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ROLE OF CRYSTALS IN THE STUDY OF ANTI-FERROMAGNETIC

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Role of Crystals in the Study of Anti-Ferromagnetic

Parveen Kumar

Assistant Professor in Chemistry, Rajiv Gandhi College, Narwana

Abstract – Single crystals are the essential building blocks for current technology. The study of development and depiction of single crystals is forming in spine of current systematic developments and also is getting growing significance due to their number of applications in solid state technology. These technical benefits have been conducted by rapid strides in crystal growth. The current technological growth depends significantly on the possibility of appropriate single crystals.

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INTRODUCTION

Crystals grow plays a vital part in upcoming years of science and technology, the crystal structure by these methods are pure and perfect crystals in mass. The creation of laser crystals to ruby sapphire NOYAG and non-linear crystal in pasture of solid state physics and electronic as well as in photonics which are based on crystal growth revolution. For technical development, some vital crystals such as Gallium, Nitride, Diamond and Silicon Carbide are studied. Single crystals may be used in the field of alteration of solar energy information storage. Some crystals are used in electro, electronic, optical & industrial instrument, so today's necessity is to produce large crystal. Crystal growth process requires the understanding of chemical, relations, thermodynamics and about its mechanical properties at a time only. The major detail about crystal and the development in the crystal growth process and the hard work made by any scientists to produce a variety of technological important crystals have been obtained from various past researches. Artificial sensors improve communication tools. Single crystal may be found widespread application in the significance of high purity and exactness and the chemical and physical characteristics of the chemical system, involved in the process of crystal growth.

Many crystals have magnetic ions that are structured in preparations other than ferromagnetic. In anti-ferromagnetic ordering, the moments pointing in a way are balanced by others pointing in the conflicting way, with the outcome that the material has no net magnetization. The switch communication between ions in this case has the conflicting sign and favors the vary measures of spins. The mark of the switch communication between ions depends on the extent of the covalent bond and the bonding angles; it may have either direction. The typical temperature linked with anti-ferromagnetism is called the Neel temperature TN. Below Neel temperature, the ions are anti-ferromagnetically ordered, while above this temperature there is no long-range anti-parallel order. Some examples of anti-ferromagnetic crystals are manganese oxide (MnO; TN = 116 K), manganese sulfide (MnS; TN = 160 K), and iron oxide (FeO; TN = 198 K). Manganese oxide is an insulator since manganese atoms are divalent and oxygen atoms accept two electrons. The manganese ion has a permanent magnetic moment. The crystal organization of manganese oxide is the same as that of sodium chloride. Under the Neel temperature, the atomic unit cell doubles in size to contain two atoms of each type of ion. This is essential because below Neel temperature , adjacent manganese atoms have moments in the conflicting direction and are no longer the same; the unit cell must therefore comprise one moment in each of the two directions. Fluorides such as manganese fluoride (MnF_2), iron (II) fluoride (FeF_2), cobalt fluoride (CoF_2) and nickel fluoride (NiF_2) are other crystals that show anti-ferromagnetic ordering of the transition metal ions.

Investigational researches of the magneto-electric result in the anti-ferromagnetic crystals Cr_2O_3, Gd_2CuO_4 and Sm_2CuO_4 have been performed in strong magnetic fields up to 20 T. The magneto-electric effect is fully determined by the equilibrium of the magnetically prearranged substance and gives hence valuable detail about magnetic ground states. When the magnetic regularity is altered at a magnetic field induced period evolution the magneto-electric effect shows errors at the phase conversion owing to the fact that the magneto-electric signal is linked to the anti-ferromagnetic order parameter L. Even at temperatures nearest to the Neel temperature TN, the obtained investigational statistics determine the magnetic properties very well, providing the opportunity to study magnetic stage conversions in the significant temperature range. Anti-ferromagnetic materials can be classified into two classes, the low-anisotropic (Heisenberg) and the high- anisotropic anti-ferromagnet. By applying the magnetic field corresponding to the sub-lattice magnetization of a low-anisotropy anti-ferromagnet, a spin-flop conversion takes place at a significant field. It refers to an unexpected rotary motion of the sub-lattice magnetization to a direction vertical to the magnetic field. In the spin-flop stage, the magnetic equilibrium will be altered. By additional rising the magnetic field, the sub-lattice magnetizations line up along the magnetic field up to the spin-flip field Hc where they are fully aligned, the anti- ferromagnetic ordering is wrecked and the material is now found to be in a paramagnetic stage. Since all materials which we have investigated belong to the class of low- anisotropy anti-ferromagnets, results of ME studies of spin-flop and spin-flip transitions are presented.

MEASUREMENT

In an external magnetic field, a type of ferrimagnetic activities may be appeared in the anti-ferromagnetic stage, with the exact value of one of the sub-lattice magnetizations conflicting from that of the other sub-lattice, ensuing in a nonzero net magnetization. Although, the exact magnetization should be zero at an absolute zero temperature, the impact of spin canting often results in a little exact magnetization to develop.

The magnetic vulnerability of an anti-ferromagnetic material usually displays a upper limit at the Neel temperature. In comparison, at the conversion between the ferromagnetic to the paramagnetic stages the vulnerability will deviate. In the anti-ferromagnetic case, a deviation is observed in the staggered susceptibility.

Many microscopic communications between the magnetic moments or spins may direct to anti-ferromagnetic structures. In the simplest case, one may think an Ising model on an bipartite lattice, e.g. the simple cubic lattice, with couplings between spins at nearest neighbor sites. Depending on the symbol of that interaction, ferromagnetic or anti-ferromagnetic order will result. Geometrical disturbance or competing ferro and anti-ferromagnetic communications may direct to different and perhaps, more complex magnetic structures.

SPHERULITIES CADMIUM IODATE CRYSTAL

Spherulities of cadmium Iodate were grown by single and double diffusion gel technique. Growth conditions were optimized. Optimum growth conditions are reported. Kinetic's of growth parameters were studied. The crystals were doped with impurities such as copper and iron. Structure of crystals was established by X-ray powder diffraction method. Crystal having orthorhombic system. Spherulities shaped crystal of 2 to 6 mm size were obtained. Study of kinetics of growth parameters explains some interesting details. Spherulities shape of crystals is reported and has been revealed previously by Bolotov. The shape may be described via model of sheet of paper crumpled into folds.

The boundaries being compacted towards the center, the result of this is curved around the crystal. But at the first, the passel planes are twisted at random. These provide at the base for two-dimensional nuclei, which grow and block up the recesses on the outer surface, thus giving crystal a spherical shape.

Very less amount and low concentration of impurity does not influence the growth and morphology of crystals. Higher concentration of copper impurity, when integrated in gel decreases the size of spherulite, while iron impurity does not affect the size at all, Cu induces light blue color, while Fe induces light brown in cream shade of undoped crystals.

GROWTH AND STUDY OF GEL GROWN CRYSTALS OF BISMUTH IODIDE

The requirement of better featured crystals in industries and technology has kept the human race developing their information in the field of crystal growth. The development of realistically bigger size crystals of higher purity and homogeneity has long exercised the minds ingenuity of research workers. An efficient process is one which generates sufficiently ideal crystals for their use at lower cost. These days, most of the solid-state researches are done by using well-developed crystals. Due to lack of natural crystals or their availability in impure form, so it is necessary to grow pure and good quality crystals. Importance of gel growth method can be visualized by the information that number of researchers have grown and are growing crystals of technological potentiality by this technique.

Growth of crystals by gel method is a promising method for growing crystals of substances, which are sparingly soluble in water and decomposes before their melting point. The method is quiet exciting as it could be used to grow ionic, organic and metallic crystals at ambient temperature. Suppression of convection currents and control of nucleation are the two primary functions of the gel, which leads to the practical utility of the method. The objective of the current work is to put the gel technique on an anvil and thus to rest its performance and potentiality in producing larger and more perfect crystals. In the current study, aqueous solutions of two salts Bismuth Chloride and Potassium iodide are brought together by diffusion through a silica gel with succeeding nucleation and the crystal growth, which continues due to the regular precipitation of the insoluble product stage of the reaction. No reaction waste material is formed within the gel. Bismuth Iodide crystals cannot be crystallized by high temperature methods, as the material starts decomposing before melting. Therefore, predictable high temperature methods for its growth are not pertinent. Gel technique is only the substitute method to grow the crystals of the appreciable size and quality as reported in the present work at ambient temperature.

Moreover, this technique is simple and cheap. Hence the crystals of, Bismuth Iodide [BiI_3] were grown by gel technique.

The present study reviews many aspects regarding the growth procedure of Bismuth Iodide [BiI3], optimum growth conditions and the kinetics i.e. influence of different growth parameters to obtain optimization conditions for the growth of these crystals.

GROWTH AND STUDY OF GEL GROWN CRYSTALS OF BISMUTH TRI- SULPHIDE BI_2S_3

The chemical reaction technique is used to develop the Bismuth Tri-Sulphide crystals. This technique comprises growing of crystals by permtting the reaction of solution of soluble salt Bismuth chloride and H_2S gas water solution by diffusion through a gel with subsequent nucleation and the crystal growth, which continues due to the regular precipitation of insoluble product.

In the present study, single diffusion technique was used. In actual process, 5cc, 2N acetic acid was taken in a small beaker, to which sodium Meta silicate solution of density 1.04 gm/cc was added drop by drop with constant stirring by using magnetic stirrer, till pH of the solution reaches a value of 4.40. A digital pocket sized pH meter of HANNA instruments is used for this purpose. Continuous stirring process avoids excessive ion concentration which otherwise causes premature local gelling and makes the final medium inhomogeneous and turbid. To this mixture, 5cc of Bismuth Chloride (one of the reactants) was added with constant stirring. The pH of the mixture was maintained at 4.4. Numbers of experiments were carried out in order to secure appropriate range of pH values which in turn gives a good gel allowing to growing good quality crystals.

The chemical reactions inside the gel can be expressed as

$$2XCl3 + 3Y2S \rightarrow X2S3 + 6YCl$$

Where X=Bi and Y= H

OBSERVATIONS

On the quality of the crystals, various concentrations of reactants have different effects. Figure 1 shows Bismuth Tri-Sulphide crystals incorporated in the gel. Spherulites of Bismuth Tri-Sulphide crystals grown for these different concentrations of $BiCl_3$ ranging from 0.1 M to 1 M are shown in the figures 1. It is observed that as the concentration of Bismuth Tri-Sulphide increased from 0.1M to 1M, the size and the quality of the spherulites also goes on increasing. The crystals so formed are spherical in shape, opaque and well isolated.

Figure 2 shows few spherical graph paper with their scaling

Fig. 1 : Crystals of Bismuth – Trisulphide inside the test-tube

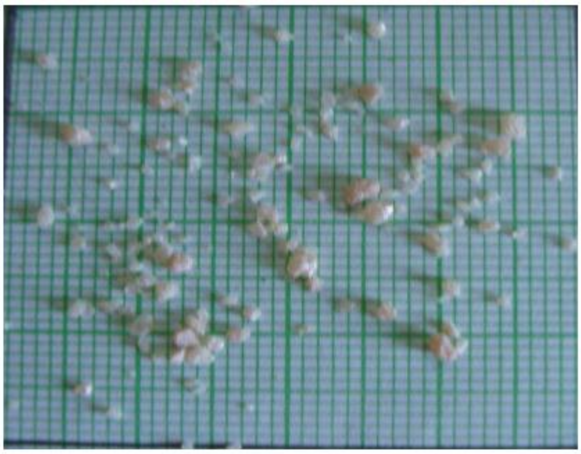

Fig. 2 : Few Crystals of Bismth – Trisulphide on gaph - paper

CONCLUSION

The outcome for the ME effect for the anti-ferromagnets Cr_2O_3, Gd_2CuO_4 and Sm_2CuO_4 have shown that the magnetic-field-induced ME effect contains full information about the magnetic ground state and the conduct of a magnetic system in strong magnetic fields. Due to the information that the ME effect in anti-ferromagnetism is associated with the anti-ferromagnetic order parameter makes this method a important tool to study magnetic systems. In high magnetic fields, these details about magnetic phase transitions are complicated to attain with other methods.

In substances which show anti-ferromagnetism, the magnetic moments of atoms or molecules, typically associated with the rotations of electrons, align in a normal pattern with adjacent rotations pointing in conflicting directions. This is, like ferromagnetism and ferrimagnetism, a manifestation of ordered magnetism.

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