

Determination of Chemical Components of Kidney Stone by the study of Energy Dispersive X-ray Spectroscopy



Physics

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ABSTRACT

Kidney stone formation is a biological process that involves complex crystallization phenomena. Various factors contribute to the formation of kidney stone in human body. For better understanding of mechanism of crystal growth formation, Energy Dispersive X-ray Spectroscopic study is made to justify the knowledge of phase compositions of the stone. To explain the underlying study of the structure of the stone, the quantitative X-ray diffraction phase analysis performed on five kidney stones.

According to the observed phase compositions, all the tested stones were classified into two chemical groups: oxalates and struvite. Further classification of oxalates it divided in to two: calcium oxalate mono-phosphate and calcium oxalate di-phosphate.

Introduction

Urinary stones have afflicted mankind since ancient times. It is estimated that in India nearly 2 million people are affected with kidney stone. Also, there is a 20% probability of re-occurrence of kidney stone in such patients. There have been remarkable technological advances in the field of medical science for treatment of kidney stones. The knowledge of the type and chemical compositions of the stones are important to understand the Kidney Stone disease.

XRD by powder method and Fourier Transform Infrared Spectroscopy [FTIR] are the powerful tools to analyze crystal phase of the Kidney Stone. Both the methods have their advantages and disadvantages. FTIR is faster and easier to apply. In case of kidney stones they made up of multiple components due to which FTIR cannot give required accuracy.

Energy Dispersive X-ray Spectroscopy [EDX] is most frequently used to analysis the kidney stones. The significant advantages of this technique are that, it does not require any separate apparatus to make analysis. It is attached to the as a on part of the apparatus of SEM. Due to which it is readily available in every analysis and this analysis is performed in some minutes.

Jungers et.al.^[1] in their work suggested that in human urine, occurrence of Calcium Oxalate Monohydrate (COM) and Calcium Oxalate Dihydrate (COD) depends also on the molar ratio of calcium and oxalate. Dorian et. al.^[2] observed evidence of aggregation in Oxalate stone formation using SEM. Phunc D. Ngo^[3] studied in his research work Energy Dispersive X-ray Spectroscopy [EDS, EDX or XEDS] is the most frequently tool used in analysis of chemical components of the stone. It has very significant advantages. Valdimir Uvarov^[4] studied about quantitative analysis, crystallite size determination and statistical characterization of kidney Stone by X-ray diffraction and SEM study.

The Kidney Stones are not easy object to analyze the phase. The majorities of biomineral composing the stone have low crystal symmetry mostly two- monoclinic and orthorhombic and may have large unit cell parameter. Therefore, XRD pattern of their mixture have stronger overlapping of peaks.^[5]

In the present work kidney stones were collected from Jamnagar and South Gujarat region from different Urological hospitals. Kidney Stones were classified by using XRD

analysis method. The classification of components of various stone and their comparison were made.

Experimentation Study

Experimental Setup

This technique depends on an interaction of source of X-ray excitation and sample. Its characterization capabilities are due in large part to the fundamental principle that each element has a typical atomic structure permitting unique set of peaks on its spectrum of X-ray emission. The high energy electron beam is focused into the sample to stimulate the emission of characteristic X-rays from specimen. The X-rays which are emitted from sample are measured by Energy Dispersive Spectrometer. EDX analysis gives the measurement of the elemental composition of the specimen because of the energy difference between the two shells and difference between the atomic structures of the element which is emitting the characteristic X-rays. To analyze materials by using EDX method, apparatus and set up which are required are the electron beam, the X-Ray detector to convert energy of X-ray into voltage signal, the pulse processor to receive and measure the voltage signal coming from X-ray detector, the analyzer to analyze and display the signals receiving from the pulse processor. The instrument which is used to analysis Kidney Stone by SEM method is from the Faculty of Technology and Engineering, The M. S. University of Baroda.

Methodology

To produced image and magnification of the sample electron beam produced by electromagnetic field. The signal produced by the interaction of the electron beam with atom at the surface of the sample. The specimen is exposed to a narrow electron beam produced by electron gun. This electron beam scans the surface of the sample due to which secondary electrons produced. The intensity of the secondary electrons depends upon the shape and chemical composition of sample. These electrons generates electronic signals are collected by a detector. These signals produce an image on CRT [Cathode Ray Tube]. Now a day SEMs have advancements to record the photographs by digital camera.

Sample Preparation

Before the characterization of the sample through SEM, the sample must be dried to remove any out gassing from organic contamination and surface dust. Kidney stone sample was cleaned using water and dried completely by hot plate. During sample preparation and transfer gloves must be worn. Samples, sample holders, sample stubs and sample exchange tool with uncovered hands. Samples are mounted

on the holder using double sided carbon or copper conductive tapes.

Table-1 shows the list of the samples used to analyze by EDX method.

Table 1 - Parameters of Experimental study

Kidney stone type	1) Calcium Oxalate Monophosphate COM 2) Calcium Oxalate Diphosphate COD 3) Struvite ST
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Observations & Discussion

Data analysis

The analyses of stone were made by EDX method is shown in Table-2. Five stones of three types were analyzed.

Observing data for the stone SG-68 [COM] elements- Ca, O, Mg, Si, P, S, Ti, Fe, Ni, and C are present among which Ti and Mg is in minimum amount and O is having maximum amount of weight %.

Observing data for the stone SG-37 [COD] the elements which are present in the stone are Ca, O, P, C and Na among which Na is in lowest amount and O is in maximum amount of weight %.

Observing data for the stone Jam-34 [COM] the elements which are present in stone are Ca, O, Mg, Si, P, S, Fe, C, Na, Al and Cl among which Cl having the minimum amount and O have the maximum amount of weight %.

Observing data for the stone Jam-109 [ST] the elements which are present in the stone are Ca, O, Mg, Si, P, C, Na and K among which Si having the minimum amount and Si having the maximum amount of Si of weight %.

Observing data for the stone SG-50 [ST] the elements which are present in stone are Ca, O, Mg, Si, P, Na and K among which K is in minimum amount and O is in maximum amount of weigh %.

Graphical analysis

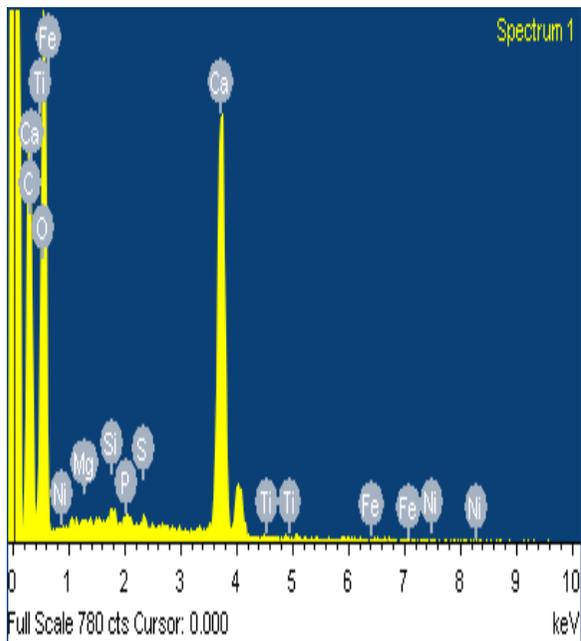


Fig-1 Stone-69 [COM]

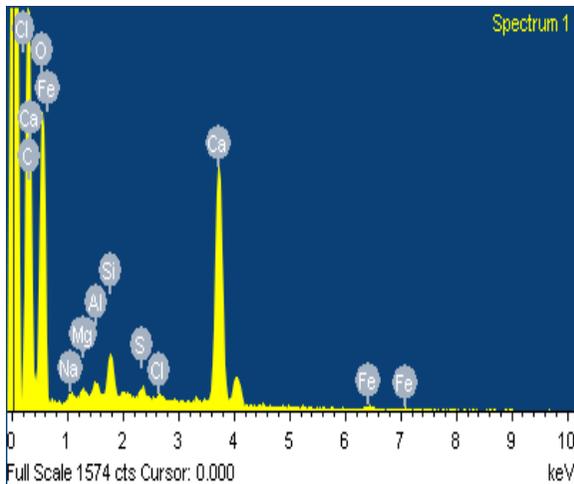


Fig-2 Stone-34 [COM]

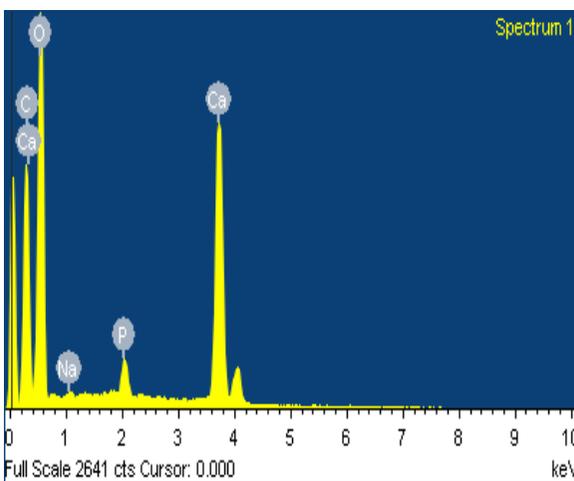


Fig-3 Stone-37 [COD]

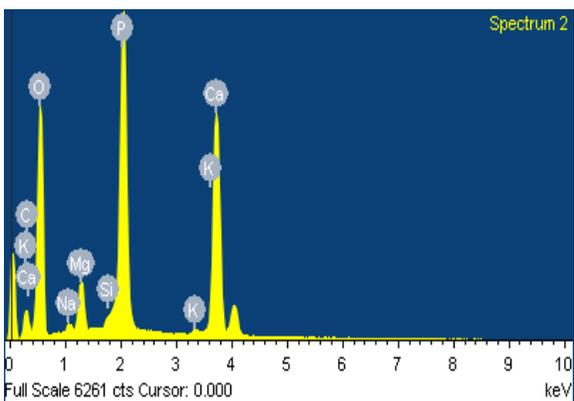


Fig-4 Stone-109 [ST]

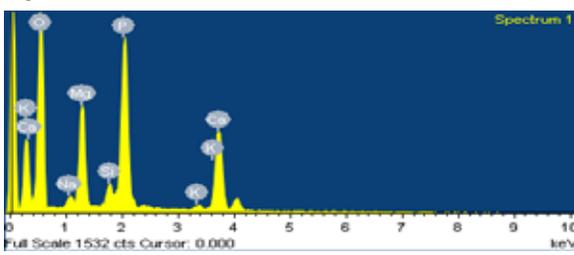


Fig-5 Stone-50 [ST]

Table 2 Analysis of the Kidney Stone components

STONE NAME & TYPE	SG-69 COD wt.%	SG-37 COD wt.%	JAM-34 COM wt.%	JAM-109 ST wt.%	SG-50 ST wt.%
Ca	18.02	18.34	14.35	21.19	13.99
O	53.86	56.50	46	50.16	56.09
Mg	.01	-	27	2.56	9.37
Si	.35	-	1.33	.26	1.59
P	.34	1.44	-	16.80	17.12
S	.27	-	.34	-	-
Ti	.01	-	-	-	-
Fe	.11	-	.75	-	-
Ni	.21	-	-	-	-
C	26.74	23.42	35	8.12	-
Na	-	.29	32	.57	1.20
Al	-	-	.39	-	-
Cl	-	-	.25	-	-
K	-	-	-	.35	.63

Conclusions

It can thus be concluded that even if the stone types are same or they belong to the same region, their chemical compositions are different.

Each stones have highest amount of Oxygen component in weight% irrespective of their region and type.

Every stone is grown from metals. The nucleation is start from the metallic elements like Na, Mg, Al, K, Ca, Ti, Fe, Ni which attract non metallic elements like C, N, O, P, S, Cl.

The components which are lowest in weight% are always stays in nuclei and are also reason for formation of stone. These components are usually metals.

In case of all the stones except SG-37 [COD type] Si is present.

Jam-109 [ST type] stone is very hard.

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