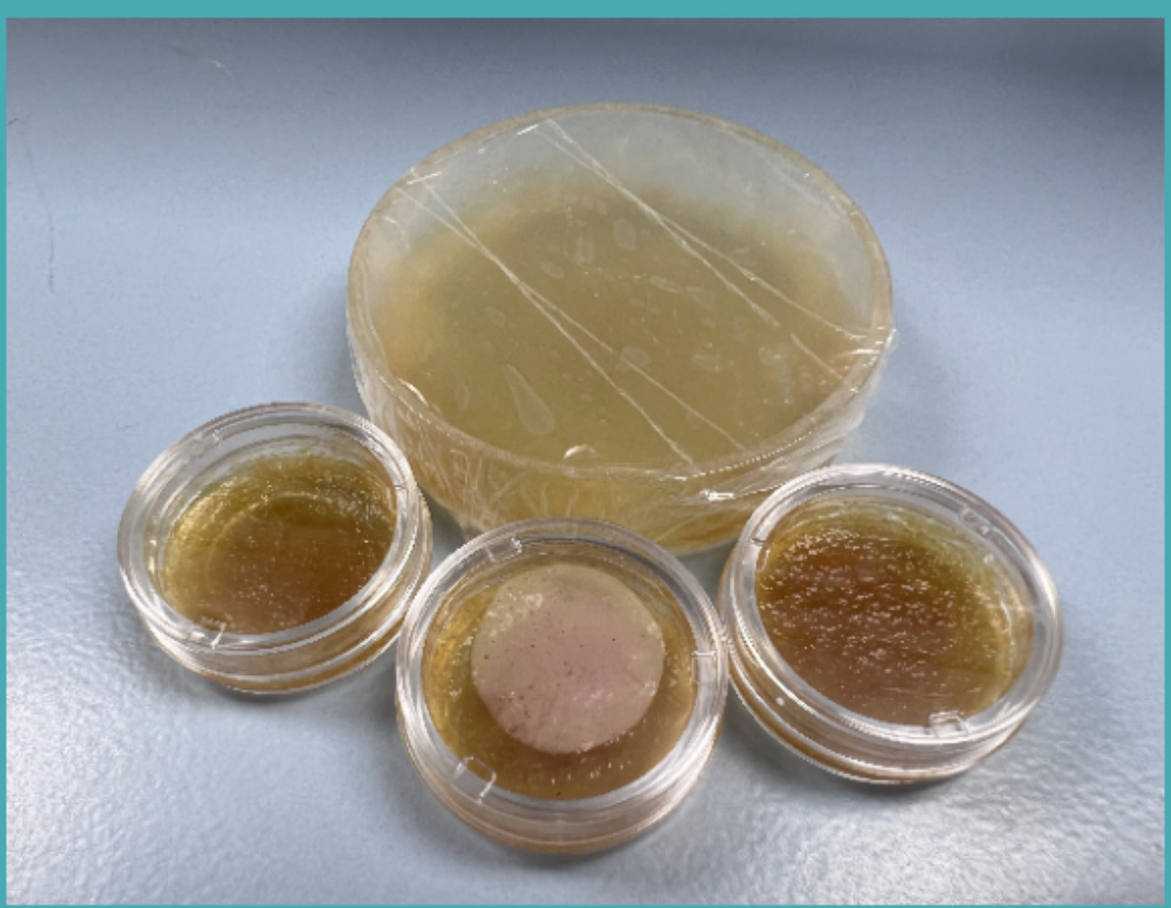
Hou Kong Middle School
Macau

Revitalize skin damage

Tea Polyphenol Hydrogel Covering



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➢Research background

In the process of taming nature, there were many bacteria and viruses that entered the human body and slowly adapted to survive within. Human medical history is simply the history of our struggle against them. In ancient times, people did not know what wound infections were, and injuries often meant the inevitability of death. Later on, wound coverings appeared; which helped with not only the continuation of human life, but also the continuation of human civilization as a whole.

There are two main types of wound dressings:

1. Dry covering

For the past century or so, it has been wildly recognized that treating wounds requires covering the wound with a dry covering to protect it from further damage and to protect the scab that has formed. This method effectively protects the protective scab formed on the outer layer of the wound to a greater extent, and allows the wound to heal itself. The representative work of a dry wound covering is the gauze. Gauze are made from cotton plants, are easy to clean and disinfect, breathable, and has a certain level of adsorption. Thus, this covering is used around the world, whilst other gauze cotton pads and non-adhesive gauze dressings were developed based on it.

2. Wet covering

For more than ten years within the development of medical research, people gradually realized that the repair of the wound needs a certain environment, just like the growth of plants, not only need base rich nutrition, and need a certain environment, wet warm environment is conducive to the growth of granulation tissue and keratinocytes crawling, so the concept of "wet environment" has become more popular, and have gradually been accepted by the majority of medical staff. Based on this need, various wet coverings have emerged. In its promotion stage, it is also known as its modern covering. In the process of "wet environment", the issue with wound exudation has attracted more and more attention. How to deal with this issue is also an important part of the treatment of the wound, the wet covering itself also has the function of absorbing exudates by using “negative pressure drainage”. However, it is clear that this negative pressure drainage effect is due to the adsorption of the covering itself, and its negative pressure value is in actuality relatively low, so often there may be only a few to a dozen mmHg. The use of this passively draining wet covering is currently becoming increasingly common throughout the world. Such coverings are mainly used in almost all developed countries.

■ 1.1 Research motivation

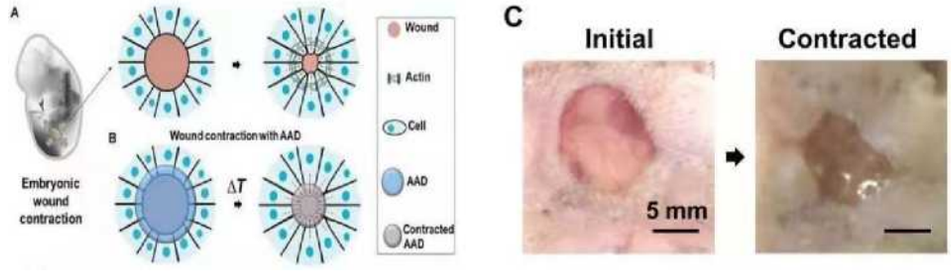
What affects wound healing?

External factors: long-term compression of the wound (affecting blood circulation), repeated damage, bacterial infection and improper treatment (such as using ineffective disinfectants or coverings); these can all slow down the rate of wound healing.

Internal factors: old age, diseases (such as diabetes), long-term drug usage, bad habits such as smoking (destroying blood vessels), alcohol (affecting nutrient absorption) etc. These can reduce our immunity, making the wound vulnerable to infection and affects healing.

■ 1.2 Research trends

Make a wet covering that can effectively maintain skin moisture, have strong air permeability, long-term antibacterial effect and improve healing efficiency.



Advantages of wet coverings

Wet coverings favor the breaking down of necrotic tissue and fibrinolysis, maintaining relatively constant wound temperature and humidity, and avoids reinjury to new granulation tissue due to scab shedding. In addition, wet coverings can effectively prevent external bacteria from contacting the wound and enhance bactericidal abilities. Studies have shown that the infection rate of wet covering application is 2.6%, while the infection rate of traditional covering application is about 7.1%. Wet healing gives the wound an environment of a certain humidity, which is conducive to shortening the wound healing time and improving treatment effect. ***Wet coverings are mainly as follows:***

Vaseline yarn block	Algal acid covering	Hydrogel covering	Silver ion covering
The surface of	It's from the		Inside it is mainly
Stay soaked in	Algal plant	Mainly can promote, into the epidermis and meat, bud growth, such as, fruit exudate is more, the wound, generally, are not	Silver ions are the
After that,	Come out, fit		Points, can
Sterile	Used for		Make infection,
Made, usually	Or a lot of		The bud tissue grows
For some tables	Liquid, and		The solution of
Skin abrasions	And		need.Cause

Ulceration and other wounds	The wound of the necrotic		Skin preimmersion

What is the difference between this product and the ordinary hydrogel covering?

- **Low cost of raw materials**
- **Easy to synthesize**
- **Specialized efficient formula**
- **Eco-friendly, biodegradable and renewable**
- **No preservatives, purely natural anticorrosion**

■ 1.3 Research question implications

Many problems exist in a variety of wound coverings available on the market:

- non-breathable
- average antibacterial properties
- easy to fall off (limits joint movement)
- adhesion to wound
- may cause allergies
- not applicable for patients with coagulation disorders
- if the covering is not chosen properly, not only will the wound healingbe inadequate, but complications may also occur

Hydrogel can avoid these problems! Hydrogel has a contraction effect and as a result, pulls the wounded area together and promotes healing; and thus results in the wound being seamless and scar-free .

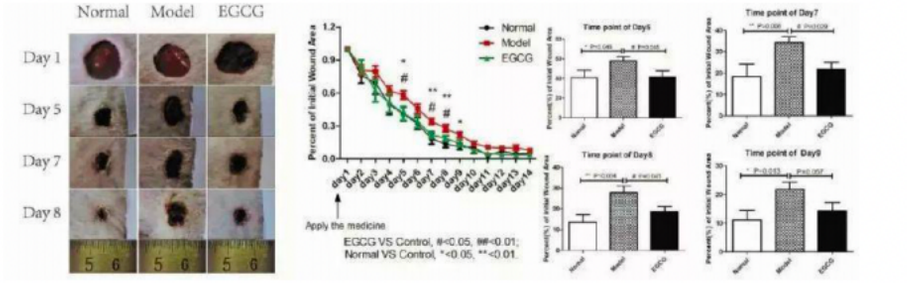
On August 2,2018, Professor Sheng Jun of the American Federation of Experimental Biology published the research and development team of Yunnan Agricultural University online

Research findings:

EGCG, the major component of tea polyphenols, suppresses inflammatory targets in diabetic wounds (Notch), which can effectively promote skin wound healing in diabetic mice.

- **The antibacterial performance is strong**

Tea polyphenols can effectively scavenge harmful free radicals



- **Hypoallergenic**

Tea polyphenols can strongly inhibit the release of histamine, and experiments have proved that the hypoallergic property of tea polyphenols are stronger than the commonly used anti-allergy drugs by 2~1.times.Tea polyphenols can inhibit the allergic reaction caused by activity factors such as antibodies, adrenaline, enzymes, etc.

To sum it up, hydrogel coverings made from tea polyphenols are a breakthrough in wound treatment, especially in the wounds of diabetic patients!

➢Design objectives

1）**Make into a hydrophilic, biodegradable, renewable hydrogel covering**

The derivative containing high quality cellulose is used as the raw material, because cellulose is a

macromolecular polysaccharide composed of glucose, which is the main component of the plant cell wall: colorless, tasteless, and insoluble in water and most organic solvents. Cellulose is the most abundant natural polymer on earth, with its biodegradable, regeneration and recycling characteristics causing it to be widely used in hydrogel, aerogels and other fields.

2）High-quality cellulose

Cotton was extracted from plants containing high-quality cellulose.

[element]

Seed hairs contained 91% cellulose, 0.4% wax and fat, and cell content 0.6

contain histamine

(Histamine) 113mg / g, fresh bud containing histamine 6mg/g.

[Functional main treatment] Hemostatic

[Other] The extract of island cotton and mainland cotton also increases blc

3）Make a scar-free hydrogel dressing with strong antibacterial, breathable properties and improved healing efficiency

We intend to add tea polyphenols and mint extract to the extracted cotton cellulose to make hydrogel coverings, which are effective as follows: (attached photo)

Tea polyphenols are an important component of material metabolism in tea, and also the general name of polyphenols in tea. It has high content, wide distribution, great change capacity, and has the most significant impact on the quality of tea. It is the most extensive and most in-depth substance studied in the biochemistry of tea, and also the main component of tea with health functions. Tea polyphenols also have an important physiological activity on the human body, with a strong antioxidant capacity (natural preservative), as the first plant antioxidant. At the same time, it can strongly remove harmful free radicals, resist allergic reactions and skin allergic reactions.

Peppermint extract is a brown powder material extracted from the aerial part of the lamiaceae plant. Chemical composition: contains volatile oil, mainly menthol, menthol and menthyl esters. It can stimulate central nervous system, promote blood circulation, and the menthol in mint can give the skin a cool feeling, can effectively reduce inflammation, relieve pain, reduce itching , detoxification, and even relieve emotions.(* However, in the eyes of Chinese medicine due to the cold nature of mint, pregnant women and weaker patients should to avoid using it.)

➢Work description

■ 3.1 Materials & Instruments

Cotton with shell, tea polyphenols, mint extract, (initiator), methyldiacrylamine (crosslinking agent), distilled water

Initiator, also known as free radical initiator, refers to a class of compounds that can be easily decomposed through heat into free radicals (i.e., primary free radicals), which can be used to trigger free radical polymerization and copolymerization reaction of olefinic and diene monomers, and can also be used for crosslinking curing and polymer crosslinking reaction of unsaturated polyester.

Crosslinking agent, also known as bridging agent, plays an important part in poly-smoke photoresist. The photochemical curing of this photoresist depends on the cross-linking agent with dual photosensitive functional groups to participate in the reaction. The crosslinking agent generates diradicals after exposure, it interacts with poly-smoke resins, form the bridge bonds between polymer molecular chains, into a three-dimensional structure of an insoluble material.

Reagent: hydroxide dynamic and hydrogen peroxide

Instruments: electronic balance, magnetic stirrer, constant temperature water bath, vacuum drying oven

■ 3.2 Experimental design

1. Extract high-quality cellulose from shelled cotton

A） **Boil plants for 100 minutes in a 2% NaOH solution at 100°C**

B） **Wait until the solution temperature drops to 70~80°C, then add H2O2 with a concentration of 5%. Continue to heat at 70-80 °for half an hour**

C) Filter and fully wash with distilled water

Filter residue to neutrality, dry to get fiber samples

2. Synthetic hydrogel

a) **Proportions** * **Mixed cellulose (tea polyphenols + mint extract + cotton cellulose)**

The ratio of cellulose to tea polyphenols: 1:0.2

Cellulose to mint extract: 1:0.2

Crosslinking agent to mixed cellulose ratio 1:30

Mixed cellulose to initiator ratio: 2:5

b) **Specific synthesis steps**

1. Stir the tea polyphenols, mint extract and cotton cellulose well.
2. Add the needed amount of mixed cellulose (tea polyphenols + mint extract + cotton cellulose) slowly into a beaker with distilled water, dissolve in magnetic stirrer.
3. Pour the mixed cellulose into a small beaker, then add the crosslinker along with a small amount of distilled water. Stir until the crosslinker is completely dissolved.
4. Add a certain amount of into the small beaker, stir slowly until even and pour into the reaction container. Cover with a thin film.
5. Place the reactor in an 80°C heated water bath for a fixed amount of time to get a flexible hydrogel.
6. Remove the hydrogel and place it in another small beaker with distilled water for a day (to remove impurities).
7. After purification, the hydrogel is placed in a vacuum oven at a set temperature of 80°C until it reaches a constant weight.

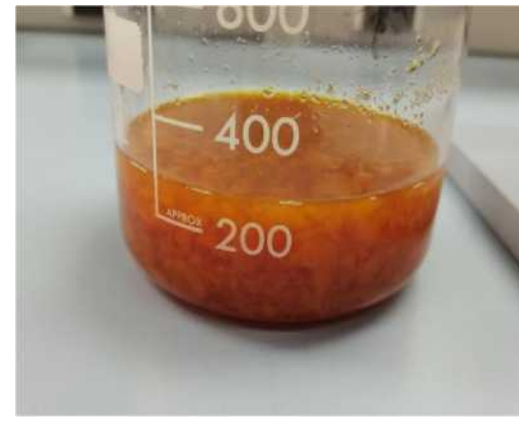
■3.3 Experimental Procedures

The first production

Materials: cellulose 28g, tea polyphenols 0.1g, mint extract 0.1g, 1.5g (initiator), 1.5g (crosslinker), distilled water 50ml each time

Equipments: electronic balance, magnetic mixer, constant temperature water bath, vacuum drying oven

Process:



1. Stir the tea polyphenols, mint extract, cotton cellulose and mix well.
2. Take the mixed cellulose (tea polyphenols + mint extract + cotton cellulose) and add slowly to the beaker filled with distilled water, then stir with the magnetic mixer until fully dissolved.
3. Place the mixed cellulose in a small beaker, weigh and add the crosslinker along with a small amount of distilled water. Stir until the crosslinker is completely dissolved.
4. Add the measured amount of into the small beaker, stir slowly evenly and pour into the reaction container, and cover with a thin film.
5. After heating in a water bath at 80°C, hydrogel is obtained.
6. Remove the hydrogel and leave it in another small beaker with distilled water for a day (impurities are removed).
7. After purification, place the hydrogel in a vacuum oven at a set temperature of 80°C until constant weight (3 hours)

Conclusion: the first trial was not very successful, as the hydrogel is fragile, uneven, inelastic and has too much water content. On the second time, we can use less water and slightly increased the amount of cellulose, crosslinker and initiator. We can verify our hypothesis through the way our solution looks after using the magnetic mixer.

The second production

Materials: 29.8g of cellulose, 0.2g of tea polyphenols, 0.2g of mint extract, 1.6g of (initiator), 1.6g (crosslinker), distilled water 10ml each time

Equipments: electronic balance, magnetic mixer, constant temperature water bath, vacuum drying oven

Process:

1. Stir the tea polyphenols, mint extract, cotton cellulose and mix well.
2. Add mixed cellulose (tea polyphenols + mint extract + cotton cellulose) slowly to a beaker with distilled water, magnetic stirrer stir and dissolve in water.
3. Put the mixed cellulose in a small beaker, weigh and add crosslinker to the small beaker, then add a small amount of distilled water, and stir until the crosslinker is completely dissolved.
4. Add to the small beaker, stir slowly and pour into the reaction container, and cover with thin film.
5. The hydrogel is obtained in an instant water bath of 80°C, after 2 hours of reaction.
6. Remove the hydrogel and leave it in another small beaker with distilled water for a single day (remove impurities).

7 After purification, the hydrogel was divided into Petri dishes and placed in a vacuum oven at a set temperature of 80°C until constant weight (1.5 hours)

Observation: for our second time,the finished product is 90% successful, as we achieved a much more gel-like form, however it is accompanied by some black impurities within. We suspect it's due to the fact that the temperature was too high, and some substances within mixture were burnt; or the precipitation time was insufficient. So on the third time,we can lower the temperature within the magnetic stirrer and lengthen the purification time (+ 0.5 hours).

The third production

Materials: 29.8g cellulose, 0.2g tea polyphenols, 0.2g mint extract, 1.6g initiator, 1.6g crosslinker, distilled water 10ml each time

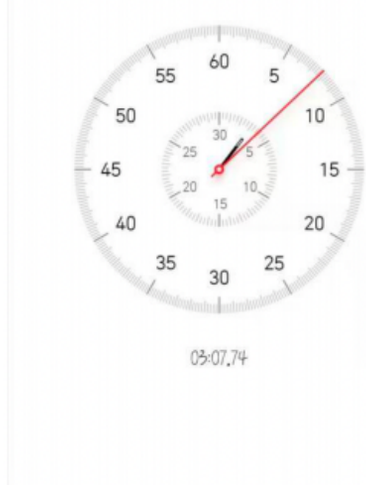
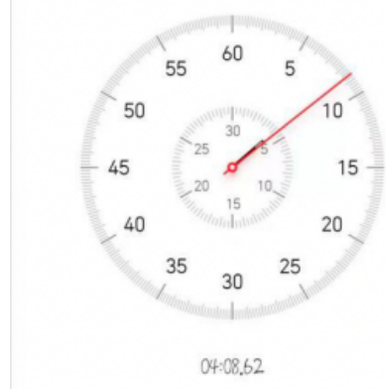
Equipments: electronic balance, magnetic mixer, constant temperature water bath, vacuum dry box

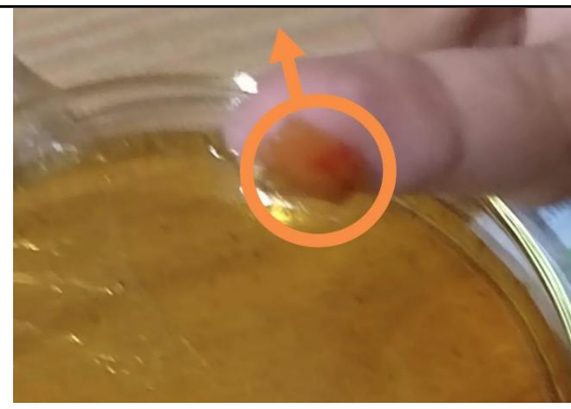
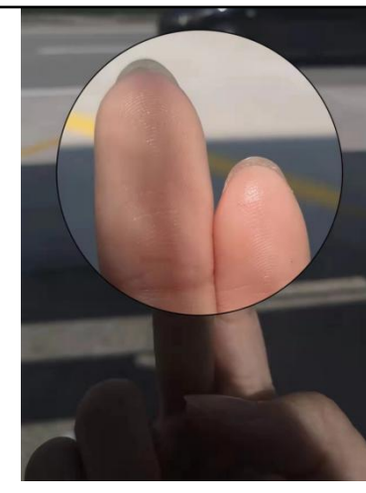
Process:

1. Stir the tea polyphenols, mint extract, cotton cellulose and mix well.
2. Add mixed cellulose (tea polyphenols + mint extract + cotton cellulose) slowly to a beaker with distilled water, magnetic stirrer stir and dissolve in water.
3. Put the mixed cellulose in a small beaker, add the crosslinker, then add a small amount of distilled water, and stir until the crosslinker is completely dissolved.
4. Add a certain amount of the small beaker, stir slowly and pour into the reaction container, and cover with thin film.
5. Get the hydrogel after 2 hours of the reaction in a water bath at 80°C.
6. Remove the hydrogel and place in another small beaker with distilled water for 0.5 hours (impurities removed).
7. After purification, the hydrogel was divided into Petri dishes and placed in a vacuum oven at a set temperature of 80°C until constant weight (1.5 hours)

Observation: The third finished product is the most successful one in my mind! The hydrogel formed with no impurities, and a light fragrance, these can maximize the effects needed; at the same time, it is biodegradable, renewable, very environmentally friendly!

■ 3.4 Test Comparison

	Tea polyphenol hydrogel covering	no covering is used
Blood clotting time		
Bleeding		

With and without covering		
Comparison of results		

Conclusion:

1.Through test and comparison, it is found that there are quite a few differences between using the tea polyphenols hydrogel covering and without, which verifies the healing effect of the tea polyphenols; 2. When the gel is attached to the wound, the gel quickly drained fluid from the wound, which prevents external bacteria from entering the wound, enhancing the sterilization ability, and improves the healing efficiency; 3. The above results can confirm that the tea polyphenols hydrogel covering can achieve the effect of non-scarring.

Feedback from one of our pilots: “The Optimus Prime for wound repair! When applying it, it has a cool sensation which is very comfortable, there is also a light natural fragrance. Although it is injured, I feel much better immediately afterwards! When the wound is almost fully healed, there is basically no trace or pain; it feels much better than ordinary band-aid, has a long use, and is airtight. Normally I wouldn’t bother dealing with small wounds, but if it is with this hydrogel covering, I wouldn’t mind using it even if they’re only tiny. It’s great!!!”

➢Similar products comparison

■ 4.1 Market Outlook

① Related Product research

Conwhir hydrogel covering

Price: 55RMB, moisturizing and absorption and balance work

(1) Helps with our natural autolytic debridement process and wet wound healing

(2) Simple and easy to use with applicator that can operated with one hand, can ensure precise control, convenient and sterile application. Dressing can be removed with water. Minimizes fluid leakage from wounds and maceration, the viscous texture of the gel not only ensures the gel is fixed in place, but also remains sticky and prevents leakage and immersion even after absorbing tissue debris and exudates.

(3) Mode of action: the hydrogel dressing can hydrate necrotic tissue and can absorb excess exudates, slough, and tissue fragments in the wound.

(4) Composition: hydrogel covering consisted of purified water, fusiform methylcellulose pin and calcium alginate. Because the hydrogel covering is made from

natural ingredients and contains no additives, it is a very mild debridement product.

Yi shi EASTDERM-hydrogel wound covering

Price: 399TWD =90RMB

- **High biocompatibility**

  a) **Does not easily cause skin irritation or allergies**

  b) **Perfect fit to skin**

- **Has a 3D mesh structure**

  a) **Gentle and long-acting release**

  b) **Higher content of active ingredients**

  c) **Forms a skin protective film**

  d) **Plastic formation into various shapes**

- **Super absorption capacity is more than 5 times**

a) Has the characteristics of moisture absorption and viscosity reduction

- **Perspectivity**
- **Easy to remove without causing wound pain**

Questionnaire survey

1. Do you usually use a covering to stop the bleeding when you are injured? Yes/ No
2. What type of dressings do you use?

   Dry covering (gauze, bandage) / wet covering (traditional Chinese medicine paste, alginate covering) / none
3. If not, why?
4. What do you think the advantages and disadvantages of the dressings you use are?
5. Would you buy a wet dressing that effectively retains skin moisture, has strong

breathability, has a long antibacterial effect andimproves healing efficiency? Yes/ No

Conclusion:

1- **From the results of questions 1,3 from the above questionnaire, we can see that there are only two more people who deal with wounds using dressings than those who don't; the main reason are "small wounds do not need to use covering, it's troublesome!"And "they're uncomfortable to use". It can be concluded from these two that a lot of people feel using dressings to stop bleeding is too much effort, as well as it being uncomfortable. Since our tea polyphenols hydrogel covering is easy to use, comfortable, breathable, and has a special efficient formula, it has exceeded part of the product!**

2- **We can conclude from question 2 that very few people use wet coverings.So for wet coverings as a whole, tea polyphenols and hydrogel coverings have a greater room for**

development in the public eye, and more publicity can be done increase people's understanding and usage.

3- **From the question 5, more than 95% of people are still willing to buy this tea polyphenols hydrogel covering that can effectively maintain skin moisture permeability, long antibacterial effect and improve healing rate. Therefore, tea polyphenol hydrogel dressings have a bright future prspect.**

■ 4.2 Innovation Point

- **Low cost of raw materials**

  Trauma coverings on the market have a large range of qualities and costs. However there are few that are both affordable and easy-to-use, so using low-cost raw materials is the primary goal of smaller-scaled creations.

- **It is easy to synthesize**

  Compared with the commercial production of making hydrogels, the method we used is simpler and faster.

- **Special efficient formula**

  The main components of hydrogel dressings are tea polyphenols, mint extract and cotton cellulose. They have the following highly efficiency effects on wounds: efficient retention of skin moisture, strong air permeability, long antibacterial effect, strong reparation effect, and no scarring. And the added mint extract will make the user feel fresher.

- **Eco-friendly, biodegradable and renewable**

  It contains high quality cellulose (extracted from cotton) as the main raw material. As cellulose is a macromolecular polysaccharide composed of glucose, and is the main component of plant cell wall, it is colorless, tasteless, insoluble in water and in most organic solvents. Cellulose is the most abundant natural polymer on earth, and has the characteristics of biodegradation, regeneration and the ability to be recycled.

- **No additional preservatives, pure natural preservation**

  Many trauma coverings on the market are added with preservatives. However, this tea polyphenols hydrogel covering does not require any. This is because tea polyphenols are an important component of material metabolism in tea, and it is also the general name of polyphenols in tea. It has high content, wide distribution, varies greatly, and has the most significant impact on tea quality. It is the most extensive and most in-depth substance studied in the biochemistry of tea, and also the main component of tea with health function. At the same time, tea polyphenols also have an important physiological activity on the human body, with a strong antioxidant capacity (natural preservatives), which are the first of plant antioxidant.

■5. Summary

This product is a high-efficiency hydrogel type covering without added preservatives. The raw materials used are: shell cotton, tea polyphenols, mint extract, initiator, (crosslinker).Because the product is purely natural made without addition, it's shelf life is about half a month.

Five main features:

- **No added preservatives.**
- **Affordableto make.**
- **Special and efficient formula.**
- **Is environmentally friendly and biodegradable.**
- **Many people find it troublesome to treat wounds, as it can be uncomfortable and inconvenient; however our tea polyphenols hydrogel covering is easy to operate, comfortable and breathable. Made with simple and safe ingredients, it helps with efficient healing and environmental protection.**