

Review Article

Rapid Methods of Synthesis of Stilbene and Phenylethynylstilbene Arms

ABSTRACT

Stilbene and phenylethynylstilbene units are excellent candidates for fluorescent sensor synthesis. In this paper we show a fast and efficient method for the preparation of fluorophores based on biphenyl nuclei with phenylene-vinylene units functionalized by donor groups. Using pallado catalysed coupling reactions of Sonogashira types and Wittig or Wittig-Horner reaction, the [stybenestilbene](#) and [phenylethylstilbene](#) arms functionalized with O-alkyl and N-alkyl donor groups were synthesized.

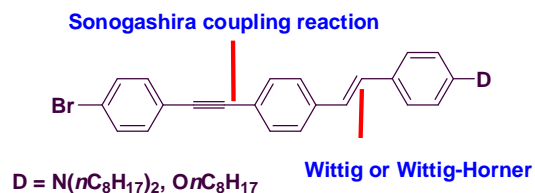


Figure 1

KEYWORDS

Stilbene, Phenylethynylstilbene, photophysical and photochemical properties

1. Introduction

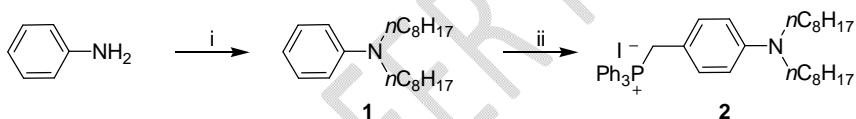
Phenylethynylstilbenes have been extensively studied during the last 30 years.¹⁻² Their interest arises from the wide variety of properties of those systems, such as efficient charge and electron transfer and high fluorescence.³⁻⁴ The origin of these photophysical and photochemical properties can be directly attributed to the conjugation π which extends along the main molecular axis. For

these reasons, that we have been interested in these compounds in this work. Today, there is a growing demand for fluorescent polymers in a wide range of sectors. For instance, in the field of safety, fluorescent marking is of interest in combating counterfeiting. In the field of forensics, it is implemented in police investigations. Fluorescent polymers are also used in chemical sensors to detect pollutants such as toxic heavy metals.⁵⁻⁸

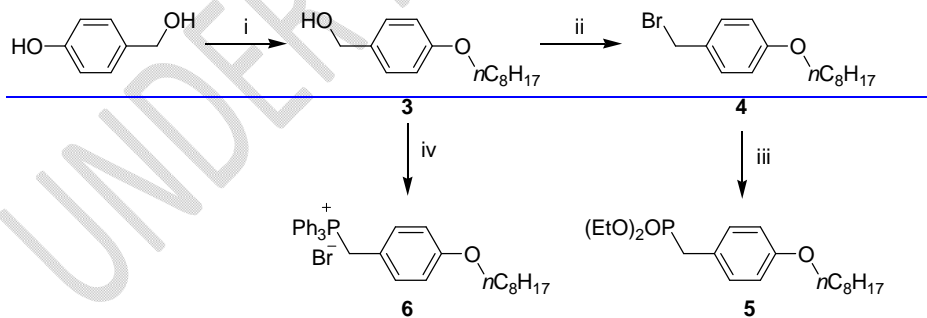
2. Experimental

2.1. Synthesis of Wittig and Wittig-Horner reagents

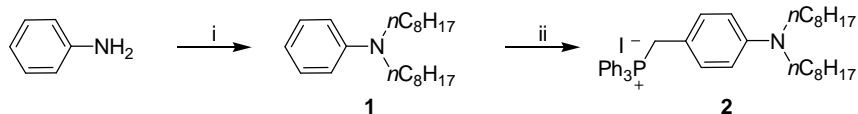
For the preparation of the halogenated arms, aniline and 4-hydroxybenzyl alcohol were used as starting materials. In the first step, by a dialkylation reaction on the amine, *N,N*-dioctylbenzenamine **1** was obtained in an excellent yield of 95%. From this, we prepared phosphonium **2** with a yield of 90%. The action of cesium carbonate in presence of 1-bromooctane on 4-(hydroxymethyl)phenol allowed the selective alkylation of the alcohol in the 4 position, leading to the derivative **3** with 56% yield.



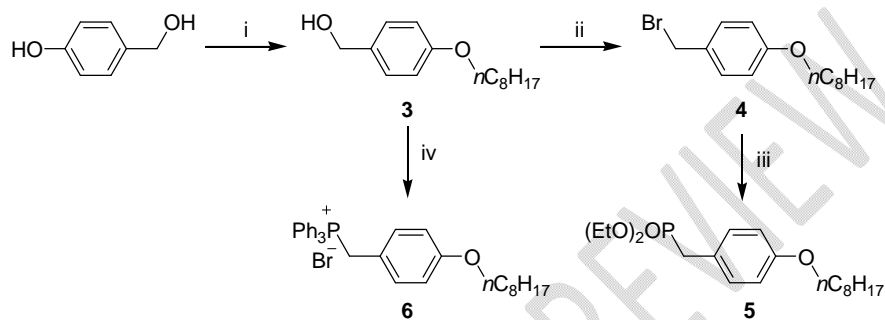
i) K_2CO_3 , NaI, $n\text{C}_8\text{H}_{17}\text{Br}$, DMF at ebb, 95% ; ii) paraformaldehyde, PPh_3 , NaI, CH_3COOH , H_2O , CHCl_3 at ebb, 75%.



i) Cs_2CO_3 , $n\text{C}_8\text{H}_{17}\text{Br}$, acetone, 56% ; ii) CBr_4 , PPh_3 , Et_2O ; iii) $\text{P}(\text{OEt})_3$ at ebb ; iv) $\text{PPh}_3 \cdot \text{HBr}$, refluxing toluene



i) K_2CO_3 , NaI, $n\text{C}_8\text{H}_{17}\text{Br}$, DMF at ebb, 95% ; ii) paraformaldehyde, PPh_3 , NaI, CH_3COOH , H_2O , CHCl_3 at ebb, 75%.



i) Cs_2CO_3 , $n\text{C}_8\text{H}_{17}\text{Br}$, acetone, 56% ; ii) CBr_4 , PPh_3 , Et_2O ; iii) $\text{P}(\text{OEt})_3$ at ebb ;
iv) $\text{PPh}_3 \cdot \text{HBr}$, refluxing toluene

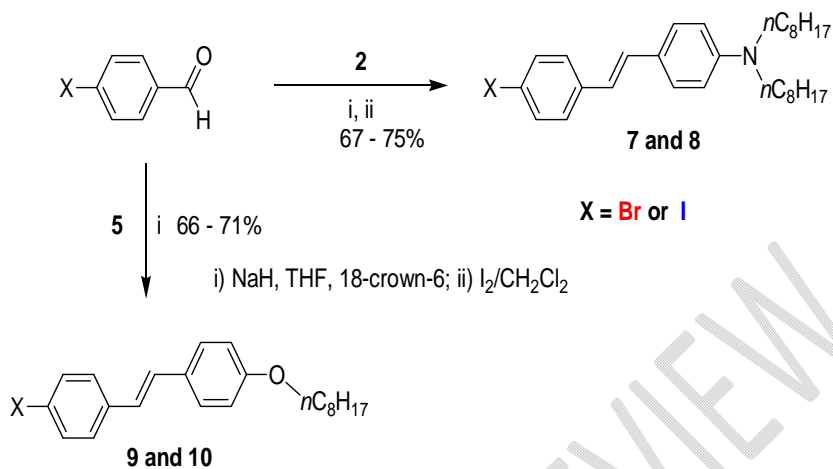
Scheme 1

A bromination reaction in presence of perbromomethane (CBr_4) on the primary alcohol of compound **3** made it possible to isolate the compound **4** functionalized with a bromine. The phosphonate **5** was synthesized with 62% in both steps. Compound **3** in presence of triphenylphosphine hydrobromide at reflux in toluene yielded phosphonium **6** quantitatively.⁹⁻¹⁴

3. Results and discussion

3.1. Obtaining halogenated arms of stilbene type.

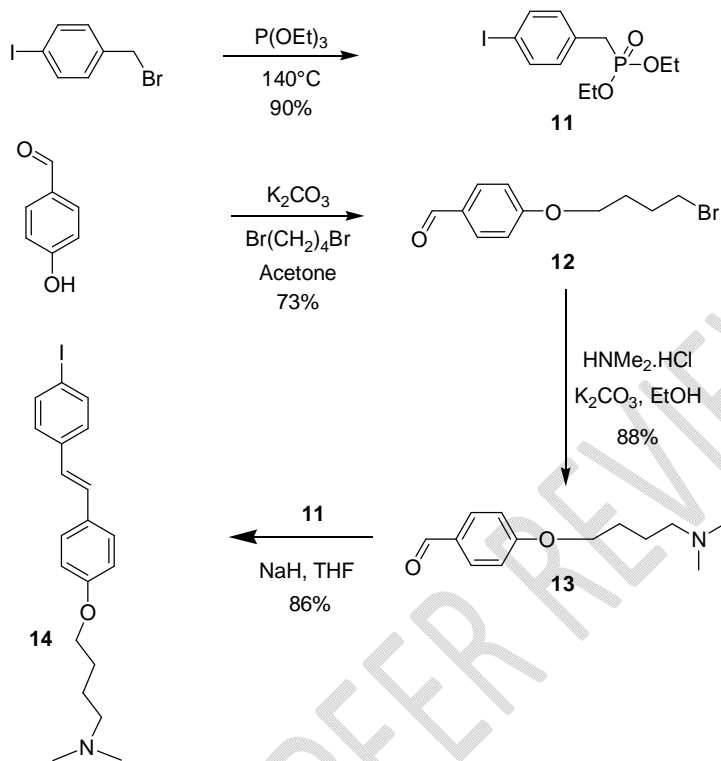
After obtaining the phosphonium and phosphonate derivatives, we synthesized two stilbene halogenated arms by Wittig and Wittig-Horner reaction by using 4-bromobenzaldehyde and 4-iodobenzaldehyde as a partner. Derivatives **7**, **8**, **9** and **10** were isolated with good yields.



Scheme 2

In order to anchor the final compounds in ionic liquids, another iodinated arm, compound **14**, has also been prepared. Starting from 4-hydroxybenzaldehyde, compound **12** was prepared by alkylation with 1,4-dibromobutane in presence of potassium carbonate. The latter with the presence of dimethylamine hydrochloride and potassium carbonate in ethanol at 100°C under pressure for 2 hours is converted to the desired compound **13**. Compound **13** is engaged in a Wittig-Horner reaction with as a partner the diethyl 4-iodobenzylphosphonate **11** which has been prepared from 1-(bromomethyl)-4-iodobenzene in order to obtain the iodized arm **14** in a good yield of 86%.

:



Scheme 3

3.2. Synthesis of phenylethynylstilbene arms

Two brominated phenylethynylstilbene arms functionalized with donor groups $\text{N}(n\text{C}_8\text{H}_{17})_2$ and $\text{Or}n\text{C}_8\text{H}_{17}$ were also synthesized. From commercial 2-(4-bromophenyl)ethynyl)trimethylsilane, trimethylsilane was deprotected by the action of potassium carbonate in a mixture of dichloromethane / methanol and the true alkyne (compound **15**) was obtained quantitatively. The latter is put into Sonogashira coupling reaction with 4-bromobenzaldehyde in order to obtain compound **16** with a good yield of 88%.

¹H NMR (300 MHz, CDCl₃): δ (ppm) = 7.41 (d, 2H, *J* = 8.7Hz), 7.51 (d, 2H, *J* = 8.7Hz), 7.67 (d, 2H, *J* = 8.1Hz), 7.86 (d, 2H, *J* = 8.5Hz), 10.02 (s, 1H).

4.2. Procedure of Wittig or Wittig-Horner reactions

To a solution of phosphonate (or phosphonium) and aldehyde in tetrahydrofuran (10 mL) at 0 °C were added 60% w/w NaH in mineral oil and 18-crown-6. The resulting mixture was stirred at room temperature for 2 hours, then quenched with water and extracted with dichloromethane (2 X 10 mL). The organic phase was dried over MgSO₄ and the volatiles removed under vacuum.

The crude product was ~~redissolved~~dissolved in dichloromethane (5 mL) and a catalytic amount of iodine was added. The solution was stirred at room temperature for 3h under light exposure then washed with saturated aqueous Na₂S₂O₃ and dried over MgSO₄. The residue was purified by flash silica gel chromatography (cyclohexane / ethyl acetate 80/20 then 70/30) to give the product

Compound 7: (E)-4-(4-bromostyryl)-*N,N*-dioctylbenzenamine

¹H NMR (200 MHz, CDCl₃): δ(ppm) = 0.91 (t, 6H, *J* = 6.9Hz), 1.31-1.40 (m, 20H), 1.55-1.65 (m, 4H), 3.29 (t, 4H, *J* = 7.8 Hz), 6.62 (d, 2H, *J* = 8.7Hz), 6.80 (d, 1H, *J* = 16.2Hz), 7.02 (d, 2H, *J* = 16.2Hz), 7.32-7.45 (m, 10H).

¹³C NMR (50 MHz, CDCl₃): δ (ppm) = 14.2, 22.8, 27.0, 27.2, 29.4, 29.6, 30.3, 31.9, 51.2, 111.7, 122.2, 124.0, 127.5, 128.0, 129.8, 131.4, 131.7, 137.4, 148.1.

Compound 14: (E)-4-(4-(4-iodostyryl) phenoxy)-*N,N*-dimethylbutan-1-amine

¹H NMR (300MHz, CDCl₃), δ (ppm) = 7.57 (2H, dd, *J* = 8.4Hz), 7.35 (2H, dd, *J* = 8.4Hz), 7.15 (2H, d, *J* = 8.4Hz), 6.98 (1H, d, *J* = 19.2Hz), 6.89-6.85 (3H, m), 3.94 (2H, t, *J* = 6Hz), 2.36 (2H, t, *J* = 7.2Hz), 2.25 (6H, s), 1.81-1.72(2H, m), 1.69-1.61 (2H, m).

¹³C NMR (75.48 MHz, CDCl₃), δ (ppm) = 24.1, 27.1, 45.3, 59.2, 67.7, 92.1, 114.7, 125.2, 127.7, 127.9, 129.1, 129.6, 137.2, 137.6, 158.9.

Compound 17: (E)-4-(4-(2-(4-bromophenyl) ethynyl) styryl)-*N,N*-dioctylbenzenamine

¹H NMR (200 MHz, CDCl₃): δ (ppm) = 0.89 (t, 6H, *J* = 6.7Hz), 1.20-1.40 (m, 20H), 1.55-1.70 (m, 4H), 3.28 (t, 4H, *J* = 7.6 Hz), 6.62 (d, 2H, *J* = 8.6Hz), 6.84 (d, 1H, *J* = 16.2Hz), 7.07 (d, 2H, *J* = 16.2Hz), 7.32-7.50 (m, 10H).

¹³C NMR (50 MHz, CDCl₃): δ (ppm) = 14.2, 22.8, 27.3, 27.4, 29.5, 29.6, 31.9, 51.2, 111.6, 125.9, 127.5, 127.9, 131.7, 131.9, 133.0, 148.0.

5. Conclusion

This work describes an efficient method for the preparation of organic ligands exhibiting electron transfer properties and significant fluorescence due to the π conjugation which extends along the main molecular axis. These [stybenestilbene](#) and phenylethynylstilbene derivatives with very interesting photophysical and photochemical properties have been synthesized by the Sonogashira coupling reaction and the Wittig or Wittig-Horner reactions.

References

- 1- Nilesh, J., Sarita, S., Surendra, K. J., Synthesis, characterization of novel p-(substituted phenyl)-2 (substituted phenyl)ethene derivatives, *Asian Journal of Pharmaceutical and Clinical Research*. **2013**, 6, 343-346.
- 2- Bell, J., Samb, I., Toullec, P. Y., Michelet, V., and Leray, I., Synthesis and complexing properties of molecular probes linked with fluorescent phosphane oxide derivatives, *Journal of Photochemistry and Photobiology A: Chemistry*. **2016**, 318, 25–32.
- 3- Ngororabanga, J.M.V., Okerio, J., and Mama, N., Synthesis of Fluorescent Poly(coumarin-triazoles) via a CuAAC 'Click' Reaction, *S. Afr. J. Chem.*, **2017**, 70, 89–93.
- 4- Bell, J., Samb, I., Toullec, P. Y., Mongin, O., Blanchard-Desce, M., Michelet, V. and Leray, I., Ultra-sensitive and selective Hg^{2+} chemosensors derived from substituted 8-hydroxyquinoline analogues, *New J. Chem.*, **2014**, 38, 1072-1078.
- 5- Monfort-Windels, F., Lumière et matière: des interactions au service de la lutte contre la contrefaçon, *L'Actualité Chimique*. **2007**, 308-309.
- 6- Théry, E., La trace mise en lumière dans l'enquête policière, *L'Actualité Chimique*. **2007**, 108-112.
- 7- Obert, E., LeBarney, P., Polymère fluorescent pour capteur physico-chimique, *FR-AI-2900408*, **2006**.
- 8- Jenkins, A. L., Uly, O. M., Murray, G. M., Polymer-based lanthanide luminescent sensor for detection of the hydrolysis product of the nerve agent Soman in water, *Anal. Chem.* **1999**, 71, 373- 378.

- 9- Mongin, O.; Porrès, L.; Morceaux, L.; Mertz, J.; Blanchard-Desce, M., Synthesis and Photophysical Properties of New Conjugated Fluorophores Designed for Two-Photon-Excited Fluorescence, *Org. Lett.* **2002**, 4, 719-722.
- 10- Porrès, L.; Bhatthula, B. K. G.; Blanchard-Desce, M., Convenient One - Pot Synthesis of 4 - (Dialkylaminobenzyl)triphenylphosphonium Salts - Application to the Synthesis of a Fluorescent Probe, *Synthesis*. **2003**, 10, 1541-1544.
- 11- Droumaguet, C. L.; Mongin, O.; Werts, M. H. V.; Blanchard-Desce, M., Towards smart multiphoton fluorophores: strongly solvatochromic probes for two-photon sensing of micropolarity, *Chem. Com.* **2005**, 2802-2804.
- 12- Zhou, N.; Wang, L.; Thompson, D. W.; Zhao, Y., A New Member of 2D-Conjugated Fluorophore Cores, *Org. Lett.* **2008**, 10, 3001-3004.
- 13- Sugiono, E.; Metzroth, T.; Detert, H., Practical synthesis of vinyl-substituted p-phenylenevinylene oligomers and their triethoxysilyl derivatives, *Adv. Synth. Catal.* **2001**, 343, 351-359.
- 14- Hernandez, P.; Merlino, A.; Gerpe, A.; Porcal, W.; Piro, O. E.; Gonzalez, M.; Cerecetto, H., One pot synthesis of benzyltriphenylphosphonium acetates from the corresponding activated benzylic alcohols, *Arkivoc*, **2006**, xi, 128-136.