Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(3), 1082-1084 | ISSN:2251-6727

Evaluation of Flexural Strength and Dimensional Stability of Pure Polycaprolactone and Mixture of Polycaprolactone with Shellac and Talc in Different Proportions

Dr. Srushti Walkikar, Dr. Umesh Palekar, Dr. Veena Saraf, Dr Akash Chaudhari, Dr Vaibhav Awinashe, Dr Minal Awinashe

(Received: 16 March 2025 Revised: 20 April 2025 Accepted: 22 May 2025)

KEYWORDS

Polycaprolactone, biocompatible, flexural strength, dentistry, dimensional stability.

ABSTRACT:

Introduction: PCL has received FDA approval and CE registration for its use in numerous drug-delivery systems and medical devices. Lately, PCL has garnered attention for the development of biomaterials and green materials for a range of applications. PCL is easy to manufacture and work with since it has better rheological and viscoelastic qualities as compared to its aliphatic polyester substitutes.

There is a need to evaluate the mechanical properties of polycaprolactone as well as different proportions of polycaprolactone combined with talc and shellac for its application in dentistry.

Objectives: This study assessed the flexural strength of polycaprolactone as well as different proportions of polycaprolactone combined with talc and shellac. The material with highest flexural strength was evaluated for its dimensional stability.

Methods: The study analyzed the flexural strength of PCL blended with talc and shellac to identify the most suitable composition for dimensional stability testing. Fifteen specimens were fabricated across three groups—pure PCL, PCL with shellac and talc (50:40:10), and PCL with shellac and talc (70:20:10)—and tested for flexural strength according to ASTM-D790-17 guidelines using a Universal Testing Machine. A stainless-steel die was used to prepare 5 specimens of the group with highest flexural strength and tested for dimensional stability under a stereomicroscope at different time intervals.

Results: Pure PCL (mean flexural strength 41.62 ± 6.10 N/mm²) with highest flexural strength significantly outperformed the other groups and revealed no variations over time, maintaining consistency with the reference die at intervals of 1 hour, 24 hours, and 48 hours.

Conclusions: Polycaprolactone exhibits remarkable flexural strength and dimensional stability.

1. Introduction

Polycaprolactone (PCL) belongs to the class of aliphatic polyesters and is a polymer made up of repeating hexanoate units. Because of its unique mechanical characteristics, biodegradability, and miscibility with a wide variety of other polymers, PCL has been extensively studied. PCL's molecular weight and degree of crystallinity primarily determine its mechanical, thermal, and physical characteristics. These factors also affect PCL's capacity to hydrolyse its ester bonds under physiological settings. PCL is strongly hydrophobic, semi crystalline, highly soluble at room temperature, and easy to process due to the low melting temperature and exceptional compatibility.

PCL has received FDA approval and CE registration for use in numerous drug-delivery and medical devices; however, a limited number have been commercialised or extensively applied in clinical studies. Lately, PCL has garnered attention for the development of biomaterials and green materials for a range of applications. PCL is easy to manufacture and work with since it has better rheological and viscoelastic qualities as compared to its aliphatic polyester substitutes.[1]

This study assessed the flexural strength of polycaprolactone as well as different proportions of polycaprolactone combined with talc and shellac. The material with highest flexural strength was evaluated for its dimensional stability.

2. Objectives

This study assessed the flexural strength of polycaprolactone as well as different proportions of polycaprolactone combined with talc and shellac. The

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(3), 1082-1084 | ISSN:2251-6727

material with highest flexural strength was evaluated for its dimensional stability.

3. Methods

This study was carried out with IEC approval in the Department of Prosthodontics, Crown & Bridge and Implantology, Rural Dental College & Hospital, Loni.

Materials used(Fig.1.):

- Polycaprolactone (MAARC Eazy Tray™, India)
- Shellac golden flakes
- Talc powder
- Burnout Furnace (SELEC™, India)
- Steel container
- Mixing spatula
- Acrylic stencil
- Glass slab
- Universal Testing Machine (ACCURATE™, India)
- Stainless steel die (ADA specification 19)
- Stereomicroscope (ZEISS™)

Groups and Proportions

A thermoplastic material was developed using polycaprolactone and its different proportions with shellac, and talc to form three groups. These groups were tested for their flexural strength and the group with maximum flexural strength was evaluated for its dimensional stability. The three groups were as follows:

Group A: Polycaprolactone

Group B: A mix of polycaprolactone, shellac, and talc in a 50:40:10 ratio by weight

Group C: A mix of polycaprolactone, shellac, and talc in a 70:20:10 ratio by weight.

The materials were precisely weighed in a digital weighing chamber according to their respective proportions and mixed to form 15-gram samples. (Fig.2.)

Flexural Strength Sample Preparation

The sample mixes were melted in a steel container at a constant temperature of 65 C in a Burnout furnace over 5-10mins (Fig.3).[2] The melted material was uniformly mixed with a spatula to a homogenous mouldable consistency to form specimens with 12.7mm width, 3.2 mm thickness and 127mm length using an acrylic stencil (Fig.4).[3]

Flexural Strength Measurement

5 specimens for each group were tested according to ASTM-D790-17 guidelines, performed using 3 Point Bend Test at a 0.5mm/min. cross head speed in a Universal Testing Machine. (Fig.5 and Fig.6)[3]

Dimensional Stability Sample Preparation

A standardized stainless-steel die (according to specification no. 19 by ADA) was made consisting of a ruled block, mold and riser(Fig.7). The height of the die was 34mm. The outer diameter of the ruled block and the mold was 38mm. The inner diameter of the ruled block and mold was 29.97mm and 30mm respectively. The diameter of the riser was 29.97mm. The ruled block had three vertical lines namely X Y Z and two horizontal lines cd, c'd'. The distance between each vertical line was 2.5mm. Three escape holes were made in the riser of 2mm in diameter.[4] The die was ultrasonically cleaned and allowed to air dry before making the sample.

To make specimens under dry condition, the soften thermoplastic material was dispensed onto the die surface and the mold was placed onto the die which acted as a tray to enclose the material and to ensure a uniform thickness of the material. The material was placed on the ruled block and to extrude the excess material a rigid, flat, riser was pressed over this specimen(Fig.8). To standardize the pressure on the material during setting a weight of 300 g was placed on top of the riser. After the setting of the material, the material disc was retrieved from the die and the markings of the die were transferred on to the material (Fig.9).

Dimensional Stability testing

The five standardized specimens were tested under the stereomicroscope after 5 mins of setting of material to evaluate the distance between the three vertical lines namely X Y Z after 1hr, 24hrs and 48hrs.(Fig.10)[5]

4. Results

The data was obtained and entered in Microsoft Excel version 13. The data was subjected to statistical analysis using IBM Statistical Package for Social Science version 21. For continuous data Mean and Standard Deviation was obtained. For comparison of the Flexure Strength between the Group ANOVA with Post Hoc Tukey's was

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(3), 1082-1084 | ISSN:2251-6727

applied. For comparison with the reference die. One Sample T Test was applied. All the statistical analysis was performed keeping confidence interval at 95% and ($p<0.05$) was considered to be statistically significant.

When comparison of the flexural strength across Groups A, B, and C was performed it was observed that mean flexural strength was the highest in Group A at 41.62 ± 6.10 N/mm², followed by Group C at 21.94 ± 7.69 N/mm², and the lowest mean flexural strength at 10.65 ± 3.59 N/mm² in Group B.(Table 1 and 2) There was a statistically significant difference in the Mean Values F = 33.727, ($p<0.05$). Statistically significant post hoc differences were found between all groups using the Tukey HSD test. (Table 3)

Group A which consisted of polycaprolactone alone showed significantly high flexural strength as compared to Groups B and C which additionally incorporated shellac and talc.

Hence, Group A was subjected to dimensional stability testing evaluated in Tables 4 and 5.

After statistical analysis there was no significant difference between the reference die and specimens and the specimens showed no difference with respect to time that is after 1 hour, 24 hours and 48 hours.

5. Discussion

In the present study, the flexural strength of three different proportions of Polycaprolactone (PCL) combined with shellac and talc have been evaluated for its potential in dentistry. PCL is a semi-crystalline, hydro-phobic polymer which is economical and easy to manipulate. PCL's remarkable blend-compatibility, low fusion temperature (59–64°C), and high solubility have sparked a lot of research into its possible uses in the biomedical industry.[2] PCL has been proportionately combined with shellac and talc to know if there is enhancement of properties as compared to pure polycaprolactone.

The significantly higher flexural strength of polycaprolactone alone shows that the addition of shellac and talc did not enhance its properties and made the mixtures unfavourable in terms of flexural strength. Furthermore, there was no significant dimensional change of PCL at 33°C and 35% humidity after 1 hr, 24hrs and 48 hrs. Thus, polycaprolactone is dimensionally stable with respect to time.

PCL can be safely used intraorally as well, for various dental applications without evoking any allergic reactions as it is proven to be biocompatible and thus FDA approved.[7]

Leveraging its mechanical properties, polycaprolactone (PCL) presents promising potential for further research into its specialized applications in dentistry.

6. Conclusion

Polycaprolactone pertains excellent flexural strength and dimensional stability, making it a reliable material for dental applications.

References

1. Guarino V, Gentile G, Sorrentino L, Ambrosio L. Polycaprolactone: Synthesis, Properties, and Applications. In: Encyclopedia of Polymer Science and Technology. 2017.
2. Woodruff M, Hutmacher D. The return of a forgotten polymer - polycaprolactone in the 21st century. Prog Polym Sci. 2010;35(10):1217-1256.
3. ASTM D790-17, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials, ASTM International, West Conshohocken, PA, 2017.
4. Revised American Dental Association Specification No. 19 for Non-Aqueous, Elastomeric Dental Impression Materials. J Am Dent Assoc. 1977;94(4):733-741.
5. Koppolu SK, Manoharan PS, Rajkumar E, Ezhumalai G. Evaluation of dimensional stability, compressive resistance, and detail reproduction of thermoplastic resin (BDIMPRESS), elastomeric and composite bite registration material: An in vitro study. J Indian Prosthodont Soc. 2023;23(1):65-70.
6. Martínez-Rus F, García C, Santamaría A, Özcan M, Pradíes G. Accuracy of definitive casts using 4 implant-level impression techniques in a scenario of a multi-implant system with different implant angulations and sub-gingival alignment levels. Implant Dent 2013; 22:268-76.
7. GC America Inc. GC Fuji COAT LC Safety Data Sheet. Alsip (IL): GC America Inc.; 2015 Apr 20.