NANOTECHNOLOGY IN TOOTHPASTE- A REVIEW

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ABSTRACT

A nanoparticle is a microscopic particle with at least one dimension less than 100 nm. Nanoparticle research is currently an area of intense scientific research, due to a wide variety of potential applications in biomedical, optical, and electric fields. The aim of the study was to determine the various nanoparticles used in toothpaste. Articles were searched in various sources like pubmed and google scholar. The articles were collected between the year 2010-2020. The outcome of this study is based on the previous study which is done on uses, advantages and disadvantages of nanoparticles used in tooth[aste. The various nanoparticles employed in toothpaste are hydroxyapatite, silver, zinc oxide, diamond, hexametaphosphate etc. Hydroxyapatite nanoparticles decrease tooth sensitivity, and significantly increases the micro hardness. Nanoparticles also help in reducing sensitivity. From this study we conclude that nanoparticles used in toothpaste have both advantages and disadvantages. Because of their small size and greater surface area, it helps to protect the teeth in minute areas also. Green nanoparticles can be utilized in the future to counteract the side effects caused by chemically synthesized nanoparticles

KEYWORDS: Nanoparticles; Toothpaste; Hydroxyapatite;zinc oxide, silver, titanium dioxide

INTRODUCTION

The size of the nanoparticle is at least half of the particles in the number size distribution and measures around 100 nm or below. Most nanoparticles are made up of only a few hundred atoms. The very small size nanoparticles have a very large surface area to volume ratio when compared to bulk material, such as powders, plates and sheets. This feature enables nanoparticles to possess unexpected optical, physical and chemical properties. The use of nanomaterials spans across a wide variety of industries, from healthcare and cosmetics to environmental preservation and air purification(1). In health care the nanoparticles are mainly employed as drugs. Nanoparticles can

be made in chemical methods and green methods. chemically synthesised nanoparticles are associated with many toxic effects and are biohazardous. Their recommendation in the field of medicine is limited due to the side effects(2). Instead, green nanoparticles prepared using plant phytochemicals are currently being researched upon and also employed. These green nanoparticles are bio safe for consumption. So in the recent past there has been an increase in the number of research based on green nanoparticles and its applications(3).

The many nanoparticles used in toothpaste are hydroxyapatite, zinc oxide, diamond, silver, trimetaphosphate and hexametaphosphate. Hydroxyapatite is a component of bone. Hydroxyapatite crystal lattice is usually made up of calcium. Which is found naturally in the teeth and bones(4). Hydroxyapatite nanoparticles are fluorides which help in the remineralization and demineralization in situ(5). Silver is a bacterial killer which has proven and it has antibacterial properties which help in the reduction of risk in gums. And reduce the gums bad breath Which is caused by bacteria in the mouth(6). and titanium dioxide which is used in the teeth whitening.

Neurotoxic effects of the titanium dioxide nanoparticle on the brains of male sprague dawley rats have been evaluated. The titanium dioxide used in the tooth paste can have potential side effects. The titanium dioxide is used in alteration, reducing cell viability(7). Silver oxide nanoparticles are antibacterial compounds. Which helps against the dental pathogens(8).

Many research has been conducted regarding oral health and various oral diseases among different populations.(9)(10,11))(12))(13)(14). Various surveys have been conducted among the undergraduates with recent advancement(11,15)(16,17))(18))(19)(20). Various studies have been conducted among the undergraduates with their advancement(20)(23)(21)(22)(23). And now this current study was done to determine the various nanoparticles used in the toothpaste and the aim of this study is to evaluate the various nanoparticles which are present in the toothpaste.

MATERIALS AND METHODOLOGY:

Articles were searched in various sources like pubmed, Google scholar. The articles were collected between the year 2010 to 2020. The outcome of this article is based on the previous studies which is done by the researcher and this study is analysed by using proper statistical tools. In Vitro studies and randomised controlled trials were searched from the database pub med Scopus and Google scholar. Review articles, articles in other languages than english and retracted articles were excluded. outcomes Measures of the study were the types of nanoparticles used in the toothpaste and its advantages and disadvantages (table:1).

DISCUSSION:

The articles that were collected from the year 2011 to 2020. A total of 11 articles were included for the review. In that, three articles are collected from the year 2017 and one article is collected from the year 2018 and five articles from the year 2019. The data from the article shows that the nanoparticles commonly employed in toothpaste include hydroxyapatite, silver, zinc oxide, diamond, trimeta phosphate and hexametaphosphate. The advantages of nanoparticles are increase

in micro hardness, decrease of hypersensitivity , increased remineralization and more antimicrobial properties(Table 1)

Nanoparticles are employed in toothpaste inorder to be used as an antibacterial agent which helps in prevention of dental caries, gingivitis and other reactive oral lesions. Nanoparticles commonly used in toothpaste are hydroxyapatite, zinc oxide, diamond, silver, trimetaphosphate, hexametaphosphate.. Hydroxyapatite reduces the sensitivity of the tooth, and thereby significantly increases the microhardness of the tooth.The ability of nanoparticles to penetrate the dentinal tubules helps in decreasing the hypersensitivity(26).
Advantages of silver nano toothpaste includes decrease in streptococcus mutans count and increase in the microhardness of the surface of the tooth. And it is known to have the highest antibacterial efficiency(30). Zinc oxide nanoparticles on the other hand does not affect the micro hardness, It helps in the increase of resistance, surface roughness and colour stability of the enamel(32). Diamond nanoparticles cluster together and combine to form a protective layer over the enamel. Trimetaphosphate helps the enamel surface to become 20% harder(34). Hexametaphosphate makes the enamel surface 42% harder(33).
Disadvantages of nanoparticles percent in the toothpaste which include the inflammation of gastrointestinal tract by silver nanoparticles (30). L-arginine is less efficient than CHS(35).

Hydroxyapatite

The hydroxyapatite is crystalline in nature and they are calcified at 800 degree celsius. The hydroxyapatite powder was characterized through x-ray diffraction, fourier transform infrared spectroscopy, ion exchange chromatography, scanning electron microscope, and plasma emission spectrometer. Hydroxyapatite is obtained from the fish waste, fish bones,fish scales. Hydroxyapatite which is obtained from the fish waste has a great potential, good physico-chemical characterization and biocompatibility(36). Nano hydroxyapatite which helps in the resemblance to nano organic bone structure. In implantology the main use of nano hydroxyapatite is used to coat titanium implant and help in osseointegration and has inflammatory response against bacteria. In tissue engineering it is used in surgery and periodontology in that it is used as a grafting material. In esthetics it is used as a dentinal hypersensitivity, remineralization potential and bleach(37). In endodontics it has advantages like biocompatibility, nontoxicity, dimensional stability and has an ability to induce regenerate response(38) . The combination of the biocompatibility chemical composition and unique structure is used for future application in functionalized degradable biomaterial. The hollow structure of the sphere can be useful for embedding drugs in the core, encapsulated by the highly mineralized outer shell. And which help in enabling the advance strategies for threatening bone related disease(39). Nano Hydroxyapatite in toothpaste helps to significantly increase the microhardness of the tooth, and decrease the hypersensitivity by inhibiting penetration(26).

Silver

Silver nanoparticles are particles in the size ranging between 1 and 100nm. The two major methods used for synthesis are physical & chemical . They are expensive and have toxicity . silver nanoparticle used in biomedical applications , infertility burns , cancer treatment , etc and various with the possible toxicology challenge(40) Silver nanoparticle has a flexible property . It is used for numerous in vitro about their toxic behaviour. The incorporation of Silver nanoparticle in to different material like textile fiber and wound dressing can extend their utility on the biomedical field while inhabiting infections and biofilm development .In bioengineering ,Silver,nano particle are considered potentially ideal gene delivery system for tissues regeneration .And it is used as a biosensor for gene therapy(41).Silver has a long and interfering history as an antibiotic in human health care . It is used in water purification , wound care , bone ,prostheses , reconstructive orthopedic surgery, cardiac devices, catheters and surgical appliances. Chronic ingestion or inhalation of silver preparation can lead to deposition of silver metal silver sulphide particles in the size, eyes and other organs. These are not life threatening conditions but cosmetically undesirable(42). silver nanoparticles in toothpaste helps to decrease the streptococcus mutans count and increase the microhardness of the surface of the tooth. It is also known to have a high antibacterial efficiency(30).

Zinc oxide

The wide uses of zinc oxide nanoparticles in industrial, cosmetics, medicine, food production and electronics are associated with increase in occupational public exposure. It has been extensively studied on many different cell types and animal systems. Comet assay was used to evaluate the genotoxic of nano-zinc(42,43)Zinc oxide nanoparticles are known for their good antioxidant and good antimicrobial property(44). zinc oxide eugenol has been used as a part filling material in primary teeth pulpectomy(45). Zinc oxide nanoparticles does not affect the micro hardness, resistance, surface roughness and colour stability of the enamel(32)

Diamond

Diamond has an outstanding mechanical, optical , thermal and electrical properties tunable. Surface characteristics and unprecedented biocompatibility (46). the diamond emerges as one of the major new biomaterials; it could shape the way medical treatment will be performed(47). Diamonds are one of the hardest materials known, they increase the surface resilience of enamel. The disadvantage being decrease in microhardness of enamel as it is harder(48)

Hexametaphosphate

Hexa meta nanoparticle has a protective effect against enamel demineralization and has the composition of biofilm in situ toothpaste could be a viable alternative to patients at high risk of caries(49). They have a wide range of uses including permanent restoration,cavity lining, fissure

sealant and adhesive. It creates an antimicrobial environment(50). Sodium hexametaphosphate was used as a valid alternative to well known cross linkers(51).

Trimetaphosphate

Trimetaphosphate used as a retention growth factor beta 1 using functionalized dextran based on the hydrogels. It has an important function for stabilization and protection. And could be applied to other proteins of clinical interest(52). It has a long term stabilization of polysaccharide in situ cross link electron fibre. Advantages of polysaccharide nanofibrous construct the tissue engineering(53). it has a chemical characterization of a degradable polymer. The bone adhesive contain hydrolysable filler and interpretation of anomalous mechanical properties(54). They help to form a layer over the surface of the teeth inorder or carry out its property of enabling the enamel to become 42% harder.

The review has shown that there are limited studies on nanoparticles in toothpaste which is a good area of future research. The advantages outweigh the disadvantages, hence in the future more green nanoparticles can be employed to counteract the above mentioned disadvantages.

The main limitation of the study is the limited articles used in the review . Further research to advocate the use of various nanoparticles in future.

CONCLUSION:

From this study we conclude that nanoparticles used in toothpaste have both advantages and disadvantages. Because of their small size and greater surface area, it helps to protect the teeth even in minute areas. Green nanoparticles can be utilized in the future to counteract the side effects of chemically formed nanoparticles.

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Table 1: Summary table showing the various nanoparticles used in toothpaste and its mode of action

Author	**Nanoparticle used**	**Type of study**	**Use and advantage**	**conclusion**
Ebadifar A et al (24)	Hydroxyapatite	Invitro	Helps in increasing the micro hardness and in stimulating the initial carious lesion formation.	The toothpaste containing hydroxyapatite was more effective than other toothpaste for the purpose of remineralization
Anand S et al (25)	Hydroxyapatite	In vitro	significantly decreases the hyper sensitivity in Dentin and it is effective be the desensitizing agent	It is a effective desensitizing agent providing relief from symptoms within five minutes of application

Manchery N et al (26)	Hydroxyapatite	in vitro	Found to be effective in remineralising artificial carious lesions.	Use in the management of early carious lesions because it is effective in remineralising the artificial carious lesion.
Amaechi BT et al (27)	hydroxyapatite	in vitro	Increase in the percentage of completely occluded tubules and % dyes penetration inhibition. It shows more effectiveness in a occluding dentin tubules	Effective in occluding dentinal tubules.
Vano M et al (28)	hydroxyapatite	Randomized controlled trial	Significantly lower the values of cold air sensitivity and tactile sensitivity. And it is a effective desensitizing agent	Nano .hydroxyapatite in gel toothpaste fluoride free is an effective desentizing agent providing relief from symptoms after 2 and 4 weeks.
Nozari A et al (29)	Hydroxyapatite and silver	Invitro study	Nanosilver fluoride statistically and significantly increases the surface area of the microhardness of the enamel. Good remineralization efficiency.	NSF could have the greatest remineralization efficiency.
Ahmed F et al (30)	Silver	Invitro	Significantly decreased streptococcus mutans	Nano-silver-containing toothpaste has the highest antibacterial against S-mutans.
AlSubaie AA et al (31)	Zinc oxide	Invitro	Does Not affect the micro hardness,surface roughness and colour stability of esthetic restoration	Activity comparable to fluoride based and ammonium oxide based dentifrices.
Abakarov SI et al (32)	Diamond	In vitro study	Cluster and combine to form a protective layer over the enamel.	Reduce the porosity of the enamel. By increasing the micro hardness and resistance.

Danelon M et al (33)	Hexameta phosphate	Randomised controlled trial	Enamel surface become 42% harder	0.5% HMP Name to a conventional fluoride toothpaste was able to Promote an additional remineralization effect of artificial carious lesion.
Danelon M et al (34)	Trimetaphos phate	Randomised controlled trial	Enamel surface becomes harder	Potential of higher remineralization