DIPLOMA IN ENGINEERING PROBIDHAN-2016

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FOOD TECHNOLOGY (669)

3rd SEMESTER

FOOD INDUSTRIAL CHEMISTRY

Topics: The Feature Of Alcohols.

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Alcohols.

An organic substance formed when a hydroxyl group is substituted for a hydrogen atom in a hydrocarbon. The type of alcohol used in alcoholic beverages, ethanol, derives from fermenting sugar with yeast.

In chemistry, alcohols are organic compounds that carry at least one hydroxyl functional group (C–OH) bound to their aliphatic substructure. The term alcohol originally referred to the primary alcohol ethanol (ethyl alcohol), which is used as a drug and is the main alcohol present in alcoholic beverages. An important class of alcohols, of which methanol and ethanol are the simplest members, includes all compounds for which the general formula is CnH2n+1OH. Simple monoalcohols that are the subject of this article include primary (RCH2OH), secondary (R2CHOH), and tertiary (R3COH) alcohols.

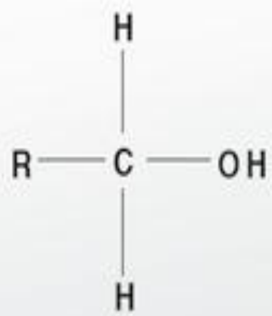
The Classification Of Alcohols.

Alcohol classification is an application of the neutral bonding patterns for organic compounds. Oxygen can only form two bonds. The alcohol functional group requires that one of these bonds form with hydrogen to create the hydroxyl group and the other bond needs to be with carbon to create an alcohol. All of the oxygen atoms of all the alcohols look the same, so a different distinction is needed. To classify alcohols, we look at the carbon atom bonded to the hydroxyl group.

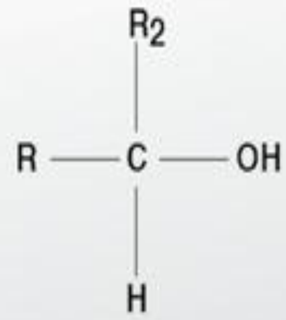
Primary alcohols
In a primary (1°) alcohol, the carbon which carries the -OH group is only attached to one alkyl group. Some examples of primary alcohols i

Notice that it doesn't matter how complicated the attached alkyl group is. In each case there is only one linkage to an alkyl group from the CH2 group holding the -OH group. There is an exception to this. Methanol, CH3OH, is counted as a primary alcohol even though there are no alkyl groups attached to the carbon with the -OH group on it.

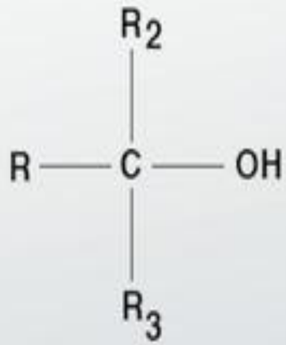
CLASSIFICATION OF ALCOHOLS AND ALKONOLS



Primary Alcohol



Secondary Alcohol



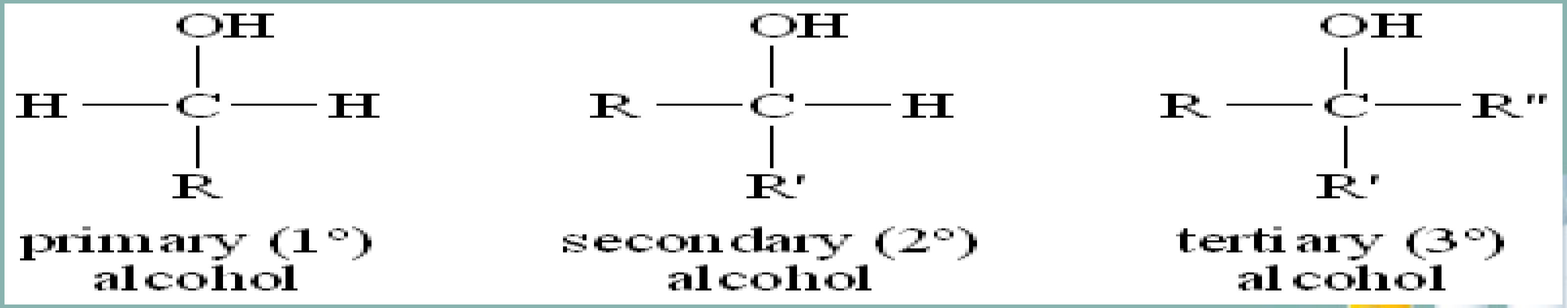
Tertiary Alcohol

Secondary alcohols

In a secondary (2°) alcohol, the carbon with the -OH group attached is joined directly to two alkyl groups, which may be the same or different. Examples:

Tertiary alcohols

In a tertiary (3°) alcohol, the carbon atom holding the -OH group is attached directly to three alkyl groups, which may be any combination of same or different. Examples:



The Structure Formula Of Four Alcohols.

Physical properties of selected alcohols

IUPAC name	common name	formula	mp (°C)
methanol	methyl alcohol	CH_3OH	−97
ethanol	ethyl alcohol	CH_3CH_2OH	−114
1-propanol	n-propyl alcohol	$CH_3CH_2CH_2OH$	−126
2-propanol	isopropyl alcohol	$(CH_3)_2CHOH$	−89
1-butanol	n-butyl alcohol	$CH_3(CH_2)_3OH$	−90
2-butanol	sec-butyl alcohol	$(CH_3)CH(OH)CH_2CH_3$	−114
2-methyl-1-propanol	isobutyl alcohol	$(CH_3)_2CHCH_2OH$	−108
2-methyl-2-propanol	t-butyl alcohol	$(CH_3)_3COH$	25
1-pentanol	n-pentyl alcohol	$CH_3(CH_2)_4OH$	−79
3-methyl-1-butanol	isopentyl alcohol	$(CH_3)_2CHCH_2CH_2OH$	−117
2,2-dimethyl-1-propanol	neopentyl alcohol	$(CH_3)_3CCH_2OH$	52

*Ph represents the phenyl group, C_6H_5—.

Nomenclature of Alcohols

Alcohols with one to four carbon atoms are frequently called by common names, in which the name of the alkyl group is followed by the word alcohol:

According to the International Union of Pure and Applied Chemistry (IUPAC), alcohols are named by changing the ending of the parent alkane name (Chapter 12 "Organic Chemistry: Alkanes and Halogenated Hydrocarbons", Section 12.5 "IUPAC Nomenclature") to -ol. Here are some basic IUPAC rules for naming alcohols:

The longest continuous chain (LCC) of carbon atoms containing the OH group is taken as the parent compound—an alkane with the same number of carbon atoms. The chain is numbered from the end nearest the OH group.

The number that indicates the position of the OH group is prefixed to the name of the parent hydrocarbon, and the -e ending of the parent alkane is replaced by the suffix -ol. (In cyclic alcohols, the carbon atom bearing the OH group is designated C1, but the 1 is not used in the name.) Substituents are named and numbered as in alkanes.

If more than one OH group appears in the same molecule (polyhydroxy alcohols), suffixes such as -diol and -triol are used. In these cases, the -e ending of the parent alkane is retained.

The Properties Of Alcohols.

Physical Properties of Alcohol

1. The Boiling Point of Alcohols

Alcohols generally have higher boiling points in comparison to other hydrocarbons having equal molecular masses. This is due to the presence of intermolecular hydrogen bonding between hydroxyl groups of alcohol molecules. In general, the boiling point of alcohols increases with an increase in the number of carbon atoms in the aliphatic carbon chain. On the other hand, the boiling point decreases with an increase in branching in aliphatic carbon chains the Van der Waals forces decreases with a decrease in surface area. Thus primary alcohols have a higher boiling point.

2. Solubility of Alcohols

The solubility of alcohol in water is governed by the hydroxyl group present. The hydroxyl group in alcohol is involved in the formation of intermolecular hydrogen bonding. Thus, hydrogen bonds are formed between water and alcohol molecules which make alcohol soluble in water. However, the alkyl group attached to the hydroxyl group is hydrophobic in nature. Thus, the solubility of alcohol decreases with the increase in the size of the alkyl group.

3. The Acidity of Alcohols

Alcohols react with active metals such as sodium, potassium etc. to form the corresponding alkoxide. These reactions of alcohols indicate their acidic nature. The acidic nature of alcohol is due to the polarity of –OH bond. The acidity of alcohols decreases when an electron-donating group is attached to the hydroxyl group as it increases the electron density on the oxygen atom. Thus, primary alcohols are generally more acidic than secondary and tertiary alcohols. Due to the presence of unshared electrons on the oxygen atom, alcohols act as Bronsted bases too.

4. Others

In general, the hydroxyl group makes alcohols polar. Those groups can form hydrogen bonds to one another and to most other compounds. Owing to the presence of the polar OH alcohols are more water-soluble than simple hydrocarbons. Methanol, ethanol, and propanol are miscible in water. Butanol, with a four-carbon chain, is moderately soluble.

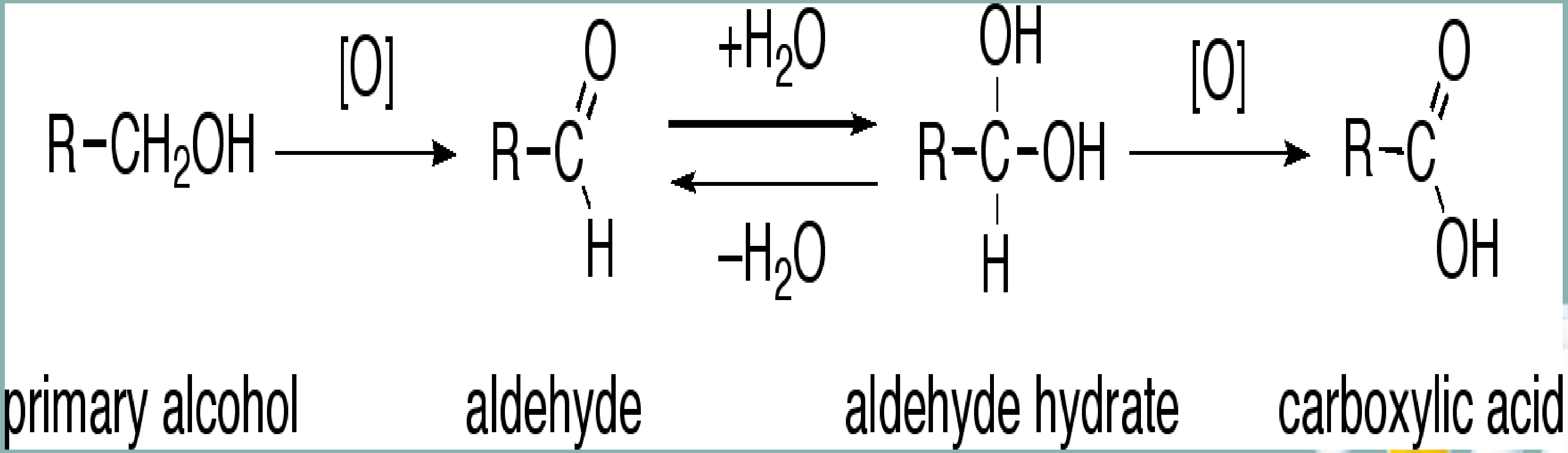
Because of hydrogen bonding, alcohols tend to have higher boiling points than comparable hydrocarbons and ethers. The boiling point of the alcohol ethanol is 78.29 °C, compared to 69 °C for the hydrocarbon hexane, and 34.6 °C for diethyl ether.

Chemical Properties of Alcohols

Alcohols exhibit a wide range of spontaneous chemical reactions due to the cleavage of the C-O bond and O-H bond. Some prominent chemical reactions of alcohols are:

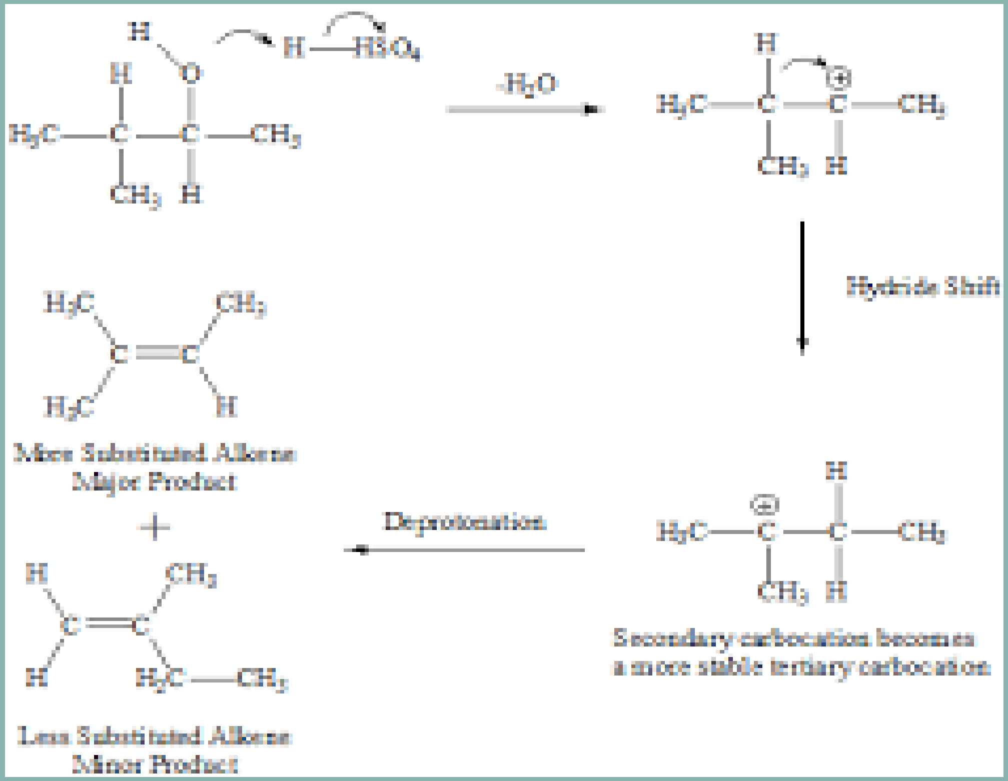
1. Oxidation of Alcohol

Alcohols undergo oxidation in the presence of an oxidizing agent to produce aldehydes and ketones which upon further oxidation give carboxylic acids.



2. Dehydration of Alcohol

Upon treatment with protic acids, alcohols undergo dehydration (removal of a molecule of water) to form alkenes.



The Manufacturing Process Of Ethyl Alcohols From Starch By Fermentation.

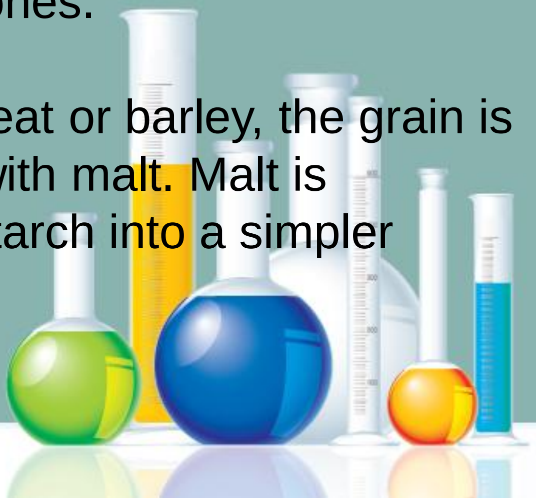
The process

The starting material for the process varies widely, but will normally be some form of starchy plant material such as maize (US: corn), wheat, barley or potatoes.

Starch is a complex carbohydrate, and other carbohydrates can also be used - for example, in the lab sucrose (sugar) is normally used to produce ethanol. Industrially, this wouldn't make sense. It would be silly to refine sugar if all you were going to use it for was fermentation. There is no reason why you shouldn't start from the original sugar cane, though.

The first step is to break complex carbohydrates into simpler ones.

For example, if you were starting from starch in grains like wheat or barley, the grain is heated with hot water to extract the starch and then warmed with malt. Malt is germinated barley which contains enzymes which break the starch into a simpler carbohydrate called maltose, $C_{12}H_{22}O_{11}$.



Maltose has the same molecular formula as sucrose but contains two glucose units joined together, whereas sucrose contains one glucose and one fructose unit.

Yeast is then added and the mixture is kept warm (say 35°C) for perhaps several days until fermentation is complete. Air is kept out of the mixture to prevent oxidation of the ethanol produced to ethanoic acid (vinegar).

Enzymes in the yeast first convert carbohydrates like maltose or sucrose into even simpler ones like glucose and fructose, both C6H12O6, and then convert these in turn into ethanol and carbon dioxide.

You can show these changes as simple chemical equations, but the biochemistry of the reactions is much, much more complicated than this suggests.

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow[\text{in yeast}]{\text{Invertase}} \underset{\text{glu cose}}{C_6H_{12}O_6} + \underset{\text{fructose}}{C_6H_{12}O_6}$$

$$\underset{\text{glucose or fructose}}{C_6H_{12}O_6} \xrightarrow[\text{in yeast}]{\text{Zymase}} \underset{\text{ethanol}}{2C_2H_5OH} + \underset{\text{carbon dioxide}}{2CO_2}$$

Yeast is killed by ethanol concentrations in excess of about 15%, and that limits the purity of the ethanol that can be produced. The ethanol is separated from the mixture by fractional distillation to give 96% pure ethanol.

For theoretical reasons, it is impossible to remove the last 4% of water by fractional distillation

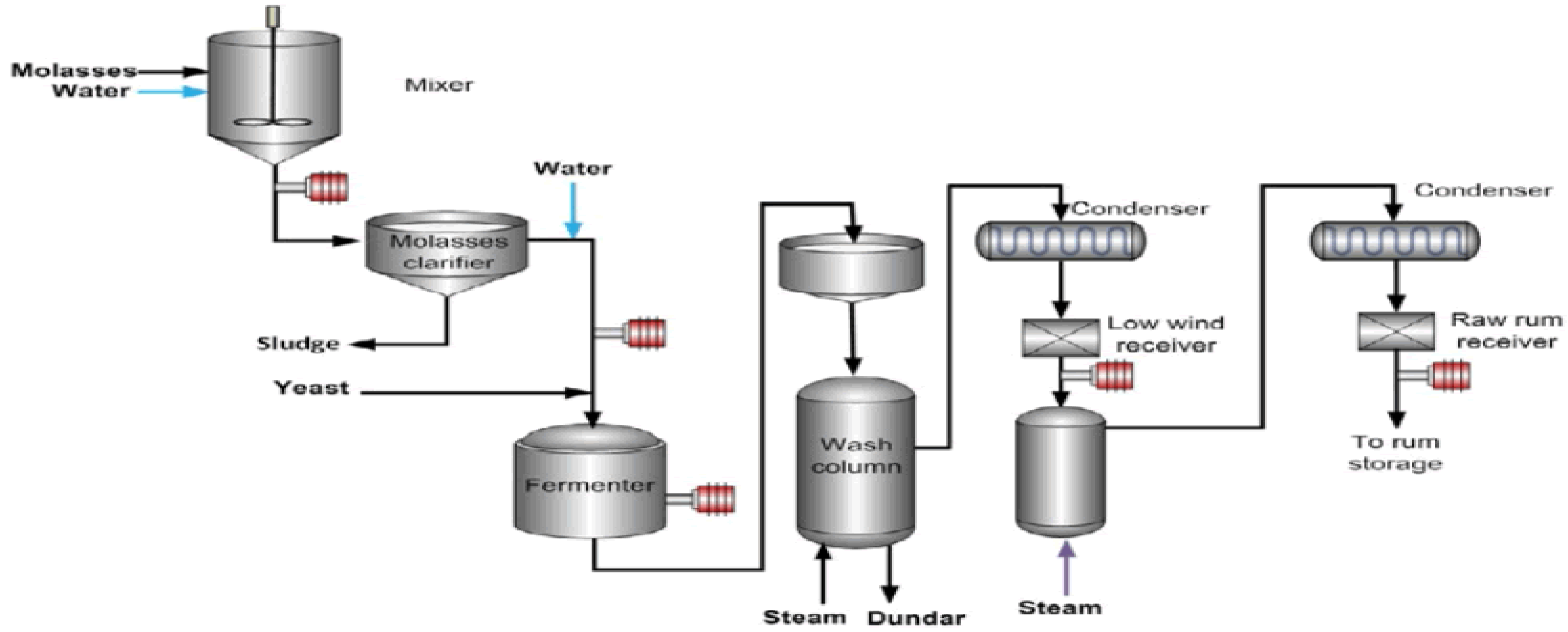


Figure 2: Ethanol production from molasses using fermentation process.

The Uses Of Alcohols.

Methanol

Chemical Feedstock

Methanol’s main use is as a chemical feedstock. Industrially methanol is converted to methanal (formaldehyde) by catalytic oxidation. Methanal is used in the manufacture of plastics, paints, explosives, textiles and cosmetics.

Solvent

Methanol is used as a solvent for inks, adhesives, resins and dyes. It is also used as a solvent in the pharmaceutical industry. It is used in antifreeze for automotive radiators and screen wash.

Fuel

Methanol is seeing increasing use as a fuel for internal combustion engines. It is also used as an additive in petrol to improve combustion.

Ethanol

Alcoholic Drinks

The alcohol content of alcoholic drinks such as wines and beers is ethanol.

Fuel

Ethanol, like other alcohols undergoes complete combustion when heated in the presence of air. It burns with a clean smokeless flame and is used as a transportation fuel or is blended with petrol.

Ethanol + air → carbon dioxide + water

$$2C_2H_5OH(l) + 6O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$$

In countries like Brazil with limited natural oil supplies but ideal conditions for growing sugar cane, large scale fermentation is used to produce ethanol to be used as a fuel.

Solvent

Ethanol is used as a solvent. It is also used to dissolve organic compounds which are not soluble in water. It is used in perfumes, cosmetics, paints, detergents and inks.

Propanol

Solvent

Propanol’s main use is as a solvent. It is widely used as a solvent in printing ink. It is also used in the manufacture of cosmetics and in the pharmaceutical industry. Like ethanol, propanol also has antiseptic properties and is used in hand sanitisers and hand wipes.

Butanol

Chemical Feedstock

Butanol is used in the manufacture of butyl ethanoate an ester used as synthetic fruit flavouring in the food and confectionary industry.

Solvent

Butanol is used as a solvent perfumes, cosmetics, paints, detergents and inks.

Fuel

There is increasing use of butanol as a biofuel produced from the fermentation of sugars and carbohydrates (bio-butanol) as a transportation fuel.

The Flashing Test Of Ethyl Alcohol.

Flash point is the temperature at which ethanol is flammable – can catch fire:
Beer (5% alcohol by weight) can catch fire, if ignited, at 144 °F (62 °C),
Wine (10% alcohol by weight) at 120 °F (49 °C),
Vodka (40% alcohol by weight) at 79 °F (26 °C) and
Concentrated alcohol (96% alcohol by weight) can catch fire at 63 °F (17 °C) .

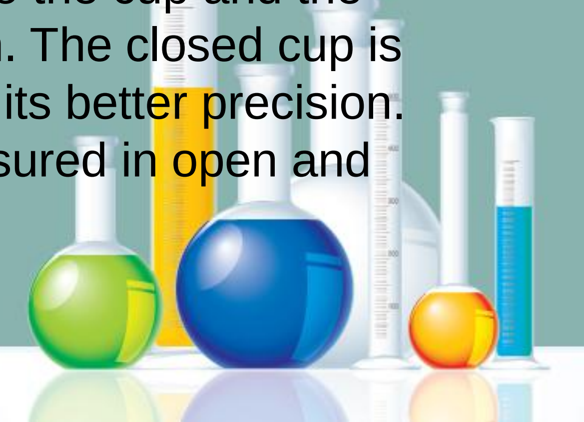
If a flash point method has been specified in a product specification or regulation, then that method should be the first choice. When testing specifically for contamination or contaminants, certain test methods and procedures are more appropriate than others. In general, an equilibrium test method is recommended for testing samples that may contain traces of volatile contaminants. When selecting a flash point method for incorporation into a product specification or regulation, it is important that the product type is included in the scope of the test method and that the temperature range of the product is covered by the test method. If the product is not included in the scope then the test may be unsuitable for the product or the quoted precision may not apply. When testing chemicals, mineral products or corrosive materials it is recommended to check that the test cup material is suitable and will not produce flammable gases or be damaged by any possible chemical reaction. Many flash point testers are available with stainless steel test cups.

There are two general classes of flash point tests: open cup and closed cup.

Automatic open-cup tester

The open-cup test CLA 5 was initially developed to assess the potential hazards of liquid spillage. An ignition source is passed horizontally over the surface of the liquid, while the cup and liquid are being heated, to test if the vapors 'flash'. If the test is repeated at increasing test specimen temperatures a point may be reached at which the specimen continues to burn without further application of the ignition source, this is the fire point. The precision of open-cup tests is somewhat poorer than closed-cup tests as the vapors produced by heating the test specimen are free to escape to the atmosphere and are more affected by local conditions in the laboratory. When open-cup tests are carried out at temperatures above ambient the result is usually higher than a result from a closed-cup test due to the reduced concentration of vapors.

The closed-cup test PMA 5 contains any vapors produced and essentially simulates the situation in which a potential source of ignition is accidentally introduced into a container. In this test a test specimen is introduced into a cup and a close-fitting lid is fitted to the top of the cup. The cup and test specimen is heated. Subsequently, apertures are opened in the lid to allow air into the cup and the ignition source to be dipped into the vapors to test for a flash. The closed cup is mostly used in product specifications and regulations due to its better precision. The following table shows the comparative flash points measured in open and closed cup apparatus for some common pure liquids.



Automatic closed-cup tester

Thanks