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Color and Chemical Indicators

Introduction

A. General Purpose/Uses of Chemical Indicators

- Ref. 1: *Colorimetric Determination of Nonmetals, Volume VIII*, Bolts, D. F. (editor), Interscience Publishers, Inc.; New York, 1958. Page 1.
    - "Colorimetry may be defined as the science that deals with the measurement of the light absorptive capacity of chemical systems."
- Ref. 2: *Merriam-Webster, Inc*., Encyclopedia Britannica Company, 2011. http://www.merriam-webster.com/dictionary. Accessed on 1/28/11.
    - Titration - "A method or process of determining the concentration of a dissolved substance in terms of the smallest amount of reagent of known concentration required to bring about a given effect in reaction with a known volume of the test"
    - Indicator – "a substance (as litmus) used to show visually (as by change of color) the condition of a solution with respect to the presence of a particular material (as a free acid or alkali)"
    - Analyte - "a chemical substance that is the subject of chemical analysis"
- Ref. 4: *Chemical Sensing Using Indicator Dyes*, Wolfbeis, Otto S., University of Regensburg, Germany, Artech House; MA, 1997. Page 2 of 57.
    - "Indicator chemistry…in optical sensing is to convert the concentration of a chemical analyte into a measurable optical signal."
    - Indicators are synthetic dies that undergo color changes upon interaction with chemical species

B. General Types of Chemical Indicators

pH Indicators

- Ref. 5: *Chromogenic and Fluorogenic Reactants: New Indicator Dyes for Monitoring Amines, Alcohols, and Aldehydes,* Mohr, Gerhard J. Optical sensors; industrial, environmental, and diagnostic applications, Vol. 1. 2004. Page 51.
    - Indicators are frequently weak acids or weak bases
    - Sensors for pH are based on the protonation/deprotantion of pH indicator dyes
- Ref. 6: *Colorimetric Recognition Using Functional Phenolphthalein Derivatives*, Tsubaki, Kazunori, J Incl Phenom Macrocycl Chem, 2008. Page 4.

- Phenolphthalein is colorless in acidic soœlutions and pink/fuchsia in basic solutions
- Phenolphthalein being colorless in acidic solutions is due to the trianion that results from the addition of a monoanion and 2 dianions

Redox Indicators

- Ref. 7: *Visualizing Redox Chemistry: Probing Environmental Oxidation-Reduction Reactions with Indicator Dyes,* Tratnyek, Reilkoff, Lemon, Scherer, Balko, Feik, & Henegar; Chem. Educator, Springer-Verlag New York, Inc., 2001. Page 1 of 8.
  - Redox indicators can be used i) as chemical probes to obtain fundamental insights into biogeochemical processes and (ii) as the basis for demonstrations suitable for teaching aspects of environmental chemistry
  - Redox indicator - Methylene Blue, or methylthioninium chloride
  - Oxidation-Reduction reactions are present in aquatic, anaerobic environments where reducing conditions can reveal information regarding microbial activity and contaminants

Complexometric Indicators

- Ref. 8: *Find Target Reference,* FindTarget.com, 2011. http://reference.findtarget.com/search. Accessed on 2/1/1
  - The most typical complexometric indicators are metallochromic indicators
  - Undergoes a definite color change in presence of specific metal ions.
  - EDTA (*ethylenediaminetetraacetic acid*) is commonly used for its chelating characteristics.
  - Eriochrome Black T is a complexometric indicator which is a light purple/red when combined with calcium, magnesium and other metal ions; when used with EDTA, it turns a clear blue when it had reached its end-point, when it's fully protonated.

C. Statement of Need and Outline of Approach

Materials & Methods

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References

[i]Introduction

A. General Purpose/Uses of Chemical Indicators

Colorimetry may be defined as the science that deals with the measurement of the light absorptive capacity of chemical systems. [1] Whereas, indicator chemistry,…in optical sensing, is used to convert the concentration of a chemical analyte into a measurable optical signal.[2] Simply put, upon interaction with a target analyte, most indicators undergo an observable change in color or fluorescence.[3] An analyte is a chemical substance that is the subject of chemical analysis, [2] so by using an indicator to identify the presence of these, it makes their analysis a bit easier. An indicator is a substance (as litmus) used to show visually (as by change of color) the condition of a solution with respect to the presence of a particular material (as a free acid or alkali);[2] it is simply a synthetic dye that undergoes a color change when interacting with a chemical species.[3] Titration is a common method used to analyze this indicator/analyte interaction. Titration is defined as a method, or process, of determining the concentration of a dissolved substance in terms of the smallest amount of reagent of known concentration required to bring about a given effect in reaction with a known volume of the test[1]. An indicator is often added to the substance being titrated so once a certain amount of titrant has been added, a color change is observed (this is called the endpoint) and one can often use concentrations and volumes to analyze these equivalence points.

B. General Types of Chemical Indicators

There are three general types of indicators that we will focus on, including pH, redox, complexometric. pH indicators are frequently weak acids or bases and sensing pH is based on the indicator's protonation or deprotonation.[5] A common pH indicator used in titrations is phenolphthalein. When in an acidic solution, it will turn colorless, and when in a basic solution, phenolphthalein will turn pink/fuchsia.[6] The lack of color of phenolphthalein when in acidic solutions is due to a colorless trianion that forms from the combination of a colorless monoanion and one colored and one colorless dianion[6]. Next are redox indicators. Redox indicators can be used as chemical probes to obtain fundamental insights into biogeochemical processes and can also be used as the basis for demonstrations suitable for teaching aspects of environmental chemistry.[7] Oxidation-reduction reactions are especially important in aquatic, anaerobic conditions, where reducing conditions are strongly linked to sediment microbial activity, and the combination of these factors controls the fate of many contaminants.[7] Redox dyes can be used as probe compounds, where the probe response is indicated by a color change (much like pH indicators). An example of redox indicators is methylene blue, or methylthioninium chloride. Solutions of this substance are blue when in an oxidizing environment, but will turn colorless if exposed to a reducing agent. These color changes can then be analyzed and information can be used to characterize thermodynamic and kinetic properties of environmental systems. [7] Thirdly, there are complexometric indicators. Complexometric indicators are typically metallochromic indicators and are usually used in general and analytical chemistry laboratories. EDTA (ethylenediaminetetraacetic acid) is a ligand that is commonly used for its chelating characteristics. EDTA can be used to determine the total metallic ions in a solution. [3] Complexometric titration can then be used to indicate the exact moment when all the metal ions in the solution are sequestered by a chelating agent, such as EDTA. EDTA will displace the Eriochrome Black T indicator from the metal cations as it is added to the solution. Eriochrome Black T is a light purple/red color when combined with calcium, magnesium, and other metal ions. When this particular indicator has changed from its light purple/red to a clear blue color this means that the dye has been displaced from the metal cations in solution, and that the endpoint has been reached. [8]

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[2] *Merriam-Webster, Inc*., Encyclopedia Britannica Company, 2011. http://www.merriam-webster.com/dictionary. Accessed on 1/28/11.

[3] *Complexometric Titration of Aluminum and Magnesium Ions in Commercial Antacids*, Shui-Ping Yang & Ruei-Ying Tsai, Journal of Chemical Education, Vol. 83 No. 6, June 2006.

[4] *Chemical Sensing Using Indicator Dyes*, Wolfbeis, Otto S., University of Regensburg, Germany, Artech House; MA, 1997. Page 2 of 57.

[5] *Chromogenic and Fluoreogenic Reactants: New Indicator Dyes for Monitoring Amines, Alcohols, and Aldehydes*, Mohr, Gerhard J. Optical sensors; industrial, environmental, and diagnostic applications, Vol. 1. 2004. Page 51.

[6] *Colorimetric Recognition Using Functional Phenolphthalein Deriviatives*, Tsubaki, Kazunori, J Incl Phenom Macrocycl Chem, 2008. Page 4.

[7] *Visualizing Redox Chemistry: Probing Environmental Oxidation-Reduction Reactions with Indicator Dyes*, Tratnyek, Reilkoff, Lemon, Scherer, Balko, Feik, & Henegar; Chem. Educator, Springer-Verlag New York, Inc., 2001. Page 1 of 8.

[8] Find Target Reference, FindTarget.com, 2011. http://reference.findtarget.com/search. Accessed on 2/1/11.