citric acid technology

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Vogelbusch Citric Acid Plants

Well-known for the development and industrial application of leading-edge citric acid processes, today Vogelbusch is the world's leading supplier of citric acid plants. This is not just because we deliver advanced technology tailored to customer and market requirements: clients also benefit from the fact that we are the only producer-independent engineering company with proprietary process and engineering know-how.

Based on decades of experience in international plant construction activities and on more than twenty years of work in the erection of citric acid plants, Vogelbusch has the know-how and ability to carry out all project work associated with the construction of a citric acid plant, from the first idea through to successful commissioning.

Services include preparatory project work such as market analysis, site analysis and testing of raw materials. If required, feasibility studies may be based on algorithms recognized by international finance institutions.

Project realization services range from basic engineering, detail engineering, project management and contracting right up to the supervision of erection and commissioning. Technical assistance is also provided for the optimization and reconstruction of existing plants and systems.

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History, Properties and Application of Citric Acid

Discovered by Scheele in 1784, up until 1919 citric acid was produced exclusively by the precipitation of its calcium salt from the juices of citrus fruits and the subsequent preparation of the free acid by treatment with sulfuric acid.

Industrial production of citric acid using a microbial process started in 1919. The acid was produced from renewable sources or by-products from the sugar and/or starch industry. Improvements of this technology continue to date, resulting in evidently increased economy of the process as well as greater variability in the use of raw materials and increased process stability.

Based on these technical and economic improvements and the good organoleptic, physiological and chemical properties, citric acid is today one of the most important organic foodstuff acids. World-wide production currently stands at 850,000 to 1,000,000 metric tons per year. The main areas of application of citric acid can be seen below in figure 1.

The main consumer is the food industry, where citric acid is particularly used as an acidifying agent, pH buffer and, in combination with other compounds, as a preservation agent. In the detergent industry it is the sequestration characteristics of citric acid and its biodegradability which make it an ideal substitute for phosphate. Because of the growing worldwide significance of environmental concern and the consequences of this for the composition of domestic and industrial chemicals, it can be assumed that there will be a disproportionate growth in this range of applications over the next few years.

Overall, the citric acid market has already been featuring stable growth rates of 5 to 7 % p.a. for a good many years, and this will continue in the future. Due to differing growth rates in individual areas of application (figure 1), applications outside the food industry will also grow in importance.

Vogelbusch Process for Citric Acid Production

With more than twenty years involvement in the development and industrial application of processes for producing citric acid, today Vogelbusch has at its disposal:

- Special processes for spore cultivation;
- Optimized technological processes for the preparation of various raw materials for citric acid fermentation;
- Fermentation procedures precisely matched to the individual raw material;
- High-performance production facilities, selected and adapted for different raw material qualities;
- Processes for isolating the citric acid from fermentation mashes, which, in addition to assuring the quality of the final product, also guarantee high yield and suitability for process automation;
- Processes for purifying and crystallizing the citric acid, which in turn make it possible to manufacture the various product configurations (anhydrous, monohydrate, syrup, sodium citrate) in accordance with internationally acknowledged quality standards (BP, USP and others) with minimal energy and chemical requirements;

as well as having recourse to experience acquired from a long series of reference plants involving the industrial implementation of these processes. Thanks to the amassed references and the accumulated company know-how, best process parameters are achieved with Vogelbusch technology. Thus today Vogelbusch is one of the leading suppliers of citric acid plants.

Spore Cultivation

A precondition for an efficient microbial production process is the availability of high-quality inoculation material. In the case of citric acid synthesis, the inoculation material is added to the fermenter in the form of spores from the production strain at the start of the process.

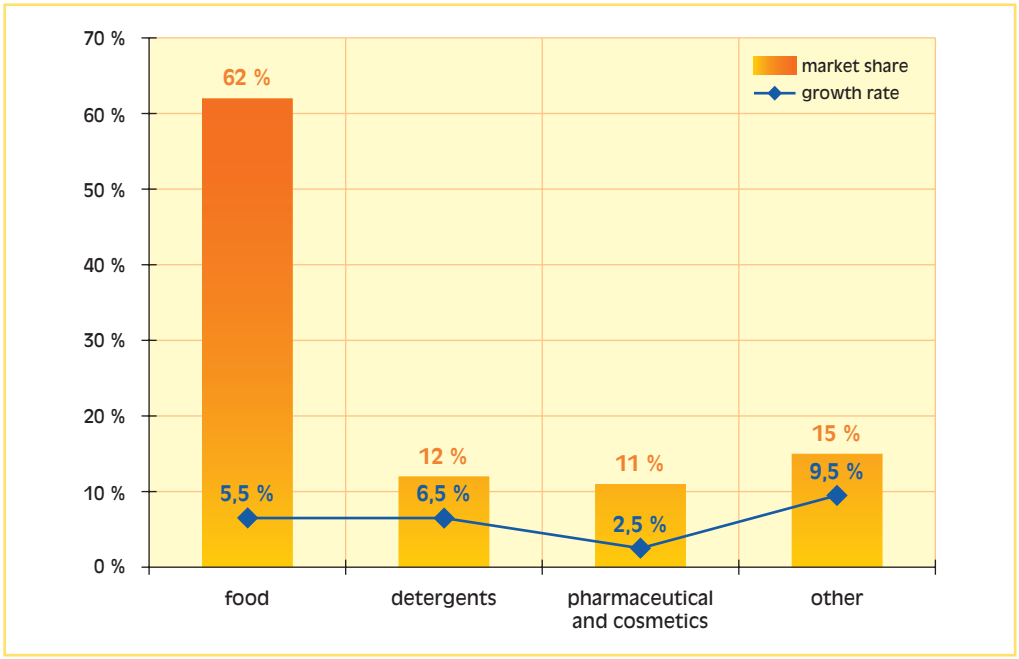

Figure 1: Industrial application of citric acid and annual growth rates in consumption

Harvesting of spores

Taking account of the demand for high quality for this material, Vogelbusch has developed appropriate technology for spore propagation, harvesting and testing. The spores are dried which improves the storage stability as well as the ease of dosage.

Raw Materials Processing

In principle, all substrates containing glucose, saccharose or starch are well-suited for the manufacture of citric acid using the Vogelbusch process. In the case of substrates containing starch, a saccharification process is introduced before the main procedure in order to convert starch into glucose which can be used by the production strain. Prime technical relevance is attached to:

- Starch hydrolysate
- Raw sugar and
- Beet and cane molasses

Due to very widely-differing levels of impurities of these substrates, Vogelbusch has developed special technologies for raw material processing which are adapted to the individual situation. In the case of starch hydrolysates with relatively low impurity, and also with raw sugar solutions, raw material preparation consists of decationization and subsequent continuous sterilization.

In the case of substrates with a high degree of impurity, particularly molasses, the raw material is subjected to hexacyanoferrate clarification, with simultaneous boiling and decontamination.

Fermentation

With bubble column fermenters, the Vogelbusch process is based on the most attractive type of fermenter from the point of view of energy consumption, as well as the most simple known type regarding design considerations.

Specially-selected production strains of the type Aspergillus niger and processes precisely matched to the individual raw material for regulating the metabolic activity of the microorganisms used guarantee the best possible substrate yields and productivity.

Citric Acid Isolation

The object of citric acid isolation is to obtain a largely pre-purified citric acid solution from the fermented mash. To achieve this, the mash is subjected to the following process stages:

- Mycelium separation;
- Calcium citrate precipitation and separation
- Calcium citrate decomposition and gypsum separation

To achieve the separation of the solids, use is made predominantly of modern, highly-automated filters. Specially developed processes for calcium citrate precipitation and decomposition have led not only to the minimization of the costs for these process stages but, above all, to the high level of reproducibility of the process which is essential for the quality of the final product.

Citric Acid Purification and Crystallization

The final purification of the citric acid which follows is effected by treating the isolated citric acid solution with activated carbon, cation and anion exchange resins in fixed bed reactors. Thanks to their automation and reactor design concept, these process stages also meet all the demands of a modern production process.

The final processing of the crystalline end product involves the following process stages:

- Evaporation
- Vacuum crystallization
- Centrifuging
- Fluidized bed drying and
- Classification

The evaporation of the citric acid solution is effected in multistage falling film evaporators combining the advantages of delicate product handling with high energy efficiency. The specific energy requirement can be reduced even further by thermal vapor compression.

Continuously operated forced-circulation vacuum crystallizers are used for the crystallization of the citric acid. The appropriate measuring and control strategies, and a crystallizer design matched to suit them, allow Vogelbusch plants to produce citric acid monohydrate (CAM) as well as anhydrous (CAA) using the same equipment. Sophisticated strategies for the recirculation of the mother liquor, separated from the crystal mash in a continuous centrifuge, allow for effective control of the quality of the final product.

The drying process used takes full account of the high demands for the quality of the final product by providing delicate product handling. Thanks to the subsequent screening of the dried final product, customer-specific fractioning is possible according to particle size.

Process Parameters

Table 1 provides a summary of the process parameters achieved by Vogelbusch in the fermentation process. For the sake of simplicity, a distinction is drawn between pure substrates and molasses as raw material.

Depending on the impurity of the fermented mash and the qualities of the raw materials, a yield of 90 to 92 % is achieved in the product isolation and purification stages.

Fermentation section

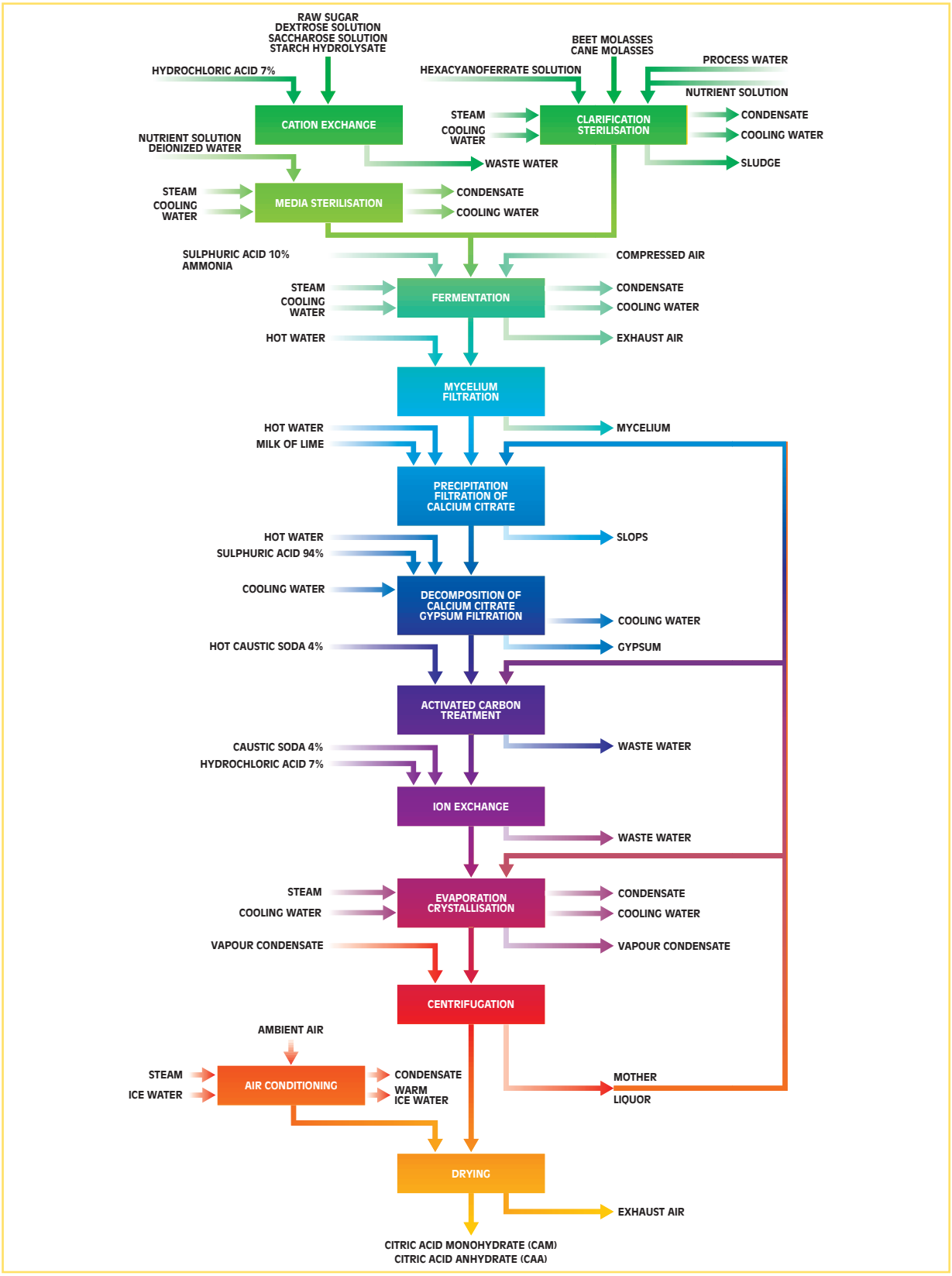

Figure 3: Block diagram - Vogelbusch process for citric acid production

Parameter	Unit	Raw material	
		pure substrate	molasses
Yield	g CAM/g DS	min. 0.84	min. 0.80
Cycle duration	h	144	144
Final concentration	g CAM/l	min. 140	min. 100

DS - fermentable sugars as disaccharide

Table 1: Main process parameters of the Vogelbusch fermentation process

The essential consumption figures, which determine feasibility, are compiled for the process as a whole in table 2. When evaluating these factors, it must be taken into account that the characteristic parameters influencing the total energy consumption (such as cooling water and steam consumption, cold water requirement, etc.) are also dependent on the plant location.

Parameter	Unit	Consumption per t CAM
Chemicals		
Slaked lime (70 % CaO)	kg	710 - 750
Hydrochloric acid (30 %)	kg	170 - 190
Sulfuric acid (94 %)	kg	860 - 910
Caustic soda (50 %)	kg	140 - 160
Utilities		
Process water	m³	50 - 56
Deionized water	m³	11 - 14
Cooling water 24 °C	MJ	10,350 - 11,300
Cooling water 32 °C	MJ	13,600 - 14,600
Cooling water 5 °C	MJ	1,050 - 1,250
Steam 9 bar	kg	8,500 - 9,000
Electrical energy	kWh	1,950 - 2,100

Table 2 : Specific consumption figures for the Vogelbusch citric acid process

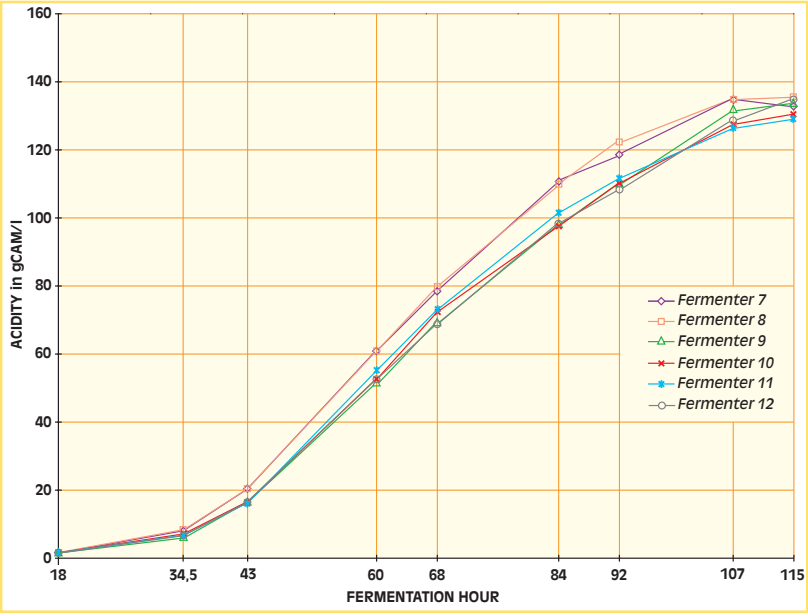

Figure 2: Citric acid test fermentation

Reference Plants

Vogelbusch has acquired skills from an extensive series of reference projects, resulting in an exceptionally strong know-how base and hands-on experience. The range of raw materials used extends from raw sugar, beet and cane molasses, to various types of starch hydrolysates. Table 3 shows a compilation of selected reference plants.

Name of plant	Capacity
Cargill Inc., Iowa, USA	75.0 t/d CAM
Ningxia Ferment Factory, PR China	10.9 t/d CAA
Tang Shan Starch Glucose Plant, PR China	10.9 t/d CAA
Wanquan Citric Acid Plant, PR China	10.9 t/d CAA
Yichang Municipal Citric Acid Plant, PR China	10.9 t/d CAA
Solaris Chemtech (former Bharat Starch), India	60.0 t/d CAM
Song Yuan Citric Acid Factory Co., P.R. China	16.7 t/d CAA
Gonzhuling Citric Acid Co., PR China	16.7 t/d CAA
Daqing Oil Construction, PR China	33.4 t/d CAA
Citro Misr Co., Egypt	36.5 t/d CAM
Kimia Gharb Gostar, Iran	36.5 t/d CAM

Table 3: Selected reference plants

Pilot plant

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