A Simple Biocompatible Matrix for Cellular Support and Accelerated Healing

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Intro

Cellular stability and small wound care is very important in regards to minor surgeries and implantation. An accelerated healing rate decreases the time a wound is open to infection and other damages which may cause scarring or rejection. There are multiple commonly available products for dealing with small wounds. However, many of them are comprised of a substantial ingredient list which may lead to internal interaction or with other materials, and do not withstand desiccation and rehydration. In addition, commercial products often have restrictions on usage such as who can use them and how they can be applied. We have developed a simple gel matrix that can be used to reduce healing time of small incisions and may be applied directly to the surface of an implant to increase bio-compatibility and reduce the chance of rejection.

Material Background

Glycinebetaine (carboxybetaine, trimethylglycine) is a naturally occurring molecule found a variety of plants and animals, the most well known being beets, for which it is named[1]. It has a large number of uses including, but not limited to: muscle growth[2], PCR stabilization[3], and protein and cellular protection[4]. Polymers made from a modified form of glycine betaine (carboxybetaine methacrylate) are being used for biocompatible implants and super low fouling surfaces[5].

Sodium alginate (alginic acid sodium salt) is a thickener and emulsifier extracted from brown algae. It is most commonly used in a variety of material sciences including cooking. It has also been shown to be a simple and functional material for 3D bioprinting[6].

Both materials are hydrophilic and biocompatible. Both are already currently used in situations where cell health and stability are important.

Methods and Testing

In an autoclave safe container add 10% glycinebetaine (Quality Supplements and Vitamins Inc.) and 3% sodium alginate (Sigma-Aldrich) in millipore filtered H20. Seal and agitate till the alginate has begun to dissolve. Allow to sit for 90 minutes to allow the remainder of the alginate to dissolve into solution. Adjustments can be made to alginate amount at adjust thickness. The resulting gel is then autoclaved and sealed.

The alginic glycinebetaine (AGB) gel was tested against a leading commercial product, Skintegrity hydrogel. For the purposes of the experiments, this was used as the positive control. Subjects were given four 2cm length surface incisions on the exterior upper arm. The primary incision had the control applied to it, the second had AGB applied to it, and the last two were unmodified and used as negative controls. Wounds were washed, coated with 0.5 ml of each gel applied with a sterile swab, and then covered with a sterile gauze dressing. Healing time was calculated as the amount of time until epithelialization had closed the wound surface.
AGB and the control were also tested for response to desiccation and re-hydration. A small drop of each gel was placed on a titanium ceramic nitride (TiN) coated prosthetic and then allowed to dry overnight at room temperature. Following 24hrs of passive dehydration, both samples were mechanically tested for adhesion to the prosthetic while dry. The effects of re-hydration through application of millipore H20 were tested as well.
AGB was tested for potential internal complications through application of .25 ml of gel, implanted at the subcutaneous level. The control could not be tested as it is not suggested for internal use.

Results

When applied to wounds, the AGB doubled the rate of healing on average. This is comparable to the control (Figure 1) After 24 hours of passive dehydration, AGB was dry to the touch and firmly affixed to the TiN surface. The control was reduced in volume and still wet to the touch. There was little surface adhesion. Rehydration caused the AGB to return to its original state while still maintaining minor adhesion to the surface. The addition of water to dehydrated control caused a failure in the matrix stability leading to removal from the surface.

The area where the AGB was implanted showed no signs of redness or irritation.

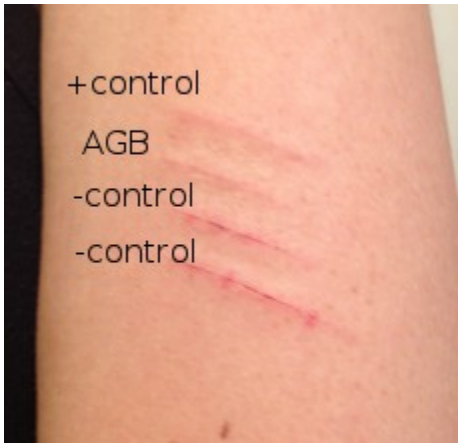

Figure 1: Photograph of small incision testing for the alginic glycinebetaine (AGB) 24 hours after application. All incisions were made at the same time and to the same depth. The AGB matches the control in degree of repair

Conclusion

While the ingredient list for the AGB is only 2 simple substances in water, the increased healing rate is matches that of commercial products. The solution is simple and can be made in a properly equipped kitchen. While a hydrogel is more structurally stable, the lack of crosslinking in this situation allows for easier sterilization and a wider range of application methods. The ability to be applied to a surface and then dehydrated could allow the AGB to be coated on an implant and then sterilized in an autoclave. This may allow for an implant that has a robust rehydratable coating that could improve both biocompatibility and healing time. The coated device need merely be dipped into a sterile saline solution before use. If the device is already sterile, it need only be dipped in the sterile AGB gel before implantation.

It is possible to load other chemicals into the gel to change the properties. This could be antibiotics, or other healing agents. However, the simplicity of the solution allows for less unseen complications.

As this is a preliminary study, it is not advised to use this substance for non research purposes. While the results are positive, more testing is necessary to confirm initial findings.

However, there are currently no materials available for non medical professionals to increase the success of implantation beyond the properties of the implants themselves. This alone makes access to this method important for the diyBio, piercing, and "grinding" communities.

References

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