Ain Shams University
Faculty of women for Arts,
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Physics Department

Elemental analysis inductively coupled plasma mass spectrometry and other spectroscopic methods of beryl

Thesis submitted for the partial fulfillment of
Master Degree in Physics (Spectroscopic Physics)

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LIST OF ABBREVIATION

Symbol	Meaning
LA-ICP-MS	Laser Ablation-Inductively Coupled Plasma Mass Spectrometer
REE	Rare Earth Element
ICP-MS	Inductively Coupled Plasma- Mass Spectrometer
SEM-EDX	Scanning Electron Microscope- Energy Dispersive X-ray
XRF	X-ray Fluorescence
ICP-OES	Inductively Coupled Plasma- Optical Emission Spectrometer
MS	Mass Spectrometer
LA	Laser Ablation
IUPAC	Union of Pure and Applied Chemistry
LREE	Light Rare Earth Element
HREE	Heavy Rare Earth Element
HR-ICP-MS	High Resolution- Inductively Coupled Plasma- Mass Spectrometer
ESA	Electrostatic Analyzer
TIMS	Thermal Ionization Mass Spectrometer
SSMS	Spark Source Mass Spectrometer
SIMS	Secondary Ionization Source Mass Spectrometer
CCT	Collision Cell Technology
ICP-DRC-MS	Inductively Coupled Plasma- Dynamic Reaction Cell- Mass Spectrometer
CRI	Collision Reaction Interface
SF-ICP-MS	Sector Field- Inductively Coupled Plasma- Mass Spectrometer
TMP	Trubo Molecular Pump
RP	Rotary Pump
PEG	Penning Gauges
PIG	Pirani Gauges
USN	Ultra Sonic Nebulizer
Nd:YAG	Neodymium-doped Yttrium Aluminum Garnet

ABSTRACT

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Beryl which is known as a gem stone and the common source of the beryllium, is under study in order to measure the concentration of its elemental compositions.

The Scanning Electron Microscope Energy Dispersive X-ray (SEM-EDX) and the X-ray Fluorescence (XRF) techniques are used to determine the major elements concentration in white beryl from Akarem, eastern desert and green beryl from Om El Debaa, eastern desert, Egypt.

The inductively coupled plasma mass spectrometer (ICP-MS) is attached to the laser ablation (LA) unit to determine the trace element concentration in the pure, white, green and blue beryl samples. The rare earth elements (REE) concentration are determined, and a normalization to a common reference material is calculated to investigate the REE distribution in the Egyptian beryl.

Also a green beryl sample from Jabal Hamarat Ghannam (GH), Al Qoseir, Egypt is treated by fusion digestion process. In order to be measured using the inductively coupled plasma optical emission spectrometer (ICP-OES).

The inductively coupled plasma mass spectrometer attached to a membrane desolvation system (Aridus) is used for the isotopic analysis of the REE of the green digestive beryl sample from Jabal Hamarat Ghannam (GH), Al Qoseir, Egypt. The possible interferences within the range of consideration are under study. To eliminate such an interferences, an algebraic correction is a must. The isotopic ratio of the algebraic corrected isotopic concentration is calculated, and found to be very close to the natural isotopic ratio.

Keyword:

Beryl - Inductively coupled plasma mass spectrometer - Elemental analysis - Trace element- Rare earth element- isotopic analysis- Interferences elimination.

AIM OF THE WORK

Trace elements analysis studies has ever attracted researchers from different disciplines, which results in great advances in the spectroscopic elemental analysis.

The objectives of the thesis are :

1- Determination of the trace, ultra trace elements in some Egyptian beryl samples.
2- The study of some references samples as a guide to the samples under investigation.
3- Study the rare earth elements distribution in some Egyptian beryl samples.
4- Determination of the interferences within the range of consideration for the elements under study.
5- Investigate the possibility of using the Inductively Coupled Plasma –Mass Spectrometer technique in isotopic analysis of some elements in the Egyptian beryl samples.

CHAPTER (1)

INTRODUCTION

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1.1. Introduction

The inductively coupled plasma (ICP) source was developed as a highly efficient ions source for mass spectrometer (MS)[1]. Nowadays, ICP-MS is one of the most sensitive analytical techniques for fast multielement determinations in the trace and ultra-trace concentration ranges. It has a wide application in geology, environmental, biological research,[2] archaeology, forensics,[3] material science [4] and gemology[5]. Geological and earth sciences applications have received the most attention since the technique has been applied to a wide variety of geochemical topics, elemental groups and sample types.

This technique performs elemental analysis with excellent sensitivity, wider dynamic range, fast analysis time, relative minimum interferences, low detection limit and isotopic information. ICP-MS holds a unique position by virtue of its high performance. It is used to determine the rare earth elements (REE) in geological and environmental samples [6-7].

In ICP-MS the chemical compounds are decomposed into their atomic constituents in the inductively coupled argon plasma and ionized at a high degree of ionization (>90% for most chemical elements) with a low fraction of multiply charged ions (~1%). The positively charged ions are extracted from the inductively coupled plasma via an interface into the high vacuum of the mass spectrometer. In the mass analyzer of the mass spectrometer, the ions are separated according to their mass to charge (and energy to charge ratio in the case of double focusing ICP-MS)[8]. It can simultaneously measure most elements in the periodic table and determine analyte concentration down to part per trillion (ppt) levels. It can perform qualitative, semi quantitative, and quantitative analysis and compute isotopic ratios.

laser ablation (LA) was developed as a special sample introduction system for solid samples into the ICP-MS, where evaporation of the solid target material is

carried out in a laser ablation chamber[9-10]. The evaporation and dissociation material (atoms, molecules, ablated particles) is transferred by a carrier gas (argon) in the inductively coupled plasma source, where the neutral species are dissociated and ionized[11]. An advantage of the laser ablation inductively coupled plasma mass spectrometer (LA-ICP-MS) when compared to the ICP-MS of aqueous solutions is not only the simple sample preparation but also the significant reduction in interferences of oxides ions, hydroxide ions with the analyte ions.

The process in the ICP-MS can be summarized in the following chart.