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Control of ionic transport vector using a reversibly temperature-responsive charged membrane

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Introduction

There are many potential applications of 'intelligent' hydrogel systems in medicine, biotechnology, industry as well as in environmental problems. Many of the hydrogels undergo abrupt changes in volume in response to external stimuli such as pH[1], temperature[2], electric fields[3] and light[4], so that the permeability of certain solutes through the gels can be controlled by these stimuli. For several of the applications of the hydrogels, such as artificial intelligence, driving devices of "smart" gel actuators and self-regulating drug delivery, it is need to have a ionic gel devises which control not only the permeability but also the transport direction of specific ions in response to external stumuli. Here we report such a temperature-responsive charged membrane, which can control the transport vector of a specific ion in response to the temperature.

Experiment

Samples. Temperature-responsive charged membranes were prepared by grafting N-isopropylacrylamide onto poly (vinyl alcohol) (PVA) and by casting a mixture of DMSO solution of the graft polymer, polyanion and PVA. The membrane obtained was crosslinked in an aqueous solution of 0.025wt% glutaraldehyde and 0.1 N HCl at 50℃ for 5 min.

Measurement of membrane charge density. The charge density was estimated by fitting membrane potential data to the Teorell, Meyer and Sievers theory[5,6]. The membrane potential was measured at temperatures between 10 °C and 50 °C, using an acrylic plastic cell of two parts separated by the membrane. One chamber of the cell was filled with 0.1M KCl solution. The other chamber was filled with 0.5M KCl solution.

Results and Discussions

Fig. 1 shows reversible membrane charge density changes in response to stepwise changes in the temperature between 10 °C and 50 °C. The charge density increases and decreases reversibly between the two values: 0.08 mol dm^{-3} and 0.28 mol dm^{-3} within 1 minute in response to stepwise changes in the temperature. The charge density, C_x, is defined as:

$$C_x \equiv Q/H \qquad (1)$$

where Q and H are the ion exchange capacity and the water content of the membrane, respectively. The water content decreases with increasing temperature because the graft polymer chains become hydrophobic at temperatures above the lower critical solution temperature (33 °C). Hence, the charge density increases with temperature.

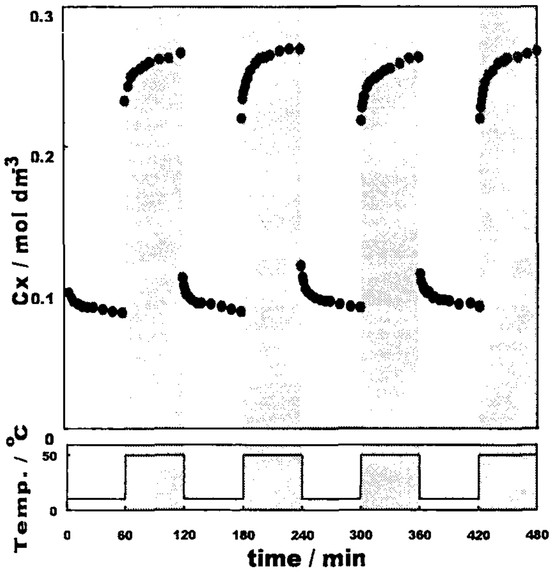

Fig. 1 Reversible membrane charge density changes in response to stepwise changes in the temperature.

It has been reported that the vector of ionic transport in a dialysis system consisting of a charged membrane and mixed electrolyte solutions depends on the membrane charge density.[7] Since the charge density of the membrane has a fast response to the temperature changes, we will examine the dependence of the vector of ionic transport through the membrane in response to stepwise changes in the temperature.

References

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