Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Investigation Design Proposal)
(Word Limit: 1,600 words, Pages: 3 pages only)

Team Number: SBBD253

Project Title: Extracting Cellulose from Cardboard for Fabric Production

Project Type: Investigation Design Proposal

***To our best knowledge, there are similar works in the field*; (if there are,) related research links are as below:**

Al Azkawi, Ahlam & Nallusamy, Sivakumar & Al-Bahry, Saif. (2018). Bioprocessing of cardboard waste for cellulase production. Biomass Conversion and Biorefinery. 8. 1-10. 10.1007/s13399-018-0309-7.
Sawada, Daisuke & Nishiyama, Yoshiharu & Shah, Riddhi & Forsyth, V. & Mossou, Estelle & O'Neill, Hugh & Wada, Masahisa & Langan, Paul. (2022). Untangling the threads of cellulose mercerization. Nature Communications. 13. 10.1038/s41467-022-33812-w.

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

After the extraction of cellulose I from cardboard waste, our team converts cellulose I to cellulose II to increase its tensile strength. Cellulose II obtained will be made into fabric for sustainable garment production.

Please delete if not applicable. The competition values the originality of works. Students must do enough literature research to ensure that their works are unique and list relevant reference materials before starting research or invention.

I. Background

- Provide background information of project and/or state the problem to tackle
- Provide highlights of the **literature review** with the support of pertinent and reliable references
- Provide an overview of work and mention the **research gap that the project is trying to fill**

Nowadays, cardboard is a ubiquitous packaging material for various goods, resulting in a surge in the amount of cardboard waste generated globally. These generated cardboard wastes are underutilized. Most of the waste is disposed of by either incineration or by exposure to an environment with slower biodegradation (Lei et al., 2018).

At the same time, the clothing industry predominantly employs cellulose fibers as a primary feedstock. Extant research indicates that the relative content of cellulose in cardboard waste is above 50%, and that can be easily converted to its monomer (– glucose) (Al Azkawi et al., 2018). Through treatments such as alkali treatment NaOH solution and bleaching treatment with NaClO respectively, impurities like ink, fillers, hemicellulose and residual lignin are removed. After acid hydrolysis with H_2SO_4, the cellulose's uncrystallized domain is hydrolysed to form cellulose I. Then, mercerization with sodium hydroxide is needed to further convert cellulose I into cellulose II. After treatment, cardboard waste can be efficiently utilized as a viable source of cellulose to manufacture clothing for sustainable development of the garment industry.

II. Objective(s)

- State the **aim(s)** of project

Our team aims to extract cellulose from cardboard waste for garment production and to maintain sustainable development in the clothing industry.

III. Hypothesis

- Propose an explanation for a phenomenon and stating how the **hypothesis** can be **tested** by experiments

Cellulose can be derived from cardboard waste and made into fabric for garment production.

IV. Methodology

- List out the materials to be used
- Describe the **experimental protocol** including the set-up of **control experiment** (if any), **repeated experiment** (if any), and its scientific theory
- Indicate with the support of reasons, the **analysis** to be used in the investigation

Through processes of alkali treatment, bleaching treatment, acid hydrolysis and mercerization, NaOH, H_2SO_4 and NaClO are used. NaOH in the alkali treatment is used to effectuate the removal of ink, fillers, and hemicellulose. Additionally, the treatment disrupted the hydrogen bonds between different cellulose chains, thereby priming the mixture for the treatment afterwards. NaClO is used to bleach and break down lignin in the mixture into smaller molecules for further treatment. The cellulose obtained from the previous processes was introduced into the H_2SO_4 solution, culminating in the generation of nano-sized cellulose I via the removal of the amorphous domain of the cellulose. Cellulose I will be converted into Cellulose II. The interaction of Na+ cations with cellulose must disrupt intrachain hydrogen bonding in anhydrous Cellulose I, thereby allowing adequate water to permeate and enlarge the fibrils, and enabling cellulose chains the requisite freedom and flexibility to fold back on themselves.

V. Expected Results and Impact of research

With the rising amount of cardboard waste being produced, it can be effectively used as a renewable source to produce cellulose II, which is used as a feedstock for garment manufacturing. It is evident that the properties of final goods are influenced by the type of raw materials used, which in this case refers to cellulose fibre. Clothes produced with cellulose fibres aids thermoregulation and enhances sweat evaporation. In hot weather, perspiration from the body will be absorbed in cellulose fabrics, and then transported along the yarns to the outer surface of the cloth, Eventually, it will evaporate into the air. Thus, the body temperature is maintained, providing comfort for users. Most importantly, cellulose fibres are biodegradable so they can be decomposed by themselves after several years, (Erdal N.B., 2022) fostering the growth of sustainable development of the textile industry.

VI. 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 team extracts cellulose from cardboard waste with the purpose of producing fabric for the garment industry. The resulting garments derived from cellulose are biodegradable in nature, thereby contributing towards the reduction of the overall waste generated globally. Additionally, this conversion process facilitates the creation of useful products that align with sustainable consumption and production patterns.

VII. 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)***

Our project focuses on sustainable consumption and production patterns. Materials used are extracted from cardboard waste and hence reduces the amount of waste in the world. Due to the materials used, the production cost of the garments are relatively cheaper than fast fashion products nowadays. The selling price will also be lower than products in the market, benefiting low-income consumer all around the world. The garments produced will be biodegradable and will not leave any waste to the world after years, and wth no waste produced during the processes, our project maintains an environmentally friendly development of the garment industry.

VIII. Conclusion

- Make a conclusion of the design project and the way forward of the research

Our study demonstrates the viability of using cardboard cellulose to manufacture fabric and textile. Through treatments such as alkali treatment NaOH solution and bleaching treatment with NaClO respectively, impurities like ink, fillers, hemicellulose and residual lignin are removed. After, acid hydrolysis with H_2SO_4, the cellulose's uncrystallized domain is hydrolysed to form cellulose I. Since cellulose I is unconventional, thus mercerization with sodium hydroxide is needed to further convert cellulose I into cellulose II.

Although acids and alkalis are needed throughout the process, reagents may be reused, or treated to form harmless compounds, which lessens the environmental impact of the whole synthesis route.

Furthermore, mercerization improves dimensional stability, dye absorption, dead cotton coverage, and tensile strength. With the rising amount of cardboard waste being produced, it can be effectively used as a renewable source to produce cellulose II, which is used as a feedstock for garment manufacturing. The cellulose fibres are biodegradable so it can be decomposed by itself after several years (Erdal N.B., 2022). It can aid in fostering the growth of sustainable development of the textile industry.