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Assessment of Color Change After Adding Nano Aluminum Oxide to Heat-Cure Acrylic

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Abstract

Objective: This study investigates the effect of introducing nano-sized aluminum oxide (Al_2O_3) particles into heat-cure acrylic resin on color stability. Color changes are an important cosmetic element in dental materials. The purpose of this work was to examine the color change of polymethyl methacrylate reinforced by varied weight percentages wt.% of nano Al_2O_3 fillersmaterials on degree of conversion and polymerization of dual cure resin cement after 24 hours. **Material and Methods**: This study was 40 disc-shaped samples (No. 10 per group) were prepared. Group A control, Group B PMMA with Al_2O_3 0.5%, Group C PMMA with Al_2O_3 1%, Group D PMMA with Al_2O_3 2%. **Results**: The results showed that group D with AL_2O_3 2% had a greater mean value of color change than the control group. While group B 0.5% had the lowest mean value of color change. **Conclusion**: Nano-Al_2O_3 can be incorporated into heat-cure acrylic to improve material properties, but concentration is critical for maintaining color stability.

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Introduction

Heat-cure acrylic resins are widely used in dental prosthetics due to their esthetic properties, cost-effectiveness, and ease of handling. However, one major drawback is their susceptibility to color change over time due to environmental exposure, aging, and chemical degradation.

Nanotechnology has emerged as a solution to improve the mechanical and physical properties of dental polymers. Nano-Al2O3 is commonly used for reinforcement due to its hardness, thermal stability, and biocompatibility. However, its effect on optical properties, particularly color stability, needs thorough investigation. Polymethyl methacrylate (PMMA) is commonly regularly fabricated denture ingredients. Despite fact that PMMA is the most often used denture material, it falls short of highest materials criteria [1]. The PMMA prostheses have poor surface quality and mechanical properties, such as hardness, flexural strength as well as impact strength. Consequently, the PMMA materials must be strengthened. Nanomaterials has been used in dental applications, and numerous studies have been carried out to determine its anticipated benefits and applications.

Nanoscale fillers encapsulated in a polymer matrix make up polymer nanocomposites [2]. According to recent research, nanoscale toughening agents can lead to new physical, mechanical, and biological functions, resulting in nanocomposites. PMMA is also strengthened by the grafting of multiple Nano fillers [2]. Nanoparticles of Aluminum oxide (Al_2O_3) (99.9%) [2]. Al_2O_3 is utilized in the formulation of high-impact acrylic resin's physical characteristics. Combination of Al2O3 into different biomaterials has been investigated besides enhancing mechanical properties [3]. Furthermore, Al_2O_3 is a low-cost multifunctional metal oxide nanoparticle with excellent chemical, optical, electrical, and biocompatibility properties. The dielectric properties of Alumina nano filler and PMMA blend nanocomposite, for example, have been observed to change. The type, form, and size of the nanoparticles define the characteristics of the new composite. Nanomaterials, despite having higher physical features, for example density, fall short in relationships of mechanical features. Because there is a growing need to improve materials' physical besides mechanical structures [4].

Material and Methods

Materials

-Heat-cure acrylic resin (PMMA)
-Nano-Aluminum Oxide (Al_2O_3) with particle size ~20–50 nm
-Spectrophotometer (to measure color using the CIE L*a*b* system)
-Artificial aging chamber (UV light, heat, humidity)

Sample Preparation

40 disc-shaped samples (10 per group) were prepared.

Table 1. Percentage of AL_2O_3

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Group	Nano-Al_2O_3 Concentration
Group A	0% (control)
Group B	0.5% by weight
Group C	1.0% by weight
Group D	2.0% by weight

Fill the bottom half of the cuvette with stones (type 4) (100 g/25 ml) (P/W) according to the manufacturer's instructions, then covered with plastic patterns [5]. Using a large brush, apply the releasing agent. Once the release medium has dried, stack the top and bottom halves of the flask and add a second layer of stamps on top of the first layer, with the clamps open after setting. Warped a towel around the flask. Stamp his second layer of plungers after removing the plastic design [6]. Following that, the mold is finished, and is ready for packing in two groups, Nano-filler powder was added by weight, with 1% and 1.5% to powder being added [9]. High precision sensitive electronic balance (0.0000g, Mettle Type AE260-S SNR H50193) was utilized [7]. To achieve homogenous mixing, the filler was well distributed in the powder using amalgamator device firm (Sinalident) produced in China utilizing (300vibration/minute) for two minutes [8].

Color Measurement

Color values (L*, a*, b*) were measured:
Before aging and After artificial aging (300 hours exposure to UV and moisture).The total color difference (ΔE) was calculated using:
ΔE=(L2−L1)2+(a2−a1)2+(b2−b1)2\Delta E = \sqrt{(L_2 - L_1)^2 + (a_2 - a_1)^2 + (b_2 - b_1)^2}ΔE=(L2−L1)2+(a2−a1)2+(b2−b1)2
A $\Delta E \geq 3.3$ is considered visually perceptible by most observers [9].

Results

As shown in Table 2, ANOVA analysis revealed a highly significant differences (P-value $P<0.01$) of color stably values between the 4 (A, B, C, D groups, respectively).

Discussion

The findings indicate that:
-Low concentrations (≤1%) of nano-Al_2O_3 have a tolerable effect on color change. Higher concentrations (2%) result in significant visual color differences, potentially due to nanoparticle agglomeration, which affects light reflection and scattering.
-The increase in ΔE values could be due to surface irregularities or heterogeneous distribution of nanoparticles. This underscores the need to optimize nanoparticle dispersion and concentration to preserve esthetic quality while enhancing physical properties.

Conclusions

-Nano-Al_2O_3 can be incorporated into heat-cure acrylic to improve material properties, but concentration is critical for maintaining color stability.
-0.5% to 1.0% nano-Al_2O_3 is the recommended range for minimizing color change.

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Table 2. Color stability of all groups with means in micrometer (μm).

Group	N	ΔE (Mean)	SD	Visual Perception	ANOVA test
A (0%)	10	1.25	0.28	Not perceptible	P = 0.00 Highly sign. (P<0.01)
B (0.5%)	10	1.60	0.35	Slight	
C (1%)	10	2.35	0.40	Noticeable	
D (2%)	10	3.85	0.50	Clearly perceptible	

*Color stability decreased with increasing nano-Al_2O_3 content, especially above 1%. The 0.5% group showed minimal change.