

Mechanical properties of minimized tensile test specimens

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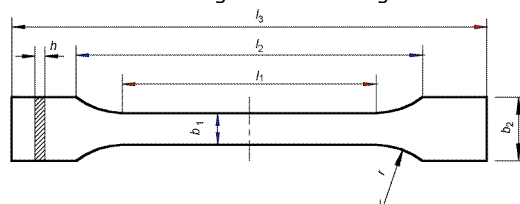
INTRODUCTION

In recent years, many research efforts aimed to minimize test specimens. Obviously, small test specimen require smaller amounts of material, which is of great advantage particularly during the development of new or modified thermoplastic materials. Here, injection molding is the most common processing technique rendering test specimens known as dog-bones. Most of the renowned machine manufactures meanwhile offer micro injection molding equipment. Undoubtedly, the mechanical properties of test specimens made of the same material depend on their dimensions and processing conditions. This investigation might shed some light on this topic by minimizing the specimen geometry and comparing the obtained mechanical properties.

EXPERIMENTAL

Luran S 797 SE 'natur', a high-impact modified ASA injection molding grade (BASF AG), was used as polymer.

Test specimens A and B were injection molded at 250°C in a DACA MicroInjector. Samples D and E were punched from a plate obtained by compression molding in a Carver Hotpress also at 250°C using a 1 mm frame. The large dog-bones C were kindly provided by BASF AG. All samples were tested according to ISO 527 at RT in an Instron 5565 universal tester in combination with an Instron 2630-101 extensometer. Mean values of seven measurements are reported. Moduli were determined at a strain rate of 0.2 mm/min; other values were obtained at a rate of 20 mm/min. The test specimen dimensions are listed in Table 1 according to the drawing below.



Entry	Process	Weight [g]	l_1 [mm]	l_2 [mm]	l_3 [mm]	b_1 [mm]	b_2 [mm]	h [mm]	Ratio	Load cell [kN]	Strain rate [mm/min]
A	Inject. mold., 4-fold	0.81	12	20	35	2.02	6	1.02	2.0	1	0.2/20
B	Inject. mold., single	1.10	24.5	47	75	3.95	12.5	1.55	2.5	1	0.2/20
C	Inject. mold., single	10.10	80	110	170	10.2	20	3.95	2.6	5	0.2/20
D	Compress. mold., punch	0.36	15	28	50	3.98	8	1.1	3.6	1	0.2/20
E	Compress. mold., punch	0.20	12	22	35	1.95	6	1.2	1.6	1	0.2/10

Table 1: Dimensions and some test conditions for the dog-bone-shaped sizes tested. More details in the text.

RESULTS & DISCUSSION

Luran S 797SE is characterized by a tensile modulus of 2 GPa using size C. This value was also determined in our measurements. By reducing the sample size to B, the target modulus of 2 GPa is also obtained, however the shot size is reduced by a factor of ten. For even smaller dimensions, realized in A, a higher modulus (2.6 GPa) was obtained; however, the standard deviation is large. Compression molded specimens show much lower moduli around 1.4 GPa. This effect could be explained by the lack of orientation induced by high shear rates during the injection molding process. In summary, only with the injected geometry B was a comparable modulus to C measured.

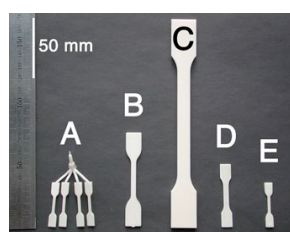


Fig. 1: Test specimen (dog-bones) used in this study.

In the case that only a few grams of a polymer are available, size A might still find its use. The shot size for this mold is less than a gram but yields four dog-bones. However, the small mold cavities sometimes impede complete filling. As compiled in Table 2, other mechanical properties increase from C to A. Again,

although D and E can't be compared to the injection molded samples, they reveal size independent values.

Entry	Process	E_{EX} [MPa]	E [MPa]	σ_{yield} [MPa]	ϵ_{yield} [%]	σ_{break} [MPa]	ϵ_{break} [%]
A	Inject. mold., 4-fold	2590 (430)	1080 (73)	51.7 (1.3)	6.2 (0.6)	57.0 (2.1)	90.0 (5.7)
B	Inject. mold., single	2100 (120)	1400 (50)	48.7 (1.6)	5.1 (0.5)	43.6 (3.5)	63.4 (3.1)
C	Inject. mold., single	1920 (130)	1370 (37)	39.7 (0.8)	4.0 (0.2)	29.8 (1.1)	14.4 (2.9)
D	Compress. mold., punch	1340 (190)	770 (30)	22.8 (1.6)	4.8 (1.2)	25.1 (1.9)	40.7 (12.2)
E	Compress. mold., punch	1460 (165)	670 (54)	20.2 (1.0)	3.8 (0.7)	23.3 (1.5)	40.8 (9.1)

Table 2: Mechanical properties of the tested specimens. E_{EX} : modulus by extensometer, E : modulus by traverse motion, σ , ϵ : stress and elongation at yield point and break. Parenthesis indicate the standard deviation.

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