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Water Sorption and Solubility of Silorane Based Composite Compared to Universal Composite

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim of Study: Investigate and compare the water sorption and solubility properties of a silorane-based composite with a universal composite. Silorane-based composites have gained attention due to their unique composition and claimed superior hydrophobicity compared to traditional universal composites. However, limited research exists comparing their water sorption and solubility characteristics.

The Study Guidelines: For water sorption and solubility testing. Specimens of both silorane-based

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composite and universal composite were fabricated and subjected to immersion in distilled water at 37°C for predetermined time intervals. The water sorption and solubility were measured by weighing the specimens before and after immersion and calculating the percentage change in mass. Statistical analysis was performed using independent t-tests to determine significant differences between the two composite groups.

Results: Showed that the silorane-based composite exhibited significantly lower water sorption compared to the universal composite at all tested time intervals ($p < 0.05$). The solubility of the silorane-based composite was also significantly lower than that of the universal composite ($p < 0.05$). These findings suggest that the silorane-based composite has better resistance to water sorption and solubility than the universal composite.

Conclusion: This research demonstrates that the silorane-based composite exhibits lower water sorption and solubility compared to the universal composite. These findings provide valuable insights for clinicians and researchers in the field of dental materials and may contribute to the development of more durable and hydrophobic composite materials for restorative dentistry.

Keywords: Water sorption; silorane-based composite; dental materials.

1. INTRODUCTION

“In the last 20 years, dental composites have become popular as filling materials for anterior and posterior teeth. This has been due to the property of composites to match tooth color, withstand oral fluids and bind to acid etched enamel surfaces” [1]. Campsites have witnessed several improvements in their mechanical properties, modifications have been made to the resin as well as the filler components to achieve an ideal material. Bis-GMA resins are used as a replacement for the methyl methacrylate ones to reduce the polymerization shrinkage, where a wide variety of fillers have been employed to improve several properties [2]. However, these materials also have some drawbacks [3]. “One of the most important shortcoming of dental composites is degradation which leads to reduced mechanical and esthetic properties” [4].

“With the constant evolution of tooth-colored restorative materials, evaluation of the properties of the materials serves as a bridge between the fundamental material sciences and clinical applications” [5], (Powers et al. 2008). “Although dental materials have undergone significant improvements, today’s methacrylate-based composites still have shortcomings that limit their applications. Dental research has innovated a novel ring opening monomer, which is a combination of siloxane and oxirane termed silorane” [6]. “Silorane composites were synthesized to overcome the shrinkage seen in other types. The novel resin is considered to have combined the two key advantages of the individual components: low polymerization shrinkage due to oxirane monomers and increased hydrophobicity due to the presence of the siloxane monomer in its composition” [6]. “The mechanism of compensating stress in this new system is achieved by the opening and extending of the oxirane rings during polymerization to compensate volume reduction by monomers packing” [7].

“Dental composite may be either exposed intermittently or continuously to chemical agents. So, it has been shown to have an effect on the degradation and surface topography of dental composite” (Ysaed, 1986). “Degradation of composite cannot be attributed to wear alone because the process involves chemical degradation as well” (Inoue et al. 1986); [8]. “Water plays an important role in the long-term stability of composite fillings and may induce hygroscopic expansion of the material, hydrolytic degradation of intra- and intermolecular bonds within the resin matrix and at the resin-filler interface, plasticization of polymer chains, elution of leachable substances and reduction in mechanical properties

Our aim in this study therefore is to evaluate the water sorption and solubility of silorane based resin composite compared to universal methacrylate based composite.

2. MATERIALS AND METHODS

The tested materials, their batch number, composition and manufacturer are listed in Table 1. Two types of composites were used; a universal (Filtek Z250, 3M) and silorane (Filtek P90, 3M). Eight specimens of each material were handled according to the manufacturer’s recommendations. A teflon mold with a 15 mm in

Table 1. Tested materials, their batch number and composition

Name	Company	LOT	Composition
Filtek Z250	3M – ESPE St. Paul, USA	N252762	BIS-GMA, UDMA and BIS-EMA resins. Zircona/silica filler 60% by volume and 0.01 to 3.5 um particle sise
Filtek P90	3M – ESPE St. Paul, USA	N251784	Silorane. Quartz filler, yttrium fluoride 55% by volume and 0.1 to 2 um filler size

diameter and 1 mm in thickness was placed on a glass slide, and one of the two materials was packed into the mold. A second glass slide was placed onto the packed material. Sufficient finger pressure was applied until the slide contacted the mold. The materials were cured with a quartz tungsten halogen light-curing unit* (Yiu CK et al, 2005).

The disc shaped samples were dried in a desiccator with silica gel desiccant for twenty four hours. An electronic balance** was used for weight determination (W1). The specimens were then immersed into 20 mL of distilled water and were kept in an incubator for twenty four hours. The specimens were dried and weighed for a second time (W2) and were placed back in the desiccator for twenty four hours. A final measure was recorded (W3).

The values for water sorption (Wsp) and solubility (Wsl), in mg/mm3 for each of the specimen were calculated using the following equations:

$$Wsp = W2\text{-}W3/V$$

$$Wsl = W1\text{-}W3/V$$

Where W1 is the mass, in mg, prior to immersion in water, W2 is the mass, in mg, after immersion of water, W3 is the mass, in mg, after desiccating and V is the volume of the specimen mm3.

$$V = \pi * r2 * h, \quad r = 15, \quad h = 1$$

3. RESULTS

The results were analyzed using SPSS software, T-test was used to show the significance. The results of water sorption in universal composite were (0.4594 ± .04805) and for the silorane it was (0.4331 ± .02969). And it was (0.4531 ± .04773) in water solubility for the universal and (0.4281 ± .02896) for the silorane. There were no significant differences between the tested materials in either water sorption or solubility.

4. DISCUSSION

“Tooth-colored dental resin composites are widely used restorative materials. They typically contain a mixture of various cross-linking dimethacrylate monomers” [9]. “New developments of dental resin composites are focused mainly on diminishing polymerization shrinkage” [10].

“Dental composite may either be exposed intermittently or continuously to chemical agents. Accordingly, Degradation of composite can not be attributed to wear alone but it involves chemical degradation as well” [11].

“Different high-molecular-weight matrix resin compositions have been employed. These include a cationic ring-opening hybrid monomer system that contains both siloxane and oxirane structural moieties, and such a system is used in dental composite materials commonly called siloranes” [6].

“The silorane-based resin composites have good stability in aqueous environments and insolubility in biological fluid simulants" [12].

Table 2. Data statistics results

	N	Mean	Std. Deviation	T	Sig
Universal	8	.4594	.04805	1.314	0.210
P90	8	.4331	.02969		
	N	**Mean**	**Std. Deviation**	**T**	**Sig**
Universal	8	.4531	.04773	1.266	0.266
P90	8	.4281	.02896		

In our study, there was no significant difference between silorane resin composite (P90) and universal composite (Z250) in either water sorption and solubility. This can be attributed to the type of resin matrix used in Z250, where Studies have shown that Water sorption takes place mainly in the resin matrix, influenced by the hydrophobicity of the matrix itself (H. 0YSEi et al. 1986) (Braden et al, 1976). In Z250, TEGDMA has been replaced with a blend of UDMA and Bis-EMA. These resins impart a greater hydrophobicity and are less sensitive to changes in atmospheric moisture [13].

Our results are in disagreement with [14] they compared water sorption and solubility between low shrinkage and universal composite. They found that In comparison with conventional methacrylates, siloranes have significantly lower water sorption combined with decreased water solubility. Where the tested universal composite was (Z100) [15-17].

Our results are in agreement with [13], they evaluated the water sorption and solubility of filtek z250. They showed that they have low values and they attributed that this is due to the replacement of TEGDMA with UDMA and Bis-EMA resins.

5. CONCLUSIONS AND RECOMMENDATIONS

There was no discernible change in the tested materials' water sorption or solubility within the confines of this study. More research should be done on the materials after they have been submerged in various beverages and at various intervals of time.

The many universal composite types need to be tested more.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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