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Study and Analysis of Self Healing Materials with Reversibility and Movement Across Cross Links;Realization of Self Healing Through the Process of Chaos, Complexity and Order

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Abstract:- Self healing materials are materials which,after fracture and are able to recover their mechanical properties and functions. The lifetime of these materials is thus increased, saving the environment. The first reports of self healing materials appeared in 2008. thus beginning the era of these materials. The reports cited supramolecular chemistry to realize the properties of self healing materials because of heir reversibility. The first report based on the hydrogen bond was reported in 2008. and since then many others have been reported Self healing properties have been found mostly in polymers, elastomers. metals, composites and ceramics. This paper further utilizes Chaos, Complexity and subsequent order in realizing the procedures of self healing.

I. INTRODUCTION

Self healing materials are artificial materials, which, after fracture, retain their original properties. The longevity of the materials is thus increased.

The first reports of self healing materials appeared in the early 2000s, thus beginning the case of these materials. The reports cited supramolecular chemistry to realize the properties of self healing and be used again.

The first report based on the hydrogen bond was reported in 2008 and since then many others have been reported.

Self healing properties are found in polymers, elastomers, metals, composites and ceramics.Usually, fatigue gradually weakens a material .Other factors are: conditions of the environment, or damage created while in use..

On a microscopic level, cracks and other areas of damage are known to change the electrical, thermal and acoustical properties of materials and the spread of fracture can lead to final failure of the material. Usually, cracks are difficult to detect early and routine inspection needs regular interventions.

Self healing materials have the unique property of healing by themselves without any human interference.

II. DESCRIBING SELF HEALING MATERIALS

➢ *Materials that are used in everyday life usually cease working for three different reasons :*

- Old Age. Most substances decay gradually with time, sometimes over long periods.
- Erosion. Most materials go through gradual wear. being used constantly (friction is one of the primary reasons, materials that are moved back and forth repeatedly will fail through fatigue.
- Defects. When applied forces cause internal fractures some materials break without notice. . The internal fractures are cracks. These cracks creep and spread fast.

The last problem to a material scientist is considered the most risky and always difficult to tackle. It is hard to spot cracks, spinning at different angles and traveling at high speeds. Testing which is not destructive , including faster than sound scanning makes it easier to detect problems during routine inspections, but are not suitable when fractures occur while the material is being used.

What is really required are artificial materials behaving as a human body does, sensing failure, stopping it from spreading and getting worse and then mending it as soon as possible all by themselves. This is the basic concept of a self healing material.

III. TYPES OF SELF HEALING MATERIALS

The first self-healing materials were polymers with a kind of embedded internal adhesive, reported by a team in 2001. which consisted of Scott White, Nancy Sottos and colleagues from the University of Illinois at Urbana Champaign. Since then, many self healing materials of different varieties have been developed.

➢ *Self Healing Materials are Primarily of Four Types:*

- Materials with healing agents that are enclosed.
- Materials with an internal circulatory system similar to blood

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- Shape memory types of materials (SMMs)
- Polymers that are reversible

➢ *Let us Look each in a Little more Detail:*

- *Embedded Healing Agents*

These best known self healing materials have tiny capsules that are inherent as micro embedded pockets filled with adhesive that is able to repair damage. If the material breaks inside, the capsules break open, the repair material comes out and the crack seals up.It works in a way similar to an adhesive called epoxy, which is supplied as two liquid polymers in distinct containers, often as a couple of syringes. As the liquids are mixed , a chemical reaction occurs and a strong adhesive, a copolymer, forms.

Materials that are self healing are able to use embedded capsules in varipus ways. The easiest approach is for the capsules to release an adhesive that fills the cracks and binds the material together.

Approaching a little differently, the main body of the material is a solid polymer while the capsules enclose a liquid. When the material fractures, thus breaking the capsules, the monomer and the polymer mix. More polymerization occurs and the damage is sealed well by creating more of the original material to replace the damaged area. Characteristically, a powdered chemical catalyst has to be enclosed as well, so the polymerization will happen at a lower temperature and pressure.

The main drawback with the encapsulation method is that the capsules have to be very small indeed otherwise they would weaken the material in which they are embedded .This restricts the amount of damage they can heal.

Another problem is that the capsules can only heal the damage once. If the materi fails again since it is weaker certainly after repair, it is unable to heal itself the second time.

- *Microcirculatory Materials*

Healing agents that are embedded are simple and effective but they have a drawback. When the structure of the material is intercepted with capsules, the structure can be weakened and the potential of ìncreasiñg the rise of fracture is enhanced, which is the very problem we are trying to solve.

The human body solves this problem by having an amazing circulatory system (a network of different sized blood vessels of different sizes that transfer blood and oxygen for energy and repair.

If there is an occurrence of damage our blood system simply pumps additional resources to the places where they are required but only when they are needed.

Materials scientists have been trying to design self healing materials that work the same way. Some have circulatory tubes which are very thin (about 100 micrometers in thickness) built into them that are able to pump healing agents (adhesives or whatever is needed) to the location of failure only when they are required to do so.

The tubes lead to pressurised reservoirs, like syringes that are pushed in slightly . The occurrence of a failure causes the pressure to be released at one end of the tube, causing the healing agent to be pumped in to the place where it is required. Although this method can seal cracks ten times the size that the microcapsule method can manage, it works more slowly , since the material for repair has to travel further . This could pose a problem if the crack is spreading faster than it is being repaired.

However, in the case of a very tall building or a bridge, where a failure might might appear and creep (spread slowly) over months or years, a system of built In tubes could indeed work well.

- *Shape Memory Materials (SMMs)*

Most of us know about shape memory materials through daily applications such as eyeglasses made from alloys , for example, nickel titanium, that spring back to shape when bent or released. In reality, shape memory materials work in a more complex and fascinating way. One needs to apply energy to the material to enable it to flex back to its original form .Shape memory materials which are self healing therefore need some sort of medium for applying heat to the area where damage has occurred.

In practice, **t**he material may be an enclosed network of fiber or optic cables that are similar to the vascular networks used in other self healing materials. The exception is that instead of pumping up a polymer or adhesive, these tubes are said to add laser light and heat energy to the location of failure . This causes them to change back into their desired shape effectively and the damage is reversed

Shape memory materials have progressed from shape memory alloys to shape memory polymers. There is also a new type, called shape memory hybrid.

Among the shape memory alloys, Those that are Nickel Titanium based, Copper based and Iron based, are of commercial importance. The first choice is mostly Nickel Titanium based, since it has a performance which is high and good biological compatibility.

- *Reversible Polymers*

When a polymer is fractured, reversible interactions that are formed between the cross linked polymer chains of the fractured surfaces can cause the polymer to self heal . Reversible cross links can be responsible for self healing in covalent and non covalent bonds. Cross links in polymers that are reversible can achieve high toughness and are useful for self healing.

IV. CHAOS THEORY IN SELF HEALING MATERIALS

Fracture of materials and formation of cracks can be described as an application of chaos.

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Self healing repairs the material by forming a bifurcation on achieving complexity where the fractured surface organizes itself where a pattern, which is similar to its original shape and features reappears

V. CONCLUSION

Artificial materials that can regain their properties after suffering a fracture are self healing materials. The life expectancy of the material can increase after self healing.

Self healing materials occur primarily in polymers, elastomers, metals, composites and ceramics.

There are three distinct reasons why materials used daily cease working : (a) When materials erode with time (b) When materials used continuously fail through fatigue, friction being one of the main causes. (c) Defects , when applied forces cause internal fractures that spread rapidly.

The third problem is the most difficult to tackle. Testing which is not destructive , including ultrasound scanning, makes it comparatively simpler to spot fractures during routine inspection but is of not much use when the material is in use and failures happen. What really works are artificial materials behaving as the human body sensing failure and repairing it as soon as possible by themselves.

- *There are Primarily four Types of Self Healing Materials;*

- Materials with enclosed healing agents
- Materials having an internal circulatory system similar to blood
- Materials that are shape memory types
- Reversible polymers .

Chaos theory may be applied to the process of self healing where the surface that is fractured organizes itself into a pattern similar in shape to the original material with the same features.

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