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New Gas Rubber Actuator Driven with Electrolysis/Synthesis of Water

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Abstract: Electrical-direct-driven new pneumatic actuator, working with no compressor and valves, has been developed. Electrolysis/synthesis of water working inside pneumatic actuator, drive actuator. Based on the principle of electrolysis, the electrical charge directly controls the generating amounts of gas, making actuator controllability much higher.

Keywords: Actuator, Pneumatic actuator, Soft actuator.

1. Introduction

Conventional pneumatic actuator needs compressor, expensive valves, and tubes. This is a reason why conventional pneumatic actuators are not used as mobile actuators. Another reason is in the energy efficiency; during decreasing the pressure in conventional pneumatic actuators, the high pressurized gas with energy is released to the atmosphere. We have previously developed electrolysis/synthesis-driven gas pressure source, showing that electrical current control realizes direct drive of fluid pressure without compressor and valve [1, 2]. Neagu et al. have developed similar idea actuator, however these actuators are only used on MEMS, and slow response [3, 4].

The principle applied to pneumatic actuator, which is shown in Fig. 1. Electrolysis/synthesis of water are controlled using proton exchange membrane fuel cell (PEM)'s charge/discharge. The PEM is just a membrane of electrolyte material covered with platinum thin layers (Fig. 1(a)). This makes PEM easy to be mounted inside actuator. In addition, this new gas source makes no noise and vibration because it needs no mechanical pumping motion. This paper shows design and experimental results of a pneumatic actuator, which is made of rubber and equipped with electrolysis/synthesis-driven pressure control device. During charging process of PEM, gasses are generated with electrolysis of water (Fig. 1(b)). And during discharging process the generated gasses are absorbed with synthesis of water (Fig. 1(c)). During

this process, the PEM's discharging energy can be recovered by external rechargeable battery.

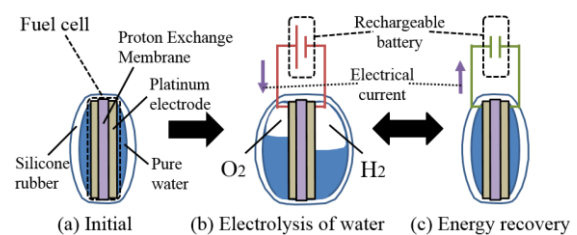
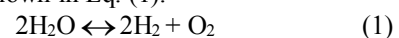


Fig. 1 Schematic diagram of fuel cell actuator

2. Basic principle

The electrolysis/synthesis reversible chemical reaction is shown in Eq. (1).



3. Experiments

3.1 Driving membrane type actuator

Figure 2 shows the experimental result of driving membrane type actuator. Figure 2(a) shows initial state of the actuator. Figure 2(b) shows the maximum expanded state of the actuator by gas generation. The maximum displacement is 4.8 mm (the expansion ratio is 50 %). And this experiment was performed under pure water. Oxygen and hydrogen gas are not leaked through the silicone rubber membrane. Figure 3 shows the experimental result, which is controlled until 15 % expansion ratio, because the actuator motion and basic principle work well under the ratio. The top is

expanded displacement, the others are measured PEM's electric current and voltage.

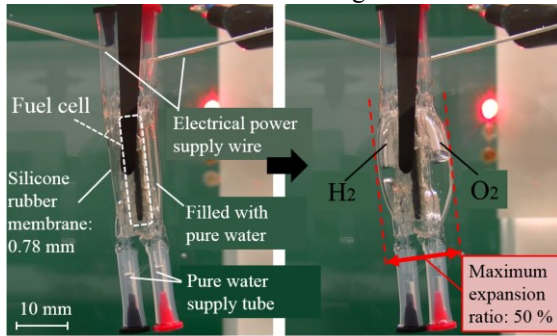


Fig. 2 Driving membrane type actuator

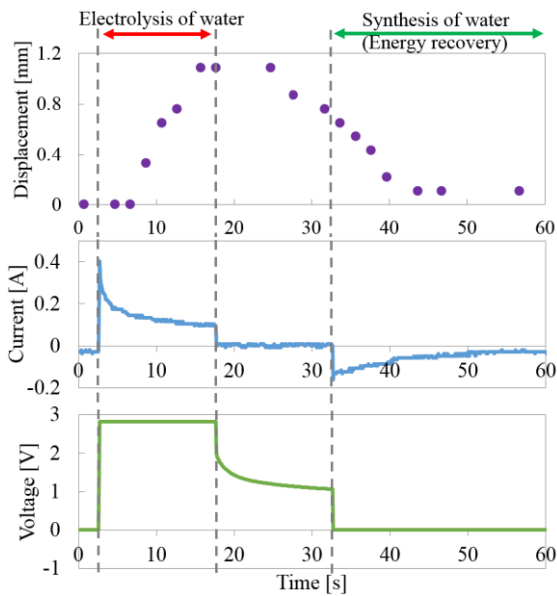


Fig. 3 Experimental result of membrane type actuator (until expansion ratio: 15 %)

3.2 Driving "Flexible microactuator"

Figure 4 shows the experimental result of driving Flexible microactuator (FMA) [5-7]. The FMA realizes bending and expansion.

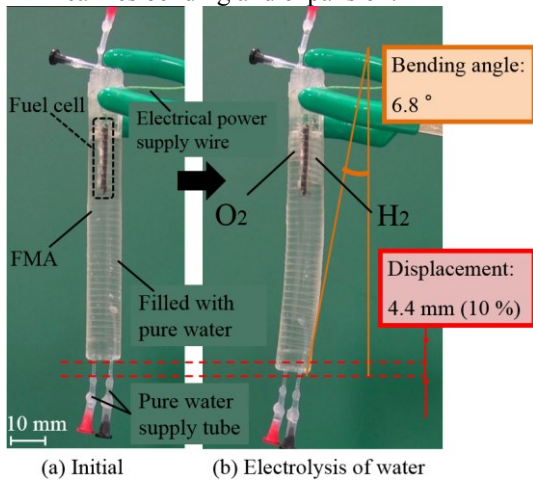


Fig. 4 Driving "Flexible microactuator" [7]

4. Conclusion

We developed two types, and each actuator works well. These actuator have different characteristics of expansion, however these actuator have same area of PEM, which can be compared as a changing PEM area ratio. The FMA type takes time to 40 s until 10 % expansion [7], however the membrane type takes 15 s until 15 % expansion. Therefore, the actuator's response time much higher by increasing PEM area ratio.

Acknowledgement

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5. References

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