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Topographical Morphology and Comparative Study of Star Shaped Grown Crystals of Copper Iodate Using Gel Technique

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Abstract: ***The copper iodate crystals are grown using single diffusion technique of crystal growth. Nucleation effect if pH and gel density and effect of supernautant, concentration programming explained and experimentally studied. The kinetic parameters demonstrate anisotropic growth, likely due to controlled supersaturation or external influences. In contrast, basic copper iodate crystals grow more uniformly, showing prismatic or block - like shapes. The modified morphology in star - shaped crystals can enhance specific functional applications, particularly in optics and catalysis***

Keywords: Copper iodide crystals, Nucleation, Gel, Morphology, transformation, Topography, comparision with intrinsic copper iodide, Applications

1. Introduction

Copper iodate grown crystals are used in optical and electronic devices due to their semiconducting properties. These crystals may be used in piezoelectric and nonlinear optical applications. it can be used as a catalyst in oxidation - reduction reactions and in biomedical applications due to their unique chemical reactivity, they may find applications in antimicrobial formulations. These crystals can be employed in chemical sensors due to their ionic conductivity. copper iodate ($Cu(IO_3)_2$) forms prismatic or irregularly shaped crystals when grown under standard conditions. The crystal structure is usually orthorhombic or monoclinic, leading to more block - like formations. Intrinsic copper iodate does not usually exhibit star - shaped morphology unless influenced by special parameters. It is observed that morphology can enhance piezoelectric properties. Increased surface area may improve catalytic efficiency. The optical and electronic materials can be used in photonic applications due to shape - dependent optical properties of copper iodate grown crystals.

1.1 Experimentation

This single diffusion method used to obtain good quality crystal of copper iodate in gel medium. In actual procedure, 5cc of 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 4.4. A digital pocket sized pH meter of HANNA instrument is used for this purpose. A 5cc of copper chloride or copper nitrate solution was added with constant stirring in mixture of acetic acid and sodium Meta silicate solution. Continuous stirring process avoids excessive ion concentration which otherwise causes premature local gelling and makes the final medium inhomogeneous and turbid. The pH of the mixture was maintained at 4.4, Number of experiments were carried out to secure appropriate range of pH values which in turn gives good gel allowing to grow good quality crystals.

It was observed that the mixture of solution with pH value less than 4.2, gelation takes quiet large time of the order of several days. However in the pH range 4.2 to 4.5, there was appropriate waiting in gelation time. The gel setting time required for the gel solutions of pH greater than 4.5 was short. Borosil glass test tubes of diameter 2.5cm and height 25cm were used as crystallizing vessels. This mixture was then transferred to the test tube, a mouth of test tube closed using cotton plug used to avoid contamination of the exposed surface with atmospheric impurities and to keep the gel at atmospheric conditions. Initially the mixture appeared in test tube was bluish, However with lapse of time its color changed towards dark blue when gel was completely set. The setting time was 10 - 13days. The completely set gel was left for aging for 4days. i. e.96 hours to120 hours. It is also observed that the aging of gel reduces the diameter of the capillaries in gel so that speed of the reaction is automatically controlled. Potassium iodate was used as supernatant having different molarities like 0.1M, 0.4M, 0.5M.1M. were added over the copper chloride set gel. As the concentrations of supernatant increases, the numbers of nucleation centers were also found to be increased. For this, numbers of test tubes were set up for the observation.

1.2 Nucleation

Formation of nuclei depends on number of parameters such as pH of solution maintained, concentrations of reactants, aging of gel, density of gel. It was observed that initial nucleation takes place on the surface of the gel and supernatant solution and rarely inside the gel. Number of nuclei is inversely proportional to the distance from the gel interface. Nucleation in gel takes place after 9 to 11 days. Generally this time varies few hours to few days depending upon the ambient temperature and circumstances.

2. Result and Discussion

It is observed that the optimum growth conditions for the growth of copper iodate crystals and its Different parameters such as gel density, gel setting time, gel aging time,

concentration of reactant, pH of gel, period of growth etc have the considerable effect on the growth rate.

Copper nitrate and copper chloride solutions are used to compared thickness transparency and quality of the crystal. The thickness of crystals grown by using copper nitrate as reactant is quiet effective in comparison when copper chloride is used as reactant. At a same time, crystals grown with reactant copper chloride are more transparent when same grown with copper nitrate. Crystals of copper iodate grown with help of copper chloride are shown in figure 1 and 2. image of figure 1 and 2 shows shape of copper iodate crystals in gel containing copper nitrate turns from spherical to star shaped are crowded. The size of copper iodate crystal in nitrate gel is small but are also transparent as shown in figure 3.

Effect of concentration of reactants:

The effect of concentration of feed solution can be investigated by preparing the gel of the same pH 4.4. Feed solution of either KIO_3, $CuCl_2$ and Cu $(No_3)_2$ were tried. Potassium iodate solutions of concentrations 0.1M to 0.4M molarities were prepared. It was observed that as the concentration of the reactant in the gel increases, the nucleation density also increases. This may be due to the more effect of Cu ions in the gel. For the growth of good quality crystal of copper iodate, suitable concentration of reactant incorporated in gel is found to be 0.5M. Number of experiments were performed with interchanging the position of reactants.

It is to mention that the reactant [0.5M of $CuCl_2$ and Cu $(No_3)_2$, 0.4M for KIO_3] were taken to grow good quality crystal of copper iodate using copper nitrate and copper chloride. Change in the position of reactants does not affect either the quality of the crystal or the number of nucleation centers. However, the use of KIO_3 and $CuCl_2$ yields the better and transparent quality of crystal, in terms of size and shape. Therefore, after getting the optimized condition, all experiment were carried out by incorporating 5cc, 1M $CuCl_2$ solution in gel and 15cc, 0.4M of KIO_3 solution as supernatant was put over the set gel acidified with 2N acetic acid as a feed solution.

1 Star shaped grown crystals of copper iodate

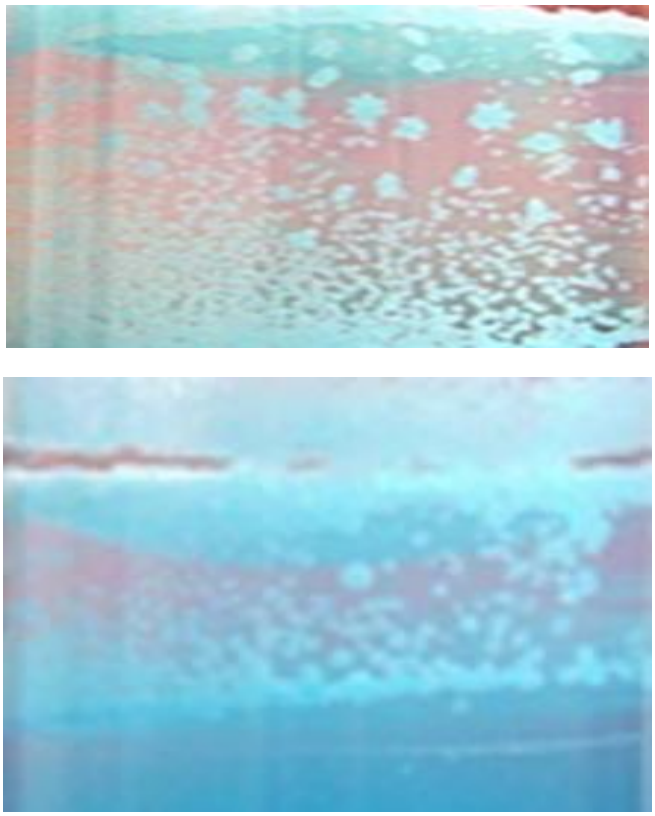

Figure 2: Spherical shaped grown crystals of copper iodate

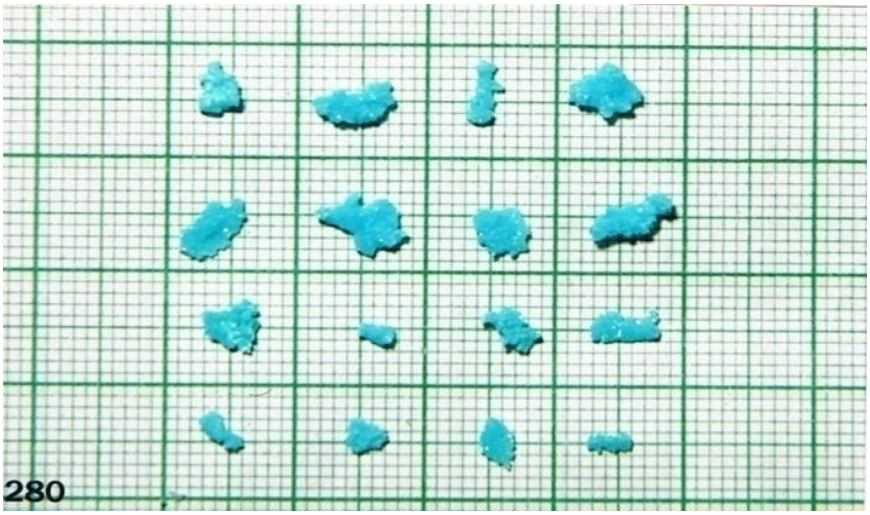

Figure 3: Grown crystals of copper iodate

3. Observations and Applications

The first image shows copper iodate crystals with a distinct star - like morphology. The star - shaped crystals indicate a unique growth pattern influenced by specific crystallization conditions. The formation suggests anisotropic growth, meaning the crystal grows at different rates in different directions. The light blue color confirms the presence of copper iodate. The star - shaped copper iodate crystals demonstrate anisotropic growth, likely due to controlled supersaturation or external influences. In contrast, basic copper iodate crystals grow more uniformly, showing

prismatic or block - like shapes. The modified morphology in star - shaped crystals can enhance specific functional applications, particularly in optics and catalysis. Typically, copper iodate (Cu (IO3) 2forms prismatic or irregularly shaped crystals when grown under standard conditions. The crystal structure is usually orthorhombic or monoclinic, leading to more block - like formations. Basic copper iodate does not usually exhibit star - shaped morphology unless influenced by special parameters.

Structural and Topographical Differences

Feature	Star - Shaped Crystals (Image 1)	Basic Copper Iodate Crystals
Shape	Star - like, branched growth	Prismatic, block - like
Growth Pattern	Anisotropic, uneven directional growth	Uniform, structured growth
Size Distribution	Irregular and extended branches	Compact and dense formation
Formation Conditions	Requires supersaturation or controlled parameters	Standard crystallization

Observations and Morphological explanation of Copper Iodate grown Crystals:

The first image shows copper iodate crystal formation in a liquid medium. Its precipitation appears as fine, dispersed particles. The topography reveals a gradual crystal growth pattern, with initial nucleation forming at the top of the solution and settling down. Third Image (Separated Crystals on a Grid) shows The extracted copper iodate crystals show a well - defined structure. The crystals are irregularly shaped but exhibit a noticeable blue coloration. The morphology suggests polycrystalline aggregation with varying sizes. The crystals demonstrate an irregular growth pattern, indicating heterogeneous nucleation. The presence of larger and smaller fragments suggests non - uniform growth rates. The surface texture appears rough, likely due to rapid precipitation in solution. The third diagram shows individual copper iodate crystals placed on a grid for measurement and analysis. The crystals appear blue in color, confirming the presence of copper iodate. The crystals are irregularly shaped, with some being more compact while others appear fragmented. The grid provides a scale reference, allowing for the size and shape distribution analysis. The crystals are not uniform, showing various structures, including angular, polygonal, and slightly elongated forms. Some crystals appear larger and more well - defined, while others are smaller fragments, indicating a non - uniform growth process. The crystals seem to have a rough texture, possibly due to rapid precipitation or imperfect growth conditions. Some crystals are separated, while others are partially clustered, suggesting secondary nucleation or breakage during crystal handling.

Comparison with Ideal Copper Iodate Crystals

Feature	Observed Crystals (Image 3)	Ideal Copper Iodate Crystals
Shape	Irregular, broken, and clustered	Well - defined prismatic or star - shaped
Size Uniformity	Varies significantly	More uniform under controlled conditions
Surface Texture	Rough, uneven	Smooth, well - formed
Crystal Growth Pattern	Random nucleation and growth	Controlled growth with defined symmetry

4. Conclusion

- The star - shaped copper iodate crystals in the first image demonstrate anisotropic growth, likely due to controlled supersaturation or external influences. In contrast, basic copper iodate crystals grow more uniformly, showing prismatic or block - like shapes. The modified morphology in star - shaped crystals can enhance specific functional applications, particularly in optics and catalysis.
- The third diagram showcases individual copper iodate crystals with varied shapes and sizes, likely due to rapid nucleation or external influences. The analysis helps in understanding growth patterns and optimizing crystallization techniques for specific applications.

References

[1] K. P. Joshi, K. B. Saraf Acrylic Starlite Crystals Grown using Gel Method and its Characterization, AJCER, VOL4 (1) 28 - 32pp **Jan, 2011**

[2] K. P. Joshi, K. B. Saraf, Growth of Multi - shaped Crystals of Copper iodide in Gel and its Characterization AJCR, Vol4 (2) 84 - 87p. p, **April, 2011**

[3] K. P. Joshi, Semiconducting copper sulphide grown Crystal in Gel and its characterisation. IORD, Vol2, 2348 - 0831p. p. Feb, **2015**

[4] K. P. Joshi, Optical Structural electronical and Band gap determination of newly grown semiconducting Copper sulphide crystal using Gel method, IJAREEIE, Vol4 (2) 23203765p. p. **Feb, 2015**

[5] K. P. Joshi, Growth of copper Sulphide and iodide Crystal in Gel and its Characterizations, JORD, Vol7 (9) 166 - 179p. p. **Dec, 2017**

[6] K. P. Joshi, Make in India for Indian Development of Economy Globally with rising influence and its reflectance with corporate head reverence, **Jan 2017.**

[7] K. P. Joshi, B. S. Nandekar, Barun. K. Mehata Growth of star shaped crystal of copper iodate in Gel and Effect of various Parameters on Crystal Growth, Volume 4, Issue 4, April **2018**International Journal of Scientific Research in Science and Technology (IJSRST) 2395 - 6011 (Print) 2395 - 602X (Online) 5

[8] K. P. Joshi, Growth of copper Sulphide and iodide Crystal in Gas - Gel and its Characterizations IJSRST international Journal of Scientific Research in science and Technology. (IJSRST), Volume 4, Issue 4, 449 - 454 **April 2018**, Online, 2395 - 602X,

[9] K. P. Joshi, Synthesis of Semiconducting Copper Sulphide crystal grown in Gas - gel and its characterization, IJSRST international Journal of

Scientific Research in science and Technology. (IJSRST), Volume 4, Issue 4, 40 - 4s **April 2018**, Online, 2395 - 602X, 5.327

[10] K. P. Joshi, Issues of scheduled tribe in remote region, Activities for and by Adivasi peoples communicated

[11] Singh and B. Kumar (2010), Impedance analysis and high temperature conduction mechanism of flux grown Pb $(Zn_{1/3}Nb_{2/3})_{0.91}Ti_{0.09}O_3$ single crystal, Cryst. Res. Technol. Vol - 45, pp 999.

[12] Syed Ali, R. Saravanan, and M. Acigoz (2011), Growth and XRD analysis of the diluted magnetic semiconductor $Zn_{1-x}Ni_xO$, Cryst. Res. Technol. Vol - 46, pp 327.

[13] Chauhan, P. M. Vyas, and M. J. Joshi (2010), Growth and characterization of Struvite - K crystals Cryst. Res. Technol. Vol - 45, pp 493.

[14] Parikh, D. J. Dave, B. B. Parekh and M. J. Joshi (2010), Growth and characterization of L - alanine doped KDP crystalsCryst. Res. Technol. Vol - 45, pp 70.

[15] Xiujun Fan, Yue Wang, Hong Xu, and Yijian Jiang (2010), Floating zone growth and characterization of ruby single crystals Cryst. Res. Technol. Vol - 45, pp 603.

[16] Ying Wu, Li - Juan Wang, and Guo - Yue Liu (2011), Explanations of the optical absorption and ESR spectrum for tetragonal Ni^+ centers in $CuAlS_2$: Ni^+ crystals, Cryst. Res. Technol. Vol - 46, pp 221.

[17] Kumar, G. Varughese, L. Iype, R. Rajesh G. Joseph, and G. Louis (2010), Electrical conductivity of sulfamic acid single crystals, cryst. Res. Technol. Vol - 45, pp 634.

[18] K. P. Joshi, IJIRT VOL Growth of Spherulite star shaped Copper iodate Crystals in Gel and its effective kinetic Parameters. Volume 7, ISSN2349 - 6002, 09 - 02 - 2021

[19] K. P. Joshi, IJSRST Growth of copper iodate Crystal in Gel and its characterization, ISSN2395 - 602X, 07/**02/2021**

[20] K. P. Joshi, IJRAR, Growth of heavily conducting metal copper iodide Crystal in Gel and its characterization, ISSN2348 - **1269, 2021**

[21] D. S. Patil, S. B. Patil, K. P. Joshi. P. H. Pawar JOICS"Studies on CIS thin Films as Solar Base Material Vol 11 issue 9 Page 595 - 604"ISSN1548 - 7741**, 2021,** UGC Approved group A Journal

[22] K. P. Joshi, S. B. Patil; Growth of Copper Sulphide Crystal in Gel and its Thermal Spectroscopic Semiconducting Characterizations' and its Kinetic Parameters YMER ISSN 044 - 00477 page 246 - 256Vol20 issue 12, **2021**, Our journal is Scopus Active and included in UGC – CARE Group – II Journals List

[23] M. M. Patil K. P. Joshi, S. B. Patil, P. V. Dalal; Studies on nanocomposites Nano plates and Perovskites Nano rod thin films YMER ISSN 044 - 00477 page 303 - 313Vol 20 issue 12, **Dec 2021**, Our journal is Scopus Active and included in UGC – CARE Group – II Journals List

[24] D. S. Patil, K. P. Joshi, S. B. Deshmukh, S. B. Patil, P. H. Pawar, 'Non stoichiometric Chemically deposited Cdx Pb1 - x S Thin films Vol - 8 - issue - 4, IJRAR E - ISSN23481269, PAGE 551 - 559, **2021,** UGC Care list

[25] K. P. Joshi, Thermal Characterisations of Grown Copper Iodate Crystal in Gel and Study of Its Parameters, International Journal of Science and Research (IJSR) **pp - 2024** 3DOI: ttps: //dx. doi. org/10.21275/SR241042142335 - 439 ISSN: 2319 - 7064, 7.942

[26] Growth of heavily conducting metal copper iodide crystals in Gel and its structural analysis with kinetic Parameters International journal for innovative research in multidisciplinary field, VOL - 10, 1/1/2024, ISSN (O): 2455 - 062, 9.47, **2024**