論文 / 著書情報
Article / Book Information

論題	
Title	New Gas Rubber Actuator Driven with Electrolysis/Synthesis of Water
著者	和田 晃, 鈴森 康一, 亀谷 英裕, 北守 隆旺, 脇元 修一
Author	Akira Wada, Koichi Suzumori, Hidehiro Kametani, Takaaki Kitamori, Shuichi Wakimoto
掲載誌/書名	, Vol. , No. 15-204, pp. 140-141
Journal/Book name	The 6th International Conference on Manufacturing，Machine Design and Tribology, Vol. , No. 15-204, pp. 140-141
発行日 / Issue date	2015, 4
URL	http://www.jsme.or.jp/publish/transact/index.html
権利情報 / Copyright	本著作物の著作権は日本機械学会に帰属します。
Note	このファイルは著者（最終）版です。 This file is author (final) version.

ICMDT 2015

Proceedings of the 6th International Conference on Manufacturing, Machine Design and Tribology

New Gas Rubber Actuator Driven with Electrolysis/Synthesis of Water

Akira Wada*, Koichi Suzumori*, Hidehiro Kametani**,
Takaaki Kitamori* and Shuichi Wakimoto**

*Graduate School of Engineering, Tokyo Institute of Technology
I1-60 2-12-1 Ookayama, Meguro-ku, Tokyo 152-8552, Japan
**Graduate School of Natural Science and Technology, Okayama University, Japan
3-1-1 Tsushima-naka, Kita-ku, Okayama, Okayama 700-8530, Japan
Corresponding author's E-mail address: wada.a.ah@m.titech.ac.jp

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.

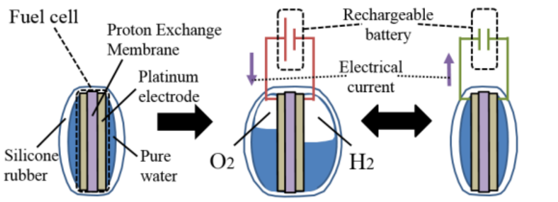


Fig. 1 Schematic diagram of fuel cell actuator

2. Basic principle

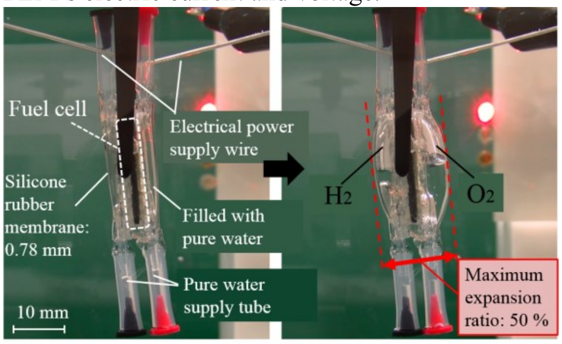
The electrolysis/synthesis reversible chemical reaction is shown in Eq. (1).

$$2H_2O \leftrightarrow 2H_2 + O_2 \quad (1)$$

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.



(a) Initial (b) Electrolysis of water

Fig. 2 Driving membrane type actuator

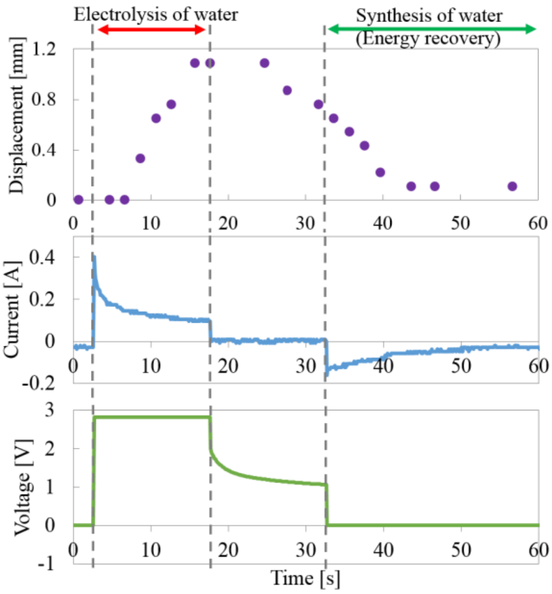
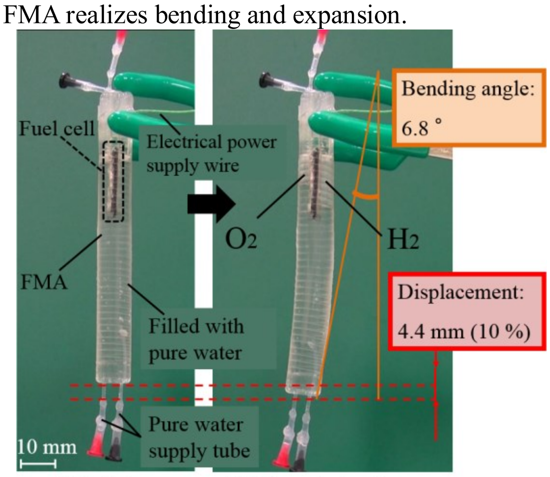


Fig. 3 Experimental result of membrane type actuator (until expansion ratio: 15 %)

3.2 Driving "Flexible microactuator"

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



(a) Initial (b) Electrolysis of water

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

This research was supported by MEXT KAKENHI Grant (A) Number 26249028 "Next-generation McKibben Artificial Muscles".

5. References

[1] Suzumori, K., Wada, A., and Wakimoto, S., "A new mobile pressure control system for pneumatic actuators using reversible chemical reactions of water," 2013 IEEE/ASME International Conference on Advanced Intelligent Mechatronics, (2013) pp. 122-127.

[2] Suzumori, K., Wada, A. and Wakimoto, S., "New mobile pressure control system for pneumatic actuators, using reversible chemical reactions of water," Sensors and Actuators A: Physical, Vol. A 201 (2013) pp. 148-153.

[3] Neagu, C.R., Gardeniers, J.G.E., Elwenspoek, M., and Kelly, J.J., "An electrochemical microactuator: principle and first results," Journal of Microelectromechanical Systems, Vol. 5 No. 1 (1996) pp. 2-9.

[4] Neagu, C., Jansen, H., Gardeniers, H. and Elwenspoek, M., "The electrolysis of water: an actuation principle for MEMS with a big opportunity," Mechatronics, Vol. 10 (2000) pp. 571-581.

[5] Suzumori, K., Iikura, S., and Tanaka, H., "Applying a flexible microactuator to robotic mechanisms," IEEE Control Systems, Vol. 12 No. 1 (1992) pp. 21-27.

[6] Wada, A., Suzumori, K., Kametani, H., and Wakimoto, S., "Electrical-driven pneumatic actuator," 31st Annual Conference of the Robotics Society of Japan, (2011), (in Japanese)

[7] Kametani, H., Wada, A., and Suzumori, K., "A new pneumatic actuator using gas-liquid reversible chemical reactions -2nd report: Trial production and driving experiment of FMA mounted on fuel cell of polymer-," Proc. of the 2014 JSME Conference on Robotics and Mechatronics, (2014), (in Japanese)