# INVESTIGATION OF THE CRYSTALLIZATION PROCESS IN THE PRODUCTION OF INORGANIC SUBSTANCES

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**Abstract**

Crystallization is the process by which a solid forms, where the atoms or molecules are highly organized into a structure known as a crystal. Some of the ways by which crystals form are precipitating from a solution, freezing, or more rarely deposition directly from a gas. The following article looks into the process of crystallization.

**Key words:** Crystallization, gas, freezing, precipitation, cooling, molecule, atom.

Crystallization is the process of arranging atoms and molecules into a rigid crystal lattice with a well-defined energetically stable structure. The smallest structural element of the crystal lattice is a cell. It is capable of accepting atoms and molecules, and due to this property, a macroscopic crystal is formed. During crystallization, atoms and molecules are joined together at specific angles, forming a characteristic crystal shape with smooth surfaces and faces. Although crystallization occurs naturally, it also has wide industrial applications. It is used in the separation and purification phase in the production of pharmaceutical and chemical products.

**Crystallization and precipitation**

The conditions of the crystallization process directly affect the size and shape of the crystals and the purity of the crystalline product. It is important to understand the essence of the crystallization process and correctly select its parameters. This will allow you to obtain uniform crystals of the desired size, shape and clarity, as well as prevent problems in subsequent stages, such as too long filtration time or insufficient drying.

**Application**

Crystallization is widely used to produce a variety of products we need, from food and medicine to fuel. Most products from the agrochemical and pharmaceutical industries undergo several crystallization stages during development and production. This process produces key food ingredients such as lactose and lysine. However, unwanted crystallization can be dangerous - for example, crystallization of gas hydrates in deep water pipelines.

**Basic concepts of crystallization**

Crystallization is the process of the formation of a solid phase in the form of crystals from solutions or melts.

Crystal— a body whose particles (atoms, ions or molecules) are located in a three-dimensional periodic structure that takes the natural form of a polyhedron.

Sedimentation - a synonym for crystallization, however this term is most often used in relation to crystallization, which occurs very quickly as a result of a chemical reaction.

Solubility - property of a substance, its amount that can dissolve in a given solvent at a given temperature.

Saturated solution - a solution containing the maximum amount of a substance that can dissolve in a given solvent at a given temperature. Crystallization takes place in a saturated solution. The amount of a substance dissolved at that time is determined by its solubility.
Supersaturation - the difference between the real and equilibrium concentration of the solute at a given temperature.
Crystallization types
Crystallization occurs when the solubility of a substance in solution decreases in some way. Standard methods for reducing solubility:
a) cooling;
b) adding an anti-solvent;
c) evaporation;
d) reaction (precipitation).
The choice of crystallization method depends on the equipment available, the objectives of the crystallization process, the solubility and stability of the solute in the selected solvent.
Difficulties in crystallization
Typical Crystallization Difficulties
Crystallization occurs due to several interrelated processes, the course of which is influenced by the selected parameters. Main steps:
the formation of active centers (nucleation);
height;
the formation of a new liquid phase;
agglomeration;
disintegration of agglomerates;
the formation of polymorphic modifications.
These processes, which often take place in a latent form, have a key influence on the result of crystallization. LBy raising the temperature, completely dissolve the product in the solvent. Undissolved impurities can be removed from the hot solution by filtration. To reduce solubility, use refrigeration, addition of an anti-solvent, evaporation, or a precipitation reaction. The solution will become oversaturated. Crystallize the product. When the solubility decreases to a certain point, nucleation and crystal growth begins. During this process, crystals of a high purity product are formed. Impurities will remain in the solution. Allow the system to reach equilibrium after cooling (or using another crystallization method). Filter and dry the finished product.

**Recrystallization**

Basic parameters and transformations during crystallization. Crystals have many characteristics, but perhaps the most important of them is the crystal size distribution. The quality of the final product and the efficiency of the process of obtaining it largely depend on this parameter. The size and shape of crystals directly affects the main technological stages following crystallization - filtration and drying. The final crystal size also determines the quality of the crystalline product. For example, the smaller the crystals obtained, the higher the bioavailability and effectiveness of pharmaceutical compositions, since they dissolve better.
The dispersion of crystals can be optimized by careful selection of conditions and parameters of the crystallization process. In order for a crystalline product to acquire the desired properties, it is important to understand how the process parameters affect the main transformations during crystallization - the formation of nuclei (nucleation), growth and decay of crystals.

The dispersion of ice crystals, for example, affects the taste and texture of ice cream: for example, crystals smaller than 50 microns are preferable to crystals larger than 100 microns. It also affects the technological properties of sprayed agrochemicals: their particles must be small enough not to clog the nozzles when spraying, but large enough so that they are not carried away to neighboring fields.

When scaling up, obtaining a crystalline product of the required size and shape at the lowest cost is possible only if all the nuances of crystallization are understood.

**Crystallization equipment**

Process analytical technology for the development of crystallization processes

The crystallization workstation allows scientists to get the most out of each experiment with a centralized software solution. Process Analytical Technology (PAT) Tools:

The automated EasyMax, OptiMax and RX-10 reactors and the RC1 reaction calorimeter provide continuous (24/7) and accurate control and recording of process parameters, including enthalpy of crystallization values, so scientists can accurately determine critical process parameters (CPP).

EasyViewer is a high resolution imaging probe and analysis tool. EasyViewer calculates the characteristics of dispersions of crystals, particles and droplets in the natural form in which they are in the process environment.

ParticleTrack is a particle size and number analyzer. The statistically reliable characterization of the properties of dispersed systems obtained with its help contributes to the successful scale-up of the process from laboratory to production in full compliance with ATEX requirements.

ReactRaman - in situ Raman spectroscopy provides information of a chemical and structural nature, which is necessary for a comprehensive study of polymorphic systems and the selection of process parameters that ensure the formation of crystals of the required shape.

ReactIR - Real-time IRFS spectroscopy provides important information about concentration and supersaturation level, metastability zone width, supersaturation release kinetics and crystallization endpoint. This data is necessary to ensure repeatability of the crystallization process and to ensure that the specified end point is reached.

IC Software - Provides interoperability between all PAT tools. All sensors and reactors can exchange information, and all analytical data (size, shape, supersaturation, etc.) can be used as process control parameters.