Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Investigation)

Team Number: JBBC118

Project Title: SeaUVeed Success

Project Type: Investigation

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

N/A

I. Background

Harmful effects imposed by ultra-violet radiation (UVR) have been constant concerns in many years. Depletion of ozone layers has significantly increased the health risks related to excessive exposure to UVR, for instance skin cancers and cataract. Not only from the sunlight, daily activities like UV nail gel pedicure might also lead to body damages due to UV exposure.

Although there are many sunscreen products available in the market, most of them are composed of ingredients that are non-renewable, which makes the use of the product not environmentally friendly and might lead to marine pollution. These ingredients include oxybenzone and zinc oxide.

It has been suggested by [1],[2] and [3] that algae possess organic compounds that have UV-absorbing and anti-oxidizing properties. However, most of the research did not focus on its application. Therefore, one of the special aspects of this project is to explore the practical application of algae in protecting against UV light and free radicals.

[1] Zhang H, Jiang Y, Zhou C, Chen Y, Yu G, Zheng L, Guan H, Li R. Occurrence of Mycosporine-like Amino Acids (MAAs) from the Bloom-Forming Cyanobacteria Aphanizomenon Strains. Molecules. 2022 Mar 7;27(5):1734. doi: 10.3390/molecules27051734. PMID: 35268833; PMCID: PMC8911825.

[2] Klisch, Manfred & Sinha, Rajeshwar & Häder, Donat. (2002). UV-absorbing compounds in algae. Current Topics in Plant Biology. 3. 113-120.

[3] Shao Z, Duan D. The Cell Wall Polysaccharides Biosynthesis in Seaweeds: A Molecular Perspective. Front Plant Sci. 2022 May 10;13:902823. doi: 10.3389/fpls.2022.902823. PMID: 35620682; PMCID: PMC9127767.

II. Objectives

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

The aim of this research is to obtain extracts from various types of algae (kelp, wakame, sea grape and seaweed) and evaluate their UV-absorbing and anti-oxidizing properties. In particular, three potential applications (sunscreens, titanium white paint and protective coating for UV nail pedicure) of algae extracts were studied in detail in hope of providing a new insight to make good use of this renewable materials to offer economic and environmentally friendly protection against UVR and free radicals.

III. Hypothesis

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

Macro-algae can survive in habitats with prolonged exposure to UV light. It contains some cellular compounds that can absorb UVR and prevent the attack of free radicals generated from UV exposure.

Therefore, one of the aims of this research is to extract UV-absorbing compounds and antioxidants from various algae species, including brown, green and red algae.

IV. Methodology

Materials used:

- Algae: kelp, wakame, sea grape, seaweed
- 95% ethanol, distilled water, absolute alcohol, olive oil, linseed oil, 2 M ammonia,0.2M hydrochloric acid,m 2% sodium carbonate solution, 0.1 % calcium chloride solution
- Nano titanium oxide, nano zinc oxide
- UV lamp, UVA lamp, UVB lamp, UV light meter, commercial UV nail gel pedicure machine
- Plastic slides, canvas paper

1. Preparation of algae extracts

Different masses of kelp, wakame, sea grape and seaweed were immersed in distilled water, 95% ethanol, olive oil and linseed oil for 24 hours to prepare their extracts.

2. **UV-absorbing ability**
   A UV detection box was made to standardize and control the environment to detect UV intensity every time; readings from pure solvents were also obtained as controls. Each experiment was repeated at least twice to minimize error.
3. **Anti-oxidizing ability**
   DPPH solution (prepared by absolute alcohol) was used as a source of free radicals. When it was allowed to react with the algae sample, any anti-oxidants present would react with the DPPH and turn DPPH solution from purple to yellow. Therefore, the intensity of purple colour was taken as an indication of the anti-oxidizing activity. A colorimeter was used to quantify the purple intensity of the solutions. A control solution (DPPH + solvent), a blank solution (sample + absolute alcohol
4. **Synthesis of sodium alginate from kelp**
   Kelp was treated with acid, and then sodium carbonate to extract alginate from them. The alginate was then used to make coating in the next step.
5. **Coating on plastic slide to block UV**
   Alginate solution of different concentrations were prepared and coated on plastic slides by spraying with calcium chloride solution. UV light was passed through the coated slides and UV light sensor was used to detect the changes in UV intensity.
6. **Formation of titanium white paint and study the yellowing of paint**
   Pure linseed oil was mixed with titanium oxide to make paint. This serves as a control.
   then other oil/algae extract was used make the paint as well. The paint were coated on canvas papers respectively and they were treated with ammonia gas to speed up yellowing process. The final colours of the painted papers were compared.

V. Results

UV-absorbing ability of algae extracts:

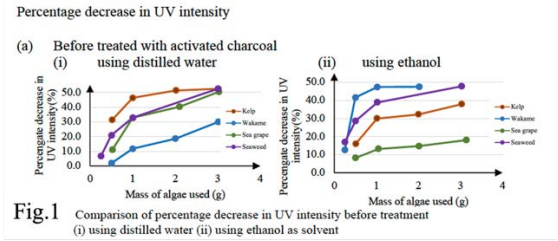


Fig.1 Comparison of percentage decrease in UV intensity before treatment (i) using distilled water (ii) using ethanol as solvent

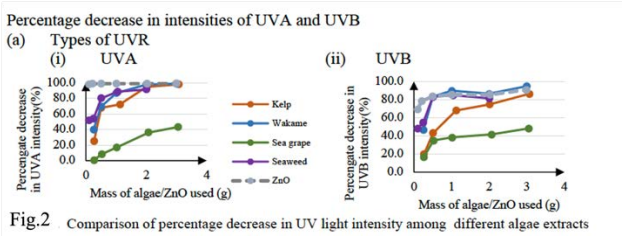


Fig.2 Comparison of percentage decrease in UV light intensity among different algae extracts

From Fig.1 and Fig.2, it can be concluded that all of the algae extract showed a significant UV-absorbing ability. In particular, kelp/water extract in Fig.1 could reduce UV intensity up to 50%. In Fig.2, extract of kelp, wakame and seaweed could reduce UVA and UVB intensity up to 90%, which is comparable to zinc oxide (a common ingredient in commercial sunscreens)

Anti-oxidizing ability of algae extracts:

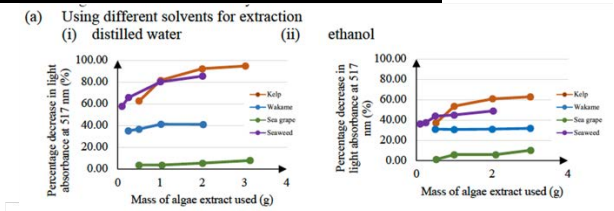


Fig.3 Comparison of percentage decrease in light absorbance at 517 nm after mixing DPPH solution with different algae extracts

The decrease in purple intensity indicates anti-oxidizing activity. From Fig. 3, all algae extracts (except sea grape) in both distilled water or ethanol showed up to 40 to 60% reduction in purple intensity of DPPH solution.

Implication: it can be concluded from the results from Fig. 1 to Fig.3 that algae extracts, especially kelp extract could be a potential ingredient in sunscreens, instead of using petroleum-based oxybenzone which will lead to marine pollution after washing to the ocean

Whiteness of paints:

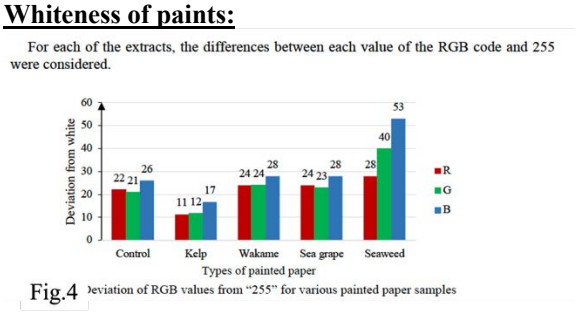
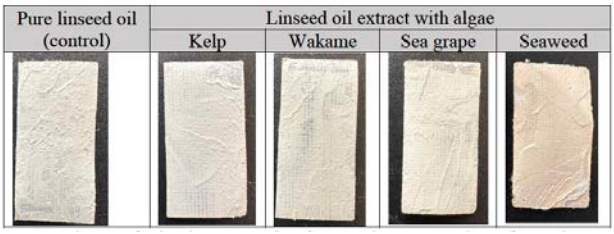


Fig.4 Deviation of RGB values from "255" for various painted paper samples



The deviation from RGB code (255, 255, 255) means a lower whiteness in paint. By comparing the RGB codes of photos of painted samples as in Fig. 4, it can be concluded kelp/linseedextract could make the white paint closer to the code of 255, 255,

255.
Implication: Kelp/linseed oil extract could be a potential additive to slow down yellowing of white paint.
UV-protection against UV nail gel machine:

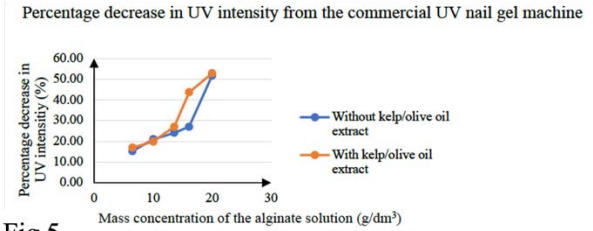


Fig.5 Comparison between UV-absorbing abilities of alginate coating with and without kelp/olive oil extract

From Fig. 5, plastic slide coated with calcium alginate obtained from kelp could reduce UV intensity up to 50%.
Implication: Alginate coating derived from kelp can be applied on nails before undergoing UV treatment.
Limitation: The coating of the alginate is not uniform enough.

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)*

Ingredients in current commerical sunscreen products include oxybenzone and zinc oxide.
Oxybenzone and octinoxate are derived from petroleum, which are non-renewable and causes much pollution along its production process. Besides, it is found that oxybenzone and other hydrocarbons in sunscreens are toxic to many marine organisms like algae and phytoplankton. In addition, nano-zinc oxide used in sunscreens has adverse effects on the growth of urchin[15] and it is toxic to algae

Therefore, our project proposes a renewable alternative, that is the extract from algae, to provide protection against UV light and free radicals. Not only does this reduce pollution to the marine habitats, it can only achieve sustainable developments as it is not petroleum-based.

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)*

Target group: marine worker, fisherman
Nowadays, algae are only mainly used in food industry or cosmetic industry. However, its potential to absorb UV light and ward off against free radicals could be a great asset to be explored. Thus, fisherman who provides supply of algae would be benefit as the demand of algae would be greatly increased if they could be used to make UV-protection materials. And due to the rising demand of algae from the findings of this project, conservation breeding of algae would be more concerned so as to allow sustainable supply of the materials. And new job specialized in growing seaweed or other algae might arise as well. This can also benefit countries which heavily based on marine food export.

VIII. Conclusion

From the above results, algae extract, especially kelp/water extract, could reduce UV intensity up to 90%. And they also showed up to 40 to 60% reduction in purple intensity of DPPH solution. And when they were incorporated into white paint, the white paint made showed resistance to yellowing. When kelp alginate was used as protective coating for UV nail gel pedicure, more than 50% UV from the gel machine was absorbed. Therefore, it can be concluded that algae extract could be an excellent potential raw material for protecting against UV light and free radicals. The aim of this project is fully achieved.

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

N/A