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Tuyoshi Fukaminato [a] & Masahiro Irie [a]

[a] Department of Chemistry and Biochemistry, Graduate School of Engineering, Kyushu University, Higashi-ku, Fukuoka, Japan

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Synthesis of a Fluorescent Diarylethene Derivative for a Single Molecule Logic Gate

Tuyoshi Fukaminato
Masahiro Irie
Department of Chemistry and Biochemistry, Graduate School of Engineering, Kyushu University, Higashi-ku, Fukuoka, Japan

A fluorescent photochromic diarylethene derivative, which has two different diarylethene derivatives, was synthesized for a single molecule logic gate.

Keywords: diarylethene; fluorescence; logic gate; photochromism

INTRODUCTION

Recently, we have reported on a digital fluorescence switching based on single-molecular fluorescence detection [1,2]. The digital optical response can be applied to the molecular logic gate with optical signals by using photochromic molecular switch. Molecular optical logic gates which can simultaneously treat multiple inputs have been extensively studied and many fluorescent logic gates showing AND, OR, XOR, NAND, and INHIBIT functions have been reported [3]. Here we report on the synthesis of a fluorescent photochromic diarylethene derivative for a single molecule logic gate.

RESULTS AND DISCUSSIONS

A fluorescent photochromic diarylethene derivative, which has two different diarylethene derivatives, was synthesized (Fig. 1).

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Address correspondence to Masahiro Irie, Department of Chemistry and Biochemistry, Graduate School of Engineering, Kyushu University, Hakozaki 6-10-1, Higashi-ku, Fukuoka 812-8581, Japan. E-mail: irie@cstf.kyushu-u.ac.jp

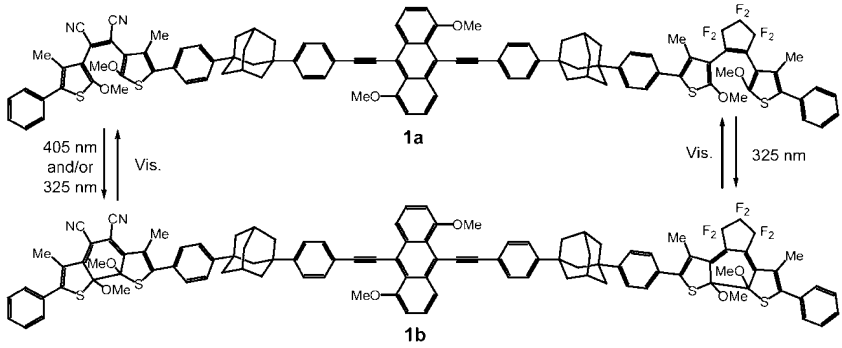
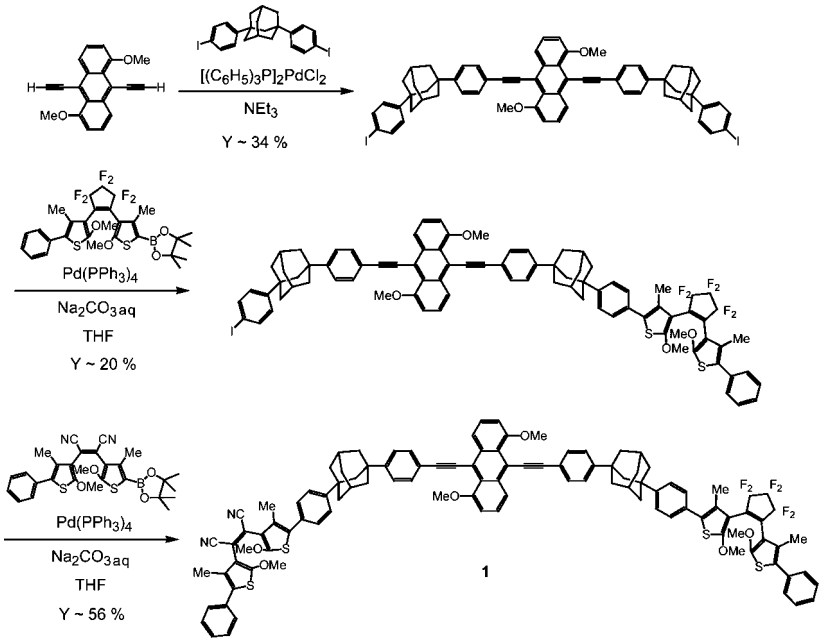


FIGURE 1 Molecular structure and photochromism of **1**.

Dicyano-type diarylethene unit, perfluorocyclopentene-type diarylethene unit and fluorescent bis(phenylethynyl)anthracene unit are covalently linked through a rigid adamantyl spacer group. The bis(phenylethynyl)anthracene unit has characteristic absorption and fluorescent bands at 493 nm and 513 nm, respectively. The fluorescence spectrum well overlaps the absorption spectrum of the closed-ring form of the diarylethene units. Therefore, the fluorescence will be efficiently quenched when the diarylethene unit converts from the open- to the closed-ring forms. On the other hand, when the diarylethene is in the open-ring form, its energy level is higher than the level of the bis(phenylethynyl)anthracene unit and the fluorescence quenching does not take place.

In the case of dicyano-type diarylethene derivatives, the absorption band of the open-ring isomer expands over 400 nm. On the other hand, in the case of perfluorocyclopentene-type diarylethene derivatives, that is shorter than 400 nm. Therefore, the open-ring isomer of dicyano-type diarylethene unit can be photoswitched selectively upon photoirradiation with around 400 nm light. Methoxy substituents are introduced at the reactive carbons to decrease the cycloreversion quantum yield [4]. The effectiveness of the methoxy substituents is a necessary condition to clearly detect the digital fluorescence switching between two discrete states due to the photochromic reaction [2].

Compound **1** was synthesized according to the similar procedure described previously [2]. The synthetic route of **1** is outlined as shown in Scheme 1. **1** was purified by silica gel column chromatography, GPC, and high performance liquid chromatograph (HPLC). The molecular structure of **1** was confirmed by ^{1}H NMR, mass spectroscopy, and elemental analysis [5].



SCHEME 1

CONCLUSION

A fluorescent photochromic diarylethene derivative, which has two different diarylethene derivatives, was synthesized. The fluorescence properties of this molecule are anticipated to apply for the molecular logic gate at the single molecule level.

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[5] *Analytical Data for* **1a**: ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 1.76$–2.44 (m, 40H), 3.71 (s, 6H), 3.77 (s, 6H), 4.10 (s, 6H), 6.91 (d, 2H, $J = 7.6$ Hz), 7.26–7.78 (m, 28H), 8.54 (d, 2H, $J = 8.8$ Hz); MS (FAB) 1776 (M^+); Anal. Calcd. for $C_{109}H_{90}F_6N_2O_6S_4$: C, 74.13; H, 5.14; N, 1.59. Found: C, 74.45; H, 4.82; N, 1.51.