



Controlling Colloidal Gels
for Novel Sustainable Materials

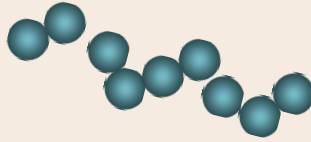
NEWSLETTER

No. 4

July 2026



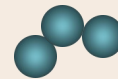
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the European Union



CoCoGel (*Controlling Colloidal Gels for Novel Sustainable Materials*) is an MSCA Doctoral Network—Industrial Doctorate project which is composed of 15 Doctoral Candidates. Thanks to their complementary approaches, CoCoGel aims at developing the next generation of colloidal gel-based materials by understanding how these out-of-equilibrium microstructures respond to internal and external stimuli.



This 4th edition puts under the spotlight new accomplishments of the consortium. Our DC8, Lennard Schulte, is inaugurating the beginning of the scientific publications. Then, as we emphasize on the employability of our DCs, we organized an Industrial Training in the Netherlands in order to discover different industrial environments, academia-industry connections, but also showing them the path of entrepreneurship. You will also discover the research activities of 3 DCs, diving into catalytic ink processing parameters, ink rheology and microstructure, and battery electrode slurry optimization.



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Upcoming Event

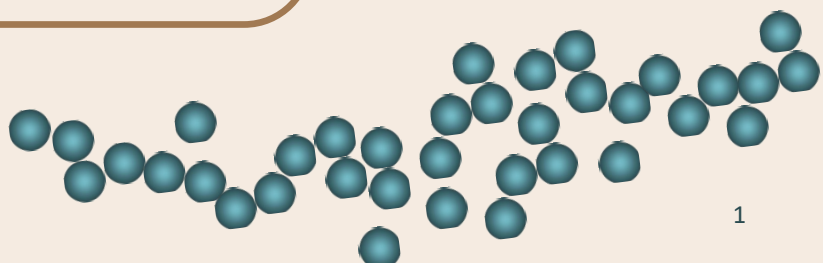
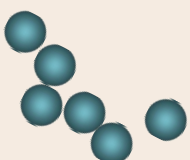
Common training



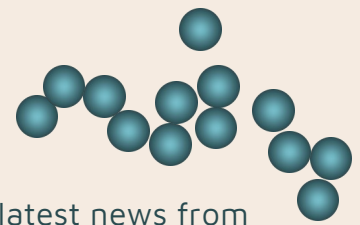
FORTH



November 2026



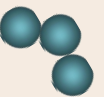
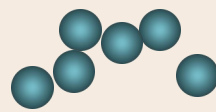
Publication



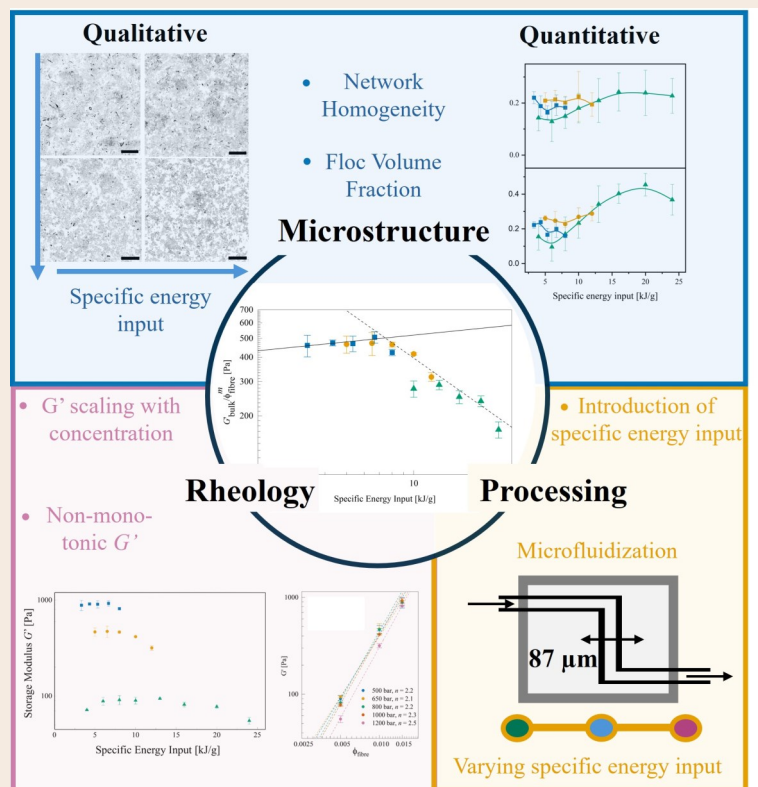
CoCoGel is now entering its 31st month, and we are delighted to share its latest news from our DCs. So far, one article has been published while more are currently in preparation.

The article by **Lennard Schulte, Krassimir P. Velikov**, entitled “Linking specific energy input to microstructure and rheology in microfluidized citrus fibre cellulose microfibril dispersions”, was published in *Food Hydrocolloids* (*Food Hydrocolloids*, volume 176, 2026, 112541).

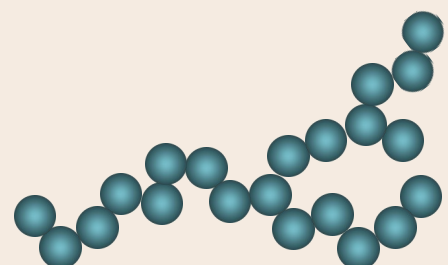
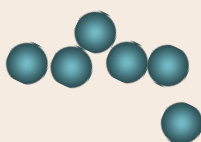
Keywords: Citrus fibre; Cellulose microfibrils; Microfluidization; Gels; Network microstructure



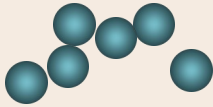
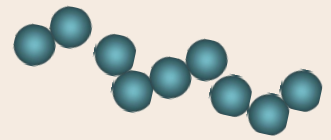
This article explores citrus-fibre dispersions at three concentrations, microfluidized at varying intensities and characterised by confocal microscopy and oscillatory rheology. Specific energy input, defined as the pressure-derived energy per unit mass of fibre, was identified as the key processing parameter controlling both microstructure and mechanics. Microscopy revealed a heterogeneous floc network whose architecture reorganised with increasing energy, while the storage modulus G' responded non-monotonically, first rising then falling. G' scaled with bulk fibre concentration as a power law, and the intra-floc elasticity exponent proved invariant across all conditions and concentrations. Normalising G' by this exponent collapsed all data onto a single master curve, defining a two-regime processing-structure-property framework, with practical relevance for the design of gels, thickeners, and structured food systems.



DOI: <https://doi.org/10.1016/j.foodhyd.2026.112541>



Industrial training-CoCoGel x BIOMAC-BP



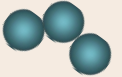
From March 30th to April 1st, CoCoGel and BIOMAC-BP co-organised a joint training on Research in Industries at Utrecht University, bringing together doctoral candidates from both projects for three intensive days.

The first day was dedicated to the fundamentals. Industrial PIs delivered a series of lectures designed to prepare our doctoral candidates for professional life beyond their PhD, whether in an R&D environment or as entrepreneurs. The programme covered intellectual property (Arnoud Fijnvandraat), innovation (Jijo Joseph), industrial R&D organisation and practices (Eline Hermans), product life cycle analysis (Damien Bourcier), academia-industry connections (Krassimir Velikov and Thijs Besseling), and how to start a business (Rut Besseling and Teun Vissers).



CoCoGel and BIOMAC-BP teams at the University of Utrecht

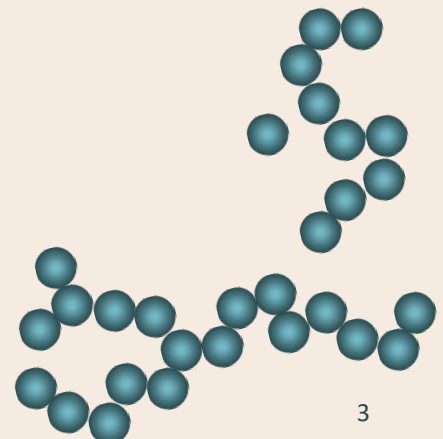
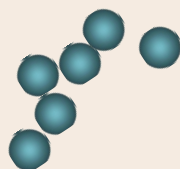
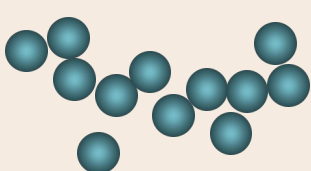
To close the week, our CoCoGel doctoral candidates visited two very different companies: InProcess-LSP and Unilever Foods Innovation Centre 'Hive'. Different scales, different contexts, but a shared lesson in what it really means to think about market applications when you come from a research background.



A warm thank you to all the PIs, speakers, and host companies who made this possible.



CoCoGel and BIOMAC-BP teams at Unilever.





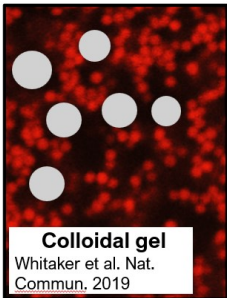

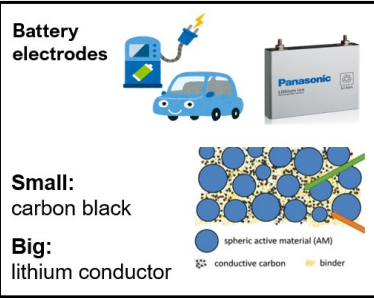
Rheology and microstructure of model catalytic inks under simple and complex shear



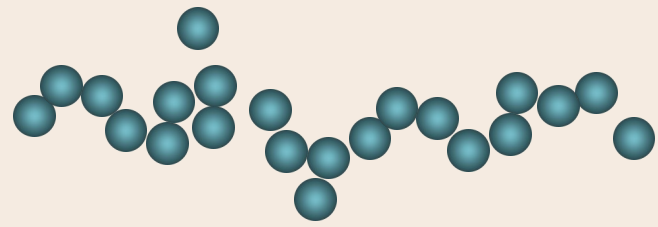
Holding Things Up with Mostly Liquid Materials

My research focuses on a fascinating class of soft materials called colloidal gels. These materials form when tiny attractive particles, known as colloids, move randomly in a liquid and connect to create a space-spanning network. Although they may contain only a very small amount of solid particles, they can behave like soft solids: they have a yield stress, meaning they resist flow until a large enough force is applied.

This type of structure appears in many familiar and important materials. In yoghurt, a colloidal network formed by casein micelles helps support larger fat droplets and gives the product its texture. In battery manufacturing, conductive carbon-black gels are used to carry larger electrode particles. However, recent findings show that whether a colloidal gel can successfully perform this carrying role is a surprisingly subtle question. The central question in my project is: how do colloidal gels behave when mixed with much larger particles, or grains? Traditionally, colloidal gels and grain suspensions have been studied separately. However, in real applications they often coexist. For example, in cathode pastes for batteries, micron-sized lithium-ion conducting grains are dispersed in a conductive carbon-black gel. The gel is expected to act as a carrier, keeping these larger grains suspended and preventing sedimentation.

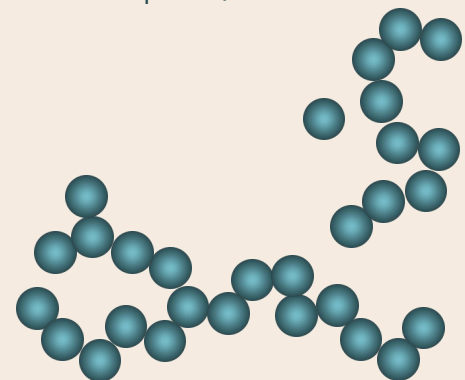
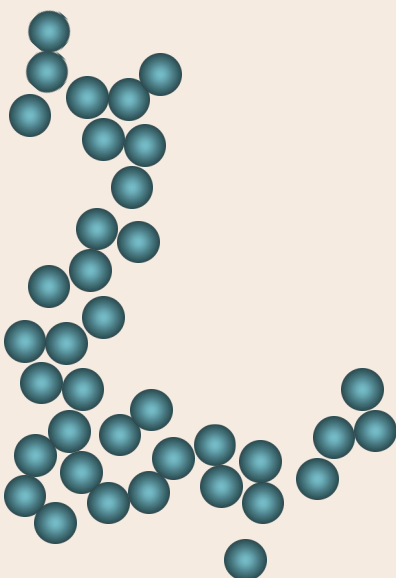
 <p>Colloidal gel Whitaker et al. Nat. Commun. 2019</p>	 <p>Small: casein micelles Big: Fat globular</p>	 <p>Battery electrodes</p> <p>Small: carbon black</p> <p>Big: lithium conductor</p> <p>● spheric active material (AM) ⊞ conductive carbon ● binder</p>
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Meyer et al, J. Energy Storage 2018



A major challenge is that these mixtures may not behave simply as “the sum of their parts.” Large grains form frictional contacts under flow, while the surrounding colloidal gel can support, constrain, or restructure around them. Previous findings show that this coupling can produce unexpected behaviour that cannot be predicted from either component alone. In particular, mixed suspensions may display bistability: depending on the shear history, the same material can switch between a more solid-like state and a more liquid-like state.

This discovery has two important consequences. On the positive side, it suggests a route to designing smart materials that can be reversibly switched between solid and liquid states using controlled shear protocols. Such materials could be processed easily when fluid and then made stable when solid-like. On the other hand, if this transition occurs unexpectedly during industrial processing, it could cause serious problems. For example, in battery cathode pastes, an unanticipated shear-induced state change could disrupt the conductive carbon-black network and dramatically degrade electrical conductivity. The expected result of my project is to have understanding of how colloidal gels and large grains interact, and why bistability emerges. This knowledge will help develop design rules for stable, efficient soft materials. In everyday life, the impact could range from better-textured and longer-lasting foods to more reliable battery electrodes and improved energy-storage devices. More broadly, this research aims to show how materials that are mostly liquid can be engineered to hold large particles in place, flow when needed, and recover solidity when required.





Anna Łapeta

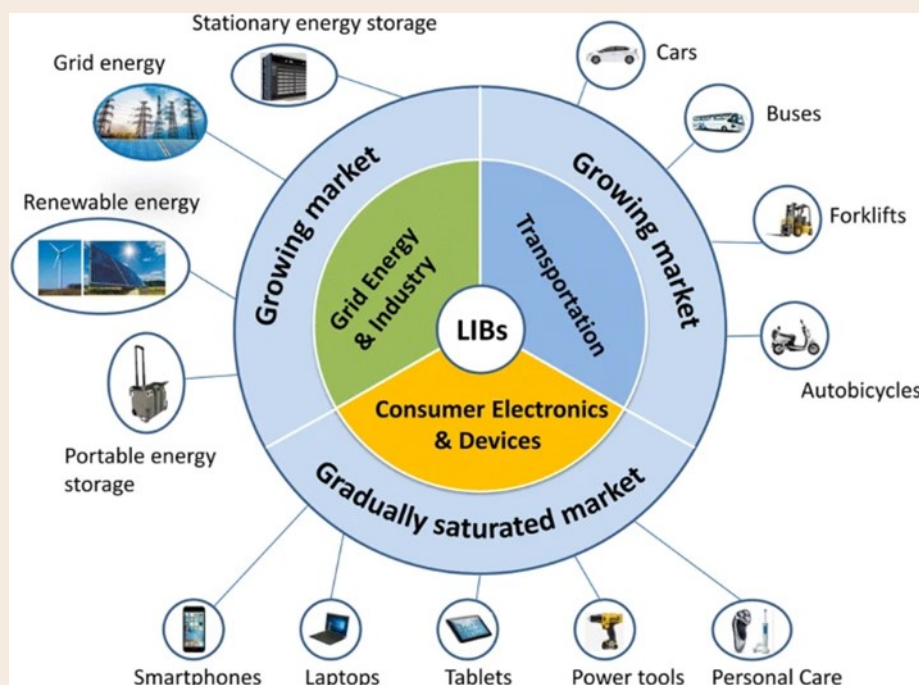
Catalytic ink processing parameters and their effects on electrode manufacturability and performance



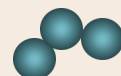
Energy: It's Everywhere — Even in Your Hand



Everything around us has energy. We store it in the form of fat and sugar, every electronic device runs on it too. But when it comes to portable devices and increasingly cars, one of the most important solutions for storing that energy is the lithium-ion battery. You probably have one in your hand right now, inside your smartphone. And if you've ever ridden in an electric vehicle (EV), you've been powered by a much bigger version of the same idea (Figure 1).



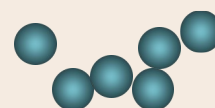
So, how does a battery actually work?



In the human body, the energy is stored in a form of glycogen or fat, which gets broken down into a simpler form before it reaches our cells and it's only released into the blood-stream when it's needed. Batteries work in a similar way. The materials inside store energy in chemical form and release it as electrical energy on demand.

In my battery system, there are two electrodes: a negative one made of graphite, and a positive one made of lithium iron phosphate. Between them sits a separator, and the whole cell is filled with electrolyte - a liquid that helps ions move around. When the battery discharges, lithium ions travel toward the positive electrode, while the electrons released during this reaction flow through an external circuit. That flow of electrons is exactly what we call electricity and it's what powers your device (Figure 2).

It may sound complex, but the principle is simple: energy exists all around us in many forms. A battery is just one way of storing and transforming it.



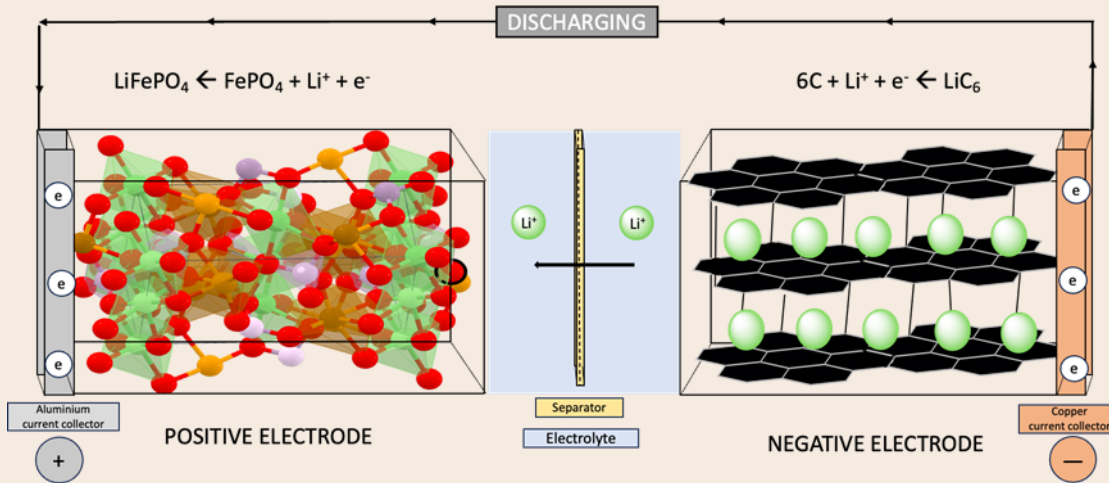


Figure 2. Schematic picture showing how energy is transformed from chemical energy to electrical energy. Lithium ions are transported between electrodes whereas electrons (e) are transported through external circuit.

From a paste to a battery

When you picture a battery, you probably imagine a small cylindrical thing you pop into a remote control. But behind every battery there's a surprisingly long journey. It all starts with a thick, paste-like suspension called a slurry, which is coated onto metal foils to form electrodes. These sheets are then stacked together, filled with electrolyte, sealed, and packaged into the final product (Figure 3).

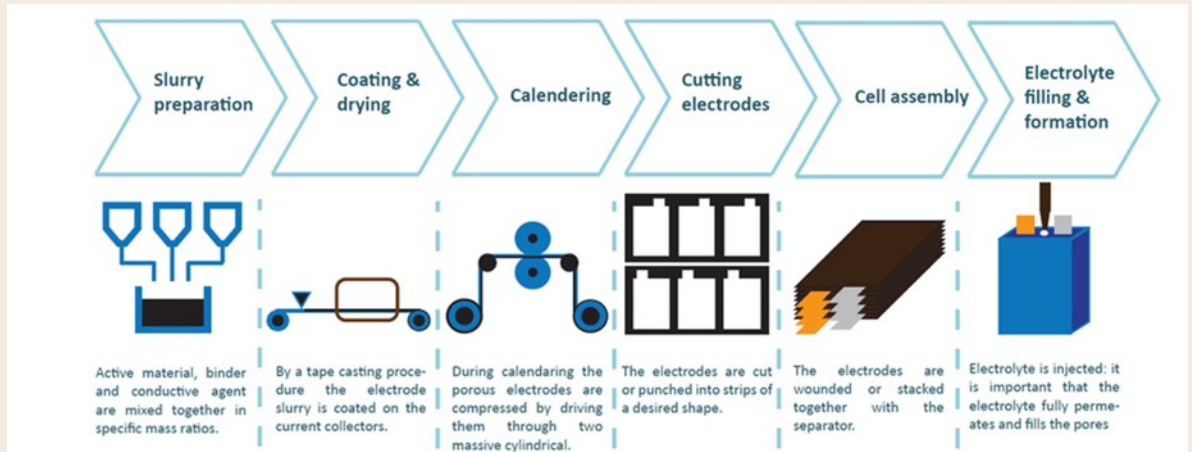


Figure 3. Overview of battery manufacturing process. Smekens et al. (2016). Influence of Electrode Density on Li-Ion Battery Performance. *Energies*, 9.

My research focuses on improving the manufacturing of the negative electrode, the anode. Although this is only one intermediate step in battery production, it strongly affects how well the final battery performs. A poorly prepared electrode can reduce battery efficiency, lifetime, and even safety.

Specifically, I'm comparing two different mixing methods. The traditional approach adds components one by one into a water-based polymer binder called CMC (carboxymethylcellulose): first graphite as the active material, then carbon black as a conductive additive, and finally a rubber binder (SBR) that helps everything stick to the metal foil.

The second method is a bit like making bread dough — you start with much less water, creating a stiff, crumbly mixture, then gradually add liquid until you reach the same final consistency. In theory, you end up with the same product. In practice, the mixing route changes how the slurry behaves and that difference matters (Figure 4).

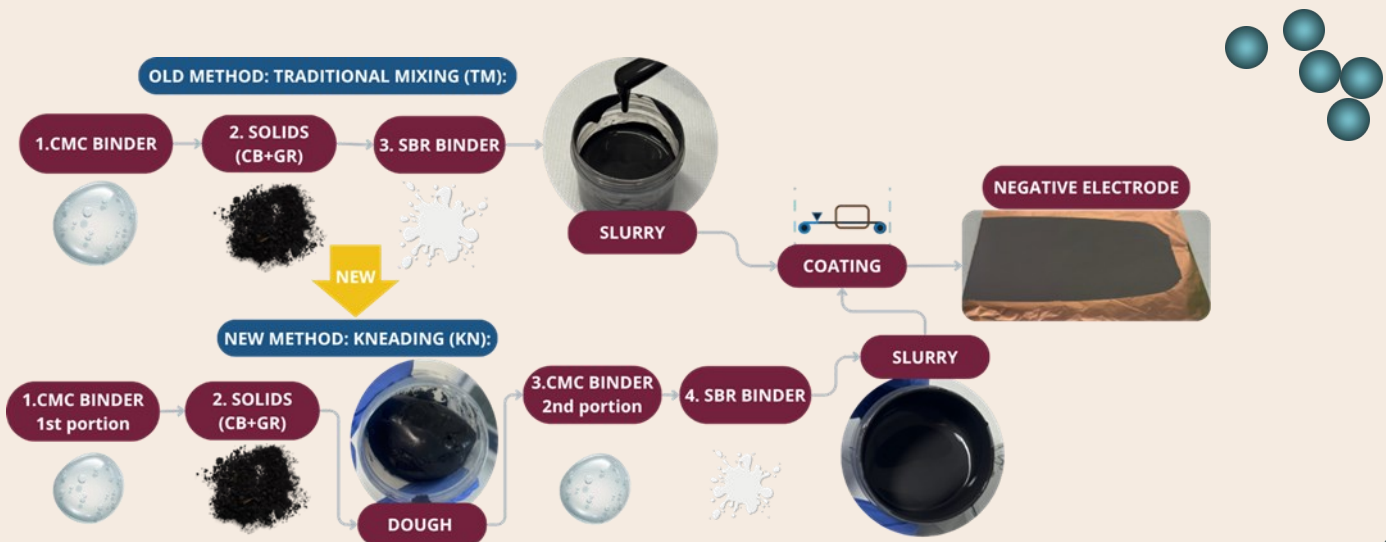


Figure 4. Two different methods of slurry preparation and its product – electrode.

Why does the mixing method matter?

Slurries are what scientists call non-Newtonian fluids because their viscosity changes depending on how fast you stir them. This has real consequences during electrode coating. To understand these differences, I use a technique called rheology, which studies how materials flow and deform.

Battery slurries are not like water. Water flows predictably, its viscosity is constant, but slurries change their viscosity depending on how strongly they are stirred, pumped, or coated. By measuring these changes, I can predict how the slurry will behave during industrial processing. After coating and drying, I also analyze the electrode structure itself: how the particles are packed, how uniform the layer is, and how this may affect battery performance. My goal is to connect what happens during the first mixing step to the final electrode properties.

This research comes with many challenges. Industrial battery materials are much more complex than idealized laboratory systems. They are less predictable, strongly time-dependent, and difficult to control. At the same time, that's exactly why this kind of applied work is needed. And honestly, it's what makes it exciting.

The bigger picture

Better-optimised slurries could mean better batteries longer-lasting, more reliable, and easier to manufacture at scale. Lithium-ion batteries are already a key alternative to fossil fuels in transport and energy storage, and demand for them is only growing. Understanding and improving even the very first step of making them is a small but real contribution to a more energy-secure future for Europe and beyond.

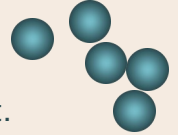


Sandeep Chinnabathina

Tuning and optimizing the structure and performance of battery electrode slurries by processing



Imagine a material that can be made stiffer or softer simply by the way you stir it.



That's the core idea behind my PhD research. I work with colloidal gels networks of tiny particles suspended in a liquid that lock together into a network-like structure. What makes these gels special is that their mechanical properties can be controlled by applying shear, in other words, by how you flow or mix them.

The connection to batteries might not be immediately obvious, so let me explain. When a battery electrode is made, the active material which is the stuff that stores charge by undergoing reversible chemical reactions is mixed into a thick slurry, gel-like paste that is coated onto a metal foil and dried. How that slurry flows and gels during processing directly affects the final electrode structure, and therefore how well the battery performs. My work uses a simplified model system to understand and control exactly that process.

The model system I study is a mixture of two very different sized particles dispersed in solvent as shown in figure 1. This bimodal particle mixture which has fine network-forming particles plus inclusions is a simplified but close model of a real cathode slurry, where carbon black and binder form a gel-like network around the much larger active material particles.

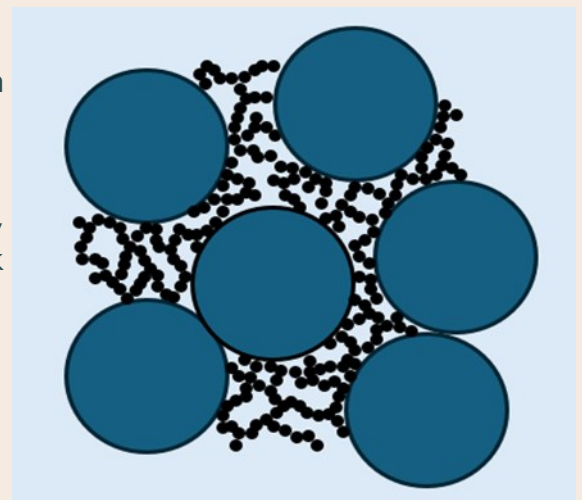
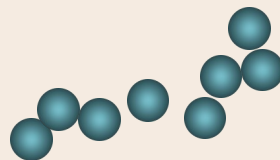
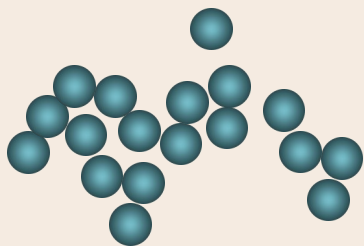
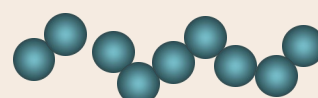


Figure 1. Schematic of the bimodal colloidal gel: small particles (black) forming network with large particles (blue) acting as inclusions.



The key discovery: How you mix determines the strength of gel

One of the most interesting findings from my research is that the properties of these materials can change dramatically depending on how they are mixed. Gentle mixing can make the material stronger and more stable, while other mixing conditions can weaken it. Surprisingly, the same ingredients can behave very differently simply because of their processing history.



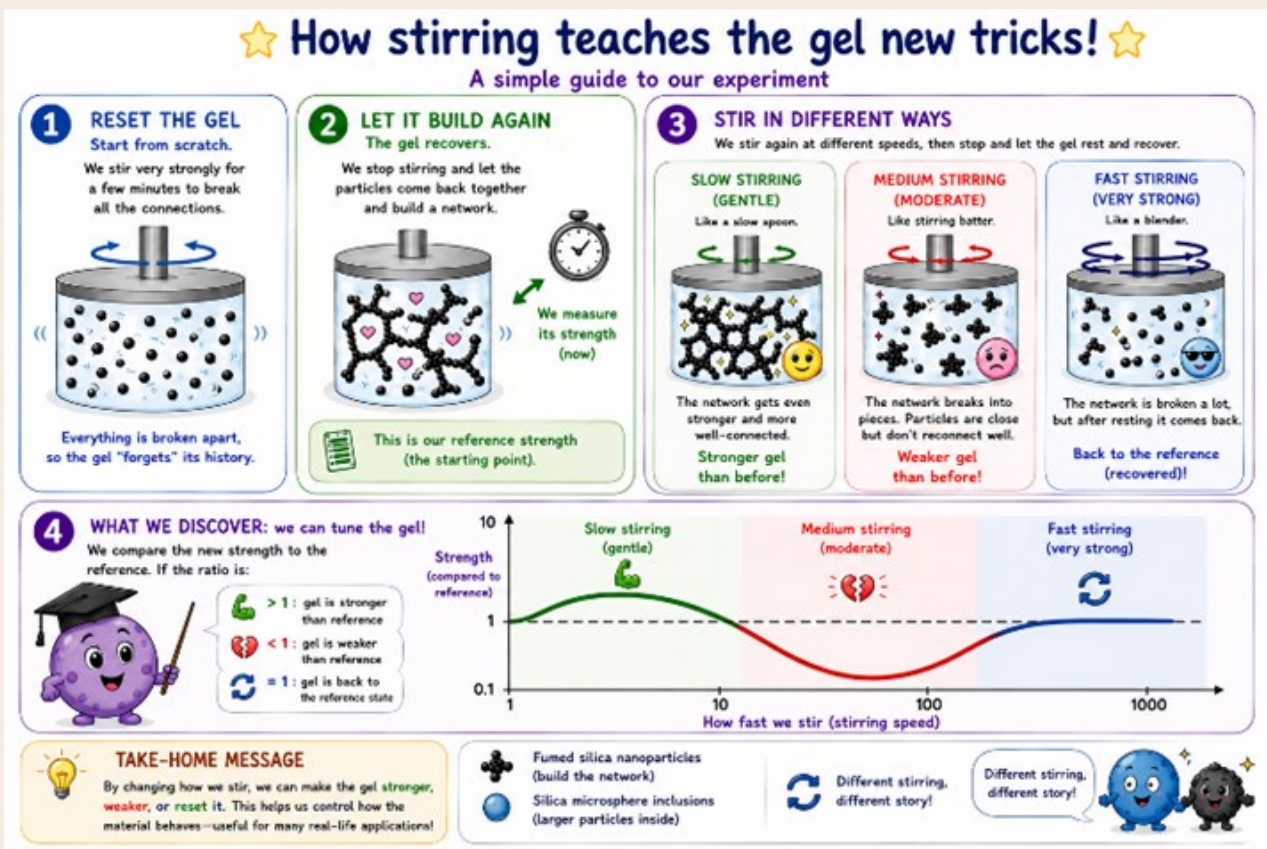
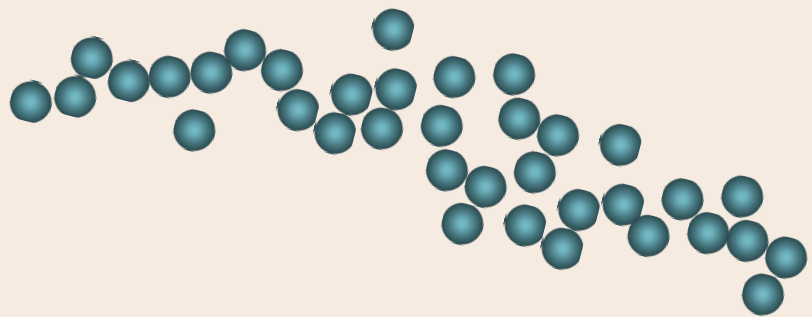
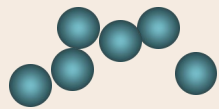
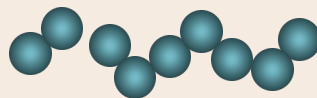


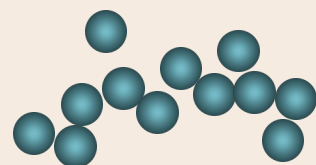
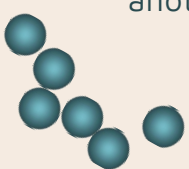
Figure 2. Mechanical tuning of strength by mixing.

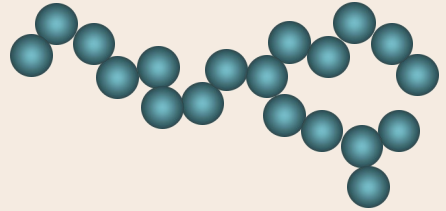


I also investigate what happens when larger particles are added to the gel. These particles represent the active materials found in real battery electrodes. Rather than being passive components, they appear to influence how the entire structure reorganizes during mixing. This means that understanding the interaction between different particles could help manufacturers gain greater control over the final product.

Future goals

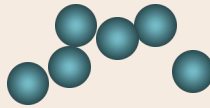
- Image the gel microstructure using confocal and electron microscopy (rheo-confocal), to directly see how the network reorganizes under different shear histories.
- Translate to a real cathode slurry, subsequently test whether the tuning principles discovered in the model system carry over to an industrially relevant formulation.
- Ultimately, my goal is to help develop smarter manufacturing strategies for battery electrodes. By understanding how mixing shapes material structure, we can take another step toward more efficient and sustainable energy technologies.





UPCOMING DELIVERABLES AND MILESTONES

July to December 2026



Deliverables



Lead Beneficiary



Date

D2.2 Application of Shear-Insight for energy materials



30/09/2026

D2.3 Effect of Interaction Anisotropy on Sheared Gels



31/12/2026

D2.4 Rheology and Micro-structure of colloidal gels with inclusions



31/12/2026

D2.5 Improved Simulation—Hydrodynamic Interactions in Gels



31/12/2026

D3.1 Tuning Gels by Shear and Electric Fields



31/12/2026

D5.1 Sustainable and Biodegradable Formulation Design



31/12/2026

D5.3 Modified Formulation of Catalytic Inks

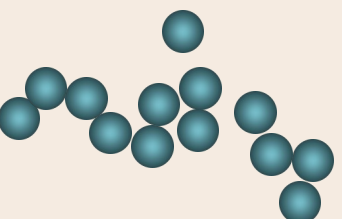


31/12/2026

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