Advanced Textiles EXPO

Characterization of Textile-grade Hemp Fiber as a Sustainable Alternative for Industrial Textiles

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Advanced Textiles Expo 2023

Industrial hemp is an incredibly useful plant, one said to have literally tens of thousands of applications.

Industrial hemp and marijuana are both types of cannabis that are very closely related, but there are some major differences between the plants and how they are generally grown.

Industrial hemp farmers tend to aim to grow the plants up, not out as is the case with medicinal cannabis – and the taller, the better when grown for fiber. This is because some of the great value of industrial hemp in fibre based applications is primarily in its stalk. Industrial hemp is also grown at quite high density.

Like its cousin, flax, hemp is a “bast” fiber, which means that the fiber-producing part of the plant is made up of strands that run its length and surround the woody core of the stem. It grows quickly, is naturally resistant to many insect species, and needs little water to cultivate. It also has a deep root system, which helps to reduce soil loss and erosion, and is useful in many different crop rotations. In China, the leading producer of hemp, farmers rotate it with soybeans, tobacco, wheat, and corn.

Harvesting

Retting

Bast V’s Hurd

Fibre from the industrial hemp plant is one of nature’s wonders – it’s used in everything from stuffing furnishings to high quality textiles. he image above shows a hemp stem. The outer material contains the prized bast fibers and the inner is the hurd, which is made up of short fibers.

There are three main stages of producing fiber from industrial hemp – harvesting, retting and separation.

Decortication

Why hemp sustainable?

Hemp VS Cotton

Hemp needs very little water to grow.	Cotton require twice as much water or more.
Hemp enriches the soil it was grown on.	Cotton depletes the soil it was grown on.
Hemp does not require any pesticides to grow.	Cotton is the highest consumer of pesticides.
Hemp produces twice as much fibers per acre.	Cotton requires twice as much land.
Hemp is the strongest natural, vegan fiber.	Cotton fabric tends to break down quickly.

Hemp fabrics

Hemp fabric VS Cotton fabric for clothes

Hemp fabric VS Cotton fabric for clothes

	Pros	Cons
Hemp fabric	• High tensile strength • Abrasion-resistant • Better air permeability and moisture permeability • Anti-bacterial function	• Stiff and scratchy
Cotton fabric	• Soft and comfortable • No bad odors	• Fade over time • Wrinkles easily • Affected by mildew

Systematic evaluation of the performance of hemp and nylon blended yarns and woven fabrics

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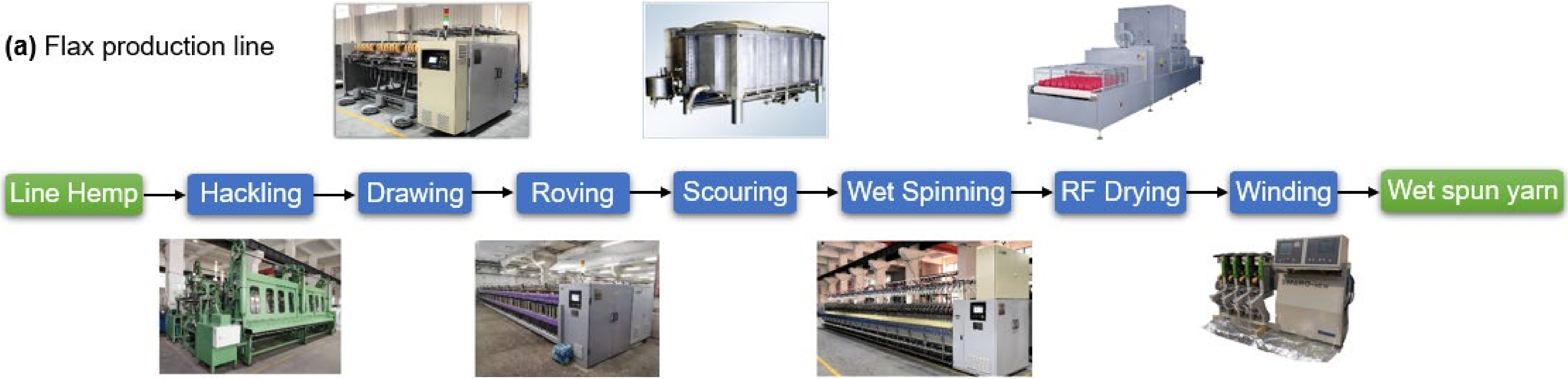
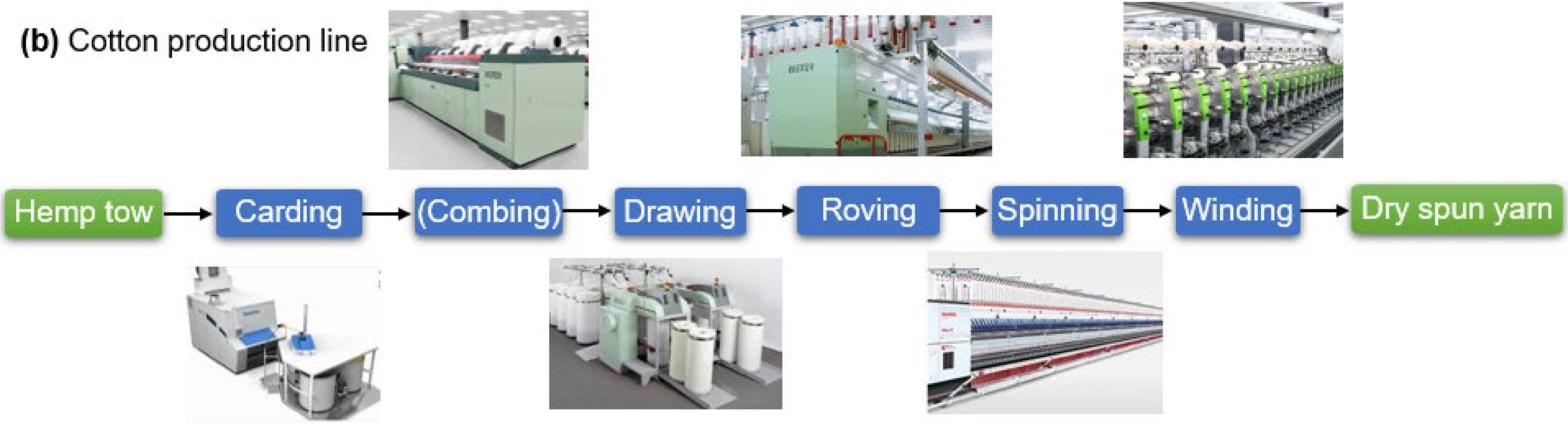
U.S. Department of Defense

Hemp yarn production process – *flax production line*

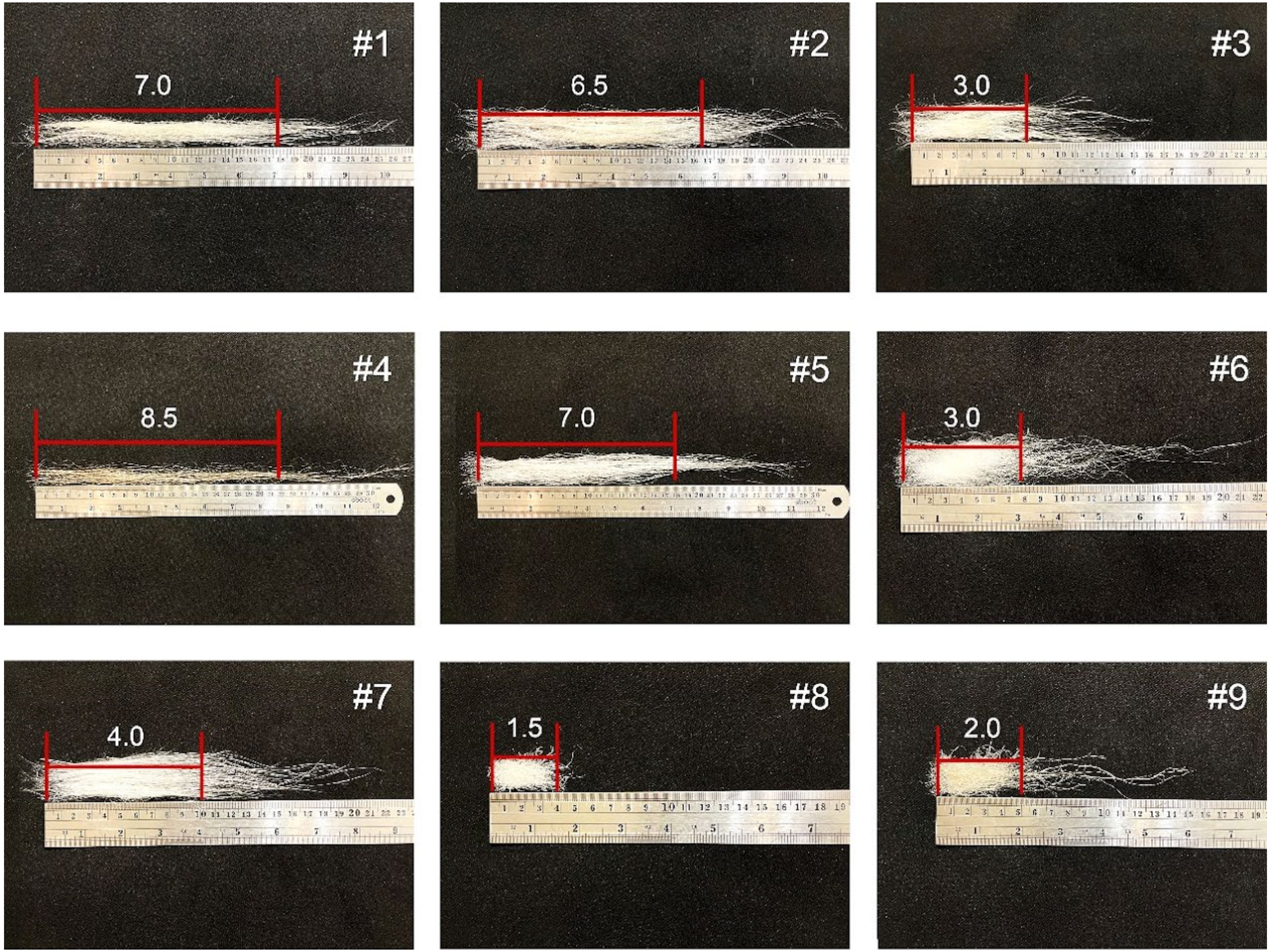


Hemp yarn production process – *cotton production line*

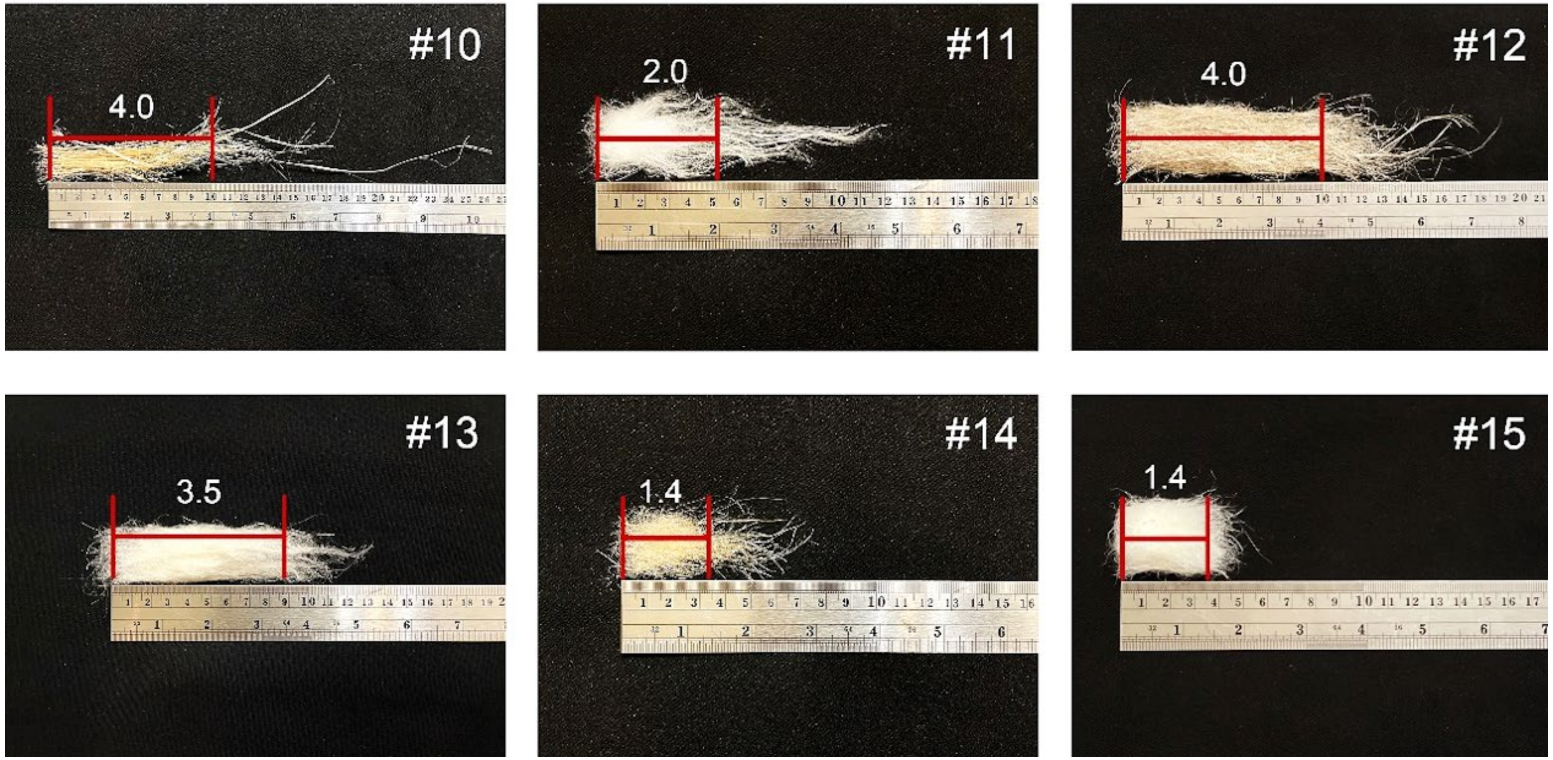


Different types of hemp fiber

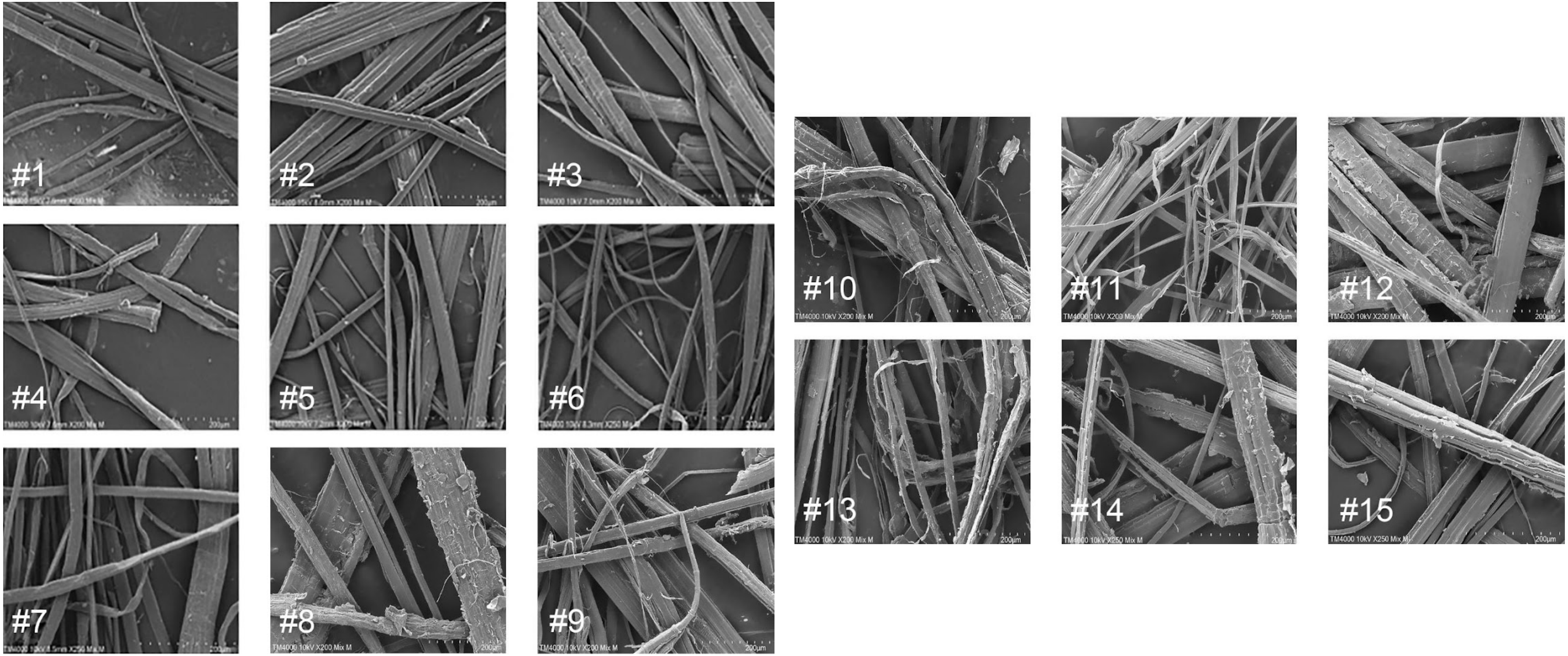
Hemp fiber length



Hemp fiber length

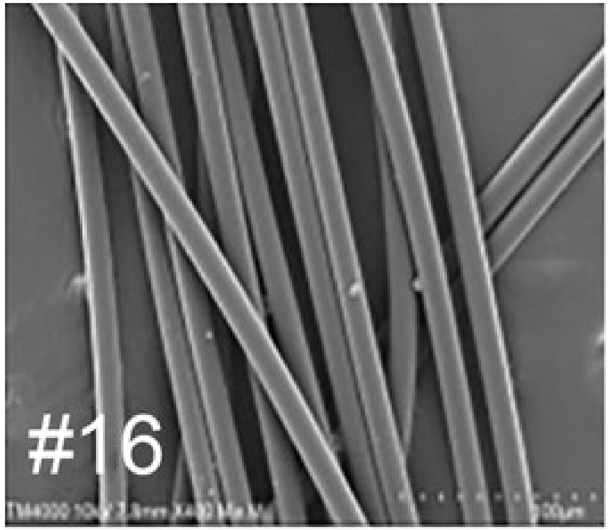


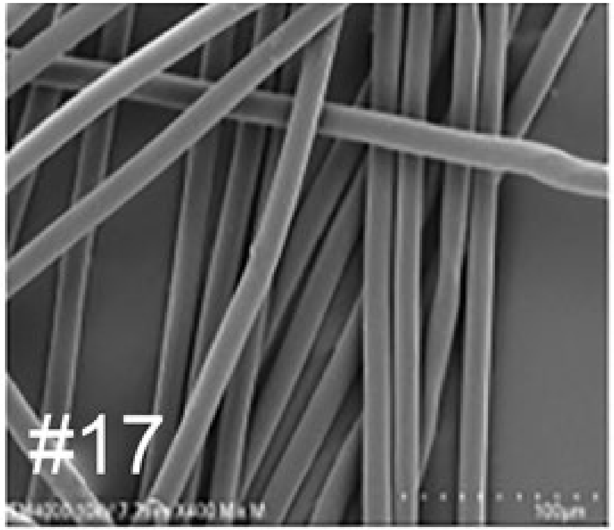
Hemp fiber morphology

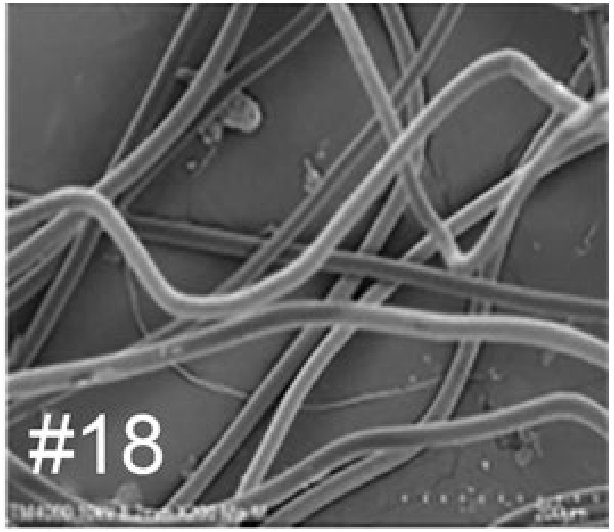


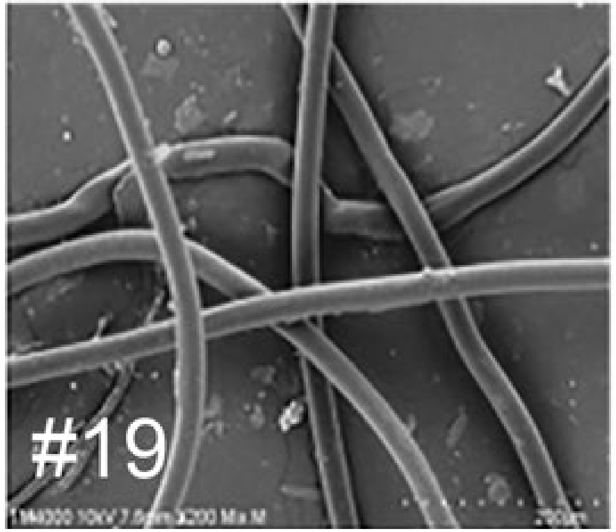
Different types of nylon fiber

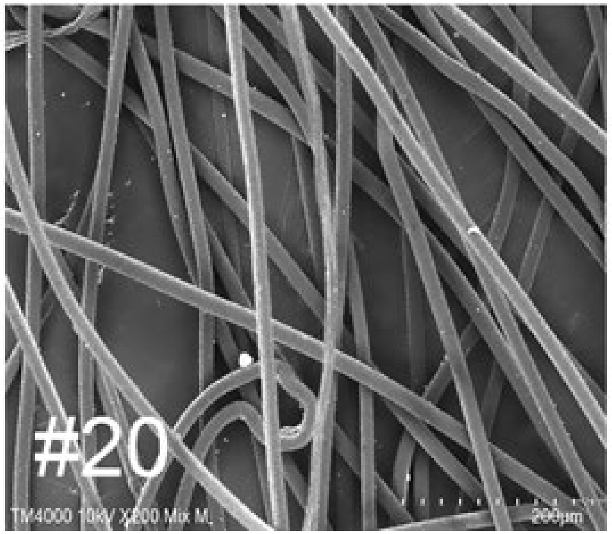
Nylon fiber morphology



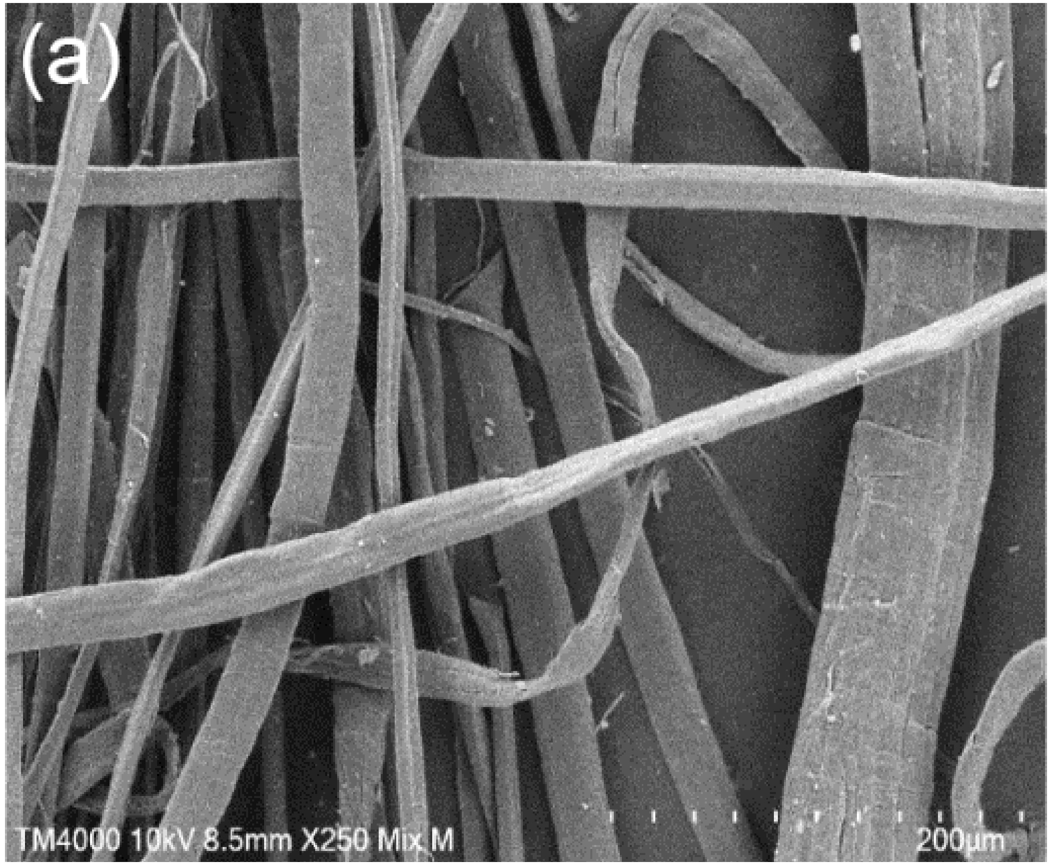






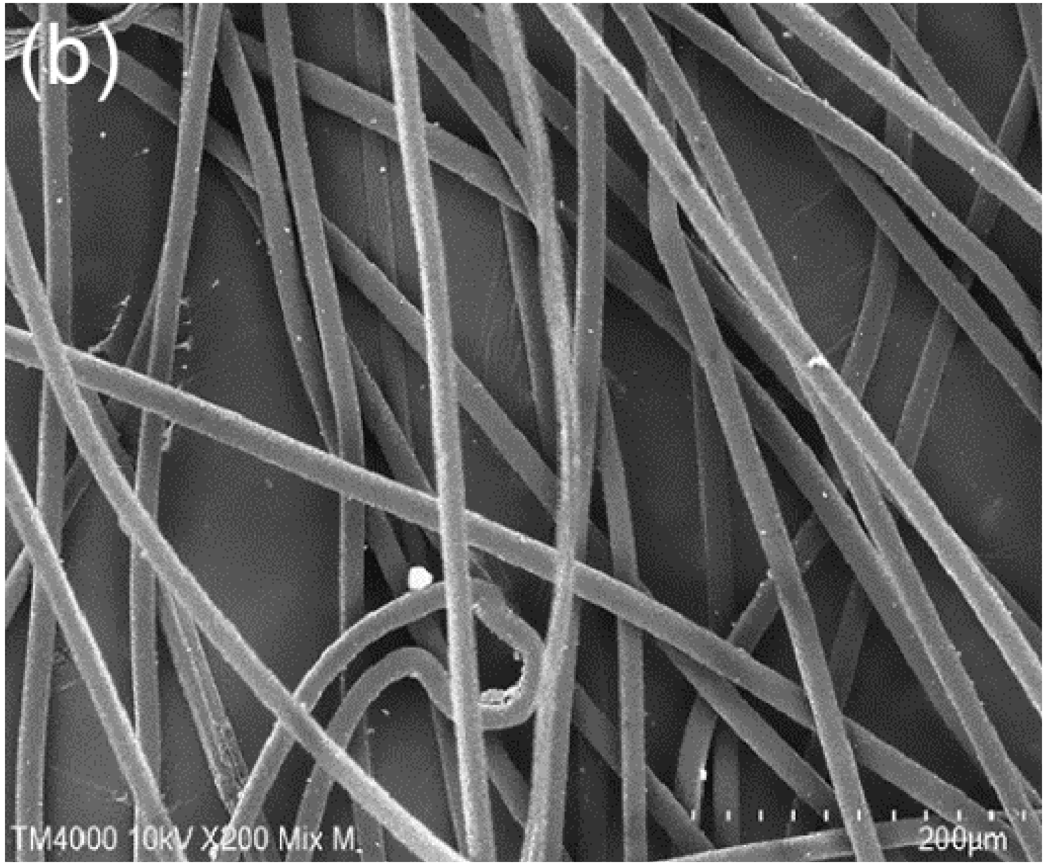


Fiber properties



Hemp fiber

Linear density: 4.97 dtex
Diameter: 26.97 μm
Tenacity: 35.55 cN/dtex



Nylon fiber

Linear density: 2.32 dtex
Diameter: 15.05 μm
Tenacity: 62.2 cN/dtex

Hemp degumming

(1) Oxygen bleaching

(2) Refining

(3) Dehydration

Hemp fiber before degumming

Degummed hemp fiber

Three blends ratio yarn

No.	Abbreviation	Fiber blend ratio	Target yarn count
1	69H/31N	69% hemp/ 31% nylon	Ne 30
2	47H/53N	47% hemp/ 53% nylon	Ne 30
3	31H/69N	31% hemp/ 69% nylon	Ne 30

Opening process

Carding Process

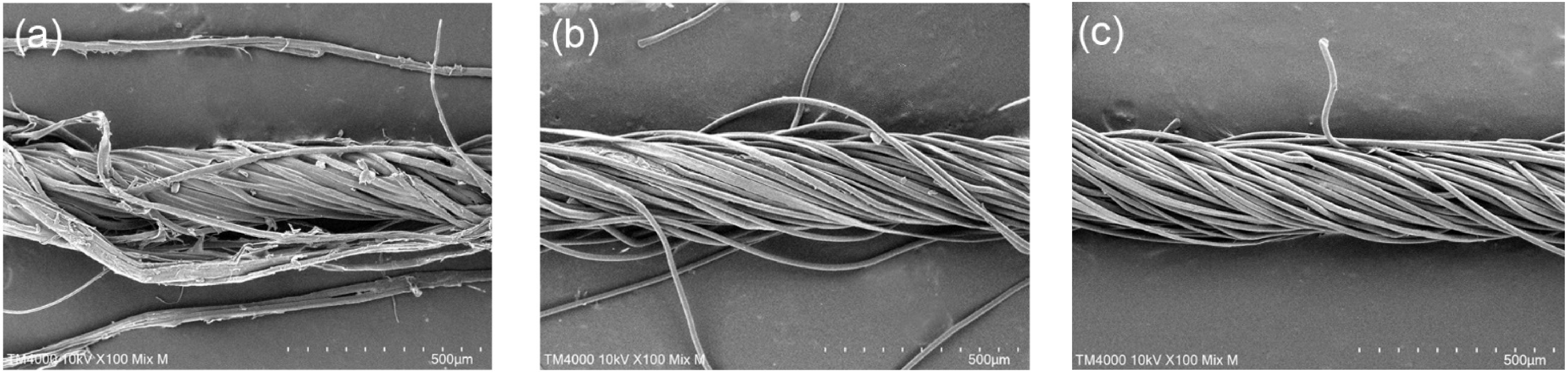
Yarn testing method

Yarn Property	Instrument	Standard
Linear Density	Skein Winder	ASTM D1907
Evenness	Uster Tester 5	ASTM D1425
Hairiness		
Tensile Properties	MTS Q test/5	ASTM D2256

Fabric testing method

Fabric Property	Instrument	Standard
Tensile strength	MTS Q Test/5	ASTM D5034
Dimensional stability	GE APPLIANCES Washer Kenmore Dryer	AATCC TM135-2018t
Abrasion resistance	Maxi Martindale 1609 Abrasion Tester	ASTM D4966
Pilling resistance	Maxi Martindale 1609 Abrasion Tester Apparatus for Fabric Evaluation	ASTM D4970

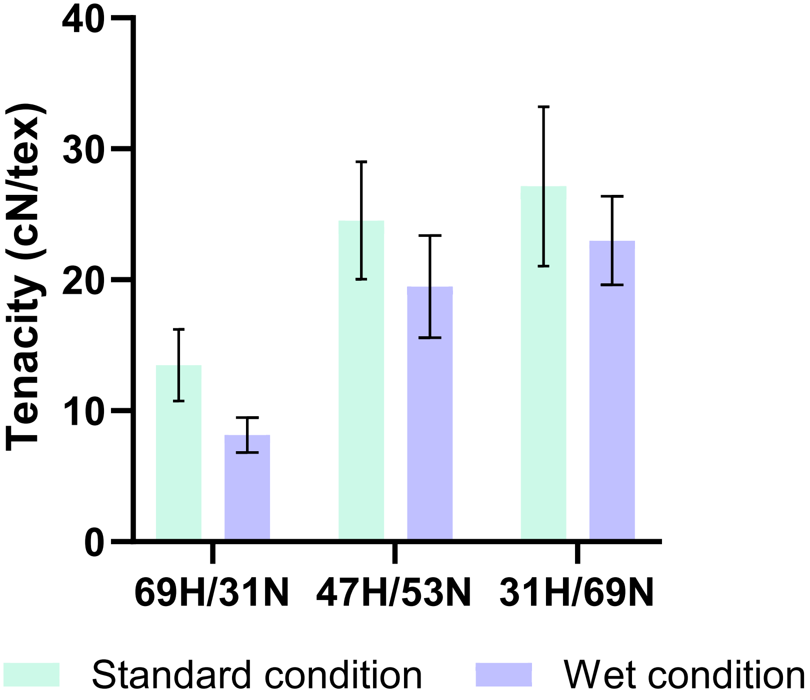
SEM micrographs of yarn

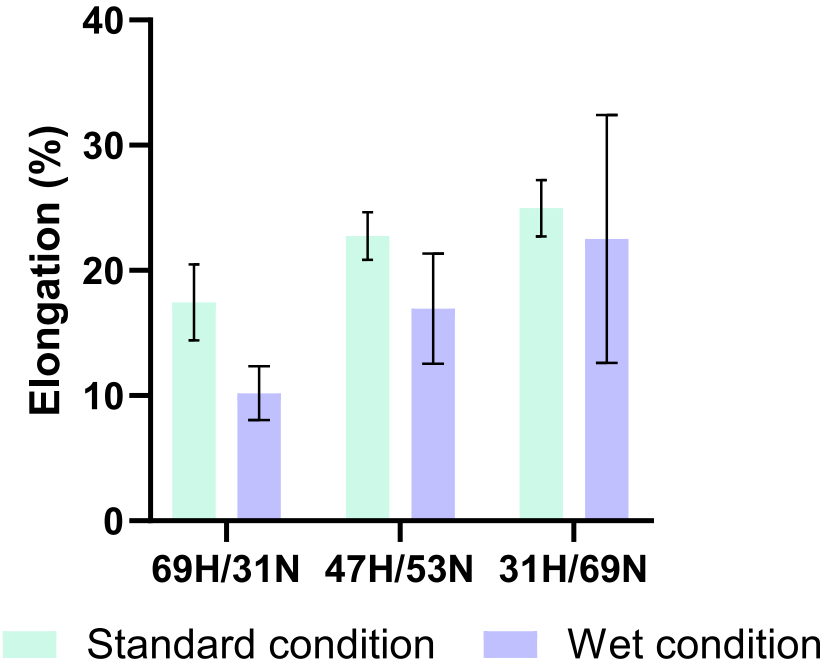


(a) 69H/31N (b) 47H/53N (c) 31H/69N

Yarn with most hemp fibers has the most hairiness sticking from its main body, and the yarn with least hemp fibers has the least hairiness.

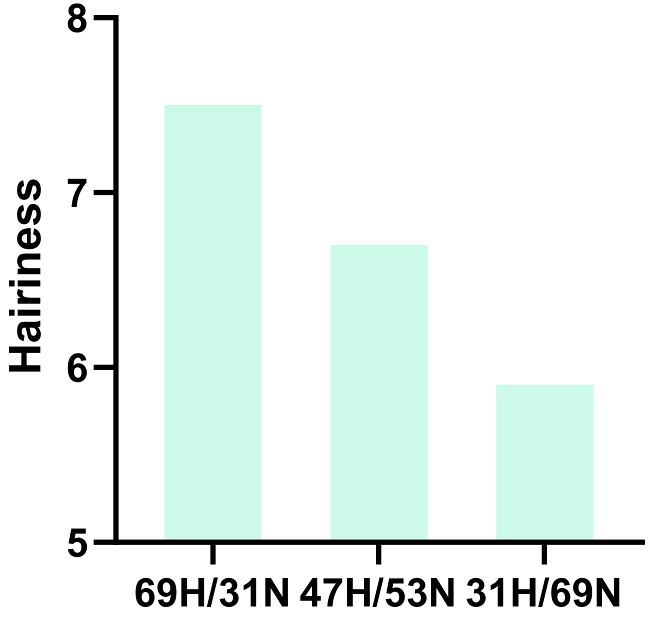
Yarn tensile property





- As the hemp fiber content decreases, the yarn strength increases.
- Yarn tenacity under wet conditions is lower than that under standard condition.
- Yarn elongation, it increases with the reduction of hemp fiber content.

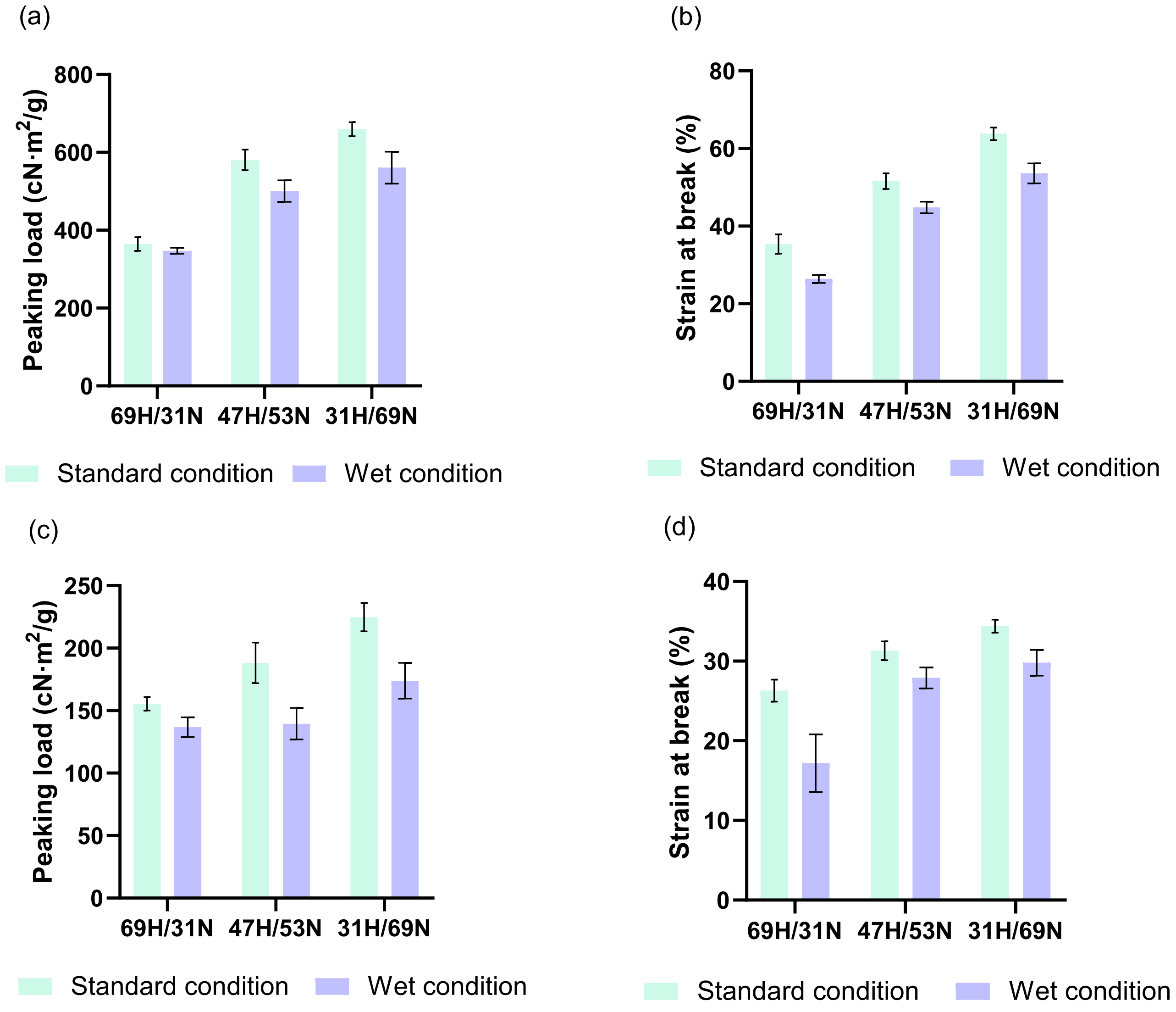
Yarn hairiness and evenness

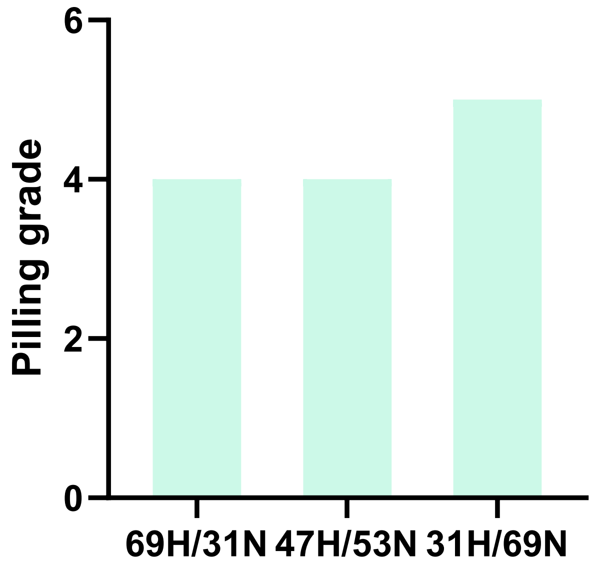


Evenness	69H/31N	47H/53N	31H/69N
CVm (%)	38.9	34.9	30.6
Thin -30%	9215	7696	5969
Thin -40%	7371	5320	3502
Thick +35%	5469	4560	3581
Thick +50%	3829	2986	2210
Neps +140%	6413	4755	3113
Neps +200%	3312	2413	1545

- As the percentage of hemp fiber increases, the blended yarns become uneven and have more imperfections.
- A higher hemp fiber content also leads to an increase in yarn hairiness.

Tensile strength and Pilling resistance of woven fabric





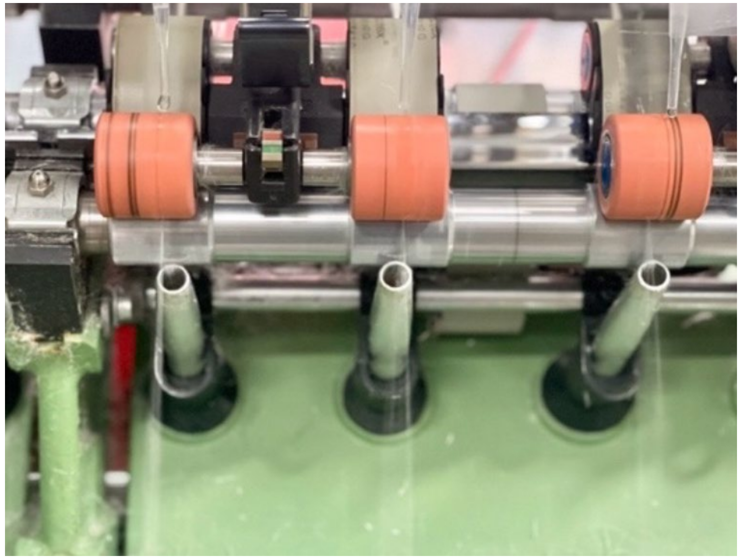
- As the hemp fiber content decreases, the fabric breaking strength becomes higher .
- With the increase of nylon content, the fabrics show better pilling resistance.

Dimensional stability of woven fabric

Dimensional Change		31H/69N	47H/53N	69H/31N
De-sizing	Warp direction (%)	-9.19	-10.96	-11.33
	CV (%)	[15.74]	[17.52]	[10.94]
	Fill direction (%)	-2.44	-3.56	-3.78
	CV (%)	[9.09]	[10.67]	[10.05]
3 laundering cycles	Warp direction (%)	-2.45	-1.56	-4.09
	CV (%)	[26.53]	[89.74]	[24.45]
	Fill direction (%)	-0.84	-1.54	-1.31
	CV (%)	[15.48]	[16.88]	[9.92]

- The size of all fabric samples changed significantly after desizing.
- Changes are not obvious after the three-laundering cycles.
- Fabric with most hemp fiber content shows the worst dimensional stability.

Future research



- Hemp fiber degumming
- Hemp fiber opening
- Hemp yarn spinning

Sustainable choice: hemp

[Hemp Extension at NCSU]

The future of hemp production is at a watershed moment. Restrictions on this once-stigmatized crop are being lifted around the world, and people have an increased awareness of the concerns accompanying input-intensive agriculture. There is much excitement about the sustainability potential of this fiber crop, but growing, sourcing, or wearing hemp won't be a solution in itself – it will all depend on how that hemp is grown.

Thanks !