

# Ion Exchange Chromatography

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## Experiment Overview

Ion exchange chromatography is a critical analytical technique routinely used for the separation of compounds based on their charge for a wide range of purposes. This experiment provides students with experience executing the technique, and also builds knowledge of the theory behind how the process works by using ion exchange columns to identify products of hydrolysed copper complexes. In so doing students are also exposed to and gain an understanding of the relationships between the strength of reaction conditions and products produced as a consequence.

Initially, students are asked to identify three complex salts from a mixture by charge and colour using an ion exchange column. Once they have developed a level of confidence in the process of identification, students then expose carbanato *bisethylenediamine* cobalt (III) chloride to varying conditions of hydrolysis; dilute hydrochloric acid, concentrated hydrochloric acid and hot concentrated hydrochloric acid; and are asked to identify the different species produced in each case. Hydrolysis removes the carbonato ligand from the complex, and students can expect to see the two coordination sites replaced by water or chloride ions to give diaquo, aquochloro and/or dichloro bisethylenediamine cobalt (III) chloride as products, the presence of each being dependant on the availability of chloride ions in comparison to water in each of the three reaction conditions. Students are expected to identify which species are present in each case based on characteristic colour and charge, and answer a series of questions concerning identification methods and reasons the products differ in each case.

## Learning Experience

Chromatography is a common technique used in analytical and synthetic chemistry. As such it is important students gain experience in this area, as they are more than likely to frequently encounter chromatography in some form should they choose to continue study in the chemistry discipline. It is important students understand this technique well, and for that reason effort should be made to confirm that the methodology used to educate them on the topic achieves the desired goals.

## Aims and Objectives

This experiment aims to familiarise students with both practical and theoretical components of ion exchange chromatography, and also how the charge on a metal ion complex influences its rate of descent down an ion exchange column. Developing an understanding of how exposing a metal complex to differing hydrolysis strengths produces different products and ratios thereof is also a key objective.

## Level of Experiment

First year undergraduate

## Keyword Descriptions of the Experiment

### **Domain**

Analytical Chemistry

### **Specific Descriptors**

Ion exchange chromatography, hydrolysis, metal complexes

## Course Context

This experiment is undertaken by first year undergraduate students in their first semester, at any one of many possible scheduled fortnightly practical sessions.

## Prerequisite Knowledge and Skills

Students undertaking this exercise are assumed to have knowledge of SACE Stage 2 Chemistry, and as such should be familiar with general principles involving chemical bond formation, interaction of charged species in solution etc required for comprehension of the chromatography process. Foreknowledge of metal complexes, ligand binding and associated chemistry may be limited or absent. This practical is undertaken by students in two distinct first year chemistry courses; a standard first year course assuming a mark of 13 or more in SACE Stage 2 chemistry, and a foundations course which, although assuming knowledge of SACE Stage 2 chemistry, does not presuppose this grade.

Skills required for this experiment include basic competence with laboratory glassware and some skill in measuring liquid and solid quantities (although this is not as crucial). A basic understanding of the interaction of charged species in solution is also required. This experiment does use concentrated hydrochloric acid and as such students will need to be familiar with the appropriate handling procedures.

Students are required to complete online pre-practical exercises before commencing any laboratory work. The aim of these exercises is to familiarise students with the OH&S issues for the chemicals they will be using in the experiment as well as some background theory.

## Time Required to Complete

**Prior to Lab:** 1-2 hours

**In Laboratory:** 3 hours

**After Laboratory:** none

## Experiment History

This experiment has a long history in the school of chemistry and physics at the University of Adelaide; whilst the authors listed in section (1.9) are responsible for the educational analysis of this experiment, their submission of it to ASELL is done on behalf of all academic staff.

## Comments

Traditionally the ion exchange columns are set up prior to student arrival. This saves time in the laboratory, and also directs student focus primarily to the technique and analysis of results required.

This experiment requires the heating of concentrated hydrochloric acid. As such the appropriate safety precautions must be exercised for both handling the acid and heating the solution.