Self-Assembly of Globular Proteins into Amyloid Fibrils: Structure, Physical Properties and Functions

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Aggregation of proteins is central to many aspects of daily life, ranging from food technology and pharmaceutical science, to blood coagulation and health disorders, such as sickle-cell disease, arterial thrombosis, or eye cataract formation. In particular, association of proteins into amyloid fibrils is a highly specific process occurring both in-vivo, such as in the Alzheimer, Parkinson or prion-related neurodegenerative diseases, and in-vitro, as in the case of processed food proteins.

In this talk I will discuss our recent contribution to the understanding of the association processes converting globular proteins into amyloid fibrils, with emphasis on β-lactoglobulin and lysozyme, which have both fundamental and practical relevance. I will first illustrate how the unique combination of experimental techniques (light, neutron and x-rays scattering, AFM and cryoTEM), with polymer and colloidal physics concepts, can reveal important structural features from the nanometer to micron lengthscales and how these information can be used to understand the main mechanisms ruling aggregation.

I will then address how these mechanisms can be engineered to produce highly ordered multistranded amyloid fibrils with tunable nanostructures, in which the number of protofilaments forming a single fibril, their topology, and the twisted ribbon, helical ribbon and nanotube polymorphism can be efficiently controlled.

Finally, I will also touch on how these protein fibrils can be exploited as unique building blocks for complex and functional fluids, serving fields as diverse as food science, biomaterials, biosensors and optoelectronics, and I will illustrate this via relevant examples for each specific category.

References

1. "*Understanding amyloid aggregation by statistical analysis of atomic force microscopy images*" Adamcik *et al.*, *Nature nanotechnology*, **5**, 423 (2010).
2. "*General Self-Assembly Mechanism Converting Hydrolyzed Globular Proteins Into Giant Multistranded Amyloid Ribbons*", Lara *et al*. *Biomacromolecules*, **12**, 1868 (2011).
3. "*Sub-persistence Length Complex Scaling Behavior in Lysozyme Amyloid Fibrils*". Lara *et al*. *Phys. Rev. Lett.* **107**, 238101 (2011).
4. "*Protein Fibrils from Polymer Physics Perspective*" Adamcik & Mezzenga *Macromolecules*, 4**5**, 1137 (2012).
5. "*Biodegradable Nanocomposites of Amyloid Fibrils and Graphene with Shape Memory and Enzyme Sensing Properties*" Li et al. *Nature nanotechnology*, **7**, 421 (2012).