Start-up shear of natural near-critical gels made of gluten proteins

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Gluten is a complex protein network crucial for the breadmaking quality, and widely used in the food industry as a texturing agent. It forms a natural transient network that include physical bonds (hydrogen bonds) and dynamic covalent bonds (disulfide bonds). The study of various gluten protein dispersions previously showed that samples can be regarded as polymeric near critical gels characterized by rheological parameters, elastic plateau, and characteristic relaxation time, which are related to one another, as a consequence of self-similarity, and span several orders of magnitude when changing the parameters such as protein concentration[1], ageing time[1] and solvent quality[2]. For its part, the protein composition controls both the distance to the gel point[3] and the critical exponent of the critical state.
In order to investigate the non-linear visco-elastic properties of gluten, a series of pre-gel samples satisfying the time-curing superposition over 5 decades of time in the linear regime, were investigated by successive start-up shear and relaxations at different shear rates. Master curves of maximum stress and strain values as function of a shifted shear rate could be plotted and a transient characteristic time of samples, different from the characteristic time defined in the linear regime, could be defined. In addition, samples totally relaxed the stress generated by very large shear strain in a relaxation time independent of the initial gelation state of samples, while the initial linear viscoelastic properties are recovered after the non-linear protocol. The molecular mechanisms at the origin of this singular behaviours will be discussed in light of our knowledge of the gluten microstructure.

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