CHAPTER 1

INTRODUCTION

1.1 Overview [1-6]

Electronic industry has been a fast growing sector of economy in many countries around the world for the past several decades. The rapid growth of this industry is expected to continue in the future. The electronic industry in fact consists of manufacturing of various products with which semiconductor is an important one. Semiconductor is used in computers and their peripherals, communication equipment, consumer electronic products, electronic control devices and scientific and medical test equipment. The wide applications have established semiconductor as one of the key electronic products. Due to the increasing demand of this product in recent years, the semiconductor industry has been growing rapidly at a double-digit rate.

Recently, tin is used in most electronic industry that leads to the contamination of tin in environment. This contamination could be harmful to human and environmental. Tin is a toxic metal which could gather in a human's body and the tissue of animals and high concentration of tin brings serious interference to the metabolism of zinc. There are many reports of organic tin species analysis [2-4] while inorganic tin species have seldom been reported [5, 6]. In general, there are mainly two chemical species of inorganic tin in environmental samples, Sn(II) and Sn(IV), respectively. Differential toxicities of the different forms of an element have dictated an increasing development and use of analytical determination of the chemical species. The behavior of inorganic tin as a moderately corrosion-resistant metal is of considerable interest due to its important applications in the food and electronic industries. Thus, speciation analysis of tin in wastewater from electronic industry has progressively become important.

In this work, the tin species in wastewater samples were studied using ion-exchange resins for speciation of tin species. The determination of tin concentration was detected by graphite furnace atomic absorption spectrometry.

1.2 Speciation [7-9]

Trace element speciation is an important factor in the toxicity and movements of trace elements in aquatic ecosystems. Many trace elements have several different chemical forms that can be present at different concentrations and which may change with inputs and biogeochemical reactions in the system. Element speciation determines the different forms of a chemical element can take within a given compound, enabling chemists to predict possible species for the environment and human health.

Frequently, these different chemical forms of a particular element or its compounds are referred to as “species”. The notion that the distribution among its various species will have a major effect on the behavior of a particular element have been accepted in such diverse fields as toxicology, clinical chemistry, geochemistry and environmental chemistry. New developments in analytical instrumentation and methodology now often allow us to identify and measure the species present in a particular system.

The International Union of Pure and Applied Chemistry (IUPAC) has defined elemental in chemistry as follows:

Table 1.1 Chemistry elemental classified by IUPAC.

i. *Chemical species*.	Chemical elements: specific form of an element defined as to isotopic composition, electronic or oxidation state, and/or complex or molecular structure
ii. *Speciation analysis.*	Analytical chemistry: analytical activities of identifying and/or measuring the quantities of one or more individual chemical species in a sample.
iii. *Speciation of an element; speciation*.	Distribution of an element amongst defined chemical species in a system.
iv. *Fractionation.*	Process of classification of an analyte or a group of analytes from a certain sample according to physical (e.g. size, solubility) or chemical (e.g. bonding, reactivity) properties.

1.3 Background information of element

1.3.1 Tin [10-12]

Tin is a chemical element with the symbol Sn and atomic number 50. It is a main group metal in group 14 of the periodic table. Tin shows chemical similarity to both neighboring group 14 elements such as germanium and lead, like the two possible oxidation states +2 and +4. Tin is the 49th most abundant element and has 10 isotopes, the largest number of stable isotopes in the periodic table. Tin is a silver-white metal, soft, highly ductile and malleable that is not easily oxidized in air and resists corrosion. It is found in many alloys and used to coat other metals to prevent corrosion.

Tin can form a variety of both inorganic and organic compounds. These two classes of compounds have different chemical and physical properties which make them suitable for different applications in industry, agriculture and elsewhere. They also have different toxicities and require separate assessments of health risk. Tin can form inorganic compounds in the oxidation state +2 (Sn (II)) and +4 (Sn (IV)). Organotin compounds have one or more carbon-tin covalent bonds that are responsible for the specific properties of such molecules. There are four types of organotin compounds depending on the number of carbon-tin bonds. These series are designated as mono-, di-, tri-, and tetraorganotin compounds.

1.3.2 Applications of tin [13-15]

Tin and organotin compounds are widely used in industrial. Electronic industrial used as solders, bronzes, pewter, alloys, etc. They are widely used in joining electronic equipment and used as a coating, because it provides excellent solderability, ductility, electrical conductivity, and corrosion resistance. In food industrials, tin used in food preservation and wrapping material for foods and drugs. In plastic industrial, tin used as catalysts and stabilizers for polymerization. The applications of inorganic tin compounds are shown in **Table 1.2**.

Currently, tin is major use as a for solder alloys for electrical or electronic and general industrial applications, this use accounts for about 34% of the tin produced and is growing with the introduction of lead-free soldering technology. An important property of tin is its ability to form alloys with other metals. Tin alloys cover a wide range of compositions and many applications. Common solder, an alloy of 63% tin and lead, is mainly used in the electrical industry, for instance, lead-free tin solders which containing up to 5% silver or antimony are used at higher temperatures. Tin alloys are important in the production of coatings by electroplating and hot tinning (the most important of these are tin–zinc, tin–nickel, tin–cobalt, and tin–copper). Among the newer alloys are niobium–tin and indium–tin alloys used in superconducting cables and magnets and indium–tin oxide for metallic photonic crystals. Dental amalgam alloys have been used for centuries. Principally, three compound (ternary) alloys of silver, tin, and copper with smaller amounts of other elements have been widely used in dentistry. Today's dental alloys are composed of silver (40–70%), tin (12–30%), copper (12–30%), indium (0–4%), palladium (0.5%) and zinc (0.1%).

Table 1.2 Applications of inorganic tin and its compounds

Compound	**Application**
Tin metal	Manufacture of tin plate, solders, bronzes, pewter, alloys, amalgams, chemicals
Tin(IV) oxide	Ceramic glaze opacifier, ceramic pigments
Tin(IV) hydride	Gas-plate tin on metal, ceramics
Tin(II) acetate	Catalyst
Tin(II) chloride	Electrotinning of steel strip, tin coating of sensitized paper antisludge agent for oils, stabilizer of perfumes in soaps, additive for drilling muds, electroplating, catalyst in organic reaction
Tin(II) fluoroborate	Tin-plating baths
Tin(II) fluoride	Toothpaste and dental preparations
Tin(II) 2-ethylhexoate	Catalyst for polyurethane foam production and incurring silicone oil formulations
Tin(II) oxide	Manufacture of gold-tin and copper-tin ruby glass
Tin(II) sulfate	Immersion plating of steel wire, electrotinning strip, with copper sulfate for lacquer finishes
Tin(II) tartrate	Dyeing and printing of textiles
Tin(IV) chloride	Mordant in dyeing of silk, preparation of other inorganic and organic tins, manufacture of blueprint and other sensitized papers
Sodium stannate	Alkaline electroplating tin baths
Sodium pentafluorostannite	Dentifrice formulations

1.3.3 The health effects of tin [16-18]

Metallic tin is not very toxic due to its poor gastrointestinal absorption. Study in human and animal showed that ingestion of large amounts of inorganic tin compounds can cause stomachache, anemia, liver and kidney problems. Breathing or swallowing, or skin contact with some organotins such as trimethyltin and triethyltin compounds can interfere working of the brain and nervous system. Some organotin compounds such as dibuthyltin and tributhyltins have been shown to affect the immune system in animals, but this has not been examined in people. Inorganic and organic tin compounds can produce skin and eye irritation.

The human body contains approximately 0.2 ppm of tin. There is no concrete evidence that suggests a dietary requirement of tin, except for the fact that it is a constituent of the gastrine hormone. A number of literature sources mention that tin deficits may lead to hair loss, anorexia and acne. Our daily intake of tin is approximately 0.3 mg, of which 0.2 mg occurs in food and the remainder is added by conserve can corrosion. In food tin concentrations of 200-300 ppm are tolerated, and in the past concentrations up to 700 ppm occurred. Consequences of toxic tin levels are vomiting and diarrhoea. Metallic tin is generally non-toxic to humans, even upon uptake of small concentrations for a long period of time. Some tin compounds do cause adverse health effects. This mainly concerns organic tin compounds. For example, tributyltin oxide causes skin irritations, breathing problems, vomiting, headaches and facial disorder. Tetraethyltin has been reported to cause bradycardia, hypertension, nausea, vomiting, irritation of upper and lower respiratory systems, abrupt variation in sinus rhythm and short term memory loss. Tin (IV) hydride is another toxic nerve gas. Trimethyltin and triethyltin are mildly toxic to humans, whereas tripentyltin is generally non-toxic and is therefore applied as a pesticide. The above-mentioned tributyltin (TBT) may cause hormonal disorder in humans, which may ultimately result in infertility.

1.3.4 Effects of tin on the environment [17]

Tin as single atoms or molecules are not very toxic to any kind of organism, the toxic form is the organic form. Organic tin components can maintain in the environment for long periods of time. They are very persistent and not fairly biodegradable. Microorganisms have a great deal of trouble breaking down organic tin compounds that have accumulated on water soils for many years, the concentrations of organic tins still rise due to this. Organic tins can spread through the water systems when adsorbed on sludge particles. They are known to cause a great deal of harm to aquatic ecosystems, as they are very toxic to fungi, algae and phytoplankton. Phytoplankton is a very important link in the aquatic ecosystem, as it provides other water organisms with oxygen. It is also an important part of the aquatic food chain.

1.4 Determination of tin speciation [5-6, 19-27]

There are several techniques for the separation of tin in various samples such as solvent extraction [19], liquid chromatography [20], gas chromatography [21, 22], solid extraction [23] and cloud point extraction (CPE) [5]. Several techniques have been employed for the determination of inorganic tin in various sample materials such as spectrometry, inductively coupled plasma-atomic emission spectrometry (ICP-

AES) [24] and flame atomic absorption spectrometry (FAAS) [25]. Graphite furnace atomic absorption spectrometry (GFAAS) was a favorable method for the determination of tin at very low concentration, which has high sensitivity, selectivity and much less interference [6].

Many reported have been studied for the speciation of tin in water samples. Gholivand *et al*. [25] studied the speciation of tin in various alloy, juice fruit, tap and waste water samples by cloud point extraction (CPE) and flame atomic absorption spectrometry (FAAS). Yuan *et al*. [26] studied tin in water samples by cloud point extraction (CPE) and graphite furnace atomic absorption spectrometry (GFAAS) They used 8-hydroxyquionoline (8-HQ) as chelating reagent and added Triton X-114 as the surfactant. The method could separate tin in water sample from most interference, and was applied to the determination of trace tin in water samples with satisfactory recoveries. Zhu *et al*. [5] studied inorganic tin in environmental water samples by cloud point extraction (CPE) and graphite furnace atomic absorption spectrometry (GFAAS). They used 1-(2-pyridylazo)-2-naphthol (PAN) as chelating agent and Triton X-100 as the surfactant. They found that the results obtained were in good agreement with the certified values and the method was applied to the speciation analysis of tin in different water samples. Puri *et al*. [27] studied a new polymeric absorbent for screening and preconcentration of organotin compounds in sediments and sea water samples by graphite furnace atomic absorption spectrometry (GFAAS). Zhu *et al*. [6] studied the speciation of tin in environmental water samples separated by ion exchange resin and detected by graphite furnace atomic absorption spectrometry (GFAAS). The anion exchange resin could be applied to separate Sn(IV) from Sn(II) and the method was applied to the determination of speciation of inorganic tin in environmental water samples.

1.5 Graphite furnace atomic absorption spectrometry (GFAAS) [28-36]

Graphite furnace atomic absorption spectrometry (GFAAS) is also known by various other acronyms, including electrothermal atomic absorption spectrometry (ETAAS). The technique is based on the fact that free atoms will absorb light at frequencies or wavelengths characteristic of the element of interest (hence the name atomic absorption spectrometry). Within certain limits, the amount of light absorbed can be linearly correlated to the concentration of analyte present. Free atoms of most elements can be produced from samples by the application of high temperatures. In GFAAS, samples are deposited in a small graphite tube, which can then be heated to vaporize and atomize the analyte.

1.5.1 Components of the graphite furnace system

Graphite furnace atomic absorption spectrometry (GFAAS) instruments have the following basic features: 1. a source of light (lamp) that emits resonance line radiation; 2. an atomization chamber (graphite tube) in which the sample is vaporized; 3. a monochromator for selecting only one of the characteristic wavelengths (visible or ultraviolet) of the element of interest; 4. a detector, generally a photomultiplier tube (light detectors that are useful in low-intensity applications), that measures the amount of absorption. A block diagram of a graphite furnace atomic absorption spectrometer is shown in **Figure 1.1.**

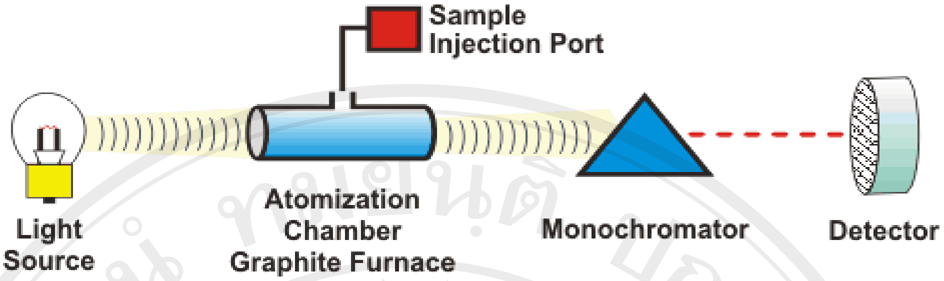

Figure 1.1 Block diagram showing basic components of a graphite furnace atomic absorption spectrometer [32].

1.5.1.1 The light source

An atom absorbs light at discrete wavelengths. In order to measure this narrow light absorption with maximum sensitivity, it is necessary to use a line source, which emits the specific wavelengths which can be absorbed by the atom. Narrow line sources not only provide high sensitivity, but also make atomic absorption a very specific analytical technique with few spectral interferences.

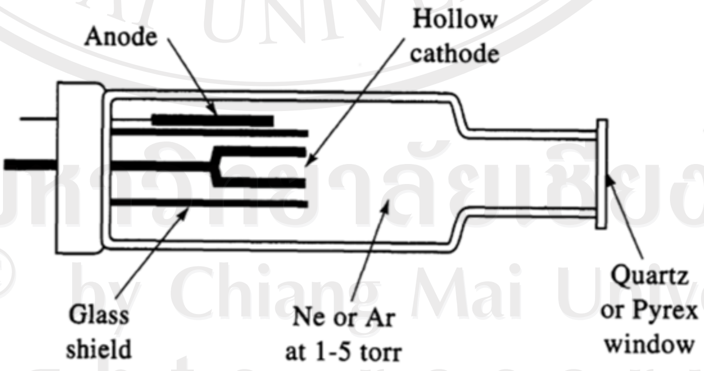

Figure 1.2 Hollow cathode source for atomic absorption spectrometry [33].

The common source of light is a hollow cathode lamp as shown in **Figure 1.2.** Hollow cathode lamps basically consist of a glass cylinder that contains a cathode and an anode. The glass cylinder itself is filled with neon or argon with a pressure of a few millibars. The cathode has the shape of a hollow cylinder and either consists of, or is filled with the element of interest. Applying a voltage of several hundred volts, a glow discharge develops between the electrodes. Sputtering atoms from the cathode surface are excited and emit the spectrum of the cathode material by a flow of positive gas ions (Ne^+ or Ar^+) impacts on its surface. Because of the lower pressure and lower temperature in a HCL, compared to that in the atomizer, the width of the lines emitted by the radiation source is significantly smaller than that of the absorption lines. Depending on the wavelength of the main analytical line the exit window of the lamp is made of silica or glass. The filled gas is selected in a way that no spectral interferences are encountered between the spectrum of the filled gas and the analytical line, and to achieve the highest possible emission intensity of the analyte spectrum.

Hollow cathode lamps have a limited life time. Firstly, sputtered atoms are deposited in part on colder parts of the lamp, e.g. the glass cylinder, forming a metal film; secondly, the fill gas is absorbed slowly by the metal film and the glass. Hollow cathode lamps can be manufactured for a wide variety of elements. For certain combinations of elements it is also possible to make so-called multi-element lamps, which contain an alloy or a mixture of several metals. These lamps have the advantage of being more economic than single element lamps. In addition they shorten the change-cover time if more than one element has to be determined.

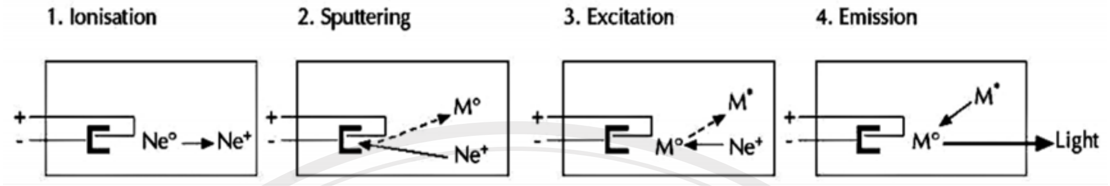

Figure 1.3 Hollow cathode lamp process [34].

A typical atomic absorption instrument holds several lamps each for a different element. The lamps are housed in a rotating turret so that the correct lamp can be quickly selected.

1.5.1.2 The atomizer

A basic graphite furnace atomizer is comprised of the following components:

(1) Graphite tube

(2) Electrical contacts

(3) Enclosed water cooled housing

(4) Inert purge gas controls

A graphite tube is normally the heating element of the graphite furnace. The cylindrical tube is aligned horizontally in the optical path of the spectrometer and serves as the spectrometer sampling cell. A few microliters (usually 5-50 μl) of sample are measured and dispensed though a hole in the center of the tube wall onto the inner tube wall or a graphite platform. The tube is held in place between two graphite contact cylinders, which provide electrical connection. An electrical potential applied to the contacts causes current to flow through the tube, the effect of which is heating of the tube and the sample.

The entire assembly is mounted within an enclosed, water-cooled housing. Quartz windows at each ends of the housing allow light to pass through the tube. The heated graphite is protected from air oxidation by the end windows and two streams of argon. An external gas flow surrounds the outside of the tube, and a separately controllable internal gas flow purges the inside of the tube. The system should regulate the internal gas flow so that the internal flow is reduced or, preferably, completely interrupted during atomization. This helps to maximize sample residence time in the tube and increase the measurement signal.

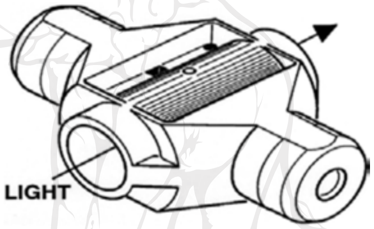

Figure 1.4 A graphite tube for a transversely-heated furnace [35].

The graphite tube of the transversely-heated furnace, shown in **Figure 1.4**, includes integral tabs which protrude from each side. These tabs are inserted into the electrical contacts. When power is applied, the tube is heated across its circumference (transversely). By applying power in this manner, the tube is heated evenly over its entire length, eliminating or significantly reducing the sample condensation problem seen with longitudinally-heated furnace systems.

A graphite furnace consists of measuring and dispensing a known volume of sample into the furnace. The sample is then subjected to a multi-step temperature program. When the temperature is increased to the point where sample atomization occurs, the atomic absorption measurement is made. Variables under operator control include the volume of sample placed into the furnace and heating parameters for each step. These parameters include:

(1) temperature	final temperature during step
(2) ramp time	time for temperature increases
(3) hold time	time for maintaining final temperature
(4) internal gas	gas type and flow rate

In additional to the above, spectrometer control functions can be programmed to occur at specified times within the graphite furnace program. While the number of steps within each program is variable, 4 steps make up the typical graphite furnace program. These steps include:

(1) The drying step

The purpose of the drying step is to remove the solvent from the sample. After the sample is placed in the furnace, it must be dried at a sufficiently low temperature to avoid sample spattering, which would result in poor analytical precision. Temperature around 100-120 °C are common for aqueous solution. During the drying process, the internal gas flow normally is left at its default maximum value (250-300 ml per minute) to purge the vaporized solvent from the tube.

(2) The pyrolysis step

The purpose of the pyrolysis step (sometimes referred to as the ashing, char or pretreatment step) is to volatilize inorganic and organic matrix components selectively from the sample, leaving the analyte element in a less complex matrix for analysis. During this step, the temperature is increase as high as possible to volatilize matrix components but below the temperature at which analyte loss would occur.

The temperature selected for the pyrolysis step will depend on the analyte and the matrix. The internal gas flow is again left at 250-300 ml per minute in the pyrolysis step, the temperature is increased as high as possible to volatilize matrix components but below the temperature at which analyte loss would occur.

The temperature selected for the pyrolysis step will depend on the analyte and the matrix. The internal gas flow is again left at 250-300 ml per minute in the pyrolysis step, to drive off volatilized matrix materials. For some sample types, it may be advantageous to change the internal gas, e.g., to air or oxygen, during the pyrolysis step to aid in the sample decomposition.

(3) The atomization step

The purpose of the atomization step is to produce an atomic vapor of the analyte elements, thereby allowing atomic absorption to be measured. The atomization temperature is a property of the analyte element. The temperature in this step is increased to the point where dissociation of volatilized molecular species occurs.

(4) The clean step

After atomization, the graphite furnace may be heated to still higher temperatures to burn off any sample residue which may remain in the furnace. An optional cool down step then allows the furnace to return to near ambient temperature prior to the introduction of the next sample.

1.5.1.3 The monochromator

A monochromator is used to select the specific wavelength of light *i.e.* spectral line, which is absorbed by the sample, and to exclude other wavelengths. The selection of the specific light allows the determination of the selected element in the presence of others. The light selected by the monochromater is directed onto a detector that is typically a photomutiplier tube. This produces an electrical signal proportional to the light intensity. A typical monochromator is diagrammed in **Figure 1.5**.

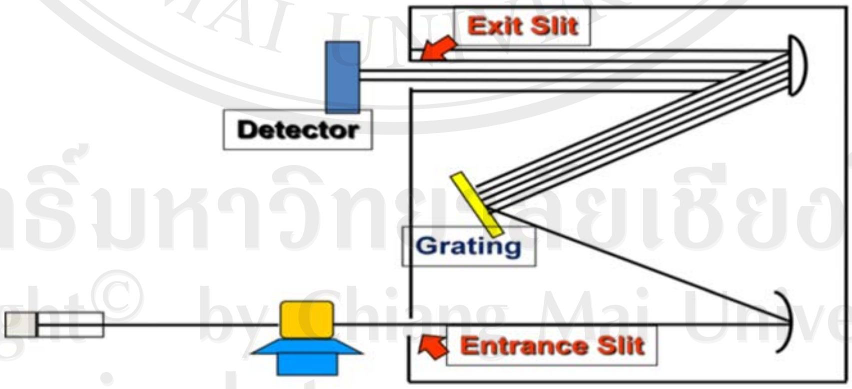

Figure 1.5 A monochromator [36].

1.5.1.4 The detector

The detection of radiation in conventional atomic absorption spectrometers is typically accomplished by a photomultiplier tube (PMT). A PMT is an electronic tube that is capable of converting a photon current into an electrical signal and of amplifying this signal. A PMT consists of a photo cathode and a secondary electron multiplier. The photons impact on the photo cathode and sputter electrons from its surface. These electrons are accelerated in an electrical field and impact on other electrodes, so-called dynodes, from the surface of which each impacting electron sputters several secondary electrons. This cascade effect results in a significant increase in the number of electrons. In order to function this way, the dynodes have to be on an increasingly positive potential. At the end the electrons impact on an anode and flow off to the mass. The resulting current is measured. The amplification factor increase exponentially with the number of dynodes. Typical PMT has some 10 dynodes, which correspond to an amplification factor of about 10^7.

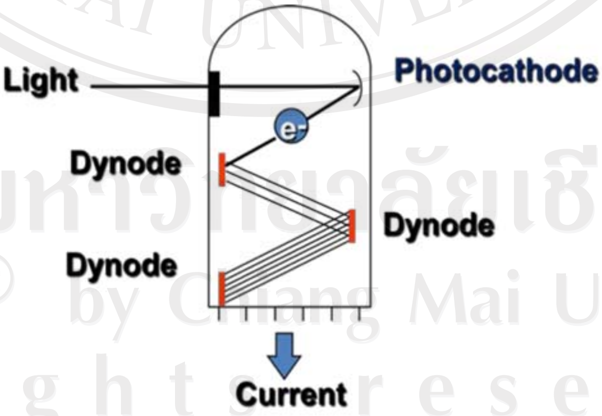

Figure 1.6 Operation principle of a photomultiplier [36].

1.5.2 Matrix modification

The main function of matrix modifiers is to react with the analyte to stabilize the element so that higher pyrolysis temperatures can be used. When the element compound is more stable, it will remain on the platform until later in the atomization step, allowing a closer approach to isothermal conditions. Alternatively, matrix modifiers may react with the matrix to make it more volatile so it can be removed more effectively.

1.5.3 Quantitative analysis by atomic absorption

The atomic absorption process is illustrated in **Figure 1.7**. Light at the resonance wavelength of initial intensity, (I_o), is focused on the flame cell containing ground state atoms. The initial light intensity is decreased by an amount determined by the atom concentration in the flame cell. The light is then directed onto the detector where the reduced intensity, (I), is measured. The amount of light absorbed is determined by comparing I to I_o.

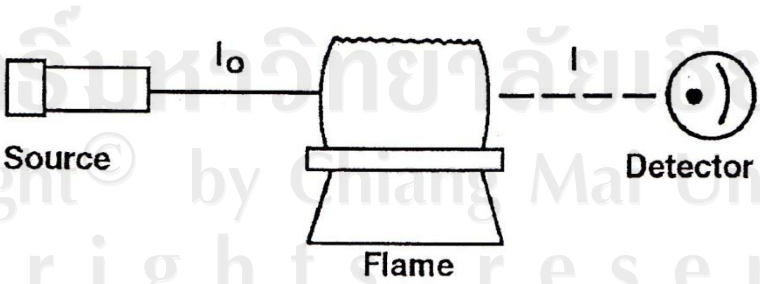

Figure 1.7 The atomic absorption process [35].

Several related terms are used to define the amount of light absorption. The "transmittance" is defined as the ratio of the final intensity to the initial intensity, by the indication of the fraction of I_o passed through the cell to fall on the detector.

$$T = I/I_o$$

The "percent transmission" is simply the transmittance expressed in percentage terms.

$$\%T = 100 \times I/I_o$$

The "percent absorption" is the complement of percent transmission defining the percentage of the initial light intensity which is absorbed in the flame.

$$\%A = 100 - \%T$$

The "absorbance", is purely a mathematical quantity of visualization on a physical basis.

$$A = \log (I_o/I)$$

Beer's Law defines this relationship; as this quantity follows a linear relationship with concentration.

$$A = abc$$

Where "A" is the absorbance; "a" is the absorption coefficient, a constant which is characteristic of the absorbing species at a specific wavelength; "b" is the length of the light path intercepted by the absorption species in the absorption cell; and "c" is the concentration of the absorbing species.

This directly proportional behavior between absorbance and concentration is observed in atomic absorption. The absorbance data are plotted against the standard concentration, a calibration relationship similar to that in **Figure 1.8** is established. Over the region where the Beer's Law relationship is observed, the calibration yields a straight line. As the concentration and absorbance increase, nonideal behavior in the absorption process can cause a deviation from linearity, as shown in **Figure 1.8**.

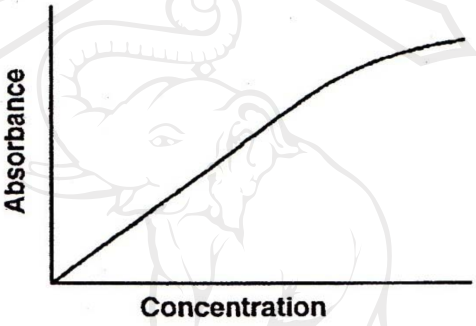

Figure 1.8 Concentration versus absorbance [35].

Concentration measurements are usually determined from a working curve after calibrating the instrument with standards of known concentration.

1.5.4 Accurate background correction

Background correction is necessary to remove absorption signals that are not due to the analyte. Unlike flame analyses, background correction is required for all types of samples analyzed with the graphite furnace. It is an extremely important part of stabilized temperature platform furnace (STPF) and should be used routinely. Zeeman-effect background correction has been of particular importance in achieving improved performance with the graphite furnace. Use of Zeeman-effect background correction with the stabilized temperature platform furnace (STPF) technique has made the analytical situation more independent of the matrix. Detection limits do not appear to be different when aqueous solutions with and without large background effects are compared (except for the calculable reduction of the radiant intensity due to background absorption).

1.5.5 Advantages of the graphite furnace technique

Detection limits for the graphite furnace fall in the ng/l range for most elements. The sample is atomized in a very short period of time, concentrating the available atoms in the heated cell and resulting in the observed increased sensitivity. Even through this technique used only microliter sample volumes, the small sample size is compensated by long atom residence times in the light path. Thus, this technique is a favorable method for determination of elements at very low concentration, and it also has high sensitivity, selectivity and much less interference.

The graphite furnace is much more automated than the other technique. Even through heating programs can be very sophisticated, the entire process is automated once the sample has been introduced and the furnace program initiated. Automatic samplers make completely unattended operation for graphite furnace atomic absorption possible.

Early experiences with the graphite furnace were plagued with interference problem, requiring detailed optimization procedures for every sample to obtain accurate results. However, extensive studies into the history of the furnace technique combined with the development of improved instrumentation have changed furnace atomic absorption into a highly reliable, routine technique for trace metal analysis.

The final and most obvious advantage of the graphite furnace is its wide applicability. The graphite furnace can determine most elements measurable by atomic absorption in a wide variety of matrices.

1.6 Ion exchange chromatography [37]

Ion exchange materials are insoluble substances containing loosely held ions which are able to be exchanged with other ions in solutions which come in contact with them. These exchanges take place without any physical alteration to the ion exchange material. Ion exchangers are insoluble acids or bases which have salts which are also insoluble and this enables them to exchange either positively charged ions (cation exchangers) or negatively charged ones (anion exchangers).

A bead of resin can be used either to remove unwanted ions from a solution passed through it or to accumulate a valuable mineral from the water which can later be recovered from the resin. Examples of the removal of unwanted ions are the removal of heavy metals from metal trade wastes. They can be used to remove interfering ions during analysis or to accumulate trace quantities of ions from dilute solutions after which they can be concentrated into a small volume by elution.

1.7 Wastewater [38-39]

Water is also used in many industrial processes and machines, such as the steam turbine and heat exchanger, in addition to its use as a chemical solvent. Discharge of untreated water from industrial used is pollution. Pollution includes discharged solutes (chemical pollution) and discharged coolant water (thermal pollution). Industry requires pure water for many applications and utilizes a variety of purification techniques both in water supply and discharge.

Wastewater is mainly comprised of water (99.9%) together with relatively small concentrations of suspended and dissolved organic and inorganic solids. Among the organic substances present in sewage are carbohydrates, lignin, fats, soaps, synthetic detergents, proteins and their decomposition products, as well as various natural and synthetic organic chemicals from the process industries. Increased use of metals and chemicals in process industries has resulted in generation of large quantities of effluent that contain high level of toxic heavy metals and their presence poses environmental–disposal problems due to their non-degradable and persistence nature. In addition mining, mineral processing and extractive-metallurgical operations also generate toxic liquid wastes. Wastewater also contains a variety of inorganic substances from domestic and industrial sources, including a number of potentially toxic elements such as arsenic, cadmium, chromium, copper, lead, mercury, zinc, etc.

The treatment is important that wastewater must be properly treated before release to the environment. Pollution caused by untreated water can have a damaging ecological impact that can harm native fish and aquatic plants. In extreme cases especially release of pollutant at catchment areas whereby supply of water is collected for human and household consumption, this could cause toxic accumulation and health impact in the long run. Thus, it is imperative that every industrial sectors and major cities have proper wastewater treatment plant to reduce the COD and BOD level, remove organic matter and toxic compounds before releasing the water to general drainage.

1.8 Research Objectives

The main proposes of this research are as follows:

1. To study analytical techniques used for speciation of tin in wastewater from the electronic industry
2. To study the speciation of tin ions in wastewater from the electronic industry