

A Literature Review on the Indicators in Precipitation

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Abstract

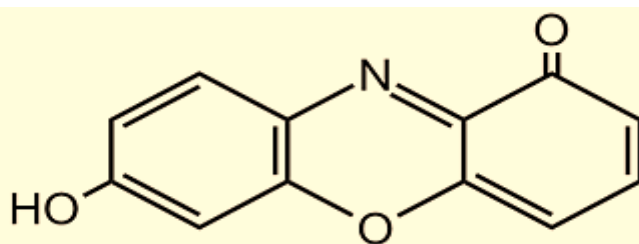
Our literature includes information and explanation for indicators in chemical reactions and principle of its using which represented by (types of indicators ,pH of indicators , instrumental precipitation,...) , principles of precipitation by indicator , methods of precipitation by indicator ,types of indicators for precipitation, conditions of precipitation .

Keywords: Type, Principle, React.

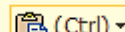
Introduction

A pH of chemical indicator is a halochromic compound added in small amounts to a solution so the pH (acidity or basicity) of the solution can be determined visually. Hence, a pH indicator is a chemical detector for (H_3O^+) hydronium ions or hydrogen ions (H^+) . Generally, the indicator appear color of the solution to change depending on the pH. Indicators can give change in many chemical and physical properties of solution ; for example, olfactory indicators show change in their odor. The pH value of a neutral solution is 7.0 at 25°C (standard laboratory conditions). Solutions have a pH value less than 7.0 are considered acidic and solutions have pH value more than 7.0 are basic -alkaline. As most naturally occurring organic compounds are weak protolytes, carboxylic acids and amines, pH indicators find many applications in biology and analytical chemistry. Moreover, pH indicators form one of the three main types of indicator compounds used in chemical analysis. For the quantitative analysis of metal cations, the use of complex metric indicators is preferred, whereas the third compound class, the redox indicators, are used in titrations involving a redox reaction as the basis of the analysis.

Chemical Indicator is substance whose solutions change color due to changes in pH. These are called acid-base indicators. They are usually weak acids or bases, but their conjugate base or acid forms have different colors due to differences in their absorption spectra



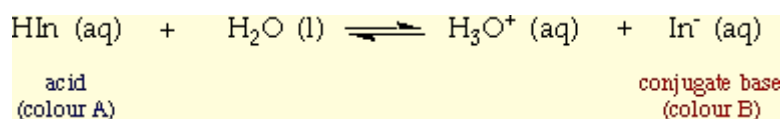
7-hydroxyphenoxazone

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Types of indicators : there are many types

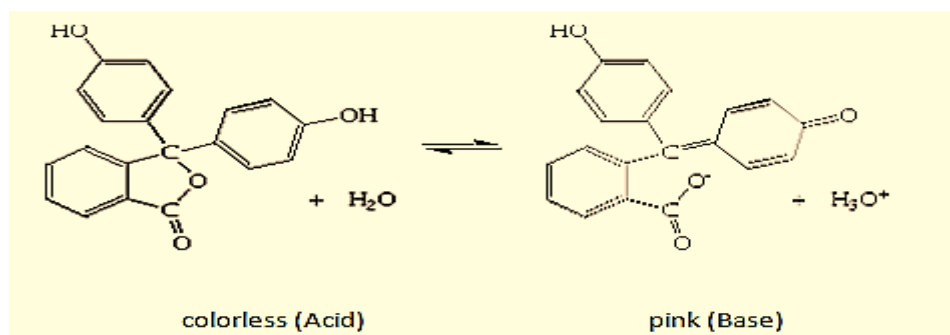
1- Acid - Base Indicators in Titrations

Acid - Base indicators are chemical substances that change color with pH. They are weak acids or bases, when dissolved in water dissociate slightly and form ions. Consider an indicator which is a weak acid, with the formula HIn . At equilibrium, the following equilibrium equation is established with its conjugate base:



The acid and its conjugate base have different colors. At low pH values the concentration of H_3O^+ is high and so the equilibrium position lies to the left. The equilibrium solution has the color A. At high pH values, the concentration of H_3O^+ is low - the equilibrium position thus lies to the right and the equilibrium solution has color B.

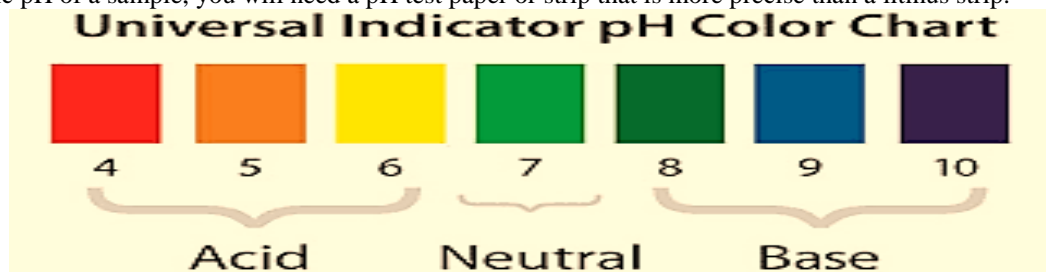
Phenolphthalein is an example of an indicator which establishes this type of equilibrium in aqueous solution:



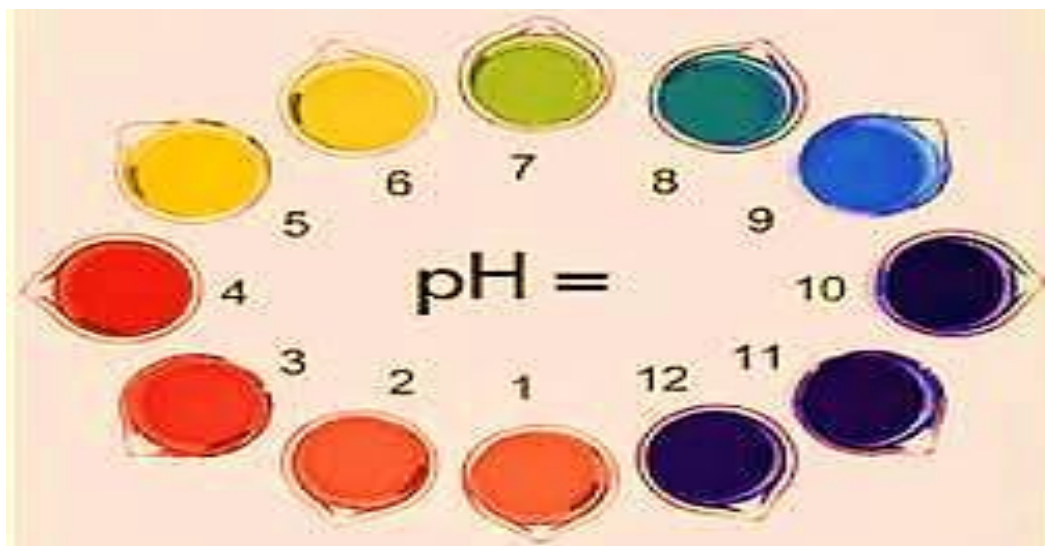
Phenolphthalein is a colorless, weak acid which dissociates in water forming pink anions. Under acidic conditions, the equilibrium is to the left, and the concentration of the anions is too low for the pink color to be observed. However, under alkaline conditions, the equilibrium is to the right, and the concentration of the anion becomes sufficient for the pink color to be observed.

2- pH Test papers

Litmus paper is the most familiar pH paper. It is used to broadly test whether a solution is acidic or basic and appear in 3 types—red, blue, and neutral. Red litmus turns blue in basic solutions, blue litmus turns red in acidic solution, and neutral litmus (usually purple) turns red in acidic solutions and blue in basic solutions. To find the specific pH of a sample, you will need a pH test paper or strip that is more precise than a litmus strip.



The pH of the solution at its turning point is called the pK_{in} and is the pH at which half of the indicator is in its acid form and the other half in the form of its conjugate base.



3- pH meters

The most precise of the 3 test types, pH meters measure a solution's pH through measuring the electrical potential difference with the pH electrode and a reference electrode. The meter then converts this potential to a pH reading. They offer readings to 0.01 pH unit, and are useful for advanced science, college, or research work that requires this level of precision.

The Range of Indicator:

At a low pH, a weak acid indicator is almost entirely in the HIn form, the color of which predominates. As the pH increases - the intensity of the color of HIn decreases and the equilibrium is pushed to the right. Therefore the intensity of the color of In^- increases. An indicator is most effective if the color change is distinct and over a low pH range. For most indicators the range is within ± 1 of the pK_{in} value:

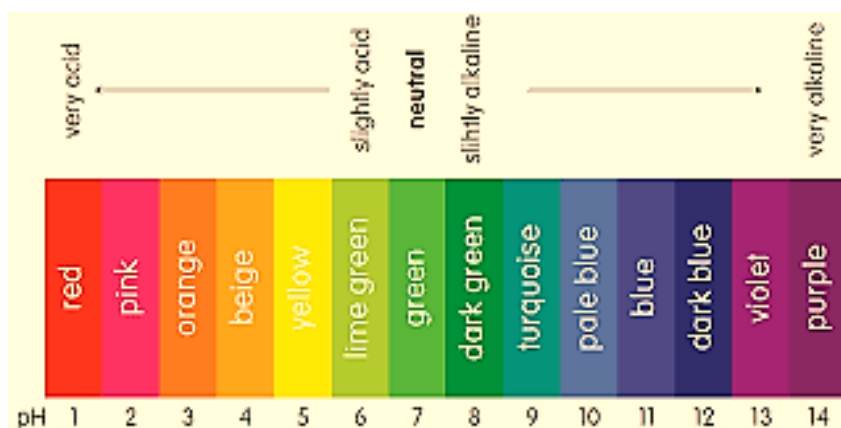
| Indicator | Colour | | pK_{in} | pH range |
|-------------------|--------|--------|-----------|-----------|
| | Acid | Base | | |
| Thymol Blue - | red | yellow | 1.5 | 1.2 - 2.8 |
| Methyl Orange | red | yellow | 3.7 | 3.2 - 4.4 |
| | | | | |
| Bromocresol Green | yellow | blue | 4.7 | 3.8 - 5.4 |
| | | | | |

| | | | | |
|------------------|-----------|------|-----|------------|
| Methyl Red | yellow | red | 5.1 | 4.8 - 6.0 |
| | | | | |
| Bromothymol Blue | yellow | blue | 7.0 | 6.0 - 7.6 |
| | | | | |
| Phenol Red | yellow | red | 7.9 | 6.8 - 8.4 |
| | | | | |
| Thymol Blue | yellow | blue | 8.9 | 8.0 - 9.6 |
| | | | | |
| Phenolphthalein | colorless | pink | 9.4 | 8.2 - 10.0 |

Precipitation is the creation of a solid from a solution. When the reaction occurs in a liquid solution, the solid formed is called the 'precipitate'. The chemical that causes the solid to form is called the 'precipitant'. Without sufficient force of gravity (settling) to bring the solid particles together, the precipitate remains in suspension. After sedimentation, especially when using a centrifuge to press it into a compact mass, the precipitate may be referred to as a 'pellet'. Precipitation can be used as a medium. The precipitate-free liquid remaining above the solid is called the 'supernate' or 'supernatant'. Powders derived from precipitation have also historically been known as 'flowers'. When the solid appears in the form of cellulose fibers which have been through chemical processing, the process is often referred to as regeneration.

Sometimes the formation of a precipitate indicates the occurrence of a chemical reaction. If silver nitrate solution is poured into a solution of sodium chloride, a chemical reaction occurs forming a white precipitate of silver chloride. When potassium iodide solution reacts with lead(II) nitrate solution, a yellow precipitate of lead(II) iodide is formed.

Precipitation may occur if the concentration of a compound exceeds its solubility (such as when mixing solvents or changing their temperature). Precipitation may occur rapidly from a supersaturated solution.



In solids, precipitation occurs if the concentration of one solid is above the solubility limit in the host solid, due to e.g. rapid quenching or ion implantation, and the temperature is high enough that diffusion can lead to segregation into precipitates. Precipitation in solids is routinely used to synthesize nanoclusters.

An important stage of the precipitation process is the onset of nucleation. The creation of a hypothetical solid particle includes the formation of an interface, which requires some energy based on the relative surface energy of the solid and the solution. If this energy is not available, and no suitable nucleation surface is available, super saturation occurs.

Precipitation reactions can be used for making pigments, removing salts from water in water treatment, and in classical qualitative inorganic analysis.

Precipitation is also useful to isolate the products of a reaction during workup. Ideally, the product of the reaction is insoluble in the reaction solvent. Thus, it precipitates as it is formed, preferably forming pure crystals. An example of this would be the synthesis of porphyrins in refluxing propionic acid. By cooling the reaction mixture to room temperature, crystals of the porphyrin precipitate, and are collected by filtration:

In chemistry, coprecipitation (CPT) or co-precipitation is the carrying down by a precipitate of substances normally soluble under the conditions employed. Analogously, in medicine, coprecipitation is specifically the precipitation of an unbound "antigen along with an antigen-antibody complex".

Coprecipitation process is an important issue in chemical analysis, where it is often undesirable, but in some cases it can be exploited. In gravimetric analysis, which consists on precipitating the sample and measuring its mass to determine its concentration or purity, coprecipitation is a problem because undesired impurities often coprecipitate with the analyte, resulting in excess mass. This problem can often be mitigated by "digestion" (waiting for the precipitate to equilibrate and form larger, purer particles) or by redissolving the sample and precipitating it again.

On the other hand, in the analysis of trace elements, as is often the case in radiochemistry, coprecipitation is often the only way of separating an element. Since the trace element is too dilute (sometimes less than a part per trillion) to precipitate by conventional means, it is typically coprecipitated with a *carrier*, a substance that has a similar crystalline structure that can incorporate the desired element. An example is the separation of francium from other radioactive elements by coprecipitating it with caesium salts such as caesium perchlorate. Otto Hahn is credited for promoting the use of coprecipitation in radiochemistry.

There are three main mechanisms of coprecipitation: inclusion, occlusion, and adsorption.^[3] An inclusion occurs when the impurity occupies a lattice site in the crystal structure of the carrier, resulting in a crystallographic defect; this can happen when the ionic radius and charge of the impurity are similar to those of the carrier. An adsorbate is an impurity that is weakly bound (adsorbed) to the surface of the precipitate. An occlusion occurs when an adsorbed impurity gets physically trapped inside the crystal as it grows.

In addition their applications in chemical analysis and in radiochemistry, coprecipitation is "potentially important to many environmental issues closely related to water resources, including acid mine drainage, radionuclide migration in fouled waste repositories, metal contaminant transport at industrial and defense sites, metal concentrations in aquatic systems, and wastewater treatment technology

References

Schwarzenbach, Gerold (1957). *Complexometric Titrations*. Translated By Irving, Harry (1st English Ed.). London: Methuen & Co. Pp. 29–46.

West, T. S. (1969). *Complexometry With EDTA And Related Reagents* (3rd Ed.). Poole, UK: BDH Chemicals Ltd. Pp. 14–82.

Zumdahl, Steven S. (2009). *Chemical Principles* (6th Ed.). New York: Houghton Mifflin Company. Pp. 319–324.

Wolfbeis, Otto F., Chemical Sensing Using Indicator Dyes: Optical Fiber Sensing 1997, 4, 53-107.)
Chromogenic And Fluorogenic Reactands: Mohr, G. J. Optical Sensors 2004, 1, 51-55.

Modern Reaction-Based Indicator Systems. Dong-Gyu Cho And Jonathan L. Sessler Chem. Soc. Rev. 2009, 38,
1647-1662.

Lopez-Lopez MT, Duran JDG, Delgado AV, Gonzalez-Caballero F (2005) J Colloid Interf Sci 291:144.

Mikhaylova M, Kim DK, Bobrysheva N, Osmolowsky M, Semenov V, Tsakalagos T, Muhammed M (2004)
Langmuir 20:2472.

Osseo-Asare K (1999) Handbook Of Microemulsion Science And Technology, Chap. 18. Marcel Dekker, Inc.,
New York.

Ezrahi S, Aserin A, Garti N (1999) Handbook Of Microemulsion Science And Technology, Chap. 7. Marcel
Dekker, Inc., New York.

Salager JL, Anton RE (1999) Handbook Of Microemulsion Science And Technology, Chap. 8. Marcel Dekker,
Inc., New York.

Selim S (1997) U.S. Patent 5695901.

Lopez Perez JA, Lopez Quintela MA, Mira J, Rivas J, Charles SW (1997) J Phys Chem B 101:8045.

Lopez-Perez JA, Lopez-Quintela MA, Mira J, Rivas J (1997) IEEE Trans Magn 33:4359.

Kodama RH (1999) J Magn Mater 200:359.

Cornell RM, Schwertmann U (1996) The Iron Oxides. Structure, Properties, Reactions, Occurrence And
Uses. VCH, Weinheim, Germany.

Lee Y, Lee J, Bae CJ, Park JG, Noh HJ, Park JH, Hyeon T (2005) Adv Funct Mater 15:2036.

Dhara, S. (2007). "Formation, Dynamics, And Characterization Of Nanostructures By Ion Beam
Irradiation". Critical Reviews In Solid State And Materials Sciences. 32 (1): 1-50. Bibcode:
2007CRSM..32.... 1D. Doi:10.1080/10408430601187624.

A. D. Adler; F. R. Longo; J. D. Finarelli; J. Goldmacher; J. Assour; L. Korsakoff (1967). "A Simplified
Synthesis For Meso-Tetraphenylporphine". J. Org. Chem. 32 (2): 476-476. Doi:10.1021/Jo01288a053.

Alan D. Adler; Frederick R. Longo; Frank Kampas; Jean Kim (1970). "On The Preparation Of
Metalloporphyrins". Journal Of Inorganic And Nuclear Chemistry. 32 (7): 2443. Doi:10.1016/0022-
1902(70)80535-8.

Dupont, J., Consorti, C., Suarez, P., De Souza, R. (2004). "Preparation Of 1-Butyl-3-Methyl Imidazolium-Based
Room Temperature Ionic Liquids". Organic Syntheses.; *Collective Volume, 10, P. 184*

AWAPARA J, LANDUA AJ, FUERST R, SEALE B. Free Gamma-Aminobutyric Acid In Brain. J Biol
Chem. 1950 Nov;187(1):35-39.

BAILEY K. End-Group Assay In Some Proteins Of The Keratin-Myosin Group. Biochem J. 1951 Jun;49(1):23-
27.

- BEEVERS H. An L-Glutamic Acid Decarboxylase From Barley. *Biochem J.* 1951 Feb;48(2):132–137.
- CALVIN M, BASSHAM JA, BENSON AA. Chemical Transformations Of Carbon In Photosynthesis. *Fed Proc.* 1950 Jun;9(2):524–534.
- Consden R, Gordon AH, Martin AJ. The Identification Of Lower Peptides In Complex Mixtures. *Biochem J.* 1947;41(4):590–596.
- Conway EJ, O'malley E. Microdiffusion Methods. Ammonia And Urea Using Buffered Absorbents (Revised Methods For Ranges Greater Than 10µg. N). *Biochem J.* 1942 Sep;36(7-9):655–661.
- DEKKER CA, STONE D, FRUTON JS. A Peptide From A Marine Alga. *J Biol Chem.* 1949 Dec;181(2):719–729.
- Dent CE. A Study Of The Behaviour Of Some Sixty Amino-Acids And Other Ninhydrin-Reacting Substances On Phenol-;Collidine' Filter-Paper Chromatograms, With Notes As To The Occurrence Of Some Of Them In Biological Fluids. *Biochem J.* 1948;43(2):169–180.
- Gordon AH, Martin AJ, Synge RL. A Study Of The Partial Acid Hydrolysis Of Some Proteins, With Special Reference To The Mode Of Linkage Of The Basic Amino-Acids. *Biochem J.* 1941 Dec;35(12):1369–1387.
- GOTTSCHALK A. Interaction Between Simple Sugars And Amino-Acids. *Nature.* 1950 Apr 29;165(4200):684–685.
- HAAS P. On Certain Peptides Occurring In Marine Algae. *Biochem J.* 1950 Apr;46(4):503–505.
- Haas P, Hill TG. A Preliminary Note On The Nitrogen Metabolism Of Seaweeds. Glutamic Acid Peptide. *Biochem J.* 1931;25(5):1472–1475.
- Haas P, Hill TG. The Metabolism Of Calcareous Algae. I. *Biochem J.* 1933;27(6):1801–1804.
- Haas P, Hill TG, Russell-Wells B. On Certain Simple Peptides Occurring In Marine Algae. *Biochem J.* 1938 Dec;32(12):2129–2133.
- HOLDEN M, PIRIE NW, TRACEY MV. A Study Of Enzymes That Can Break Down Tobacco-Leaf Components; Digestive Juice Of Helix On Leaf Fibre. *Biochem J.* 1950 Oct;47(4):399–407.
- HULME AC, ARTHINGTON W. Rho-AMINO-Butyric Acid And Alanine In Plant Tissues. *Nature.* 1950 May 6;165(4201):716–716.
- JOSLYN MA, STEPKA W. The Free Amino Acids Of Fruits. *Food Res.* 1949 Nov-Dec;14(6):459–467.
- Neuberger A, Sanger F. The Nitrogen Of The Potato. *Biochem J.* 1942 Sep;36(7-9):662–671.
- PARTRIDGE SM, DAVIS HF. Preferential Release Of Aspartic Acid During The Hydrolysis Of Proteins. *Nature.* 1950 Jan 14;165(4185):62–62.
- Rees MW. The Estimation Of Threonine And Serine In Proteins. *Biochem J.* 1946;40(5-6):632–640.

ROBERTS E, FRANKEL S. Gamma-Aminobutyric Acid In Brain: Its Formation From Glutamic Acid. J Biol Chem. 1950 Nov;187(1):55–63.

SANGER F, TUPPY H. The Amino-Acid Sequence In The Phenylalanyl Chain Of Insulin. I. The Identification Of Lower Peptides From Partial Hydrolysates. Biochem J. 1951 Sep;49(4):463–481.

SYNGE RLM. Methods For Isolating Omega-Amino-Acids; Gamma-Aminobutyric Acid From Rye Grass. Biochem J. 1951 Apr;48(4):429–435.

Tracey MV. Leaf Protease Of Tobacco And Other Plants. Biochem J. 1948;42(2):281–287.

Tristram GR. The Basic Amino-Acids Of Leaf Proteins. With A Discussion Of Various Methods Of Analysis. Biochem J. 1939 Aug;33(8):1271–1283.

UDENFRIEND S. Identification Of Gamma-Aminobutyric Acid In Brain By The Isotope Derivative Method. J Biol Chem. 1950 Nov;187(1):65–69.

Vernon Lp, Aronoff S. Metabolism Of Soybean Leaves. Ii. Amino Acids Formed During Short-Term Photosynthesis. Arch Biochem. 1950 Nov;29(1):179–186.

Williams RJ, Kirby H. Paper Chromatography Using Capillary Ascent. Science. 1948 May 7;107(2784):481–483.

Work E. The Isolation Of Alpha Epsilon-Diaminopimelic Acid From Corynebacterium Diphtheriae And Mycobacterium Tuberculosis. Biochem J. 1951 Jun;49(1):17–23.

Patnaik, P. Dean's Analytical Chemistry Handbook, 2nd Ed. McGraw-Hill, 2004.

Harvey, D. Modern Analytical Chemistry. McGraw-Hill, 2000.

A.-H. Lu, E. L. Salabas And F. Schüth, Angew. Chem. Int. Ed., 2007, 46,1222–1244

Otto Hahn, "Applied Radiochemistry", Cornell University Press, Ithaca, New York, USA, 1936.

Alan Townshend And Ewald Jackwerth, "Precipitation Of Major Constituents For Trace Preconcentration : Potential And Problems", Pure & App. Chem., Vol.61, No.9, Pp. 1643-1656, 1989.,

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