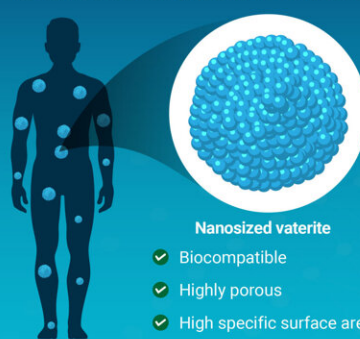


Researchers propose an organic-solvent-free method for producing nanosized vaterite

November 7 2023

Seawater-Based Synthesis of Nanosized Vaterite

Nanosized vaterite, a form of calcium carbonate (CaCO_3), is a promising material for drug delivery



Nanosized vaterite

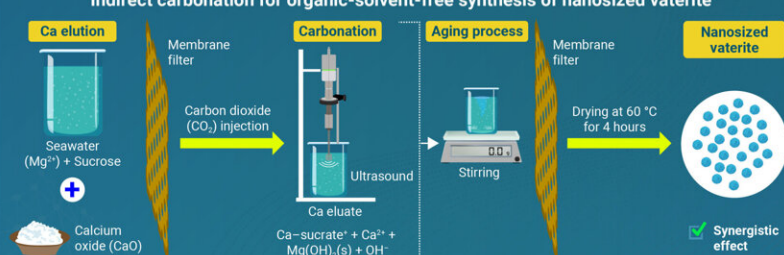
- ✓ Biocompatible
- ✓ Highly porous
- ✓ High specific surface area

However, traditional nanosized vaterite production requires a large amount of organic solvents, making it

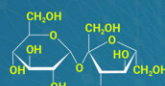


- ⚠ Expensive
- ⚠ Not scalable
- ⚠ Toxic

How to mass-produce nanosized vaterite in an environmentally friendly and cost-effective manner?

Indirect carbonation for organic-solvent-free synthesis of nanosized vaterite



Optimal conditions for synthesizing 683-nm-sized vaterite with 100% CaCO_3 content

Ca elution	Carbonation	Aging
 <ul style="list-style-type: none"> ✓ Sucrose concentration = 2.3 mM 	 <ul style="list-style-type: none"> ✓ End pH = 8 or 9 ✓ Ultrasonication intensity = 30% ✓ Stirring speed = 400–600 rpm 	 <ul style="list-style-type: none"> ✓ Stirring speed = 200 rpm for 10 minutes

The proposed three-stage process can facilitate easy, cost-effective, and environmental friendly mass production of nanosized vaterite

Nanosized vaterite production through organic-solvent-free indirect carbonation
 Kim et al. (2023) | DOI: 10.1016/j.ultsonch.2023.106495

NATIONAL KOREA MARITIME & OCEAN UNIVERSITY

Researchers from Korea propose a three-stage process for the synthesis of nanosized vaterite that avoids the use of toxic organic solvents and produces 683-nm-sized vaterite particles with 100% calcium carbonate content. Credit: Myoung-Jin Kim, Korea Maritime & Ocean University

Vaterite is one of the three forms of calcium carbonate, along with calcite and aragonite. Nanosized vaterite is valuable for various applications, such as drug delivery, cosmetics, and bone defect filling,

owing to its biocompatibility, high porosity, solubility, and large specific surface area.

Vaterite is not commonly found in nature as it transforms into calcite over time. In laboratory settings, [organic solvents](#) are used to prevent its recrystallization and hinder particle growth. However, the solvents are expensive, highly toxic, and generate significant waste, making them harmful both to humans and the environment. Therefore, there is an urgent need for a method that circumvents these challenges, is cost-effective, and results in environmentally friendly synthesis of vaterite.

Addressing these concerns associated with vaterite production, a team of researchers from Korea Maritime & Ocean University, led by Professor Myoung-Jin Kim of the Department of Environmental Engineering, has reported an indirect carbonation method that uses seawater to produce nanosized vaterite. Their work was published in [Ultrasonics Sonochemistry](#).

Speaking about the method developed by them, Prof. Kim says, "The entire process comprises of three stages: calcium elution, carbonation, and aging." In the calcium elution stage, a solution containing seawater and sucrose is mixed with [calcium oxide](#). The [magnesium ions](#) present in seawater facilitate the dissolution of calcium into the solution, leading to the release of free Ca^{2+} ions. Sucrose forms a complex with Ca^{2+} ions.

The eluted Ca^{2+} ions are then reacted with injected [carbon dioxide](#) in the carbonation stage, resulting in the formation of calcium carbonate (CaCO_3) as a solid precipitate. The growth of the CaCO_3 particles is subsequently suppressed by ultrasonic vibrations generated by a sonifier. Subsequently, the mixture undergoes aging, where CaCO_3 particles are further reduced in size, resulting in the formation of nanosized vaterite.

Each step of the proposed method contributes to vaterite production and

particle size reduction, with optimal conditions resulting in nanosized particles with 100% vaterite. The size and content of vaterite are highly sensitive to the sucrose concentration used in the [calcium](#) elution stage. The researchers further report that the ideal concentration was found to be 2.3 mM, which produced a large amount of free Ca²⁺ ions, without increasing the viscosity of the solution.

In the carbonation step, controlling the end pH, ultrasonic intensity, and stirring speed is critical. The researchers determined that stopping the carbonation reaction at pH levels of 8 or 9 resulted in 100% vaterite content, while ultrasonication at 30% intensity and stirring at 400–600 rpm produced nanosized particles. Moreover, stirring at a speed of 200 rpm for 10 minutes was optimal for aging.

The outcome of these steps is the production of pure vaterite with particle sizes of 683 nm, achieved without organic solvents. "These findings highlight the possibility of mass-producing nanosized vaterite using seawater, which is an environmentally friendly solvent. The proposed method can be highly advantageous from economic and environmental viewpoints for the mass production of nanosized vaterite, without requiring a substantial amount of organic solvent," concludes Prof. Kim.

More information: Sehun Kim et al, Nanosized vaterite production through organic-solvent-free indirect carbonation, *Ultrasonics Sonochemistry* (2023). [DOI: 10.1016/j.ultsonch.2023.106495](https://doi.org/10.1016/j.ultsonch.2023.106495)

Provided by National Korea Maritime and Ocean University

Citation: Researchers propose an organic-solvent-free method for producing nanosized vaterite (2023, November 7) retrieved 28 April 2024 from <https://phys.org/news/2023-11-organic->

solvent-free-method-nanosized-vaterite.html

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.