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Developing a Self-Healing Concrete Filler Using Poly(Methyl Methacrylate) Based Two-Part Adhesive

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Abstract : Concrete is an essential building material used in the majority of structures. Degradation of concrete over time increases the life-cycle cost of an asset with an estimated annual cost of billions of dollars to national economies. Most of the concrete failure occurs due to cracks, which propagate through a structure and cause weakening leading to failure. Stopping crack propagation is thus the key to protecting concrete structures from failure and is the best way to prevent inconveniences and catastrophes. Furthermore, the majority of cracks occur deep within the concrete in inaccessible areas and are invisible to normal inspection. Few materials intrinsically possess self-healing ability, but one that does is concrete. However, self-healing in concrete is limited to small dormant cracks in a moist environment and is difficult to control. In this project, we developed a method for self-healing of nascent fractures in concrete components through the automatic release of self-curing healing agents encapsulated in breakable nano- and micro-structures. The Poly(methyl methacrylate) (PMMA) based two-part adhesive is encapsulated in core-shell structures with brittle/weak inert shell, synthesized via miniemulsion/solvent evaporation polymerization. Stress fields associated with propagating cracks can break these capsules releasing the healing agents at the point where they are needed. The shell thickness is playing an important role in preserving the content until the final setting of concrete. The capsules can also be surface functionalized with carboxyl groups to overcome the homogenous mixing issues. Currently, this formulated self-healing system can replace up to 1% of cement in a concrete formulation. Increasing this amount to 5-7% in the concrete formulation without compromising compression strength and shrinkage properties, is still under investigation. This self-healing system will not only increase the durability of structures by stopping crack propagation but also allow the use of less cement in concrete construction, thereby adding to the global effort for CO2 emission reduction.

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