

Hong Kong Student Science Project Competition 2023

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

Team Number: SBBC077

Project Title: Anti-Forma Chitogel

Project Type: Investigation

*To our best knowledge, there are / are no * similar works in the field; (if there are,) related research links are as below:*

nil

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

nil

**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

Formaldehyde is an air-borne, carcinogenic indoor pollutant. It is categorized as class 1 carcinogen by the International Agency for Research on Cancer. It may cause adverse effects on human health such as irritation of eyes and respiratory system. Shells of *hermetia illucens*, Black Soldier Flies (**BSF**) are leftovers when the insects mature from pupae to adults. **BSF** shells are rich in chitin which can be converted into chitosan by demineralisation and deacetylation. Many common commercial products are used to remove formaldehyde but they all have different drawbacks such as low efficiency, not eco-friendly and not convenient to use. Especially the commonly used anti-formaldehyde wall paint with TiO_2 and Fe_2O_3 , which are toxic and cause many adverse health effects such as lung fibrosis. To deal with the problem, **Anti-Forma Chitogel** is developed. It is a hydrogel of chitosan formed when chitosan dissolved in vinegar. It could remove formaldehyde by condensation to form non-pollution and harmless water.

II. Objectives

1. To produce **Anti-forma Chitogel** using shells of Black Soldier Fly (**BSF**)
2. To investigate the percentage of formaldehyde removed by **Anti-forma Chitogel** and common commercial products.
3. To investigate the percentage of formaldehyde removed by **Anti-forma Chitogel** in a newly renovated Innovation laboratory, a new wardrobe and as filter in an air purifier.
4. To investigate the percentage of formaldehyde removed by **Anti-forma Chitogel** obtained from treated shells of Black Soldier Fly (using 2M nitric acid & 16.7M NaOH) and **Anti-forma Chitogel** obtained from untreated shells of Black Soldier Fly (using vinegar only)

III. Hypothesis

Anti-Forma Chitogel aims to provide a more environmentally friendly alternative for removing the harmful and carcinogenic pollutant of formaldehyde without the drawbacks of various commercial products available. **Anti-Forma Chitogel** could be made from shells of black soldier flies (**BSF**) which are biodegradable. It does not produce any harmful substances when removing formaldehyde because it reacts with formaldehyde through condensation to give harmless substances such as water.

IV. Methodology

1. Production of **Anti-Forma Chitogel** as the hydrogel of chitosan and its salt
Shells of **BSF** are put into nitric acid for demineralization and then sodium hydroxide for deacetylation to convert the shells into chitosan. Chitosan is then ground to fine powder and mixed well with vinegar. After drying, a piece of **Anti-Forma Chitogel** is obtained.
2. Comparison of the absorption of formaldehyde by shells of **BSF** before and after demineralization, deacetylation and action of vinegar

BSF untreated shells, chitin, chitosan and chitogel were put into air-tight containers respectively with formaldehyde solution for 48 hours. Formaldehyde levels in each container were then measured with 2 formaldehyde meters after 5 minutes.

3.1 Comparison of formaldehyde removing ability with commercial products and chitogels from different sources

Chitogels made with chitosan of **BSF**, crab, shrimp, lobster respectively and formaldehyde remover, formaldehyde spray, anti-formaldehyde wall paint and ion-air purifier were put into air-tight containers with formaldehyde solution for 48 hours.

Formaldehyde levels in each container were then measured with 2 formaldehyde meters after putting them in 5 minutes.

3.2 Comparison of formaldehyde removing ability of **Anti-forma Chitogel** obtained from deacetylated shell of **BSF** (2M nitric acid followed by 16.7M NaOH) and that from untreated **BSF** (using vinegar only)

4. Testing the formaldehyde removing ability of **Anti-Forma Chitogel** in a newly renovated Innovation Laboratory

The efficiency of the **Anti-Forma Chitogel** was tested in the newly renovated Innovation Laboratory of our school which contains a considerable amount of formaldehyde.

4.1 Testing **Anti-Forma Chitogel** in chamber

The initial level of formaldehyde in the chamber was first recorded with 3 formaldehyde meters. Afterwards, dried anti-formaldehyde wall paint and chitogel were put inside sealed bell jars for 30 minutes respectively, the formaldehyde levels were measured again.

4.2 Testing **Anti-Forma Chitogel** in drawer

The efficiency of **Anti-Forma Chitogel** was tested in a smaller and less ventilated area, formaldehyde test was carried out in a drawer. The initial formaldehyde level was first recorded by 3 formaldehyde meters. Then, the **Anti-Forma Chitogels** were put into the drawer for 24 hours. The formaldehyde level was then recorded after 24 hours.

4.3 Testing **Anti-Forma Chitogel** in drawers of a new wardrobe

5. Testing **Anti-Forma Chitogel** as filter in an air-purifier

6. Determination of the structural change of **Anti-Forma Chitogel** after absorption of formaldehyde by FTIR

7. Biodegradability of **Anti-Forma Chitogel**

V. Results

Formaldehyde causes various kinds of health problems, and may even cause cancer at high concentration levels (safety limit of 0.125g/m³) [1] and long term exposure. In this project, **Anti-forma Chitogel** made with 0.2g **BSF** chitosan powder with 10 mL vinegar was found to be able to remove 73.7% 1:100 by mass of formaldehyde to give harmless substances, such as water. **Anti-forma Chitogel** was found to be the most effective (removal of 91.2% 1:20 by mass of formaldehyde) among all commercial products including ion air purifier, formaldehyde remover, anti-formaldehyde wall paint, formaldehyde removing spray. **Anti-forma Chitogel** removed 84.9% formaldehyde in only 30 minutes when placed in the chamber of the Innovation Laboratory reducing the conc. of formaldehyde from 0.53 mg/m³ to 0.08 mg/m³ which was below the safety limit of 0.125 mg/m³ [1]. **Anti-forma Chitogel** removed 54.8% formaldehyde when placed in a drawer in the Innovation Laboratory in 24 hours. Concentration of formaldehyde in drawers with **Anti-forma Chitogel** was kept below 0.125mg/m³ most of the time over a month especially when temperature was below 21oC) Removal of formaldehyde was found to be as high as 83.7% at 20.2oC in 1 day reducing the conc. of formaldehyde from 0.49 mg/m³ to 0.08 mg/m³ (with 0.43g/0.0113cm² **Anti-forma Chitogel**) Conc. of formaldehyde in air-tight boxes (5g of construction adhesive in 9.3 dm³) with air purifiers with and without **Anti-forma Chitogel** as filter before and after 3 hours was reduced by 44.5% (from 6.25mg/m³ to 3.47mg/m³) and 27.7% respectively showing that **Anti-forma Chitogel** as filter in air purifier outperformed that without by 160%. **Anti-forma Chitogel** obtained from shells of **BSF** (treated with 2M nitric acid & 16.7M NaOH removed 74.8% formaldehyde of 1:20 by mass from 2.14 mg/m³ to 0.54 mg/m³ and **Anti-forma Chitogel** obtained from shells of **BSF** (treated with vinegar only) removed 64.5% formaldehyde of 1:20 by mass from 2.14 mg/m³ to 0.76 mg/m³. At the same time, the **Anti-forma Chitogel** has no adverse effects on human health and the environment at all. It took 11 days for **Anti-forma Chitogel** to be completely biodegraded in soil. Unlike **Anti-forma Chitogel**, anti-formaldehyde wall paint emitted volatile organic chemicals which posed harm to the environment. The density of **Anti-forma Chitogel** is low and it is thin, portable, stackable, biodegradable, efficient in removal of formaldehyde and convenient to be applied. Moreover, the production and use of the **Anti-forma Chitogel** meet the 12th and 3rd sustainable development goals of the United Nations. As the supply of **BSF** is continuous, the production of **Anti-forma Chitogel** is sustainable. To summarise, the **Anti-forma Chitogel** is an eco-friendly product with high formaldehyde removal efficiency and can be applied to households widely.

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)

Anti-forma Chitogel meets the 12th Sustainable Development Goal (SDG) of the United Nations - ensure sustainable consumption and production patterns. Shells of **BSF** are used to be disposed of after the **BSF** had matured. In this project, **BSF** shells were converted into chitosan which became the raw material for making **Anti-forma Chitogel** and hence reducing the waste production. Apart from this, black soldier fly larvae are fed on organic wastes, going from creature waste to food scraps. When they become pupae, they can be used as a poultry feed, pet food, residue fertiliser for soil amendment, and are a good source of protein.

Also, the **Anti-forma Chitogel** is biodegradable as it took 11 days to be completely biodegraded in soil, no hazardous products are produced upon decomposing formaldehyde, thus no negative impacts were dealt to the environment. By making use and converting **BSF** shells to chitosan as the raw material for the production of **Anti-forma Chitogel** can help achieve the Target 12.5 of the Sustainable Development Goals - Substantially reduce waste generation.

Anti-forma Chitogel also meets the 3rd SDG of the United Nations - ensure healthy lives and promote well-being for all at all ages.

Formaldehyde is classified as class 1 carcinogen by the International Agency for Research on Cancer Group [25] which can cause many health problems, such as cancer like the nasopharyngeal carcinoma. While the **Anti-forma Chitogel** reacts with formaldehyde to give harmless substances such as water, it poses no threat to the environment. From our experiment results, **Anti-forma Chitogel** removed around 91.2% of formaldehyde (1:20 by mass), proving that it had a significant efficiency on removing formaldehyde. This helps achieve the Target 3.9 of the Sustainable Development Goals - substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.

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)

No

VIII. 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)

Formaldehyde causes various kinds of health problems, and may even cause cancer at high concentration levels (safety limit of $0.125\text{g}/\text{m}^3$) [1] and long term exposure. In this project, **Anti-forma Chitogel** made with 0.2g **BSF** chitosan powder with 10 mL vinegar was found to be able to remove 73.7% 1:100 by mass of formaldehyde to give harmless substances, such as water. **Anti-forma Chitogel** was found to be the most effective (removal of 91.2% 1:20 by mass of formaldehyde) among all commercial products including ion air purifier, formaldehyde remover, anti-formaldehyde wall paint, formaldehyde removing spray. **Anti-forma Chitogel** removed 84.9% formaldehyde in only 30 minutes when placed in the chamber of the Innovation Laboratory reducing the conc. of formaldehyde from $0.53\text{ mg}/\text{m}^3$ to $0.08\text{ mg}/\text{m}^3$ which was below the safety limit of $0.125\text{ mg}/\text{m}^3$ [1]. **Anti-forma Chitogel** removed 54.8% formaldehyde when placed in a drawer in the Innovation Laboratory in 24 hours. Concentration of formaldehyde in drawers with **Anti-forma Chitogel** was kept below $0.125\text{mg}/\text{m}^3$ most of the time over a month especially when temperature was below 21°C) Removal of formaldehyde was found to be as high as 83.7% at 20.2°C in 1 day reducing the conc. of formaldehyde from $0.49\text{ mg}/\text{m}^3$ to $0.08\text{ mg}/\text{m}^3$ (with $0.43\text{g}/0.0113\text{cm}^2$ **Anti-forma Chitogel**) Conc. of formaldehyde in air-tight boxes (5g of construction adhesive in 9.3 dm^3) with air purifiers with and without **Anti-forma Chitogel** as filter before and after 3 hours was reduced by 44.5% (from $6.25\text{mg}/\text{m}^3$ to $3.47\text{mg}/\text{m}^3$) and 27.7% respectively showing that **Anti-forma Chitogel** as filter in air purifier outperformed that without by 160%. **Anti-forma Chitogel** obtained from shells of **BSF** (treated with 2M nitric acid & 16.7M NaOH removed 74.8% formaldehyde of 1:20 by mass from $2.14\text{ mg}/\text{m}^3$ to $0.54\text{ mg}/\text{m}^3$ in 15 hrs and **Anti-forma Chitogel** obtained from shells of **BSF** (treated with vinegar only) removed 64.5% formaldehyde of 1:20 by mass from $2.14\text{ mg}/\text{m}^3$ to $0.76\text{ mg}/\text{m}^3$ in 15 hrs. At the same time, the **Anti-forma Chitogel** has no adverse effects on human health and the environment at all. It took 11 days for **Anti-forma Chitogel** to be completely biodegraded in soil. Unlike **Anti-forma Chitogel**, anti-formaldehyde wall paint emitted volatile organic chemicals which posed harm to the environment. The density of **Anti-forma Chitogel** is low and it is thin, portable, stackable, biodegradable, efficient in removal of formaldehyde and convenient to be applied. Moreover, the production and use of the **Anti-forma Chitogel** meet the 12th and 3rd sustainable development goals of the United Nations. As the supply of **BSF** is continuous, the production of **Anti-forma Chitogel** is sustainable. To summarise, the **Anti-forma Chitogel** is an eco-friendly product with high formaldehyde removal efficiency and can be applied to households widely.

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

No