A NEW TYPE OF MICROPUMP DRIVEN BY A LOW ELECTRIC VOLTAGE

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ABSTRACT: In this paper, we propose a new prototype model of a micro pump using ICPF (Ionic Conducting Polymer Film) actuator as the servo actuator. This micro pump consists of two active one-way valves that make use of the same ICPF actuator. The overall size of this micro pump prototype is 12mm in diameter and 20 mm in length. The actuating mechanism is as follows: (1) The ICPF actuator as the diaphragm is bent into anode side by application of electricity. Then the volume of the pump chamber increases, resulting in the inflow of liquid from the inlet to the chamber. (2) By changing the current direction, the volume of the pump chamber decreases, resulting in the liquid flow from the chamber to the outlet. (3) The ICPF actuator is put on a sine voltage, the micro pump provides liquid flow from the inlet to the outlet continuously. Characteristic of the micro pump is measured. The experimental results indicate that the micro pump has the satisfactory responses.

KEY WORDS: micro machine, micropump, ionic conducting polymer film (ICPF) actuator, medical applications, biotechnology

1 INTRODUCTION

Intracavity intervention is expected to become increasingly popular in the medical practice, both for diagnosis and for surgery. As we know, many kinds of microactuator such as an electrostatic actuator, a piezoelectric actuator, a giant magnetostrictive alloy (GMA) actuator, a shape memory alloy actuator, a polymer actuator and an optical actuator have been actively investigated for their potential applications to micromachine technologies. In the medical field and in biotechnology, a new type of micro pump that can supply micro liquid flow has urgently been demanded[1,2]. The micro pump is one of the micro and miniature devices, which is installed with sensing and actuating elements. It can supply micro liquid flow. Recently, several types of micro pump using polymer actuator and PZT actuator have been reported so far[3~5]. However there are some problems, such as compact structure, low response, leaking electric current, safety in body and so on. The micro pump with supplying micro liquid flow and safety has never been developed so far. It is our purpose to develop a type of micro pump that has the characteristics of flexibility, driven by a low voltage, good response and safety in body. In this paper, we propose a new prototype model of a micro pump using ICPF (Ionic Conducting Polymer Film) actuator as the servo actuator. This micro pump consists of two one-way valves that make use of the same ICPF actuator. The overall size of this micro pump prototype is 10 mm in diameter and 20 mm in length. The actuating mechanism is as follows. ICPF actuator is made from the film of perfluorosulfonic acid polymer (Nafion 117, du Pont and company) chemically plated on it is both sides with platinum. In many points, ICPF actuator is superior to usual polymer gel actuator such as fast response, driven by low voltage (about 1.5 V) in wet condition without electrolysis, safety in body and so on[6]. This paper describes the new structure and the motion mechanism of a micro pump using ICPF actuator and discusses the possibility of the micropump.
2 STRUCTURE OF MICROPUMP

2.1 Total Structure of the Micropump

Figure 1 shows the basic structure of the developed micropump using ICPF actuator. This pump consists of the driving ICPF actuator as the diaphragm (A), pump chamber (B) and two one-way valves driven by ICPF actuator installed on one side of the pump chamber (C). ICPF actuators are installed in serial structure for supplying a large flow range. The photo of the developed micropump is shown in Fig.2.

![Fig.1 Total structure of the micropump](image1)

polymer gels. It is because that electrical condenser is generated on the polymer membrane. Circular ICPF actuator used for micro pump is shown in Fig.3. Amplitude ($2h$) is obtained by using sine wave voltage input.

![Fig.3 Circular ICPF for the micropump](image3)

3 MOTION MECHANISM OF THE MICROPUMP

The developed micropump has two active one-way valves. The structure of one-way valve is shown in Fig.4. The valve designed in the shape of taper, has a through hole leading from the tip to outside. When the ICPF actuator is bent into the flow direction driven by using the same sine voltage, the solution flows into the valve from the through hole. And it flows out through an outlet tube. It is prevented that the solution flows from the outlet tube into the valve, since through hole is closed by the ICPF actuator.

![Fig.4 Working mechanism of the one-way valve](image4)

The actuating mechanism of micropump is as follows.

1) The ICPF actuator as the diaphragm is bent