

SUPPLEMENTARY INFORMATION

Correlating Processing Induced Orientation with Tensile Properties for Mass Polymerized Acrylonitrile Butadiene Styrene Test Specimens

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Specimen N°	Modulus (MPa)	0.2% Offset Stress (MPa)	0.2% Offset Strain (%)	Yield Stress (MPa)	Yield Strain (%)	Break Strain (%)
1	1890	35.8	1.94	38.1	2.35	45.6
2	1860	37.4	2.08	38.1	2.33	47.2
3	1880	36.5	1.99	38.1	2.31	47.8
4	1890	36	1.97	38.1	2.4	58.4
5	1880	35.8	1.95	38.1	2.38	39.2
6	1880	36.7	2.01	38.2	2.31	44
7	1880	35.5	1.93	37.9	2.38	51.6
8	1880	36.9	2.01	38.7	2.39	38.7
9	1910	36.4	1.96	38.4	2.35	41.8
Average	1883.3	36.3	1.98	38.2	2.36	46.0
SD	4.5	0.7	0.05	0.1	0.04	0.1

S1: Tensile results of ISO 527 1A samples: injection moulded + annealed: tested with a crosshead velocity of 1 mm/min for modulus determination and 50 mm/min after 0.3% strain.

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Specimen N°	Modulus (MPa)	0.2% Offset Stress (MPa)	0.2% Offset Strain (%)	Yield Stress (MPa)	Yield Strain (%)	Break Strain (%)
1	1900	42.6	2.31	42.9	2.31	23.6
2	1860	42.3	2.35	42.4	2.35	35.5
3	1830	42.8	2.42	42.9	2.42	34.5
4	1920	42.4	2.26	42.4	2.26	30.9
5	1930	41.9	2.24	41.9	2.24	40.2
6	1890	42.8	2.33	42.8	2.33	35.2
7	1920	42.4	2.29	42.4	2.29	32.4
8	1950	42.3	2.23	42.3	2.23	24.8
Average	1900.0	42.44	2.30	42.50	2.30	32.14
SD	39.3	0.30	0.06	0.34	0.06	5.60

S2: Tensile results of ISO 527 1BA samples: injection moulded + annealed: tested with a crosshead velocity of 1 mm/min for modulus determination and 50 mm/min after 0.3% strain.

Specimen N°	Modulus (MPa)	0.2% Offset Stress (MPa)	0.2% Offset Strain (%)	Yield Stress (MPa)	Yield Strain (%)	Break Strain (%)
1	2020	36.3	1.84	40.8	2.36	49.7
2	1950	37.5	1.98	41.4	2.45	44.3
3	1960	35.3	1.84	41.3	2.48	43.4
4	1890	38.6	2.1	41.4	2.49	50.7
5	1800	40.5	2.32	41.5	2.52	53.3
6	1910	37	1.98	40.9	2.48	48.3
7	1910	35.4	1.89	40.4	2.45	54.5
8	1920	37.7	2.01	41.2	2.46	50
Average	1920.0	37.3	2.00	41.1	2.46	49.3
SD	63.3	1.7	0.16	0.4	0.05	3.9

S3: Tensile results of ISO 527 1BA samples: injection moulded + annealed: tested with a crosshead velocity of 0.333 mm/min for modulus determination and 16.7 mm/min after 0.3% strain.

Specimen N°	Modulus (MPa)	0.2% Offset Stress (MPa)	0.2% Offset Strain (%)	Yield Stress (MPa)	Yield Strain (%)	Break Strain (%)
1	1890	40.4	2.2	42.1	2.52	38.9
2	1860	41.3	2.27	41.9	2.45	47.1
3	1940	40.7	2.17	42	2.44	53
4	1900	40.1	2.16	41.8	2.45	35.4
5	1940	40.1	2.12	41.9	2.4	56.1
6	1910	41	2.21	41.8	2.46	46.2
7	1910	40.5	2.17	41.9	2.43	51.1
8	1910	40.1	2.15	41.4	2.41	38.3
Average	1907.5	40.53	2.18	41.85	2.45	45.76
SD	26.1	0.45	0.05	0.21	0.04	7.56

S4: Tensile results of ISO 527 1BA samples: injection moulded + annealed: tested with a crosshead velocity of 0.52 mm/min for modulus determination and 26 mm/min after 0.3% strain.

Specimen N°	Modulus (MPa)	0.2% Offset Stress (MPa)	0.2% Offset Strain (%)	Yield Stress (MPa)	Yield Strain (%)	Break Strain (%)
1	1920	35.2	1.89	39.1	2.51	50.1
2	1900	35	1.89	38.9	2.51	55.9
3	1920	34.7	1.86	38.9	2.54	49.7
4	1910	35.5	1.91	39	2.46	55.6
5	1910	35.2	1.89	38.9	2.53	50.4
6	1920	35.4	1.89	38.9	2.47	39.3
7	1910	34.8	1.87	38.8	2.54	38.7
8	1920	34.5	1.84	38.8	2.53	65.8
Average	1913.8	35.0	1.88	38.9	2.51	50.7
SD	7.4	0.4	0.02	0.1	0.03	8.9

S5: Tensile results of ISO 527 1A samples: injection moulded with no post treatment: tested with a crosshead velocity of 1 mm/min for modulus determination and 50 mm/min after 0.3% strain.

Specimen N°	Modulus (MPa)	0.2% Offset Stress (MPa)	0.2% Offset Strain (%)	Yield Stress (MPa)	Yield Strain (%)	Break Strain (%)
1	1860	37.1	2.04	41.9	2.66	20.7
2	1790	37.9	2.16	41.4	2.72	24.1
3	1960	34.4	1.8	41.6	2.63	19.1
4	2020	32	1.63	41.4	2.63	19.9
5	2030	32.1	1.64	41.6	2.65	16.9
6	2020	32.1	1.64	41.2	2.61	34.6
7	2060	31.9	1.6	41.5	2.61	22.8
8	1780	37.8	2.17	41.2	2.72	36.7
9	2000	33	1.71	41.6	2.68	19.3
10	1990	32.6	1.68	41.6	2.67	21.2
Average	1951	34.1	1.81	41.5	2.66	23.5
SD	102.8	2.5	0.23	0.2	0.04	6.7

S6: Tensile results of ISO 527 1BA samples: injection moulded with no post treatment: tested with a crosshead velocity of 0.33 mm/min for modulus determination and 16.7 mm/min after 0.3% strain.

Specimen N°	Modulus (MPa)	0.2% Offset Stress (MPa)	0.2% Offset Strain (%)	Yield Stress (MPa)	Yield Strain (%)	Break Strain (%)
1	1936	35.7	2.02	41.7	3.75	70.5
2	1964	36.6	1.97	42.5	3.84	45.6
3	1620	37.9	2.57	40.9	4.08	43.1
4	1725	33.6	2.14	41.3	4.33	45.3
5	1707	35.0	2.25	40.3	3.97	
6	1665	35.9	2.37	41.8	4.36	55.8
7	1684	34.5	2.25	39.5	3.97	51.2
Average	1770	35.8	2.22	41.4	4.05	54.0
SD	145	1.4	0.23	0.8	0.25	11.3

S7: Tensile results of ISO 527 1BA samples: injection moulded in a steel mould @ 60mm/s with no additional post treatment: tested with a crosshead velocity of 1 mm/min for modulus determination and 50 mm/min after 0.3% strain.

Sample	Width (mm)		Thickness (mm)		Surface (mm ²)		Decrease (%)
	Initial	Neck	Initial	Neck	Initial	Neck	Surface
1A-1	9.958	9.138	3.928	3.594			
1A-2	9.97	9.258	3.963	3.618			
1A-3	9.973	9.061	3.941	3.537			
Average 1A	9.967	9.152	3.944	3.583	39.310	32.793	16.579
SD 1A	0.008	0.099	0.018	0.042	0.013	0.070	
1BA-1	5.055	4.717	1.932	1.776			
1BA-2	5.082	4.704	1.932	1.83			
1BA-3	4.999	4.600	2.001	1.84			
Average 1BA	5.045	4.674	1.955	1.815	9.864	8.484	13.985
SD 1BA	0.042	0.064	0.040	0.034	0.041	0.049	

S10: Cross section measurements to compare the amount of necking between annealed ISO 527 1A and 1BA samples, tensile tests of both sample types were stopped at 25% strain. Prior to the test, the thickness and width were measured. With the sample still inserted between the clamps at 25% strain, which is done to avoid elastic relaxation of the tensile sample, the thickness of the sample is measured again at its thinnest location. These measurements were repeated three times with the optimal cross head velocity for 1A bars (1 mm/min and 50 mm/min) and 1BA bars (0.333 mm/min and 16.666 mm/min).

S8: Tensile results of ISO 527 1BA samples: injection moulded in a steel mould @ 10mm/s with no additional post treatment: tested with a crosshead velocity of 1 mm/min for modulus determination and 50 mm/min after 0.3% strain.

All standard specimens were injection molded with an injection velocity of 60 mm/s (forward movement of the screw). To emphasize on processing related orientation however, an injection velocity of 10 mm/s has also been applied to produce the smaller ISO 527 1BA test bars in the steel mold.

Specimen N°	Modulus (MPa)	0.2% Offset Stress (MPa)	0.2% Offset Strain (%)	Yield Stress (MPa)	Yield Strain (%)	Break Strain (%)
1	1868.18	34.9	2.07	41.5	4.19	10.7
2	1892.56	34.3	2.00	41.3	3.84	9.9
3	1860.26	35.5	2.09	42.1	4.21	11.0
4	1850.23	36.6	2.19	43.6	4.39	12.6
5	1927.03	36.9	2.11	41.8	3.79	
6	1913.99	35.5	2.04	42.5	4.09	10.6
7	1920.36	36.5	2.10	42.5	4.04	11.4
Average	1890	35.7	2.15	42.2	4.14	10.7
SD	31	1.0	0.19	0.9	0.26	1.1

S9: Tensile results of ISO 527 1BA samples: injection moulded in a multi jet fusion polyamide 11 mould @ 10mm/s with no additional post treatment: tested with a crosshead velocity of 1 mm/min for modulus determination and 50 mm/min after 0.3% strain.

To broaden the investigation, parts have also been made at an injection velocity of 10 mm/s in a polyamide 11 (PA11) mold made via multi jet fusion (MJF). Since the thermal conductivity of this alternative mold material is much lower than conventional mold steel, different flow and cooling behavior may be expected. Furthermore, this mold has a higher surface roughness.