Advances in alginate impression materials: a review

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INFORMATION

Article History

Received *26 September 2019*
Accepted *11 October 2019*
Available online
15 November 2019

KEYWORDS

Alginate
Dust-free alginates
Chromatic alginate
Self-disinfectant alginates
Tray adhesives
Nanoparticles

ABSTRACT

Alginate is an irreversible elastic hydrocolloid which has various applications in dentistry. The applications of alginates include making impressions of edentulous and partially edentulous arches, duplication of casts, and for making study models. Alginates possesses numerous vital properties such as hydrophilicity, ability to record finer details, elastic recovery and inexpensive; makes this material widely used in dentistry. Though alginate is the most commonly used impression material, it has some inherent disadvantages. Alginates contain low-density fine filler particles, which may arise in the form of dust and inhalation these dust particles may cause respiratory problems. Further, they are highly dimensionally unstable due to syneresis & imbibition. Besides, alginates do not adhere to non-perforated trays, low viscosity resulting in gag reflex in some patients, and the inability to identify the correct consistency to load. Several modifications were made in the composition of conventional alginates to address their shortcomings. This article reviewed various recent advances in the alginate impression materials and their performance.

1. Introduction

Alginate is an elastic and irreversible hydrocolloid impression material, which has been using in dentistry for many years. Alginate impression materials is essentially an alginic acid, which is obtained from brown seaweed (marine plant). Alginate is a high molecular weight linear polymer of anyhydro-D-mannuronic acid [1]. Alginate is a linear acidic polysaccharide comprising β-d-mannuronate (M) and its C-5 epimer α-l-guluronate (G). In alginate polymers, the residues are arranged in a block structure of a homopolymer (polymannuronate (PM) or polyguluronate (PG)) or heteropolymer (a mixed sequence of these residues). The properties of alginate depend on the degree of polymerization and the ratio of mannuronan (M) and Guluronan blocks (G). As shown in figure 1, the mannuronan chains are stretched

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How to cite this article: Alaghari S, Velagala S, Alla RK, Ramaraju AV. Advances in alginate impression materials: a review. Int J Dent Mater 2019;1(2): 55-59.

DOI: http://dx.doi.org/10.37983/IJDM.2019.1203

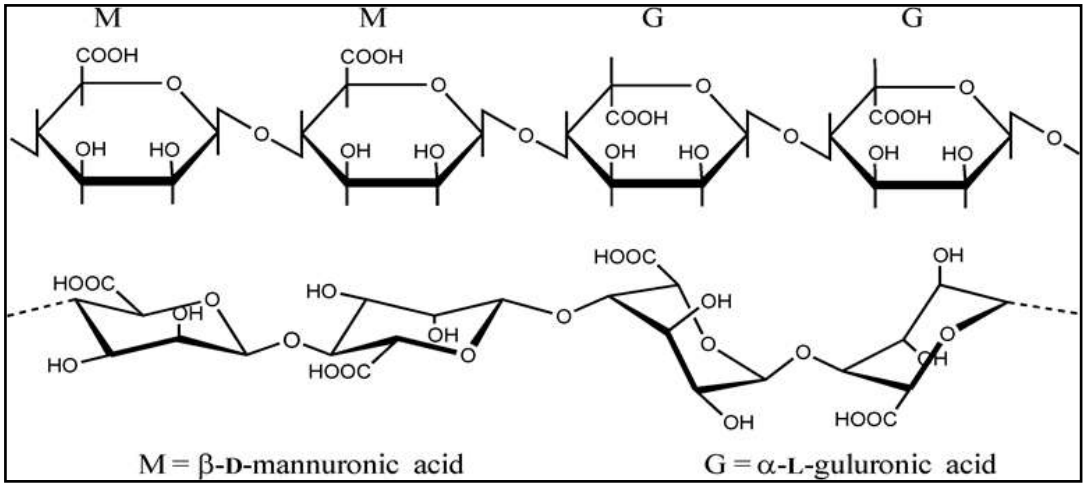

Figure 1. Structure of Alginic acid

and flat, which are more flexible compared to guluronan blocks. Guluronan blocks react with calcium and produce a strong and brittle gel, whereas mannuronan block produces weaker and elastic [2,3].

Alginate impression material contains soluble alginic acid as a principle reactive ingredient. The average molecular weight of alginic acid is in the range of 32000 – 200,000. The molecular weight of the alginic acid influence the viscosity of the sol. The more the molecular weight more will be the viscosity of the sol and vice versa [3]. The composition of alginate impression materials is detailed in table 1.

Alginate is widely used, though this material is not ideal in every aspect, for making edentulous and partially edentulous impressions for the fabrication of complete and removable partial dentures respectively. Alginate impression materials are easy to use, records fine details, and cost-effective compared to its counterpart elastic impression materials [1].

However, alginate impression materials contain fine diatomaceous earth fillers particles. These fillers rise in the form of dust on the opening of the alginate storage container's lid due to their lack of density. Alginates are highly hydrophilic tend to absorb water or moisture, leading to dimensional changes. Further, their low viscosity may result in the gag reflex in patients. It is necessary to use perforated trays to make impressions with these materials as they do not adhere well to the impression trays [1-4].

S.No.	Ingredient	Functions
1.	Soluble alginate	Main reactive ingredient.
2.	Calcium sulfate dihydrate	Reactor
3.	Trisodium phosphate	Retarder
4.	Diatomaceous earth and Zinc Oxide	Fillers
5.	Potassium-titanium fluoride	Gypsum hardener
6.	Flavoring agents	Provide appropriate taste
7.	Colour pigments	Provide characteristic colour.

Table 1. Composition of alginate impression material

2. Evolutionary changes in the alginate impression material

2.1 Dustless alginates

These materials were developed to eradicate silicosis, which is caused by the presence of diatomaceous earth in the form of fillers in conventional alginate impression materials. These fillers are low-density siliceous fibers with dimensions of 3-20 µm and more potential carcinogens. These fibers will raise in the form of dust during usage and inhalation of those fibers may cause respiratory problems [1].

An attempt was made to increase the density of siliceous fibers by coating them with dedusting agents like glycerin, glycol, polyethylene glycol, and polypropylene glycol [1,3]. Recently, sepiolite (natural mineral fiber-containing magnesium silicate -20%) was added to the alginate materials that helps in holding alginate particles together to prevent the leaping of dust particles. This reduced the dust generation from alginate impression materials during dispension. Numerous manufacturers also incorporated tetrafluoroethylene to avoid the dust particles raising by forming the cobweb during mixing [5].

2.2 Alginate in the form of two-paste system

Alginates were developed in two-paste systems to prevent the contamination of powder, and inconsistency in dispensing a certain amount of powder. It consists of base paste and catalyst paste. The base paste contains soluble alginate, water, and fillers, whereas catalyst paste contains calcium salts, viscous liquids like liquid paraffin and magnesium hydroxide as a pH stabilizer [6-8].

2.3 Chromatic alginates (Alginates with color indicators)

The problem observed among some of the undergraduate students is difficulty in identifying the ideal consistency of alginate material during manipulation. Various color indicators were added to the alginate impression materials to identify the different stages of manipulation. These color indicators change the color of the alginate mix as setting reaction taking place due to the change in the pH [1,3,9]. This change in the color of the alginate mix facilitates identification of the ideal consistency to load it into the tray and make accurate impressions.

2.4 Self-disinfected alginates

Disinfection of impression is an essential and necessary procedure in dental practice to prevent cross-infection and safety of patients, dentists, and dental personnel. Disinfection of impression should prevent spreading of infection from dental clinic to dental laboratory technician, other patients, and dental auxiliaries. Mantena SR *et al.* (2019) reviewed various methods employed to disinfect dental impressions. It was reported in the literature that the conventional disinfection procedures such as immersion and spraying methods which may lead to the unwanted dimensional changes in the alginate impression as they were hydrophilic [10].

Numerous researchers developed alginate impression materials by incorporating disinfectant agents in their compositions. The disinfectant materials incorporated include quaternary ammonium compounds, chlorhexidine, bisquanidine compounds, chlorhexidine, didecydimethy ammonium chloride [11-14]. Addition of disinfecting agents into the impression materials eliminates separate disinfection of the impression immediately after removing it from the patient's mouth.

Recently, researchers have experimented incorporating different antimicrobial nanoparticles into alginate impression materials. Several studies have reported that the addition of silver nanoparticles is more effective against S. aureus, Lactobacillus acidophilus, Actinomyces viscosus, and Pseudomonas aeruginosa [15-17]. Particle size and concentration of the silver nanoparticles are the essential factors that play a significant role in antimicrobial activity in alginate impression materials. It was suggested that the silver nanoparticles with the average particle size of 80–100 nm impart superior antimicrobial property to the alginate in a concentration-dependent manner than the finer nanoparticles [15,16]. It was also reported that the flow, gelation time and strength of alginate impression materials were adversely affected by the incorporation of greater than 1.0wt% of silver nanoparticles [15,16]. Several researchers also experimented the antimicrobial efficacy of Zinc oxide and Copper oxide nanoparticles in alginate impression materials. They reported that these nanoparticles were also proved to be effective self-disinfecting agents for alginate impression materials with no adverse effect on physical and mechanical properties [18].

2.5 Extended pour alginates

Due to syneresis and imbibition, it is unable to store the alginate impression for a longer duration. Attempts made by the manufacturers to address this problem led to the development of two new alginate materials such as CAVEX Color Change (Darby Dental Supply, USA) and Extend a Pour (Dux Dental Products). Cavex color change material can be preserved for about 100hrs and extend a pour can be preserved up to 4 weeks [5,19-22].

2.6 Alginate with polyacrylamide incorporation

On mixing with water, conventional alginates may tend to form a grainy mass with lumps of unmixed material as the water does not wet the powder easily. A thickening and stabilizing agent such as 0.01-0.25wt% polyacrylamide (molecular weight-200,000 to 6,000,000) were incorporated into the conventional alginates resulted in improving the mixing characteristics, and the formation of smooth alginate sol with water [3, 23, 24].

2.7 Storage medium for alginates

Traditional alginates, being hydrocolloid, are dimensionally unstable due to syneresis and imbibition. Hence, it is necessary to pour the gypsum cast as early as possible after the impression is removed from the mouth [3,25]. A storage solution is now available to store the alginate impressions without any dimensional changes. It was reported that storage of alginate impression in that solution did not show significant dimensional changes up to 100 hrs [3,26].

2.8 To improve the wettability of alginate powder by water

In general, water has less ability to penetrate the conventional alginate powders during mixing. Hence, the formation of a smooth and uniform mix requires longer mixing time with a resultant decrease in the working time. To address this, alginate impression materials were incorporated with hydrophobic materials and surfactants such as polyoxyethylene alkyl phenyl ether, Polyoxyethylene/polyoxypropylene alkyl ether, polyoxyethylene alkyl ether. These materials increased the permeation of water into the powder particles that resulted in the formation of sol rapidly with sufficient fluidity [3, 5, 27,28].

2.8 Other modifications

The other disadvantage with the alginate impression materials is its shorter mixing time. Hence, the operator should be skilled enough to mix the alginate material within the shorter mixing time to obtain homogenous consistency and make an accurate impression. Mechanical or automatic mixing devices were developed to address this problem. Mechanical mixing devices give more accurate consistency within a shorter time compared to hand mixing [29,30].

Flavouring agent such as cinnamon, strawberry, peppermint, watermelon, cherry, orange, and spearmint are added to the conventional alginates to improve the patient acceptance and to make the material more pleasant during use in the mouth [3,31].

Recently, tray adhesives were developed for alginate impression materials to accomplish better retention with the non-perforated metal or plastic trays. These tray adhesives are dispensed as liquids which contain polyamide or diethylenetriamine polymer, ester gum and rosin in isopropyl alcohol or an amalgamation of isopropyl alcohol with ethyl acetate. [3,5,32,33].

Conclusion

Alginate impression material is widely used for making the primary impression of edentulous and partially edentulous patients. The recent modifications in the composition of alginate impression material led to the enhancement of handling and clinical performance compared to unmodified alginate.

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