

Self-healing intelligent composites – Heal thyself

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Abstract- Dental composite resins are dental cements made of synthetic resins. Composite resins evolved as restorative materials as they were insoluble, tooth-like appearance, easy to manipulate. Dental composites are increasingly popular due to their esthetics and direct-filling capabilities. The composite structures fail due to internal cracks. Self-healing materials are designed and prepared to heal their cracks. Self-healing mechanisms and various advanced self-healing materials are recently used for repairing composite materials.

Keywords: Dental composite, self-healing, recovery, microcapsules.

INTRODUCTION

Composites are tooth coloured excellent aesthetic restorative materials.[1]

In recent years, a new generation of intelligent dental composites has been developed to create the property of spontaneous repair of damages such as microcracks in the composite bed. [2]

Dental composites are commonly utilized in dental treatments because

- 1) they have the ability to preserve the natural appearance of teeth
- 2) minimally invasive
- 3) Conservative
- 4) enhance the overall physical and mechanical attributes.
- 5) Can be repaired
- 6) Bonds to tooth structure. [3]

There are some disadvantages of composites such as

- 1) Polymerization shrinkage
- 2) Technique sensitive
- 3) Lack of anticariogenic property
- 4) Dental composites have limited durability and stability.
- 5) Dental composites can experience damage, like small cracks, due to factors like temperature changes and physical strain, which can reduce their effectiveness. [2]

SELF HEALING COMPOSITES:

Self-healing smart materials have been under extensive research and development during the past decade.

Self-healing dental composites (SHDC) are resin-based materials that incorporate microcapsules or vascular networks filled with a healing agent.

Edge v-notch beam test is used to examine changes in composite fracture toughness before and after healing process. [4]

Self-healing dental composites are promising materials that could help to produce a stable interface that resists secondary caries and reduces marginal gaps [3].

Recent developments in self-healing materials have resulted in new generation of load-carrying smart material systems with the ability to heal microscale to structural-scale damage. [2,3] The potential for crack repair and recovery of mechanical properties has been achieved in bulk thermosetting polymers, self-healing fibre-reinforced composites, self-healing dental composites, self-healing adhesives, self-healing bonding resins, elastomers and coatings [3].

Self-healing dental composites are promising materials that could help to produce a stable interface that resists secondary caries and reduces marginal gaps [3].

CLASSIFICATION -

self-healing materials are classified into three groups:

- based on capsule embedding,
- using embedding hollow tubes or vascular network,
- intrinsic self-healing materials

CAPSULE EMBEDDING MATERIALS

When crack or damage occurs, the healing agent is released and reacts with a catalyst to form a new bond, restoring the material's mechanical properties.

Detecting these tiny cracks in dental composites can be quite challenging, and in certain situations, it may even be impossible. [6] In addition, it is not possible to repair these damages in situ by using conventional materials and methods. Therefore, the self-healing ability in dental composites is necessary. In recent years, the spontaneous repair of damages such as micro-cracking in dental composite materials has been developed without any type of human intervention and the replacement of new components.

The most widely used approach to create self-healing dental composites involves encapsulating a healing agent within polymer shells and dispersing these microcapsules within the acrylate matrix of the dental composite.

Review of researches on self-healing dental composites used melamine

(5 wt.%) to modify the shell of DCPD-containing micro-capsules to improve the mechanical properties of Polyurea-formaldehyde (PUF)

micro-capsules. Melamine formaldehyde polymer has high strength bonds due to its ability to form crosslinks. To improve the properties of micro-capsules, especially their adhesion to dental composite tissue, melamine-formaldehyde polyurea microcapsules were prepared. [3]

An initiator is an essential component in the resin composite mixture. In order to facilitate chemical polymerisation with the healing agent involved in the microcapsules [4], a benzoyl peroxide (BPO) catalyst and an *N, N*-dihydroxyethyl-*p*-toluidine (DHEPT) amine have commonly been used to chemically cure composites [4]. Studies have reported the use of poly(urea-formaldehyde) microcapsules, which encapsulate TEGDMA monomer and DHEPT amine accelerator, as healing agents in self-healing dental composites. [5] Capsule-based self-healing materials are able to heal small cracks, while vascular systems are more suitable for healing larger damaged areas. [1,6]

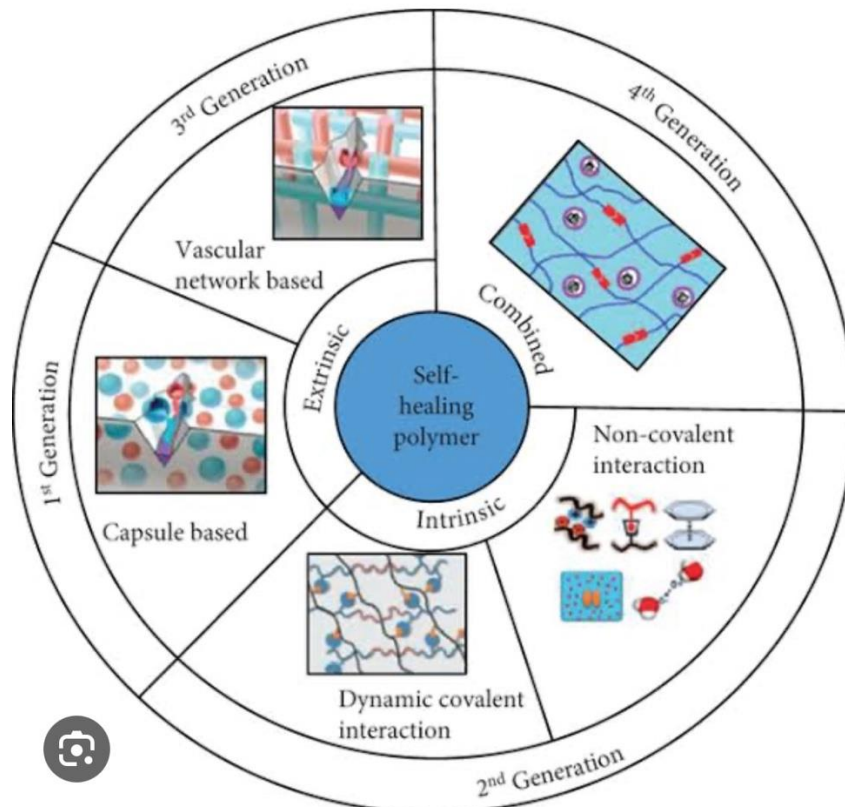


Diagram: Classification of self healing materials

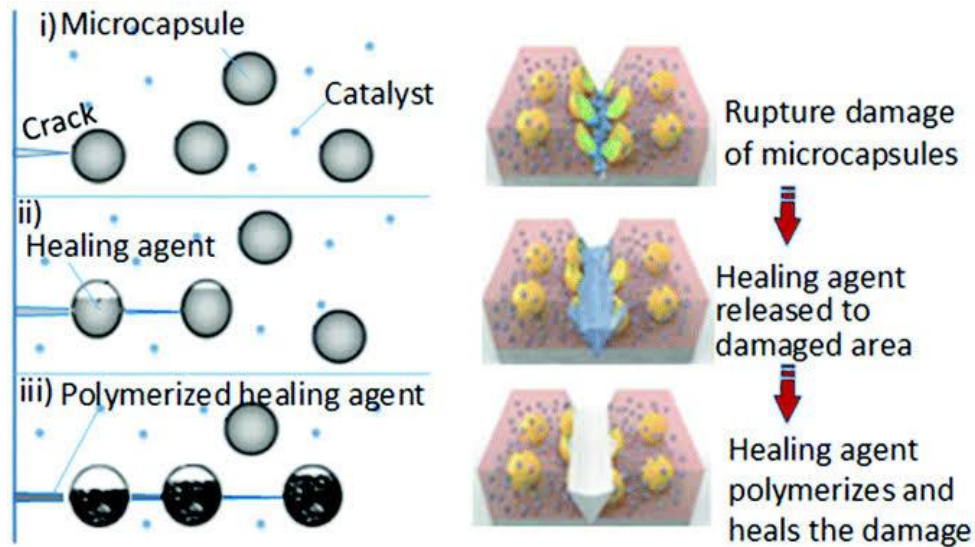


Diagram: mechanism of action

CONCLUSION:

It is concluded that future applications are based on such advanced self-healing composite materials and thus needed to review advanced self-healing composite structures. In recent years, spontaneous repair of microcracks without the need for human intervention has been developed through self-healing polymers and intelligent composites. Inspired by nature and biological systems, research has been at the forefront of the field of self-healing composites. [7]

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