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High Power Ultrasonic for Crystalization

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Abstract: ***High-power ultrasonics is a new powerful, technology that is not only safe and environmentally friendly in its application but is also efficient and economical. It can be applied to existing processes to reduce or eliminate the need for chemicals and/or heat application in a variety of industrial processes. This innovative new technology, of low frequency, high-power ultrasound (20 kHz - 1MHz), can be applied to a large number of industry processing applications including Crystallization***

Keywords: Laser ultrasound, High Power, Crystallization.

1. Introduction

It has been known for a long time that both the crystal structure and kinetics of crystallisation can be affected by ultrasound. In the past systems used have relied on high power ultrasonic probes to produce crystals. The majority of these probes produce cavitation in the system and it has been difficult to differentiate between effects caused by the ultrasound alone or by the cavitation produced by ultrasound on the crystal structure. Some materials, such as fats, are very susceptible to the production of free radicals that lead to "off-flavours" being obtained. These "off-flavours" are easily produced when the standard high power probes are used. This has meant that, although the crystal structure of the final product might be improved, the presence of 'off' flavours has prevented ultrasound being considered as a commercial technique for the crystallisation of edible fats. At Unilever R&D a system has been developed which can investigate the effect of ultrasound on the crystallisation of fats under controlled conditions covering a range of intensities and cooling rates. The intensity levels used were both below and above the cavitational threshold. By keeping the cooling regime constant it has been possible to show that the structure of the final product can vary from a material looking similar to cottage cheese through to a fine cream simply by varying the ultrasonic intensity. This paper describes the effect of ultrasound on both the crystal structure and kinetics of palm oil crystallisation at intensities below and above the cavitational threshold.

2. Mechanism

High powered ultrasound can assist the crystallization process in several ways, as it can influence the initiation of crystal nucleation, can control the rate of crystal growth; ensuring small and even-sized crystals are formed, and can prevent fouling of surfaces by the newly formed crystals. If such processes are not well controlled, nucleation and subsequent crystallization can occur randomly, (often from small fluctuations in temperature and pressure) which generally produce a poor quality product. This can be of considerable financial significance in a large commercial process.

Ultrasound offers enhanced control over the point at which nucleation occurs, by both homogeneous and heterogenous mechanisms. Homogenous crystallization using ultrasonics in a saturated solution or in a super cooled liquid produces new crystallization sites. The mechanisms have not been fully characterised but they are probably associated with the pressure released from the collapse of cavitation bubbles, which either increases the melting point of the crystals or induces spontaneous formation of new crystals when the melt is close to the metastable point. Heterogeneous crystallization is associated with the mechanical effect of cavitation, which breaks up crystals to generate new nuclei for further crystallization.

Ultrasonic crystallization results in the formation of small, evenly sized crystals. Their small size appears to be related to the large number of nuclei that can develop and is not simply due to the fragmentation of large crystals. Crystal morphology can in certain cases be affected by ultrasonics, however their size can be significantly reduced with increased power input. Similarly the rate of nucleation can increase with increasing ultrasonic power at reduced frequency. Thus ultrasonics offers control over both these processes. In the metals industry, this has been applied to the manufacture of zeolite where nucleation time and overall process times have been substantially reduced, compared to conventional crystallization technology (Table 1).

Table 1: Effect of ultrasound on the crystallization of zeolite

	Nucleation Time	Completion Time
Conventional Technology	5 hrs	10 hrs
Ultrasonics at 38kHz	3 hrs	7 hrs
Ultrasonics at 20kHz	1 hr	3.5 hrs

3. Conclusions

Ultrasonic crystallization technology can be applied to foods where it can be used to control the size and rate of development of ice crystals in frozen foods. As food is frozen, small crystals form within matrix. With conventional freezing, the time taken from the initiation of crystallization to complete freezing (the dwell time) can be lengthy, and then during storage the crystals can expand. With cellular materials such as meats, fruits and vegetables the extended dwell time and crystal expansion softens and sometimes ruptures cell walls, resulting in textural softening and the release of cellular liquid on thawing. Freezing using ultrasonics ensures rapid and even nucleation, short dwell times and the formation of small, evenly sized crystals, greatly reducing cellular damage and preserving product integrity, even on thawing. An added bonus from ultrasonics induced crystallization is the continuous cleaning effect from cavitation, which prevents encrustation of crystals on the cooling elements and ensures continuous heat transfer during the process. In wine making, a number of authors claim that ultrasonic treatment results in a significant reduction in the time taken to precipitate potassium tartrate, with no adverse effects on the composition or organoleptic qualities of the wine.

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