Reworkable Dry “Superglue”: A Shape Memory Chemical Velcro Approach to Sustainable Bonding/Debonding

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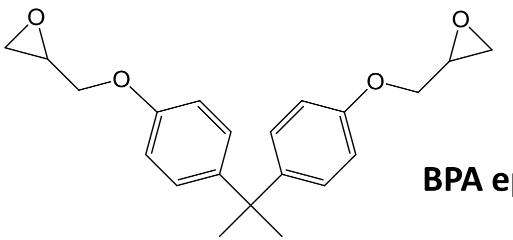
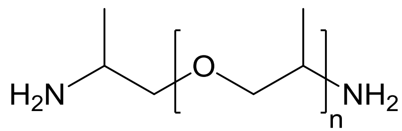
We aim to develop a completely new dry adhesive that combines chemical and topological designs together with shape memory polymers (SMPs) with tunable materials bulk properties upon heating/cooling, mimicking the hooks and loops in Velcro®.

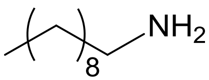
SMPs can memorize temporary shapes and recover to their permanent shape upon exposure to an external stimulus, such as heat, light, and solvent. Here we formulated epoxy based SMP, which had a Young’s modulus of 2.5 Gpa at room temperature and a glass transition temperature, T_g of 60^{o}C. When heated to 80^{o}C, the SMP became rubbery and the Young’s modulus dropped to 3.1 MPa.



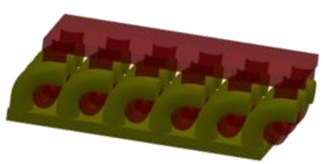
BPA epoxy (BADGE)



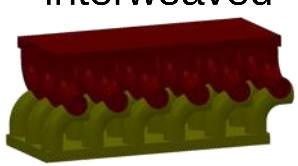
Jeffamine D230
n~2.5



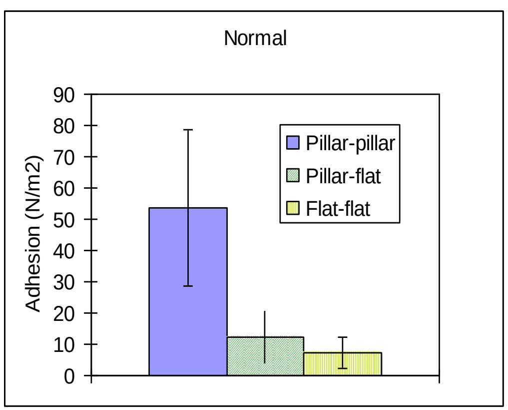
Decylamine (DA)



interweaved



indented



Two identical high aspect ratio (HAR) SMP pillars in hexagonal array (1 μm in diameter, 4 μm in height, 2-3 μm in pitch) were engaged at 80^{o}C at a preload larger than the critical buckling threshold. The pillars interweaved and/or indented with each other. After cooling down to room temperature, a stronger and anisotropic pull-off force was observed in the normal (~ 53.6 N/cm^2) vs. the shear (~ 71.9 N/cm^2) direction compared to those from pillar-to-flat and flat-to-flat surface contact. When the pillars were reheated at 80^{o}C, they were easily separated.