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Learning/memory Effect of Composite Conducting Polymer Network Device

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Introduction

Conducting polymers with fractal patterns have been prepared electrochemically on a bottom surface of a cell, not on a work-electrode. The patterns of conducting polymers depends on the experimental or environmental conditions[1,2]. A neuron-like conducting polymer is prepared under controlling the polymerization conditions: (i) a disc-like conducting polymer is prepared. (ii) dendrite conducting polymer is prepared at the edge of the disc-like one by changing the polymerization conditions. Two neuron-like conducting polymers can be connected each other via dendrites. That is , a network of neuron-like conducting polymer is fabricated. A shape of the path/channel of the network and the number of the paths depend on the experimental/environmental conditions. This means that the weights of the network of the conduction polymer depend on the environmental conditions. Thus this network contains the environmental conditions as shape. if the weight , *i.e.* the conductivity, of the paths is changed by the electrical pulses passing through the path, a new type network device of conducting polymer which has parameters of the environmental conditions can be proposed. Furthermore, if it has a non-linear characteristics, a neuron device of conducting polymer can be fabricated.

The learning effect in the path has been realized using the third electrode which is set near the path[3]. Amount of dopant is controlled by the electrical potential of the third electrode. The installation of the third electrode , however, becomes difficult since the number of the paths increase when the network of conducting polymer becomes complicated. So another method is required.

Some conducting polymers have property of gel. It is possible to control the amount of the dopant in conducting polymer gel since the dopant moves in or out of conducting polymer in some solvent[4]. It is, however, hard to control the amount of the dopant since the dopant easily moves out in solvent. The conducting polymer without property of gel is stable for such solvent. Thus composite of gel and conventional conducting polymer has been investigated to add the learning effect to the path. The conductivity of network conducting polymer fabricated is low. It does not contribute to the function of. learning effect Thus two kinds of conducting polymer were fabricated on it. This means that the network conducting polymer is a base layer, and other layers work as learning effect layer.

In this paper, the learning effect of many kinds of composite conducting polymers is investigated. The simple artificial network of composite conducting polymer has been used since it is hard to control the pattern of neuron-like network of conducting polymer.

Experimental

Simple network of composite film of polypyrrole and poly(3-alkylthiophene), PATn, were prepared as show in Fig.1. The size of the film was 20mm x 24mm, the width and the length of the pass was 4mm and 4mm, respectively. Learning method using supervisor signal was used. The simple network of conducting polymer was immersed in chloroform (30 ml) containing iodine(0.1M). An uni-polar sinusoidal voltage[AC voltage of 5Vp-p(20kHz) + DC voltage of 5V] was applied between terminal b and terminal 3. for 10 min as supervisor signal. This learning-process is called pretreatment. After passing supervisor signal in the simple composite conducting polymer network, the simple network was dried. Then it was soaked in ethanol. Each current between terminal b and others was measured after drying it. If the current between terminal b and terminal 3 is higher than other paths, network has then memorized the paths across which the supervisor signal have passed. That is, the network learned according the supervisor signal.

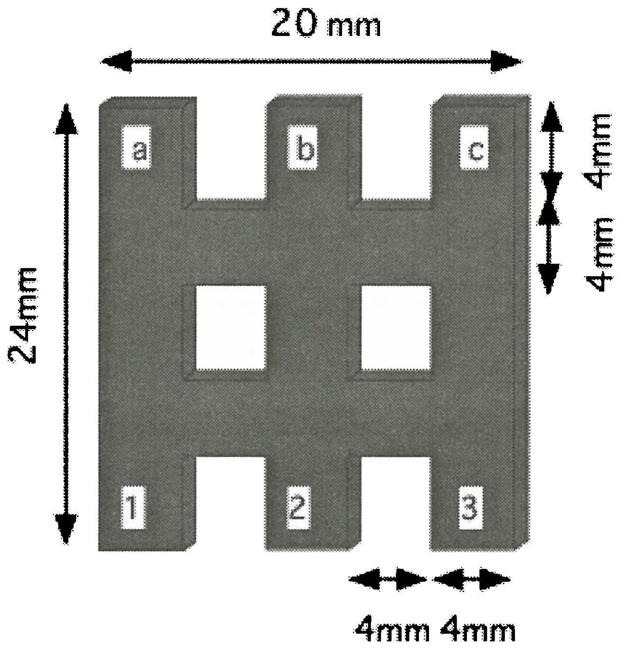


Fig.1 Simple network of conducting polymer

The simple network of composite conducting polymer of polypyrrole and PAT6 has been broken after measurement because PAT6 shrank due to property of gel. Composite conducting polymer of PATn was investigated.

Results and discussion

Figure 2 shows the composite conducting polymer of polypyrrole and PAT6 after investigating learning effect. This simple network of conducting polymer shows the learning effect. However it is not mechanically stable because of the shrink of PAT6 by ethanol. In order to

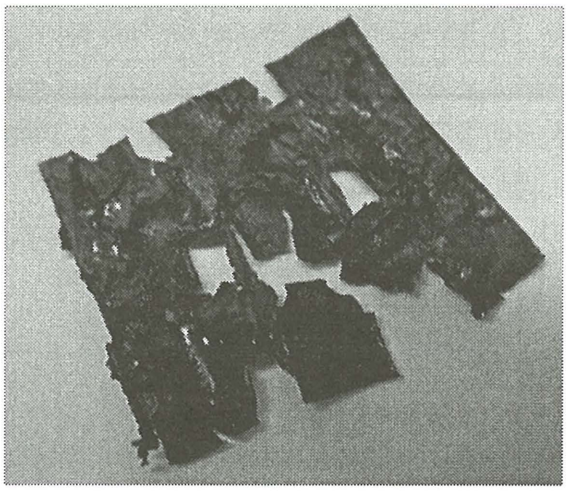
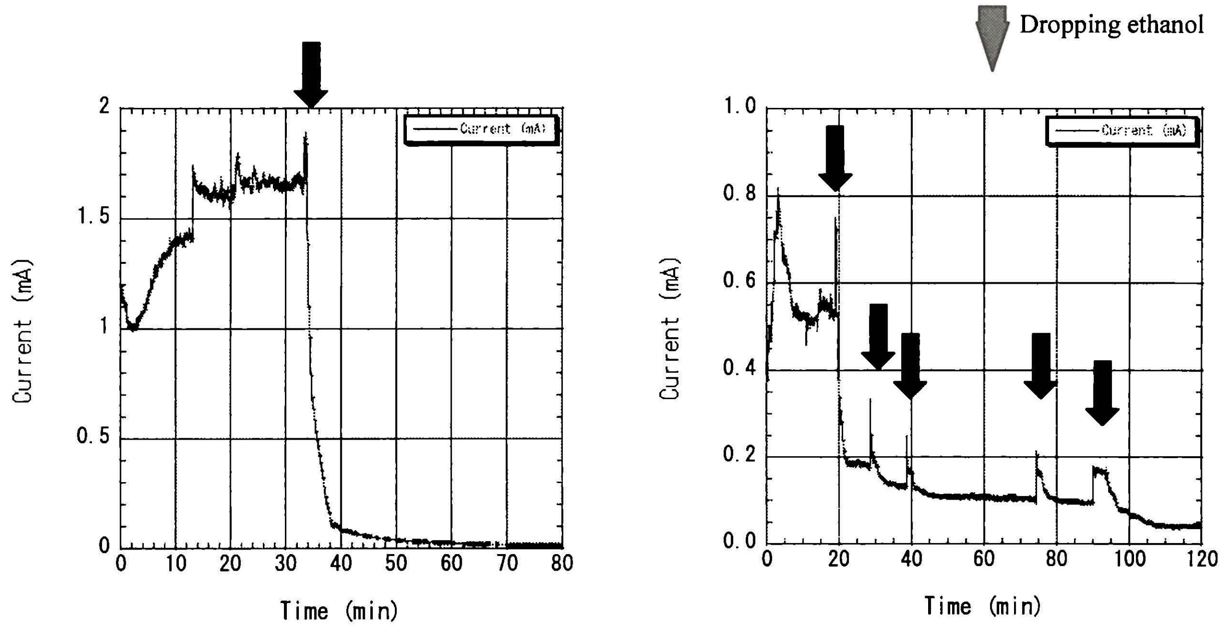


Fig.2 Composite conducting polymer of polypyrrole and PAT6 after measurement

obtain the flexible simple network conducting polymer, the suitable concentration of ethanol and the kind of PATn were investigated.

The composite films were used to investigate the effect of the ratio of ethanol and chloroform on the keeping ratio of dopant. 100%, 50% and 25% ethanol were used. Figure 3 shows the change of the current through the pretreated composite film by dropping ethanol of 100% and 50%.



(a) (b)

Fig.3 Change of current by dropping ethanol
(a) 100% and (b) 25% ethanol

In the case of 25% ethanol the current still kept on after dropping. IN the cases of 50% and 100% ethanol, both current t in pretreated and non-pretreated film decreased to small value.

Five kinds of PAT were used as composite film with polypyrrole:n=0, 1, 2, 6, 8.The currents in the composite

Table 1 Current and mechanical stability of pretreated composite conducting polymer after cropping 25% ethanol

PATn n=	0	1	2	6	8
Current (mA)	0.5	33	41	5.1	1.4
Mechanical stability	○	○	○	△	△

conducting polymer films pretreated were measured after dropping 25% ethanol. The mechanical stability was also checked after drying films. The results show Table 1. The current was kept high in the case of PAT2. For mechanical stability, PAT(n=0 to 2) were unstable and thus can be used as device.

The currents between the terminals of the simple network of the composite of polypyrrole and PAT2 were measured. The supervisor signal passed from terminal b to terminal 3 under liquid-doped state. Figure 4 show the change of the current before/after dropping 5% of ethanol. The change of the current between path b-3 is small. This means the weight of the path depends on the amount of the supervisor signal. This result suggests that the neuron-like conducting polymer device can be designed.

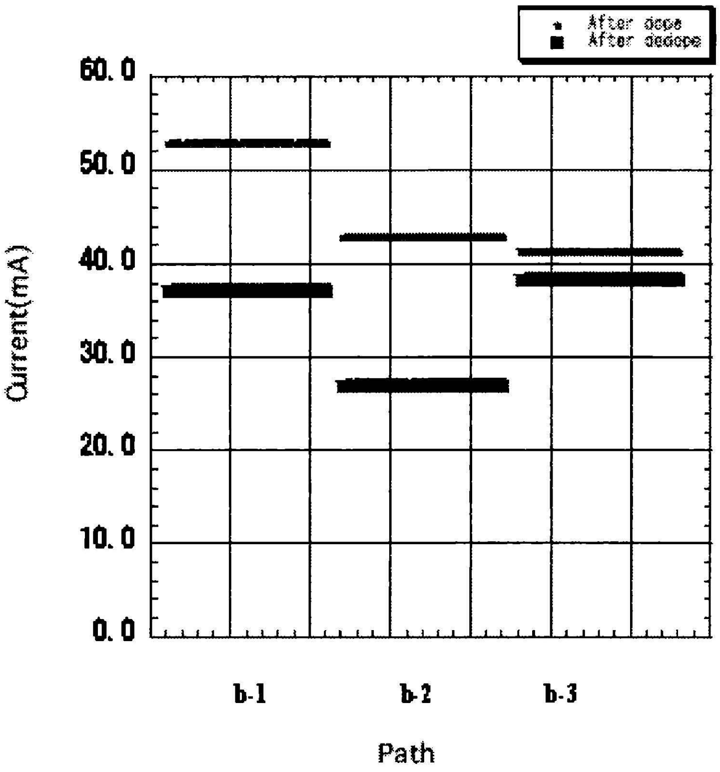


Fig. 4 Change of current between each path before/after dropping 5% of ethanol

Conclusion

Learning effect at the path in the simple network of conducting polymers is examined in order to develop the new device of neuron-type conducting polymer. Composite conducting polymers of polypyrrole and PATn has been investigated. The composite of PAT(n=0 to2) was mechanically stable and PAT2 showed the highest keeping ratio of dopant after dropping ethanol. The concentration of ethanol is also important factor.

It is found that the learning effect can be added to the simple network of composite conducting polymer.

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