Can we effectively make *Biodegradable Clothes*? An investigation

Introduction

Clothing waste is a huge problem in our world today. More than 15 million tons of textile waste is created each year in the United States, and the amount has doubled in the last 20 years[1]. Fashion is constantly changing and we as the public are forced to buy more catch up with it. The world's population is consuming at an unstoppable rate. The average British person spends £1042 on clothes each year[2]. The massive amounts of clothes we are consuming today is contributing massively to the Earth's pollution levels in landfills worldwide. This has a negative effect as it pollutes water supplies and soil which can cause heart and lung diseases.

We all love clothes and fashion and have a huge interest in fashion. We want to find a way combat the amount of uncontrollable waste being created. We think a biodegradable fibre would help with the problem of overfilling of landfills. Landfills pollute water supply (eg. rivers), food supply (eg. poisoning of farmland and crops) and also visual pollution.

Background

Previous research has been done in the creation of biodegradable clothes and PLA clothes. An investigation is being led in using live organisms to grow pieces of biodegradable textiles.They are creating environmentally friendly materials in the laboratory—and are even producing some near-complete items without the need for factory assembly. Theanne Schiros, Fashion Institute of Technology (FIT) in NYC, assistant professor in the maths and science department thinks some of the future's fashion could potentially be bioengineered, made from living bacteria, algae, yeast, animal cells or fungi which would break down into non-toxic substances when eventually thrown away. Many of today's garments are woven from plastic-based acrylic, nylon or polyester threads, and cut and sewn in factories. All these materials are chemically produced and nonbiodegradable. These methods could reduce waste and pollution.[8]

Experimental methods

We created the biodegradable polymer calcium alginate (CA) in our school lab. We also melted PLA beads to make threads. We attempted to make a film of PLA and some threads using calcium alginate but after contacting Dr. Ramesh Babu in TCD we learned that the the method of electrospinning would be better.

We tried many solvents to dissolve the PLA and CA but couldn't find any that worked.We suggested using chloroform and DMF. We realised that calcium alginate is insoluble in water and therefore cannot be used in a solution. A component of calcium alginate, sodium alginate, is soluble in water. A solution was created with sodium alginate, PLA and a solvent which was 80% chloroform and 20% DMF.

The solution was electrospun into a fibre. A backing tissue was used to add support to the fibre. We then tested our fibre in our school lab for its tensile strength, water absorption,and plan to make a home compost to test it's biodegradability. We also tested our initial fibres for air and water permeability.

Results

Tensile Strength

The fibre we created, enforced by backing tissue,has a higher tensile strength than the backing tissue alone.

PLA+Sodium Alginate fibre

1	2.2 N	
2	2.1 N	
3	3.9 N	
4	3.7 N	
5	3.4 N	
6	3.0 N	
7	3.2 N	
8	2.8 N	
9	2.7 N	
10	2.5 N	**Average: 2.95N**

Backing Tissue

1	1.8 N	
2	1.9 N	
3	1.7 N	
4	2.0 N	
5	1.4 N	
6	1.9 N	
7	1.0 N	
8	1.1 N	
9	1.1 N	
10	2.1 N	**Average: 1.6 N**

PLA

1	9.7 N	
2	15.0 N	
3	11.5 N	
4	10.4 N	
5	9.2 N	
6	10.1 N	
7	9.1 N	
8	13.2 N	
9	12.1 N	
10	**9.9 N**	**Average: 11.02 N**

The cross sectional area of the PLA-Sodium Alginate fibres used to test tensile strength was 15 cm x 0.7 cm = 10.5 cm^2. The average force required to break the fibre was 2.95 Newtons. The tensile strength is calculated by force required to break the fabric divided by cross-sectional area (units N/cm^2). So the tensile strength is 2.95/10.5 = 0.28 N/cm^2 which is over 9 times weaker than a cotton-polyester blend tested under similar conditions (between 2.32 - 9.61 N/cm^2).

Water Absorption

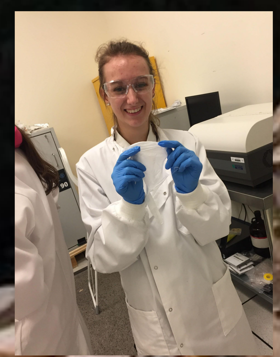
The fibre we created absorbs more water than the backing tissue.

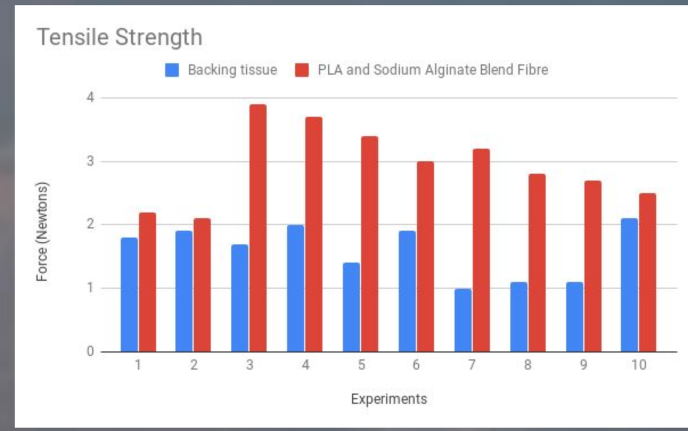
PLA+Sodium Alginate fibre

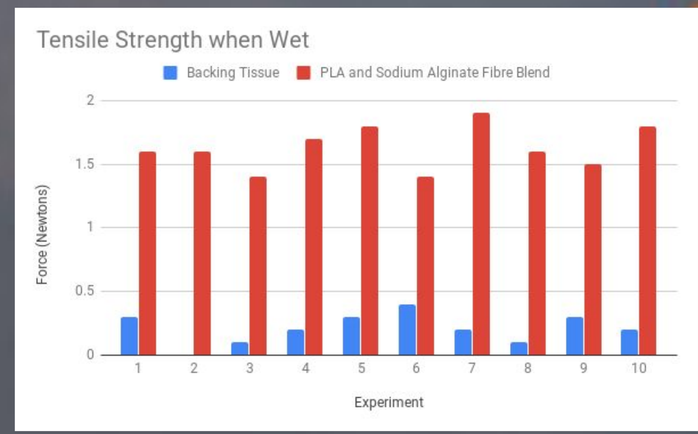
Initial Mass	Final Mass	Change in mass
0.03 g	0.12 g	+ 0.09 g
0.03 g	0.09 g	+ 0.06 g
0.03 g	0.07 g	+ 0.04 g
0.03 g	0.10 g	+ 0.07 g
0.03 g	0.09 g	+ 0.06 g
0.03 g	0.11 g	+ 0.08 g
0.03 g	0.14 g	+ 0.11 g
0.03 g	0.08 g	+ 0.05 g
0.03 g	0.11 g	+ 0.08 g
0.03 g	0.13 g	+ 0.10 g
	Average change in mass:	**+ 0.074 g**

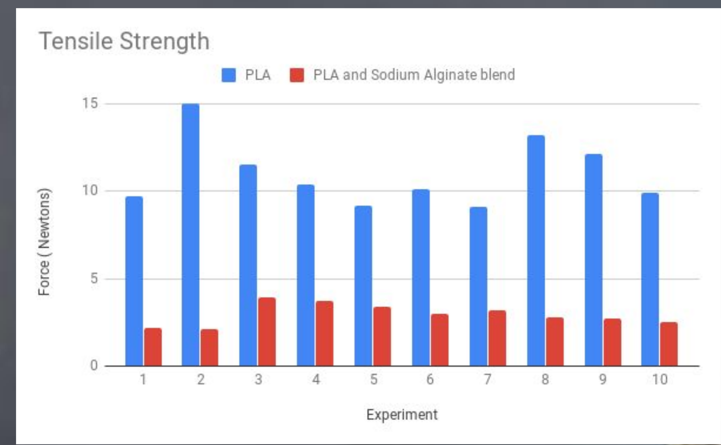
Backing Tissue

Initial Mass	Final Mass	Change in mass
0.03 g	0.08 g	+ 0.05 g
0.03 g	0.09 g	+ 0.06 g
0.03 g	0.08 g	+ 0.05 g
0.03 g	0.10 g	+ 0.07 g
0.03 g	0.08 g	+ 0.05 g
0.03 g	0.09 g	+ 0.06 g
0.03 g	0.08g	+ 0.05 g
0.03 g	0.09g	+ 0.06 g
0.03 g	0.09 g	+ 0.06 g
0.03 g	0.08 g	+ 0.05 g
	Average change in mass:	**+ 0.056g**









Summary

We set out to create a biodegradable fabric. A fabric that is suitable for textile use and that can biodegrade. We wanted to create a polymer solution that could be electrospun into a fibre. We decided to look at the biomaterials calcium alginate and polylactic acid (PLA). Calcium alginate and PLA are biodegradable.[9, 10] Combining the two materials together into a solution is something that has never been done before. We tried dissolving the materials in many solvents including acetic acid, ethyl acetate and acetone. The solution that was finally created was a mix of sodium alginate and PLA in a solvent of 80% chloroform and 20% DMF. Sodium alginate is a component of calcium alginate. Calcium alginate is insoluble in water, but sodium alginate is soluble in water.

We went to Trinity College, Dublin to electrospin our fibre. We learned how the electrospinning machine works and how to use it and we created a sheet of fibre. We tested the fabric for its tensile strength and water absorption. We also created a home compost in our garden where in we placed a sample of the fibre to test it for biodegradability.

The fibre was electrospun for a total of 20 minutes. It was placed on a backing tissue. The fibre was quite thin and delicate and if it was electrospun for longer, it could be made thicker. The fibre is too thin to be used alone as a textile at the moment but can be added to another material to be stronger. We tested the backing tissue's strength alone and the strength of the backing tissue with the fibre attached. The backing tissue was much stronger when the fibre was attached. From this we can conclude that the fibre would add strength to another substance.

Conclusion

The fabric we created is currently too weak and the fibres are too spaced out for it to be suitable for use in the clothing industry.

In the future we hope that by electrospinning for longer we can make the tissue stronger and suitable for clothing.

Also using a higher ratio of PLA in the solution may strengthen the tissue as the SA weakens the fabric as shown in our results.

The results show the potential that if made stronger the fabric would be effective in clothing. It is already stronger than the backing tissue.

We would like to investigate that if the fibres were more densely woven like a typical fabric, it would be suitable for use in outerwear such as raincoats or rain hats.

The investigation into the improvement in biodegradability of PLA due to the addition of sodium alginate is in progress in an outdoor compost bin.

Acknowledgements

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