The Anflow System

In 1974 and 1975, Seed Money researchers developed a new, highly efficient flow-through system for processes that use microorganisms, or bacteria, to convert organic matter into more beneficial products. Two common examples of such processes are the fermentation of grain into beer and the processing of municipal waste into clean water.

The new system, called ANFLOW, performs such functions more quickly and less expensively than conventional methods. Two important factors contributing to these advantages are the use of a special class of bacteria, called anaerobic bacteria because they live and thrive in the absence of oxygen, and the use of a steady-state, continuous flow method of processing. ANFLOW derives its name from the two words anaerobic and flow.

In bioconversion processes, continuous flow systems have long been known to have a number of advantages over so-called batch methods. Unlike continuous flow systems, batch methods require containment of the organic matter and the bacteria in large fermentation vessels or vats for long periods of time. Such methods tend to be slow and occupy large amounts of space. They require expensive machinery and monitoring instruments. They also consume large amounts of energy in maintaining precisely controlled temperatures and environments as the biological reactions take place over time in increasing concentrations.

The ANFLOW system, by contrast, processes organic matter in a continuous, steady-state mode of operation. It is inherently simpler and occupies less space. It exhibits higher yields, produces less by-product waste, and reduces processing time from days to a matter of hours.

Although the ANFLOW system, since patented, is a generalized one with many applications, one of its first uses was to convert municipal wastes into a harmless effluent suitable for discharge into rivers and streams. Laboratory testing showed that the ANFLOW system treated sewage at higher loading rates than the prevailing activated sludge process.

Technically speaking, the ANFLOW system is an upflow, packed-bed bioreactor. Prior to its development, there had always been a number of serious difficulties in using anaerobic bacteria in flow systems.

Seed Money researchers overcame these difficulties in two ways. First, they made use of an upflow, packed column of organic liquids to keep the biosystem free of air, using a concept first developed at Stanford University. Second and importantly, they developed a special packing material and coating.

The combination of the special packing material and coating immobilized the microorganisms so that they did not flow out of the system as the organic matter passed by. Also, it enabled the researchers to control the rate of bacterial growth, which optimized efficiency and kept the system from clogging. Finally, the packing material greatly expanded the available surface area inside the bioreactor. This increased the production yield and reduced the concentrations per unit surface area of certain chemicals in the waste stream that otherwise might kill the functioning bacteria.

Pursuing this line of research, the Seed Money researchers investigated several methods by which the live cells could be fixed or immobilized in the packed bed. They coated small ceramic shapes, such as saddles, rings, or glass spheres, each about the size of a grain of sand, with an adhesive material called a polyelectrolyte, and loaded them into the column. The polyelectrolyte was then chemically activated and cross-linked to form an interconnected structure that trapped microorganisms on its surface and accumulated them in the packing spaces.

Laboratory tests showed that, as a result, the bacteria remained healthy and intact (immobilized) as the process stream passed over the surfaces and through the packed bed. Biological activity increased. After 2 years of successful operation, no clogging had occurred.

This success paved the way for the advancement from batch type bioconversion processing to continuous flow type systems in a wide range of other applications. In one experiment, the ANFLOW system increased the conversion efficiency of glucose to ethanol (grain alcohol) by 50 percent over conventional methods.

ANFLOW has also been tested and showed promise in a number of other areas. These include: converting organic wastes to fuel gas, converting cottage cheese whey to lactic acid, processing coal liquefaction wastes to remove dissolved carbon, breaking down cellulosic products into glucose, and converting methane into methanol (wood alcohol).

Moreover, the utility of the ANFLOW system itself may be further and dramatically increased by the availability of improved anaerobic bacterial strains. This is a line of research that has been encouraged by the above developments.

Two ANFLOW units have been installed and operated. The first was a 5,000 gallon per day (GPD) waste treatment pilot facility in Oak Ridge, Tennessee. This project benefited from the participation of the Norton Chemical Company, a private firm interested in the commercial development of the ANFLOW system. This installation helped Norton meet waste water discharge standards with a highly efficient and economic process.

A 50,000 GPD plant was built in Knoxville, Tennessee, and operated in 1980 and 1981 by the city of Knoxville and the Department of Energy. Glitsch Manufacturing Company provided the ceramic rings for packing the bed. The unit successfully demonstrated process scale-up, treating both municipal and industrial wastes.