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Reversible and irreversible self-folding behavior of water responsive poly (vinyl alcohol) films

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Self-folding of biopolymers arising from mechanical instabilities has a vast scope for investigation in futuristic smart engineering applications. Motivated by enormous examples available in nature in the form of pine cone responding to humidity, mimosa pudica plant folding responding to touch, the biopolymers can be engineered to respond in a smart way. The response of the biopolymers can be in the form of water, temperature, light etc. Poly (vinyl alcohol) (PVA) is a biodegradable and biocompatible polymer with hydroxyl reactive group. It responds to water by performing reversible folding behavior. The self-folding phenomena is characterized by the folding time and rate of folding. It will be interesting to design these films in a certain three dimensional geometries and permanently retaining the shape undergone during folding. Reversible/permanent folding is based on the molecular interaction of the reactive groups between biopolymer and solvent molecules. The chains in a PVA matrix are relaxed due to the mobility of water molecules, leading to reversible folding. However, the chain relaxation can be restricted by the presence of different biomolecules in the matrix, where the competitive interaction between the reactive sites can lead to a permanent folding. This competitive interactions are explored using molecular dynamics simulations. Moreover, control over the folding in terms of total time and rate is possible to achieve by correct choice of a solution. In this work, we are reporting the possibility of obtaining permanent folding shape of pristine PVA films by designing one such biopolymer solution. Experimentally, it is observed that permanent shape of PVA films depends on the physical property of that particular solution. Furthermore, by changing these properties, a control over the time and rate of folding is achieved. In this work, we will discuss in detail the reversible and permanent folding characteristics of pristine PVA films in terms of folding time and rate. The results will include the effect of the thickness on the folding behavior. Also, the molecular mechanisms observed from MD simulations will be used to address the experimental observations.

Biography

Amrita Rath is currently pursuing her integrated Master's and PhD in Department of Applied Mechanics, Indian Institute of Technology Madras, India. She has completed her Bachelor's in Mechanical Engineering from ITER, Bhubaneswar, Odisha in the year 2012. Her research interests include designing of smart biopolymers that would find interesting futuristic and novel applications in the field of bio-engineering, sensors, water purification etc. This needs development of various methodologies for fabrication of the bio-films of desired mechanical strength and rigidity by understanding its mechanical behavior. This is performed experimentally by applying nano-mechanical characterization. The mechanical performance of the bio-polymers can be engineered better by getting an insight into the molecular mechanics. This is investigated by modelling the dynamics of polymer system at molecular length scale. Currently, she is working on "Designing of controlled self-folding bio-polymer".

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