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# Evaluation of Water Sorption and Color Stability of Nylon Denture Base Materials: A Literature Review

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## Abstract

A wide range of thermoplastic materials for the fabrication of removable partial dentures is available for use in the everyday dental practice. Evaluation of the physical properties of the materials used for the fabrication of these removable dentures is important, because they affect not only the aesthetics of the construction but also its longevity and function. Thermoplastic polyamides, also known as nylons, are one of the four major groups of flexible materials used for treating partially edentulous patients with removable partial dentures.

Aim. The aim of the current review was to evaluate and compare the advantages and disadvantages between the different types of thermoplastic materials available and conventional polymethyl-methacrylate dentures in regards to their physical properties.

Materials and methods. A literature review was conducted using PubMed, Web of Science, Google Scholar, and others including scientific papers up to December of 2024. There was no restriction on the date of publishing and language of publications. The keywords used for conducting the search were combinations of the following: “nylon dentures”, “flexible dentures”, “polyamide”, “physical properties”, “color stability”, “water absorption”, “adhesion” and “PMMA”.

Conclusion. According to the results of the studies, currently, nylon-based, flexible polyamide represents an alternative to the conventional acrylic resins due to its clinically acceptable physical properties. The thermo-injectable flexible resins demonstrate better aesthetic qualities when compared to the conventional acrylic based dentures. When it comes to the water absorption the chemical composition of the nylon material is of key importance, however it remains a topic of discussion between researchers.

***Keywords:*** denture base material, nylon, physical properties, polyamide, PMMA

## Introduction

Even with the advances in modern digital and implant technologies, the need for the fabrication of conventional removable dentures remains a reliable and needed method of treatment for partial and completely edentulous patients (1).

Polymethyl-methacrylate (PMMA) has been the most commonly available and used denture base material since its application in the 20th century and is usually characterized with satisfactory mechanical, physical and biological properties, as well as ease of manipulation and cost effectiveness (2,3). However, a shift towards better materials can be observed with the introduction of the more aesthetic, more comfortable and

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monomer free flexible non-metal clasp dentures (NMCD) such as denture base materials made from different types of nylon (polyamide).
Nylon is synthesized from monomers, dibasic acid, and di-amine. It is characterized by great heat and chemical resistance, high physical strength, and flexibility, making it ideal for flexible tissue-supported removable partial dentures (4).
In contrast, PMMA materials possess advantageous physical properties for denture bases, including their ability to absorb oral fluids due to molecular polarity, acting as plasticizers that influence dimensional stability (5,6) Maintaining minimal sorption and solubility is crucial to ensure dimensional stability, aligning with ISO 20795-1 standards (ISO 20795-1, 2013) (7).
Polyamides, while effective, often exhibit rougher surfaces compared to other resin materials, this increase in roughness is accompanied with a reduction in the aesthetic properties of the denture base material. In addition, it is proven that different types of Nylon used in fabrication of removable dentures possess different physical properties, especially related to water absorption (8).
Therefore, selecting the appropriate thermoplastic resin depending on the clinical case remains one of the key factors of success of the prosthetic treatment.
The current review focuses on the physical properties of the thermoplastic polyamides used in the fabrication of removable partial dentures, and more specifically on the water absorption and color stability of the denture base material. These properties are essential for the aesthetics and longevity of the prosthesis.

## Aim

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## Material and methods

A literature review was conducted using PubMed, Web of Science, Google Scholar, and others including scientific papers up to December of 2024. There was no restriction on the date of publishing and language of publications. The keywords used for conducting the search were combinations of the following: “nylon dentures”, “flexible dentures”, “polyamide”, “physical properties”, “color stability”, “water absorption”, “adhesion” and “PMMA”.

## Results

### Water sorption

Flexible plastics, belonging to the Nylon 12 group, possess a longer hydrocarbon chain between the amide groups. Nylon 12 contains 11 methylene (-$CH_2$-) groups between each amide group (-CONH-), whereas Nylon 6 has five methylene groups and Nylon 66 has six methylene groups (9).
The longer hydrocarbon chain in Nylon 12 makes it more hydrophobic by increasing the proportion of nonpolar, water-repellent segments in the polymer. These longer chains reduce the overall density of polar amide groups, which are the primary sites for hydrogen bonding with water (8).
There is a lower density of amide groups in Nylon 12. This material has a reduced concentration of amide groups per unit length of the polymer chain. Fewer amide groups mean fewer sites for hydrogen bonding with water molecules, resulting in lower water absorption (10).

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The water absorption properties are also influenced by the crystallinity and arrangement of polymer chains. Nylon 12 typically exhibits a lower degree of crystallinity compared to Nylon 6 or Nylon 6/6. However, its molecular structure still limits water penetration due to the effective alignment of its long, flexible chains. The spatial arrangement and organization of these chains further reduce the pathways available for water molecule diffusion into the polymer (8,9).

Longer chains are characterized by a hydrophobic nature. The increased number of nonpolar methylene groups enhances the hydrophobicity of Nylon 12, making it less susceptible to water absorption compared to the shorter chains of Nylon 6 or Nylon 6/6. Nylon 12 also exhibits higher thermal stability and chain flexibility. The longer hydrocarbon segments provide greater molecular flexibility, helping Nylon 12 resist structural changes (such as swelling) when exposed to water (11).

In summary, the lower water absorption of Nylon 12 is attributed to its longer hydrocarbon chain, reduced density of amide groups, and more hydrophobic molecular structure. These properties make it particularly suitable for applications such as dental prostheses, where dimensional stability and moisture resistance are critical.

Lai et al. in 2003 (12) studied the water absorption of a polyamide material, a silicone material and two heat-cured acrylic resins. In this study, the polyamide (Flexite Supreme) absorbed the largest amount of water, while silicone showed the least water absorption after 56 days of water storage. The high levels of water absorption is attributed to the structural characteristics of Flexite Supreme, which the authors believe to be a co-polyamide.

In the study conducted by Takabayashi in 2010 (13), the water absorption of two tested polyamide materials (Valplast and Flexite Supreme) meets the ISO standard (32 μg/mm) (14), but Lucitone FRS shows the highest water absorption due to its higher degree of hydrophilic properties, as demonstrated by contact angle measurements. They conclude that the higher the concentration of the amide group, the higher the water absorption. Therefore, it is suggested that the concentration of the amide group in polyamide-type prosthesis materials can be regulated to a level as low as in popular materials like nylon 6 or 66 (13).

In another study by Shah et al. in 2014, the water absorption and solubility of conventional PMMA resin and flexible polyamide (nylon) resin for prostheses were compared, and it was found that heat-cured PMMA has higher water absorption and solubility than the flexible resin (15). The study suggests that since the contact angle between the flexible resin and water is high with low surface free energy, their water-repelling ability is high, leading to lower water absorption values. It is mentioned that there is a strong hydrogen bonding among amide groups, which reduces the areas available for binding water molecules; therefore, the amount of water absorption in flexible resin is lower than in conventional PMMA. Higher content of residual monomer is mentioned as a reason for higher solubility levels in PMMA (15).

When comparing the polyamide denture base material to 3D-printed materials used for the fabrication of removable dentures Aliem Elbanna et al. (16) came to a conclusion that the material used for 3D-printing demonstrated higher water absorption than the thermoplastic polyamide material. They also note that the absorption between the PA and conventional PMMA materials show similar absorption which they attribute to the manufacturing process.

When comparing the PA material to conventional PMMA or 3D-printed materials in regards to the water sorption the results and conclusions vary. A majority of authors agree that there are similarities in the water absorption between PMMA and PA materials used in the dental practice (17,18).

**Color stability**

The color stability of the removable dentures made from polyamide can be influence by different factors, including the patient's oral hygiene, the cleaning methods used by the patient, the manufacturing process of the denture and what the patient eats and drinks (19–21).

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Dentures made from this material possess great color stability, which is due to the addition of color to each granule of the raw granulate. In this way, an even distribution of colors is observed, and the risk of obtaining random color spots in the denture, during the manufacturing process is eliminated.

In the study by Lai et al. in 2003 (12) the color stability of one co-polyamide (Flexite Supreme), one silicone (Gingivamoll), and two heat-polymerized acrylic resins (QC-20 and Vertex) was studied using a spectrophotometer after immersion in coloring solutions of coffee and tea for 7, 14, 30, 120, and 180 days. The co-polyamide had the greatest discoloration in the tea solution, and the silicone material in the coffee solution. Discoloration of different materials and the presence of stains played a key role in the decolorization of the materials in this study. The color changes of silicone and co-polyamide materials stored in the coffee solution for 180 days were greater than 3 NBS (National Bureau of Standards) units, which would be characterized as significant and clinically unacceptable (22).

Takabayashi et al. in 2010 (13) compared the color stability of six thermoplastic resins for prostheses (three polyamides, two polycarbonates, and polyethylene terephthalate) after immersion in coffee and curry solutions for 60 hours. In this study, three polyamides (Valplast, Lucitone FRS, and Flexite) had significant color change in the curry solution, while Valplast and Flexite showed significant color change after immersion in the coffee solution.

Sepúlveda-Navarro et al. In 2011 (23) compared the color stability of two heat-cured acrylic resins for prostheses (Lucitone 550, VipiCril) with a thermoplastic nylon resin (Transflex) in different beverages (coffee, cola, red wine, and distilled water) using an ultraviolet spectrophotometer. The strongest discoloration was shown with red wine, followed by coffee; Transflex showed significant color change after 15 and 30 days of immersion in cola.

In a similar study conducted by Mostafa M et al. in 2023 (24) the impact of popular beverages on the color stability between PMMA and PA denture base materials was investigated and they concluded that the PMMA material demonstrated higher color stability.

Denture cleanser can be considered as a common source of discoloration for the denture base material. The majority of authors agree that the improper use of denture cleansers can lead to a change in color of the polyamide denture base material (25–28).

Greater color changes in nylon dentures would be related to their hygroscopic and higher water absorption properties (29,30). It has been established that the frequency of amide groups along the chain has influenced water absorption and the chemical properties of each type of nylon (31). Another reason may be the differences in dental laboratory processing and polishing of nylon materials compared to PMMA. Rougher surfaces are more susceptible to discoloration (32–34).

## Conclusion

The water sorption of the polyamide materials can depend on the liquid they are stored in, their structural properties and the manufacturing process. Overall these materials demonstrate clinically acceptable levels of water absorption, however it is still considered to be higher than conventional PMMA materials.

It can be concluded that the thermoplastic polyamide materials have a lower color stability when compared to conventional materials such as PMMA. Their easier discoloration can be attributed to their structural and mechanical properties.

Clinicians need to be aware of the advantages and disadvantages of the thermoplastic polyamide materials and advice their patients accordingly as the choice of the material for the fabrication of the removable dentures is crucial for the overall treatment.

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