ENVIRONMENTALLY-ASSISTED DEGRADATION AND EROSION OF POLYMERS FOR ATTRITABLE METAMATERIALS

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The proposed work is part of a project aiming to design and manufacture marine biodegradable structures for which the rate of degradation can be tailored to the requirements of a particular mission. In this context, an attritable component is defined as one exhibiting gradually reduced multifunctional performance capabilities during its sustained operation. The utilization of attritable structures presents a unique opportunity for developing and deploying architected metamaterials with a controlled rate of degradation for specific missions. For engineering applications requiring tunable attritability in marine environments, polyesters, such as poly(glycolic acid) (PGA), poly(lactic) acid (PLA), poly(L-lactide) (PLLA), and polyvinyl alcohol (PVA) are of interest because of their capability to degrade in water, their environment-friendliness and the range of their mechanical performance.

Because it is the most common polymer material used in fused filament fabrication processes, the current work focuses on PLA and aims to model its hygrothermally-induced degradation involving diffusion of water and hydrolysis reaction. The degradation rate will depend on the effects of water diffusion through a quasi-linear viscoelastic material behavior. Using a continuum damage mechanics (CDM) approach, a damage parameter will be utilized to capture the evolution of the chosen constitutive multiphysics behavior. In addition, the hydrolysis reaction describing the mass loss of material when the structure is exposed to the saltwater environment will be considered. Because for some materials the water diffusion is much faster than the hydrolysis degradation, bulk erosion rather than surface erosion will be first investigated. A parametric study will be conducted in order to investigate the effects of the parameters influencing the erosion rates.

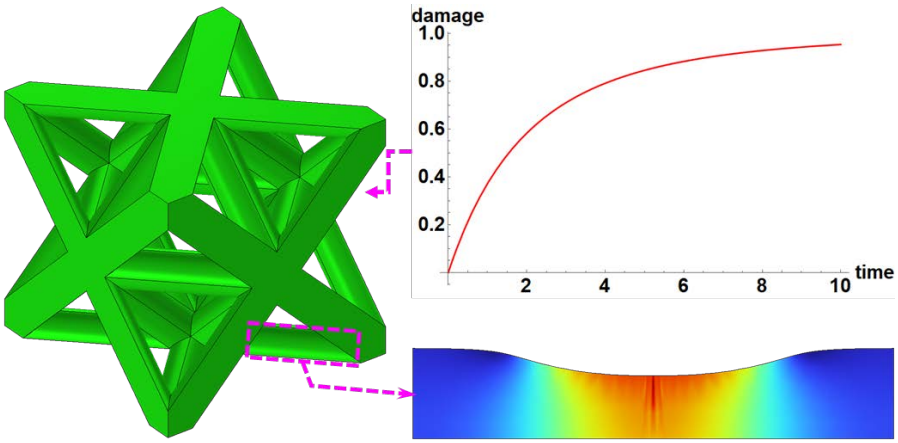

Figure 1 – Schematic of the proposed work showing a typical damage evolution law which will be used to degrade the constitutive properties associated with the constitutive response of a lattice structure that will undergo surface erosion under simultaneous volume diffusion as shown for one of the struts.