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# Nonlinear vibrations of pre- and post-buckled lipid supramolecular micro/nano-tubules via nonlocal strain gradient elasticity theory

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**Abstract**

The unique geometry with high surface ratio makes lipid micro/nano-tubules as an excellent self-assembled supramolecular structure in various biological applications such as controllable release systems and drug delivery. In the present study, the size-dependent nonlinear vibrations of axially loaded lipid micro/nano tubules associated with the both prebuckling and postbuckling domains are explored comprehensively. To accomplish this purpose, the nonlocal strain gradient theory of elasticity including simultaneously two entirely different features of size dependency is utilized within the framework of the third-order shear deformable beam model. With the aid of Hamilton's principle, the non-classical governing differential equations of motion are established incorporating the nonlinear prebuckling deformations and the large postbuckling deflections. At the end, the Galerkin method in conjunction with an improved perturbation technique is employed to initiate explicit analytical expressions for nonlocal strain gradient nonlinear frequency of pre- and post-buckled lipid micro/nano-tubules. It is seen that by taking the nonlocal size effect into consideration, the influence of geometrical parameters of the lipid micro/nano-tubule on the nonlinear vibration characteristics within the both prebuckling and postbuckling domains decreases and the frequency-deflection curves are more close to each other. However, the strain gradient size dependency has an opposite effect and leads to increase the gap between the frequency-deflection curves of axially compressed lipid micro/nano-tubules with different geometrical parameters.

**Keywords:** Nanotechnology; Biomechanics; Small scale effect; Self-assembly molecular structure; Nonlinear dynamics.

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