Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 8 Issue 3, March - 2021

An Introduction To Self-Healing Materials

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***Abstract*—Things break, and constantly replacing a broken object can sometimes be frustrating and costly. Over the past few decades, scientists have been conducting theoretical and experimental research in different disciplinary areas to create self-healing materials with a focus on cost reduction and efficiency improvement. Self-healing materials are artificial or synthetically created substances with the ability to automatically recover damage without any external diagnosis of the problem or human intervention. While the current stage of technology can produce auto-repair polymers, they require certain conditions such as temperature or pressure to reach the state of self-reconstruction. This manuscript presents an introduction to self-healing materials and briefly reviews their current state of development. The key goal of research related to self-healing products is to create materials that can eventually repair themselves under different circumstances without external factors.**

Keywords—self-healing; self-repairing; polymers; self-reconstruction

I. INTRODUCTION

Self-healing is the property of the material to recover from any kind of damage automatically without any peripheral intercession. Self-healing materials are divided into two main categories. The category for which no other interferences are involved is called automatic while the non-automatic category requires external stimulation. Although they are all self-healing materials, they have their own self-repairing techniques. Some of these materials use embedded healing agents which are small glue-like chemicals and they work similar to a type of adhesive (glue) called epoxy. Some of these are microvascular materials and others are shape-memory materials. These types of materials are involved in many applications which include aerospace, construction, and electronics. They are also applied and used as real-world products such as self-healing polymer composites, self-healing electric cables, and self-healing anticorrosion coating.

Self-healing materials are designed to sense the failure and respond autonomously for the restoration of structural function [1]. Ideal repair methods are ones that can be carried out effectively and quickly on damaged location so that the need to remove a component for doing the repair work is eliminated [2]. The ability of self-healing materials to regain their initial properties, is primarily dependent on the selection of the healing agents [3]. As an example, it is now possible to develop smart polymers capable of regaining their initial characteristics without the need for an external input. These polymers are known as intrinsic polymers and they constitute a very important category of self-healing materials. Another term used for these polymers is stimuli-responsive polymers. Polymers have a preference over metals for self-healing since it is much harder to heal metallic materials. This is because the metallic bonds are strong, have small volumes, and low diffusion rate [4]. Healing of a polymer refers to the recovery of a range of characteristics, such as, fracture toughness, tensile strength, and surface smoothness. To describe the extent of healing in polymeric materials, a commonly used approach involves determination of healing efficiency of the polymeric system [5]. The healing efficiency of a material can be assessed by a comparison of the fracture toughness of the material before and after healing. The three key tests used to assess self-healing include fracture test [5], fatigue test [6], and tear test [7].

II. KEY TYPES OF SELF-HEALING MATERIALS

The key types of self-healing materials are briefly described here. These types include embedded healing agents, microvascular materials, shape-memory materials, and reversible polymers.

1. Embedded Healing Agents

. Best known self-healing material.

. Have built-in microcapsules filled with a glue-like chemical to repair damage.

. Simple repair mechanism.

. The material cracks inside, the capsules break open, the repair material drains out, and the crack is sealed.

. The capsules need to be very small otherwise they will weaken the material in which they are embedded.

2. Microvascular Materials

. Contain a vascular network for the storage and transportation of functional fluids within a host material.

. The vascular network also provides a means to modulate electromagnetic properties.

. Slow working mechanism.

. Can pose a problem if the crack is spreading fast.

3. Shape-Memory Materials

. Need mechanism to deliver heat to snap back the material to its original form.

. Quite similar to vascular network.

. Strengthen the material by turning it into a fiber-reinforced composite.

4. Reversible Polymers

. Energized by either heat or light.

. Fragments try to rejoin naturally.

. Examples include thermoplastics and thermosets.

III. CONCLUSION

Over the past few decades, there has been a significant interest in the development of self-healing materials. The ability to self-heal can increase the system life- time, reduce the cost of replacement, and enhance the product safety. Self-healing materials have a great potential when considering the design methodologies for sustainable infra-structure. A brief overview of self-healing materials is presented in this manuscript. The key types of these materials are listed. Some of the applications of self-healing materials are outlined.

REFERENCES

[1] Kessler, M. R., “Self-Healing: A New Paradigm in Materials Design.” Retrieved from: [1]

[2] Aissa, B., Therriault, D., Haddad, E., and Jamroz, W., “Self-Healing Material Systems: Overview of Major Approaches and Recent Developed Technologies.” Retrieved from: [2]

[3] Bekas, D. G., Tsirka, K., Baltzis, D., and Paipetis, A. S., “Self-Healing Materials: A Review of Advances in Materials, Evaluation, Characterization and Monitoring Techniques.” Retrieved from: [3]

[4] Ferguson, J. B., Schultz, B. F., and Rohatgi, P. K., “Self-Healing Metals and Metal Matrix Composites”, JOM66, 866-871 (2014). Retrieved from: [4]

[5] Wool, R. P. and O’Connor, K. M., “A theory of crack healing in polymers”, Journal of Applied Physics, Vol. 52, No. 10, pp. 5953 – 5963, 1981.

[6] Brown, E.N., Sottos, N. R., and White, S. R., “Fracture testing of a self-healing polymer composite”, Experimental Mechanics, Vol 42, No. 4, pp. 372 – 379, 2002.

[7] Keller, M. W. White, S. R., and Sottos, N. R., “A self-healing poly (dimethyl siloxane) elastomer. Advanced Functional Materials”, Vol. 17, No. 14, pp. 2399 – 2404, 2007.