Separation of complex cations of chromium(iii) by ion exchange chromatography

Health & Medicine

Separation of Complex Cations of Chromium (III) by Ion Exchange Chromatography Separation of Complex Cations of Chromium (III) by Ion Exchange Chromatography

Aim

This practical endeavours to demonstrate how to separate elements using ion exchange chromatography. This method uses an ion exchange material to separate the different ions which have different affinities.

Introduction

Chromium III complexes are formed through the reactions of hydrochloric acid and sulphuric acid with elemental chromium (Weiss, 2008 p97). It is resistant to oxidation by atmospheric oxygen thus it is safe to say that it does not corrode easily (Crompton, 2002 p350). They are formed very slowly in aqueous solutions but not in surfactant solutions. Chromium III is very stable at low pH and easily oxidizes at high pH. Water soluble compounds of Chromium III do not occur naturally and are unstable in the environment (Nriagu & Nieboer, 1988 p68). Different oxides of chromium oxide are also used as pigments.

Cation exchange chromatography can be used to separate different chromium III complexes into their pure forms. The most common complexes are chromium III and IV which exist at different ionisation states. Chromium III is a cation and IV is an anion. Chromium VI is toxic to humans (Vincent, 2011 p101). The separation of these complexes is based on their different ionisation states which are the principles behind ion exchange chromatography. The use of UV-Vis as analytical tools is essential in determining the value of 10q of elements. The coupled use of these diagrams and spectroscopic information enables someone to correctly calculate the electromagnetic absorption of metal compounds and how the crystal fields split energy or 10Dq (Kettle, 2008 p69).

Method

1. The separation process starts with the preparation of an ion exchange column and in this case three columns are required.
2. Perchloric acid solutions are then prepared to act as eluting compounds to the desired complexes.
3. Chromium solutions are then prepared that will be used throughout the experiment. At this stage, progress should immediately be made towards separation of trans--[CrCl2(H2O)4]+, [CrCl(H2O)5]2+ and [Cr(H2O)6]3+ after which their spectrums are measured between wavelengths 350 nm and 750 nm immediately after their collection (Beran, 2010 p200).
4. The final step involves the estimation of relative crystal field strength for Cl- and H2O. Two bands are observed in the region of 350nm and 750nm with the longest wavelength band having energy equal to 10Dq or the octahedral Crystal field splitting energy for the complex ion. Chromium III compounds have bands that are easy to interpret and they exist either in an excited state which has higher energy than the ground state which has less energy but more stable.

Results

(Add the UV – Vis Spectrums here).

These bands are used to calculate:

a) 10Dq for [Cr(H20)6]3+ , [CrCl(H2O)5]2+ and [CrCl2(H2O)4]+ at a peak of 579. 20 – 0. 360 and 410. 80 – 0. 101. 10Dq is got by using the relationship below:

= (1×) c = 14. 577 c for [Cr(H20)6]3+

= = (1×) c = 16. 313 c for [CrCl(H2O)5]2+

= = (1×) c = 17. 265 c for [CrCl2(H2O)4]+

Discussion

The values of 10Dq are shown to decrease with the increasing charge of a neighbouring anion and the decreasing number of coordinating anions (Crabtree, 2011 p110). According to reported literature, the experimental results display some consistency with reported results in journals even though they do not match the actual values. This shows that the experiment was a success and that complexes prepared exhibited the expected properties witnessed in other experiments. Bond ionisity is also a contributing factor to 10Dq splitting and the overall charge determines the extent of the separation; it can either be complete or partial separation (Gopalan, 2012 p158). The value of the calculated 10Dq is established to be about half of the experimental value in all the three tests. This value is also influenced by the charge, size and the type of ligand it forms (Crabtree, 2011 p112). The resin that is used has both anion and cation functional groups making it possible for the two most common types of complexes to adhere to the different groups independently.

The three chromium complexes have different charges which is a fundamental principle in the separation of these complexes ion exchange chromatography. The cation with the biggest charge binds first and on top of the column followed by those with lesser charges; [Cr(H20)6]3+ > [CrCl(H2O)5]2+ > [CrCl2(H2O)4]+ . The same case also applies when liberating the different complexes and the one with the least charge is substituted first by the protons in the acid ending with the complex with the most charge. This principle is also applied in washing powders where complexes are used to soften water by removing Calcium and Magnesium ions. It is also widely applied to separate complex mixtures and isolate pure substances. The phenomenon also occurs naturally in soil where clay and humus minerals bind cations in the soil solution taken up by plants (Nriagu & Nieboer, 1988 p78). The use of a solid phase column in the experiment enabled proper observation of the different binding abilities of the complexes and it was easier to distinguish the colours in this phase. The use of Perchloric acid over Hydrochloric acid was because it is a strong oxidising agent (Gopalan, 2012 p160).

The aims of the experiment were successfully accomplished and it was able to clearly demonstrate the principles behind ion exchange chromatography. Ion exchange chromatography has made it possible to be able to separate pure substances from complex compounds. The principle has also been applied in the detergent industry for softening water where ligands are used to remove Calcium and Magnesium ions from water.

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