High-Productivity Bioreactor

Batch fermentation processes using microorganisms suspended directly in the fermenting broth suffer from low product yields, accumulation of impurities which contaminate the desired product, and the loss of microorganisms from the batch when processing is completed. In order to increase productivity sufficiently for economically competitive industrial fermentation processes, it will be necessary to use more efficient continuous processing techniques. DOE research in continuous fermentation processes has increased ethanol productivity by greater than an order of magnitude in an advanced fluidized bed reactor system. The study of the kinetic properties of immobilized microorganism biocatalysts has led to a better understanding of the behavior and predictability of bioreactors. The A.E. Staley Company has expressed interest in the research and has provided raw corn dextrose slurry and corn light steep water (LSW) for laboratory tests. Experiments in a continuous stirred tank reactor using yeast extract as a nutrient source have been completed. The steady-state productivity was not changed when glucose was substituted for crude corn dextrose or when yeast extract was replaced with a 1:5 dilution of LSW. The only operational difficulty was some fouling because of the high lipid content of corn dextrose. During the 300-hour run, 25 grams/liter-hour of ethanol were produced at a 90 percent conversion rate. These results suggest that higher productivities for a fluidized-bed column at greater than 200 grams/liter-hour are possible when industrially acceptable feedstocks and media such as corn dextrose and LSW are used.

Base Oil Separation and Characterization

The American Society of Mechanical Engineers Research Committee on Lubrication has estimated that friction and wear losses in all mechanical systems account for up to 11 percent of total annual U.S. energy consumption. A wide variety of lubricants are currently required for mitigating energy losses from friction and wear in many important advanced energy conversion applications. To formulate better lubricants and establish lubricating base oil specifications and standards, an understanding of the influence of the molecular structure of the lubricant on its friction/wear characteristics needs to be developed. An extensive series of experiments on determining the tribological properties of base stock oils has been completed under DOE funding. Three lubricating base oils of various viscosity grades from Mideastern crudes were separated into various molecular compound classes using high-performance liquid chromatography (HPLC). Characterization of the fractions was made using infrared spectroscopy (IR), high-resolution mass spectroscopy (HRMS), nuclear magnetic resonance spectroscopy (NMR), Fourier Transform infrared spectroscopy (FTIR), and elemental analysis. Each compound class was subjected to microsample, four-ball wear testing for friction/wear characterization and free radical titration testing for oxidation stability. Results indicated that the organic acids subfraction of the polar fraction of the mideast 600 neutral base oil exhibited the lowest coefficient of friction. Having isolated and characterized the desirable components of base stock oils, researchers should now be able to further investigate and understand the relationship between the molecular structure and the lubricating qualities of base stock oils and, subsequently, to synthesize the "slipperiest" fraction for formulating superior energy-saving lubricants.

Intermediate and High-Temperature Lubricants

The development of laboratory techniques and procedures is necessary to enable lubrication engineers to characterize and evaluate candidate lubricants with a range of important properties for elevated-temperature and energy-conserving applications. Under DOE funding, a thermogravimetric analysis (TGA) method has been developed for screening candidate high-temperature lubricants. The procedure uses a pair of experiments to obtain measures