SHIMADZU
Excellence in Science

Application News

No. MT-001

Material Testing System

Tensile Properties of Rigid and Semi-rigid Plastics (ASTM D638 and ISO 527)

Keywords: Elastic Modulus, Yield Strength, Break Strength, Ultimate Tensile Strength, Elongation at Yield, Elongation at Break

■ Introduction

Every manufactured plastic is subjected to mechanical loading conditions throughout its operating lifetime. In order to prevent mechanical failure, it is imperative that the mechanical properties be determined and routinely verified to confirm that the material is suitable for the intended application. Tensile testing is one such method routinely used to determine the mechanical properties of plastics. Manufacturers, consumers, researchers and governing agencies are some examples of groups who perform tensile tests to ensure consistency, verify quality, and develop standards. Tensile tests are most commonly performed using a universal test frame, grips and an extensometer. Shimadzu Scientific Instruments offers a full line of test frames, grips and extensometers that meet or exceed the requirements outlined in testing standards such as ASTM D638 and ISO 527.

■ Experimental

The mechanical properties of acrylonitrile butadiene styrene (ABS), Polyoxymethylene (POM), Polyethylene terephthalate (PET) and polystyrene (PS) were measured using a Shimadzu AG-X Plus universal test frame. The frame was equipped with a 10 kN class 1 load cell, 10 kN pneumatic flat grips and a Shimadzu TRViewX class B-1 video extensometer.

ASTM D638 Type I samples, with a thickness of 3.45 mm, were prepared via injection molding. Five samples of each material type were tested at a speed of 5 mm/min. The ultimate tensile strength, tensile strength at break, yield strength, elastic modulus, percent elongation and elongation at yield were easily determined using the data processing functions within the Trapezium X testing software. The elastic modulus was calculated by using the least squares method to fit a linear trendline to the elastic region of the stress strain curve. The yield point was determined using a 0.2% offset and the break point was defined as the point at which a drop in force of 100 N/sec occurred.

Prior to testing, the samples were marked with two adhesive flags to mark the boundaries for the gage length (Figure 1). The video extensometer detects the distance between flags before and during the test to precisely measure the initial gage length and displacement with an accuracy of 0.5%. TRViewX's auto gage length detection feature enables fast sample preparation without sacrificing the accuracy of strain calculations.

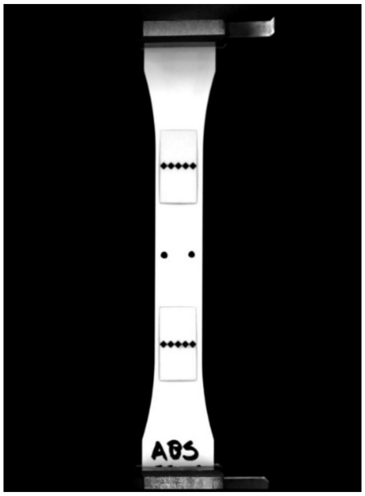

Figure 1: Image of sample with flags attached to mark the boundaries of the gage length.

The distance between grips was adjusted to 115mm and the crosshead was zeroed. The samples were loaded and aligned using the guidance marks established by the video extensometer. Once aligned, the test was started and continued until the criteria for break was met. The force and displacement measurements were directly measured and used to calculate stress and strain. The test was performed a total of five times for each sample. The average values for strength, elongation and elastic modulus were reported along with averaged stress strain curves.

■ Results

The average values and standard deviation of five samples are reported in table 1 followed by the stress strain curves in figure 2. All of the samples except PS demonstrated yielding before failure. This is to be expected with a brittle material such as PS. The results for elastic modulus, yield strength and ultimate tensile strength produced less than 3% variation, while the results for the elongation at yield, and tensile strength at break produced less than 5% variation. The variation in elongation at break ranges from 2% to 30%. Although 30% variation is rather large, there are many factors that can contribute to this, including variations in molecular structure, composition, and processing. For the purposes of this report, we will not attempt to explain the cause of these results through further analysis.

Table 1: Results from testing tensile tests reporting the mean value and standard deviation of five samples for each type of plastic tested.

	Elastic Modulus (GPa)		Yield Strength (MPa)		Elongation at Yield (%)		Ultimate Tensile Strength (MPa)		Tensile Strength at Break (MPa)		Elongation at Break (%)	
	Average Value	Standard Deviation	Average Value	Standard Deviation	Average Value	Standard Deviation	Average Value	Standard Deviation	Average Value	Standard Deviation	Average Value	Standard Deviation
ABS 3501	2.19	0.016	37.1	0.30	1.9	0.045	39.8	0.30	31.3	0.16	5.4	0.75
ABS ESCR 3501	2.49	0.033	39.5	0.32	1.8	0.045	42.7	0.24	33.1	0.63	21	2.6
POM	2.41	0.049	35.7	0.76	1.4	0.045	60.4	0.26	54.5	2.8	38	11
PET	9.67	0.25	103	2.2	1.2	0.055	132	1.3	132	1.3	2.1	0.045
PS	3.23	0.063	N/A	N/A	N/A	N/A	41.2	0.30	41.2	0.30	1.4	0.045

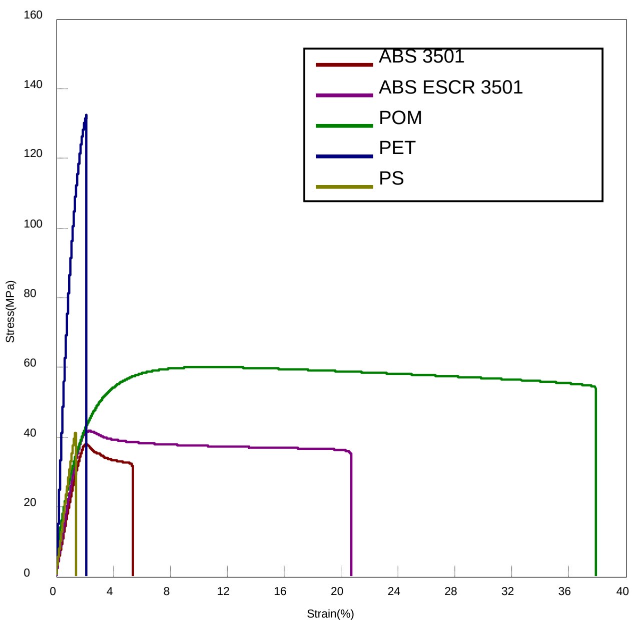

Figure 2: Averaged stress strain curves for ABS 3501, ABS ESCR 3501, POM, PET and PS

■ Conclusion

The Shimadzu AG-X Plus in combination with the TRViewX video extensometer meets or exceeds the requirements of the testing standards described in ASTM D638 and ISO 527. Shimadzu's mechanical testing configuration, in conjunction with the data processing capabilities of Trapezium X software, provides a solution for an operator to easily and accurately perform tensile tests on plastic dog bone samples that conform to ASTM D638 and ISO 527 standards.

First Edition: December 2017

SHIMADZU

SHIMADZU Corporation
www.shimadzu.com/an/

SHIMADZU SCIENTIFIC INSTRUMENTS
7102 Riverwood Drive, Columbia, MD 21046, USA
Phone: 800-477-1227/410-381-1227, Fax: 410-381-1222
URL: www.ssi.shimadzu.com