

# The commercial use of enzymes



**ASSIGN  
BUSTER**

Throughout this project I will be looking at the use of enzymes in industry. I will focus my thoughts onto the medical area and furthermore onto the portable medical devices.

This will include looking at biosensors in great detail along with medical test strips. Enzymes are chemical catalysts; this means that they increase the rate of chemical reactions without being consumed in the process. The exact nature of how enzymes work is not known. The majority of the reactions that occur in living organisms are enzyme controlled and without them, the reactions that are necessary for the organisms to function would be reduced to a rate too slow as to cause serious/fatal damage. Without enzymes, toxins would rapidly build up in the organism and the supply of respiratory substrate would fall.

Most enzymes are proteins which themselves are polymers of amino acids (A few rib nucleoprotein enzymes have been discovered and, for some of these, the catalytic activity is in the RNA part rather than the protein part). This means that they have a specific shape. Therefore an enzyme is specific in the reactions that they catalyse (one enzyme will only react with one molecule of a substrate). The site on the surface of the enzyme where the reactions take place is known as the active site. The active site for all the molecules of one enzyme is made up of the same arrangement of amino acids and therefore makes the active site a highly specific form.

There are two theories on how the substrate binds to the enzyme to react: The Lock and Key Theory - This theory was first put forward in 1894 by Emil Fisher who described the specific action of an enzyme with a single substrate

as being the same as how a lock and key works. As like a lock and key, only the specific substrate fits into the active site of the enzyme. Substrates without the correct qualities/features will not be able to bind with the active site on the enzyme. This theory is represented in the diagram below.

**Induced Fit Theory** – This came about as a modification to the previous theory due to the fact that some experimental evidence could not be explained by the lock and key theory. This theory assumes that the enzyme is partially flexible and the substrate plays a role in determining the final shape of the enzyme. In other words the substrate induces the active site to change shape. This explains why certain compounds can bind with the enzyme but reactions don't occur as the enzyme has been deformed too much. Other molecules may be too small as to induce the proper alignment and therefore no reactions can occur. Only the correct substrate can bring on the correct shape of the active site.

This theory is represented in the diagram below. Read also The lack of specific enzymes can cause various disorders. These include albinism, diabetes, and cystic fibrous.

All three are traceable to either a lack of a specific enzyme or an imbalance of one. An example of a place that is thriving with enzymes is the human digestive tract and the saliva. The saliva contains salivary amylase, an enzyme that breaks down starch to glucose. While the stomach combines the enzyme pepsin with dilute hydrochloric acid to speed the digestion of proteins. Enzymes are carried to the intestines to smooth the progress of the digestion of fats.

Biosensors The ability of enzymes to recognise specific molecules means that they can be used in special ways. They can be used as molecular probes or biosensors. A biosensor is an instrument for quickly and easily carrying out a diagnostic test. The electromical biosensor contains an immobilised enzyme, which reacts with the substrate molecule to be detected. This change transmits a small electric current to a transducer\*, this small electric current is then transduced into an electrical signal. (The change might be the formation of a product, the movement of electrons during it, or even the emission of light).

The small electrical current is proportional to the amount of product and therefore the amount of product can be converted onto a digital LCD display. The digital read out takes roughly twenty seconds to appear and gives a precise measure of the concentration of the substrate.\* A transducer is an electrical device that can register chemical changes and convert them into an electrical signal. This signal can then be amplified.

A diagram of the mechanics of a typical electromical biosensor is shown at the top of the following page. A successful biosensor must possess at least some of the following beneficial features: 1. The biocatalyst must be highly specific for the purpose of the analysis and be stable under normal storage conditions. 2. The reaction should be independent of factors such as temperature and pH (as much as possible).

This would allow the analysis of samples with minimal pre-treatment. 3. If the biosensor is to be used for invasive monitoring in clinical situations, the probe must be small and biocompatible, having no toxic or antigenic effects.

If it is to be used in fermenters it should be sterilisable. 4. The biosensor should not be prone to fouling or proteolysis.

5. The complete biosensor should be cheap, small, portable and capable of being used by semi-skilled operators. 6. There has to be a market for biosensors, clearly without a market there will be no use in making them. An example for the use of biosensors is measuring glucose levels in the blood/urine.

This is very important for diabetics, as they have to constantly maintain a controlled blood-glucose level. This biosensor works using the enzyme glucose oxidase. This is immobilised\* in a gel (semi permeable cellophane acetate membrane) attached to a silicone-sheathed platinum oxygen electrode. This measures the concentration of oxygen dissolved in a solution.

When the tip is placed in a drop of blood, glucose within the blood diffuses into the pores of the gel. This uses up the oxygen in the enzyme as it has to break down the glucose. The electrode monitors the oxygen levels and converts it to an electrical signal. This is transduced and sent to a display that has been pre-calibrated to show the amount of glucose in the blood.\*When an enzyme is immobilised it means that it is not in a solution but instead attached to or trapped within an insoluble material. These are much more useful than free enzymes, as:

- o They are much more thermo stable (stable at high temperatures).

- o They are more resistant to changes in pH.
- o They are less likely to be degraded by organic solvents.
- o The products are uncontaminated by enzyme and can be collected more easily.
- o The enzyme can be retained and

<https://assignbuster.com/the-commercial-use-of-enzymes/>

re-used. o Use of columns of immobilised enzyme allows automation of the industrial process.

(All of these factors are important when scaling up the use of enzymes to a commercial level.)The first attempt to use a biosensor was in 1962 by a man named Professor Leland C. Clark. The first biosensor made was a simplified version of the glucose oxidase biosensor described above.

This type of sensor was initially used by surgeons to monitor the blood-glucose levels of their patients during surgery. Apart from electromical biosensors there are two other important biosensors; optical biosensors and immuno biosensors. Optical biosensors are the second major family of biosensors (after electromical biosensors) to be exploited commercially. These biosensors pick up characteristic light properties (wavelength, fluorescence) emitted by certain molecules or a light source emitted by the sensor itself, onto the sample to be measured. These properties are absorbed by optic fibres covered in a biological element.

Molecules present at the surface of the fibre will absorb certain wavelengths of incoming light. The light that passes through the biological layer is measured. The outgoing spectrum will be different from the incoming one and therefore the difference can be measured. This is then compared with a pre printed reference, which allows the determination of the level of analyte (any material/chemical, subject to analysis).(Even though this type of biosensor is just a sensor that detects light and therefore doesn't use enzymes, it is still worth mentioning, as it is a means of comparing the

different types of biosensors that are commercially used.)Immuno biosensors can accurately detect bacterial pathogens in food products.

This type of sensor follows the same principle of enzyme biosensors but the enzyme catalysed reaction causes antibodies to physically bond to antigens in the sample. When they bond together this gives the reaction/change needed to induce a small current needed for the transducers to convert into a circuit which can, in turn, give a numeric reading. Such sensors promise to speed up detection of harmful bacteria in food processing industries.

Biosensors have a number of key advantages:

- o Fast to use
- o Simple to use
- o Has continuous monitoring capabilities
- o Only a small amount of substance has to be used (a pin-prick of blood for example)
- o Convenient
- o Mass produced and therefore low cost

Biosensors are not just used for medicinal purposes though; currently they are greatly used in the field of agriculture and environmental science for various tasks which include: Testing for nitrates and pesticides in water supplies, testing for alcohol in blood when police stop drink drivers, testing for cholesterol in blood as a dietary measure, meat probe which looks for decay by measuring the sugar content in meat etc. Biosensors also greatly simplify the workload of doctors, the police and analytical chemists. There are hundreds of uses for a biosensor in all different industries but I was mostly interested in their medical applications and therefore used medical tests as the main example of operation.

**Enzyme Biochip**The miniaturisation of biosensors has led to the development of probes where the enzyme is immobilised on the surface of a silicon chip, making a ' biochip'. These biosensors are miniscule, some measuring only

<https://assignbuster.com/the-commercial-use-of-enzymes/>

2mm across. One of these biochips has been developed to detect blood glucose levels, again using the immobilised enzyme glucose oxidase but this time measuring the amount of gluconic acid produced. These biochips are so small and because they are self-contained, it may soon be possible to implant them under the skin. This would be a huge advance to medical science and would greatly benefit diabetic sufferers (and the like), as they would be able to get a reading of their blood-glucose levels wherever or whenever needed.

Test Strips Enzymes are widely used in test strips because of their specificity. Their specificity enables them to identify one type of molecule in a mixture of different types. They are also very sensitive and therefore can measure the amount of substance even if they are present in low concentration. The test strips used to measure glucose in urine samples are another example of the use of enzymes in the analysis of small quantities of biochemicals.

These strips contain two chemical enzymes. These enzymes are glucose oxidase and peroxidase and a colourless hydrogen donor compound called chromagen. When the strip is dipped in the urine sample the glucose oxidase catalyses the oxidation of glucose to gluconic acid and hydrogen peroxide. Once this has happened the hydrogen peroxide produced then oxidises the colourless chromagen and by removal of the hydrogen, the chromagen gains colour. The second reaction is catalysed by peroxidase and the more glucose present in the urine; the more coloured dye is formed.

An equation for this whole process is shown below: The colour is then compared to a universal printed scale to indicate the amount of glucose



present in the urine. A diagram of a glucose test strip is shown below: Test strips aren't as accurate as biosensors as they only show a colour as apposed to a digital numeric reading. The strips can only be used once unlike biosensors that can be used time and time again. The benefit of test strips over biosensors is that they cost a great deal less as they are just a piece of card/plastic rather than an electronic device.

Recent advances in biochemistry, molecular biology, and immunochemistry have expanded the range of biological sensing elements, improving assay selectivity and sensitivity, while the advent of diode and LEDs has enabled the development of small, inexpensive optical biosensors. In addition, developments in fiber optics and microelectronics have yielded signal transducers that are smaller and more durable, and which offer improved signal/noise ratios and reduced manufacturing costs. These two points along with the ever advancing bio sensor chips show that the market for biosensors will always be here and as long as they remain useful to both the general public and businesses, they will continue to progress as fast as technology will allow. The demand for chemical sensors in the US is predicted to grow 8.

6 percent annually through 2006. Optical sensors and biosensors are predicted to grow the fastest, although nearly all products will benefit from improving performance, lower costs and the penetration of new, large-volume markets. The large medical/diagnostic segment should continue to offer the best opportunities.