtures + Glycine

w_1=0.0005 mass fraction of aqueous folic acid mixtures + L-Alanine

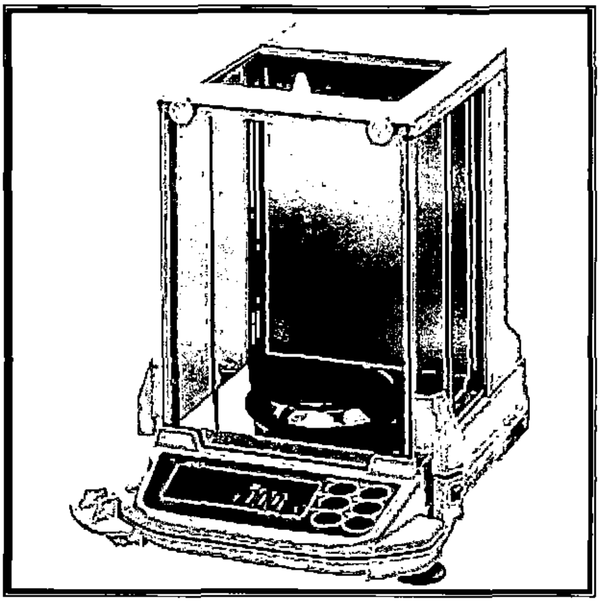
w_1=0.0005 mass fraction of aqueous folic acid mixtures + L-Valine

III.2.4 MEASUREMENTS OF EXPERIMENTAL PROPERTIES

III.2.4.1 MASS MEASUREMENT

Mass measurements were made on digital electronic analytical balance (Mettler Toledo, AG 285, Switzerland).

It can measure mass to a very high precision and accuracy. The weighing pan of a high precision (0.0001g) is inside a transparent enclosure with doors so that dust does not collect and so any air currents in the room do not affect the balance's operation.



Mettler Toledo, AG 285

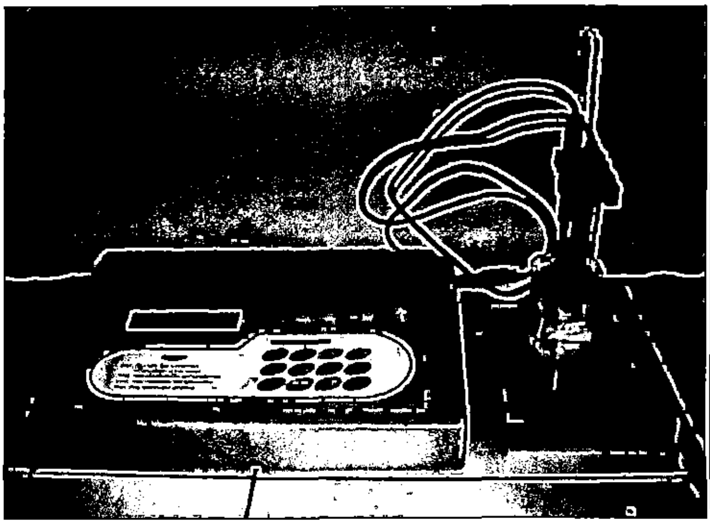
Instrument Specification:

Readability	*: 0.1 mg/ 0.01mg*
Maximum capacity	*: 210 g/81g/41g*
Taring range	*: 0. . . . 210 g*
Repeatability	*: 0.1 mg/ 0.05 mg*
Linearity	*: ±0.2 mg/±0.1 mg*
Stabilization time	*: 3 s/ 15 s*
Adjustment with external weights	*:200 g*
Sensitivity	*: ±0.003%*
Display	*: LCD*
Interface	*: LocalCAN universal interface*
Weighing	*: Φ 85 mm, stainless steel*
Effective height above pan	*: 240 mm*
Dimensions(w/d/h)	*: 205×330×310 mm*
Net wt/with packaging	*: 4.9 kg/7.25 kg*

III.2.4.2 CONDUCTIVITY MEASUREMENT

Conductivity measurement was done using Systronics Conductivity TDS meter-308. It can provide both automatic and manual temperature compensation.

Systronics Conductivity-TDS meter 308 is a microprocessor based instrument used for measuring specific conductivity of solutions. It can provide both automatic and manual temperature compensation. The instrument shows the conductivity of the solution under test at the existing temperature or with temperature compensation. Provision for storing the cell constant and the calibrating solution type, is provided with the help of battery back-up. This data can be further used for measuring the conductivity of an unknown solution, without recalibrating the instrument even after switching it off.



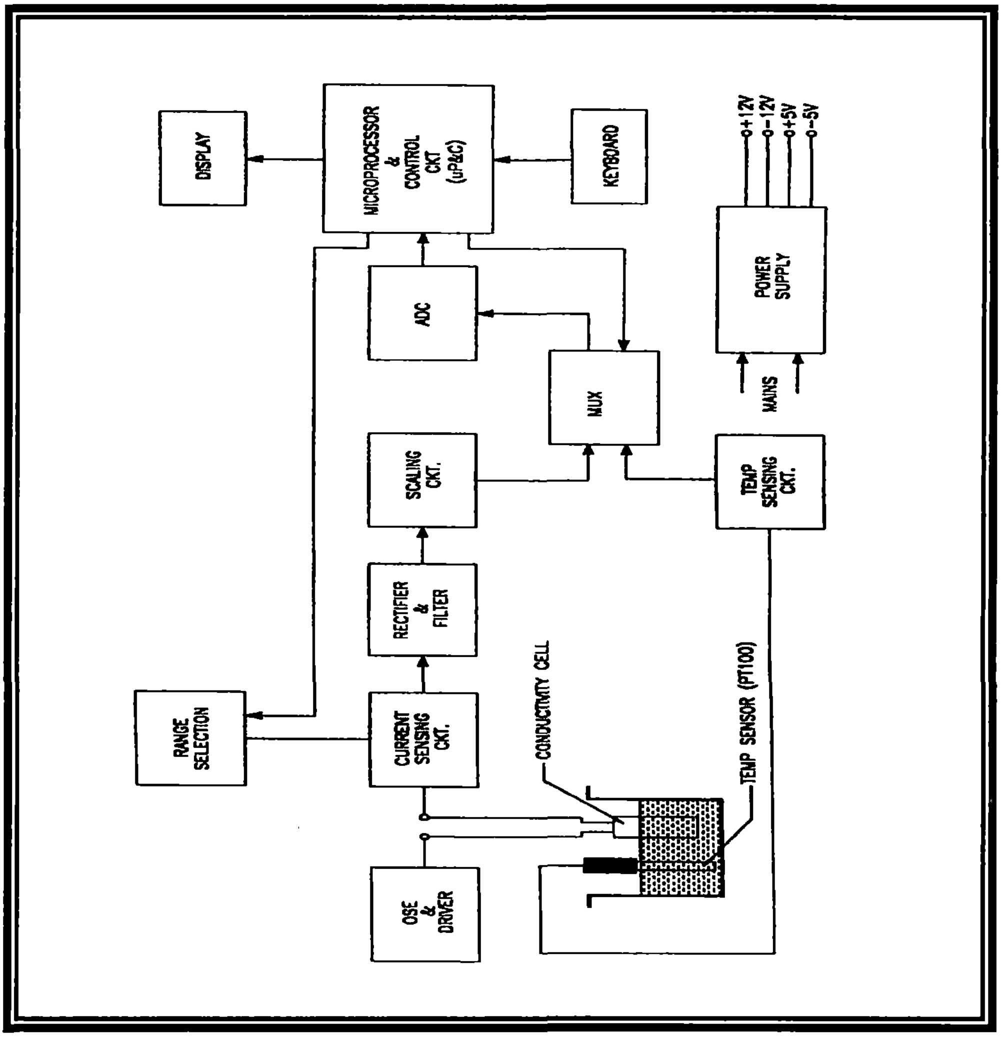
Systronic-308 Conductivity Bridge

The conductance measurements were carried out on this conductivity bridge of accuracy ±0.01%, using a dip-type immersion conductivity cell, CD-10 having a cell constant of approximately (0.1±0.001) cm^{-1}. Measurements were made in a thermostate water bath maintained at T = (298.15 ± 0.01) K. The cell was calibrated by the method proposed by Lind et al.[IV.14] and cell constant was measured based on 0.01 M aqueous KCl solution.[IV.15] During the conductance measurements, cell constant was maintained within the range 1.10–1.12 cm^{-1}. The conductance data were reported at a frequency of 1 kHz and the accuracy was ±0.3%. The conductivity cell was sealed to the side of a 500 cm^3 conical flask closed by a ground glass fitted with a side arm through which dry and pure nitrogen gas was passed to prevent admission of air into the cell when solvent or solution was added. The measurements were made in a thermostatic water bath maintained at the required temperature with an accuracy of ± 0.01 K by means of mercury in glass thermoregulator.[IV.16]

Instrument Specifications:

Frequency	*:100 Hz or 1 KHz Automatic*
Conductivity	
Range	*: 0.1 μS to 100 mS. (6 decadic range)*
Accuracy	*: ±1% of F.S. ±1 digit*
Resolution	*: 0.001 μs*
TDS	
Range	*:0.1 ppm to 100 ppt. (6 decadic range)*
Accuracy	*: ±1% of F.S. ±1 digit*
Temperature	
Range	*: 0°C to 100°C (Auto/Manual)*
Accuracy	*: ± 0.2 °C ±1 digit*
Resolution	*: 0.1 °C*
Cell Constant	*: Acceptable from 0.1 to 5.0*
Auto Temp. Compensation	*: 0°C to 100°C with PT 100 sensor*
Manual Temp. Compensation	*: 0°C to 60°C user selectable*
Conductivity temp. Co-efficient	*: 0.0% to 9.9% user selectable*
Display	*: 7 digits, 7 segment LEDs* *(3 digits for TEMP/TEMPCO* *4 digits for Conductivity/TDS)* *With automatic decimal point selection*
TDS-factor	*: 0.00 to 9.99 user selectable*
Printer Port	*: Epson compatible 80 Column Dot Matrix*
Power	*: 230V AC, ±10%, 50 Hz*
Dimensions	*: 250(W)× 205(D)× 75(H)*
Weight	*: 1.25 Kg (Approx.)*
Accessories	*: i) Conductivity cell, cell constant 0.1* *ii) Conductivity cell, cell constant 1.0* *iii) Temp. Probe (PT-100 sensor)* *iv) Stand & Clamp*

Solutions were prepared by weight precise to ± 0.02 %. The weights were taken on a Mettler electronic analytical balance (AG 285, Switzerland). The molarity being converted to molality as required. Several independent solutions were prepared and runs were performed to ensure the reproducibility of the results. Due correction was made for the specific conductance of the solvents at desired temperatures. The following figure shows the Block diagram of the Systronics Conductivity-TDS meter 308.

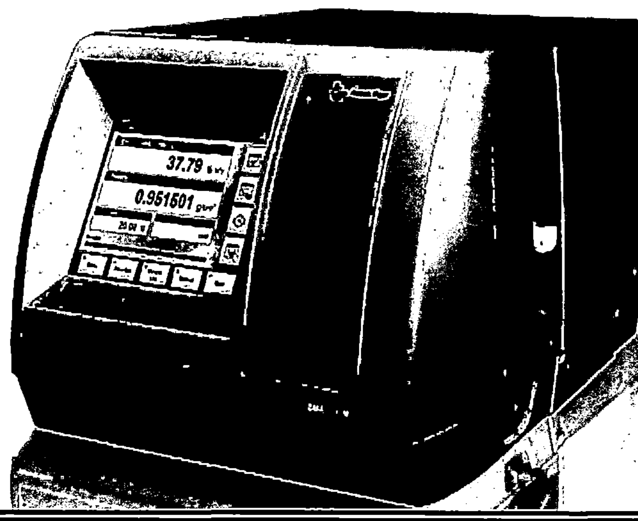


Block Diagram of the Instrument

III.2.4.3 DENSITY MEASUREMENT

The density measurement was performed with the help of Anton Paar DMA 4500M digital density-meter with a precision of ±0.0005 g·cm^{-3}.

In the digital density meter, the mechanic oscillation of the U-tube is e.g. electromagnetically transformed into an alternating voltage of the same frequency. The period τ can be measured with high resolution and stands in simple relation to the density ρ of the sample in the oscillator



Anton Paar DMA 4500M digital density-meter

In the digital density meter, the mechanic oscillation of the U-tube is e.g. electromagnetically transformed into an alternating voltage of the same frequency. The period τ can be measured with high resolution and stands in simple relation to the density ρ of the sample in the oscillator:

$$\rho = A \cdot \tau^2 - B \qquad \text{(III.1)}$$

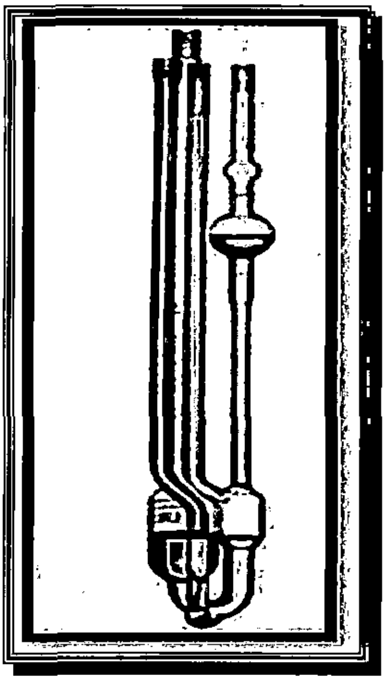
A and B are the respective instrument constants of each oscillator. Their values are determined by calibrating with two substances of the precisely known densities ρ_1 and ρ_2. Modern instruments calculate and store the constants A and B after the two calibration measurements, which are mostly performed with air and water. They employ suitable measures to compensate various influences on the measuring result, e.g. the influence of the sample's viscosity and the non-linearity caused by the measuring instrument's finite mass. The instrument was calibrated by triply-distilled water and dry air.

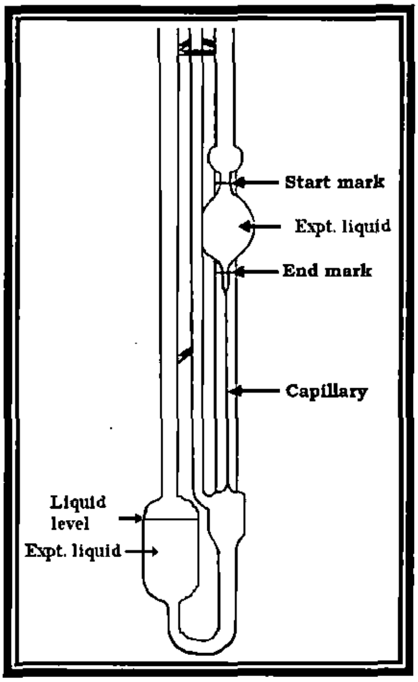
Instrument Specification:

Density	*: 0 to 1.5 g.cm^{-3}*
Temperature	*: 15°C to 25°C*
Pressure	*: 0 to 6 bar*
Repeatability Standard Deviation	
Density	*: 0.00001 g.cm^{-3}*
Temperature	*: 0.01 °C*
Additional information	
Minimum sample volume	*: approx. 2 ml*
Dimensions (L×W×H)	*: 400×225×231 mm*
Weight	*: approx. 15 kg*
Automatic bubble detection	*: yes*
Interfaces	*: 2×CAN*
Power	*: Supplied by the master instrument*

III.2.4.4 VISCOSITY MEASUREMENT

The kinematic viscosities were measured by means of a suspended-level Ubbelohde viscometer. The time of flow was measured with a stop watch. The viscometer was always kept in a vertical position in the water- bath. The viscometer needed no correction for kinetic energy.





Suspended-level Ubbelohde Viscometer

By Ubbelohde-type viscometer: Initially Solution viscosity (η) was measured by means of suspended Ubbelohde type viscometer, calibrated with triply distilled water, purified methanol and dry air with dryer. A thoroughly cleaned and perfectly dried viscometer filled with experimental solution was placed vertically in a glass-walled thermostat (Bose Panda Instruments Pvt. Ltd.) maintained to ±0.01K of the desired temperature. After attaining thermal equilibrium, efflux times of flow were recorded with a stop watch. The flow times were accurate to ±0.1s. At least three repetitions of each data reproducible to ± 0.1s were taken to average the flow times. Adequate precautions were taken to minimize evaporation loses during the actual measurements.

Instrument specification:	
Universal size number	*: 1*
Product Type	*: Glass Capillary*
Accuracy	*: ±0.2%*
Approximate constant	*: 0.01 cSt/sec*
Sample volume needed	*: 11 mL*
Range	*: 2 to 10 cSt*
Model	*: 9721-R59*
Brand	*: Cannon*

The absolute viscosity (γ) and the kinematic viscosity (η) are given by the following equations.

$$\gamma = \left(K \cdot t - \frac{L}{t}\right) \tag{III.2}$$

$$\eta = \gamma . \rho \tag{III.3}$$

where, t is the time of flow, ρ is the density of experimental liquid K and L are the characteristic constants of the particular viscometer. The precision of the viscosity measurement was ± 0.003 %. In all cases, the experiments were performed in at least three replicates and the results were taken as the average of the triplicates.

Relative viscosities (η_r) were obtained using the equation:

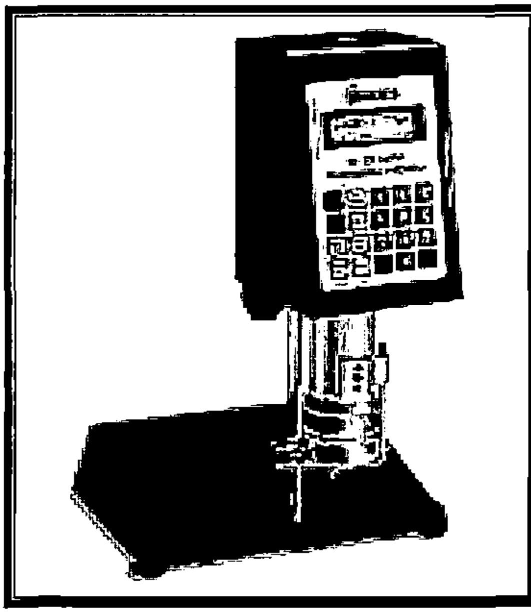
$$\eta_r = \frac{\eta}{\eta_0} = \frac{\rho t}{\rho_0 t_0} \tag{III.4}$$

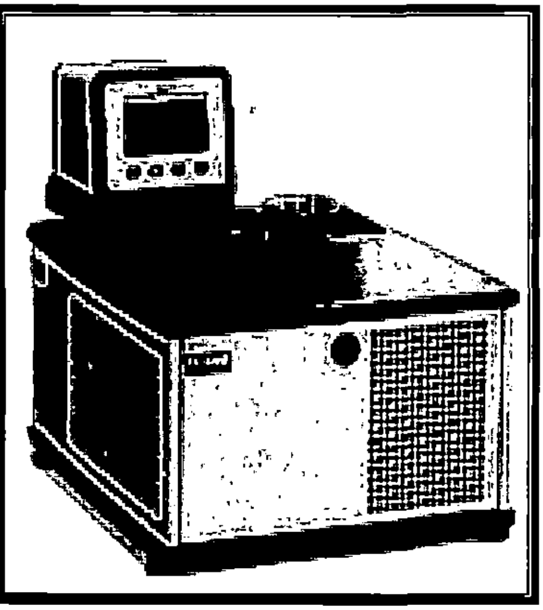
where η, η_0, ρ, ρ_0 and t, t_0 are the absolute viscosities, densities and flow times for the experimental solution and solvent respectively.

By Brookfield DV-III Ultra Programmable Rheometer: The viscosities (η) were measured using a Brookfield DV-III Ultra Programmable Rheometer with fitted spindle size-42. The viscosities were obtained using the following equation

$$\eta = (100 / RPM) \times TK \times \text{torque} \times SMC$$

where *RPM*, *TK* (0.09373) and *SMC* (0.327) are the speed, viscometer torque constant and spindle multiplier constant, respectively. The instrument was calibrated against the standard viscosity samples supplied with the instrument, water and aqueous $CaCl_2$ solutions.[IV.17] The temperature was maintained to within ± 0.01°C using Brookfield Digital TC-500 thermostat bath. The viscosities were measured with an accuracy of ± 1 %. Each measurement reported herein is an average of triplicate reading with a precision of 0.3 %.





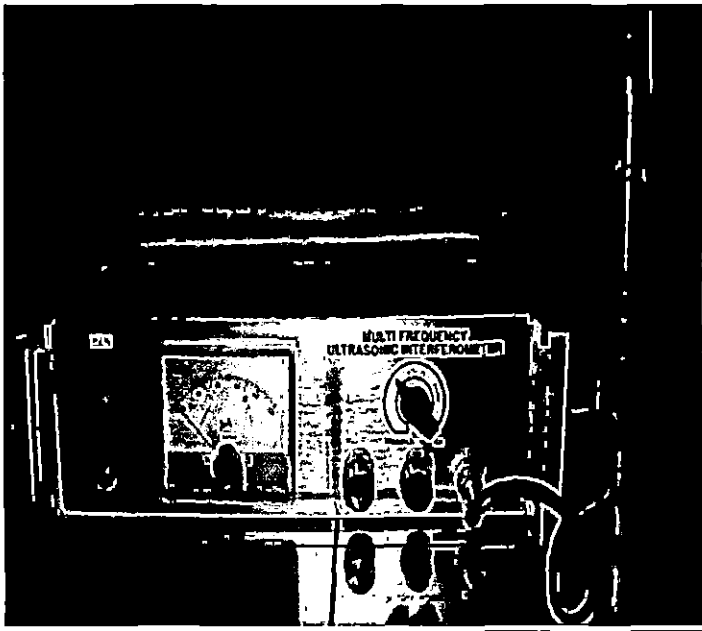
Instrument Specifications:

Speed Range	*: 0-250 RPM, 0.1 RPM increments*
Viscosity Accuracy	*: ±1.0% of full scale range for a specific spindle running at a specific speed.*
Temperature sensing range	*: -100°C to 300°C (-148°F to 572°F)*
Temperature accuracy	*: ±1.0°C from -100°C to 150°C ±2.0°C from +150°C to 300°C*
Analog Torque Output	*: 0 - 1 Volt DC (0 - 100% torque)*
Analog Temperature Output	*: 0 - 4 Volts DC (10mv / °C)*

III.2.4.5 ULTRASONIC SPEED MEASUREMENT

The ultrasonic speed was measured with an accuracy of 0.2% using single-crystal variable-path ultrasonic interferometer (Model M-81 Mittal Enterprises, New Delhi) operating at 4MHz which was calibrated with water, methanol and benzene at required temperature.

Ultrasonic speeds were measured, with an accuracy of 0.2 %, using a single-crystal variable-path ultrasonic interferometer (Model M-81, Mittal Enterprise, New Delhi) operating at 4 MHz, which was calibrated with water, methanol and benzene at required temperature. The temperature stability was maintained within ± 0.01 K by circulating thermostatic water around the cell by a circulating pump.



Multifrequency Ultrasonic Interferometer

Insrument Specification:

High Frequency Generator	*: Single and Multi-frequency*
Model No.	*: M-81 Mittal Enterprises*
Measuring Cell	*: Four cell (1, 2,3, & 4 MHz)*
Max. displacement of the reflector	*: 20 mm*
Required Quantity of liquid	*: 10 c.c.*
Least Count of micrometer	*: 0.01mm/0.001mm*
Accuracy	*: 0.2%*
Shielded Cable Impedance	*: 50 Ω*

Working Principle of Ultrasonic Interferometer

The principle used in the measurement of the ultrasonic speed (u) is based on the accurate determination of the wavelength (λ) in the medium. Ultrasonic waves of known frequency (f) are produced by a quartz crystal fixed at the bottom of the cell. These waves are reflected by a movable metallic plate kept parallel to the quartz crystal. If the separation between these two plates is exactly a whole multiple of the sound wavelength, standing waves are formed in the medium. This acoustic resonance gives rise to an electrical reaction on the generator driving the quartz crystal and the anode current of the generator becomes a maximum.

If the distance is now increased or decreased and the variation is exactly one half of wave length ($\lambda/2$) or integral multiples of it, anode current becomes maximum. From the knowledge of the wave length (λ), the speed (u) can be obtained by the relation.

$$\text{Ultrasonic speed } (u) = \text{Wave Length } (\lambda) \times \text{Frequency } (f) \qquad \text{(III.5)}$$

Experimental set-up - ultrasonic interferometer consists of the following parts,

a. One high frequency generator.
b. Measuring cell, 1, 2, 3 and 4 MHz.
c. Shielded cable

The measuring cell is connected to the output terminal of the high frequency generator through a shielded cable. The cell is filled with the experimental liquid before switching on the generator. The ultrasonic waves move normal from the quartz crystal till they are reflected back from the movable plate and the standing waves are formed in the liquid in between the reflector plate and the quartz crystal. The micrometer is slowly moved till the anode current on the meter on the high frequency generator shows a maximum. A number of maxima readings of anode current are passed and their number (n) is counted. The total distance (d) thus moved by the micrometer gives the value of the wavelength (λ) with the following relation.

$$d = n \times \lambda/2 \qquad \text{(III.6)}$$

Further, the velocity is determined from which the isentropic compressibility (β_S) is calculated by the following formula:

$$\beta_S = 1 / (u^2 . \rho) \qquad \text{(III.7)}$$

where ρ is the density of the experimental liquid.

The following Figure shows the Multifrequency Ultrasonic Interferometer i.e.

(a) Cross-section of the measuring cell,

(b) Position of reflector vs. crystal current (Note: The extra peaks in between minima and maxima occurs due to a number of reasons, but these do not effect the value of $\lambda/2$) and)

(c) Electronic circuit diagram of the instrument

The Multifrequency Ultrasonic Interferometer

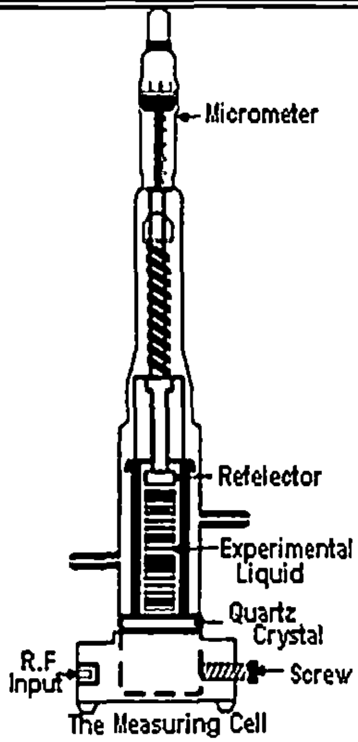


Figure 1(a): Cross-Section of the Measuring Cell

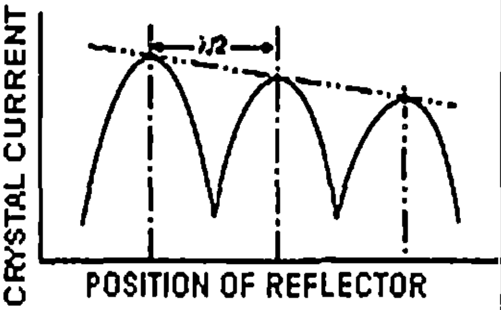


Figure 1(b): Position of Reflector versus Crystal Current

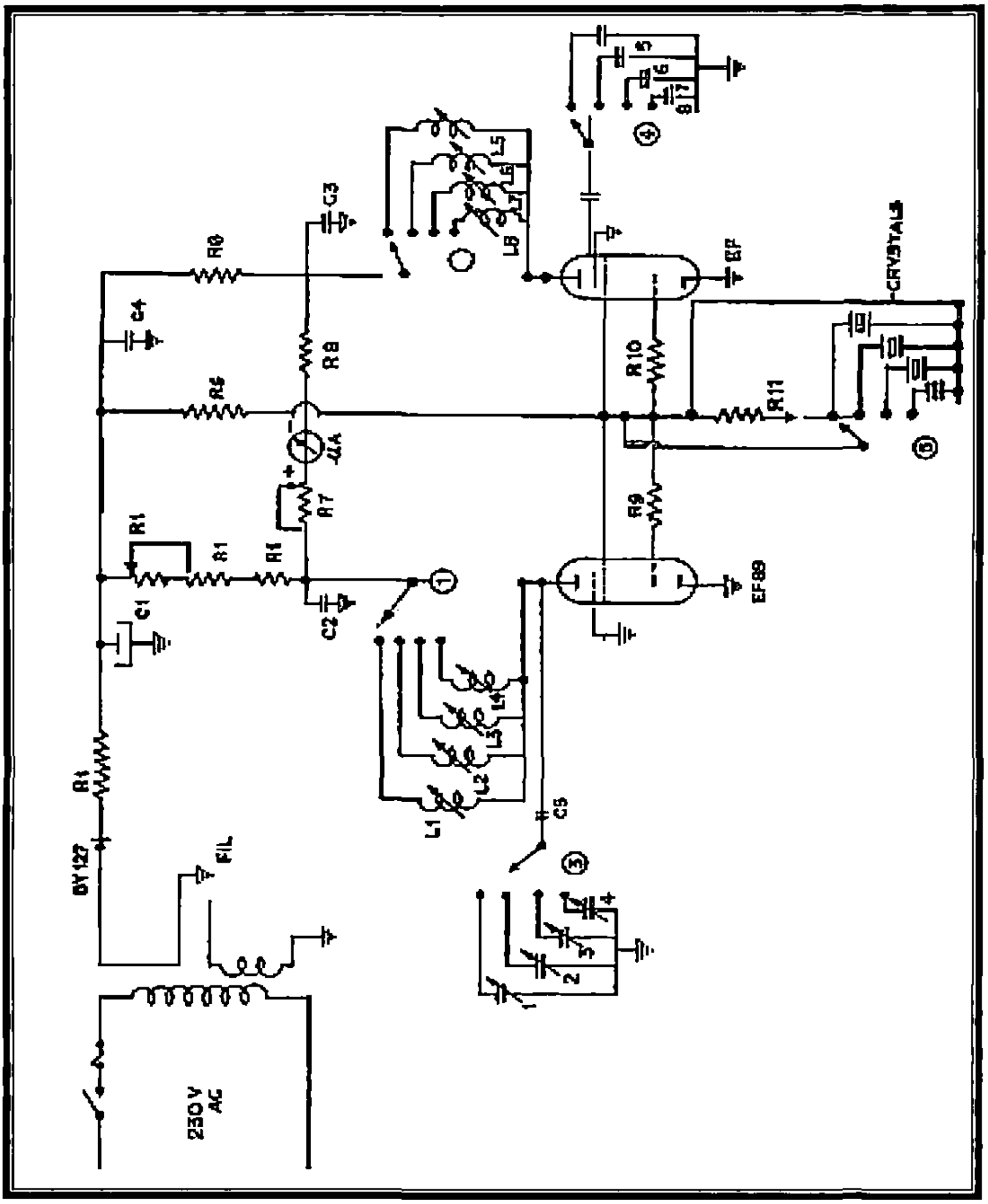
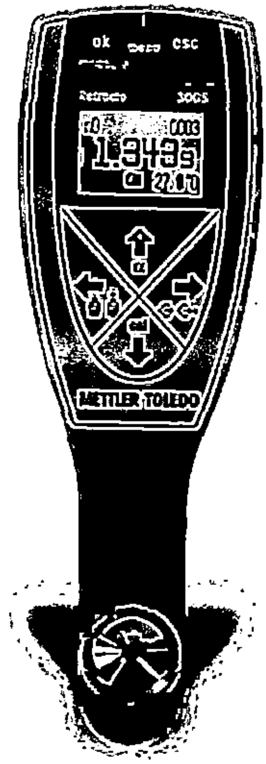


Figure III.1(c): Electronic Circuit Diagram of the Instrument

III.2.4.6 REFRACTIVE INDEX MEASUREMENT

Refractive index was be measure with the help of Digital Refractometer (Mettler Toledo 30GS).



Calibration was performed by measuring the refractive indices of double-distilled water, toluene, cyclohexane, and carbon tetrachloride at defined temperature. The accuracy of the instrument is ±0.0005. 2-3 drops of the sample was put onto the measurement cell and the reading was taken. The refractive index of a sample depends on temperature. During measurement, refractometer determines the temperature and then corrects the refractive index to a temperature as desired by the user.

Specifications-Refracto 30GS- extended RI measuring range

Model	*: Refracto 30GS*
Measurement range	*: 1.32 -1.65*
Resolution	*: 0.0001*
Accuracy	*: +/- 0.0005*
Measurement range BRIX	*: 0 - 85 Brix%*
Resolution	*: 0.1 Brix%*
Accuracy	*: +/- 0.2 Brix%*
Temperature range	*: 10 - 40°*
Resolution of temperature	*: 0.1°*
display	*: °C or °F*
Trade Name	*: 51324660*

The ratio of the speed of light in a vacuum to the speed of light in another substance is defined as the index of refraction (aka refractive index or n_D) for the substance.

$$Refractive\,index\,of\,the\,substance\,(n_D) = \frac{Speed\,of\,light\,in\,a\,vacuum}{Speed\,of\,light\,in\,substance} \quad (III.8)$$

Whenever light changes speed as it crosses a boundary from one medium into another its direction of travel also changes, i.e., it is refracted (Figure 1). (In the special case of the light traveling perpendicular to the boundary there is no change in direction upon entering the new medium.) The relationship between light's speed in the two mediums (v_A and v_B), the angles of incidence (q_A) and refraction (q_B) and the refractive indexes of the two mediums (n_A and n_B) is shown below:

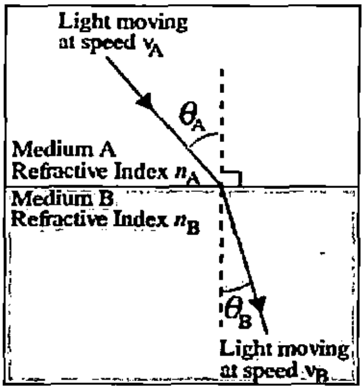


Figure 1. Light crossing from any transparent medium into another in which it has a different speed, is refracted, i.e., bent from its original path (except when the direction of travel is perpendicular to the boundary). In the case shown, the speed of light in medium A is greater than the speed of light in medium B

$$\frac{V_A}{V_B} = \frac{\sin\theta_A}{\sin\theta_B} = \frac{n_B}{n_A} \quad (III.9)$$

Thus, it is not necessary to measure the speed of light in a sample in order to determine its index of refraction. Instead, by measuring the angle of refraction, and knowing the index of refraction of the layer that is in contact with the sample, it is possible to determine the refractive index of the sample quite accurately.[III.18] Nearly all refractometers utilize this principle, but may differ in their optical design.

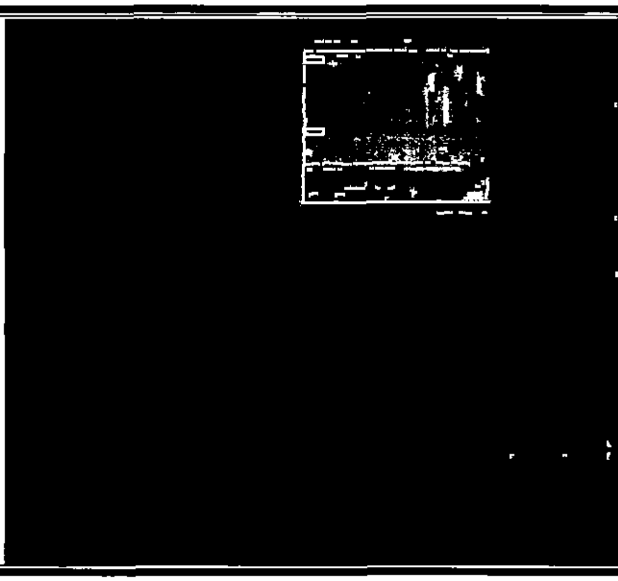
A light source is projected through the illuminating prism, the bottom surface of which is ground (i.e., roughened like a ground-glass joint), so each point on this surface can be thought of as generating light rays traveling in all directions.

Inspection of Figure 2 shows that light traveling from point A to point B will have the largest angle of incidence (q_i) and hence the largest possible angle of refraction (q_r) for that sample. All other rays of light entering the refracting prism will have smaller q_r and hence lie to the left of point C. Thus, a detector placed on the back side of the refracting prism would show a light region to the left and a dark region to the right.

III.2.4.7 FTIR MEASUREMENT

Infrared spectra were recorded in 8300 FTIR spectrometer (Shimadzu, Japan).

It measures the intensity of light passing through the blank and measures the intensity of light passing through the sample. It is useful to calculate the transmittance and the absorbance



The intensity of light (I_0) passing through a blank is measured. The intensity is the number of photons per second. The blank is a solution that is identical to the sample solution except that the blank does not contain the solution that absorbs light. The intensity of light (I) passing through the sample solution is measured. (In practice, instrument measures the power rather than the intensity of the light. The power is the energy per second, which is the product of the intensity (photons per second) and the energy per photon. The experimental data is used to calculate two quantities: the transmittance (T) and the absorbance (A).

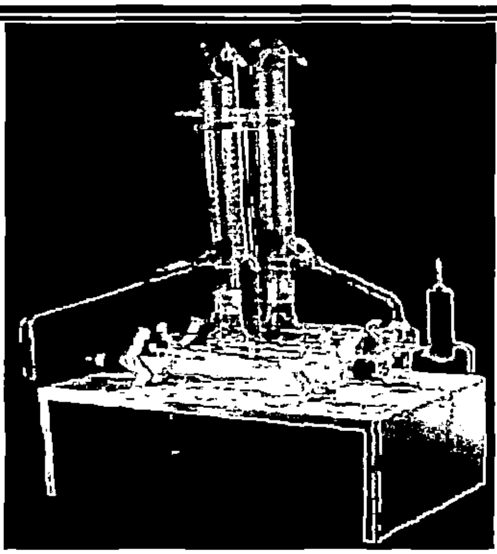
$$T = \frac{I}{I_0}; \qquad A = -log_{10} T \qquad \text{(III.10)}$$

The transmittance is simply the fraction of light in the original beam that passes through the sample and reaches the detector.

Other Instruments Used:

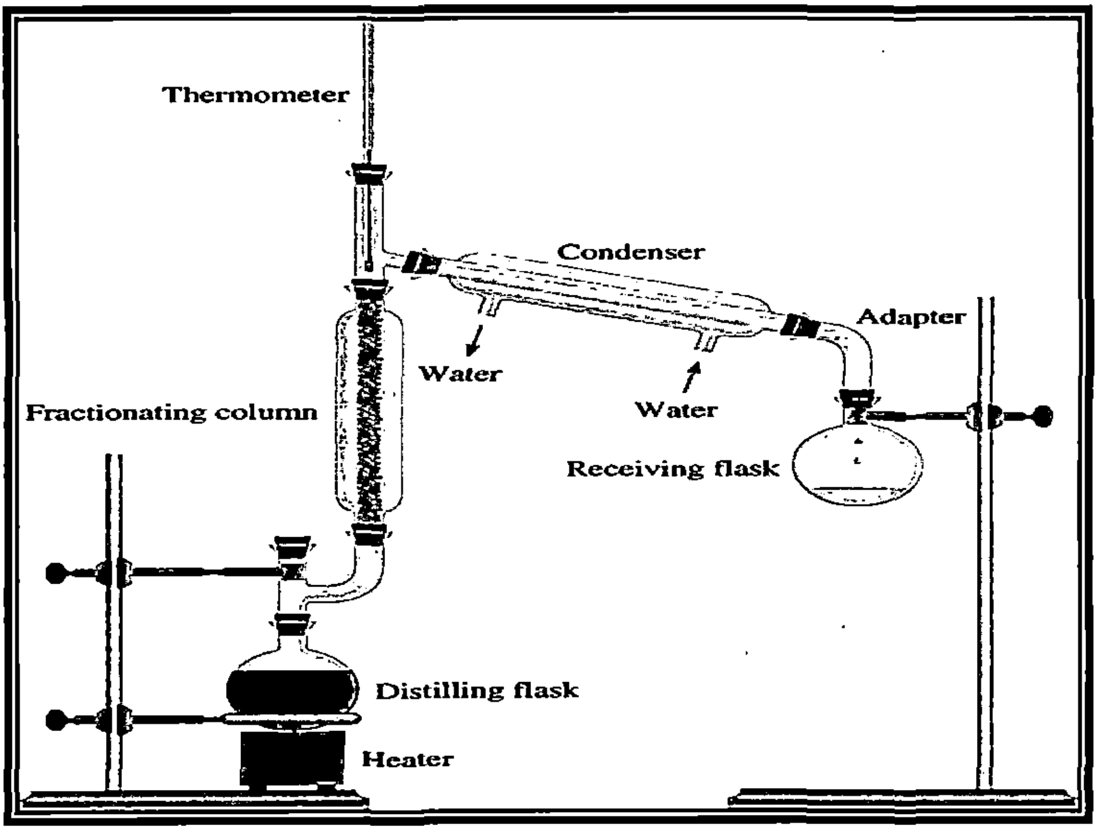
III.2.4.8 WATER DISTILLER

Water distillation units produce highly treated and disinfected water for laboratory usage. The distillation process removes minerals and microbiological contaminants and can reduce levels of chemical contaminants. A water distiller works by boiling water into water vapour, condensing it and then returning it to its liquid state. It is collected in a storage container.



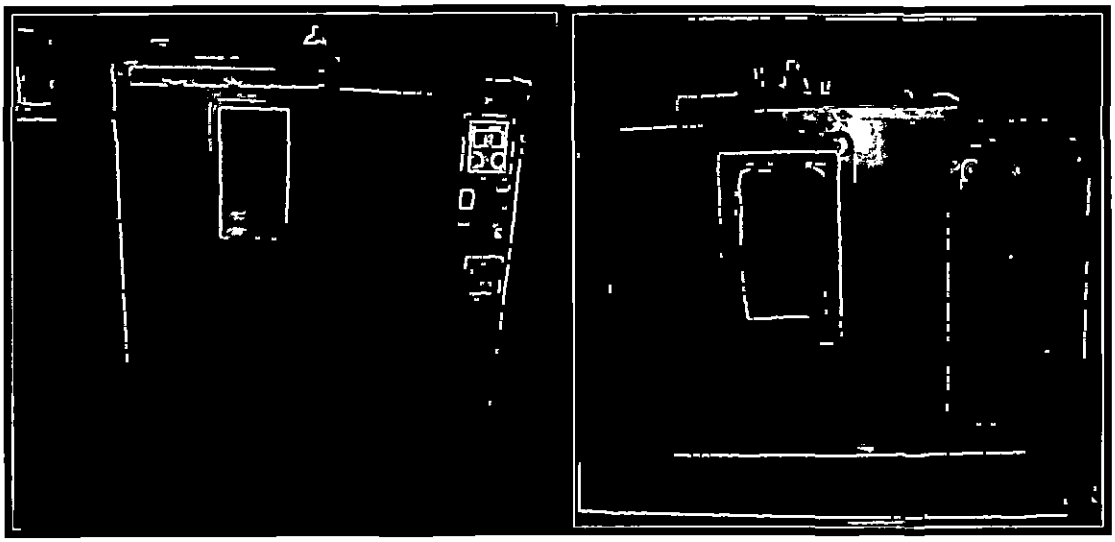
Municipal or well water is manually or automatically fed into the distiller unit's boiling chamber. A heating element in the boiling chamber heats the water until it boils. The steam rises from the boiling chamber. Volatile contaminants (gases) are discharged through a built-in vent. Minerals and salts are retained in the boiling chamber as hard deposits or scale. The steam enters a coiled tube (condenser), which is cooled by cool water. Water droplets form as condensation occurs. The distilled water is collected in a storage tank. If the unit is an automatic model, it is set to operate to fill the storage tank. The distillation apparatus consists of flask with heating elements embedded in glass and fused in spiral type coil internally of the bottom and tapered round glass, joints at the top double walled condenser with B-40/B-50 ground glass joints, suitable to work on 220 volts, 50 cycles AC supply.

Fractional Distillation Apparatus



III.2.4.9 THERMOSTAT WATER BATH (Science India, Kolkata):

The measurements were carried out in thermostatic water bath maintained with an accuracy of ± 0.01 K of the desired temperature.



Laboratory water bath is a system in which a vessel containing the material to be heated is placed into or over the one containing water and to quickly heat it. These laboratory equipment supplies are available in different volumes and construction with both digital and analogue controls and greater temperature uniformity, durability, heat retention and recovery. The chambers of water bath lab products are manufactured using rugged, leak proof and highly resistant stainless steel and other lab supplies.

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