Controlling Colloidal Gels
for Novel Sustainable Materials

# NEWSLETTER

**No.2** **July 2025**

Funded by
the European Union

CoCoGel (*Controlling Colloidal Gels for Novel Sustainable Materials*) is an innovative project aimed at developing the next generation of colloidal gel-based materials through rational design – by understanding how these out-of-equilibrium microstructures respond to internal and external stimuli.

Colloidal gels are fundamental to technologies used in a wide range of applications, from personal care and food products to batteries, fuel cells, and cementitious materials.

To achieve this ambitious objective, 15 Doctoral Candidates (DCs) will conduct experimental and computational studies to explore the effects of these stimuli. The DCs are hosted in optimal research environments and supported by both academic and industrial supervisors, providing the ideal conditions to tackle the project's research challenges.

This academia-industrial collaboration also facilitates effective knowledge-transfer from academia to industry, enabling the transformation of academic insights into practical industrial applications.

CoCoGel is a research project funded by the European Union via MSCA (MARIE SKŁODOWSKA-CURIE ACTIONS) Doctoral Network action of the Horizon Europe program under CoCoGel Grant Agreement n°101120301



## Upcoming Events

**Summer School Computational Methods**
FORTH (Greece)
25-27/09/2025

**European Researchers' Night**
FORTH (Greece)
26/09/2025

**International Soft Matter Conference**
Chania (Greece)
29/09 – 03/10/2025

**Soft Skills Workshop**
Edinburgh (Scotland)
08-10/12/2025

## Mid-Term Review meeting—FORTH (Greece)

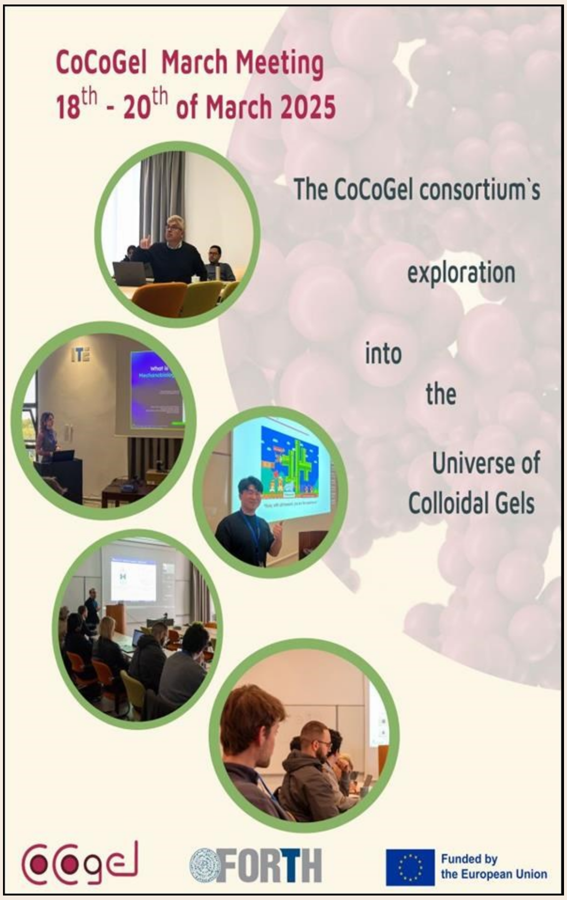
The Mid-Term review was held at FORTH during the 15th month of the project's. PIs and DCs presented to the Project Officer the overall progress of the project.

PIs introduced themselves their organization and their involvement within the consortium. DCs defended their PhD research by explaining their results and by informing about their upcoming milestones.

The CoCoGel consortium at FORTH for the Mid-Term review

Finally, the Project Officer held two separate meetings, one with the DCs so as to address their questions, and with the coordinator providing further input and guidance with respect to the project's progress.

## Second workshop—FORTH (Greece)




This event was held at FORTH from 18th to 20th of March 2025. The DCs presented topical literature review lectures on ultrasound effects on colloidal gels, tuning colloidal gels by external fields & shear, effects on inclusions & applications in systems, hydrodynamic interactions and gel structure/yielding.

George Petekidis (FORTH), John Royer (University of Edinburgh), Joost de Graaf (University of Utrecht), Valeria Garbin (TU Delft) and Juan de Vicente (University of Granada), offered introductory lectures on the topics and guided the DCs in the preparation of their literature review.

We also thank our external guest, Damien Vandembroucq (ESPCI Paris), for his lecture on "Memory effects in amorphous materials".

Aoxuan Wang

# Tuning colloidal gels with ultrasound
# Application to gel flow and structuration

Super Mario is one of the most iconic video game characters of all time. The story is simple: a brave plumber dives into a maze of endless pipes, overcomes strange creatures and difficult obstacles, and finally saves the princess. Along the way, Mario faces many challenges—dangerous enemies, shifting landscapes, and perhaps most memorably, an overwhelming number of confusing pipes. But thanks to his many special forms—fire Mario, flying Mario, giant Mario—he finds ways to adapt and move forward.

Now imagine this story, not as a game, but as a real-life industrial problem. In the real world, we also deal with complex "pipelines"—not for rescuing princesses, but for transporting materials like concrete, oil, or even medical drugs. But unlike in Mario's world, these pipelines don't lead to castles—they often lead to blockages. Over time, materials jam, age, or react chemically, causing pipes to clog. This can slow down production, cause equipment damage, or even lead to system failure.

Unfortunately, we can't jump into the pipes like Mario, or try them one by one. We can’t change the composition of concrete thousands of times just to find one that flows better, and we certainly can’t modify crude oil buried kilometers underground. And as fun as it sounds, using a hammer to knock on the pipe isn’t exactly safe or feasible in an industrial setting. A hammer might damage fragile pipelines, especially those carrying high-pressure or corrosive materials. It could interrupt continuous production lines, cause costly delays, or even pose safety risks to workers. And practically speaking—how would you hammer a pipe that’s buried a thousand meters below the surface?

That’s where my research comes in. Instead of one big hammer, what if we used millions of tiny ones? I’m exploring how ultrasound—high-frequency sound waves—can act like invisible, intelligent micro-hammers. They can shake particles loose, improve flow, and do so without touching or damaging the pipe. Even better, we can tune the ultrasound remotely and precisely, allowing for smart, adaptive control.

So, in a way, I’m not just studying materials—I’m helping build the tools for real-life Mario's. Because in the end, even superheroes need a smart way to keep the pipes flowing.
In this way, ultrasound becomes our real-world tool to tackle hidden enemies inside the pipes—whether it's stubborn gel blockages or sudden shear-thickening jams. Like Mario switching into the right form to beat each challenge, we can now switch the right "waveform" to deal with each material.

“So maybe you don’t need a fireball or a power-up. Now, with ultrasound, you are the superhero”.

Matthew Roniger

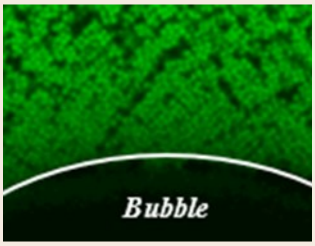
# Structuring of colloidal gels by ultrasound-activated inclusions

## Applications to new products

Just like me and you, bubbles love moving to the beat of sound. Instead of music, they prefer the rhythm of ripples in the air, the tiny pulses of pressure that sound is made of! At their favorite frequency, which depends on their size, you will observe them expand and contract in breathing-like pulses. Bubbles about the size of a grain of sand (~100 μm, or one-tenth of a millimeter), respond to frequencies at the edge of human hearing, known as ultrasound (~20 kHz).

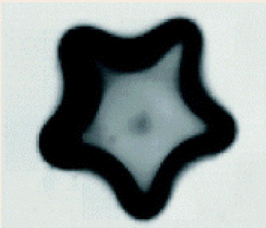
*AI-generated illustration of the microscopic network that makes up soft materials like mayonnaise creams and even batteries, where our tiny bubbles "dance" to sound and can shape a material's architecture.*

We introduce these sound-sensitive bubbles into soft materials, substances with textures similar to mayonnaise and hand creams, made from disordered networks of microscopic particles. As the bubbles pulse, they stir up tiny flows in their surroundings to steer nearby particles, gradually reshaping the material from within. Bubbles can also deform in more complex ways, pulsing in different shapes to generate unique flow patterns that could offer finer control over a material's internal structure.




*Angular structures in our particle network formed by bubble pulses. The particles in green are just 1/100$^{th}$ the width of a human hair*

At TU Delft, within the CoCoGel project, we are investigating how these phenomena could be harnessed to controllably reshape soft materials. Achieving this requires overcoming key challenges such as fundamentally understanding structural changes, the stability of bubbles, and scaling up the technique. Solving these problems could open the door to a sustainable method of crafting tomorrow's batteries, personal care products and foods.



*Bubble deforming into a star shape under ultrasound. The bubble is around 1/10th of a millimeter. (From: Poulichet, Huerre, & Garbin, 2017)*

This research is part of a broader effort to understand and control the behavior of soft materials through external forces, and brings us one step closer to form soft-materials through an inner-framework that responds to sound in a precise dance to the beat of our bubbles.

Nicollas Safanelli

# Rheology and impact of power ultrasound on mixtures of cement and limestone fillers

Tuning Cementitious Materials with Ultrasound: A Future Possibility for Construction

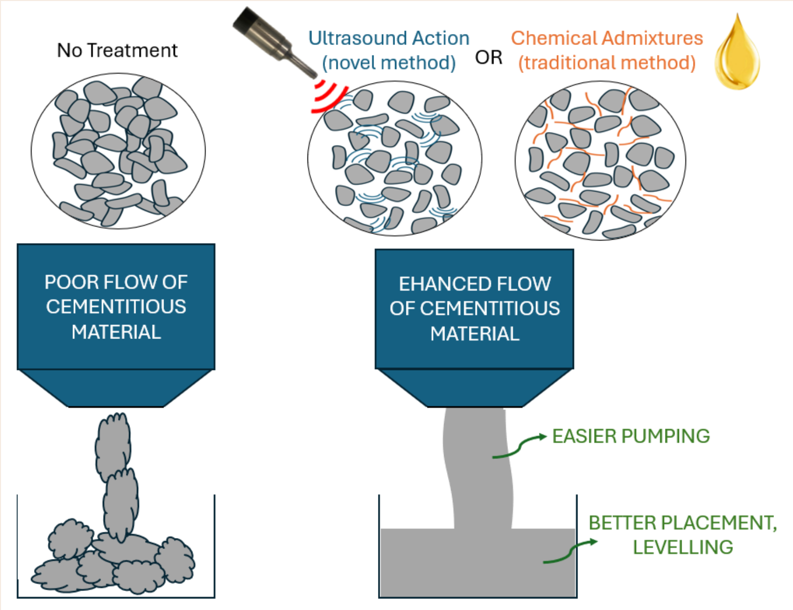
When we hear about ultrasound, the first application that generally comes to mind is medical imaging. But what if these sound waves could also be used to make concrete – the most used construction material - smarter, more efficient, and more sustainable? Would it be possible and viable? The answer to this question is targeted by my research project presented below!

## What Am I Researching?

My work explores the use of ultrasound to control the workability and flow of materials like mortar and concrete. Controlling flow is crucial for processes such as mixing, pumping, levelling, and even for novel applications like 3D printing. Currently, adjusting flow often requires adding chemical products (admixtures) during production. My goal is to go the other way and achieve new possibilities of flow control, facilitating novel applications and reducing the use of chemicals.

## What Challenges Am I Facing?

Systems like mortar and concrete are complex and can be impacted at different scales, from nanoparticle interactions to a few centimeters structures. Therefore, ultrasound can influence these systems in several ways. Two mechanisms are mainly analyzed:




1) Mechanical Vibration, that can reduce contact forces and make particles move in an easier way, improving flow.

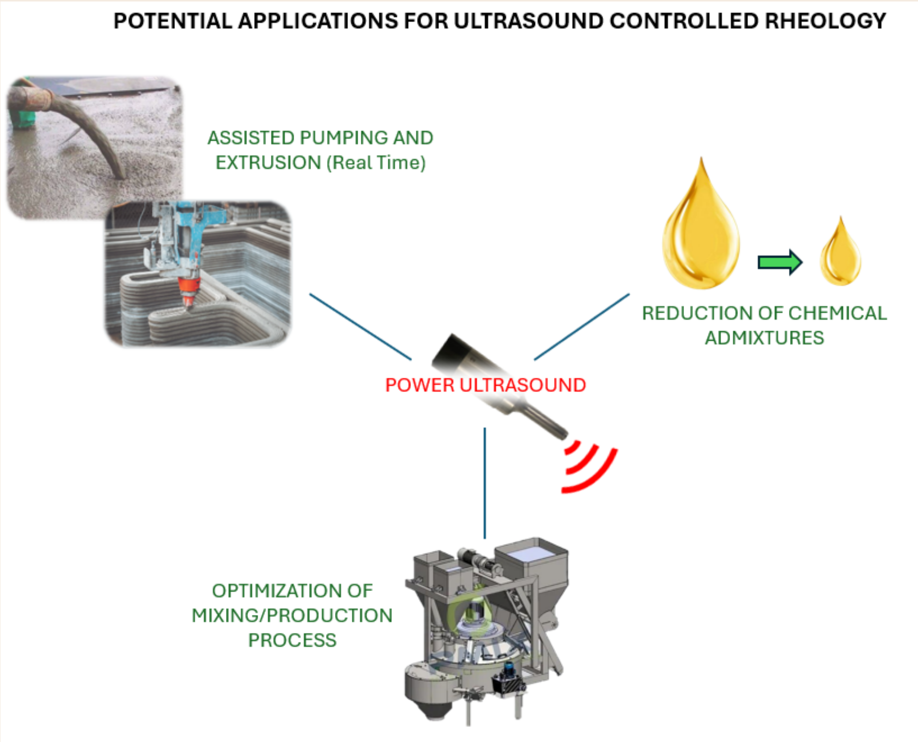
2) Bubble Cavitation, when small bubbles can be rapidly formed and collapsed inside the mixture. The explosion of these bubbles releases enough energy to break up flocs and networks.

Optimizing these processes can be a challenge and generally requires a good ultrasound "recipe": frequency, power, time. On top of it, side effects also needed to be considered. For example, ultrasound can affect cement's hydration reactions, influencing its setting and hardening properties.

## What is the Expected Result of My Project?

My project aims to develop ideas and applications to ultrasound that can be applied in a real construction context. Imagine a construction site where:

- Adjustment of concrete's workability can me made on the construction site, allowing applications with complex molds, self-compacting, or precise extrusion for 3D printing.
- The use of chemical additives can be decreased, meaning lower material costs and a smaller environmental impact
- The long-term properties of concrete could be improved alongside the fresh-state properties: Changes in particle dispersion and hydration by ultrasound could lead to more uniform, stronger and durable structures




With the success of this research, I hope that my project will be a tool that contributes to the development of the construction industry, a sector that impacts many people's lives and plays a big role in the progress of our world.

## UPCOMING DELIVERABLES AND MILESTONES

July to December 2025

| Deliverables | Milestones | Lead | Date |
|---|---|---|---|
| | M19 Assessment of secondments | INPROCESS LSP | 31/12/2025 |
| D2.2 Application of Shear-Insight for energy materials | | SUNLIGHT POWER IS KNOWLEDGE | 31/12/2025 |
| D2.4 Rheology and Microstructure of colloi-dal gels with inclusions | | THE UNIVERSITY OF EDINBURGH | 31/12/2025 |
| D3.2 Deploy Magnetic Fields to control Colloidal gels | | UNIVERSIDAD DE GRANADA | 31/12/2025 |
| D4.5 Inclusion-Based Modification for food products | | Unilever | 3!/12/2025 |
| D5.2 Processing Morphology Relation for Batteries Slurries | | SUNLIGHT POWER IS KNOWLEDGE | 31/12/2025 |
| D5.8 Rheological re-sponse of cement lime-stone filler paste | | HOLCIM | 31/12/2025 |

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