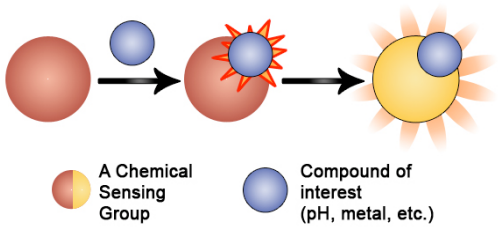
General Purpose/ Uses of Chemical Indicators

Chemical indicators are useful in chemistry primarily to identify when a reaction has undergone a chemical change or reached completion. The idea of using chemical indicator is to represent chemical concentrations with visible signals, most commonly a color change (Scheme 1).[1]

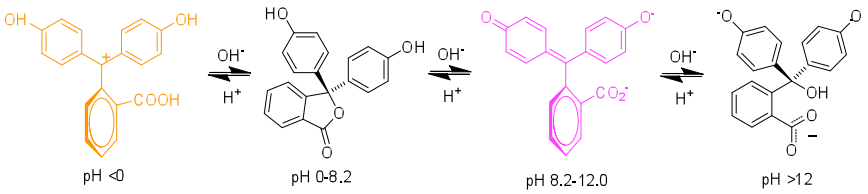


Scheme 1. Color Change Due to Binding of Sensor to Chemical of Interest

A titration can be performed to measure the concentrations of components. The titration uses a buret filled with titrant of a known concentration. The titrant is slowly added to the analyte of unknown concentration until the completion of the reaction is indicated by the chemical indicators.[2] Usually, the titrant employs weak, reversible noncovalent bonding to interact with the analyte. Specificity is important so that the synthetic host molecules can recognize and bind to the guest molecules. Other times, a chemical indicator can be a reaction based indicator which works irreversibly. This technique is more effectively used in identifying pathogens and hazardous chemicals.[3]

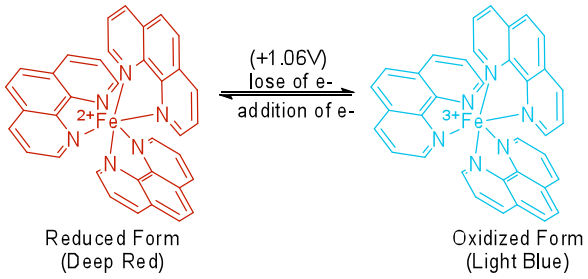
General Types of Chemical Indicators

Most chemical indicators are divided into five groups: acid-base, oxidation-reduction, complexometric, adsorption, and chemiluminescent. The pH indicators are acid-base indicators. Mostly weak acids, such as Bromothymol blue, Phenol Red, and Palatine Chrome Black, are colored differently in the dissociated and associated forms (Scheme 2).[1]



Scheme 2. pH-Dependent Structures and Colors of Phenolphthalein

The reduction-oxidation indicators are substances capable of being oxidized or reduced within certain ranges of the redox potential and undergoing a color change at the same time. Methylene blue, diphenylamine, ferroin, and starch are such indicators (Scheme 3).[4]



Scheme 3. Color Changes Due to Electrical Potential in Redox Indicator Ferroin

However, there are also chemical indicators that fall outside of the five typical groups of indicators. Reaction-based indicator systems are one such example. These indicators have visualized responses based on an irreversible or essentially irreversible reaction. This allows for superior selectivity as a result of exploiting specific reactions that are less dependent than traditional systems on the complementarity between the analyte and the receptor and more so on the analyte specific reactions.[5] The diversity seen among and outside the five groups, makes chemical indicators a critical tool in analytical processes.

References

(1) Chemical Sensing Using Indicator Dyes: Wolfbeis, Otto F. *Optical Fiber Sensing* **1997**, *4*, 53-107.
(2) What is a Titration: Purdue. Department of Chemistry; *Titration*. http://chemed.chem.purdue.edu/genchem/lab/techniques/titration/index.html.
(3) Chromogenic and fluorogenic reactands: Mohr, G. J. *Optical Sensors* **2004**, *1*, 51-55.
(4) International Union of Pure and Applied Chemistry Division Commission on Analytical Reactions and Reagents, Redox Indicators. Characteristics and Applications. Hulanicki, A.; Glab, S. *Pure & App*. **1978**, *50*, 463-498.
(5) Modern reaction-based indicator systems. Dong-Gyu Cho and Jonathan L. Sessler *Chem. Soc. Rev.* **2009**, *38*, 1647-1662.