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Application Note

Tip Log #116

Applications Tip of the Week
Conductivity and Concentration Relationship

Conductivity can be used to measure concentration based on an empirical relationship between conductivity and concentration.

- Conductivity is the ability of a substance to conduct electrical current. Conductivity of aqueous solution comes from the dissolved electrolytes that dissociate to ions; ions are responsible for the conductivity. The solution ability to carry current is increased when ion concentration is increased. This relationship between conductivity and concentration allows converting a measured conductivity value to the concentration.
- Conductivity as indirect method of determining concentration is often used in many industrial applications. This method has many benefits - it is sensitive, easy of measurement, and allows to minimize analytical costs, especially in applications that required real-time monitoring.
- However, this indirect method has limitations that we will discuss in this Tip.

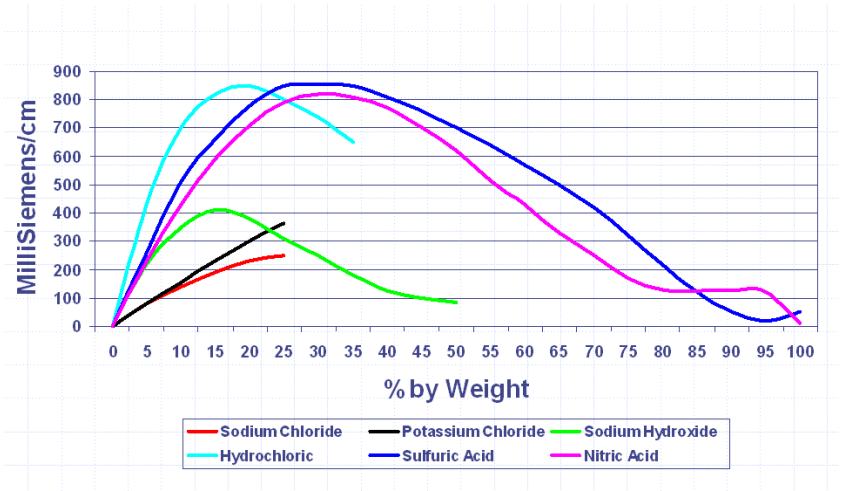
Conductivity is not specific.

Conductivity measures the total concentration of ions in solution; it cannot distinguish one electrolyte from another. It is better to use for an aqueous solution that has only a single ionic species.

Correlation of conductivity versus concentration is different for each electrolyte

- The shape of a conductivity versus concentration curve is different for each salt, acid, or base. In most cases, the conductivity versus concentration function is linear in certain concentration. Curves can be in various forms. As you can see from the graph below, for some electrolytes (such as potassium chloride) conductivity/concentration correlation is linear in a wide concentration range, but for some it exhibits a bell shaped curve.

Conductivity of common acids, bases, and salts at 25°C[1]



- Many electrolytes have a curve with maxima as it shown on the graph. In this case, a single conductivity value corresponds to two different concentrations. The conductivity can be used here to measure concentration over the range before or after the maxima and where conductivity is measurably increasing or decreasing over the range. For example, based on the sulfuric acid curve (see the graph), conductivity can be used to measure sulfuric acid concentration in the range from 0 to ~ 23% or 40 to 85%. The concentration of sulfuric acid cannot be determined accurately in the range between 23 and 43% where conductivity was not practically changed.

The shape of the conductivity versus concentration curve depends on temperature

- The conductivity of ionic solutions is strongly temperature dependant. This dependence is usually expressed as a relative change in conductivity per degree Celsius, known as the temperature factor or coefficient. Different electrolytes have different temperature factors; for some salts, acids, and bases, it is a known value, for some it should be determined experimentally.
- The conductivity versus concentration correlation will change with temperature change. For many electrolytes, the conductivity versus concentration curves are established at the reference temperature of 25°C. If testing at 25C, the available curve may be applied.
- If the measurement is conducted at a temperature other than the reference temperature, and the temperature factor is known, the temperature compensation option can be applied. See the Application Tip # 110 "Conductivity Temperature Compensation for Process" for details about temperature compensation options on Thermo Scientific Orion and AquaSensors conductivity meters.
- If the temperature factor is not known, it can be determined experimentally in the range of interest. Alternately, generate a custom curve for conductivity versus concentration at the specific process temperature of interest.

1. (http://www.fairtec.com.cn/document/Training/)Conductivity.ppt#263)