Testing Polyacrylamide Hydrogel Microneedle Patches on Agarose Phantom Gels via Calcium Studies

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Introduction

All medical devices released on the market go through countless rounds of trials from a lab setting to clinical studies to ensure it's safe for public use. However, errors and discrepancies occur when switching from the ideal lab setting to animal or clinical studies. To investigate this issue, researchers will develop gels of their desired test area, including skin-like/phantom gels and artificial perspiration. Using this methodology, researchers can pinpoint the errors and remedy them appropriately.

The microneedle patches used in our lab puncture the epidermis and read calcium levels within interstitial fluid (ISF) since it carries similar calcium properties to that of blood. In our experiments, the hydrogel microneedle patches worked as expected in an ideal environment, but did not emulate these results in an animal study where the fluorescence will decrease in the presence of calcium. To investigate this dilemma, we developed phantom gels and artificial ISF (aISF). We treated the aISF-diffused phantom gels as a human's forearm and conducted calcium studies using the microneedle patches. After testing 5 different types of agarose, we concluded that type 1 produced the most skin-like gel while the others precipitated instantly after adding aISF. However, the results from the calcium studies supported the fact that type B absorbed the most calcium and decreased the microneedles' fluorescence the most. Due to these conflicting results from both type 1 and B, we have to investigate further with another type of agarose and a different aISF procedure.

Methods & Experimental Design

The aISF was created using 200 mL of DI water instead of 100 mL. All corresponding components from the procedure outlined in figure 1 were adjusted to accommodate for the ratio.

Composition of Synthetic Interstitial Fluid

Component	Molar concentration	by weight
NaCl	107.7 mM/L	6.3 gm/L
KCl	3.48	0.26 gm/L
$CaCl_2$	1.53	$CaCl_2$ 10% solution 1.7 ml
$MgSO_4$	0.69	$MgSO_4.7H_2O$ 0.17 gm/L
$NaHCO_3$	26.2	2.2 gm/L
NaH_2PO_4	1.67	$NaH_2PO_4.2H_2O$ 0.26 gm/L
Na gluconate	9.64	2.1 gm/L
glucose	5.55	1.0 gm/L
sucrose	7.6	2.6 gm/L

Figure 1: aISF Procedure

Conclusion

- Phantom gel with agarose type 1 mimicked skin better than type B
- Agarose type B decreased the fluorescence of the microneedle patches the most
- Despite precipitation, agarose type B is best for calcium studies
- Need to test other agarose and methods to create aISF

Works Cited

[1] **Microneedle-Based Detection of Ketone Bodies along with Glucose and Lactate: Toward Real-Time Continuous Interstitial Fluid Monitoring of Diabetic Ketosis and Ketoacidosis** Hazhir Teymourian, Chochanon Moonla, Farshad Tehrani, Eva Vargas, Reza Aghavali, Abbas Barfidokht, Tanin Tangkuaram, Patrick P. Mercier, Eyal Dassau, and Joseph Wang Analytical Chemistry 2020 92 (2), 2291-2300
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Results

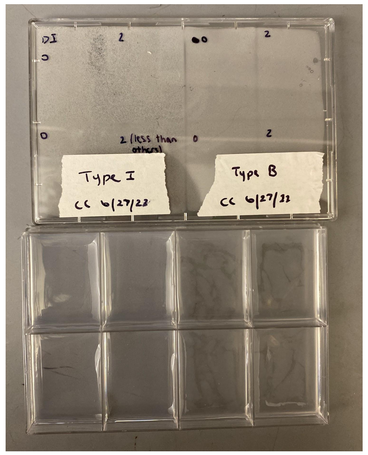

Figure 2: Phantom Gels Before Calcium Studies

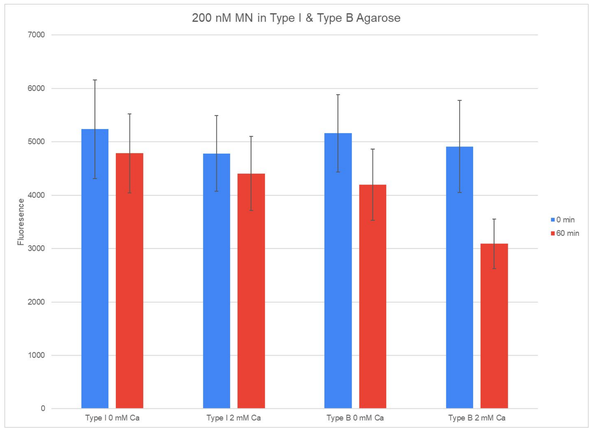

Figure 3: Comparison of Agarose Type 1 & B Phantom Gels Calcium Study

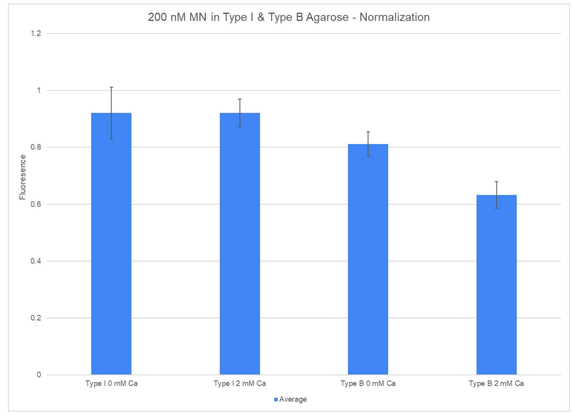

Figure 4: Normalization of Phantom Gel Calcium Study