ADES 4215

SWIMMING UPSTREAM

A Fact Finding Mission to Understand Microplastics in Swimwear

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HOW IT STARTED

**Sustainability is everywhere now.
But is everything that's marketed as green actually good for the environment?**

A new take on sustainable swimwear includes using fabrics made of recycled polyester or nylon, but research also shows that swimwear can be a serious source of **microplastics** when worn in bodies of water. While making use of plastic litter is positive, it is a short-sighted approach to sustainability.

Based on this understanding, we wanted to ask the question:

"Are there next generation fibers that can shed less microplastics while also not losing the performance qualities necessary for athletic swimwear?"

In order to test this theory, we decided to perform a handful of textile tests relevant to swimwear on a variety of fabrics including:

- **Virgin Synthetics: virgin polyester, virgin nylon**
- **Recycled Synthetics (recycled polyester, recycled nylon)**
- **Bio-Based Fabrics: Sorona Agile, EVO, Tencel Lyocell**
- **Natural Fibers: Cotton**

WHAT ARE MICROPLASTICS?

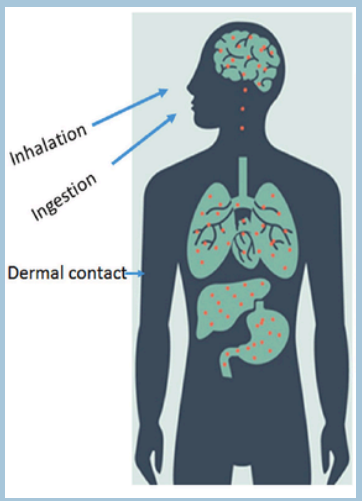
microplastic (n.): small plastic pieces less than 5mm long

Microplastics are a serious form of pollution that can now be found in the air, ground, oceans, sea creatures/seafood, as well as the human body, including the blood, liver, and brain.

Microplastics can come from being directly manufactured ("primary microplastics") or from the breakdown of larger plastic products ("secondary microplastics) such as car tires.

EFFECTS OF MICROPLASTICS

- Sea creatures can mistake microplastics for food and consume them, causing humans to ingest microplastics when eating seafood
- Microplastics disrupt animals' development, reproduction, and immune systems
- Microplastics in water disrupt the natural carbon sequestering done by zooplankton and can enter the food chain here.
- Microplastics in water can speed up the melting of ice as they affect the amount of light refracted by water.
- Human ingestion of microplastics can lead to gastrointestinal disturbances, endocrine disruption, and the potential transmission of pathogenic bacteria.



- Can be found:
  - Air, Soil & Water
  - Sea creatures/seafood
  - The human body includes the blood, liver, and brain
- May come from manufacturing, called **"primary microplastics"**
- Also, coming from the breakdown of larger plastic products, called **"secondary microplastics"**

MICROPLASTICS
IN THE APPAREL INDUSTRY

- While microplastics have been a known problem since the 1960s, it was only in 2011 when a study revealed how polluted by microplastics our oceans are made them a hot button topic
- In 2016, a study by the University of Plymouth revealed that the washing of clothing in a machine can be a major releaser of microplastics into our water systems
- All in all, the study of microplastic fiber (MPF) shedding in the apparel industry is pretty new
- Some sources contradict one another
- Some product solutions exist, such as the GUPPYFRIEND bag

What Current Research Has Found:

- 84% of MPFs come from edges
  - Laser cut vs. knife cut
- Initial washes can release 6 to 120x more MPFs
- Denser, more tightly constructed fabrics are less likely to shed

However, a 2024 study done by Arizona State University found that a single day of water activities, such as swimming and tubing, caused water microplastic numbers to increase by 8x.

MICROPLASTICS
& SWIMWEAR

A popular new take on sustainable swimwear is to make them from recycled polyester and nylon, often derived from ocean litter like PET bottles and old fishing nets.

PROJECT EVOLUTION

HOW OUR PROJECT CHANGED WITH NEW INFORMATION

RESEARCH Q1

How can we create a swimsuit that **releases the least amount of microplastics** and market it towards large retailers to **show capital gain?**

Hmm, maybe materials research goes deeper than we thought...

RESEARCH Q2

How do we **accurately test materials** for their micro-plastic release under different conditions, and **how can we educate brands** and retailers on their material choices?

What does testing look like? What does regulation look like?

RESEARCH Q3

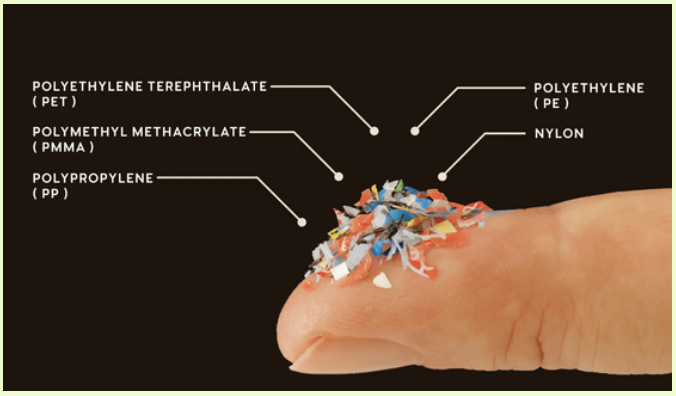
How can we **standardize** the current state of materials testing and show that **micro-plastics from swimsuits is a problem** effecting oceans?

Wait a minute, Bio Materials is greenwashing??

RESEARCH Q4

How can we **educate ourselves and our peers** about the real state of *"Bio-Materials"* and why **interdisciplinary design is important?**

GLOBAL STANDARDS
REGULATIONS AND CERTIFICATIONS



Despite the major micro plastics issue in the apparel industry , there are currently...

NO

GLOBAL STANDARDS OR REGULATIONS TO LIMIT THE SHEDDING OF MICROPLASTIC FIBERS IN TEXTILES

Standards in the materials industry concerning micro-plastics are relaxed due to the lack of research in the industry. The focus on micro-plastics is in the food and packaging industries, even though our available synthetic textiles we have create the same byproducts.

NO

LAWS FOCUSED ON MICROPLASTIC FIBER SHEDDING IN OCEANS IN COASTAL STATES

In states such as California and Hawaii, the focus on micro-plastic release is in the cosmetics industry, specifically the release of microbeads in water.

02

YEARS IS THE AGE OF ISO'S FIRST AND ONLY STANDARDS CONCERNING THE ANALYSIS OF MATERIAL LOSS IN FABRICS

There is a lack of research in micro-plastics as a whole, and an overall lack of standardization for microplastic loss in fabrics. The first and most recent standard released by the ISO was released in 2023.

WE ARE ALL VICTIMS OF GREENWASHING!

The apparel industry is notorious for marketing its products to appear more environmentally friendly than they are. However, this industry is an incredible contributor to worldwide pollution and waste. $400 billion dollars worth of clothing go to landfills each year while 90% of them are still reuseable or recyclable (Moazzem et al., 2021). Despite the marketing claims that boast “eco-friendly” or “bio-based” fabrics, they may not be as much of a friend to the environment as consumers think.

The purpose of this section is to understand new “sustainable” textiles from a molecular point of view in comparison with virgin synthetic textiles. It also examines how brands are currently marketing these textiles to educate consumers on how to look beyond the buzz and understand what they are really buying.

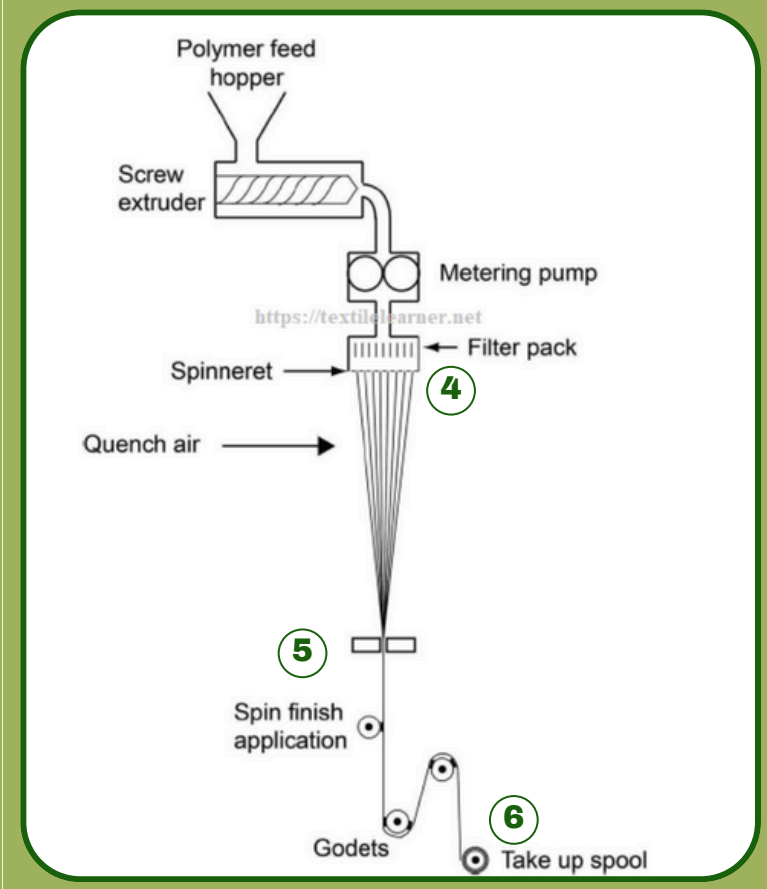
CHEMISTRY OF POLYMERS

HOW POLYESTER IS MADE

To understand how virgin synthetic fibers and their “sustainable” alternatives compare, we must first know how synthetic fibers are formed. Below is a description of the polyester creation process.

1 Crude oil is extracted from the ground, refined and distilled

2 Then, it is separated into the monomers terephthalic acid and ethylene glycol*



3 Monomers go through condensation polymerization in a reactor vessel to form a chain, this creates the polymer polyethylene terepthalate or PET

4 Molten PET is extruded through a spinnerette to form long filament

5 It cools as it falls and is spun into yarn, this is also when finsihes are applied

6 Finished yarns are wound onto spools to get ready for the knitting/weaving phase

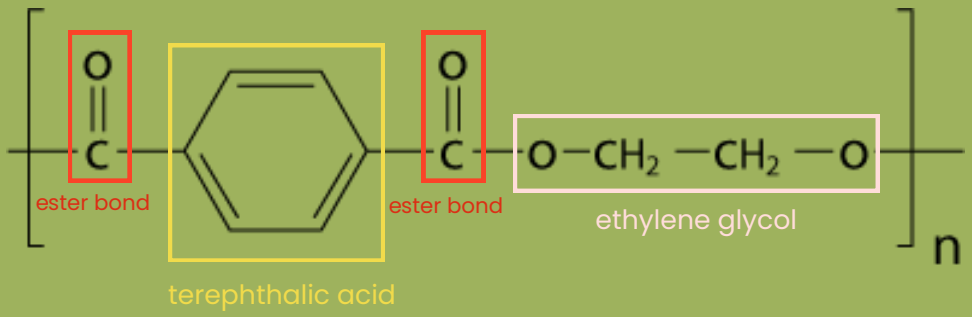
*Nylon is made using a similar process but with hexamethylenediamine and adipoyl chloride

CHEMISTRY OF POLYMERS

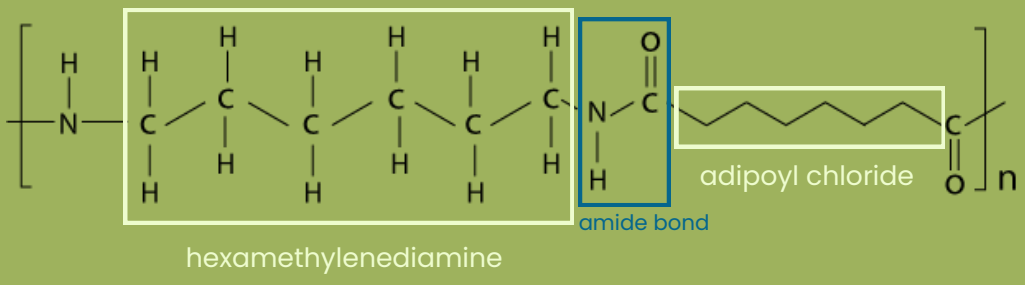
POLYESTER VS. NYLON VS. PLA FIBERS

In terms of molecular structure, polyester, nylon and PLA fibers are formed in similar ways. The kind of polymer can be identified by the type of monomers they're made of and the type bond that chains them together. "Poly" means many and indicates that there are many monomers chained together. For example, polyester is formed of the two monomers terephthalic acid and ethylene glycol. The bonds that hold them can either be "ester" bonds or "amide" bonds. Both polyester and polylactic acid are bonded with "ester" bonds, whereas nylon has "amide" bonds which are hydrogen bonds and are more difficult to break. This also means that polyamides are more difficult to recycle. When polyesters or polyamides are recycled, the resulting polymer has an identical struture to the original and will degrade in the same fashion.

POLYESTER polyethylene terepthalate

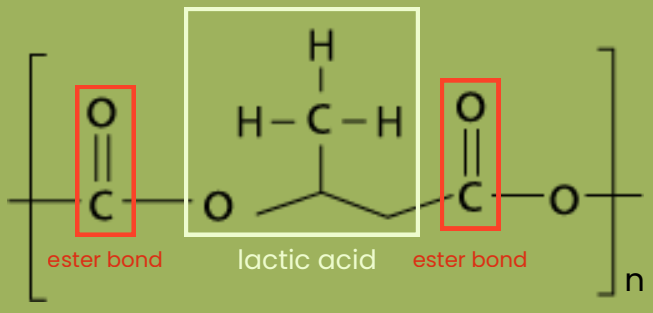


NYLON polyamide nylon 6, 6



PLA FIBERS polylactic acid

PLA fibers have a structure that allows it to be broken down by naturally occuring microbes more easily than the other two. Because of this, it is often used for compostable plastic products. However, this material is only biodegradable when exposed to high concentrations of microbes that exist solely in industrial composting facilities. It will not break down in nature.



“SUSTAINABLE” ALTERNATIVES

A COMPARISON

There are numerous types of “sustainable” alternatives to virgin polyester and virgin nylon that claim to be more environmentally friendly. These polymers can be categorized in to the three main categories of recycled, bio-based and biodegradable as defined in the figure below:

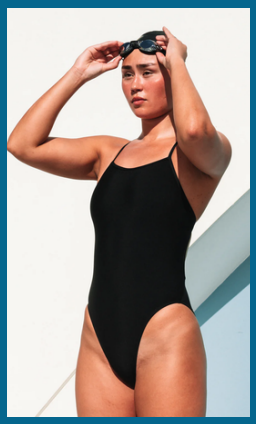
Recycled	Bio-based	Biodegradable
Textiles made from recycling polymers like PET through melting and respinning. Can be derived from virgin synthetic textiles, plastic water bottles and other PET products. Is referred to as rPET.	Textiles made from naturally-occurring and renewable sources like castor beans and corn. Has the same structure as polyester or nylon polymers and will break down in a similar fashion.	Textiles derived from natural sources like beets, corn and castor beans. It is the form of polylactic acid or PLA. The structure allows microbes to break down more easily when composted industrially.

The largest differentiators between these three types of polymers are the feedstock they are made from and the waste stream they enter at the end of their life. Recycled fibers come from synthetic fibers which are a petroleum feedstock and will enter the recycling stream to be used again. Recycled fibers have an identical molecular structure to virgin synthetic fibers and will degrade in the same fashion, possibly contributing to microplastic pollution. Bio-based fibers come from natural feedstocks like castor beans and corn which are also renewable sources, however they are not biodegradable and so will have to be recycled or will go into landfill waste--possibly contributing to microplastic pollution.. Biodegradable fibers are derived from natural and renewable feedstocks and are also industrially compostable--the only waste stream it can enter without disrupting the process. Our recycling centers cannot handle these fibers and they will not compost naturally in landfills. The current research on PLA is inconclusive on whether or not they produce a greater, equal or lesser amount of microplastics than other forms of plastic.

	Recycled	Bio-based	Biodegradable
Synthetic			
Petroleum-derived			
Sheds MPs			
Degrades in nature			
Composted industrially			

BRAND CASE STUDY

BRANDS AND THEIR MARKETING TACTICS



Jolyn

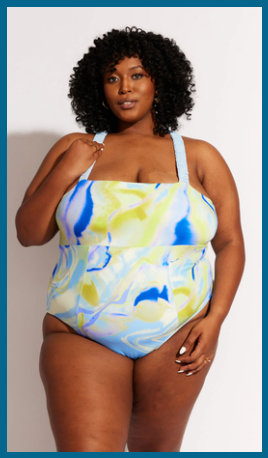
- **100% Polyester**
- "We are committed to completely replacing our original Foreverever® fabric with Recycled Foreverever® by the end of 2024. 51% of the fiber in this polyester fabric comes from recycled water bottles."

Here, Jolyn has claimed that they have phased out their virgin fabrics and are trying to use only recycled fabrics, yet they still are selling suits that are 100% virgin polyester. Also while they have a whole line of suits that cater to surfing, there are no mentions or ocean microplastics in there website.

Mesa

- **Sewn with elastic thread**
- 100 % Cotton "Certified Safe – OEKO-TEX Standard
- "Our 100% cotton swimsuits offer exceptional stretch, quick drying, and complete freedom from synthetic plastic fibers... [these swimsuits] complement healthy, seed oil-free skin—so you can soak up the sun without also soaking toxic plastic."

The irony with these suits is that there is no way for cotton to be quick-drying or have good stretch recovery. The way that Mesa archives this is through smocking the fabric with elastic thread, which is made from plastic. So their tag lines of freedom from synthetics and not soaking up "toxic plastic" are not entirely telling the whole story.



NOMADS

- **46% Bio-based Nylon, 46%** Recycled Nylon, 8% Elastane
- Crafted from ultra-soft, biodegradable, and recycled Nylon

On first glance, Nomads seems to be doing everything right. They highlight that they are: "a Black woman-owned swimwear brand that creates luxe, sustainable swim and resortwear for sizes XS-5X". With a design focus on creating styles for plus sizes and larger cup sizes. They highlight that some of their suits are "biodegradable", due to the use of Bio-based nylon, but as stated previously, just because the carbon is coming from a natural source does not mean that it is biodegradable. This nylon has the same properties as virgin nylon, will still shed microplastics and not biodegrade.

MANUFACTURING CASE STUDY

FIBER MANUFACTURERS AND THEIR MARKETING TACTICS

These are all different emerging or next generation fabrics that are marketing themselves as the answer to all of the industry's sustainably calls. These quotes are all taken from their websites. They are all knowingly greenwashing to apparel brands and designers that don't fully understand the chemistry behind what they are doing. By marketing themselves as luxury activewear fabrics, they can appeal to designers.

COVATIONBIO. sorona®

"The content of your fabric tells the world what you're made of.
Apparel made with Sorona® fabric enables people to look good and feel good while doing good for our planet."
"Fashion a sustainable future, today.
Sorona® answers the global call for sustainably sourced fabrics, bridging the personal and societal at a defining moment in our ecological stewardship. Sorona® gives you the opportunity to make sustainability a reality."

- **Sheds microplastics**
- **Creating more plastic but using a different carbon source**
- **Will not biodegrade**

This fabric and technology are owned by DuPont, a massive brand known for its less-than-sustainable practices. They have created a separate website, most likely to distance themselves from this reputation.

REPREVE®

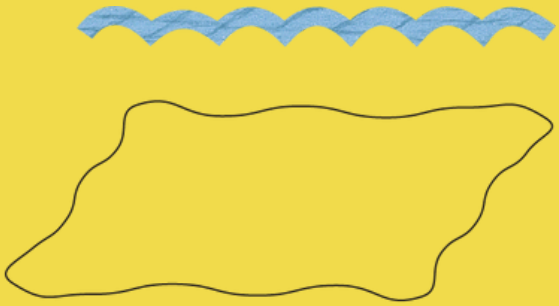
"REPREVE® reduces reliance on virgin raw materials and gives waste a purpose. Whether you're focused on protecting our world's oceans or championing waste responsibility, purchasing REPREVE® means purchasing certifiably-recycled products, transparent labeling, and responsible habits."

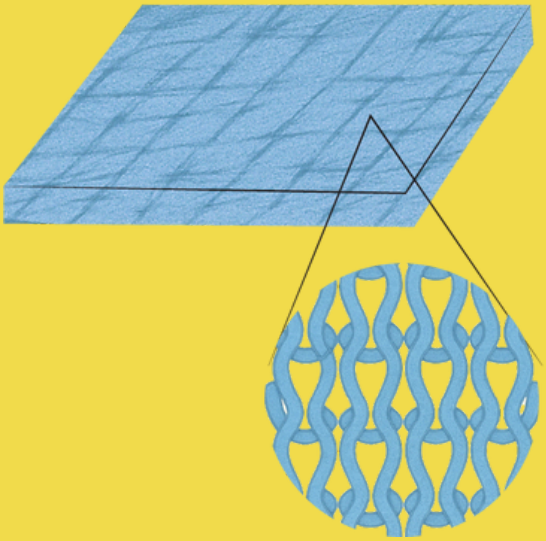
- **Sheds microplastics**
- **Limited fiber-to-fiber recycling and pulling from non-textile waste stream**
- **Will not biodegrade**

While claiming to protect the world's oceans, this fabric is still shedding microplastics. Also, by using PET plastic, they are taking waste out of another stream to recycle and not focusing on recycling textiles. This will eventually result in more plastic PET being created to make up for the loss of used bottles to recycle.

FABRIC ANALYSIS

ALL FABRICS HAVE MICROPLASTICS - WHERE CAN WE REDUCE SHEDDING?





PROBLEM	OPPORTUNITIES
• Poly threads most commonly used • Weak seam types	• Thread coatings • Regulations on swimwear construction/testing to ensure garments are properly made
• Repetitive washing to degrade fibers during user period	• New Low Friction Coatings
• Intense washing. and abrasion from dying and print	• Regulation of washing filters to limit microfibers enter water stream • Natural dyes and prints
• Synthetic fiber fabrics used because of useful swim properties • Microfibers from cut fabric	• Focus on biodegradable materials • Laser-cutting over scissors or knives
• Structure always needs percentage of spandex (synthetic) • Typically knits used in swimwear	• New Xlance elastane fiber for minimal microfibre shedding • Further research to determine microfibre shedding between wovens and knits

KEY TAKEAWAY:

Why isn't innovation from all parts of fabric being combined to reduce microplastics?

CONCLUSION

OUR RECOMENDATIONS FOR AREAS OF FUTURE RESEARCH

- **Legislation and regulation**
  - If states were to require textile companies to test for microplastics, there would be an overall greater understanding of the extent of this issue, and a plan for limiting microplastics could be put in place. For example, limiting the types of fabrics used for creating swimwear. Another aspect of this would be to require companies to have an end-of-life plan for garments, shifting this issue from consumers back onto the companies that create these polluting garments.

- **Educate designers and the industry about this problem**
  - Overall, there could be better textile training for folks working in the apparel industry at all levels, and not just people who work with textiles, but also designers. This could be introduced as certifications
  - Increased education about microplastics

- **More educational components in industry events and conferences**
  - Create more tangible outcomes and changes at industry events and conferences. An example of this would be to have certifications and textile training integrated into events. This would create another productive element to the conferences and give attendees really helpful information to take back to their work.

- **Changes to the ADES program**
  - These changes could mainly focus on how the textile class is taught. These changes could look like more hands-on elements when learning about how synthetic fabrics are made, and touching on the topic of microplastics. This could be done by having Dr. Mauer-Jones, a microplastics researcher and Chemistry / Biochemistry professor, give a guest lecture about this topic. Another aspect could be expanding elective options to allow ADES students to take material science classes as upper-level electives.

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APPENDIX A

FABRIC TESTING

TESTING OVERVIEW

Key Test: Microplastic Fiber Shedding	5 washes
Additional Tests:	
• Abrasion Resistance - Wet & Dry	N/A
• Stretch & Recovery - Wet & Dry	2 hours
• Saltwater Resistance & Drying	1.5 hours

TESTING PROCEDURES

MICROPLASTIC FIBER SHEDDING

1. Weigh the initial mass
2. Wash all fabric samples (9) in the domestic washing machine
3. Allow to air dry
4. Weigh the new mass
5. Repeat 2 more times

ABRASION RESISTANCE

1. Weigh the initial mass
2. (Soak the wet samples in saline solution)
3. Pin the sample to the foam board
4. Apply the sanding drill for 20 sec
5. Remove the sample and take detailed pictures
6. Remove (and allow to air dry)
7. Weigh and analyze for abrasion resistance

STRETCH & RECOVERY

1. Measure length and width of the sample
2. Stretch the sample out on the foam board for 6 hours
3. (Submerge the wet samples in saline water)
4. Remove sample and allow it to recover for 1 min
5. Measure the final length and width of the sample

SALTWATER RESISTANCE & DRYING

1. Weigh sample
2. Submerge all fabric samples in a tub of saline solution, weighed down
3. Remove and lay on a flat surface in a standard temperature and humidity room, away from windows
4. Observe samples every (15 min) for 2 hours for dryness and record when each is finished drying
5. Weigh sample once fully dry
6. Observe for colorfastness