TMS 211 (203) Fiber Library

Kevlar

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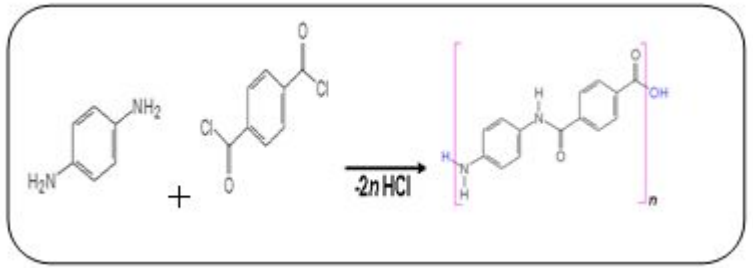
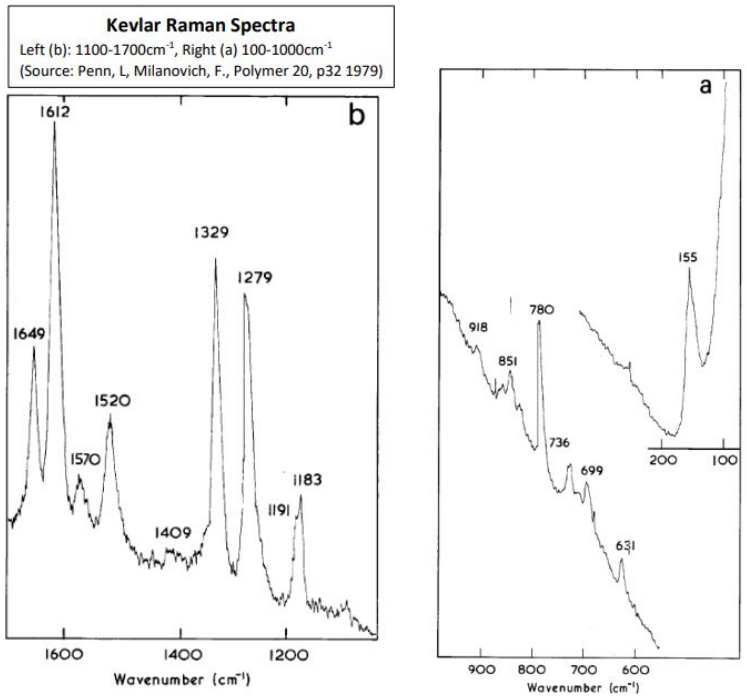
Fiber Classification	Organic fiber in the aromatic polyamide family.
Fiber Density	1.44 g/cm^3
Brand name and/or major manufacturer	DuPont
Typical Fiber Applications	• Used to manufacture spun yarns. • Used in felt and nonwovens to increase insulation. • Used in firefighting equipment, such as SCBA gear, escape harnesses, and belts. • Used in fall protection for the safety of workers. • Military and Aerospace gear
Typical Fiber Properties	• High strength • High modulus - stiff and resistant • Toughness • Thermal stability
Additional Facts (3 Fun facts)	Viewing the two materials pound to pound, Kevlar is 10 times stronger than steel.
	Kevlar's intense strength is from its inter-chain bonds, which are similar to woven fibers.
	Kevlar is heat resistant and although it is a plastic, it can be heated up to 850 Fahrenheit and won't melt.

Chemical Structure

Kevlar is an aromatic polyamide, which equals the molecules forming long, strongly-oriented chains. It is made by a condensation reaction of a amine and acid chloride. The chains themselves are rigid and form planar sheets, similar to chains in silk. This is because of the orientation of the benzene rings, which lock together during spinning using H-bonds, which causes high strength. They also stack and overlap, causing more interactions and thus, increasing the overall strength of the fiber.



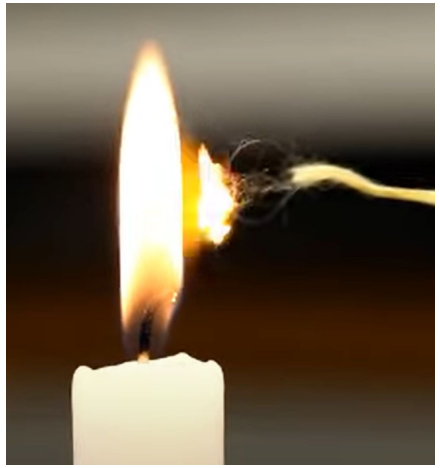
Raman Spectra

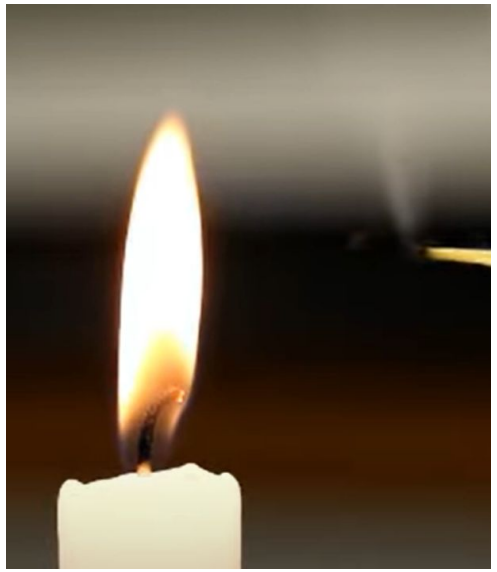


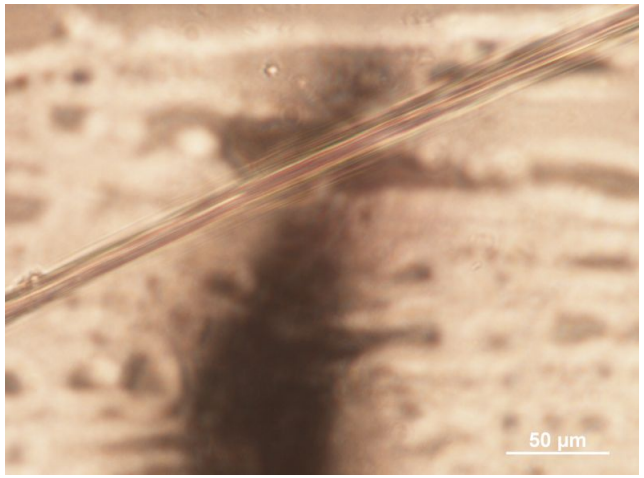
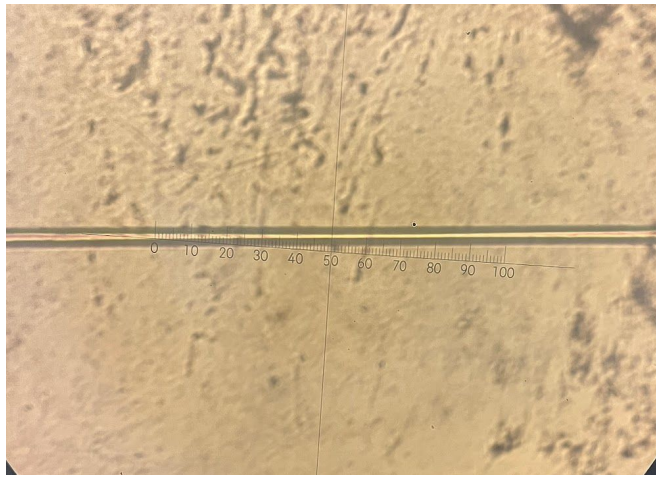
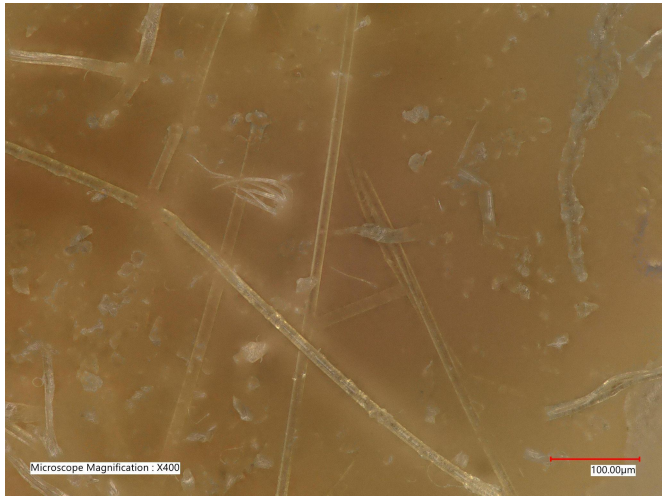
Major Raman Peaks at:

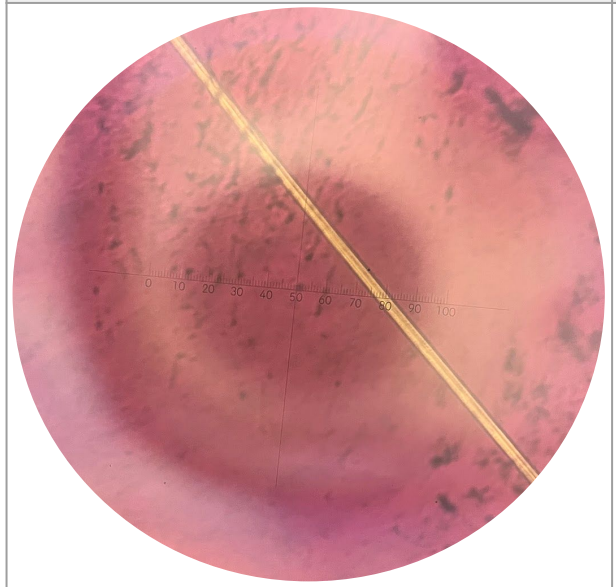
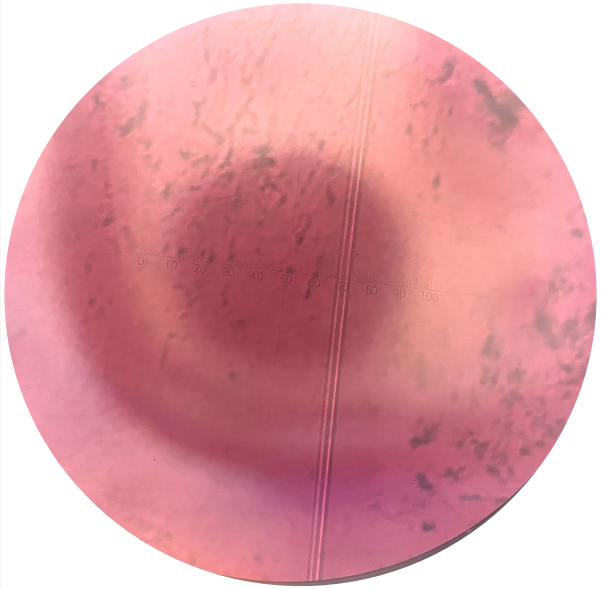
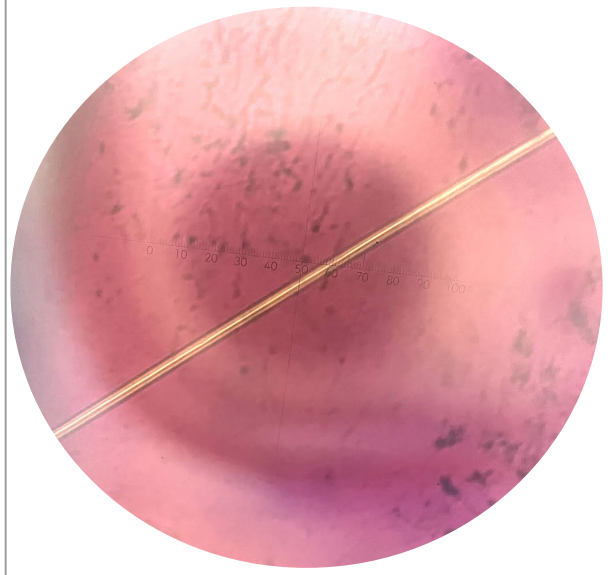
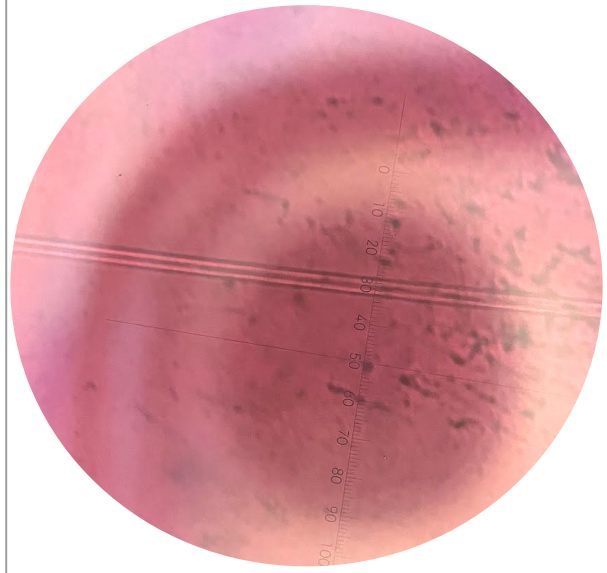
- 1649 cm^{-1} - C=O functional group
- 1612 cm^{-1} - Aromatic ring
- 1329 cm^{-1} - C-N bond
- 1279 cm^{-1} - C-C function group, highly mixed in complex molecule

Flammability	**Approach**	Kevlar, when initially approached to a flame, shrinks.
	In-Flame	When in-flame, Kevlar burns quickly. The color of the flame is yellow and red, and the size of the flame is relatively small. Based on the video footage, there is little smoke during ignition, but some gray smoke once it is pulled away from the fire. The odor is similar to nylon burning.
	Remove/Reside	When removed, it does not have any afterglow. It also stops burning once it is removed from the direct flame. It also has charred fibers that fall off when you try to crush the Kevlar.






LONGITUDINAL						CROSS-SECTION		
Magnification	400x					**Magnification**	400x	
								
After viewing Kevlar in the 400x magnification level, you can generally see its morphology. The shape is very straight, with no crimp or waviness visible to the human eye. The surface is relatively smooth, and you cannot see many bumps, dark lines, etc. Additionally, in the center of the fiber, you can see a bright yellow center, almost like its glowing.						While somewhat difficult to tell from the cross-sectional image, Kevlars cross section looks like it could be a dog bone or lobed. From this image, you can see some surface imperfections, like bumps. The cross section looks solid throughout the inside, with no hollow elements.		
Fiber diameter (µm)	12.040	12.956	11.420	11.125	11.410	**Average fiber diameter (µm)**	296.0904	
	18.656	18.438	15.038	14.587	11.912	**Linear Density**	3.84 den	4.26 dtex

UNDER CROSS POLARIZATION			
Extinct at which directions?	N-S and E-W		
NW-SE (\)	**N-S (|)**	**NE-SW(/)**	**E-W (–)**
			
Bright yellow in color, slightly darker yellow on the outside of the fiber's surface. Straight and no crimp in the shape.	**Dark pink in up-and-down direction, which difficult to differentiate from red plate itself. Fiber has some darker lines on its center. Based on this red plate image, it is extinct in this direction .**	**Same as NW-SE direction, generally bright yellow in color with some dark yellow/brown on the outside edges. Straight and thin in shape. NOT extinct in this direction based on the bright color!**	**Same or similar to N-S direction, with the general color being a dark pink/red with some color differentiation on the surface. Based on color difference, it is also extinct in this direction.**

References:

- DuPont. (2019). Kevlar technical guide (March 2019). Retrieved from https://www.dupont.com/content/dam/dupont/amer/us/en/safety/public/documents/en/Kevlar_Technical_Guide_0319.pdf
- Sturges Manufacturing Co. (n.d.). The ultimate guide to Kevlar fiber and applications. Retrieved from https://www.sturgesmfgco.com/ultimate-guide-to-kevlar-fiber-and-applications/
- DuPont. (n.d.). Kevlar properties. Retrieved from https://www.dupont.com/news/kevlar-properties.html
- EpicentRx. (n.d.). Bullet blog #3: Fast facts about Kevlar. Retrieved from https://www.epicentrx.com/blog/bullet-blog-3-fast-facts-about-kevlar/
- Karthikeyan, B., Binoj, J. S., Edwin Raj, R., & Sabu, T. (2012). A study on mechanical and thermal properties of Kevlar and its hybrid composites. American Journal of Materials Science, 2(6), 126-130. doi:10.5923/j.textile.20120106.04