



Anexo 1

Resultados de los ensayos

ABS						
Temperatura de impresión (°C)	e (mm)	b (mm)	Ao (mm ²)	Fmax (N)	Resistencia a la tracción (MPa)	Módulo elástico (MPa)
200	3.00	3.35	10.05	398.76	39.68	1881.65
200	3.00	3.45	10.35	429.65	41.51	2355.85
200	3.00	3.50	10.50	432.36	41.18	1974.18
200	3.00	3.40	10.20	418.61	41.04	1904.01
200	2.95	3.35	9.88	408.41	41.33	2229.94
200	3.05	3.55	10.83	449.74	41.54	1769.13
210	3.00	3.40	10.20	414.34	40.62	1954.17
210	3.00	3.45	10.35	433.88	41.92	1935.81
210	3.05	3.45	10.52	433.57	41.20	2039.86
210	3.00	3.40	10.20	427.03	41.87	2075.12
210	3.00	3.40	10.20	416.06	40.79	2073.87
210	3.00	3.40	10.20	407.99	40.00	2054.59
220	3.10	3.50	10.85	419.21	38.64	2032.04
220	3.15	3.50	11.03	412.67	37.43	2024.76
220	3.10	3.45	10.70	419.92	39.26	2053.08
220	3.10	3.45	10.70	410.43	38.38	2176.87
220	3.10	3.45	10.70	421.67	39.43	1997.78
230	3.20	3.60	11.52	451.42	39.19	2037.67
230	3.20	3.55	11.36	463.97	40.84	2133.29
230	3.20	3.55	11.36	447.13	39.36	2293.50
230	3.10	3.60	11.16	425.84	38.16	2184.36
230	3.20	3.65	11.68	445.90	38.18	2007.07
230	3.25	3.65	11.86	444.50	37.47	1920.71
240	3.15	3.55	11.18	417.31	37.32	1889.49
240	3.10	3.55	11.01	415.07	37.72	1990.29
240	3.15	3.55	11.18	414.12	37.03	2030.02
240	3.20	3.60	11.52	422.31	36.66	1917.82
240	3.20	3.55	11.36	427.66	37.65	1949.26
240	3.15	3.55	11.18	416.04	37.20	2179.17
250	3.05	3.65	11.13	401.92	36.10	1935.12
250	3.15	3.75	11.81	424.90	35.97	1810.60
250	3.10	3.65	11.32	408.44	36.10	1902.54
250	3.05	3.65	11.13	403.04	36.20	1880.80
250	3.00	3.65	10.95	391.25	35.73	1856.66
250	3.01	3.64	10.96	392.95	35.87	1854.32
260	3.25	3.65	11.86	361.51	30.48	1570.89
260	3.25	3.63	11.80	373.07	31.62	1926.35
260	3.25	3.75	12.19	366.82	30.10	1522.63
260	3.21	3.68	11.81	367.78	31.13	2091.12
260	3.19	3.69	11.77	372.29	31.63	2006.53
270	3.31	3.77	12.48	352.50	28.25	1612.24
270	3.17	3.73	11.82	354.35	29.97	1446.78
270	3.36	3.77	12.67	356.73	28.16	1586.04
270	3.41	3.78	12.89	361.20	28.02	1557.52
270	3.25	3.78	12.29	353.87	28.81	1413.54

ABS						
Altura de capa (mm)	e (mm)	b (mm)	Ao (mm ²)	Fmax (N)	Resistencia a la tracción (MPa)	Módulo elástico (MPa)
0.30	3.35	3.66	12.26	320.82	26.17	1314.81
0.30	3.24	3.61	11.70	382.07	32.67	1515.29
0.30	3.19	3.55	11.32	358.38	31.65	1467.53
0.30	3.44	3.56	12.25	310.81	25.38	1232.60
0.30	3.33	3.55	11.82	326.66	27.63	1290.73
0.30	3.21	3.55	11.40	322.74	28.32	1437.10
0.25	3.13	3.55	11.11	363.14	32.68	1540.94
0.25	3.24	3.61	11.70	381.77	32.64	1577.85
0.25	3.13	3.62	11.33	386.03	34.07	1652.13
0.25	3.13	3.60	11.27	401.01	35.59	1922.04
0.25	3.15	3.63	11.43	386.47	33.80	1618.92
0.25	3.15	3.57	11.25	392.86	34.93	1833.01
0.20	3.20	3.60	11.52	451.42	39.19	2037.67
0.20	3.20	3.55	11.36	463.97	40.84	2133.29
0.20	3.20	3.55	11.36	447.13	39.36	2293.50
0.20	3.10	3.60	11.16	425.84	38.16	2184.36
0.20	3.20	3.65	11.68	445.90	38.18	2007.07
0.20	3.25	3.65	11.86	444.50	37.47	1920.71
0.15	3.05	3.65	11.13	481.95	43.29	2128.38
0.15	3.05	3.65	11.13	444.02	39.89	1898.72
0.15	3.05	3.60	10.98	452.31	41.19	2012.50
0.15	3.05	3.65	11.13	455.82	40.94	2136.52
0.15	3.05	3.65	11.13	435.71	39.14	1836.95
0.15	3.00	3.60	10.80	446.54	41.35	2029.00
0.10	3.05	3.60	10.98	491.81	44.79	2404.11
0.10	3.10	3.65	11.32	490.71	43.37	2088.72
0.10	3.15	3.70	11.66	503.44	43.19	2022.14
0.10	3.05	3.65	11.13	482.23	43.32	2197.66
0.10	3.15	3.70	11.66	503.00	43.16	2300.77
0.10	3.25	3.65	11.86	508.43	42.86	1741.90

ABS						
Angulo de impresión (°)	e (mm)	b (mm)	Ao (mm ²)	Fmax (N)	Resistencia a la tracción (MPa)	Módulo elástico (MPa)
0	3.20	3.60	11.52	451.42	39.19	2037.67
0	3.20	3.55	11.36	463.97	40.84	2133.29
0	3.20	3.55	11.36	447.13	39.36	2293.50
0	3.10	3.60	11.16	425.84	38.16	2184.36
0	3.20	3.65	11.68	445.90	38.18	2007.07
0	3.25	3.65	11.86	444.50	37.47	1920.71
45	3.31	3.48	11.52	376.22	32.66	1726.14
45	3.22	3.60	11.59	371.38	32.04	2244.59
45	3.45	3.65	12.59	391.87	31.12	1872.10
45	3.42	3.62	12.38	387.18	31.27	1654.06
45	3.32	3.57	11.85	373.91	31.55	1688.57
90	2.89	3.53	10.20	317.43	31.11	1704.95
90	2.85	3.60	10.26	303.04	29.54	1806.69
90	3.25	3.52	11.44	342.09	29.90	1772.10
90	3.30	3.46	11.42	335.31	29.37	2037.39
90	3.20	3.50	11.20	296.58	26.48	1725.12
0/90	3.21	3.52	11.30	379.76	33.61	2271.76
0/90	3.21	3.50	11.24	353.20	31.44	1944.83
0/90	3.20	3.56	11.39	370.62	32.53	1612.61
0/90	3.21	3.56	11.43	369.35	32.32	2029.13
0/90	3.26	3.61	11.77	371.09	31.53	1878.77
45/-45	3.30	3.65	12.05	392.73	32.61	1766.01
45/-45	3.30	3.70	12.21	418.10	34.24	1763.63
45/-45	3.30	3.65	12.05	418.05	34.71	1583.22
45/-45	3.30	3.70	12.21	419.07	34.32	1889.09
45/-45	3.30	3.65	12.05	408.00	33.87	1996.33
45/-45	3.30	3.65	12.05	409.98	34.04	1869.29
0/45/90	3.09	3.59	11.09	377.42	34.02	1845.64
0/45/90	3.07	3.51	10.78	375.84	34.88	1844.25
0/45/90	3.13	3.61	11.30	390.18	34.53	2120.08
0/45/90	3.15	3.61	11.37	387.46	34.07	2139.78
0/45/90	3.09	3.61	11.15	389.90	34.95	1974.09
0/45/90	3.11	3.60	11.20	389.05	34.75	1671.32
0/45/90/135	3.36	3.58	12.03	405.20	33.69	1986.16
0/45/90/135	3.26	3.65	11.90	402.79	33.85	1837.52
0/45/90/135	3.33	3.55	11.82	404.24	34.20	1925.70
0/45/90/135	3.15	3.60	11.34	362.72	31.99	1724.92
0/45/90/135	3.21	3.57	11.46	391.05	34.12	1593.64

ABS						
Angulo de impresión (°)	b (mm)	e (mm)	Ao (mm ²)	Fmax (N)	Wm (J)	Wb (kJ/m ²)
0	7.88	4.04	31.84	220.71	0.30	9.5
0	7.93	4.05	32.12	218.45	0.37	11.4
0	7.84	3.88	30.42	222.41	0.30	9.9
0	7.94	3.81	30.25	201.54	0.36	11.9
0	8.01	3.93	31.48	192.17	0.35	11.0
0	7.81	3.84	29.99	225.13	0.31	10.3
0	8.00	3.84	30.72	208.20	0.22	7.1
0	7.81	3.83	29.91	195.29	0.35	11.8
0	7.89	3.81	30.06	199.79	0.34	11.2
0	7.96	3.98	31.68	220.09	0.36	11.3
45	7.81	3.90	30.46	179.09	0.20	6.7
45	7.96	3.94	31.36	192.38	0.13	4.3
45	8.04	3.99	32.08	193.53	0.12	3.8
45	7.88	3.96	31.20	157.60	0.12	3.9
45	8.00	3.89	31.12	188.22	0.12	4.0
45	7.94	4.02	31.92	174.42	0.13	4.0
45	7.88	3.95	31.13	172.12	0.12	3.8
45	7.92	4.03	31.92	164.65	0.12	3.7
45	7.96	3.90	31.04	169.86	0.12	3.7
45	7.80	3.95	30.81	157.13	0.21	6.7
45	8.02	3.84	30.80	186.51	0.13	4.2
90	7.85	3.90	30.62	151.83	0.07	2.2
90	7.85	3.85	30.22	187.06	0.13	4.1
90	7.94	3.83	30.41	141.89	0.06	2.0
90	7.93	4.15	32.91	223.44	0.13	3.9
90	7.80	3.95	30.81	116.67	0.06	1.9
90	7.88	3.88	30.57	209.14	0.13	4.2
90	7.88	4.09	32.23	181.50	0.12	3.8
90	7.82	4.02	31.44	124.80	0.08	2.7
90	7.92	4.00	31.68	179.27	0.12	3.7
90	7.92	4.00	31.68	147.56	0.06	2.0
0/90	7.93	4.00	31.72	168.24	0.11	3.6
0/90	8.01	3.83	30.68	171.13	0.12	3.9
0/90	7.87	3.86	30.38	138.92	0.11	3.5
0/90	7.95	4.03	32.04	126.87	0.11	3.4
0/90	7.76	3.85	29.88	170.98	0.13	4.4
0/90	7.90	3.86	30.49	184.64	0.12	4.0
0/90	7.73	3.89	30.07	147.27	0.12	3.9
0/90	8.01	3.95	31.64	134.61	0.11	3.6
0/90	7.84	3.97	31.12	157.24	0.12	3.7
0/90	7.88	3.60	28.37	139.94	0.10	3.6

ABS						
Angulo de impresión (°)	b (mm)	e (mm)	Ao (mm ²)	Fmax (N)	Wm (J)	Wb (kJ/m ²)
45/-45	7.86	4.03	31.68	179.10	0.12	3.7
45/-45	7.85	4.00	31.40	206.84	0.13	4.1
45/-45	7.83	4.00	31.32	177.42	0.12	3.9
45/-45	8.14	4.00	32.56	171.44	0.13	3.9
45/-45	8.09	4.19	33.90	224.61	0.13	3.9
45/-45	7.91	4.01	31.72	212.45	0.13	3.9
45/-45	7.83	3.84	30.07	182.46	0.13	4.2
45/-45	8.09	4.12	33.33	179.63	0.12	3.7
45/-45	8.01	4.20	33.64	180.26	0.12	3.7
45/-45	8.02	3.88	31.12	179.74	0.12	3.9
45/-45	7.99	4.04	32.28	208.66	0.21	6.6
0/45/90	7.96	3.93	31.28	205.00	0.13	4.0
0/45/90	7.93	3.97	31.48	157.29	0.12	3.9
0/45/90	7.90	3.99	31.52	175.23	0.12	3.9
0/45/90	7.87	3.89	30.61	149.69	0.20	6.6
0/45/90	7.91	3.84	30.37	214.58	0.13	4.3
0/45/90	7.87	3.88	30.54	177.10	0.14	4.5
0/45/90	7.92	3.95	31.28	169.21	0.12	4.0
0/45/90	7.86	4.03	31.68	190.12	0.13	4.0
0/45/90	7.95	3.94	31.32	177.96	0.13	4.0
0/45/90	7.88	3.97	31.28	216.26	0.13	4.1
0/45/90/135	8.10	3.96	32.08	159.15	0.12	3.7
0/45/90/135	8.06	4.07	32.80	195.15	0.13	3.9
0/45/90/135	7.94	4.01	31.84	187.73	0.12	3.7
0/45/90/135	7.79	4.00	31.16	140.43	0.12	3.7
0/45/90/135	7.89	4.13	32.59	161.40	0.11	3.5

ABS						
Contenido de nanoarcillas (wt. %)	e (mm)	b (mm)	Ao (mm ²)	Fmax (N)	Resistencia a la tracción (MPa)	Módulo elástico (MPa)
0	3.02	3.51	10.60	317.94	29.99	1729.51
0	3.05	3.46	10.55	320.74	30.39	1639.86
0	3.04	3.61	10.97	300.60	27.39	1903.93
0	3.02	3.51	10.60	321.10	30.29	1576.46
0	2.93	3.45	10.11	362.38	35.85	1974.46
0	2.88	3.67	10.57	375.11	35.49	1649.38
1	2.96	3.68	10.89	397.71	36.51	1982.11
1	2.95	3.48	10.27	378.76	36.89	2147.28
1	2.96	3.47	10.27	404.40	39.37	1949.17
1	2.99	3.49	10.44	367.66	35.23	1824.93
1	2.98	3.56	10.61	335.66	31.64	1805.90
2	3.12	3.68	11.48	425.84	37.09	1724.04
2	2.96	3.60	10.66	396.92	37.25	1669.90
2	3.01	3.65	10.99	407.61	37.10	1695.97
2	3.05	3.65	11.13	414.47	37.23	1689.10
2	3.02	3.60	10.87	392.82	36.13	1597.35
3	3.07	3.45	10.59	358.31	33.83	1658.70
3	3.10	3.53	10.94	392.00	35.82	2062.10
3	3.10	3.45	10.70	385.37	36.03	1893.99
3	3.12	3.45	10.76	354.22	32.91	1700.74
3	3.12	3.52	10.98	395.17	35.98	1925.98

ABS						
Contenido de nanoarcillas (wt. %)	b (mm)	e (mm)	Ao (mm ²)	Fmax (N)	Wm (J)	Wb (kJ/m ²)
0	7.98	3.72	29.69	137.21	0.16	5.2
0	7.85	3.89	30.54	189.38	0.12	4.0
0	7.83	3.82	29.91	99.97	0.05	1.7
0	7.80	3.88	30.26	130.22	0.10	3.1
0	7.86	3.91	30.73	125.24	0.17	5.5
0	7.80	3.92	30.58	122.06	0.10	3.4
0	7.77	3.50	27.20	98.76	0.08	3.0
0	7.92	3.78	29.94	223.62	0.22	7.3
0	7.84	3.81	29.87	92.44	0.06	2.1
0	7.83	3.81	29.83	187.30	0.13	4.2
0	7.89	3.86	30.46	118.96	0.10	3.3
2	7.75	3.92	30.38	116.09	0.06	1.8
2	7.83	3.88	30.38	102.87	0.05	1.6
2	7.84	3.97	31.12	149.25	0.06	1.9
2	7.82	3.86	30.19	90.59	0.07	2.3
2	7.86	3.82	30.03	143.86	0.06	1.9
2	7.89	3.90	30.77	110.36	0.05	1.7
2	7.80	3.80	29.64	82.71	0.04	1.4
2	7.80	3.80	29.64	94.14	0.08	2.7
2	7.88	3.80	29.94	147.35	0.06	1.9
2	7.87	3.86	30.38	153.27	0.05	1.8
3	7.86	3.93	30.89	117.25	0.09	2.9
3	7.82	3.92	30.65	159.22	0.06	2.1
3	7.86	3.85	30.26	125.94	0.06	1.9
3	7.87	3.90	30.69	161.80	0.06	2.0
3	7.92	3.88	30.73	135.97	0.09	2.8
3	7.92	3.90	30.89	118.92	0.09	3.0
3	7.93	3.95	31.32	112.66	0.06	1.8
3	7.89	3.85	30.38	120.81	0.09	2.9
3	7.87	4.05	31.87	157.11	0.06	1.9
3	7.80	3.77	29.41	76.88	0.04	1.4

PLA						
Temperatura de impresión (°C)	e (mm)	b (mm)	Ao (mm ²)	Fmax (N)	Resistencia a la tracción (MPa)	Módulo elástico (MPa)
200	3.34	3.45	11.52	645.34	56.00	2993.85
200	3.33	3.46	11.52	671.89	58.32	3081.37
200	3.30	3.46	11.42	640.94	56.13	2828.81
200	3.33	3.46	11.52	625.14	54.26	2747.60
200	3.40	3.50	11.90	677.98	56.97	3240.77
210	3.10	3.40	10.54	634.93	60.24	3613.15
210	3.10	3.35	10.39	595.16	57.31	2968.02
210	3.10	3.45	10.70	600.21	56.12	3162.80
210	3.15	3.45	10.87	591.47	54.43	3319.27
210	3.20	3.45	11.04	596.33	54.02	3305.30
210	3.15	3.30	10.40	604.45	58.15	3674.20
220	3.35	3.50	11.73	678.81	57.89	3085.82
220	3.25	3.50	11.38	657.20	57.78	3157.80
220	3.30	3.60	11.88	663.29	55.83	3525.22
220	3.30	3.55	11.72	679.94	58.04	4008.70
220	3.35	3.55	11.89	722.43	60.75	3370.64
220	3.35	3.60	12.06	667.59	55.36	3291.80
230	3.20	3.45	11.04	661.31	59.90	3102.05
230	3.30	3.55	11.72	716.25	61.14	3504.79
230	3.30	3.60	11.88	699.37	58.87	3404.19
230	3.30	3.55	11.72	679.05	57.96	2788.17
230	3.20	3.35	10.72	628.08	58.59	2528.29
240	3.25	3.65	11.86	686.77	57.89	3312.87
240	3.20	3.55	11.36	677.67	59.65	3318.52
240	3.20	3.55	11.36	681.52	59.99	3681.34
240	3.25	3.55	11.54	729.04	63.19	3395.96
240	3.20	3.50	11.20	672.76	60.07	3250.25
250	3.20	3.60	11.52	697.71	60.56	3154.09
250	3.20	3.55	11.36	708.81	62.40	2808.31
250	3.20	3.60	11.52	713.00	61.89	2895.86
250	3.15	3.55	11.18	679.65	60.78	3012.32
250	3.25	3.55	11.54	695.63	60.29	3266.41
260	3.18	3.66	11.64	658.50	56.58	2857.25
260	3.24	3.54	11.47	622.03	54.23	3040.30
260	3.17	3.74	11.86	663.98	56.00	3312.63
260	3.18	3.73	11.86	637.68	53.76	2684.97
260	3.19	3.68	11.74	654.72	55.77	3100.98
260	3.25	3.65	11.86	638.84	53.85	3455.49
270	3.29	3.79	12.47	661.38	53.04	3071.73
270	3.18	3.76	11.96	618.50	51.73	2973.50
270	3.19	3.79	12.09	659.33	54.54	2937.66
270	3.26	3.81	12.42	670.28	53.97	3622.28
270	3.22	3.78	12.17	636.12	52.26	3041.18
270	3.05	3.71	11.32	604.32	53.41	3005.03

PLA						
Altura de capa (mm)	e (mm)	b (mm)	Ao (mm ²)	Fmax (N)	Resistencia a la tracción (MPa)	Módulo elástico (MPa)
0.30	3.28	3.66	12.00	681.39	56.76	3241.20
0.30	3.26	3.56	11.61	690.54	59.50	3090.92
0.30	3.29	3.68	12.11	667.27	55.11	3247.40
0.30	3.28	3.58	11.74	635.26	54.10	3028.82
0.30	3.30	3.68	12.14	716.75	59.02	3012.52
0.25	3.35	3.62	12.13	679.79	56.06	2928.73
0.25	3.27	3.69	12.07	704.30	58.37	3396.15
0.25	3.34	3.61	12.06	684.70	56.79	2992.41
0.25	3.43	3.64	12.49	639.96	51.26	3226.83
0.25	3.33	3.68	12.25	704.97	57.53	3298.43
0.20	3.20	3.45	11.04	661.31	59.90	3102.05
0.20	3.30	3.55	11.72	716.25	61.14	3504.79
0.20	3.30	3.60	11.88	699.37	58.87	3404.19
0.20	3.30	3.55	11.72	679.05	57.96	2788.17
0.20	3.20	3.35	10.72	628.08	58.59	2528.29
0.15	3.24	3.58	11.60	683.26	58.91	3183.92
0.15	3.27	3.45	11.28	663.65	58.83	2942.04
0.15	3.31	3.54	11.72	681.88	58.19	3153.41
0.15	3.19	3.58	11.42	658.14	57.63	3308.46
0.15	3.36	3.51	11.79	672.52	57.02	3091.43
0.10	3.24	3.49	11.31	674.91	59.69	3561.05
0.10	3.24	3.42	11.08	630.28	56.88	4303.82
0.10	3.27	3.49	11.41	639.44	56.03	3777.67
0.10	3.28	3.42	11.22	682.00	60.80	3164.50
0.10	3.39	3.40	11.53	672.22	58.32	3079.28

PLA						
Angulo de impresión (°)	e (mm)	b (mm)	Ao (mm ²)	Fmax (N)	Resistencia a la tracción (MPa)	Módulo elástico (MPa)
0	3.20	3.45	11.04	661.31	59.90	3102.05
0	3.30	3.55	11.715	716.25	61.14	3504.79
0	3.30	3.60	11.88	699.37	58.87	3404.19
0	3.30	3.55	11.715	679.05	57.96	2788.17
0	3.20	3.35	10.72	628.08	58.59	2528.29
45	3.33	3.5	11.655	667.79	57.30	3094.94
45	3.39	3.59	12.17	702.07	57.69	3013.47
45	3.36	3.53	11.861	670.25	56.51	2948.55
45	3.36	3.58	12.029	679.79	56.51	4372.53
45	3.23	3.48	11.24	643.75	57.27	3307.08
90	3.09	3.38	10.444	567.11	54.30	2810.91
90	3.16	3.41	10.776	575.99	53.45	2887.74
90	3.14	3.51	11.021	630.04	57.17	3169.37
90	3.11	3.43	10.667	564.01	52.87	3251.60
90	3.1	3.48	10.788	546.42	50.65	2898.36
0/90	3.29	3.5	11.515	635.77	55.21	3053.90
0/90	3.15	3.52	11.088	623.84	56.26	3218.94
0/90	3.26	3.52	11.475	641.43	55.90	2626.08
0/90	3.22	3.49	11.238	638.04	56.78	2766.49
0/90	3.28	3.44	11.283	623.51	55.26	3090.43
0/90	3.3	3.53	11.649	641.28	55.05	3011.19
45/-45	3.38	3.5	11.83	627.96	53.08	3269.11
45/-45	3.33	3.54	11.788	674.41	57.21	3108.60
45/-45	3.3	3.57	11.781	657.32	55.79	3583.42
45/-45	3.31	3.55	11.751	646.23	55.00	3994.81
45/-45	3.26	3.57	11.638	670.56	57.62	3040.21
0/45/90	3.19	3.57	11.388	681.62	59.85	2923.70
0/45/90	3.2	3.48	11.136	648.43	58.23	3528.17
0/45/90	3.24	3.58	11.599	646.28	55.72	3361.69
0/45/90	3.27	3.42	11.183	642.54	57.46	3033.48
0/45/90	3.24	3.62	11.729	709.04	60.45	2862.62
0/45/90	3.24	3.49	11.308	623.90	55.18	3612.34
0/45/90/135	3.33	3.53	11.755	644.13	54.80	3313.09
0/45/90/135	3.19	3.41	10.878	612.73	56.33	3322.03
0/45/90/135	3.31	3.62	11.982	610.28	50.93	2765.99
0/45/90/135	3.25	3.56	11.57	617.98	53.41	2768.11
0/45/90/135	3.28	3.49	11.447	637.59	55.70	3245.55

PLA						
Angulo de impresión (°)	b (mm)	e (mm)	Ao (mm ²)	Fmax (N)	Wm (J)	Wb (kJ/m ²)
0	8.00	3.94	31.52	180.43	0.06	2.0
0	8.40	3.88	32.59	172.69	0.07	2.0
0	7.96	4.00	31.84	218.94	0.01	0.4
0	8.06	3.94	31.76	207.90	0.08	2.4
0	8.17	3.84	31.37	150.74	0.08	2.5
0	8.08	3.84	31.03	180.82	0.06	2.1
0	7.97	4.07	32.44	210.91	0.06	2.0
0	8.00	3.90	31.20	132.52	0.08	2.5
0	8.06	3.93	31.68	131.56	0.07	2.1
0	8.00	3.90	31.20	173.20	0.07	2.2
45	7.99	4.04	32.28	160.55	0.06	1.9
45	8.04	4.10	32.96	202.22	0.01	0.4
45	8.10	4.12	33.37	194.18	0.05	1.5
45	8.00	4.11	32.88	216.90	0.07	2.2
45	7.99	4.05	32.36	211.20	0.01	0.4
45	7.98	4.10	32.72	15853.08	0.22	6.9
45	7.92	4.07	32.23	214.70	0.01	0.4
45	8.08	4.09	33.05	298.62	0.08	2.5
45	7.90	4.10	32.39	206.23	0.07	2.2
45	7.98	4.07	32.48	195.28	0.05	1.6
90	7.94	4.15	32.95	298.10	0.09	2.6
90	8.04	4.05	32.56	210.38	0.08	2.4
90	8.05	4.02	32.36	266.00	0.08	2.4
90	8.05	4.18	33.65	177.64	0.07	2.0
90	8.15	4.00	32.60	244.17	0.08	2.4
90	8.08	4.08	32.97	256.84	0.08	2.4
90	8.03	4.01	32.20	177.27	0.05	1.4
90	8.03	4.01	32.20	295.78	0.09	2.7
90	8.01	4.12	33.00	282.55	0.08	2.5
90	7.96	4.15	33.03	261.34	0.07	2.2
0/90	8.12	4.10	33.29	264.95	0.09	2.6
0/90	8.04	4.08	32.80	196.32	0.05	1.6
0/90	8.00	4.06	32.48	199.34	0.08	2.4
0/90	8.06	3.97	32.00	167.07	0.05	1.7
0/90	8.12	4.16	33.78	234.93	0.12	3.6
0/90	8.02	4.14	33.20	215.47	0.12	3.6
0/90	8.12	4.12	33.45	210.27	0.09	2.6
0/90	8.01	4.09	32.76	250.15	0.09	2.6
0/90	8.02	4.09	32.80	213.77	0.05	1.6
0/90	7.90	4.15	32.79	208.04	0.09	2.7

PLA						
Angulo de impresión (°)	b (mm)	e (mm)	Ao (mm ²)	Fmax (N)	Wm (J)	Wb (kJ/m ²)
45/-45	8.05	4.08	32.84	202.77	0.06	1.7
45/-45	8.17	4.07	33.25	223.65	0.05	1.6
45/-45	8.07	4.02	32.44	220.95	0.09	2.7
45/-45	7.96	4.09	32.56	318.80	0.09	2.6
45/-45	8.03	4.11	33.00	252.43	0.08	2.4
45/-45	7.98	4.15	33.12	202.77	0.07	2.1
45/-45	8.05	4.01	32.28	254.19	0.09	2.7
45/-45	7.97	4.02	32.04	257.66	0.09	2.7
45/-45	8.00	4.16	33.28	245.54	0.05	1.6
45/-45	8.07	4.02	32.44	225.97	0.08	2.5
0/45/90	7.94	4.07	32.32	250.15	0.08	2.4
0/45/90	8.13	4.16	33.82	252.47	0.09	2.7
0/45/90	7.88	4.06	31.99	195.34	0.01	0.4
0/45/90	7.94	4.16	33.03	241.13	0.07	2.3
0/45/90	8.00	4.12	32.96	221.04	0.01	0.4
0/45/90	7.98	4.15	33.12	237.91	0.08	2.3
0/45/90	8.09	4.14	33.49	267.46	0.09	2.8
0/45/90	8.11	4.07	33.01	218.96	0.09	2.7
0/45/90	7.98	4.10	32.72	255.95	0.09	2.8
0/45/90	7.99	4.12	32.92	207.98	0.07	2.2
0/45/90/135	7.92	3.96	31.36	167.73	0.06	1.8
0/45/90/135	8.07	4.00	32.28	238.43	0.09	2.6
0/45/90/135	7.89	4.11	32.43	219.53	0.08	2.3
0/45/90/135	8.06	3.89	31.35	171.72	0.06	1.8
0/45/90/135	7.89	4.09	32.27	195.91	0.08	2.5

PLA						
Contenido de nanoarcillas (wt. %)	e (mm)	b (mm)	Ao (mm ²)	Fmax (N)	Resistencia a la tracción (MPa)	Módulo elástico (MPa)
0	3.13	3.78	11.83	659.34	55.73	3121.66
0	3.02	3.41	10.30	581.22	56.44	2856.44
0	2.85	3.55	10.12	556.05	54.96	3164.87
0	3.14	3.60	11.30	618.26	54.69	3015.24
0	3.27	3.50	11.45	585.64	51.17	2530.59
1	3.07	3.50	10.75	598.84	55.73	3030.70
1	3.30	3.57	11.78	626.35	53.17	3006.50
1	2.88	3.61	10.40	564.87	54.33	3158.67
1	3.27	3.55	11.61	601.02	51.77	3137.01
1	2.90	3.50	10.15	540.67	53.27	2926.82
2	2.65	3.73	9.88	425.73	43.07	2527.28
2	3.35	3.60	12.06	622.85	51.65	3327.53
2	3.18	3.95	12.56	624.80	49.74	2721.01
2	3.20	3.63	11.62	603.11	51.92	2731.32
2	3.15	3.65	11.50	590.47	51.36	2680.10
2	3.23	3.66	11.82	611.96	51.77	2829.57
2	2.97	3.50	10.40	534.97	51.46	2481.83
3	2.93	3.42	10.02	536.10	53.50	2999.99
3	2.98	3.39	10.10	538.86	53.34	2876.56
3	3.07	3.54	10.87	565.04	51.99	2856.00
3	3.21	3.53	11.33	571.66	50.45	2935.32
3	3.03	3.43	10.39	537.71	51.74	2919.81
3	2.95	3.51	10.35	534.02	51.57	3373.31

PLA						
Contenido de nanoarcillas (wt. %)	b (mm)	e (mm)	Ao (mm ²)	Fmax (N)	Wm (J)	Wb (kJ/m ²)
0	7.83	4.13	32.34	180.83	0.08	2.3
0	7.77	3.93	30.54	149.84	0.01	0.4
0	7.91	3.94	31.17	158.19	0.04	1.4
0	7.75	4.00	31.00	165.23	0.07	2.2
0	7.88	3.70	29.16	135.95	0.06	2.2
0	7.72	3.93	30.34	150.19	0.04	1.4
0	7.85	3.72	29.20	157.16	0.04	1.5
0	7.74	3.95	30.57	146.89	0.01	0.4
0	7.82	3.71	29.01	120.12	0.05	1.8
0	7.83	4.00	31.32	154.27	0.04	1.3
1	7.96	3.90	31.04	179.33	0.05	1.5
1	7.91	3.86	30.53	143.24	0.06	1.9
1	7.86	3.86	30.34	155.06	0.04	1.4
1	7.82	3.80	29.72	175.59	0.06	2.1
1	7.78	3.80	29.56	132.31	0.04	1.3
1	7.82	3.92	30.65	134.23	0.06	1.9
1	7.80	3.82	29.80	122.95	0.05	1.7
1	7.83	3.91	30.62	135.77	0.05	1.7
1	7.80	3.83	29.87	109.35	0.05	1.8
1	7.97	3.94	31.40	120.56	0.04	1.3
2	7.80	4.05	31.59	175.35	0.01	0.5
2	7.88	3.94	31.05	179.84	0.07	2.3
2	7.79	3.98	31.00	157.15	0.01	0.4
2	7.84	3.97	31.12	183.66	0.05	1.6
2	7.85	3.95	31.01	154.99	0.05	1.5
2	7.86	3.97	31.20	148.37	0.05	1.7
2	7.92	3.89	30.81	165.24	0.05	1.6
2	7.76	3.98	30.88	135.45	0.01	0.3
2	7.90	3.88	30.65	156.24	0.01	0.3
3	8.14	4.21	34.27	212.27	0.01	0.4
3	8.08	4.04	32.64	226.46	0.07	2.2
3	8.14	4.09	33.29	196.11	0.07	2.2
3	7.94	4.12	32.71	181.98	0.01	0.4
3	7.90	4.02	31.76	184.91	0.07	2.3
3	7.94	3.76	29.85	132.30	0.09	3.2
3	7.93	3.70	29.34	154.05	0.06	2.1
3	7.87	3.95	31.09	2497.43	0.01	0.2
3	7.95	3.76	29.89	135.36	0.06	2.0
3	8.01	3.92	31.40	135.15	0.05	1.6



Anexo 2

Materiales

Grade: ABS448T, ABS448TUV
 Molding Grade ABS and w/ UV

Typical Material Properties

326 Jack Burlingame Dr, Millwood, WV 25262 USA
 Phone: 304.273.0352, Fax: 304.273.0355

Physical	Nominal Values	ASTM Test
Specific Gravity	1.04	D792
Melt Flow (230 °C/3.8 kg)	5.0 g/10 min	D1238
Mechanical		
Tensile Modulus	350,000 psi	D638
Tensile Strength at Yield	6,500 psi	D638
Flexural Modulus	350,000 psi	D790
Flexural Strength at Yield	10,500 psi	D790
Impact		
Notched Izod Impact (73 °F, 0.125 in)	5.0 ft-lb/in	D256
Thermal		
DTUL @ 264 psi-unannealed (0.125 in)	183 °F	D648
Mold Shrinkage		
Linear Flow	.004 - .008 in/in	D955
UL Rating	HB (1.5 mm)	UL 94

The information provided above is based upon typical values, and are intended only as guides. Star Plastics, Inc./SDR Inc assumes no obligation or liability for any advice furnished or for any results obtained with respect to this information. **No guarantees or warranties are expressed or implied.**

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Recommended Processing Guidelines

	Nominal Values
Drying Time and Temperature	2.0 - 4.0 hrs at 180 - 200 °F
Suggested Max Moisture	0.15%
Rear Temperature	370 - 425 °F
Middle Temperature	400 - 450 °F
Front Temperature	425 - 475 °F
Nozzle Temperature	425 - 525 °F
Processing (melt) Temperature	425 - 525 °F
Mold Temperature	120 - 170 °F
Back Pressure	25 - 100 psi
Screw Speed	25 - 75 rpm

The conditions listed above are only guidelines. You may want to adjust conditions to meet your requirements.

Your Competitive Advantage in an Ever Changing Market!

Ingeo™ Biopolymer 4043D Technical Data Sheet

Biaxially Oriented Films – General Purpose

Film Characteristics/ Applications

Ingeo 4043D – a product from NatureWorks LLC – can be converted into a biaxially oriented film with use temperatures up to 265°F (130°C). This film has excellent optics, good machinability and excellent twist and deadfold. These properties make 4043D film an ideal candidate for candy twist wrap and other packaging applications. Additional properties include advantageous barrier to flavor and grease and superior oil resistance.

Polymer Characteristics

4043D polymer is available in pellet form. Drying prior to processing is essential. The polymer is stable in the molten state, provided that the extrusion and drying procedures are followed.

Machine Configuration

Ingeo polymers will process on conventional extruders using general purpose screws with L/D ratios from 24:1 to 30:1 and compression ratio of 2.5:1 to 3:1. Smooth barrels are recommended. Ingeo resins will process on conventional cast tenter equipment that has been designed for OPS or OPET with minimal modifications. Optimization to your specific equipment may require NatureWorks LLC technical support

Process Details

Startup and Shutdown

Ingeo 4043D is not compatible with a wide variety of polyolefin resins, and special purging sequences should be followed:

1. Clean extruder and bring temperatures to steady state with low-viscosity, general-purpose polystyrene or high MFR polypropylene.
2. Vacuum out hopper system to avoid contamination.
3. Introduce Ingeo polymer into the extruder at the operating conditions used in Step 1.
4. Once Ingeo polymer has purged, reduce barrel temperatures to desired set points.
5. At shutdown, purge machine with high-viscosity polystyrene or polypropylene.

Typical Material & Application Properties ^(1, 2, 3)			
Film Properties		Ingeo 4043D	ASTM Method
Density		1.24 g/cc	D1505
Tensile Strength	MD	16 kpsi	D882
	TD	21 kpsi	D882
Tensile Modulus	MD	480 kpsi	D882
	TD	560 kpsi	D882
Elongation at Break	MD	160%	D882
	TD	100%	D882
Elmendorf Tear	MD	15 g/mil	D1922
	TD	13 g/mil	D1922
Spencer Impact		2.5 joules	
Transmission Rates	Oxygen	675 cc-mil/ m ² -24hr-atm	D1434
	Carbon Dioxide	2,850 cc-mil/ m ² -24hr-atm	Internal
Dioxide	Water Vapor	375 g-mil/ m ² -24hr	F1249
Optical Characteristics	Haze	2.1%	D1003
	Gloss, 20°	90	D1003
Thermal Characteristics	Melting Point	145-160°C	D3418

- (1) Typical properties; not to be construed as specifications.
- (2) All properties measured on 1.0 mil film.
- (3) Typical values for a film oriented 3.5x in MD and 5x in TD.

Processing Temperature Profile		
Melt Temp.	410±15°F	210±8 °C
Feed Throat	113°F	45°C
Feed Temp.	355°F	180°C
Compression Section	375°F	190°C
Metering Section	390°F	200°C
Adapter	390°F	200°C
Die	390°F	200°C
Screw Speed	20-100 rpm	
MD Draw Temp.	140-160°F	60-70°C
TD Draw Temp.	160-175°F	70-80°C

Drying

In-line drying is required. A moisture content of less than 0.025% (250ppm) is recommended to prevent viscosity degradation. Typical drying conditions are 4 hours at 175°F (80°C) or to a dew point of -30°F (-35°C), with an airflow rate greater than 0.5 cfm/lb of resin throughput. The resin should not be exposed to atmospheric

conditions after drying. Keep the package sealed until ready to use and promptly reseal any unused material.

Food Packaging Status

U.S. Status

On January 3, 2002 FCN 000178 submitted by NatureWorks LLC to FDA became effective. This effective notification is part of list currently maintained on FDA's website at

<http://www.fda.gov/food/ingredientspackaginglabeling/packagingfcs/notifications/default.htm>

This grade of Ingeo biopolymer may therefore be used in food packaging materials and, as such, is a permitted component of such materials pursuant to section 201(s) of the Federal, Drug, and Cosmetic Act, and Parts 182, 184, and 186 of the Food Additive Regulations. All additives and adjuncts contained in the referenced Ingeo biopolymer formulation meet the applicable sections of the Federal Food, Drug, and Cosmetic Act. The finished polymer is approved for all food types and B-H use conditions. We urge all of our customers to perform GMP (Good Manufacturing Procedures) when constructing a package so that it is suitable for the end use. Again, for any application, should you need further clarification, please do not hesitate to contact NatureWorks LLC.

European Status

This grade of Ingeo biopolymer complies with Plastics Regulation 10/2011 as amended. No SML's for the above referenced grade exist in Plastics Regulation 10/2011 as amended. NatureWorks LLC would like to draw your attention to the fact that the EU- Plastics Regulation 10/2011, which applies to all EU-Member States, includes a limit of 10 mg/dm² of the overall migration from finished plastic articles into food. In accordance with Plastics Regulation 10/2011 the migration should be measured on

finished articles placed into contact with the foodstuff or appropriate food simulants for a period and at a temperature which are chosen by reference to the contact conditions in actual use, according to the rules laid down in Plastics Regulation 10/2011.

Please note that it is the responsibility of both the manufacturers of finished food contact articles as well as the industrial food packers to make sure that these articles in their actual use are in compliance with the imposed specific and overall migration requirements.

This grade as supplied meets European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste heavy metal content as described in Article 11.

Should you need further clarification, contact NatureWorks LLC.

Bulk Storage Recommendations

The resin silos recommended and used by NatureWorks LLC are designed to maintain dry air in the silo and to be isolated from the outside air. This design would be in contrast to an open, vented to atmosphere system that we understand to be a typical polystyrene resin silo. Key features that are added to a typical (example: polystyrene) resin silo to achieve this objective include a cyclone and rotary valve loading system and some pressure vessel relief valves. The dry air put to the system is sized to the resin flow rate out of the silo. Not too much dry air would be needed and there may be excess instrument air (-30°F dew point) available in the plant to meet the needs for dry air. Our estimate is 10 scfm for a 20,000 lb/hr rate resin usage. Typically, resin manufacturers specify aluminum or stainless steel silos for their own use and avoid epoxy-lined steel.

Safety and Handling Considerations

Safety Data Sheets (SDS) for Ingeo biopolymers are available from NatureWorks. SDS's are provided to help customers satisfy their own handling, safety, and disposal needs, and those that may be required by locally applicable health and safety regulations. SDS's are updated regularly; therefore, please request and review the most current SDS's before handling or using any product.

The following comments apply only to Ingeo biopolymers; additives and processing aids used in fabrication and other materials used in finishing steps have their own safe-use profile and must be investigated separately.

Hazards and Handling Precautions

Ingeo biopolymers have a very low degree of toxicity and, under normal conditions of use, should pose no unusual problems from incidental ingestion or eye and skin contact. However, caution is advised when handling, storing, using, or disposing of these resins, and good housekeeping and controlling of dusts are necessary for safe handling of product. Pellets or beads may present a slipping hazard.

No other precautions other than clean, body-covering clothing should be needed for handling Ingeo biopolymers. Use gloves with insulation for thermal protection when exposure to the melt is localized. Workers should be protected from the possibility of contact with molten resin during fabrication.

Handling and fabrication of resins can result in the generation of vapors and dusts that may cause irritation to eyes and the upper respiratory tract. In dusty atmospheres, use an approved dust respirator.

Good general ventilation of the polymer processing area is recommended. At temperatures exceeding the polymer melt temperature (typically 175°C), polymer can release fumes, which may contain fragments of the polymer, creating a potential to irritate eyes and mucous membranes. Good general ventilation should be sufficient for most conditions. Local exhaust ventilation is recommended for melt operations. Use safety glasses (or goggles) to prevent exposure to particles, which could cause mechanical injury to the eye. If vapor exposure causes eye discomfort, improve localized fume exhausting methods or use a full-face respirator.

The primary thermal decomposition product of PLA is acetaldehyde, a material also produced during the thermal degradation of PET. Thermal decomposition products also include carbon monoxide and hexanal, all of which exist as gases at normal room conditions. These species are highly flammable, easily ignited by spark or flame, and can also auto ignite. For polyesters such as PLA, thermal

decomposition producing flammable vapors containing acetaldehyde and carbon monoxide can occur in almost any process equipment maintaining PLA at high temperature over longer residence times than typically experienced in extruders, fiber spinning lines, injection molding machines, accumulators, pipe lines and adapters. As a rough guideline based upon some practical experience, significant decomposition of PLA will occur if polymer residues are held at temperatures above the melting point for prolonged periods, e.g., in excess of 24 hours at 175°C, although this will vary significantly with temperature.

Combustibility

Ingeo biopolymers will burn. Clear to white smoke is produced when product burns. Toxic fumes are released under conditions of incomplete combustion. Do not permit dust to accumulate. Dust layers can be ignited by spontaneous combustion or other ignition sources. When suspended in air, dust can pose an explosion hazard. Firefighters should wear positive-pressure, self-contained breathing apparatuses and full protective equipment. Water or water fog is the preferred extinguishing medium. Foam, alcohol-resistant foam, carbon dioxide or dry chemicals may also be used. Soak thoroughly with water to cool and prevent re-ignition.

Disposal

DO NOT DUMP INTO ANY SEWERS, ON THE GROUND, OR INTO ANY BODY OF WATER. For unused or uncontaminated material, the preferred option is to recycle into the process otherwise, send to an incinerator or other thermal destruction device. For used or contaminated material, the disposal options remain the same, although additional evaluation is required. Disposal must be in compliance with Federal, State/Provincial, and local laws and regulations.

Environmental Concerns

Generally speaking, lost pellets, while undesirable, are benign in terms of their physical environmental impact, but if ingested by wildlife, they may mechanically cause adverse effects. Spills should be minimized, and they should be cleaned up when they happen. Plastics should not be discarded into the environment.

Product Stewardship

NatureWorks has a fundamental duty to all those that use our products, and for the environment in which we live. This duty is the basis for our Product Stewardship philosophy, by which we assess the health and environmental information on our products and their intended use, and then take appropriate steps to protect the environment and the health of our employees and the public.

Customer Notice

NatureWorks encourages its customers and potential users of its products to review their applications from the standpoint of human health and environmental quality. To help ensure our products are not used in ways for which they

were not intended or tested, our personnel will assist customers in dealing with ecological and product safety considerations. Your sales representative can arrange the proper contacts. NatureWorks literature should be consulted prior to the use of the company's products.

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For additional information please contact NatureWorks via our [website](#) on the tab called [FAQ's](#) or by clicking [here](#).



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Product Specification

Product Name:

Nanoclay, surface modified – contains 0.5–5 wt. % aminopropyltriethoxysilane, 15–35 wt. % octadecylamine

Product Number:

682632

TEST

Specification

Appearance (Color)

White to Off-White

Appearance (Form)

Powder

Loss on Drying

≤ 3.0 %

Size

≤ 20 micron

Density

200 - 500 kg/m³

(Bulk Density)

Specification: PRD.0.ZQ5.10000023839

Sigma-Aldrich warrants, that at the time of the quality release or subsequent retest date this product conformed to the information contained in this publication. The current Specification sheet may be available at Sigma-Aldrich.com. For further inquiries, please contact Technical Service. Purchaser must determine the suitability of the product for its particular use. See reverse side of invoice or packing slip for additional terms and conditions of sale.



Anexo 3

Parámetros de extrusión

	ABS	PLA
T Zona 1 (°C)	90	60
T Zona 2 (°C)	210	190
T Zona 3 (°C)	225	220
T Zona 4 (°C)	225	220
T Zona 5 (°C)	225	220
T Zona 6 (°C)	225	220
T Zona 7 (°C)	225	220
T Zona 8 (°C)	225	220
T Zona 9 (°C)	220	220
T Zona 10 (°C)	215	215
Velocidad del tornillo (RPM)	140	90
Velocidad de alimentación (RPM)	13	9

** los mismos parametros fueron usados al introducir las nanoacillas en el ABS y PLA*