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PREFACE

Crystals have ever fascinated mankind. The growth of crystals occurs either in nature or artificially in a laboratory. The Mother Nature has grown a variety of crystals in the crust of earth, which are mainly diamond and other precious stones. Systematic study of the growth and properties of crystals is covered under the subject "Crystal Growth." Today, the growth of crystals does not remain the phenomena only occurring in nature, but it has become a well advanced as well as widely used laboratory technique. There always has been a requirement of good quality crystals for various applications. In this regard the crystals having specific properties can be treated as the backbone of today's technological development. This led the investigators and scientists to concentrate on the developments of new variety of defect-free crystals of high degree of purity. Earlier crystal growth techniques were considered an art rather than science. Theories are now available on the growth of crystals so that crystal growth is no more an art. A variety of experimental techniques are developed and modified to such a level as to grow tailor made crystals for specific applications.

To explore the inherent properties in a crystal single crystal are always required. The search for high quality crystals -for better analytical results brought in different techniques for crystal growth. Growth of crystals from all the three phases of matter is tested by various methods. A particular method has been selected only after considering the constraints such as the specific requirement; the quality of the sample, economy etc. Among the various methods used for the growing single crystals, the gel technique is believed to be simple, sordid and elegant in many respects. The gel is a neutral medium. It allows the free passage of ions and sustains nucleation, which are essential for the growth of a crystal. It is believed that many natural crystals have been formed in gelatinous mediums. The versatility of the method and its close resemblance with biological systems has attracted the attention of many workers.

This book reports the detailed studies on the growth of lanthanides tartrate crystals in gel medium. Materials in the form of tartrate compounds deserves special attention because of their many interesting physical properties such as dielectric, piezoelectric, ferroelectric and optical second harmonic generation. The rare earth compounds have attracted considerable attention on account of their luminescent and magnetic properties. Among the rare earth compounds lanthanum, cerium and neodymium tartrate crystals were selected because of their promising technical applications in optics and magnetism. Beside this the lack of work on the growth of these materials prompted the initiation of this work.

This book is a comprehensive account of the experimental and theoretical aspects of various stages of crystal growth and growth controlling parameters in gel medium. The scope of the book is straight forward and designed in six chapters. It contains the observations and results of the growth of lanthanum tartrate, cerium tartrate and neodymium tratrate crystals.

Chapter 1 contains various aspects of the growth of crystals and begins with an outline of the developments of the subject. A discussion on the classification of the methods of crystal growth and the essential fragments of the theories which seems to be logical and consistent with the elementary nature of the thesis are included in this chapter. An outline on the importance of lanthanide series elements (rare earths) materials and the topic of the present problem is also seated in this chapter.

Chapter 2 introduces the subject of gel growth. The advantages of gel method over the conventional methods in growing certain type of materials especially the tartrate crystals are described. Exhaustive surveys of the literature concerning the subject, the various modifications of the methods are discussed.

Chapter 3 deals with growth of lanthanum tartrate crystals. The experimental setup, chemical reactions involved, growth kinetics, effect of the change in different parameters on growth mode are described in full length in this chapter. By changing the concentration of reactants, age, density and pH of the medium the nature of the growth has been investigated. Appreciable changes in the habit of the crystals, nucleation density, advancement of the crystallization front into the medium etc are attributed to the changes in the environmental conditions of the growth. All observations and findings are correlated to the theories.

Chapter 4 gives a detailed account of the growth of cerium tartrate crystals.

Chapter 5 covers the growth of neodymium tartrate crystals in detail.

Chapter 6 devoted to the summary and comparative study on the growth of these gel grown crystals.

H. M. PATIL

Dedicated To

My parents

For

Their Inspiration,

Their Warmth,

But Mostly

For

Their Ethics

Acknowledgement

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Finally, I would like to thank all the people who assisted directly or indirectly for the success of this work.

Abstract

Crystal Growth by Gel Method is a novel approach for high-quality crystals. The gel method is a versatile technique for growing crystals, offering precise control over crystal formation and morphology. In this approach, a gel-like medium, typically a hydrogel or a polymer, serves as a solvent and a template for crystal growth. The gel's properties, such as viscosity and chemical composition, can be tailored to optimize crystal formation.

Key benefits of the gel method include:

- Slow and controlled crystal growth, reducing defects and imperfections

- Ability to grow crystals with specific shapes and sizes.

- Enhanced crystal purity and optical quality.

- Reduced solvent usage and environmental impact.

This method has been successfully applied to grow various crystals, including proteins, nanoparticles, and inorganic materials, with potential applications in fields like biomedicine, optoelectronics, and catalysis.

The gel method offers a promising alternative to traditional crystal growth techniques, enabling the production of high-quality crystals with tailored properties.

Pure crystals of lanthanum tartrate, cerium tartrate and neodymium tartrate were grown by the diffusion of aqueous solutions of lanthanum chloride, cerium chloride and neodymium chloride as an upper reactant into the set gel embedded with tartaric acid. The single diffusion gel growth technique was employed for the growth of these crystals. The growth conditions were optimized by varying various parameters such as gel density, pH, gel setting time, aging of the gel, concentration of the reactants and temperature. Crystals of various dimensions and morphologies were obtained. Most of them were platelet, acicular and spherulites in shape.

Abbreviations

LaT	Lanthanum tartrate
CeT	Cerium Tartrate
NdT	Neodymium Tartrate
TG	Thermogravimetric
TGA	Thermogravimetric analysis
DTA	Differential thermal analysis
DTG	Derivative Thermogravimetric / Differential scanning calorimetry
DSC	Differential scanning calorimetry
UV-vis	Ultraviolet-visible spectroscopy
XRD	X-Ray Diffraction
SEM	Scanning Electron Microscope
NLO	Nonlinear Optics
KDP	Potassium di-hydrogen phosphate
DKDP	potassium di-deuterium phosphate
TGS	tri-glycine sulphate
KAP	potassium acid phthalate
LAP	Lithium Arginine Phosphate
SMS	Sodium Metasilicate
RHT	Rubidium hydrogen tartrate
CHPD	Calcium Hydrogen Phosphate Dihydrate
SHP	Strontium Hydrogen Phosphate
(BHP)	Barium Hydrogen Phosphate (BHP)
FT-I R	Fourier Transform Infrared
CCD	Charge-Coupled Device
DH	Dollimore-Heal
BJH	Barrett, Joyner and Halenda
DFT	Density Functional Theory
t-plot	Statistical thickness method
DR	Dubinin-Radushkevic
BET	Brunauer, Emmett and Teller

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ABOUT THE BOOK

This book is intended for use as reference book for undergraduate, postgraduate and research scholars who desire to work in the field of crystal growth by gel method. Useful for the beginners who desires to work in the field of crystal growth by gel method. The book provides a complete and comprehensive material on various topics of crystal growth by gel method. The subject matter is divided into six parts in simple and lucid language. Easy to understand most of the difficult and intricate topics. The book provides a comprehensive material on various topics of crystal growth by gel method. Book provides detailed study on growth of Lanthanum Tartrate, Cerium Tartrate and Neodymium Tartrate crystals by gel method.

ABOUT THE AUTHOR

Dr. Hiralal Motilal Patil graduated from prestigious Pratap College, Amalner affiliated to Poona University, Pune in 1987 with First Class. He passed his M.Sc. degree examination in Physics from M.J. College, Jalgaon affiliated to Poona University in 1989 with First Class. He obtained M.Phil. Degree from Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon (Formerly known as North Maharashtra University, Jalgaon) in 1997 and now he holds a Ph.D. degree in Physics from a prestigious Kavaitri Bahinabai Chaudhari North Maharashtra University, Jalgaon and has conducted research at renowned institutions. He has 34 years of teaching experience at undergraduate level. Presently he is working as an Associate Professor at renowned Jijamata Education Society's Arts, Science and Commerce College, Nandurbar. He has authored one Text Book for undergraduate students. Dr. Hiralal Motilal Patil is a renowned researcher and scholar in the field of materials science and crystallography. He has made significant contributions to the development of novel crystal growth techniques, including the gel method. Their research focuses on understanding the properties and applications of gel-grown crystals, with a particular emphasis on thermal properties. Dr. Hiralal Motilal Patil has published numerous papers in esteemed scientific journals and has presented their work at various national and international conferences. He is actively involved in the scientific community; continue to advance the field of crystal growth by gel method through his innovative research.

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