



POLYAMIDE AS A DENTURE BASE MATERIAL- A REVIEW

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ABSTRACT

Aim: the aim of the study is to understand the properties of polyamide as a denture base material. **Objective:** The purpose of this article was to review the biocompatibility, physical, and mechanical properties of the polyamide denture base materials. **Background:** Polyamide resin was proposed as a denture base material in the 1950s. Nylon is a generic name for certain types of thermoplastic polymers belonging to the class known as polyamides. Nylon is a crystalline polymer and this crystalline effect accounts for the lack of solubility of nylon in solvents, as well as high heat resistance and high strength ductility. On the other side, it is reported that this material has several problems such as water sorption, surface roughness, bacterial contamination, color deterioration and difficulty in polishing. **Reason:** Since there is a very limited knowledge about polyamide's clinical performance, strict and careful follow up evaluation of the patients rehabilitated with polyamide prosthesis is required.

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INTRODUCTION

Polyamide resin was proposed as denture base material in 1950s. Nylon is the generic name of certain types of thermoplastic polymers belonging to the class known as polyamides. Nylon is a crystalline polymer and this crystalline effect accounts for the lack of solubility of nylon in solvents, as well as high heat resistance and high strength coupled with ductility [1]. Thermoplastic acrylic has been used in dentistry for many years in the form of temporary crowns and thermal polymerized as baseplate material for partial and complete dentures. Thermal polymerized PMMA demonstrates high porosity, high water absorption, volumetric changes and residual monomer. They have poor impact resistance, tensile and flexural strength for a variety of applications. Thus, improvised thermoplastic nylon can be a useful alternative to polymethylmethacrylate in special circumstances where higher flexibility, higher resistance to flexural fatigue, higher impact strength is required [2]. These often lead to denture failure during chewing or when fall out of the patient's hand. In order to enhance some properties of PMMA, various efforts have been taken including addition of metal wires or plates, fibers, [3-6] metal inserts, [7] and modification of chemical structure. In recent years, nylon polymer has attracted attention as a denture base materials. On the other side, it is reported that this material has several problems such

as water sorption, surface roughness, bacterial contamination, warpage, color deterioration, and difficulty in polishing.[8] The present study is a literature review to appraise some physical, mechanical and clinical properties of nylon/polyamide denture base materials.

DISCUSSION

Physical properties of polyamide

PMMA is a strong and lightweight material. It has a density of 1.17-1.20 g/cm³, [9,10] which is less than half that of glass[9]. It also has good impact strength, higher than both glass and polystyrene; however, PMMA's impact strength is still significantly lower than polycarbonate and some engineered polymers. PMMA ignites at 460 °C (860 °F) and burns, forming carbon dioxide, water, carbon monoxide and low-molecular-weight compounds, including formaldehyde [11].

PMMA transmits up to 92% of visible light (3 mm thickness), and gives a reflection of about 4% from each of its surfaces due to its refractive index (1.4905 at 589.3 nm).^[3] It filters ultraviolet (UV) light at wavelengths below about 300 nm (similar to ordinary window glass

Hardness

Ucar *et al.* in 2012[13] compared the hardness of a polyamide based denture material (Deflex) with another injection-molded PMMA base material and a conventional compression-molded PMMA. The results of the study on Deflex specimens were found to be much lower than other

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materials and that material was not as hard as other materials. In the study by Shah *et al.* (2014) [14] PMMA demonstrated higher hardness values when compared with flexible resin. This result might be attributed to a high monomer-polymer ratio, the attachment of this material, and the presence of methyl-methacrylate monomer. Moreover, cross-linking agents may exist in the material. Flexible resin demonstrated lower hardness values and also possessed lower amounts of cross-linking agents, indicating that cross-linking agent may affect surface hardness.

Surface Roughness

A rougher surface can cause discomfort to patients and also discoloration of the prosthesis; it may contribute to microbial colonization and biofilm formation. Abuzar *et al.* in 2010[15] evaluated the surface roughness of a polyamide denture base material (Flexiplast) in comparison with PMMA (Vertex RS), and found that polyamide specimens produced a rougher surface than PMMA, both before and after the polishing process. Similar to polymethacrylate resin materials, [16] the conventional polishing technique provided a polyamide surface smoothness, well within the clinically acceptable standard. The same results were found in another study done by Kawara *et al.* in 2014[17] who evaluated the surface roughness of four thermoplastic (polyamide: Valplast, Lucitone FRS, polyethylene terephthalate: EstheShot, and polyester: EstheShot Bright) and two conventional acrylic (Heat-polymerizing: Urban, and Pour type auto-polymerizing: Pro-Cast DSP) denture bases by using scratch test. The results showed that the surface of thermoplastic denture base resins was easily damaged compared with polymethyl methacrylate.

Mechanical Properties

Polymethyl methacrylate (PMMA) resins are the most commonly used denture materials; however, they do not have a high flexural strength (FS). This study aimed to compare the mechanical properties of a polyamide-based, injection-molded denture material (Deflex) with another injection-molded PMMA base material (SR-Ivocap) and a conventional compression-molded PMMA (Meliodent). Ucar Y suggested that While polyamide denture material produced good fracture resistance, its modulus is not yet sufficiently high to be equal to standard PMMA materials [18].

Hamanaka *et al.* in 2011,[19] compared some mechanical properties of two polyamides (Nylon 12 and Nylon PACM12), one polyethylene terephthalate and one polycarbonate with a conventional heat-polymerized polymethyl methacrylate (PMMA). They showed that the two polyamides had the lowest values of flexural strength at proportional limit as well as the lowest elastic moduli between denture base resins. They also found that Charpy impact strength was the highest for Nylon PACM12, while Nylon 12 had low impact strength. This study demonstrated that the mechanical properties of injection-molded thermoplastic denture bases differ from each other; hence, the clinicians should be well aware of these properties in order to choose the most suitable one for an RPD without metal clasps that is suitable for each patient.

Biocompatibility

For biocompatible full dentures one may choose monomer-free thermoplastic acrylic resin. The prosthetic solution of partial edentations with the help of metal-free removable

partial dentures represents a modern alternative solution to classical framework dentures, having the advantage of being lightweight, flexible and much more comfortable for the patient. Superflexible polyamide resin is especially indicated for retentive dental fields, which would normally create problems with the insertion and disinsertion of removable partial dentures [20-23]. Dentures made of PMMA, can be color-matched to the patient's teeth & gum tissue. PMMA is also used in the production of ocular prostheses, such as the osteo-odonto-keratoprosthesis.

Chemical Properties

In the study carried out by Takabayashi in 2010,[24] water sorption of two of the tested polyamide materials (Valplast and Flexite Supreme) met the ISO standard (32 $\mu\text{g}/\text{mm}^2$), but Lucitone FRS revealed the highest water sorption due to the greater degree of hydrophilic characteristics supported by the contact angle measurements. It is thought that the higher the amide group concentration, the greater the water sorption. Therefore, it has been suggested that the amide group concentration, in the polyamide type denture base materials, could be adjusted to a level as low as that in popular industrial materials such as nylon 6 or 66.[24] On the other hand, in another study which was done by Shah *et al.* in 2014, the sorption and solubility of heat-cured polymethyl methacrylate denture base resin and flexible denture base resin were compared and it was found that heat-cured PMMA had more sorption and solubility values than flexible (thermoplastic polyamide nylon) resin.[26] The study suggested that since the contact angle between the flexible resin and water was high with low surface free energy, their water repellency was also high, and these all resulted in lower water sorption values. Likewise, it was mentioned that there was a strong hydrogen bonding between amide groups and a reduction in attachment areas for water molecules; therefore, the amount of water sorption in flexible resin was lower than conventional PMMA. The higher residual monomer contents were mentioned as a cause for the higher solubility level in PMMA [26].

Cytotoxic evaluation of polyamide

There are several studies in regard to cytotoxicity of denture base materials. [27-30] It has been reported that the acrylic resins used for the fabrication of denture bases have displayed various degrees of in vitro cytotoxicity and in vivo allergic responses, which have been probably caused by non-reacting components that remain after the polymerization process.[31] Nevertheless, studies about cytotoxic effect of polyamides are very limited. Uzun *et al.*[32] investigated the long-term cytotoxic response of an injection-molded polyamide (Deflex) and heat- and cold-cured PMMA resins. According to the results of their study, all materials had a similar toxic effect in the short term and all tested materials reached the highest levels of toxicity after 8 weeks of their aging time. In their study, polyamide specimens had a comparable toxicity profile with the conventional PMMA denture base materials.

CONCLUSION

The dentists today have to meet growing demands for prosthetic rehabilitation due to population aging and higher requirements on the quality of life. That means higher demands on the functional reliability of dental appliances, their aesthetical and biological properties.

Thermoplastic resins have been used in dentistry for many years. During that time the applications have continued to grow and the interest in these materials by both the profession and the public have increased. The materials have superior properties and characteristics and provide excellent esthetic and biocompatible treatment options. With the development of new properties, there are certain to be additional new applications for thermoplastic resin in the future, to help patients with damaged or missing teeth.

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