Preparation and characterization of electrochromic device using ion conductive DNA films

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Introduction

Since DNA has the excellent characteristics beside the molecular memory, DNA was expected to be used in many fields. We have successfully prepared ion conductive DNA films with the aid of poly(ethylene oxide) (PEO) or ionic liquids.[1] This ion conductive DNA was prepared as flexible and transparent films. In this study, we prepared all solid state electrochromic device (ECD) with these ion conductive DNA films.

Experimental

Prussian blue (PB) was used as an electrochromic material in this system. The PB film was electrodeposited on the ITO glass electrode in an aqueous ferric ferricyanide solution mixture of 20mM $K_3Fe(CN)_6$, $FeCl_3$, and 10mM HCl. Pt and Ag wire were used as working and reference electrodes, respectively.

DNA potassium salt isolated from salmon milt was a gift from Daiwa Kasei Co. $PEO_{200}/KClO_4$ (1 to 5 mol% to EO unit) were added to DNA (5 to 20 EO unit/base pair) in water. The solution was cast on Teflon® plate, and dried under air and *in vacuo* for 1 day. The ionic conductivity of the obtained films was measured by complex impedance method, Schlumberger Solartron 1260. All solid state ECDs were prepared by sandwiching DNA film with ITO glass electrode and PB coated ITO glass electrode.

Results and Discussion

We prepared ion conductive DNA films with the aid of PEO/salt or ionic liquids. The obtained DNA films were transparent and flexible. In order to precede electrochemical redox reaction of PB based ECD, alkali metal cation are required. Accordingly, ECDs equipped with DNA film containing ionic liquid showed no color change even efficient given potentials. On the other hand, PEO/salt mixture was suitable for this kind of ECD. It is easy to prepare non-volatile electrolyte solution by mixing PEO with inorganic salt such as $KClO_4$. Their performance was the function of ionic conductivity, in other words, salt content. DNA containing $PEO_{200}/KClO_4$ (1 mol% to EO unit) showed the good ionic conductivity. The ionic conductivity of DNA/PEO_{200} (13 EO unit/base pair) mixture with $KClO_4$ (1mol% to EO unit) was 1.54×10^{-5} S cm^{-1} at 50 °C (Fig.1). By increasing PEO content, the ionic conductivity increased but at the same time it induced poor mechanical properties.

In order to determine suitable operation voltage of the prepared ECDs, electrochromic response was compared under various voltages. As the results, the given voltage and response speed showed good correlation. However, the response speed was hardly improved above 2.6V. The absorption change of thus prepared ECD was accordingly performed by the given potential from -2.6V to +2.6V (Fig.2). The maximum absorption at 700nm decreased when -2.6V was given to the working electrode. During this potential cycling, coloring-bleaching processes are repeatedly carried out. The absorbance changing from 80% to 20% at 700nm was performed within 20 s. Without dissolution of PB to an electrolyte phase and leakage of the electrolyte solution, color change was operated more than 100 cycles. Moreover, this ECD keeps more than 85% absorbance of the initial value after 24 hours under open circuit.

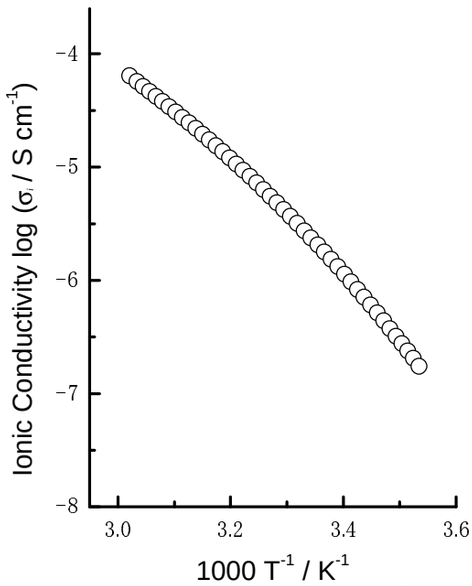

Fig.1 Temperature dependence on the ionic conductivity of DNA/PEO_{200} (13 EO unit/base pair)mixture with $KClO_4$ (1mol% to EO unit).

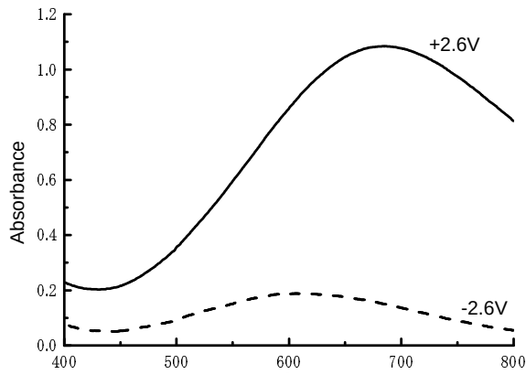

Fig.2 UV-vis spectra of ITO | PB | DNA/PEO/$KClO_4$(5mol%) | ITO-cell. Potential was driven between +2.6V and -2.6V with the interval of 20 s.

References

1. N. Nishimura and H. Ohno, *J. Mater. Chem.*, **12**, (2002) 2299.