

New Options for Textiles

The performance of Ingeo™ fibers in the standard flammability tests described below confirm that Ingeo fibers, without any flame retardant (FR) treatment, are a viable alternative to untreated polyester, cotton, nylon 6, acrylic and wool. The flammability characteristics of Ingeo fibers are inherent in the fiber, requiring no treatment or finish to pass various flammability tests. Details of each test and score are included here. Further flammability results obtained by our downstream customers in their specific end use applications are available as case studies at www.ingeofibers.com.

Flammability tests were conducted on pure Ingeo fiber or on fabrics made from Ingeo fibers, without any FR treatment, to evaluate ignition characteristics, flame propagation characteristics, and smoke and heat generation performance in combustion.

1. Ignition Characteristics

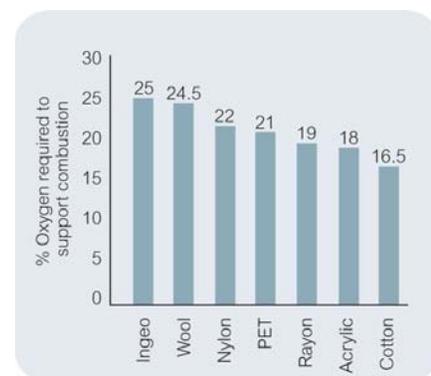
The ease of ignition is of key interest in the interior furnishings area for public occupancy buildings, including drapery, bedding, cubicle curtains, and for outdoor coverings.

A. Limited Oxygen Index (LOI)

The LOI test measures the minimum percentage of oxygen in the atmosphere that is required to marginally support combustion. Since air is comprised of about

21 percent oxygen by volume, any material with an LOI of less than 21 will burn easier in air. Materials that rank in the 21 to 28 percent range are known as slow burning. Ingeo fiber received slow burning rating with a 24 to 26 percent measured LOI as tested per ASTM D2863.

The testing demonstrates that fabrics made from Ingeo fibers¹ outperform untreated PET, Cotton, Nylon, Rayon, and Acrylic fabrics.²



Akzo Nobel Reports on PLA; Fire Protection Handbook, 18th Ed.

B. Ignitability

See Crespi customer case study for detailed results of further ignitability testing to BS 7177 performed by the Fire Technology Services for Manifattura Crespi srl. This, and any other available case studies, can be found at www.ingeofibers.com.

¹PLA Value from Akzo-Nobel Reports, January 14, 2000

²Values for PET 20-22, Cotton 16-17, Rayon 19, Nylon 6 20-24, Acrylic 18, and Wool 24-25, from Fire Protection Handbook, 18th Edition, Arthur E. Cote, P>E., 1997, Table A-5

2. Flame Propagation & Time to Self-extinguish

Once ignition has occurred, the length of time over which the flaming is maintained, and the speed with which flame propagation occurs in various geometries, are key parameters of interest.

A. time to self-extinguish

Some fibers self-extinguish after a period of time once they are removed from the heat source. The lower the period of time to self-extinguish, the higher the performance of the fiber.

a) material time to self-extinguish

test: Cone Calorimeter–ASTM E1354

results: Fabrics made of Ingeo fibers self-extinguish rapidly compared to fabrics made from untreated polyester and cotton. While some fabrics will pass the self-extinguish test without a treatment, others will not pass without flame retardant treatment. Fabrics made from Ingeo fibers achieve lower self-extinguish times without flame retardants.

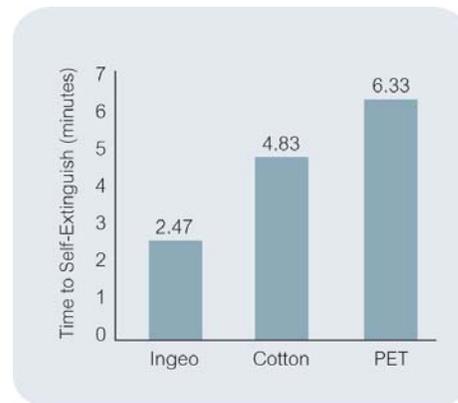
b) reaction of fabrics to fire

test: UNI 8456 (1987), UNI 9174 (1987) – UNI 9174/A1 (1996)

This test determines the time to self extinguish after the fabric is removed from the heat source (afterglow), the rate of propagation, the char length, and the time of flaming of the drippings.

results: The untreated fabric from 100% Ingeo fiber met the test criteria of UNI 8456 (1987) for afterglow time, char length, flame propagation time, and time of flaming drippings to extinguish, to be classified as Category I, as required by the Italian drapery market.

Laboratorio Prevenzone Incendi srl., April 21st, 2004,
Report # 327.oUNo150/4



ASTM 1354 Cone Calorimetry

Sample #	Afterglow Flame (sec)	Char Length (mm)	Flame Propagation Speed (mm/min)	Time of Flaming Drippings to Extinguish (sec)	Classification
1	N.D. ¹	<100	N.D. ²	Not Flaming	Category I
2	N.D.	<100	N.D.	Not Flaming	Category I
3	N.D.	<100	N.D.	Not Flaming	Category I
4	N.D.	<100	N.D.	Not Flaming	Category I
5	N.D.	<100	N.D.	Not Flaming	Category I
6	N.D.	<100	N.D.	Not Flaming	Category I
Overall Result	N.D.	<100	N.D.	Not Flaming	Category I

N.D. = Not Determined

¹ The Afterglow Time is not determined when the CHAR length does not reach the 300mm mark

² Flame Propagation Time is not determined when the Char Length does not reach the 150mm mark

B. vertical flame propagation

The flame propagation of textiles and films test, NFPA 701, covers fire safety requirements that apply to textile materials, which are used extensively in interior furnishing for public occupancy buildings including drapery, cubicle curtains, wall coverings, and for protective outdoor coverings such as tarpaulins and tents.

test: NFPA 701 Small Scale

This is a vertical flammability test where the test specimens are suspended over a specified ignition source for 11 seconds. At the end of the 11 seconds the ignition source is removed, the “after flame” (time of flaming of the sample after the ignition source has been removed) is timed, and the char length is measured. In addition pass/fail determinations are made based on the observations whether any flaming fragments or residuals continue to burn after they reach the floor of the tester.

results: Untreated fabrics of Ingeo fiber passed the requirements for the NFPA 701 Small Scale 1989 and 1996 test versions.

SGS U.S Testing Company, March 15, 2002, test report # 166372.

C. horizontal flame propagation

See Interface customer case study for results of horizontal flame propagation testing conducted by the Interface Fabrics Group on panel fabrics in Ingeo fiber as well as equivalent PET fiber panel fabrics. (ASTM E-84 Surface Burning of Building Materials (Steiner Tunnel Test)). This and any other available case studies can be found at www.ingeofibers.com.

NFPA 701-89 Small Scale			
Parameters	Test Criteria	Observations	Results
After Flame	2 seconds Maximum	0	Passed
Char Length	5.5" 10 specimen average/6.5" single specimen measurement for fabrics 6.0 oz/sq. yd.	5.4/6.2	Passed
Flaming Residues	Shall not continue to burn after reaching the floor of the tester (Y/N)	No	Passed
Overall Test Result			Passed

NFPA 701-96 Small Scale			
Parameters	Test Criteria	Observations	Results
% Weight Loss	10 specimen average weight loss maximum 40%	35.46	Passed
	Individual specimen weight loss (1% WtL) not more than the mean value plus 3 standard deviations	Max. 1% WtL=45.37" Mean=35.46" 3 std dev.=23.22 Avg+3 std dev=58.68"	Passed
Flaming Residues	Shall not continue to flame after reaching the floor of the tester for more than an average of 2 seconds for 10 specimens	2.0 sec	Passed
Overall Test Results			Passed

3. Smoke Generation

The amount of smoke generated by the material during combustion is a critical flammability characteristic.

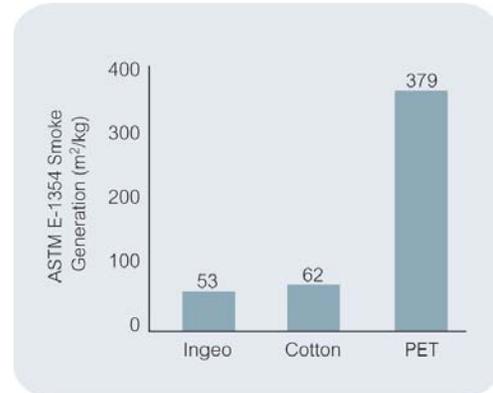
a) smoke generation measurement

test: ASTM E-1354, Cone Calorimeter

Determines the amount of smoke released by the material upon ignition. Using a cone calorimeter, the visible smoke development and release can be measured in square meters of visible obscuration per kilogram burned (m^2/kg).

results: Overall, Ingeo fiber fabrics released significantly less smoke than PET or cotton fabrics.

VTEC Labs, October 23, 1998. Report # 100-879-1, 2, 3



4. Heat Generation

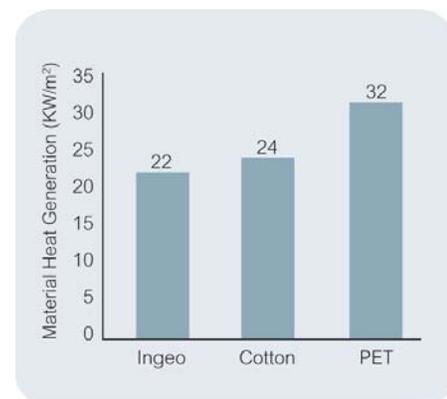
Peak heat release during combustion, measured in KW/m^2 , is an important measurement in assessing the fire development potential of materials and products.

test: ASTM E-1354 Cone Calorimeter tests

The lower the number of peak heat release measured in cone calorimeter combustion testing, the better the performance of the fiber.

results: Fabrics made from untreated Ingeo fibers outperformed fabrics made from untreated cotton and PET based on heat release.

VTEC Labs, October 23, 1998. Report # 100-879-1, 2, 3



Other Testing

Independent testing of fabrics containing 100 percent Ingeo fibers has indicated additional flammability attributes. Fabrics made of Ingeo fibers passed the EN1021-1+2 European standard for cigarette and match with a 15-second flame ignition, British standard 5852-2:1082 using ignition source 2 (Large butane gas flame) for fiber filling for pillows, and FR 16, part 1615 and part 1616 flammability standard for children's sleepwear. A prototype mattress with 100 percent Ingeo fibers successfully passed Cal 129 for furniture flammability.

The laboratory results described in this document were developed under controlled laboratory conditions and are not intended to reflect actual fire hazards. All testing of Ingeo fibers was conducted on fabrics made from 100% PLA without FR treatment, or on fibers made of 100% PLA without FR treatment. Results may vary based on construction or the presence of other materials, including dyes or finishes. Because such matters are outside of NatureWorks LLC's control, customers are solely responsible for their own product claims and for ensuring compliance with applicable laws and regulations.

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