

Abstract

The steady decline in fossil fuel reserves means that renewable and sustainable alternatives are becoming increasingly important to explore. A key tool in studying biological process is thermodynamics. Thermodynamics has been successfully used to understand chemical processes and similar techniques can be applied to biological processes. Using continuous data from a chemostat the thermodynamic properties, that is the enthalpy of formation and of maintenance and Gibbs free energy of formation and of maintenance, were estimated for the bacterium *Clostridium Thermolacticum*. The benefit of this method is that the estimated properties are for the living microorganism as they are found in a biological system. The results can be used to predict the possible products based on a given substrate and the thermodynamically feasible region for the system. The feasible region is a useful tool in determining the limits of performance of the system. The estimated maintenance requirements of the microorganism can be superimposed on the feasible region as a vector to show how the requirements of the microorganism affect the product yield. A special case, the maintenance limited case where there is no formation of new biomass, is considered in light of the feasible region and maintenance vector. The maintenance limited case is used to predict the product spectrum when there is no formation of biomass. The feasible region can be extended to consider the effect that additional products and alternative feeds have on the system. For a given feed and possible products is possible to predict the the product spectrum. This approach can be used to determine the maximum amount of biomass that can be formed or how the products are affected when there is no biomass formation. The maintenance requirements of the microorganism

will limit the product spectrum as determined by the maintenance vector. A similar approach is used for the analysis of photosynthesis and combustion. It is shown that, from a thermodynamic point of view, photosynthesis can be treated as the reverse combustion process. This analysis highlights the inefficiencies in the combustion reaction based on the Carnot temperature of the process. In a similar way it is shown that the photosynthetic reaction can be operated at close to reversible due to the Carnot temperature requirements of the process and the entropy associated with light entering the system.