Hydrogel-coated microelectrode array for neural interface

Sang Beom Jun[1,2], Matthew R. Hynd[3], Jae Kyoo Lee[1,2], James Turner[3,4], William Shain[3,4], Sung June Kim[1,2*]

1 Nano-Bioelectronics & Systems Research Center, Seoul, Korea
2 School of Electrical Engineering, Seoul National University, Seoul, Korea
3 Wadsworth Center, New York State Department of Health, Albany NY, USA
4. Department of Biomedical Science, School of Public Health, University at Albany, Albany NY, USA
* Corresponding author. E-mail address: kimsj@snu.ac.kr

Recently, hydrogel has been extensively used in various biomedical applications including soft contact lenses, wound healing materials and as a means for controlled drug delivery and release. In this study, we propose to use hydrogel as a novel neural interface. Planar microelectrode arrays were coated with hydrogel in order to improve the quality of the interface and to aid in drug delivery to cells on microelectrode arrays (MEAs).

1 Hydrogel coating on MEAs

A polyacrylamide gel matrix consisting of acrylamide (19:1, 40% acrylamide:bis-acrylamide), in 30% glycerol, 0.83% methylene blue, 0.12% TEMED, and 100 mM Tris Cl (pH8.5) was prepared. Various compositions (12.5, 25, 50, 70%) of acrylamide were prepared to measure the difference of electrochemical impedances after polymerization over microelectrode sites. Nerve growth factor(0.1mg/ml in PBS) was prepared and added to the hydrogel solution with the concentration of 10%(v/v). The mixture(10μl) was applied onto MEAs pretreated with Bind-Silane(3-(trymethoxyslyl)-propyl acrylate, acetic acid, dH_2O) for 1 hour. Quartz coverslips were used as a backing template during polymerization. Prior to use, coverslips were treated with PlusOne Repel-Silane ES for 30 min, then rinsed in dH_2O and dried at room temperature. A treated glass coverslip was placed on top of the hydrogel solution dropped on MEAs. The acylamide solution was photopolimerized by exposure to UV light for 15 min on a 312nm UV lamp. Following polymerization the backing coverslip was carefully detached from the MEAs and washed a stream phosphate buffered saline (pH7.4) for 10 min to remove any unpolymerized gel solution.

2 Electrochemical Characterization

The electrochemical impedances of microelectrode recording sites were measured through polymerized hydrogel in order to check if the neural signal can be detected through hydrogel. The impedances of electrode sites covered by various compositions of acrylamide were measured by potentiostat at 1 kHz in PBS. After hydrogel polymerization on MEAs, the impedances were increased by 1.8, 3.4, 10.8, and 57.1 times for 12.5, 25, 50, and 70% composition of hydrogel coating respectively.

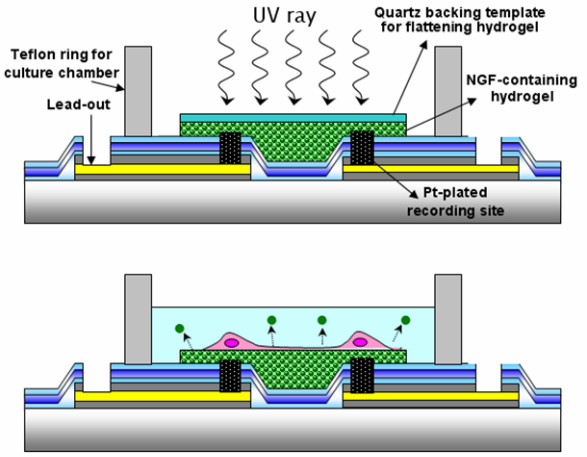

Fig. 1 Cartoons for hydrogel coating on MEAs (top) and neuronal culture (bottom)

3 Neuron culture and neural recording

Poly-L-lysine was patterned onto the surface of hydrogel using microcontact printing. Primary rat hippocampal neurons were applied to hydrogel surfaces and cultured on stamped patterns. Neural signals were successfully recorded from cultured neural networks through hydrogel (12.5% acrylamide) at 21 days *in vitro*. (Fig. 2)

ISBN 3-938345-02-0

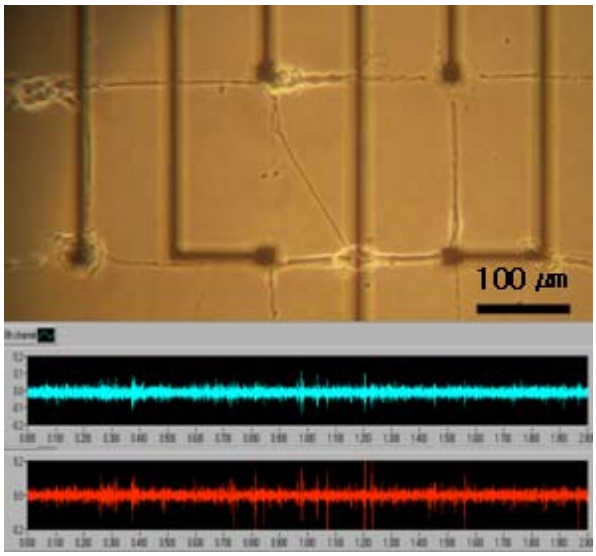

Fig. 2 Patterned neural network on hydrogel-coated MEA (top) and recorded spontaneous activity (bottom)

4 Drug delivery from hydrogel

The release of NGF from hydrogel was verified by the differentiation of PC12 cell. PC12 cells were cultured on NGF-containing hydrogel. After 2 days in culture, PC12 cells successfully differentiated by released NGF as shown in Fig. 3.

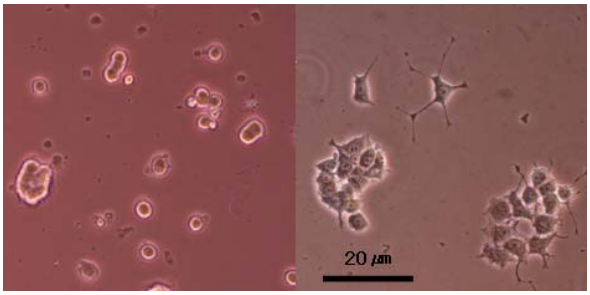

Fig. 3 PC12 cells cultured on normal hydrogel (left) and differentiated PC12 cells on NGF-containing hydrogel (right) at DIV 2

5 Summary

We showed that hydrogel can be used as a neural interface material with a drug delivery function. Hydrogel coated on MEAs with a low concentration of acrylamide hardly affect the quality of neural recording. In near future, hydrogel could be employed in neural prosthetic devices using its noble properties such as responsiveness to pH, electrical fields, temperature, light, and organic compounds.

Acknowledgement

This work was supported by the International Collaboration Program, NBS-ERC (Nano Bioelectronics and Systems Engineering Research Center)/KOSEF (Korea Science and Engineering Foundation) and also supported in part by the Nanobiotechnology Center (NBTC), an STC Program of the National Science Foundation under Agreement No. ECS-9876771.

References

[1] MR Hynd, M-R Burnham, DL Martin, JN Turner, W Shain, Spatial control of cell growth using protein micropatterning on biocompatible surfaces, 34th Neuroscience Meeting, San Diego, USA, 2004

[2] Stephane Woerly, Giles W. Plant, Alan R. Harvey, Cultured rat neuronal and glial cells entrapped within hydrogel polymer matrices: a potential tool for neural tissue replacement, Neuroscience Letters, vol 205, pp197-201, 1996