World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:16, No:01, 2022

Modeling of the Cellular Uptake of Rigid Nanoparticles: Investigating the Influence of the Adaptation of the Cell's Mechanical Properties during Endocytosis

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Abstract : Nanoparticles have recently emerged as a possible cancer treatment tool. Several formulations have been used to enhance the uptake of these nanoparticles by cancer cells and avoid their immediate clearance when administrated in vivo. Most of the previous studies focus on the investigation of the influence of the mechanical properties of the cell membrane and the particle. However, these studies do not account for the variation of adhesion and tension during the wrapping of the nanoparticle by the membrane. These couplings should be considered since the cell adapts to the interaction with the nanoparticle by, e.g., increasing the number of interactions (consequently leading to an increase of the cell membrane/nanoparticle adhesion) and by reorganizing its cytoskeleton, leading to the releasing of the tension of the cell membrane. The main contribution of this work is the proposal of a novel model for representing the cellular uptake of rigid circular nanoparticles based on an energetic model tailored to take into account the adaptation of the nanoparticle/cell membrane adhesion and of the membrane stress during wrapping. Several coupling models using sigmoidal functions are considered and compared. The study calculations revealed that the results considering constant parameters underestimated the final wrapping degree of the particle by up to 50%.

Keywords : adhesion, cellular adaptation, cellular uptake, mechanical properties, tension
Conference Title : ICAME 2022 : International Conference on Advanced Mechanical Engineering
Conference Location : Singapore, Singapore
Conference Dates : January 07-08, 2022