Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Investigation)

Team Number: JDBC002

Project Title: FireFibre

Project Type: Investigation

We have researched about the main ingredients in our product (abalone shell, corn cob, and okara), however, the research is mainly about seafood shells, and does not include the other materials we are using in our investigation.

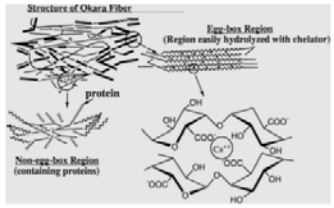
The enhancement our project made / the difference with related research are:

Our product uses more food waste, abalone shell, corn cob residue, and okara to repurpose and creates a fireproof product instead of a plastic-like material.

I. Background

With 90%-100% east-Asian population being lactose intolerant (“Why Lactose-Free Is Going to Be Massive in Asia | DSM Food & Beverage”), the popularity of soybean milk and other soy-based products gained traction in Hong Kong. With family members having roots of lactose intolerance, my family has frequently made homemade soy milk and other soy-based food products at home. During the process, lots of soybean residue, non-consumable hard parts of the soybean, are discarded or fed to animals, a waste considering the usable nutrients in the byproduct.
With the combination of biodegradable materials, including soybean residue and corn cob, and chitin found in crab shells, our product will be both environmentally friendly and non-flammable.

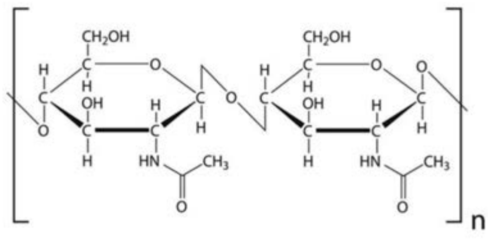
Soybean residue (okara)
Soybean residue contains 50% dietary fibre, 25% protein, 10% lipid, 4% low molecular weight carbohydrates and 4% ash (Li et al.) The soybean residue serves as a binding agent, a medium to store all the other ingredients, which in our case, is used in FireFibre to store both the corn cob and the crab shell.



(Li et al.)

Corn cob
The chemical composition of dry matter basis of corn cob consists of Cellulose, Hemicellulose and Lignin, of which together take up 90% of the dry matter. Overall, it has low fat, protein, and mineral contents, and rich in carbohydrate and lignin contents. High in fibre, Corn Cob, like Okara, aims to bind the product together and act as a binding agent. (Berber-Villamar et al.)

Abalone shell
Abalone shells are mainly made of chitin ($C_8H_{13}O_5N$), The chitin ($C_8H_{13}O_5N$) present in the abalone shell gives Firefibre a nonflammable property, and is an excellent way of repurposing food waste.(“Sustainable Chitin Nanofibrils Provide Outstanding Flame-Retardant Nanopapers”) Studies have shown seashells (including abalone shells) can act as flame retardants. Seashells have also displayed improved fire retardancy performance somewhat more than PURE calcium carbonate, suggesting a possible positive impact from other minerals seashells, e.g. Iron. (“Seafood Shell Waste as Natural Flame Retardants - Pinfa”) (“Fine Chemicals Made from Discarded Crab Shells by Chemical and Mechanical Force”)


(Chemical Structure) (mlblevins)

Abalone shells consist mainly of chitin, protein, and calcium carbonate, taking up to approximately 30%, 16%, and 55% respectively, indicating that the largest composition of abalone shells was calcium carbonate $CaCO_3$. (Aklog et al.)

Vinegar
Vinegar has the ability to bind with other compounds and is used in our product to bind the different ingredients together, in order to make a shape and to create a stronger product. (Xie et al.)

II. Objectives

Fire Fibre aims to repurpose food waste, bringing forth a product with nonflammable and insulating properties, and a safe and environmentally disposable method, decomposing and being used as fertiliser.

III. Hypothesis

We believe that by using blended abalone shell powder and mixing it with blended corn cob and okara, the materials can make a fireproof yet sustainable product and material.

Methodology

Materials & Methodology:
Dry Soybean 100g, Balance x1, Filter bag x1, Blender x1, Moulds, Corn cob (blended) 20g, Abalone shell 20g, Measuring cylinder x1
We have mixed okara, corn cob residue, and abalone shell to create FireFibre. By soaking soybeans in water overnight, we then blended them with water into a mixture. We then filtered the liquid out and used the residue (okara) in our final product. We blended corn cob and abalone shell separately into a very fine dust/powder and mixed it in the okara. We then put it into moulds to dry for at least 48 hours.
After making FireFibre, we then conducted some tests to see if it reaches the requirements and criteria to be fireproof. We have conducted 7 tests, testing for strength, brittleness/hardness, biodegradability, melting point, fire resistance, fire barrier, and water absorption.
Then, testing procedures for the product were implemented in order to determine and operationalise the strengths of this product.

Testing methods:

i. Test for strength by dropping FireFibre from different heights (m): Drop the product from 0.2m to 1m (i.e. 0.2, 0.4, 0.6, 0.8, 1m), and stop when the product shatters
ii. Test for strength by dropping different slotted mass onto FireFibre (g): Place weights (100g, 200g, 300g, 400g, 500g) onto product until physical deformation occurs
iii. Observation of biodegradability over 6 days: Place product and 50g of soil into a beaker, and pour 10 ml of water daily. Observe changes that occur. (Bettas Ardisson et al.)
iv. Melting Point (ºC) of FireFibre: Using melting-point apparatus, place samples into the sample tube and note down changes that occur.
v. Observation when FireFibre catches fire / Time taken (s) taken for Firefibre and Cardboard to catch fire: Place product over bunsen burner, and record the time for the product to 1) catch fire and 2) be disintegrated. Observe any changes. ("Flammability Test Methods")
vi. Average time (minutes) of the material's ability to maintain the original shape / Time taken (s) for 50ml water to become 50ºC (Heat Barrier): With set-up (see below), simultaneously start the stopwatch and bunsen flame, with product as a 'heat barrier'. Stop when the 100ml of water is 50ºC.
vii. Water absorption - change of mass (g) after putting in water for 20 minutes: (See set-up below) Place product into 10 ml of tap water and wait for 20 mins. Record the mass change.


Setup for (v)


Setup for (vi)


Setup for (vii)

IV. Results

Results and observation

i. Test for strength by dropping FireFibre from different heights (m)
After dropping it from 0.2, 0.4, 0.6, and 0.8m, Firefibre did not shatter or break whatsoever in all three trials. After dropping it from 2m, FireFibre broke in two of the trials, deeming it quite brittle in terms of strength. The limit of this product's strength is dropping it from 2m.

ii. Test for strength by dropping different slotted mass onto FireFibre (g)
After dropping a 100g weight onto FireFibre, there was no visible change and did not shatter or break in all three trials. However, after dropping a 200g weight onto the FireFibre, it shattered, deeming it quite fragile and brittle. Therefore the limit for this product is 200g weight.

iii. Observation of biodegradability over 6 days
After watering the FireFibre in the soil to test for biodegradability, we noticed changes over 6 days:
On the first, second and third days, there was no change. On the fourth day, mould started to grow and the green beans started to sprout. On the fifth day, more mould had grown in the pot and the green bean continued to sprout. On the sixth day, the surface area of the pot had been covered with a thin layer of mould, and the green beat sprouts were about 0.5cm tall.

iv. Melting Point (ºC) of FireFibre
After heating a sample of FireFibre up to 110ºC, there seems to be no change in the product. Therefore, the melting point of firefibre is over 110ºC.

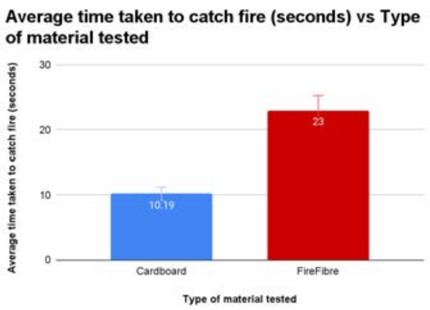
v. Observation when FireFibre catches fire / Time taken (s) taken for Firefibre and Cardboard to catch fire
After putting FireFiber above a bunsen burner, it took on average 23 seconds to catch fire, compared to the short average time of 10 seconds with a piece of similarly shaped cardboard. Therefore, FireFibre is more heat resistant than cardboard.

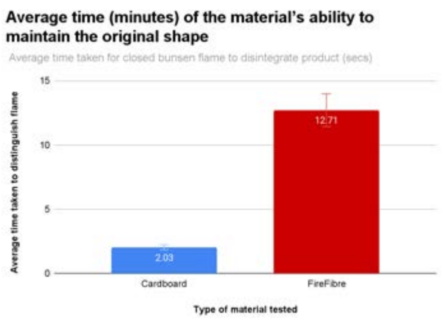
vi. Average time (minutes) of the material's ability to maintain the original shape / Time taken (s) for 50ml water to become 50ºC (Heat Barrier)

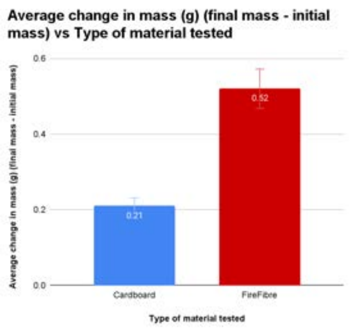
FireFibre would turn into a black colour after the first 5 seconds and would catch on fire in about 10 seconds. FireFibre also does not fall apart, compared to burning cardboard of similar size. The cardboard would catch on fire in about 5 seconds and immediately start to turn into ash.
FireFibre has been tested as a heat barrier by conducting tests with a bunsen burner with an open flame hole, degrees reaching up to 1500º celsius. Results have shown that FireFibre exhibited better fire-retardancy abilities, i.e. taking longer to catch fire than cardboard of similar thickness.

vii. Water absorption - change of mass (g) after putting in water for 20 minutes
After soaking FireFibre in 10 ml of water for 20 minutes, on average, the mass increased by 0.52g, compared to the cardboard, which increased by an average of 0.21g. Therefore, FireFibre is more water-absorbent.
With these tests, it can be deduced that FireFibre is a good heat-retardant product. It is able to sustain drops of up to 2m, collisions with 200g weight, is biodegradable, has a melting point of over 110ºC, is heat resistant, able to hold up as a heat barrier withstanding degrees up to 1500ºC, and is water absorbent.
Apart from displaying surprisingly good heat-latency properties, FireFibre is also constructed entirely out of food waste products – i.e., with no brought ingredients, the creation of FireFibre essentially has no cost. Therefore, in the future, FireFibre, with even further development, can be implemented in fire-resistance products and used.

Results for tests (v), (vi) & (vii) respectively







V. If your team will compete the Sustainable Development Award, please indicate the specific sustainable development goal the project is related to, and provide justification for competing for this award. ***(Word limit: 300 words)***

Our product, FireFibre, built of ingredients made entirely out of food waste, repurposes food waste into something useful. By combining Okara, a by-product made in the process of creation of soy products, Abalone Shell, which is not consumed and Corn Cob, indigestible, with each of its own properties, one can reuse waste material while making a brand new product.
By upcycling this material, we can reduce the amount of food waste that will go to our landfills, while providing the public with a useful product to use. Due to the increasing popularity of soy-based products, we can reuse the by-products produced when making soybean milk or tofu and repurpose them along with other food waste products to make FireFibre.

VI. If your team will compete the Social Innovation Award, please list the target group or social issue the project focuses on, and provide justification for competing for this award.
(Word limit: 300 words)

With 90%-100% east-Asian population being lactose intolerant ("Why Lactose-Free Is Going to Be Massive in Asia | DSM Food & Beverage"), the popularity of soybean milk and other soy-based products gained traction in Hong Kong. With family members having roots of lactose intolerance, my family has frequently made homemade soy milk and other soy-based food products at home. During the process, lots of soybean residue, non-consumable hard parts of the soybean, are discarded or fed to animals, which is a waste considering the usable nutrients in the byproduct.
As a result, we have developed an innovative product: FireFibre. By supporting the usage of soy products for lactose intolerant people, and with the increasing popularity of soy products in Asian regions, including Hong Kong, this socially innovative product is justified.

VII. Conclusion

From the tests for the product properties, it can be deduced that FireFibre is a good heat-retardant product, with a melting point of over 110ºC, is heat resistant, able to hold up as a heat barrier with degrees up to 1500ºC, and displaying properties of water absorbency. To add onto these properties, FireFibre is also constructed entirely out of food waste products – i.e., with no brought ingredients, the creation of FireFibre essentially has no cost.
Therefore, our product did justify the objectives of this proposed project, i.e. using waste products to produce a non-flammable material.

□ **Our project is developed based on previous project and the enhancement is below:**

N/A