

CSTR EXPERIMENT (CONTINUOUS STIRRED TANK REACTOR)

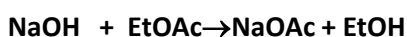
Aim:

1. Improvement of reaction speed expression with batch reactor and continuously stirred reactor data
2. Improving the reaction rate and reaction rate constant temperature dependence with batch reactor and continuous mix reactor data
3. Understand continuous reactor performance and compare with batch reactor
4. Investigation of the effect of mixing speed on the reaction rate

PRELIMINARY INFORMATION

Chemical reactors can be considered as the most important equipment of many chemical processes because of the change of the raw material to the desired product. The reactors may take many different forms depending on the chemical process involved. The simplest form involved in laboratory applications is the mixing tank type in which the reactants are in the liquid phase (single phase).

The reaction chosen for this study is the saponification of ethyl acetate with sodium hydroxide.



EXPERIMENTAL

Equipment: The ARMFIELD CEM liquid-phase stirred liquid phase reactor will be used in the study.

The details of the reactor are given in the operating Instructions. The reactor is a glass cylinder with a stainless steel base. It has detachable PVC top cover for cleaning purpose. The water passes through the submersible pipe placed in the reactor and the temperature of the water can be adjusted to the desired temperature by the temperature control on the control panel. Initially, the cold water passes through the solenoid valve and enters the heating tank. After the operation level is reached, the valve closes with the help of the floating switch placed inside the heater tank. When the controller is set to cooling, the upper flow pipe is activated, the solenoid valve is opened, the cold water is pumped into the reactor vessel and the hot water is discharged from the upper flow pipe. The upper flow pipe is only activated when the reactor is operated in the cooling position. The liquid level in the reactor can be determined by the height-adjustable upper flow pipe. The butterfly valve located under the container can be used for the sampling required for chemical analysis. The reactor outlet is collected in the outlet tank for the necessary operations before the waste. The equipment contains PVC tank divided into two sections with drainage outlet. There are two positive diaphragm pumps for flowing from each tank and flowmeters with valves placed on the control panel. The overfeed is returned to the tanks by a constant recirculation line. The retention time in the reactor is a function of the flow rate set by flowmeters. On / off switch located on the front panel, pump switch temperature, scale and mixer motor switch can control the equipment.

CHEMICALS AND MATERIALS

For this assay 0.1 N NaOH, 0.1 N HCl, 0.1 N EtOAc and phenolphthalin are required. There is a need for titration system (burette, pipette, segmented cylinder, flask etc.) for the analysis of the reactants and products. For the batch reactor system, one liter glass, flask, stopper, thermometer, water bath is required.

EXPERIMENTAL

1. In one liter flasks, the reactants (250 ml, 0.1 N NaOH and 250 ml 0.1 N EtOAc) are combined. Run the reaction at 30C. Record the data that gives the time change of the concentration of the reaction mixture by taking samples from the reaction mixture at different times.
2. In a continuously stirred reactor, the reaction at a constant temperature is run using an equal volumetric flow rate for the reactants. Measure the concentration of the reactant (NaOH) by taking samples from the output stream at different times until the steady state is reached.
3. Operate the reaction experiments in a continuously stirred reactor at a constant temperature using an equal volumetric flow rate for the reactants. Repeat these experiments for different retention times (5 different values). Measure the concentration of the reactant (NaOH) by taking samples from the output stream at different times until the steady state is reached.
4. Repeat the experiments by changing the constant retention time, the rate of reactant at constant temperature (four EtOAc / NaOH ratio).
5. Repeat the experiments at different temperatures (four different values) in the ratio of constant reactants to constant retention time, temperature and feed rate.
6. Repeat the experiments at constant mixing rates and constant mixing rates of constant reactants at constant temperatures and constant temperatures in the feed stream.

CALCULATIONS

1. Calculate the conversion rates for each experiment.
2. Determine the reaction degree and the reaction rate constant. Compare the result of the batch reactor data with the results obtained from batch reactor data.
3. Compare the obtained kinetic data for the equilibrium flow rate and the different flow rate ratios used for the feeding current.
4. Determine the activation energy of the reaction and the temperature dependence of the rate constant of the reaction.
5. Model the behaviour of the regressive reactor in a non-steady state. Study the consistency with experimental data.

PRELIMINARY STUDY

1. Read the booklet and the related sections in the textbook.
2. How do you analyse the reactants and products of the saponification reaction by titration? (You can also use the experiment sheet for Determination of Reaction Rate Expression)
3. How do you improve reaction speed expression using batch reactor data?
4. Improve the uniformity of the continuous mixing reactor design.
5. Determine the behaviour of the continuous stirred reactor until it reaches its steady state (remove the concentration-time relationship).
6. Determine the experimental method before starting the experiment.
 - a. What kind of calculations can be made and determined about the reaction and the system when the studies in each item mentioned in the experimental section are carried out. Discuss.
 - b. Discuss what kind of experiments should be carried out in the continuous stirred reactor system in order to improve the speed expression (reaction rate, temperature dependence and reaction degree).
 - c. How can you find the reaction activation energy.

RESOURCES

“Armfield CEM Liquid Phase Chemical Reactor”, Instruction manual, 1993.

Fogler, H.S., “Elements of Chemical Reaction Engineering”, Prentice-Hall Int., USA, second Ed., 1992.

Levenspiel, O., “Chemical reaction Engineering”, John Wiley & Sons, New York Second Ed., 1972.

Smith, J.M., “Chemical Engineering Kinetics”, McGraw Hill Int., 1981.