The Glassy State of Biopolymers: Why It's Important?

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An important aspect of the protein physics is the low temperature glass transition experimentally observed at approximately 200 K . The understanding of this transition is achieved by combining information obtained via rather different methods: micro-mechanical experiments , NMR , Moessbauer spectroscopy, calorimetric studies, pressure release experiments, and X-ray scattering of synchrotron radiation .Although there still open important questions here, the rough physical picture of the glass transition in globular proteins is constructed in close analogy to glass forming liquids and synthetic polymers. In particular, it is believed that the large-scale conformational motion of proteins freezes at (approximately) 200 K, analogously to freezing of cooperative motion in glass-forming liquids and segmental motion in synthetic polymers .Thus, the glassy features as such are not important in the native state of globular proteins at physiological temperatures, though the glass transition at much lower temperatures can be still employed for gaining some understanding on the relevant motion in proteins.

Here we shall demonstrate via micro-mechanical methods that the native type I collagen fibril (made of fibrous protein, type I collagen triple-helices) is in a glassy state at physiological temperatures. This state is displayed via frequency-dependent visco-elastic characteristics (the Young's modulus and the decrement of damping) of the native fibril. Upon heating the fibril goes out of the glassy state at temperatures around 340K , a phenomenon known as the softening transition (in contrast to the proper glass transition, where the system enters into the glassy state upon cooling). Approximately in the same temperature interval the fibril starts to undergo the denaturation process ; this fact might explain why the glassy state of the native fibril went so far unnoticed in the vast literature devoted to collagen. We stress that the glassy state is a feature of the native fibril, and it is absent for the heat-denatured fibril, as seen below.