

# A Survey on Tools & Techniques for the Implementation of Ion-Exchange Chromatography

Hemang Harishbhai Vaidya<sup>1</sup> Mr. Manan Shah<sup>2</sup>

<sup>1</sup>M.E. Student

<sup>1</sup>Department of Electronic & Communication Engineering <sup>2</sup>Department of Geo Sciences

<sup>1</sup>GTU PG School, Ahmedabad, Gujarat, India <sup>2</sup>Physical Research Laboratory Ahmedabad, INDIA

**Abstract**—Rare Earth elements are located inside the Earth's surface that are important to many modern-day technologies which include health care, transportation, national defense, and many others. There are 17 chemical elements series included in the uncommon earth elements. Alongside strontium is chemical element that is generally used to make different applications and in chemical processes. Strontium lies in Alkaline earth metallic. We can isolate these elements from chondritic meteorites. These elements are not in pure shape and form in earth surface and must be separated before accurate operations to be done. There is different separation techniques used for this. We can say, mainly the REE and Sr would be used in earth science and geology application. The traditional approach was very time consuming and requires more effort. So inside the proposed work it is going to be much less time consuming and decrease human effort. Reviewed papers are condensed inside tables in view of the statistics applied for identification motive. In this survey, a quick portrayal of data assets, generation & strategies are included.

**Key words:** Uncommon earth elements, Chromatography, Strontium

## I. INTRODUCTION

### A. Rare Earth Elements

The group includes cerium and the other 15 factors (lanthanum, yttrium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium) is the collection of the uncommon earth elements.

Uncommon earth elements (REE) have been used to model geochemical strategies in addition to constrain excessive temperature fractionations and redox situations in the early solar gadgets. They had been carried out to radiometric age determinations and petrogenetic tracer research. Further, the decay of long-lived radionuclide  $^{87}\text{Rb}$  to solid  $^{87}\text{Sr}$  has also been carried out to radiometric age determinations of rocks and minerals. That permits you to attain strong ion elements of REE and strontium throughout thermal ionization mass spectrometry, elements have to be separated from pattern matrices and be as smooth a salt as feasible. Particularly, the isolation of calcium from strontium or REE is vital because ionization efficiencies of goal elements are closely suppressed if a big amount of calcium remains in the measured sample.

The goal to look at lower processes previously set up for rock analysis after which to make the new extraction chromatography appropriate for small-length meteoritic samples.

Despite their name, uncommon earth elements are – aside from the radioactive promethium – notably abundant in Earth's crust, with cerium being the 25th maximum ample element at sixty eight parts in step with million, or as ample as copper. They are not particularly uncommon, but they will be inclined to arise together in nature and are difficult to split from one another. However, because of their geochemical properties they are no longer frequently located focused as uncommon earth minerals in economically exploitable ore deposits. The primary such mineral observed have become a mineral composed of cerium, yttrium, iron, silicon and various factors.

### B. Strontium

Strontium (atomic number 38, symbol Sr) is an alkaline earth metal that is commercially available. Its chemical and physical properties are similar to that of elements such as barium and calcium. It was discovered in 1790 by the Scottish chemist William Cruickshank and the physician and chemist Adair Crawford. Today, strontium is obtained from two of its most common ores, celestite ( $\text{SrSO}_4$ ) and strontianite ( $\text{SrCO}_3$ ). The strontium chloride, usually mixed with potassium chloride (KCl), is then melted and electrolyzed, forming strontium and chlorine gas ( $\text{Cl}_2$ ).

Lots of the strontium produced at present is used within the manufacture of color TV photograph tubes. It is usually used to refine zinc and is mixed with iron to make magnets. Strontium is a silvery aspect found without doubt as a non-radioactive element. Roughly 99% of the strontium within the human physique is concentrated within the bones. Numerous different forms proteins differing via handiest one charged amino acid. In Ion alternate chromatography approach possible chooses whether or not to bind the substance of hobby and permit the infection to bypass through the column and vice versa. This technique has been developing in view that 19th century which turned into first of all used for purifying the consuming water. Ion change chromatography is distinct precepts of chromatography carried out in the column of strontium are used as in purpose of medicine. Radioactive strontium-89 is given intravenously (by IV) for prostate cancer and advanced bone cancer Strontium chloride is the maximum common shape of Ion exchange chromatography uses an ion exchange mechanism to separate analytics based on their respective charges. It is usually

performed in columns but can also be useful in planar mode. Ion exchange chromatography uses a charged stationary phase to separate charged particles including anions, cations, amino acids, strontium observed in nutritional dietary supplements. Peptides and proteins, in conventional methods the stationary phase is an ion exchange resin that carries charged groups that interact with oppositely charged groups of the compound to retain. However, there isn't lots of clinical information groups that separate the molecules on the basis of its charge and the operation requirements which is also based on the other elements. Sr90, a radioactive isotope of strontium, is a normal fabricated from nuclear explosions. It has a half-life of roughly 28 years and decays into yttrium-90 via beta decay. Sr90 is above all lethal because it has a terribly extended half-life, is strongly radioactive and is absorbed by the use of the body, wherein it accumulates inside the skeletal process. The radiation influences the producing of latest blood cells, which ultimately ends in loss of life.

### C. Chromatography

Chromatography is the collective terminology for a set of laboratory techniques for the separation of mixtures. The combination is dissolved in a fluid called phase, which includes it through a shape the mobile maintaining other material referred to as the stationary phase. The various elements of the combination travel at distinct speeds, inflicting them to separate. The separation is based totally on differential partitioning between the mobile and stationary stages. Diffused variations in a compound's partition coefficient bring about differential retention on the stationary section and consequently converting the separation.

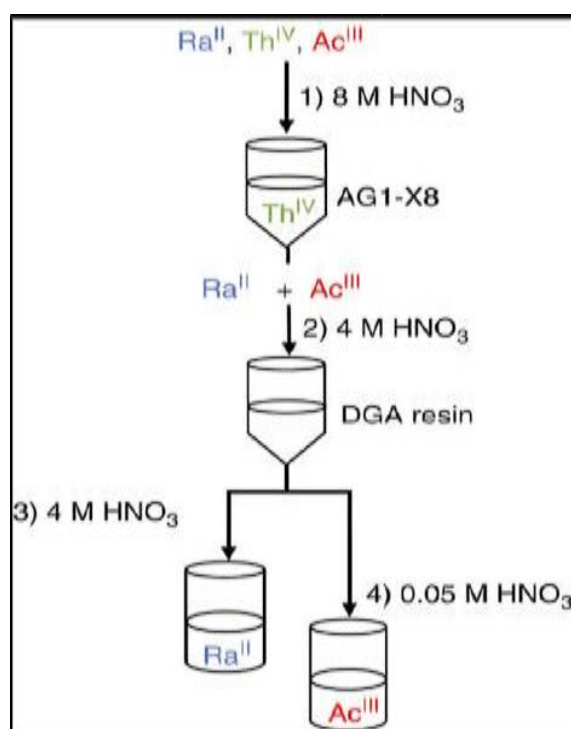


Fig. 1: Chemical Process of Separation

Chromatography is to separate the components of a combination for greater superior use (and is for this reason a form of purification). Analytical chromatography is achieved usually with smaller amounts of material and is Beads of the resin modified so that they contain a cationic or anionic functional group that can be positively charged, negatively charged, or neutral depending on pH. A solution that contains the species of interest is applied to the column containing the resin, and the sample either binds to the resin or passes through the column. For measuring the relative proportions of aggregate.

## II. SEPARATION BASED CHROMATOGRAPHY TECHNIQUES

### A. Ion Exchange Chromatography

Ion change chromatography may be defined as the reversible exchange of ions within the solution with ions electro statically bound to some sort matrix or a stationary segment." This of insoluble approach is extremely useful in the separation of rate compounds like Columns used for ion exchange are characterized by the presence of charged groups covalently attached to the stationary phase. Anion exchangers contain bound positive groups, whereas cation exchangers contain bound negative groups. Ion exchange resins are used for the separation of small molecules. Ion exchange gels are used for the separation of large molecules like proteins, nucleic acids. The separation of the cation and anions, mostly known as the ion exchange chromatography.

Scheme for the separation of REE  
(RE Resin volume=80 $\mu$ l)

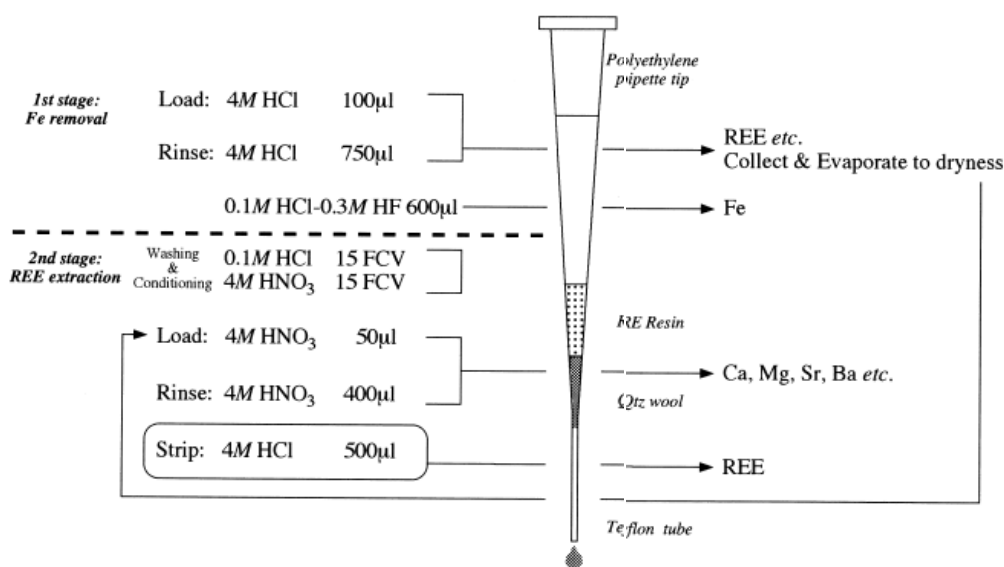


Fig. 2: Separation Scheme for REE [1]

Ion exchange resins are used for the separation of small molecules. Ion exchange gels are used for the separation of large molecules like proteins, nucleic acids. Separations involving harsh chemical conditions (high temperature, high radiation levels, strongly basic solutions or powerful oxidizing agents) employ inorganic ion exchangers. Such as this is most appropriate technique for the separation of the cation and anions, mostly known as the ion exchange chromatography.

Figure 1 shows the separation scheme for the rare earth elements. Figure 2 shows the separation scheme for the strontium.

Scheme for the separation of strontium  
(Sr Resin volume=50 $\mu$ l)

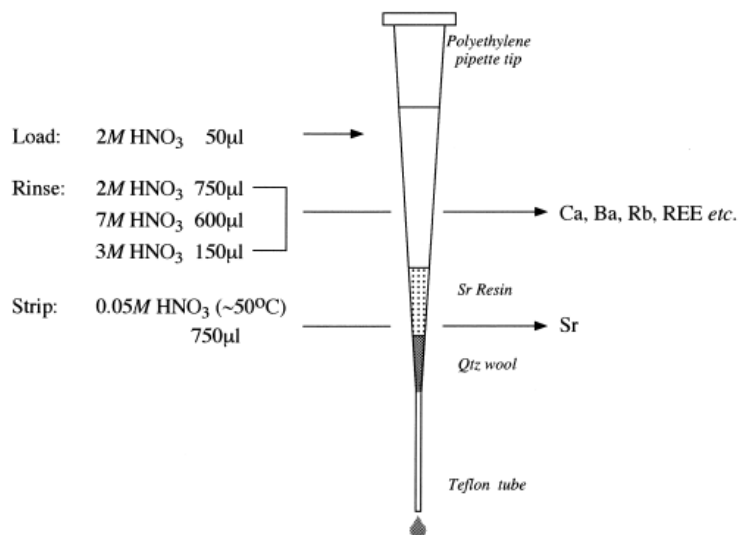


Fig. 3: Separation Scheme for Strontium [1]

B. Size-Exclusion Chromatography

Size-exclusion chromatography (SEC) is also referred to as gel permeation chromatography (GPC) or gel filtration chromatography and separates molecules in step with their size (or greater appropriately consistent with their hydrodynamic diameter or hydrodynamic extent). Smaller molecules are capable of enter the pores of the media and, therefore, molecules are trapped and removed from the drift of the mobile section. The common residence time within the pores depends upon the powerful length of the analyte molecules. However, molecules which can be large than the average pore size of the packing are excluded and accordingly suffer basically no retention, such species are the primary to be eluted. It is usually a low-decision chromatography method and as a consequence its miles frequently reserved for the very last, "sharpening" step of purification. It's also useful for figuring out the tertiary shape and quaternary structure of purified proteins, especially considering it can be done below native solution situations.

### III. COMPARATIVE TOOLS & TECHNIQUES TO IMPLEMENT

Sr. No.	Title	Authors	Overview of studied Research paper
1	Separation of rare earth elements and strontium from chondritic meteorites by miniaturized extraction chromatography for elemental and isotopic analyses	Misawa, Fumie, Yamazaki, Nami Ihira and Noboru Nakamura	From Chondritic meteorites it is hard to separate the REE from the matrix elements by other methods
2	FPGA based DC Servo motor Control for Remote Replication of Movements of a Surgical Arm	Vivek Ramakrishnan, Nalamwar Sanchit Gopal, Rahul Ashok and S. Moorthi	DC motor can be controlled with the help of PWM and Serial Communication which control the robotic arm
3	Simulation Time Analysis of Matlab and LabVIEW for Control Applications	Civan Cansalar, Ertan Mavis, Cosku Kasnakoglu	Graphical programming language is better for simulation of real time application
4	Ultra-compact and Robust FPGA-based PUF Identification generator	Maire O'Neill, Chongyan Gu	Spartan FPGA LX9 would be useful hardware for such encryption and security of hardware
5	Physical Implementation and control of multi axis Motion Control System using LabVIEW	D.K. Krishna Kumari, Arvind Kumar, Sagar Narang	DC Motor control using LabVIEW Implementation of system is well defined and gives exact results
6	Fast direct determination of strontium in seawater using high performance chelation ion chromatography	Ekaterina P. Nesterenko, Pavel N. Nesterenko, Brett Paul, Melissa Meléndez, Jorge E. Corredor	HPCIC is the proposed technique which provide selectivity and efficiency for separation of strontium and rare earth elements

Table 1: Comparison of various tools

This table shows the results and techniques which can be implemented to get done the chromatography procedure. Some research papers are containing the software details of real time applications. Some research papers are containing the details of the hardware which can be used to implement such crucial design in real environment.

### IV. EVALUATION

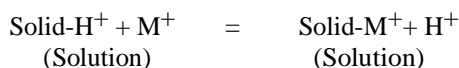
Below are the basic principle and the basic equations for the ion exchange chromatography:

#### A. Principle

- Ion exchange chromatography relies on the attraction between oppositely charged stationary phase, known as an ion exchanger, and analyte.
- To these covalently bound functional groups the oppositely charged ions are bounded (mobile counter ion), which will be exchanged with like charge ions in the sample having charge magnitude more than the ions bounded to the matrix.
- Thus if anion exchange chromatography is performed, negatively charged sample components will interact more with the stationary phase and will be exchanged for like charged ions already bounded to the matrix.

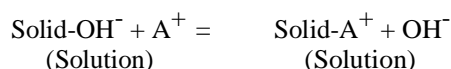
#### B. Equations

##### 1) Separation of Cations



The cations retained by the solid matrix of ion exchange resin can be eluted by using buffers of diff strength and hence separation of cations can be effected.

##### 2) Separation of Anions



The anions retained by the solid matrix of ion exchange resin can be eluted by using buffers of different strength.

##### 3) Practical Requirement

###### a) Column

The column must be made up of glass, stainless steel or polymers. The length should be diameter ratio of 20:100 to 100:1.

b) Packing the column

The packing of the column would be wet type method. After which the sample is added to the top of the column using syringe or pipette.

c) Elution

Components of mixture separate & move down the column at different rates depending upon the affinity of the ion for ion exchanger. Such that elutes are collected at different stages.

d) Analysis of the eluate

Using the spectrographic process or polar graphic process, the analysis of the elution can be done.

#### V. ACKNOWLEDGEMENT

I want to thank Physical Research Laboratory, Ahmedabad, India for their support where a part of this research work has been going on. I also want to thank Mr. Manan Shah with whose support research work has successfully going on and Physical Research Laboratory staff for their much suggestion and help during the survey work.

#### REFERENCES

- [1] Keiji Misawa, Fumie Yamazaki, Nami Ihira and Noboru Nakamura, "Separation of rare earth elements and strontium from chondritic meteorites by miniaturized extraction chromatography for elemental and isotopic analyses" – *Geochemical Journal*, Vol. 34, pp.11 to 21,2000.
- [2] Vivek Ramakrishnan, Nalamwar Sanchit Gopal, Rahul Ashok and S. Moorthi, "FPGA based DC Servo motor Control for Remote Replication of Movements of a Surgical Arm" - *TENCON 2011*, 978-1-4577-0255-6/11, IEEE-2011.
- [3] Civan Artun Cansalar, Ertan Mavis, Cosku Kasnakoglu, "Simulation Time Analysis of MATLAB/Simulink and LabVIEW for Control Applications" - 978-1 4799-7800-7/15, IEEE-2015.
- [4] Zhou Bin, Wuhan, Wang Lei, Fang Pengcheng, "The Simulation and Analysis of Gas Detection System in Infrared Absorption Spectrum Based on LabVIEW" -2015 International Conference on Industrial Informatics- Computing Technology, Intelligent Technology, Industrial Information.
- [5] Ekaterina P. Nesterenko, Pavel N. Nesterenko, Brett Paull, Melissa Meléndez, Jorge E. Corredor, "Fast direct determination of strontium in seawater using high-performance chelation ion chromatography", *Microchemical Journal*, 2013.
- [6] D. K. Krishna Kumari, Arvind Kumar, Sagar Narang, "Physical Implementation and Control of MultiAxis Motion Control System using LABVIEW", *International Conference on Innovations in Electrical and Electronics Engineering (ICIEE'2012)* Oct. 6-7, 2012 Dubai (UAE).