

Hong Kong Student Science Project Competition 2023

Team Number: **SABC073**

Project Title: **Smart Infection-Indicator Dressing**

Project Type: **Invention**

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

1. <https://doi.org/10.3390/polym9110558>
2. <https://doi.org/10.1016/j.eurpolymj.2021.110744>

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

Our project focuses on the relationship between pH and wound infections whereas previous studies focuses on wound healing. Black goji extract was used in our product, which has antioxidant and anti-inflammatory properties. We also investigated the biodegradability of our product.

**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

Wound infections may arise when bacteria enter and multiply in wounds. They can cause serious consequences, including limb amputation and death. Misdiagnoses of wound infections may cause inappropriate prescribing of antibiotics and unnecessary treatment side effects. However, detecting wound infections is a challenge as it relies on a clinician's judgment, which is subjective and influenced by expertise, or microbiological analysis of wound tissue, which is time consuming and may delay treatment.

Research has shown than an **increase in the pH of wounds correlates with a higher risk of wound infection** (Metcalf et al., 2019; Dheansa et al, 2015). Therefore, an increase in the pH of wounds can be an **indicator of an increased risk of wound infections** and thus help detect emerging wound infections in an objective and non-invasive manner. By continuous measurement of the pH of a wound, when the pH rises and becomes alkaline, early detection of an increased risk of a wound infection can be facilitated. This enables early action to be taken by clinicians or the patients themselves to mitigate the risk so as to prevent the worsening and spreading of wound infections. Therefore, using wound pH as a risk and diagnostic indicator has the potential to increase the accuracy of clinical judgement and diagnosis, and improve wound management.

Natural pH indicators are plant extracts which exhibit a different colour at different pH levels. **Black goji extract** can act as a pH indicator for a wide pH range as it contains a high amount of anthocyanins, a pigment that changes colour at different pH levels due to changes in its chemical structure with changes in pH. The extract appears pink in acidic conditions, purple in neutral conditions and blue in alkaline conditions.

II. Objectives

Through the development of a pH sensitive wound dressing that can be used to indicate the risk of wound infections, we aim to:

- enable early detection of wound infections
- reduce the incidence and severity of wound infections
- alleviate the suffering in people with potential wound infections

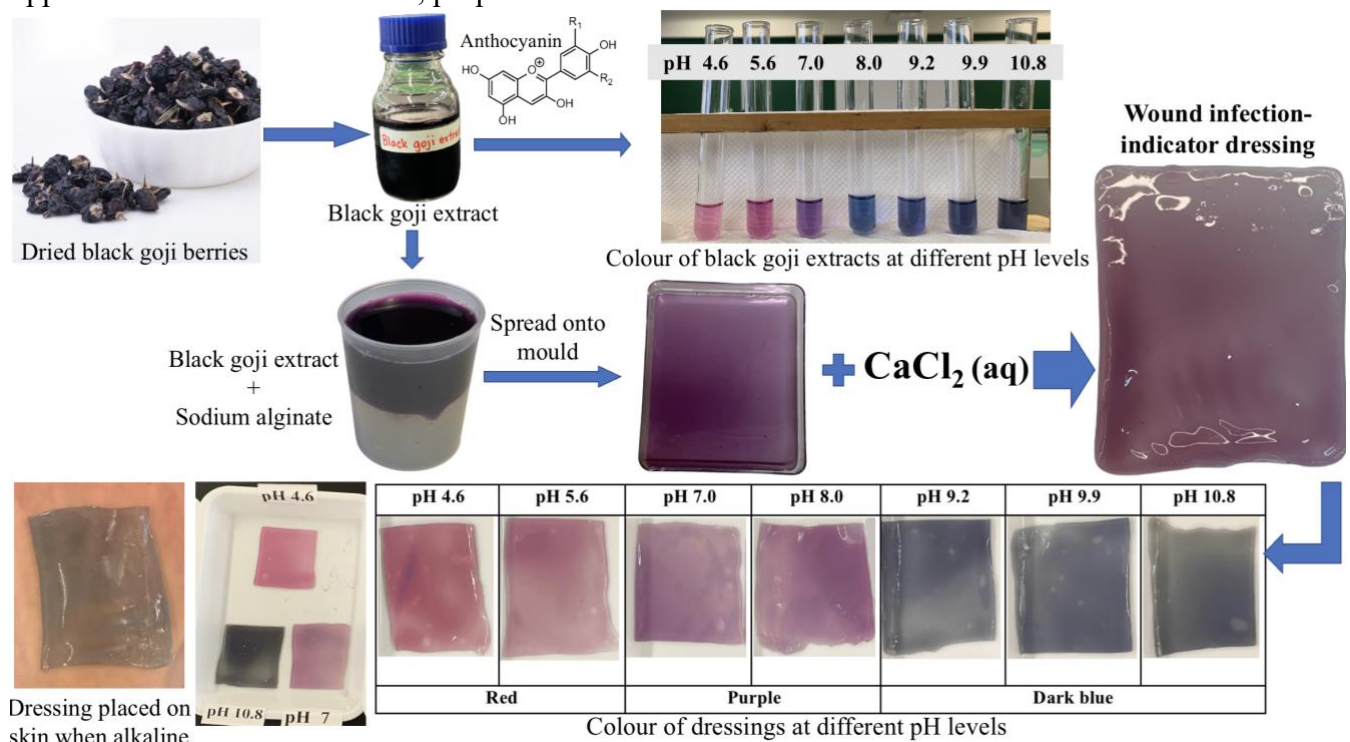
III. Methodology

There are 4 main stages in this project. First, we carried out bacterial culture at different pH levels to confirm that a higher pH favours bacterial growth. Second, we screened 8 different plant extracts to select

one that gives sharp and distinct colours at different pH ranges for use as a natural pH indicator in our dressings. During the tests, plant extracts containing the colour changing pigments were extracted by the water extraction method and added to buffer solutions of different pH. Third, we produced a wound dressing made of **calcium alginate** and investigated the effects of sodium alginate and calcium chloride solution concentration (the raw materials of the dressing) on the tensile strength of the dressing produced so as to determine their optimum concentrations. The tensile strength of a wound dressing is an important measure as a dressing should not break easily upon movement. Fourth, we incorporated black goji extract into the calcium alginate dressing and investigated its properties, including its colour changes at different pH levels, tensile strength, swelling index, water permeability and biodegradability.

IV. Design of Invention

Our infection-indicator dressings contain black goji extract and are made of calcium alginate, which is produced by reacting sodium alginate with calcium chloride. Calcium alginate dressings are a type of hydrocolloid and promotes healing as they can maintain a moist wound environment. The dressing appears red in acidic conditions, purple in neutral conditions and dark blue in alkaline conditions.



V. Application / Market Need

The smart infection-indicator dressing takes in wound fluids and **changes its colour based on the pH** of the fluids to indicate the pH of wounds. When the dressing appears dark blue, the wound is alkaline and thus has a high risk of infection. This warns users of the increased risk so that appropriate actions can be taken to mitigate the risk. It also allows **infections to be detected at an early stage**, so that actions can be taken immediately to improve outcomes.

The main users of our invention will be individuals with surgical wounds and chronic wounds. The HK wound dressing market has a growth rate of 5.8% (Research and Markets, 2021). There is great demand for wound care products due to a large elderly population and high prevalence of diabetes. Both of these groups are susceptible to developing wounds, particularly chronic wounds, and wound infections. Our wound dressing **promotes wound healing and helps to reduce the incidence and severity of infections** whilst being economical (the cost of one infection-indicator dressing is about \$0.40). By enabling early detection of wound infections, our dressings can also **minimise treatment costs** arising

from wound infections and their complications. Therefore, our dressings can improve the wellbeing of its users.

Commercially available hydrocolloid dressings are not pH sensitive and lack the colour changing feature. Thus, commercially available hydrocolloids can only act as a normal wound dressing. In addition to the normal properties and functions that a hydrocolloid dressing possesses, our infection-indicator dressings have an added feature of being able to indicate the pH of wounds and thus detect any increased risk of infection. They are also **biodegradable, less expensive, and have a higher moisture permeability** than commercial dressings. Black goji extracts in the dressing also have anti-inflammatory and antioxidant properties. However, in terms of limitations, the colour changing function of our dressings can only be used in non-bleeding wounds, such as chronic wounds, as blood from bleeding wounds will mask the colour change of the dressing.

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.

Commercial bandages commonly used today are made of synthetic materials, which produces a lot of waste and requires a long time to break down after they are discarded. Our dressings are eco-friendly and biodegradable, as proven by our experimental results where the mass of the dressing decreased by over 70% after being buried in soil for 5 weeks. In addition, a major component of our dressings, sodium alginate, comes from a sustainable resource - the cell wall of brown algae. Therefore, our dressings contribute to the 12th Sustainable Development Goal, **“responsible consumption and production”**.

In addition, by warning users of a high risk of wound infections when applicable, our dressings enable its users to take early action to prevent infections from occurring and spreading. This reduces the pain and discomfort brought by wound infections and its complications. Hence, the health and wellbeing of people in the community can be promoted, contributing to the 3rd Sustainable Development Goal, **“good health and wellbeing”**.

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.

Wound infections increase patient morbidity and mortality, and prolongs hospital stays, which increases the cost of healthcare. Our dressings reduce the incidence and severity of infections by facilitating early detection of an increased risk of wound infections in a rapid and non-invasive manner. This helps to minimise the detrimental consequences and high treatment costs which could be brought about by wound infections and its complications. Therefore, our invention helps to improve the quality of life of its users, ensures healthy lives and promotes wellbeing for people of all ages.

The cost of one of our dressings is about **\$0.40**. It's low cost can help to reduce the government's expenditure on healthcare, so the money saved can be used in other important areas. Also, our low-priced dressing substantially helps to relieve the financial burden on patients and individuals with wounds.

VIII. Conclusion

Out of the plant extracts screened, black goji extracts demonstrated distinct colours at different pH levels and was therefore chosen for use in our dressings. 3% sodium alginate and 5% calcium chloride solution was used to produce our dressings as these concentrations found to give the higher tensile strength. Our wound infection-indicator dressing can indicate the pH range of wounds as it exhibits a different colour at different pH levels. Therefore, it can be used to indicate the risk of wound infections and thus enable early detection of wound infections. Our dressing is also biodegradable, evidenced by the decrease in mass by about 70% after 5 weeks, and is permeable to moisture.

□ Our project is developed based on previous project and the enhancement is below: N/A