Application of Titration in the Food Industry

Titration is “a method or the process of determining the concentration of a dissolved substance in terms of the smallest amount of a reagent of known concentration required to bring about a given effect in reaction with a known volume of the test solution.” There are many different types of titrations and the applications for which these titrations are used are extremely diverse. This paper seeks to explore the different types of titrimetry used in the Food and Beverage Industry and the applications of such titrations.

To understand the applications of titrimetry in the food industry it is first critical to understand exactly what is being measured in a titration test. For the purpose of this paper, the main focus will be on the two methods of titration used in the Food and Beverage Industry: Potentiometric Titration and Karl Fisher Titration. Potentiometric Titration measures the potential between two electrodes. In most potentiometric titrations two different electrodes are used, an indicator electrode and a reference electrode. The potential in the indicator electrode will vary while the potential in the reference electrode is held constant. Potentiometric titration curves have an S or Backward S shape and focus on plotting the Potential (E) of the solution vs. the volume of added titrant. Acid-Base, Redox, Precipitation and Complexometric are all examples of Potentiometric Titration. When performing these titrations the user is searching for the point of equilibrium of a given property (whether it be pH as is in the case of acid-base titrations or charge as is in the case of redox titrations). From this point the amount of titrant required to bring the solution to equilibrium is measured and the properties of the original solution can be calculated based upon the stoichiometry of the reaction. (Britannica) In the food industry the most common types of Potentiometric titrations are Acid-Base, Redox (oxidation-reduction), and precipitation titrations (Analytical Chemistry of Foods).

Karl Fisher titration focuses on the water content of a given substance. There are two types of Karl Fisher Titration: Volumetric and Coulometric. The techniques for these two types of titrations are almost identical, differing only in how the water-reactive
Iodine complex is introduced into the test solution. Coulometric Titration involves the application of an electrical current and measures the amount of current required to restore the potential of the solution to neutral. This type of titration is best for low moisture levels (<100ppm). Volumetric Titration involves the application of a titrate by an automatic burette. In this case, the amount of titrant required to restore the potential of the solution to neutral is measured. This type of titration works best for high water content (>30%) or non-homogenous samples (Vinny’s Paper).

The Food and Beverage Industry commonly utilizes titration techniques for regulatory requirements and quality control. Some of the regulatory requirements on the food industry include the Nutrition Labeling Education Act and the Enrichment Flour Law. In 1990 the Nutrition Labeling Education Act (NLEA) mandated that all food labels state the sodium, iron and calcium content. It is therefore important for every food manufacturer to test and measure the quantities of these minerals in their products. The Enrichment Flour Law requires the level of iron in white flour to be replaced to the level in which it naturally occurs in the wheat kernel before the removal of the bran. All of these minerals can be tested using complexometric and precipitation titrations. In the case where a specific separation of minerals from the food matrix is required, a nonspecific measurement (such as the volume of the titrant) will be made. This volume will then be converted to the mass of the mineral based on the stoichiometric relationship of the reaction, which occurs when the titrant is added to the solution (Food Analysis).

Karl Fisher titrations are also important procedures for Food and Beverage companies to comply with government regulations. There are legal limits to the minimum and maximum amount of water that must be present in certain foods. Manufacturers of food often want to include as much water as possible because of water’s cheap production costs. Karl Fisher Titrations allows the manufacturer to measure the moisture content in foods so the manufacturer is able to add as much water as possible without over exceeding government limits (http://people.umass.edu/~mcclemen/581Moisture.html).
Quality Control is another important application of titrimetry in the Food and Beverage Industry. The Food and Beverage Industry utilizes titration to help regulate taste, nutrition, texture, appearance and stability of the food. Acidity in foods is a major contributor to how bitter a food or beverage will taste. By performing an acid-base titration, food and beverage manufacturers are able to measure the amount of acid in their product and in turn be able to regulate the flavor of the product. By regulating the acid number, manufacturers are able to ensure the product will taste the same from batch to batch. Another example of quality control in the Food and Beverage Industry is nutrition. An example of this is Vitamin C content in fruit juice. Using an acid-base titration and the appropriate stoichiometry of the reaction, manufacturers are able to control the amount of vitamin C in each batch of fruit juice and ensure the labels on their products are correct. Finally, wine manufacturers frequently use titrations to regulate pH, sulfur content and the TA value in wine. All of these quantities can be measured using a potentiometric titrator. Sulfur Content utilizes a redox titration while pH and TA value are found by performing an acid-base titration.

Along with Potentiometric Titrations, Karl Fisher Titrations are extremely valuable in maintaining quality in the Food and Beverage Industry. Many dried foods that have the ability for long shelf lives are dried below a critical moisture level to ensure the quality of that food. Water content also controls the texture, appearance, taste and stability of food. Volumetric and Coulometric titration techniques are both used in the food industry depending on the water content. Water content should be less than 100ppm if Coulometric Titration is to be used or over 30% if Volumetric Titration will be used. However, when utilizing the Volumetric Titration technique for various food products it is important that the water content is not too high. Water in food molecules may be present in a variety of different molecular environments giving them different physiochemical properties and requiring different techniques to test water content in food. Karl Fisher Titrations are most suitable for foods whose masses change or have volatile compounds that can be lost during heating. Examples of these foods include dried fruits, vegetables, confectionary, coffee, oil, fats, spices and herbs. (http://people.umass.edu/~mcclemen/581Moisture.html)
Koehler Instrument’s Automatic Potentiometric Titration is able to perform a wide range of titrations including acid-base or aqueous titrations, redox titrations, complexometric titrations or EDTA titrations, Blank Titrations, Silver Assay Titrations, Non-aqueous titrations, Argentometric or Precipitation titrations, and Back Titrations. With the purchase of a separate accessory the K90500 also has the capabilities to run Voltametric/ Karl Fisher Titrations. The instrument is easy to use and comes complete with a two-point auto-calibration and standardization offset. The instrument is capable of displaying the pH and mV of the sample with temperature compensation and is able to accept a wide variety of electrodes making it a complete solution for all of your titration needs. The liquid path is compromised of Teflon tubing, a Teflon lined valve and a gas tight burette with a Teflon plunger head. The titrator creates a chemically inert system for any sensitive analysis. Most importantly, the K90500 is accurate to ±0.1mV (± 0.0016pH) providing results operators can depend on. For more information on the K90500, Automatic Potentiometric Titrator, please contact a Koehler Representative.