Guest Editorial

MEMBRANES AND BIOTECHNOLOGY

Why link membranes and bioengineering? Research on synthetic membranes has a long history, and a special focus on membrane technology has been important for at least ten years, as demonstrated by this Journal. Biotechnology has also been the focus of attention, especially since the advent of antibiotics. A prominent journal in this field, *Biotechnology and Bioengineering,* has been published for the past 25 years. So, what has occurred recently to bring membrane technology and biotechnology closer together? One important development has been the recent breakthroughs in biology, namely recombinant DNA and hybridoma methodologies.

These capabilities have made possible some new industrial processes for the production of highly valuable substances. Some of these new processes are costly because they can biosynthesize products only in small amounts. For substances like protein hormones and growth factors, procedures must be gentle so as not to denature the proteineous product. In some cases, cells require unusual nutrition in a somewhat protective environment in order to yield certain products, and in these unique "bioreactors," maintaining sterility is critical. Thus, these new processes, with their special requirements, have led to the search for new approaches to separation, isolation, and measurement, and have allowed the consideration of new culturing configurations and separation processes based on synthetic membranes. Although expensive to develop, if proved efficacious and demonstrated to conserve these valuable materials, the industrial implementation of these new membrane-based techniques would certainly be promoted.

Membranes have characteristics that are particularly suitable for biotechnology applications. First of all, they usually can be operated at ambient temperatures, since the driving forces normally utilized for transport across membranes are based on concentration, electric field, or pressure gradients. Second, many membrane systems are designed to perform best with aqueous solutions, which is often the milieux of biochemical processes. Third, membranes can act as a barrier, providing sterility or preventing contamination of the products. This property is particularly important where membranes are a part of the culture system, e.g., where the selective removal of products is effected *in situ.*

Another factor that has drawn the fields of membrane research and biotechnology together lies in the sociology of research. Some of the most creative minds in biological research are involved in the "new" biotechnology. These individuals are driven to seek new solutions to their problems, and they are not afraid to branch into new territories. They have already redefined the boundaries of traditional approaches. Membranologists also tend to be a venturesome breed of bright scientists and engineers, building careers on promising new techniques. Thus, in recent years there has been an unusual symbiosis of research breakthroughs and technical needs – a stimulation of creative research in membranes, driven by the needs of biotechnology. This issue of the *Journal of Membrane Science* reflects some of the fruits of this interaction.

Let's review some of the properties of membranes that have led to innovative applications in biotechnology. Membrane structures can be categorized as continuous or porous. Those that are continuous provide a new material phase that can be used to separate parts of the process system. As a new phase, a number of properties can be modified and controlled to provide unique process capabilities. These include solute-distribution coefficients that can be "tuned" to extract selected substances, transport rates that can be modulated to effect a separation of very similar materials, and the capability to incorporate reactants or catalysts that can selectively transform particular compounds into desired products. Those that are porous allow separation of solutes based on size and shape. Membranes introduce new degrees of freedom into process designs, e.g., a variety of configurations – hollow fibers, tubes, sheets, spirals, and the like – that can be harnessed by creative new designs.

The development of new membrane applications for biotechnology is limited by the availability of membrane materials in forms that can be readily utilized in process development. Although membranes can be formed from most polymers, most polymers are not available in the form of membranes. Thus, for the most part, designers are restricted to membranes and membrane "modules" that are available from relatively few suppliers. On the other hand, because some membrane applications are well established, modules and membrane materials used in these applications are available as articles of commerce, and then can sometimes be modified for testing new processes or membrane applications.

Some of the problems with the modification of commercial membrane modules are related to materials. For example, if the surface properties of the membrane are changed to make it more biocompatible or selectively absorptive, the integrity of the membrane may be compromised, reducing its strength or long-term stability. If a module must be sterilized by heat or radiation, the adhesives and sealants may be affected, thus weakening the module. One can expect these problems to be overcome through membranologists and biotechnologists working together in the early stages of process development to customize the design of the membrane system.

Another use of membranes in biotechnology is in the development of novel monitoring techniques and biosensors. The composition of the media and solutions associated with biotechnical processes are usually very complex and not amenable to ready analysis. This problem has led to new ways of using membranes for sampling process streams by ultrafiltration, dialysis, and gas-permeable membranes (mass spectrometry). Further, a number of new approaches are under development for measuring metabolites and products directly in the culture media. These sensors are based on a variety of principles, including ion-selective electrodes, enzyme reactions, immunoassays, and bioreceptor binding. In almost all of these approaches, at least one membrane is required to provide a protected environment for the active selective-sensor chemistry. In some cases, several membranes are used to make multiple compartments. One of the major research needs for these applications are methods for depositing membranes that have the required properties onto the very small areas of the sensors, and methods for securing membranes to these minute devices.

Potentially, a major outcome of the interaction between the fields of biotechnology and membrane technology is the development of new synthetic membranes based on imitating the structure and function of biological membranes. Membranes comprise some of the most elegant and exquisitely engineered structures of biological cells; they have the ability to selectively transport substances and messages between the cell and its environment. As the science of biology progresses to identify and understand the mechanism of membrane transport in living cells, our capability to create similar, synthetic systems that can be used in industrial processes could foster an even greater era of membrane research than the one we are currently witnessing.

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