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SYNTHESIS AND CHARACTERIZATION OF 2,6- AND 2,7-DISUBSTITUTED BIPHENYLENS

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Abstract

Many 2,6-disubstitued biphenylenes were prepared which are expected to have liquid crystal properties; also 2,7-disubstituted biphenylenes, which might also show mesogenic properties, were synthesized.

Key words: Biphenylene, liquid crystal, misogynic properties.

Introduction

The chemistry of biphenylene (I) has been extensively reviewed by McOmie[(1)] Batron[(2)], Cava[(3)], Lioyd[(4)] and Shepherd[(5)]. Electrophilic substitution occurs extensively in the ß-position, experimentally biphenylene reacts with acylating[(6)], formylating[(7)], halogenating[(8)], nitrating[(9)] and other electrophiles to yield 2-substituted derivatives in good yields[(10)]. The positions of the entry of the second substituent depend on the electronic and steric effects of the groups involved. Biphenylene with a meta-directing, deactivating substituent forms mainly 2,6-disubstituted products.

2-Monosubstituted biphenylenes bearing an ortho/para directing strongly activating group yield exclusively 2,3-disubstituted biphenylene. For biphenylenes with an ortho / para directing deactivating substituent 2-halobiphenylenes, the 7-position is favored over the 3-or 6-position[(11)].

In recent years the misogynic properties of a wide range of biphenyl and naphthalene derivatives have been investigated in order to improve an existing liquid crystal systems or to find a novel liquid crystal. It is surprising that little research into the possibility of misogynic biphenylenes has been carried out, especially when considering the similarity in molecular structure of biphenylene and naphthalene.

Most naphthalene based liquid crystals are disubstituted[(12)], the position of the substituents has a significant effect on the misogynic properties of the derivatives, it

was found that the 7-alkoxy-2-naphthoic acids are not misogynic but the 2-alkoxy -6- naphthoic acids[13] are show misogynic properties.

In view of the above information and the knowledge of the chemistry of biphenylene, the target molecules were the 2,6-disubstituted biphenylenes; these are the most likely isomers to be misogynic.

Results and Discussions

For the synthesis of 2,6-disubstituted biphenylenes, the first step was that 2-monosubstituted biphenylene should be obtained. The second step introducing another different substituent into the 6-position is regarded as the key step, the rest of the synthesis only involves group interconversions. In order to obtain a 2,6-derivative, the 2-substituent must be either a meta-directing deactivating group or an ortho/para – directing deactivating group. In order to obtain 2,6- derivatives the route as described in scheme **(I)** was suggested. Biphenylene **(I)** was prepared from anthranilic acid as a pala yellow crystals using Friedman method[14]. 2-Bromobiphenylene **(II)** was synthesized in 54 % yield using Chadwick method[15].

The 2-bromobiphenylene **(II)** was treated in carbon disulphide with acetyl chloride and anhydrous aluminium chloride to yield the acetylbromobiphenylene **(III)** in 81 % as bright yellow crystals, the mass spectrum of **III** has apparent ion at m/z = 272 (M^+).

2-Bromo-7-nitrobiphenylene **(IV)** was prepared by treating **II** with nitropyrazole under nitrogen atmosphere to give **IV** in 30 % as yellow crystal; the structure was confirmed by mass spectroscopy and other spectral data. The acid **V** was prepared by oxidizing the acetyl compound **III** using a basic solution of sodium hypochlorite, the acid was obtained as yellow powder in 55 % yield, m-p. 250°C. The IR (cm^{-1}) spectrum of **III** showed peaks at 1673 (νCO) and 3200 – 3300 (νOH) cm^{-1}, which are assigned to (-CO<u>OH</u>).

The methyl ester of the acid **V** was prepared using boron trifluoride-methanol complex, the ester **VI** was obtained in 96 % yield as bright yellow needles, mp. 130-130°C. The structure of the ester was confirmed from its mass spectrum, it showed a parent ion at m/z = 288 (M^+). Elemental analysis as well as spectral data further proved the structure of this compound.

Baeyer-villigar oxidation of compound **III** gave a product of molecular formula $C_{14}H_9O_2Br$ (M^+ = 288) that corresponds to the acetoxybromobiphenylene **(VII)**, it was obtained in 36 % yield.

The acid **V** was synthesized by a different route (Scheme-II). Biphenylene **(I)** was acetylated using Buckland's method[16] to give 2- acetylbiphnylene **(VIII)**. The tribromoacetylbromobiphenylene **(IX)** was synthesized by sulphonating for 24 hr at room temperature and then brominating was carried out using bromine in glacial acetic acid. Working up the reaction mixture and using column chromatography, two products were isolated. The first product off the column was the tetrabromobiphenylene **(IX)**, which was obtained in 8 % yield, Elemental analysis and the mass spectrum of this product proved the assignment structure which supported further by base hydrolysis to give the acid **V** in 70 % Yield. The mass spectrum of the second product m/z = 430 (M^+) indicated a tribromo compound, ^{1}H-NMR inferred that the structure is a trisubstituted biphenylene, 2,3-dibromo-6-(bromoacetyl)–biphenylene **(X)**.

Experimental Section

Melting points were recorded on a electrothermal melting point apparatus and are uncorrected. ^{1}H-NMR and C^{13}- NMR spectra were obtained on Jeol GX 270 and GX 400 spectrometer; samples were run as solutions in $CDCl_3$. IR spectra were recorded on a Perkin Elmer 597 infrared spectrophotometer as KBr pellets. Mass spectra were obtained on an AE1MS- 902 instrument operated at 70 eV and a source of 200° C.

*Biphenylene **(I)***

Biphenylene was prepared as pale yellow crystals in 48 %, m.p. 108 – 110 °C (Lit[14]., 110-111 °C).

*2- Bromobiphenylene **(II)***

Biphenylene **(I)** (1 g, 5.6 mmol) in N,N-dimethylformamide (15 ml) was brominated by N-bromosuccinimide (1.28g, 7.2 mmol) then following the method of Chadwick[15]. Sublimation of the crude product gave II (0.97 g, 64 %), mp. 63-65°C (lit[15]., 61-63°C).

*2- Acetyl-6-bromobiphenylene **(III)***

Biphenylene **(I)**:(10 g, 56 mmol) was brominated as above. The crude product (12.4g, 82%) obtained was acetylated without purification. Anhydrous aluminum

chloride was added over 30 min. to the crude 2- bromobiphenylene **(II)** and acetyl chloride (22 ml) in carbon disulphide (200 ml). The reaction was stirred for 2h at room temperature then cooled to 0^{o}C and ice-cold hydrochloric acid (3M, 200 ml) was added slowly with stirring. The mixture was extracted with chloroform and the organic layer washed with water (20 ml). Evaporation of the solvent under reduced pressure gave a dark solid, which was subjected to column chromatography on alumina with toluene as the eluent, to yield bright yellow plates of acetylbromobiphenylene **(III)**, which was recrystallized from chloroform/hexane mixture (1:3). (9.6g, 53 %), mp. 138-141^{o}C; IR (KBr)/cm^{-1} revealed band at 1667 νCO; ^{1}H- NMR ($CDCl_3$) showed signals at δ = 2.50 (s, 3H, CH_3), 6.61 (d, 1H,d, J=7.33, 4-H), 6.70 (d, 1H, J=7.33, 8–H), 6.87 (dd, 1H, J=7.33, 5-H), 6.99 (dd, 1H, J =7.33, 7- H) 7.20(s, 1 H, 1-H), 7.50 (dd, 1H, J= 7.33, 3-H); C^{13} NMR (CDCl3) δ62,38(CH_3), 116.23, 117.05, 120.01,122.1.123.18. 131.31, 131.56, 132.04, 148.07, 150.13, 151.47, 155.28, (C-4a, C-4b, C-8a, C-8b), 196.68(CO); m/z, (%) 273 (M^+, 20), 272 ((M^+-1), 73), 257 (60), 229 (33), 150 (100), 75 (30). 28 (31).

1-Nitropyrazole

Pyrazole (5g, 73mmol) was nitrated by fuming nitric acid (3.5 ml) in glacial acetic acid (15ml) then following up the method of Buckland[16] to yield 1-nitropyrazole (0.6g, 72%), m.p. 93^{o}C (lit[15] 92 –93^{o}C).

*2- Bromo-7-Nitrobiphenylene **(IV)***

2–Brombiphenylene (0.7g, 3mmol) was dissolved in dichloromethane (25 ml) with 1-nitropyrazole (0.45g, 4 mmol) under nitrogen atmosphere. A solution of boron trifuoride etherate (1.5 ml) in dichloromethane was added with stirring and the reaction mixture stirred further at room temperature for 96 hs. The mixture was poured onto water (50 ml) and extracted with ether (2× 50 ml), the ethereal extract was washed with aqueous sodium bicarbonate (5%, 25 ml) followed by brine (20 ml) and dried over anhydrous magnesium sulphate. Evaporation of the solvent under reduced pressure gave a solid which was purified on alumina column with toluene – hexane (1:1) as the eulent to yield 2–bromo-7- nitrobiphenylene (IV), (0.359, 30%), mp. 150 - 152^{o}C; Its ^{1}H-NMR spectrum showed signals at δ = 6.68 (d, 1H, J = 7.32, 4H), 6.76 (d, 1H, J= 7.69, 5-H), 6.95 (s, 1H, 1-H), 7.08 (dd, 1H, J= 7.32, 3-H), 7.41(d, 1H, J= 7.33, 8-H), 7.84 (dd, 1 H, J= 7.69, J= 7.33, 6- H); m/z = 275 (M^+, 82%), 229 (21), 150(100).

*2-Bromobiphenylene-6-Carboxylic acid **(V)***

The acetylbromobiphenylene **(III)** (1g, 3.66 mmol) was dissolved in a hot methanol (35 ml). A solution of sodium hydroxide (0.7g) in water (7 ml) containing sodium hypochlorite (14 %, 10.5 ml) was added over 20 min. the reaction was refluxed for 45 min, a yellow precipitate (A) was formed. The mother solution was allowed to cool and then filtered. The filtrate was treated with sodium metabisulphite and then neutralized with 3 M HCl and left overnight. A yellow precipitate (B) was formed which collected and dried. The initial residue (A) was dissolved in aqueous solution sodium hydroxide (2.21g, 15 ml). This was then filtered and neutralized with 3M HCl and left overnight. A yellow precipitate (C) was formed which collected and dried. Products (B) and (C) were bromobiphenylenecarboxylic acid (V). (0.55g, 55 %), mp. 250°C; IR: 1673 (νCO) ($CHBr_3$)/cm^{-1}; ^{1}H-NMR (DMSO) δ = 6.86 (dd, 2H, J = 7.33, 3-H), 7.1 (dd, 1H,1-H, 5-H), 7.25 (dd, 1H, J= 7.33, 8-H), 7.56 (dd, 1H, J= 7.33, 6-H); 7.08 (dd, 1H, J = 7.33, H-3); C^{13}-NMR (DMSO) δ = 117.88, 117.97, 120.61, 122.13, 131.12, 131.28, 132.45, (C-1–C-8), 148.01, 149.28, 151.37, 154.07, (C-4a, C-4b, C-8a, C-8b), 166.58 (-CO_2H); m/z 274 (M^+, 100), 257 (13), 229 (12), 150 (29).

*Methylester of acid **(VI)***

The bromoacid **V** (0.25, 0.91 mmol) and boron trifluoride-methanol complex (14 %, 1 ml, 2 equiv.) were dissolved in methanol (1.5 ml), the mixture was refluxed for 48 hs, during which more complex (0.2 ml) and then methanol (3 ml) was added. The mixture was allowed to cool and then poured into a saturated solution of sodium bicarbonate (20 ml) and then extracted with ether (30 ml). The ethereal extract was washed with more saturated sodium bicarbonate solution (2 x 10 ml) and dried over anhydrous magnesium sulpate. Evaporation of the solvent under reduced pressure yielded the ester, which was recrystallized from aqueous methanol to yield the ester as bright yellow needles **(VI)**. (0.253 g, 96 %) mp. 130-132°C (Found: C 57.9; H 3.10; Br 27.52. $C_{14}H_9O_2Br$ requires C, 58.16; H, 3.14; Br, 27.64%); ^{1}H-NMR ($CDCl_3$) δ = 3.86 (s, 3H, OCH_3), 6.59 (d, 1H, J=7.33, H– 4)), 6.72 (dd, 1H, J = 7.73,H – 3) 7.23 (s, 1H, 5-H), 7.62 (dd, 1H, J=7.33, 7-H), 6.95 (s, 1H, H-1), 7.41 (d, 1H, J = 7.33, 8-H); ^{13}C-NMR ($CDCl_3$) δ52.11 (-CH_3), 117.16, 117.76, 119.83, 121.89, 122.94, 130.11, 131.13, 132.65, (C-1 – C-8), 148.18 149.83, 151.61, 155.07 (C-4b, C-8b); m/z 288 (M^+, 100 %), 257 (43), 229 (27), 150 (81).

*Baeyer- Villigar oxidation of 2-Acetyl-6-bromobiphenylene **(III)***

Acetylbromobiphenylene **(III)** (0.172g, 0.63 mmol) was dissolved in glacial acetic acid (3 ml) added by gentle warming and stirring for 5 min. The heat source was then removed and peracetic acid (38-40 %, 1.8 ml) was added while stirring. The reaction mixture was stirred for 48 hs at room temperature during this time a yellow precipitate was formed. Water (10 ml) was added and the product extracted into ether (3 x10 ml). The ethereal extracts were washed with water (3 ml) and then dried over anhydrous magnesium sulphate. Evaporation of the solvent under reduced pressure yielded the crude yellow product which was recrystallized from ethanol to yield the pure acetoxybromobiphenylene (VII) (0.066 g, 36 %), m p. 139°C; ^{1}H-NMR ($CDCl_3$) δ = 2.25 (s, 3H, CH_3), 6.45 (dd, 3H, 1-H,), 6.93 (1H, dd, J=7.62, 7-H); m/z 288(M^+, 12%), 246 (100).

*2- Acetylbiphenylene **(VIII)***

Biphenylene (6g, 31 mmol) was acetylated according to the method of Buckland[16] to yield 2-acetylbiphenylene, (6.5 g, 85%) mp. 134-135°C [Lit.[16], 135°C].

*2-(Tribromoacetyl)-6-bromobiphenylene **(IX)***

2-acetyl-biphenylene **(VIII)** (1 g, 5.2 mmol) was sulphonylated by dissolving in concentrated sulphuric acid (40 ml) and stirring for 24hs, during which the solution turned red. The mixture was poured slowly into cold water (200 ml). Bromine (1.6 ml) in glacial acetic acid (4 ml) was added dropwise over 30 min. then the reaction mixture was stirred for 3.5hs at 70°C, during which a yellow precipitate formed. After cooling the yellow solid was collected. Two products were separated by column chromatography on silica with toluene-hexane (1:1) as the eluent. The first product was shown to be 2-(tribromoacetyl)-6-(bromoacetyl)-biphenylene (IX) (0.21g %) mp. 201-205°C; (Found: C 33.56; H 1.32; Br 62.11, $C_{14}H_6OBr_4$ requires C, 32.8; H, 1.19; Br, 62.69 %) ^{1}H-NMR ($CDCl_3$) δ = 6.66 (s, 1H, 8-H), 6.88 (d, 1H, J=7.33, 5-H), 7.72 (s, 1H, 4-H), 7.78 (s, 1H, 4-H) 7.33 (s, 1H, 1-H), 7.67 (dd, 1H, J=7.33, H-3); m/z: 510 (M^+, 30%), 430 (25) 401 (8), 337 (100) 309 (22) 228 (22) 150 (29).

The second compound was assumed to be 2- (acetyl bromo) - 6, 7 dibromo biphenylene (X) (0.13 g, 6 %) mp. 202-205°C; (Found: C 39.08; H 1.96; Br 56.90 $C_{14}H_7OBr_3$ requires C, 39.02; H, 1.64; Br, 55.63 %); ^{1}H-NMR ($CDCl_3$) δ = 4.37 (s, 2H, CH_2Br), 6.86 (d, 1H, J=7.33, 4-H), 7.49 (s, 1H, 5-H), 7.57 (s, 1H, 8-H), 7.28 (s,

1H, 1-H), 7.58, (dd, 1H, J=7.33, 3-H); m/z: 430 (M^+, 63 %), 336 (100), 309 (25), 150 (25).

*2-Bromobipheylene-6-carboxylicacid **(V)***

The tetrabromo compound **(IX)** (0.11g, 0.22 mmol) was dissolved in ethanol (15 ml) and aqueous sodium hydroxide (2M, 1m ml) was added. The mixture was refluxed for 105 min. during which the solution turned orange. The reaction mixture was poured into water (80 ml) and filtered off. The filtrate was neutralized with 3M HCl from which a yellow precipitate was formed. This product was extracted with chloroform and dried over anhydrous magnesium sulphate. Evaporation of the solvent yielded the acid (V), (41 mg, 70 %).

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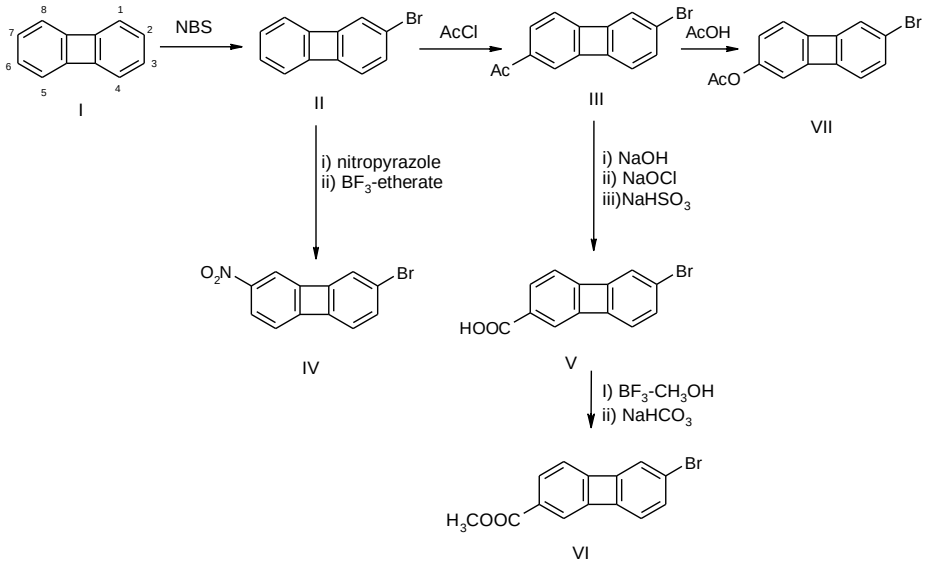
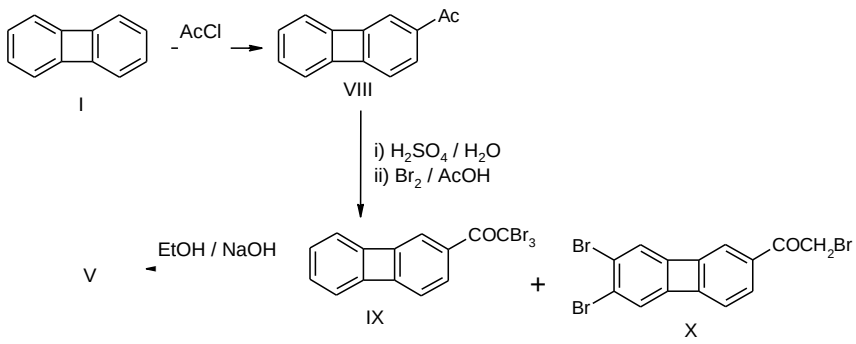


Scheme 1



Scheme II

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