CHEM 360 L

EXPERIMENT 8

The Inversion of Sucrose

Introduction

This experiment is the second in a series of kinetic studies. Sucrose hydrolyzes in acidic solution to give dextrose and levulose (*d*- and *l*-glucose). The rate of the reaction will be influenced by the concentration of hydrogen ions in the solution. The reaction:

$$C_{12}H_{22}O_{11} + H_2O \rightleftharpoons C_6H_{12}O_{6\,(dextrose)} + C_6H_{12}O_{6\,(levulose)}$$

should be bimolecular as written, but, since the concentration of water remains constant, the rate depends only on the sucrose concentration for a given $[H^+]$ concentration and temperature. Thus, we may treat the reaction as essentially first order in sucrose:

$$\frac{d[A]}{dt} = -k[A]$$

where *[A]* is the molarity of sucrose, and *k* is the rate constant. The integrated form of the equation above is:

$$ln\left(\frac{[A]}{[A]_0}\right) = -kt$$

We may follow the progress of the reaction by monitoring the angle through which light is rotated by the solution. Sucrose and dextrose are both dextrorotatory, but the levulose is more levorotatory than the dextrose is rotatory. Thus, as the inversion continues, the solution becomes more levorotatory. At equilibrium, a final angle of rotation is observed, which will be proportional to the initial concentration of the solution. The value of the angle of rotation may be used to obtain the rate constant for the reaction:

$$ln\left(\frac{[A]_0 - [A]_c}{[A]_t - [A]_c}\right) = kt$$

where $[A]_0$ is the initial rotation, $[A]_c$ the rotation at completion, and $[A]_t$ the rotation at time t. Thus, a plot of $ln\left(\frac{[A]_0-[A]_c}{[A]_t-[A]_c}\right)$ versus *t* should yield a straight line, the slope being *k*.

Procedure

All groups will work at the same temperature (30°C). Prepare 250 mL each of 4 M HCl, $HC_2H_3O_2$, $HC_2ClH_2O_2$, $HC_2HCl_2O_2$, and $HC_2Cl_3O_2$. The instructor will assign each group a set of acids, the groups will share the raw data at the end of the experiment. Store these solutions in a constant temperature bath. Prepare 250 mL of a solution containing 50 grams of sucrose, storing this in the water bath as well. Rinse the polarimeter cell several times with distilled water, and determine its volume. The reaction is initiated by mixing the solutions (the sucrose solution plus one of the acid solutions) in a beaker, then immediately pouring the contents of the beaker into the polarimeter cell. The mixture should use equal volumes of each solution. Be sure to eliminate air bubbles from the optical path, and ensure that the seals are leak-tight. Store the filled polarimeter cells in the bath when not measuring the rotation. Once the solutions have been mixed (call this *t=0*), read the rotation as quickly as possible, then once every ten minutes for the first half hour (for the stronger acids, you may need to read the rotation more often), once every fifteen minutes for the second half hour, and hourly thereafter for the next several hours. Check the rotation twice daily until a constant rotation is obtained. Remember that the $[H^+]$ concentration is 2 M in the polarimeter tubes, due to dilution.

Calculations

Determine the rate constants for each of the solutions, using the appropriate plots described above and a least-squares linear regression. Compare the observed rate constants for the various acids, noting any observed trends.