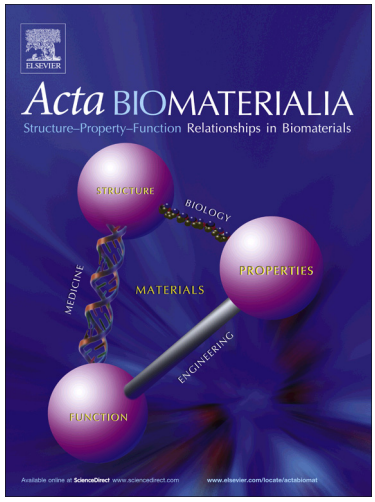

Full length article

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Cavitation Nucleation in Gelatin: Experiment and Mechanism

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Abstract

Dynamic cavitation in soft materials is becoming increasingly relevant due to emerging medical implications such as the potential of cavitation-induced brain injury or cavitation created by therapeutic medical devices. However, the current understanding of dynamic cavitation in soft materials is still very limited, mainly due to lack of robust experimental techniques. To experimentally characterize cavitation nucleation under dynamic loading, we utilize a recently developed experimental instrument, the integrated drop tower system. This technique allows quantitative measurements of the critical acceleration (a_{cr}) that corresponds to cavitation nucleation while concurrently visualizing time evolution of cavitation. Our experimental results reveal that a_{cr} increases with increasing concentration of gelatin in pure water. Interestingly, we have observed the distinctive transition from a sharp increase (pure water to 1% gelatin) to a much slower rate of increase (~10x slower) between 1% and 7.5% gelatin. Theoretical cavitation criterion predicts the general trend of increasing a_{cr}, but fails to explain the transition rates. As a likely mechanism, we consider concentration-dependent material properties and non-spherical cavitation nucleation sites, represented by pre-existing bubbles in gels, due to possible interplay between gelatin molecules and nucleation sites. This analysis shows that cavitation nucleation is very sensitive to the initial configuration of a bubble, i.e., a non-spherical bubble can significantly increase a_{cr}. This conclusion matches well with the experimentally observed liquid-to-gel transition in the critical acceleration for cavitation nucleation. (226/250 words)

Key words: soft materials, cavitation nucleation, gelatin, impact, cavitation model, acceleration, biomaterials

Graphical abstract