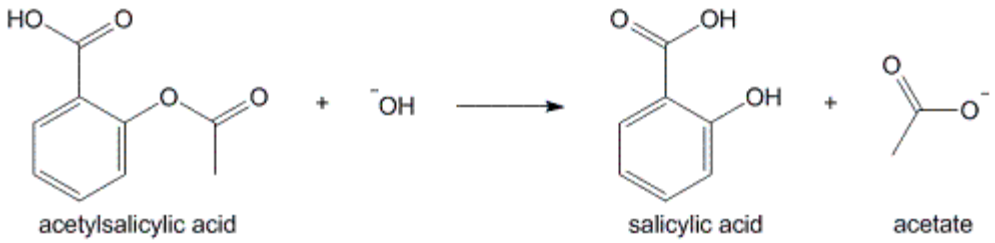
Kinetics of Hydrolysis of Acetylsalicylic Acid, Aspirin

by Paul Prenzler, Dan Bedgood

Experiment Overview

In this experiment, students examine the hydrolysis of aspirin, acetylsalicylic acid, under different conditions. The hydrolysis of aspirin occurs much more rapidly in basic conditions, a fact which is illustrative of an important principle in pharmacology. That is, the stability of drugs and their mechanisms of action can be strongly dependent on the pH conditions of the body system in which they operate. This experiment includes a quantitative kinetic study of the hydrolysis of aspirin under basic conditions.



Aims and Objectives

Aims of the experiment are:

- To study the kinetics of hydrolysis of aspirin by UV spectrophotometry.
- To investigate the mechanism of ester hydrolysis.
- To examine the role of alcohol in aspirin hydrolysis.

Level of Experiment

Second year undergraduate

Keyword Descriptions of the Experiment

Domain
physical chemistry, organic chemistry

Specific Descriptors
kinetics, hydrolysis, aspirin

Course Context

The hydrolysis of aspirin is an example of ester hydrolysis – a reaction that may be catalysed by both acid and base. This gives rise to a composite rate law: rate = (k_0 + $k_{OH}[OH^-]$ + $k_H[H^+]$)[ester], where k_0 = the rate constant for the uncatalysed reaction, k_{OH} = the rate constant for the base catalysed reaction, and k_H = the rate constant for the acid catalysed reaction. Above pH 7, only the $k_{OH}[OH^-]$ term is significant, therefore the rate law becomes: rate = $k_{OH}[OH^-]$[ester]. Furthermore,

if the conditions of the experiment are chosen such that [OH^-] >> [ester] (pseudo order conditions), then the rate law is rate = k_{obs}[ester], where k_{obs} is the pseudo order rate constant, and is equal to k_{OH}[OH^-]. Thus a plot of ln[ester] versus time will give a straight line with –slope = k_{obs}.

The hydrolysis products of aspirin are salicylic acid and acetic acid. Salicylic acid has an absorbance maximum at 295 nm, whereas aspirin does not absorb at this wavelength. The progress of the reaction may readily be followed by monitoring the increase in absorbance at 295 nm as salicylic acid is formed.

There are a number of drugs for which the simultaneous consumption of alcohol is not advised. The addition of ethanol to the reaction mixture is necessary to keep salicylic acid solubilised, and the effect of ethanol on kobs is investigated by comparing the experimental rate constant to a literature value.

Prerequisite Knowledge and Skills

- Ability to use volumetric glassware correctly - pipettes, volumetric flasks.
- Some knowledge of ln functions and ability to manipulate them.
- Basic knowledge of kinetics and integrated rate laws for zero, first and second order reactions.

Time Required to Complete

Prior to Lab: 30 min - 1 h (basic reading)
In Laboratory: 2-2.5 h (experimental work)
After Laboratory: 2-3 h (plotting data, data analysis, answering questions about concepts, and writing the formal report)