TECHNICAL REPORT 6806

MECHANICAL PROPERTIES OF PLASTICS USED IN ORTHOTIC APPLICATIONS

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Reported by

John W. Hodge, Jr.
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U.S. ARMY MEDICAL BIOMECHANICAL RESEARCH LABORATORY
WALTER REED ARMY MEDICAL CENTER
Washington, D.C. 20012

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ABSTRACT

The mechanical properties of Prenyl, Orthoplast Isoprene, Orthoplast Vinyl, and Bioplastics were determined.

This study was conducted to enhance the knowledge of the orthotist in his use of these materials in the fabrication and application of braces and splints.

The tests considered appropriate for determining the pertinent characteristics were tensile strength, Barcol hardness, impact, and creep relaxation.

The results indicate Prenyl and Orthoplast Isoprene to be comparable, with Orthoplast Vinyl and Bioplastics comparable at a much different magnitude.

INTRODUCTION

Several types of thermoplastics, Prenyl, Orthoplast Isoprene, Orthoplast Vinyl and Bioplastics, which are commonly used by orthotists for braces and splints are not easily compared because of the unavailability of data listing pertinent characteristics of the materials.

This study was designed to evaluate the mechanical properties of these materials. It is felt that a knowledge of the properties will permit more intelligent use of the material and an attainment of a higher level of performance in the application of these materials.

Five tests were chosen to determine the characteristics of the plastics which were considered most significant to the orthotists in their applications. These tests were Tensile Strength, Barcol Hardness, Impact (Izod, unnotched), Impact (Izod, notched), and Creep Relaxation.

EXPERIMENTAL PROCEDURES

Tensile strength was determined with a Baldwin Universal Testing machine at a crosshead speed of 0.2 in./min. Load-deformation curves were obtained with the test machine from which stress and strain were determined. Tensile test specimens were dumbbell types incorporating a 2 inch gage length with the specimen being 1/2 inch in width through the gage length. Specimen thickness was taken from the material as supplied by the manufacturer and was approximately 0.1 inch.

Hardness of the material was observed with a Barcol tester. Several readings were taken and the average recorded. The Barcol tester contains a sharp point which penetrates the surface of the material on applying a load to the instrument. Hardness values are read from a dial graduated between 0 and 100 units.

Impact tests were conducted on a Baldwin Impact Tester, 2 ft.-lb. capacity. Unnotched samples, 1/2 inch in width, were tested from each of the materials with the impact force being applied to the long side (1/2 inch). Other samples were notched (45 degrees) along the narrow edge and tested for impact. ASTM Method D256-56 (1961) served as a guide for the Izod type test. The impact for the notched samples was reported in ft.-lbs. per inch of notch.

Creep relaxation was determined by taking samples and measuring deflection under a 500 gram load applied at mid-span of a beam (3" x 1/2" x t*) of the plastic supported over a 2 inch span. The load was applied perpendicular to the 1/2 inch side with the end of the sample free to move as deflection occurred.

The creep relaxation test was conducted at a temperature of 40 ± 1 degree Centigrade. All other tests were conducted at 75 ± 1 degree Fahrenheit and 50 per cent relative humidity.

RESULTS AND DISCUSSION

Test results are tabulated in Tables I and II and indicate that the materials might be placed in two categories with regard to the physical properties, because of the great difference in magnitudes. Prenyl and Orthoplast Isoprene are soft and more flexible, whereas the Orthoplast Vinyl and Bioplastics are rigid by comparison.

The tensile strength of Bioplastics and Orthoplast Vinyl was 6420 psi and 5030 psi, respectively. The Orthoplast Isoprene and Prenyl yielded long before failure and a tensile stress was determined at the yield point, this being the maximum load. Stress strain curves are shown in Figure I.

In the hardness test, it was observed that Prenyl and Orthoplast Isoprene did not possess sufficient rigidity to produce readings on the Barcol Impressor On the other hand, Orthoplast Vinyl and Bioplastics were much harder and produced average readings of 67 and 69, respectively.

In the impact tests, application of the force to the 1/2 inch side of the test specimen in general produced a crazing on the harder materials. Prenyl and Orthoplast Isoprene had comparatively high energy absorbing capacities at 7.20 and 5.66 ft.-lbs. per inch of notch. For Orthoplast Vinyl and Bioplastics, impact resistances of 0.49 and 0.54 ft.-lbs. per inch of notch were noted.

It is readily apparent from the impact results that the softer materials evaluated here possess a higher capacity for absorbing impact, whereas the harder materials gave brittle fracture.

*Approximately 0.1 inch thickness as supplied.

A comparison of creep relaxation is presented in Table II. During this test, a sample of the material was placed under constant load as previously described at slightly above body temperature (37 degrees Centigrade) and deflection observed. For each material, except Bioplastics, the test was stopped after the test specimen had deflected approximately 1/2 inch at midspan. It appeared that the rate of creep would be most revealing as a comparison between the materials, so this was determined at the midspan deflection observation before stopping the test. Prenyl had a creep rate of 0.2 in./min., Orthoplast Isoprene 0.02 in./min., Orthoplast Vinyl 0.003 in./min. After 120 minutes, Bioplastics had deflected only 0.046 in. and the rate at this point was 0.0004 in./min. This rate could be considered negligible.

SUMMARY AND CONCLUSIONS

The results of the tests indicated that Prenyl and Orthoplast Isoprene had comparable mechanical properties, and Orthoplast Vinyl and Bioplastics were also comparable. Prenyl and Orthoplast Isoprene, the softer materials, had low tensile strength with a comparatively high capacity for absorbing impact. Orthoplast vinyl and Bioplastics, the harder materials, had high tensile strength with a low capacity for absorbing impact. The data indicated that Bioplastics would be the least likely to creep under a prolonged load at a temperature at, or slightly above, body temperature.

Because of the possibility of failure due to impact on the rigid material, it is felt that such failures can be reduced by avoiding sharp corners when trimming the materials.

The properties presented may be used as a set of guidelines to enable the orthotist to select a material from this group of plastics for a specific application.

TABLE I

- THERMOPLASTIC MATERIALS -

PHYSICAL PROPERTIES

TEST	PRENYL (Dusty Rose)	ORTHOPLAST ISOPRENE (Bone White)	ORTHOPLAST VINYL (Glossy White)	BIO-PLASTICS (Flesh)
Tensile Strength (psi)	905	1460	5030	6420
Barcol Hardness	No Reading	No Reading	67	69
Impact Izod, Unnotched	Elastic Strain	Elastic Strain	Crazing	Crazing (one failure, possibly due to edge effects)
Impact Izod, Notched-Ft.#/in.	7.20	5.66	0.49	0.54

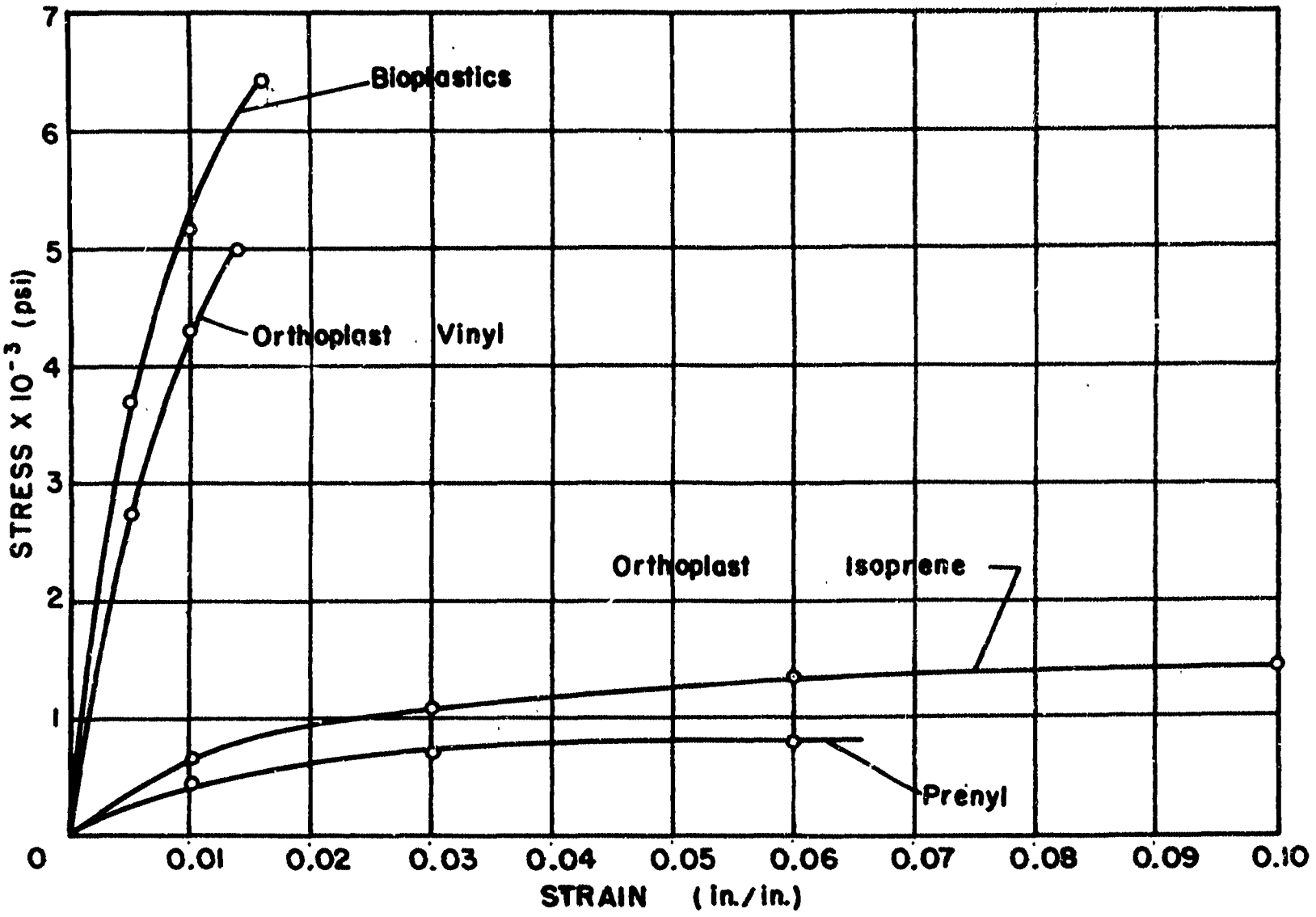
TABLE II

- THERMOPLASTIC MATERIALS -

MIDSPAN DEFLECTION
(IN.)

TIME (min.)	PRENYL (Dusty Rose)	ORTHOPLAST ISOPRENE (Bone White)	ORTHOPLAST VINYL (Glossy White)	BIO-PLASTICS (Flesh)
0.5	0.180	0.094		
1.0	0.244	0.110	0.010	0.019
1.5	0.302	0.124		
2.0	0.401	0.147	0.0103	0.020
3.0	Test* Stopped	0.170	0.011	0.021
4.0		0.195	0.012	0.0217
5.0		0.215	0.013	0.022
10.0		0.293	0.019	0.024
15.0		0.313	0.0255	0.0255
20.0		0.324	0.029	0.026
30.0		Test* Stopped	0.055	0.028
60.0			0.117	0.034
90.0			0.258	0.040
120.0			Test* Stopped	0.046

*Test stopped at approximately 0.5 in. deflection.



Stress-Strain Curves

Figure I

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