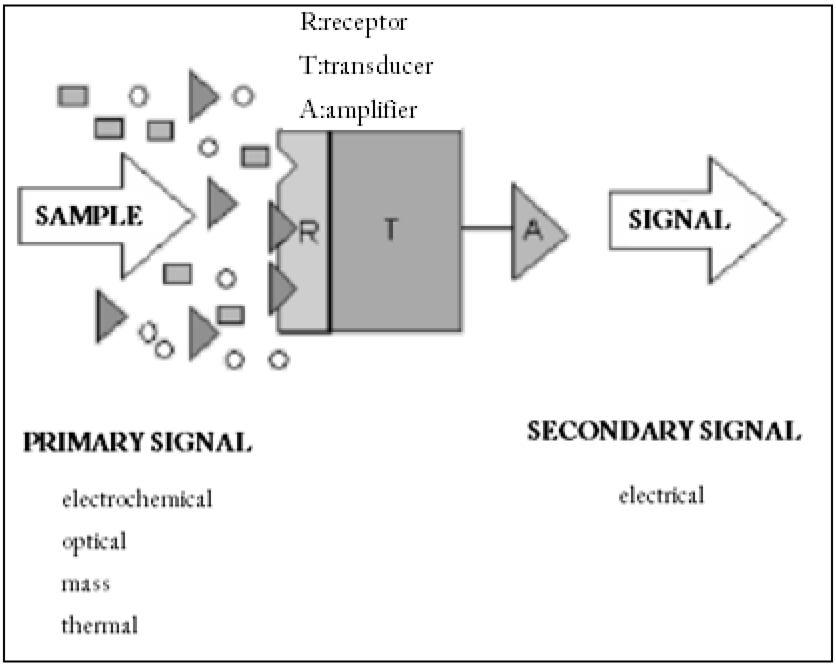
CHEMICAL SENSORS

1. DEFINITION

A chemical sensor is a device that transforms chemical information (composition, presence of a particular element or ion, concentration, chemical activity, partial pressure…) into an analytically useful signal. The chemical information, mentioned above, may originate from a chemical reaction of the analyte or from a physical property of the system investigated. They can have applications in different areas such as medicine, home safety, environmental pollution and many others.

2. COMPOSITION

Chemical sensors usually contain two basic components connected in series: a chemical (molecular) recognition system (receptor) and a physicochemical transducer. In the majority of chemical sensors, the receptor interacts with analyte molecules. As a result, its physical properties are changed in such a way that the appending transducer can gain an electrical signal.



- Receptor: The function of the receptor is fulfilled in many cases by a thin layer which is able to interact with the analyte molecules, catalyze a reaction selectively, or participate in a chemical equilibrium together with the analyte. The receptor layer can respond selectively to particular substances or to a group of substances. The term *molecular recognition* is used to describe this behavior. Among the interaction processes, the most important for chemical sensors are adsorption, ion exchange and liquid-liquid extraction. Primarily these phenomena act at the interface between analyte and receptor surface.

- Transducer: Nowadays, signals are processed almost exclusively by means of electrical instrumentation. Accordingly, every sensor should include a transducing function, i.e. the actual concentration value, a non-electric quantity must be transformed into an electric quantity, voltage, current or resistance. Some of them develop their sensor function only in combination with an additional receptor layer. In other types, receptor operation is an inherent function of the transducer.

3. EXAMPLES

- **CARBON MONOXIDE DETECTOR**

It is a device that detects the presence of the carbon monoxide (CO) gas. CO is a colorless and odorless compound produced by incomplete combustion. It is also known as "silent killer" because it is virtually undetectable without using detection technology. Elevated levels of CO can be dangerous to humans depending on the amount present and period of exposure. Smaller concentrations can be harmful over longer periods of time while increasing concentrations require less exposure times to be harmful.

Carbon monoxide detectors trigger an alarm based on an accumulation of carbon monoxide over time. Detectors may be based on a chemical reaction causing a color change, an electrochemical reaction that produces current to trigger an alarm, or a semiconductor sensor that changes its electrical resistance in the presence of CO.

While CO detectors do not serve as smoke detectors and *vice versa*, dual smoke/CO detectors are also available. Smoke detectors detect the smoke generated by flaming or smoldering fires, whereas CO detectors detect and warn people about dangerous CO buildup caused, for example, by a malfunctioning fuel-burning device. At home, some common sources of CO include open flames, space heaters, water heaters, blocked chimneys or running a car inside a garage.

- **GLUCOSE DETECTOR**

Blood glucose monitors are devices that are used to measure the concentration of glucose within a person's blood. Along with the term blood glucose this reading is also often referred to as blood sugar. Most basic blood glucose monitors have three separate parts that are required for them to work properly: a lancer, a test strip and the meter itself.

Blood glucose monitors measure the amount of sugar in a sample of blood using a complex chemical process. Within the test strip the blood is mixed with glucose oxidase, which reacts with the glucose in the blood sample to create gluconic acid. Another chemical within the test strip, called ferricyanide, then reacts with the gluconic acid to create ferrocyanide. The electrode within the test strip then runs a current through the blood sample and the ferrocyanide influences this current in such a way that the concentration of blood glucose within the sample can be accurately measured within a fair margin o of error.

- **MOSQUITO**

Mosquitoes have a battery of sensors in their antennas and one of them is a chemical sensor. They can sense carbon dioxide and lactic acid up to 36 meters away. Mammals and birds release these gases when they breathe. Certain chemical in sweat also seem to attract mosquitoes. This is the reason that those who sweat more easily will tend to attract more mosquitoes.

- **PREGNANCY TEST**

While there are a number of ways to chemically test for pregnancy, the easiest and most reliable test is one that looks for the presence of the hormone known as human chorionic gonadotropin, or hcG. hcG is produced by the placenta and can be found in a woman's system as soon as implantation of a fertilized egg has occurred.

The most common way to test for hgC, as well as one of the most accurate, is a home pregnancy test, which works through the use of lateral flow technology. A lateral flow test is a type of chemical analysis test which is commonly used to test liquids for the presence of a specific substance, such as drugs, hard water chemicals or hormones.

When urine is collected on the test strip of a home pregnancy test, it then moves across the strip by way of wicking action. Stretched across the test strip is a membrane made of nitrocellulose, a material used because it assists the movement of proteins. As the urine comes into contact with the membrane, it mixes with colored particles present in the nitrocellulose. Then, as the mixture of urine and color moves along the membrane, it comes in contact with a test line. This line contains antibodies for the hcG which, if they come into contact with the mixture, will trap particles in place, creating a colored line. When the liquid moves to the end of the membrane, the color solution is caught at a second test line. This line also contains an antibody, but this antibody will catch the color particles whether or not the solution contains hcG. This means that the second line will appear for both positive and negative results, but if both lines appear, the test is confirmed positive.

4. NANOTECHNOLOGY AND CHEMICAL SENSORS

Nanomaterials and nanotechnology are new fields of science and technology. Nanotechnology is still in its infancy, as it has become a hot area only a few years ago. However, nanotechnology is expected to dramatically change operating characteristics of chemical sensors and will probably gain in importance in all fields of sensor application over the next ten to twenty years. It has been found that with reduction in size, novel electrical, mechanical, chemical, catalytic and optical properties can be introduced. Besides it was established that 1-D structures can be ideal system for studying the nature of chemical sensing effects.

Nanotechnology enables us to create functional materials, devices, and systems by controlling matter at the atomic and molecular scales, and to exploit novel properties and phenomena. Consider that most chemical and biological sensors, as well as many physical sensors, depend on interactions occurring at these levels and you'll get an idea of the effect nanotechnology will have on the sensor world.

Nanotechnology can be used to fabricate sensors that detect very small amounts of chemical vapors. Various types of detecting elements, such as carbon nanotubes, zinc oxide nanowires or palladium nanoparticles have been already used in nanotechnology-based sensors. These detecting elements change their electrical characteristics, such as resistance or capacitance, when they absorb a gas molecule. Due to the small size of such nanotubes, nanowires, or nanoparticles, a few gas molecules are sufficient to change the electrical properties of the sensing elements. This allows the detection of a very low concentration of chemical vapors. The goal is to have small, inexpensive sensors that can sniff out chemicals just as dogs are used in airports to smell the vapors given off by explosives or drugs.

As a conclusion, nanosensors and nano-enabled sensors have applications in many industries, among them transportation, communications, building and facilities, medicine, safety, and national security, including both homeland defense and military operations. Consider nanowire sensors that detect chemicals and biologics, nanosensors placed in blood cells to detect early radiation damage in astronauts, and nanoshells that detect and destroy tumors. Many start-up companies are already at work developing these devices in an effort to get in at the beginning.