**Hong Kong Student Science Project Competition 2022**

Extended Abstract (Investigation)

(Word Limit: 1,000 words, Pages: 2 pages only)

**Team Number:** JBBC173

**Project Title:** Coffee Ground-based Elastomer

**Project Type: Investigation**

**To our best knowledge and after thorough literature research, as at _28__/_6__/_2022__ , there ~~are~~ / are no* similar works. If there are, the reference links are as below:**

**The enhancement our project has made for the existing related products or research is summarized as below:**

Explore the alternative use of coffee ground and chemically-modified cooking oil as the raw materials to prepare green elastomer, which can be used as the artificial leather.

***Please delete if not applicable. HKSSPC values the originality of works. Students must conduct literature research thoroughly to ensure that their works are unique, and to list relevant reference materials to complement the 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**

Problem to tackle: In 2020, there are 20 million kg of used cooking oil disposed across the Territory, while only 15% (2.8 million kg) was converted to biodiesel for local use. Majority of used cooking oil was disposed as sewage. Cooking oil is one of the major causes of water contamination. 1 liter of oil contaminates up to 1 million liters of water, is the equivalent of the average consumption of a European in 14 years. Hence, this project aims at using waste cooking oil and coffee ground to prepare a biocomposite for making elastomer, plastic with full elasticity.

Literature review and reference

1. Xu, H., Canisag, H., Mu, B., Yang, Y. *ACS Sustainable Chem. Eng.* 2015, 3, 11, 2631–2639
2. Zhang, C., Madbouly, S. A., Kessler, M. R. *ACS Appl. Mater. Interfaces* 2015, 7, 2, 1226–1233

This project reported the one of the possible methods to functionalize used cooking oil molecule as monomer and cross-link with citric acid to form a polymeric matrix. The physical properties of polymeric matrix were extended by incorporating with plant-based filler, coffee ground (another food waste), which opens up the possibility of development of green bioplastic and alternative effective method of cooking oil treatment for new generation.

## II. Objectives

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

Our aim and objectives are to design a green elastomer by using functionalized cooking oil molecules, and to optimize the properties of our elastomer by incorporating with plant-based filler and explore the

potential uses of our product.

## III. Hypothesis

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

Functionalized cooking oil molecules and citric acid can be cross-linked to form a polymeric matrix.
Coffee ground can be used as green filler to alter the properties of biocomposite.
Cooking oil was chemically modified and reacted with citric acid by esterification.
Different mass-ratio of coffee ground was incorporated with the polymeric matrix prepared by functionalized cooking oil molecules and citric acid.

## IV. Methodology

- List out the materials 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** used in the investigation

- Waste cooking oil, hydrogen peroxide, acetic acid, brine solution, citric acid, coffee ground.
- Vegetable oil (canola oil) was firstly converted to polyepoxide by epoxidation reaction initiated by hydrogen peroxide in acidic condition. The as-prepared polyepoxide can be used as the monomer for polymerizing with citric acid (another monomer) to give a polyester. Citric acid-cross-linked polyepoxide serves as the matrix or binder to incorporate with coffee ground as filler for functionalization.
- The optimum mass ratio of citric acid was investigated by repeating the experiment with different mass ratio of citric acid (2 – 20%).
- The optimum mass ratio of coffee ground was investigated by repeating the experiment with optium mass ratio of citric acid and different mass ratio of coffee ground (30 – 75%).
- Tensile strength, surface stiffness, stability of sample in different pH environment were used to compare and figure out the optimum mass ratio of citric acid and coffee ground in our green elastomer.

## V. Results

- Present the **data** with figures, tables or photos
- **Data analysis** (if any, with emphasis on data reliability and the reproducibility based on statistics)
- Interpret the results and its implication
- Discuss **limitation** and compare with existing related works (if any)
- Discuss the importance or impact of the research and how it is applicable to real problems

- The samples with 15% by mass of citric acid and 45% by mass of coffee ground exhibited the most promising properties with high tensile strength (265 N $cm^{-2}$), surface stiffness (90 N $cm^{-2}$) and high stability towards water, dilute acid and boiling water. Samples display less than 3% loss in mass after treating with hot acid for 30 days.
- At least three trials were repeated for each single measurement.

Final product made from waste cooking oil, citric acid and coffee ground

## VI. Conclusion

- Make a **data-driven** conclusion of the project and the way forward of the research
- Justify if the proposed project meets the objective(s)

- Our samples exhibited a high tensile strength (265 N $cm^{-2}$) and surface stiffness (90 N $cm^{-2}$), with high stability towards hot water and dilute acid. The high flexibility and durability make it as the idea candidate which is used as an artificial lather.
- Using used vegetable oil and citric acid as the raw materials for synthesizing the biopolymer opens up the possibility of development of green bioplastic and alternative effective method of cooking oil treatment for new generation.

☐ **Our project is developed based on our school's previous project and the enhancement is as below:**