Volatility (chemistry)

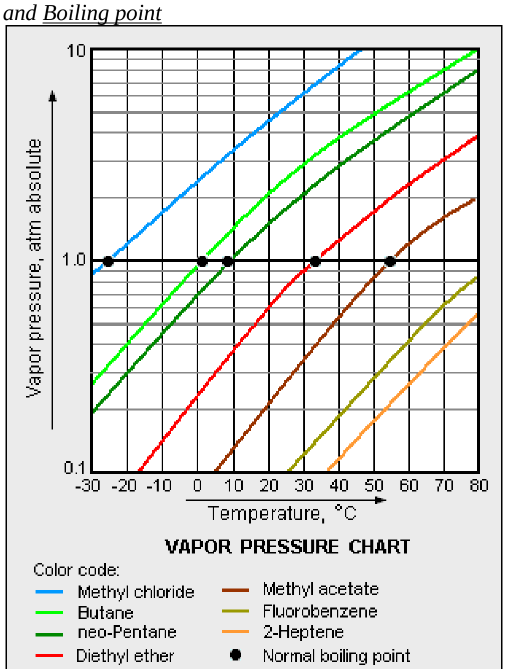
In chemistry and physics, **volatility** is a term used to characterize the tendency of a substance to vaporize.[1] At a given temperature, a substance with a higher vapor pressure will vaporize more readily than a substance with a lower vapor pressure.[2][3][4] In other words, at a given temperature, the more volatile the substance the higher will be the pressure of the vapor in dynamic equilibrium with its vaporizing substance — i.e., when the rates at which molecules escape from and return into the vaporizing substance are equal.

In common usage, the term applies primarily to liquids. However, it may also be used to characterize the process of sublimation by which certain solid substances such as ammonium chloride (NH_4Cl) and dry ice, which is solid carbon dioxide (CO_2), change directly from their solid form to a vapor without becoming a liquid.

Any substance with a significant vapor pressure at temperatures of about 20 to 25 °C (68 to 77 °F) is very often referred to as being ***volatile***.

Vapor pressure, temperature and boiling point

For more information, see: Temperature and Boiling point



Source: Milton Beychok
Vapor pressures of various liquids

The vapor pressure of a substance is the pressure at which its gaseous (vapor) phase is in equilibrium with its liquid or solid phase. It is a measure of the tendency of molecules and atomsto escape from a liquid or solid.

At atmospheric pressures, when a liquid's vapor pressure increases with increasing temperatures to the point at which it equals the atmospheric pressure, the liquid has reached its boiling point, namely, the temperature at which the liquid changes its state from a liquid to a gas throughout its bulk. That temperature is very commonly referred to as the liquid's *normal boiling point*.

Not surprisingly, a liquid's normal boiling point will be at a lower temperature the greater is the tendency of its molecules to escape from the liquid, namely, the higher is its vapor pressure. In other words, the higher is the vapor pressure of a liquid, the higher is the volatility and the lower is the normal boiling point of the liquid. The adjacent vapor pressure chart graphs the dependency of vapor pressure upon temperature for a variety of liquids[5] and also confirms that liquids with higher vapor pressures have lower normal boiling points.

For example, at any given temperature, methyl chloride (CH_3Cl) has the highest vapor pressure of any of the liquids graphed in the chart. It also has the lowest normal boiling point (–26 °C), which is where its vapor pressure curve (the blue line) intersects the horizontal pressure line of one atmosphere (atm) of absolute vapor pressure.

In terms of intermolecular forces, the boiling point represents the temperature at which the liquid molecules possess enough kinetic energy to overcome the various intermolecular attractions binding the molecules to each other within the liquid. Therefore the boiling point is also an indicator of the strength of those attractive forces. The higher the intermolecular attractive forces are, the more difficult it is for molecules to escape from the liquid and hence the lower is the vapor pressure of the liquid. The lower the vapor pressure of the liquid, the higher the temperature must be to initiate boiling. Thus, the higher the intermolecular attractive forces are, the higher is the normal boiling point.[6][7]

Relative volatilty

Relative volatility refers to a measure of the difference between the vapor pressure of the more volatile components of a liquid mixture and the vapor pressure of the less volatile components of the mixture. This measure is widely used in designing large industrial distillation processes.[4][5][8] In effect, it indicates the ease or difficulty of using distillation to separate the more volatile components from the less volatile components in a mixture. The use of relative volatility applies to multi-component liquid mixtures as well as to binary mixtures. By convention, relative volatility is typically denoted by the Greek letter alpha ($\boldsymbol{\alpha}$).

Volatile Organic Compound

The term *Volatile organic compound (VOC)* refers to organic chemical compounds having significant vapor pressures and which can have adverse effects on environmental air quality and human health. VOCs are numerous, varied and include man-made (anthropogenic) as well as naturally occurring chemical compounds. The anthropogenic VOCs are regulated by various governmental environmental entities worldwide.

There is no universally accepted definition of VOCs. Some regulatory entities define them in terms of their vapor pressure at ordinary temperatures, or their normal boiling points, or how many carbon atoms they contain per molecule, and others define them in terms of their photochemical reactivity.

The U.S. Environmental Protection Agency (U.S. EPA) currently defines them as any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions (i.e., the reactions that produce photochemical smog). However, any such carbon compounds that have been determined to have a low photochemical reactivity, and are specifically listed in the regulation, are exempted from regulation.[9]

Special definitions

There are a number of special definitions of the terms *volatility* and *volatile* commonly used in certain fields of study but which are still within the overall context of chemistry:

Wine making

The wine industry uses the term ***volatile acids*** to refer to organic acids that are water-soluble, have short carbon chains (six carbon atoms or less) and which occur in wine. For example: carbonic acid, acetic acid, formic acid, butyric acid and proprionic acid.

Cosmetics and flavorings

Certain volatile oils obtained from plants have distinctive, pleasant aromas which are used in cosmetics and food flavorings. These oils are commonly referred to as ***essential oils***.

Coal

Coals contain a certain amount of ***volatile matter***, defined as the portion of a coal sample which, when heated in the absence of air, is released as inorganic and organic gases.

Anesthetics

Inhalational anesthetics, commonly referred to as ***volatile anesthetics*** are organic liquids at room temperature which are easily vaporized. Some examples are: halothane, isoflurane and sevoflurane.

References

1. **Note:** To vaporize means to become a vapor, the gaseous state of the substance.
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3. James G. Speight (2006), *The Chemistry and Technology of Petroleum*, 4th Edition, CRC Press, ISBN 0-8493-9067-2.
4. Henry Z. Kister (1992), *Distillation Design*, 1st Edition, McGraw-Hill, ISBN 0-07-034909-6.
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6. The Forces Between Molecules, Department of Chemistry, University of Florida.
7. Intermolecular Forces, School of Chemistry, the University of New South Wales, Sydney, Australia.
8. J.D. Seader and Ernest J. Henley (1998), *Separation Process Principles*, Wiley, ISBN 0-471-58626-9.
9. U.S. Code of Federal Regulations: 40 CFR 51.100(s) - Definition - Volatile organic compounds (VOC)

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