CHME 401 CHEMICAL ENGINEERING LABORATORY II
EXPERIMENT 401-4
CHEMICAL REACTORS

OBJECTIVE

The objective of this experiment is to investigate the performance of tubular and continuously stirred tank reactors in the production of ethylacetate from sodium hydroxide (NaOH) and ethyl acetate. The effect of feed flow rate will be studied.

PRELIMINARY WORK

1. Study on reaction kinetics in Continuously Stirred Tank Reactors (CSTR) and Plug Flow Reactors (PFR) (model equations, assumptions made material and energy balances) .

2. Visit the lab. in advance to experiment and familiarize yourself with the experimental set-up with the consent of the teaching assistant.

DESCRIPTION OF THE EXPERIMENTAL SET-UP

The unit is composed of a main service unit and two types of reactor apparatus which can be mounted on this service unit. Plug flow or Continuously Stirred Reactor is selected according to the kinetics of the chosen reaction.

Continuously stirred reactors are vessels that are stirred with impellers to keep the concentration of chemicals and temperature in the reactor homogeneous. On the other hand in the plug flow reactors, chemicals move through the reactor in plug flow and the concentration of the reactants and products vary with the length of the reactor (tubular reactors).

These two units will be used to carry out the reaction between sodium hydroxide and ethyl acetate (Eqn.1). Equipment consists of two feed reservoirs with two centrifugal feed pumps, agitator, conductivity detector (determination of concentration in reactors) and hot water reservoir for controlling the reactor temperature, as shown in Figure 1.

$$CH_3COOC_2H_5+NaOH \rightarrow CH_3COONa+C_2H_5OH \quad (1)$$

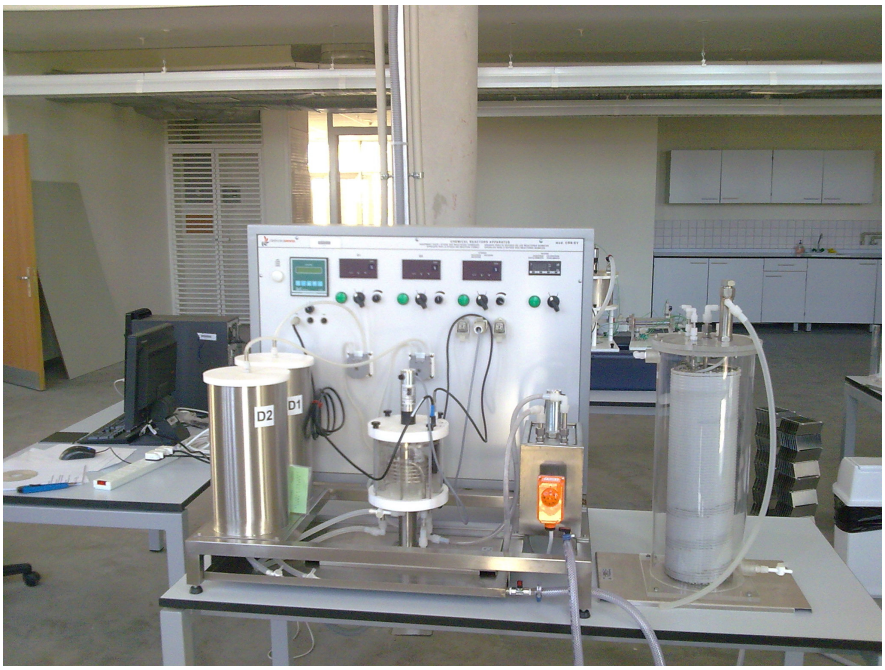

Figure 1. Chemical Reactor Apparatus

EXPERIMENTATION

During the experiments, reactant flow rates reactor temperature and conductivity readings must be recorded.

Procedure

Conductivity Calibration

Conductivity measured during the experiment is resulted from NaOH (reactant) and sodium acetate (product) so a calibration curve with respect to the conversion factors can be obtained by measuring the conductivities of solutions made by these two species.

1) Prepare 1L of 0.05 M NaOH and Sodium Acetate (NaAc) solutions
2) Prepare standart solutions of 100 ml for calibration as below (all ratios are by volume):

Assumed conversion of NaOH	Standard solution composition
1	only 0.05M NaAc sol'n.
0.75	¾ 0.05 M NaAc + ¼ 0.05 NaOH sol'n.
0.5	½ 0.05 M NaAc + ½ 0.05 NaOH sol'n.
0.25	¼ 0.05 M NaAc + ¾ 0.05 NaOH sol'n.
0	only 0.05 NaOH sol'n.

CSTR Experiments

1) Fill the hot water reservoir with de-ionized water
2) Fill the feed tanks D1 and D2 with reactants (5L of 0.1 M NaOH and Ethyl Acetate)
3) Set feed flow rates of G1 and G2 to 25 % which corresponds to 20 ml/min (pumps can be re-calibrated prior to experiment).
4) Set agitator speed to 50%.
5) Set reactor temperature to 25 ^{0}C from the panel and also in order to prevent over heating set temperature limit on the heater tank to 30^{0}C.
6) Wait until steady state is reached and record conductivity and temperature of the reaction medium.
7) Change feed flow rates to 50 and 100 % and repeat steps 3-6

PFR Experiments

1) Mount equipment for PFR Setup
2) Make hot water inlet and outlet which will fill around the tubular reactor.
3) Connect feed tanks by using the nuts on the lines
4) Fill the vessel with water which tubular reactor is immersed by using the hot water pump.
5) Mount the conductivity detector to the exit of the reactor
6) Mount temperature sensor to the place left on the lid of the vessel.

7) Set temperature to 25^0C from the panel and also in order to prevent over heating set temperature limit on the heater tank to 30^0C.
8) Feed the reactants to the reactor at a speed of 75% each.
9) Wait until steady state is reached and record conductivity of fluid at the exit of the reactor and temperature of the water in the vessel

Analysis

1) Decide the order of the reaction by using the data obtained from the CSTR experiments by the help of model equation for CSTR (it is expected to be first order for NaOH and Ethyl Acetate making 2^{nd} order in total)
2) Calculate experimental reaction rate constant by using data obtained from CSTR experiments
3) Since you know the order of the reaction calculate reaction rate constant for PFR and compare with the reaction rate constant calculated previously

Useful Data about the apparatus

V_{PFR} = 0.4 L

V_{CSTR} = 1.4 L (it can be measured during drainage of the reactor after the experiment.)