

OPEN ACCESS

Soliton electric generators based on conducting polymers

To cite this article: Hiromasa Goto 2014 *IOP Conf. Ser.: Mater. Sci. Eng.* **54** 012019

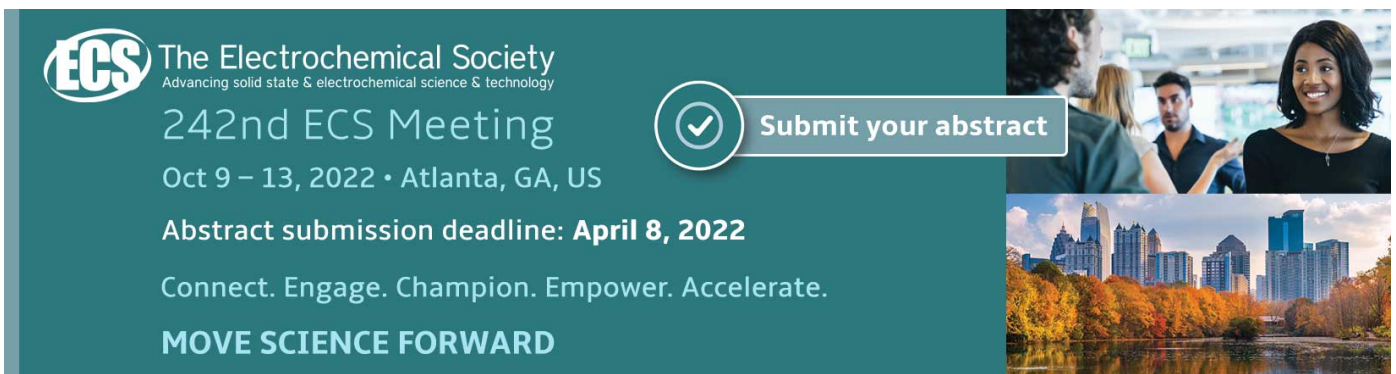
View the [article online](#) for updates and enhancements.

You may also like

- [Conjugated Polymer Nanosheets for Photocatalytic Overall Water Splitting](#)
Hangxun Xu
- [Preface](#)
- [Conductive Directly Fused Metalloporphyrin Coatings By Chemical Vapour Deposition – from Singly to Triply Fused](#)
Nicolas D. Boscher, Giuseppe Bengasi, Kamal Baba et al.

Recent citations

- [A MetaAnalysis of Conductive and Strong Carbon Nanotube Materials](#)
John S. Bulmer *et al*




ECS The Electrochemical Society
Advancing solid state & electrochemical science & technology


242nd ECS Meeting
Oct 9 – 13, 2022 • Atlanta, GA, US

Abstract submission deadline: **April 8, 2022**

Connect. Engage. Champion. Empower. Accelerate.

MOVE SCIENCE FORWARD

 Submit your abstract



Soliton electric generators based on conducting polymers

Hiromasa Goto

Division of Materials Science, Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Ibaraki 305-8573, Japan

E-mail: gotoh@ims.tsukuba.ac.jp

Abstract. Iodide doping produces charge carriers in π -conjugated polymers. Motivated by the SSH theoretical model of solitons in one-dimensional conjugated polymers, chemical doping of polyacetylene film is experimentally carried out to generate solitons. An Arago-type wheel electric generator is assembled based on the doped polyacetylene in place of a copper or aluminium plate. This is the first report of electric generation in conducting polymers based on solitons.

1. Introduction

π -Conjugated polymers consist of alternation of single and double bonds. π -Electrons are delocalized along the main-chains. Polyacetylene is a typical conjugated polymer [1]. It shows metallic refraction because of its highly developed conjugated system, and displays quite high electrical conductivity accompanied by insulator-metal transition by doping [2,3]. Electrical conductivity of the doped polyacetylene is comparable to metals, such as copper. In this case, the charge species of polyacetylene can be characterised as solitons, according to the SSH model proposed by Su, Schrieffer, and Heeger [4].

The spinning-disk-based motor phenomenon was discovered by Arago in 1824. Later, Michael Faraday studied this rotation-induced mechanism [5]. Nikola Tesla investigated this system in his research on alternating current generators and motors [6]. The generator and motor have been constructed with non-ferromagnetic metals such as copper and aluminium. The generators function through movement of free electrons in the metal wheel. The Arago wheel has been employed for induction type energy meter for consumers (for house hold and industrial use). In the present research, the electricity was generated by flow of solitons in the doped polyacetylene (Figure 1). This is the first example of **polymer electric generators** based on charge carriers. The generation of voltage may be related to the magneto-resistance of solitons in the polyacetylene films [7]. Although current from the generator was quite low, electromotive force voltage was achieved.



Figure 1. Polyacetylene



2. Solitons in polyacetylene

Solitons in the polyacetylene can be produced by electron-acceptor doping, as shown in Figure 2. The neutral state of the polyacetylene consists of long extended polyene having no charge carriers. Acceptor vapour-phase doping (iodine) produces polarons in the main-chain. Further doping (heavy doping) allows formation of bipolarons. The polarons and bipolarons behave like solitons in polyacetylene (Figure 2) [8]. In this report, "solutions" for the charge carriers are employed for simplification.

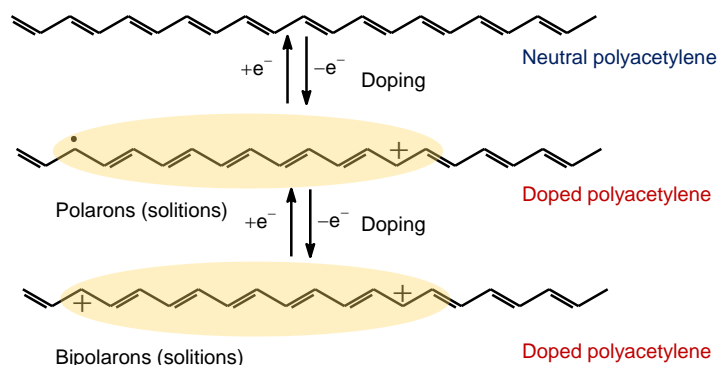


Figure 2. Doping of polyacetylene and generated solitons.

3. Assembly of soliton generator

Based on consideration of polyacetylene as an electrical conductor, assembly of electric generator using polyacetylene was carried out. An Arago disk-type generator was constructed using polyacetylene in place of a metal wheel to demonstrate electric generation by a conducting polymer. Iodine-doped polyacetylene film is attached onto a polyacrylonitrile circular board by adhesive, forming a conducting wheel (diameter: 10 cm). The disk is rotated by an external motor, and the film generates voltage between its centre and edge of the disk, which can be confirmed by an electrometer and an oscilloscope. This instrument demonstrates the possibility that conducting polymers may be used as materials for power generation.

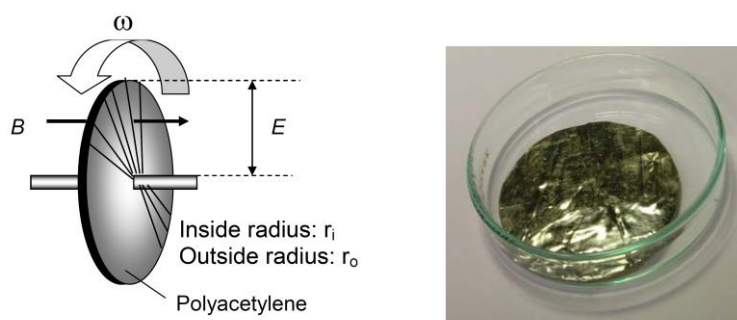


Figure 3. (a) Polyacetylene dynamo system. (b) Polyacetylene disk prepared on a polyacrylonitrile plate (insulator plastic plate).

If a conductive disk rotating at angular frequency ω is subjected to a magnetic flux density B (Figure 3), the electromotive force induced in an infinitesimal length Δr can be described as [9]:

$$\Delta E = r\omega B\Delta r \quad (1)$$

Integration of the formula from r_i to r_o is

$$\int_{r_i}^{r_o} E = \omega r B dr = 1/2 \omega B (r_o^2 - r_i^2). \quad (2)$$

A fixed-magnetic-type generator was constructed with a neodymium magnet, drive motor, dynamo brush (copper) and thin polyacetylene film on polyacrylonitrile circular-shaped board (insulating plastic plate), as shown in Figure 4.

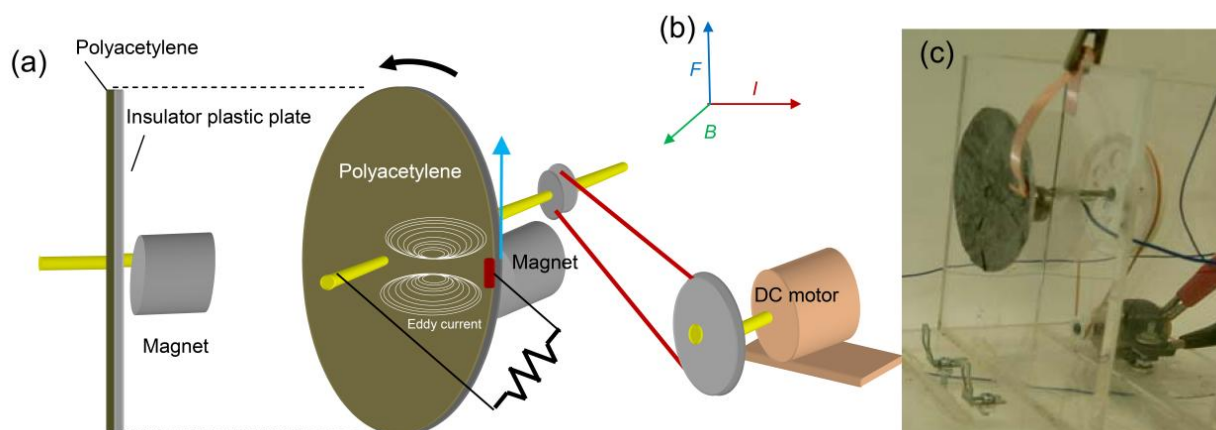


Figure 4. Magnet fixation-type generator based on polyacetylene. (a) Illustration of the entire figure. (b) The Fleming's right hand rule. (c) A photograph of the polyacetylene electric generator.

The magnetic field in the device influences solitons of polyacetylene as the electrically charge particle in the disk, producing electricity perpendicular direction against the magnetic field. The surface contact between the polyacetylene and the dynamo brush in the device is not smooth, resulting unstable generation of electricity. Generated voltage was ca. 0.2 mV (dynamo rotation = ca.1000 rpm measured with a laser revolution indicator). Current from the generator is very low, although the electricity generation function of the device was confirmed. The Fleming's right hand rule can explain direction of current flow (eddy current) across the magnetic field in the device (Figure 4(b)). The Lorentz force from magnetic field can make generation of electricity.

4. Conclusion

An Arago-type polyacetylene dynamo was assembled. Flow of the solitons under the magnetic field affords generation of electricity in the device. To date, electrical conduction of the organic conducting polymers has been well studied. This is the first trial for electric generation in conducting polymers, although practical application of the soliton generator seems to be difficult in the present stage. This study demonstrated that plastics can make electricity.

Acknowledgments

The author would like to express sincere appreciation to Prof. Emeritus Hideki Shirakawa (U. Tsukuba) and alumni of the (former) Shirakawa lab.

References

- [1] Ito T and Shirakawa H 1975 *J. Polym. Sci. Polym. Chem.* **13** 1943
- [2] Shirakawa H, Louis E J, MacDiarmid A G, Chiang C K and Heeger A J 1977 *Chem. Commun.* 578

- [3] Chiang C K, Druy M A, Gau S C, Heeger A J, Louis E J, MacDiarmid A G, Park Y W and Shirakawa H 1978 *J. Am. Chem. Soc.* **100** 1013
- [4] Heeger A J, Kivelson S, Schrieffer J R and Su W-P 1988 *Rev. Mod. Phys.* **60** 781
- [5] Faraday M, *Faraday's diary (26 December, 1831): being the various philosophical notes of experimental investigation made by Michael Faraday* (London: Bell G and Sons Ltd 1936)
- [6] Martin T C, *The inventions, research and writings of Nikola Testla* (CA: Angriff Press, originally published, NY: The Electrical Engineer 1894)
- [7] Park Y-W, 2010 *Chem. Soc. Rev.* **39**, 2428
- [8] Kudo Y, Kawabata K and Goto H 2013 *J. Phys. Conf. Ser.* **428** 012006
- [9] Kato T, Jimbo M 1995 *Bull. Daido. Inst. Tech.* **31** 59