Energy-efficient Conversion of Castor Oil for Biodiesel Production

The production of biodiesel is a field of continuous interest in the energy production sector, as an alternative renewable fuel to replace the use of fossil fuels. Biodiesel is generally produced from the transesterification of vegetable oils and animal fats with alcohol such as methanol. Even though chemicals such as sodium hydroxide and sulfuric acid are the common choice to catalyze the reaction, enzymes can be used as an alternative. The process catalyzed by enzymes is less harmful to the environment and consumes less energy. Meanwhile, enzymes can be used for different raw materials and assure a good product separation after the reaction. However, enzymes are more expensive than chemical catalysts. Common in countries like India, China and Brazil, castor oil can be used for biodiesel production. This oil is different from other oils due to the presence of ricinoleic acid in its composition.

Intending to maximize the reaction yield, the influence of different reaction conditions was evaluated, including the reaction temperature and the amounts of methanol, enzymes and water added in the reaction. Two different enzymes were used: Eversa Transform and Resinase HT. These enzymes were available in a liquid solution. Even though extra addition of methanol could increase the biodiesel production, excess alcohol inhibits the activity of enzymes in the reaction. Under the best reaction conditions, the final product contained 94.3 % of biodiesel using Eversa Transform as catalyst.

Kinetics studies showed that the molecules of triglycerides present in castor oil react simultaneously with methanol and water. Kinetic parameters describing the mechanism of the reactions were obtained.

The complete process for biodiesel production catalyzed by Eversa Transform was simulated and economically evaluated, in order to investigate the feasibility of industrial implementation of this process. For a biodiesel production of 250,000 tons per year, the process resulted in a production cost of 0.76 US$/kg and annual profit of US$ 56 million. For comparison purposes, a process catalyzed by an enzyme in the immobilized form was also simulated. However, because of the higher price of the immobilized enzymes, this enzyme should be reused in the reaction at least 300 times to achieve the same annual profit as when Eversa Transform was used as the catalyst. The environmental impact of these two processes showed that the process with liquid enzyme is more environmentally friendly.

Finally, the recovery and reuse of the liquid enzymes were tested in order to decrease the biodiesel production costs. High biodiesel production was obtained when the enzymes were recovered from centrifugation and reused for three consecutive reactions. However, the amount of enzyme reused should be only half of the required amount of enzymes, while the other half should be enzymes not previously used. The enzyme solutions recovered from centrifugation were filtered with ceramic membranes to eliminate from the solution components that decrease the enzyme performance, such as glycerol and methanol. Compared to the enzyme recovery by centrifugation, the filtration approach increased the production of biodiesel when the enzyme was reused.