International Poster Journal IPJ of Dentistry and Oral Medicine

Int Poster J Dent Oral Med 2010, Vol 12 No 1, Poster 477

Mechanical Properties of Heat-curing Resins by Stress-Strain Diagrams

Language: English

Authors:
Prof Dr Cristina Maria Bortun DMD, PhD, Assist. Prof. Sorin Porojan, PhD student, Assoc. Prof Liliana Sandu, PhD,
Victor Babes University of Medicine and Pharmacy, University School of Dentistry, Specialization Dental Technology, Timisoara, Romania
Prof Nicolae Faur, PhD, Assist. Prof. Anghel Cernescu, PhD,
Politehnica University Timisoara, Mechanical Engineering Faculty, Department Strenght of Materials, Timisoara, Romania

Date/Event/Venue:
April 1st-4th, 2009
IADR 87th General Session
Miami, Florida, USA

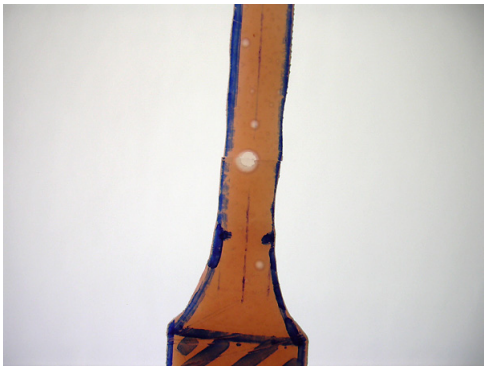
Poster Award

Introduction

The appearance of acrylic resins has practically revolutionized dental techniques. Their continuous development set the ground for the discovery of new materials and technologies, more and more advanced, which allow the realization of high quality prostheses. Acrylic resins, as well as fibbers and rubber, are included in the category of plastic compounds and are synthetically produced. They are constituted of organic compounds, which can be reshaped, in the plastic phase, in various forms, and then they harden, giving birth to solid structures. Complete dentures often suffer unaccountable deteriorations, which can lead to total destruction of the prosthetic pieces without any chance for recovery (fig. 1, 2). It appears the necessity of some guaranties regarding the mechanic strength, the lifetime of the prostheses.

Author: Prof Dr Cristina Maria Bortun

Fig. 1: Meliodent complete denture crack



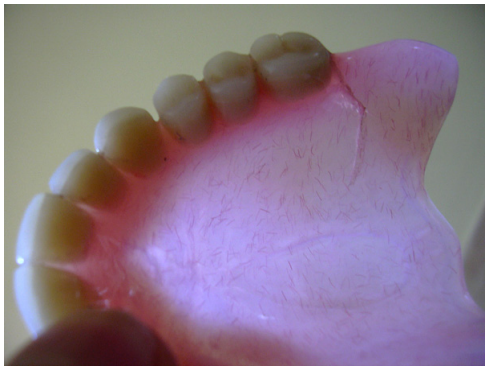


Fig. 2a: Hidden defects that can determine fractures of acrylic resins: structural defect in the plate-aerial inclusions

Fig. 2b: Hidden defects that can determine fractures of acrylic resins: cracks at the bottom of the prosthesis

Objectives

The general objectives are based on multidisciplinary research of biomaterials used in dental medicine.
The specific objectives are focused on: dental prostheses durability predictions based on mechanical strength and biofunctional performances of biomaterials.

Material and Methods

For experimental researches, there were used heat cure resins, such as: Meliodent - (Heraeus Kulzer, Senden, Germany) and Royaldent Plus (Royaldent, Palatinál Foggyártó KFT, Gyöngyös Batthyány, Ungaria). According to complete dentures technology there were made plates using these materials (in the department of Dental Technician Specialization from the Faculty of Dentistry, Timisoara), with the following parameters: 2mm in thickness, 30 mm in length and 5 mm in width (fig. 3). Through experimental tests and software analysis, using Zwick Roell (Zwick GmbH & Co. KG, Ulm, Germany) equipment (fig. 4), there were determined the moments of sample breaks or fractures after stretching. Zwick contains testing software named testXpert, who can standardize the applications. The Graphical Sequence Editor has an integrated simulation mode that combines tests, parameters, results. Measurement up to specimen break is possible using self clamping grips and mechanical long stroke extensometer (up to a maximum force of 50 kN). The main target was measuring the Strain - the deformation of materials caused by the action of stress (an applied force divided by original cross sectional area of the specimen). Strain is calculated firstly by assuming a change between two body states: the beginning state and the final state. The yield stress ratio (YSR) is calculated (in N/mm2) from the upper yield stress and the maximum stress: YSR = (ReH / Rm). A simple static tension test determines the breaking point of the material and its elongation, designated as strain (change in length per unit).

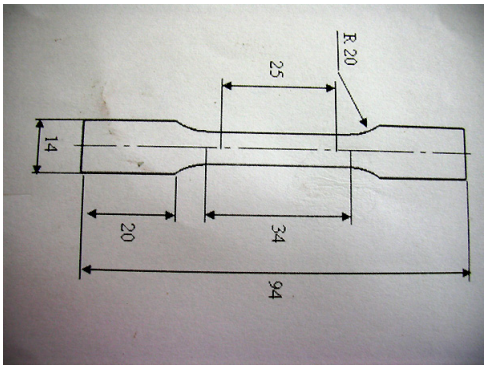


Fig. 3a: Realization of the testing plates: sketch with dimensions for the testing plates

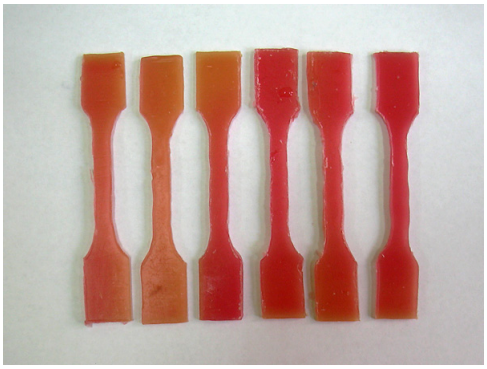


Fig. 3b: Realization of the testing plates: plates wax pattern

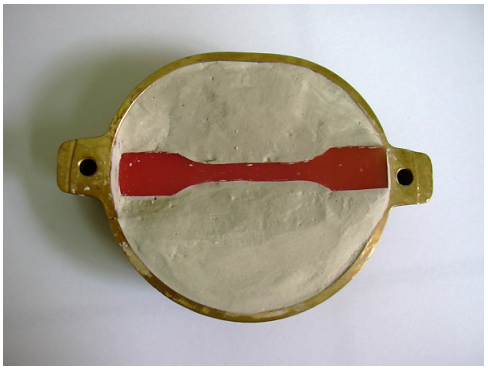


Fig. 3c: Realization of the testing plates: investment of wax pattern

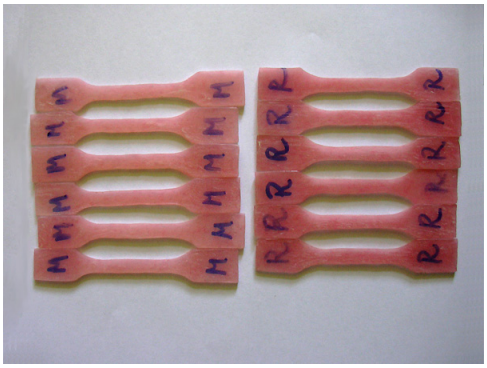


Fig. 3d: Realization of the testing plates: finite plates

Fig. 4: Zwick Roell (Zwick GmbH & Co. KG, Ulm, Germany) equipment

Results

There are noticeable differences, depending on material type (fig. 5, 6). Based on tensile tests, there were determined the Stress-Strain diagrams for comparative evaluation of Royaldent and Meliodent mechanical properties: For Royaldent: - Tensile Ultimate Strength - 71.5 MPa, Yield Strength - 4.24 MPa, Total Elongation - 8.46 %, Young Modulus - 1019.25 Mpa. For Meliodent: Tensile Ultimate Strength - 63.29 MPa, Yield Strength - 4.22 MPa, Total Elongation - 7.9 %, Young Modulus - 1215 MPa. Based on data tests and processed statistics and diagrams Stress-Strain, there was determined a theoretical characteristic curve of linear variation, whose equation is: (σ - Tensile Stress [MPa]; ε - Strain [%]). To determine a and b parameters, we used a Table Curve TM 2D software, in which stress and specific deformation registered values were used. Based on defined data, picked as a theoretical characteristic curve, the diagram describes the most representative points. Based on the determined equations, specific deformation of the material can be evaluated for any tension applied to material. Stereomicroscopic analysis emphasized the elongation for each material (higher for Royaldent - up to 1 mm) and proved that Meliodent is more fragile, containing fibbers which do not brake at the same time as the basic matrix. Royaldent also contains reinforcement fibbers, but these seem to be realized from materials similar to the matrix, because they break at the same time as the basic matrix.

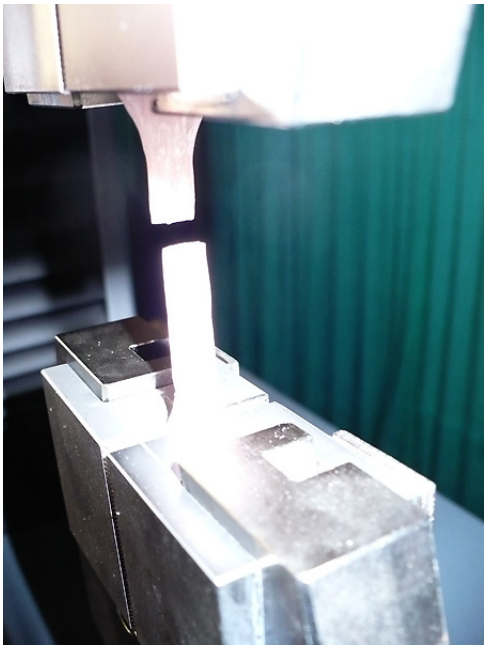


Fig. 5: Testing Royaldent Plus - heat cure resin (Royaldent, Palatinál Foggyártó KFT, Gyöngyös Batthyány, Ungaria): a. Optimal fractured plate - in the middle;

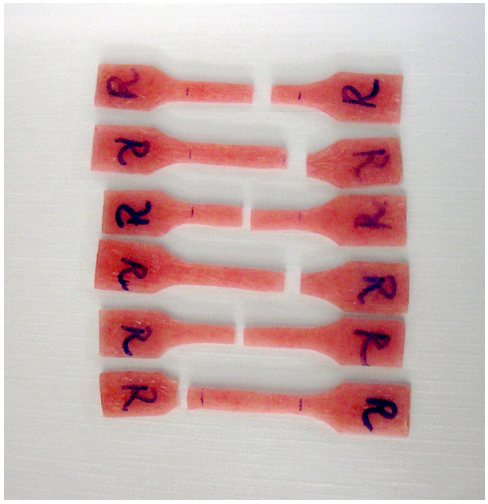


Fig. 5: Testing Royaldent Plus - heat cure resin (Royaldent, Palatinál Foggyártó KFT, Gyöngyös Batthyány, Ungaria): b. Aspects of fractures for 6 plates;

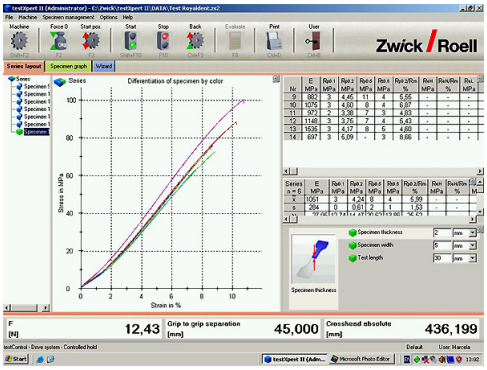


Fig. 5: Testing Royaldent Plus - heat cure resin (Royaldent, Palatinál Foggyártó KFT, Gyöngyös Batthyány, Ungaria): c. Computer evaluation using Zwick testXpert software;

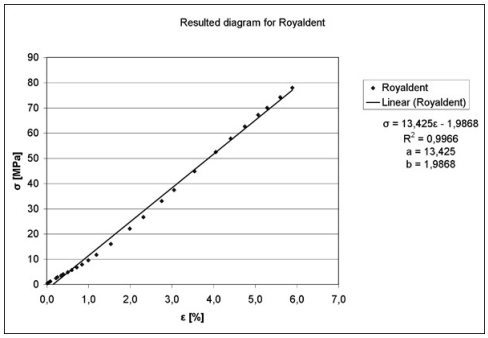


Fig. 5: Testing Royaldent Plus - heat cure resin (Royaldent, Palatinál Foggyártó KFT, Gyöngyös Batthyány, Ungaria): d. stress/strain diagram;

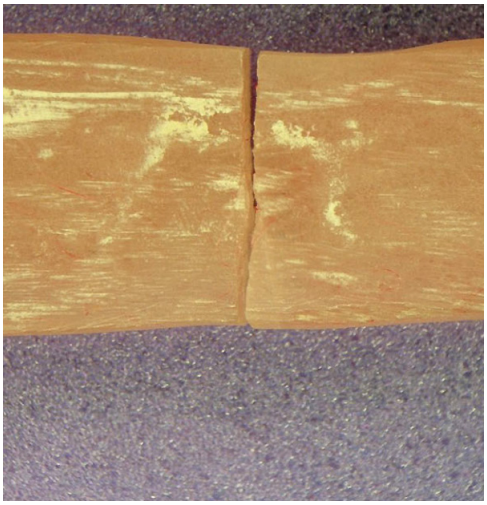


Fig. 5: Testing Royaldent Plus - heat cure resin (Royaldent, Palatinál Foggyártó KFT, Gyöngyös Batthyány, Ungaria): e. stereomicroscopical aspects

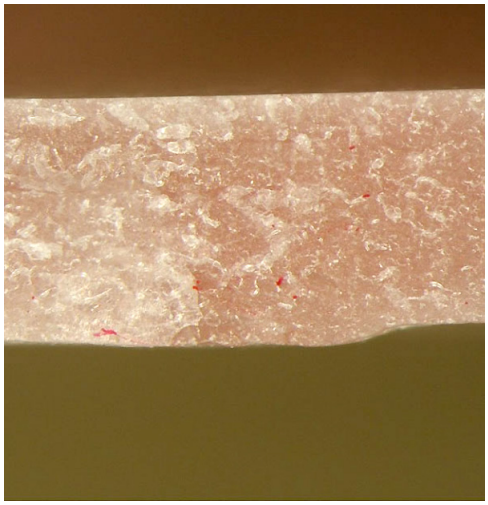
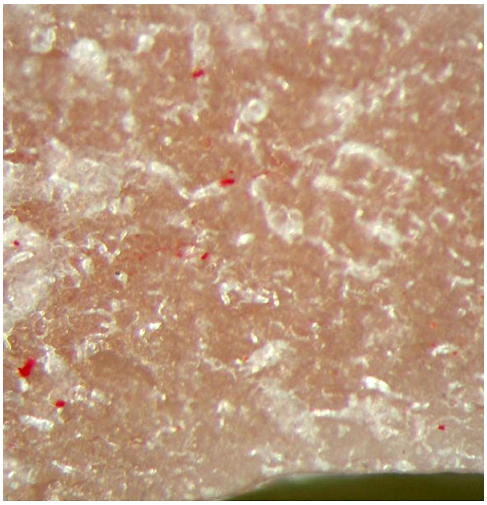


Fig. 5: Testing Royaldent Plus - heat cure resin (Royaldent, Palatinál Foggyártó KFT, Gyöngyös Batthyány, Ungaria): e. stereomicroscopical aspects



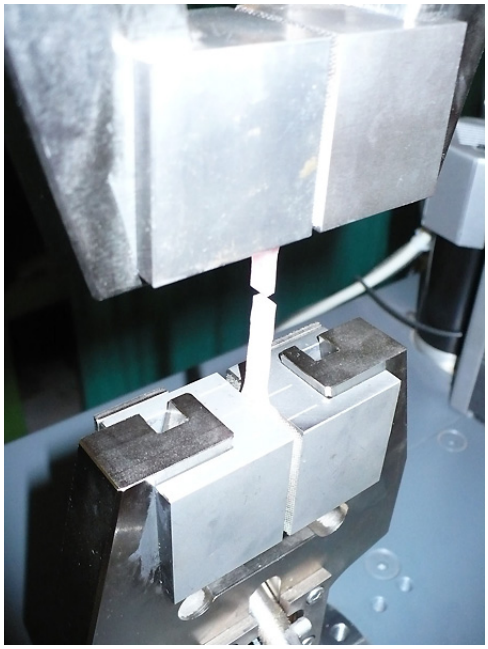


Fig. 5: Testing Royaldent Plus - heat cure resin (Royaldent, Palatinál Foggyártó KFT, Gyöngyös Batthyány, Ungaria): e. stereomicroscopical aspects

Fig. 6: Testing Meliodent - heat cure resin (Heraeus Kulzer, Senden, Germany): a. Asymmetrical fractured plate

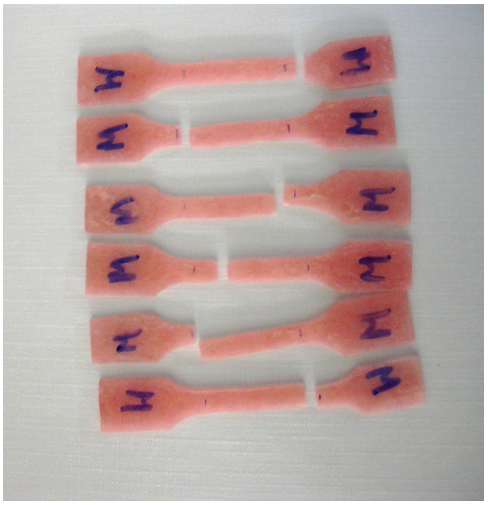


Fig. 6: Testing Meliodent - heat cure resin (Heraeus Kulzer, Senden, Germany): b. Aspects of fractures for 6 plates

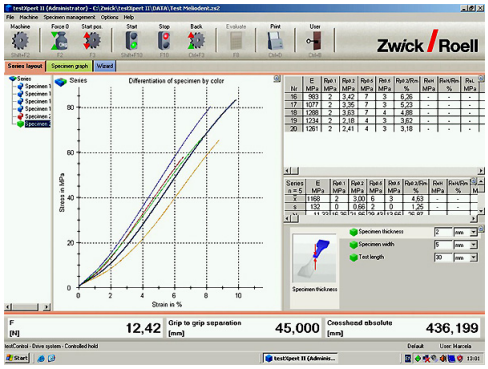


Fig. 6: Testing Meliodent - heat cure resin (Heraeus Kulzer, Senden, Germany): c. Computer evaluation using Zwick testXpert software

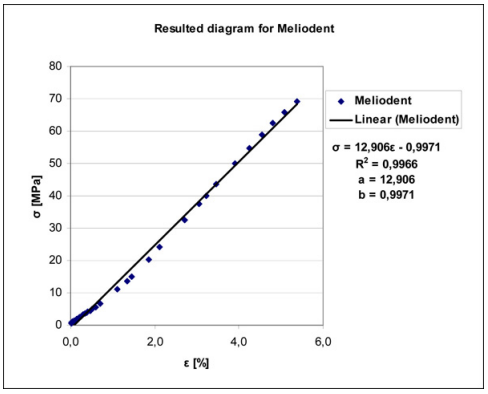


Fig. 6: Testing Meliodent - heat cure resin (Heraeus Kulzer, Senden, Germany): d. stress/strain diagram

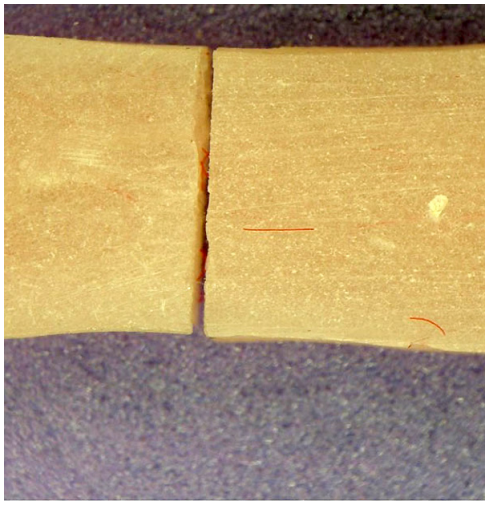


Fig. 6: Testing Meliodent - heat cure resin (Heraeus Kulzer, Senden, Germany): e. stereomicroscopical aspects

Fig. 6: Testing Meliodent - heat cure resin (Heraeus Kulzer, Senden, Germany): e. stereomicroscopical aspects

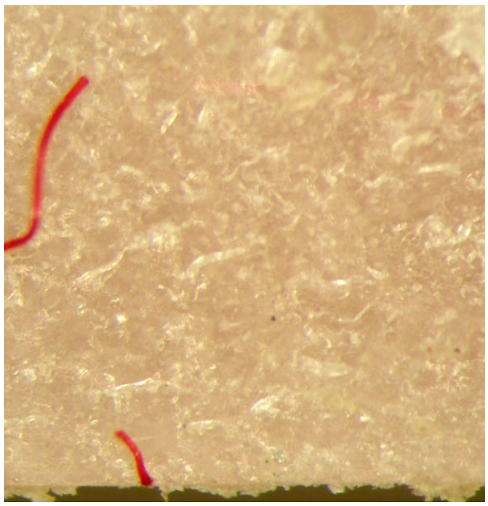


Fig. 6: Testing Meliodent - heat cure resin (Heraeus Kulzer, Senden, Germany): e. stereomicroscopical aspects

Conclusions

Meliodent fractures itself more often and at lower force and stress than Royaldent Plus, when submitted to traction.
The methods allow evaluation of tensile strength dental prostheses, and the certification of dental materials quality.
The registered results show a brittle character concerning material breaking, proved by diagrams Stress-Strain shape and samples breaking without registering massive plastic deformation.

Literature

1. Darbar, U.R., Huggett, R. and Harrison, A. (1994). Denture fracture - a survey. Br. Dent. J., 7; 176(9): 342-345.
2. Dixon, D.L., Ekstrand, K.G. and Bredding, L.C. (1991). The transverse strengths of three denture base resins. J. Prosthet. Dent., 66: 510-513.
3. Mese A, Guzel KG. (2008 Feb): Effect of storage duration on the hardness and tensile bond strength of silicone- and acrylic resin-based resilient denture liners to a processed denture base acrylic resin. J Prosthet Dent.; 99(2):153-9.
4. Polyzois GL, Tarantili PA, Frangou MJ, Andreopoulos AG. (2001 Dec): Fracture force, deflection at fracture, and toughness of repaired denture resin subjected to microwave polymerization or reinforced with wire or glass fiber. J Prosthet Dent.; 86(6):613-9.
5. Uzun G, Hersek N. (2002 Jul): Comparison of the fracture resistance of six denture base acrylic resins. J Biomater. Appl.; 17(1):19-29.
6. Valittu, P.K., Alakuijala, P., Lassila, V.P. and Lappalainen, P. (1994). In vitro fatigue fracture of an acrylic resin-based partial denture: an exploratory study. J. Prosthet. Dent., 72: 289-295.

Acknowledgements: This study was supported by CNCSIS grant type A, no 744 and Ideas grant, type CNCSIS, 2009, no 1878, from the Ministry of Education and Research of Romania

This Poster was submitted by Prof. Dr. Cristina Maria Bortun DMD, PhD.

Correspondence address:
Prof. Dr. Cristina Maria Bortun
"Victor Babes" University of Medicine and Pharmacy
University School of Dentistry, Specialization Dental Technology
B-L Revolutiei 1989, No. 9
Code 300041
Timisoara, Romania

Poster Faksimile: