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Early stage of cheese making, a two-step aging dynamics in soft protein gels

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ESI Workshop 2024, Vienna, Austria:

Linking Microscopic Processes to the Macroscopic Rheological Properties in Inert and Living Soft Materials

Soft matter has a long history at the interface of food science [1], with cheese making as a quintessential example. Cheese making involves concentrating milk proteins and fats by removing whey, a process that relies on enzymatic gelation and destabilization of casein micelles. Milk gels naturally undergo aging, which increases their mechanical strength over time, allowing them to be cut and enhancing syneresis (the expulsion of whey [2]). The timing for cutting is essential to control water content, maximize yield, and minimize protein and fat loss. Yet, the mechanisms of gel formation and aging remain largely empirical. From a fundamental soft matter perspective, we address the following questions: In the initial phase of cheese making, when macroscopic syneresis is prohibited (as the gel is attached to the container walls and unable to contract), how do casein micelles—soft, attractive colloids—gel and age? What role do internal stresses, created by constrained syneresis, play in this process?

In our recent study [3], Using time-resolved mechanical spectroscopy coupled with structural characterizations (SAXS and confocal) and dynamics (XPCS), we have shown that the aging of enzymatic milk gels involves two sequential stages. First, a particulate network forms at the gelation point, leading to a rapid increase in firmness. Second, the gel's microstructure solidifies, and further aging occurs through the evolution of contacts between the particles constituting the gel as evidence from the gel yielding properties [4]. Identifying these two distinct aging phases, separated by a critical time, is crucial for optimizing the early stages of industrial cheese production. It also provides new theoretical insights into the aging of colloidal gels made of "soft" particles. We finally discuss these findings in light of other studies [5-9]

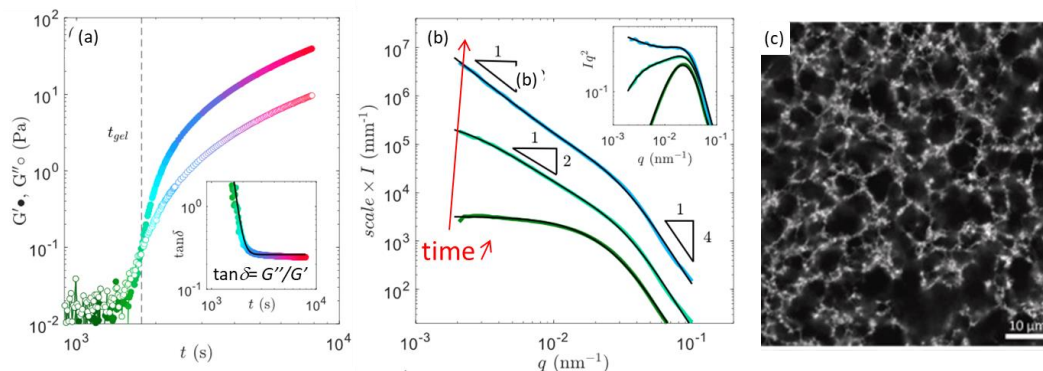


Figure. (a) time evolution of the viscous and elastic modulus. (b) Time evolution of the scattering intensity as a function of scattering vector. (c) Confocal image of the casein micelle gel at $t=1$ h.

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