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Bioreactor: Design of Bioreactor and its Types

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Editorial note

Any manufactured equipment or system that supports a biologically active environment is referred to as a bioreactor. A bioreactor is a vessel in which a chemical process involving organisms or biochemically active compounds produced from such organisms is carried out. This process might be aerobic or anaerobic in nature. These bioreactors are typically cylindrical in shape, with sizes ranging from liters to cubic meters, and are frequently composed of stainless steel. In the context of cell culture, it can also refer to a device or method for growing cells or tissues. These devices are being created for tissue engineering and biochemical/bioprocess engineering applications.

A bioreactor can be characterized as batch, fed batch, or continuous depending on how it operates (e.g. a continuous stirred-tank reactor model). The chemostat is an example of a continuous bioreactor. Because bioreactors are highly nonlinear, a variety of unique control mechanisms have been developed.

In bioreactors, organisms can be submerged in liquid medium or affixed to the surface of a solid medium. Suspended or immobilized submerged cultures are possible. Because particular attachment surfaces are not required, suspension bioreactors can use a wider range of organisms and function at a far larger scale than immobilized cultures. The organisms, on the other hand, will be evacuated from the reactor with the effluent in a constantly running process. Immobilization is a broad term that encompasses a wide range of cell or particle attachment and trapping techniques.

It can be used on enzymes, cellular organelles, animal and plant cells, and almost any other sort of biocatalyst. Because the organisms will not be eliminated with the reactor effluent, immobilization is beneficial for continuously running processes, but it is limited in size because the bacteria are only present on the vessel's surfaces.

Design of Bioreactors

The subject of biochemical/bioprocess engineering studies bioreactor design, which is a relatively challenging engineering problem. Microorganisms or cells can execute their desired purpose with little impurity formation under ideal conditions. Temperature, nutrient concentrations, pH, and dissolved gases (particularly oxygen for aerobic fermentations) all have an impact on the organisms' development and production inside the bioreactor. A cooling jacket coils, or both maintain the temperature of the fermenting medium. Exothermic fermentations, in particular, may necessitate the usage of external heat exchangers.

Nutrients can be added to the fermenter on a continuous basis, as in a fed-batch system, or charged into the reactor at the start of fermentation. Depending on the fermentation, the pH of the medium is measured and changed with small amounts of acid or base. The addition of reactant gases (particularly oxygen) to aerobic (and some anaerobic) fermentations is required. Air (or purified oxygen) must be regularly provided because oxygen is highly insoluble in water (the base of practically all fermentation media).

The rising bubbles aid in mixing the fermentation medium while also "stripping" waste gases like carbon dioxide. Bioreactors are frequently pressured in practice, which improves the solubility of oxygen in water. Optimal oxygen transport is sometimes the rate limiting stage in an aerobic process. Oxygen is poorly soluble in water, and even less so in warm fermentation broths, and is scarce in the atmosphere (20.95 %). Agitation, which is also required to combine nutrients and keep the fermentation homogenous, aids oxygen transmission. Air bubbles are broken up and circulated around the vessel using gas dispersing agitators.

Fouling can reduce the bioreactor's overall efficiency, particularly the heat exchangers. The bioreactor must be easy to clean in order to avoid this. Stainless steel is commonly used for interior surfaces to make cleaning and sanitation easier. Typically, bioreactors are cleaned in between batches or are engineered to minimize fouling when running continuously. A cooling jacket can be used to cool small vessels, while bigger vessels may require coils or an external heat exchanger.

Types of Bioreactor

Photo Bioreactor

A Photo Bioreactor (PBR) is a type of bioreactor that includes a light source (that may be natural sunlight or artificial illumination). A PBR could be any translucent container; however the word is more usually used to refer to a closed system than an open storage tank or pond. Small phototrophic organisms such as cyanobacteria, algae, and moss plants are grown in photo bioreactors. These organisms do not require carbohydrates or lipids as an energy source and instead rely on light through photosynthesis. As a result, when compared to bioreactors for heterotrophic organisms, the danger of contamination with other organisms such as bacteria or fungi is lower in photo bioreactors.

Sewage Treatment

The primary purification steps in conventional sewage treatment are carried out in bioreactors. A chemically inert medium with a large surface area is used as a substrate for the formation of biological film in some of these systems. Excess biological film is separated using settling tanks or cyclones. Aerators provide oxygen to the sewage and biota in other systems, resulting in activated sludge, in which the biological component is freely mixed in the liquor in "flocs."

The Biochemical Oxygen Demand (BOD) of the liquid is lowered sufficiently in these techniques to make the contaminated water fit for reuse. Bio solids can be collected and processed further, or they can be dried and utilized as fertilizer. A septic tank is a very simple sewage bioreactor in which the sewage is left in place, with or without supplementary media to house microorganisms. In this case, the bacteria's primary host is the bio sludge itself.

Bioreactors for Specialized Tissues

Many cells and tissues, particularly those found in mammals, require a surface or other structural support to thrive, and disturbed environments are typically harmful to many cell types and tissues. Auxotrophic organisms require extremely specialized growth medium as well. When the goal is to cultivate greater amounts of cells for therapeutic production, this presents a difficulty since a design that is fundamentally different from that employed in commercial bioreactors for growing protein expression systems like yeast and bacteria is required.

In order to replicate organ-like tissue architectures in vitro, many research groups have built innovative bioreactors for growing specialized tissues and cells on a structural framework. Tissue bioreactors that can generate heart tissue, skeletal muscle tissue, ligaments, cancer tissue models, and other tissues are among them. Scaling up the manufacturing of these specialized bioreactors for industrial usage is still a challenge, and it's a hot topic of research right now.