

Supporting On-line Material for Counteranion-dependent mechanisms of intramolecular proton transfer in aprotic solution

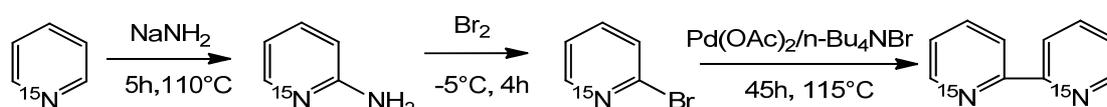
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Synthesis of 2,2'-¹⁵N-bipyridine

Principial scheme of the synthesis:



Synthesis of 2-Amino-¹⁵N-pyridine¹

23.7 ml (218 mmol) of dry toluene and 5.9 g (151 mmol) of fine freshly prepared granular sodamide were placed into a 100 ml three-necked flask equipped with magnetic stirrer, reflux condenser, thermometer and inlet tube for nitrogen. A steady stream of nitrogen was bubbled through the toluene solution. The mixture was vigorously stirred and heated in an oil bath until the internal temperature reached 110 °C. 7.9 g (97.5 mmol) of pure dry pyridine was added drop-wise through the condenser over a period of 30 min while intensive stirring and stream of nitrogen were maintained. When all pyridine has been introduced the heating was continued for 5 h by maintaining internal temperature at 110°C. After 1 hour the reaction mixture became black in colour, and after another 3 h it became viscous. The reaction mixture was allowed to cool without the nitrogen stream and stirring. 13.8 ml of water was added over 10 min under the nitrogen stream. At that time the temperature raised up to about 70 °C. Stirring was resumed for 1 h.

The flask content was transferred into a separatory funnel; the lower aqueous solution was separated and washed with toluene. The combined toluene fraction was dried over anhydrous potassium carbonate for 2 h. Toluene was removed by distillation. The 2-amino-¹⁵N-pyridine was collected after sublimation at 94°C / 10 mbar as white to slightly yellow crystalline powder.

Yield: 2.2 g (23.1 mmol, 23.4 %)

M_w = 95 g/mol

M.p. 54-57°C

¹H-NMR (250 MHz, CDCl₃). δ (ppm): 4.65 (s, 2H, -NH₂), 6.45 (d, *J*_{HH} = 8.2Hz, 1H), 6.59 (t, *J*_{HH} = 7.29 Hz, 1H), 7.40 (t, *J*_{HH} = 5.5Hz, 1H), 8.05 (d, *J*_{HH} = 4.6Hz, 1H)

Synthesis of 2-Bromo-¹⁵N-pyridine²

A 100 ml three necked flask equipped with magnetic stirrer, a reflux condenser and a thermometer for reading low temperatures was immersed in an ice-salt freezing mixture. 11.6 ml (103.4 mmol) of 48 % hydrobromic acid was placed into the flask and 2.2 g (23.1 mmol) of 2-amino-¹⁵N-pyridine was added over a period of about 10 minutes. While the temperature was kept at 0 °C or lower 3.5 ml (70.4 mmol) of bromine was added drop-wise over 30 min, than a solution of 4.0 g (59.0 mmol) of freshly prepared sodium nitrite in 5.8 ml of water drop wise over a period of 2 h. After additional 30 minutes of stirring a solution of 8.8 g (220 mmol) of sodium hydroxide in 8.8 ml of water was added carefully maintaining below 20 °C. The yellow reaction mixture was extracted with diethylether. The organic solution was dried for 1 hour over potassium hydroxide and then distilled through a Vigroux column 15 cm in length. 2-Bromopyridine was distilled at 74-75 °C/13mbar.

Yield: 2.0 g (12.5 mmol, 54.3 %)

M_w= 159 g/mol

¹H-NMR (250 MHz, CDCl₃). δ (ppm): 7.13 - 7.16 (m, 1H) , 7.34 - 7.43 (m, 1H), 7.45-7.52 (m, 1H), 8.23 - 8.26 (m, 1H)

Synthesis of the sodium amide³

A 500-ml three-necked flask equipped with magnetic stirrer, a reflux condenser with soda-lime guard-tube was charged with 300 ml of anhydrous liquid ammonia. The liquid ammonia was condensed into the flask from the cylinder by cooling the flask in dry ice. Addition of 0.5 g of clean sodium metal by stirring led to blue colour of the solution. Then, 0.5 g of powdered Fe(NO₃)₃ was added to catalyse the conversion of sodium into sodium amide. Finally, another 13.3 g of clean sodium metal was added over a period of 30 min. When the blue solution changed to a grey suspension, the ammonia was allowed to evaporate. The volume of the liquid was kept at about 300 ml by addition of anhydrous ether through a dropping funnel. The suspension of sodium amide was stirred and heated under reflux for 15 min, then cooled down to room temperature. 23.4 g of the suspension of sodium amide in dry ether was obtained.

Synthesis of 2,2'-¹⁵N-bipyridine⁴

1.74 g (12.60 mmol) of potassium carbonate, 0.14 g (0.62 mmol) of palladium acetate, 2.03 g (6.30 mmol) of tetra-n-butyl ammonium bromide, 2.00 g (12.65 mmol) of 2-bromo-¹⁵N-pyridine dissolved in a mixture of DMF/ H₂O (1.42 ml / 0.55 ml) were placed in a 25 ml two necked flask equipped with magnetic stirrer and reflux condenser. The mixture was stirred under nitrogen atmosphere for 15 min at 115 °C and 0.76 g (11.90 mmol) of isopropyl alcohol was

added. The stirring was continued for 45 h at 115 °C. The solution was cooled down to room temperature and water and ether were added. The organic phase was additionally washed with water and dried over magnesium sulphate for 1 h. After evaporation of the ether the 2,2'-¹⁵N-bipyridine was obtained as a yellowish crystalline solid. The solid was finally purified by sublimation given colourless crystals.

Yield: 0.3 g (1.9 mmol, 30 %), C₁₀H₈N₂ (M 158.2 g/mol)

M_w= 158 g/mol

M.p.: 72 - 75 °C

¹H-NMR (250 MHz, CDCl₃). δ (ppm): 7.35 (t, *J*_{HH} = 6.38 Hz, 2H), 7.86 (t, *J*_{HH} = 8.2 Hz, 2H), 8.46 (d, *J*_{HH} = 7.29 Hz, 2H), 8.69 (d, *J*_{HH} = 4.55 Hz, 2H).

Mass spectrum (MS): M/z = 158.0 (100 %, [M]⁺), 79.2 (38.94 %, [M-M/2]⁺), 50.9 (49.3 %, [M-M/2-C₄H₃]⁺), 129.0(31.4 %, [M-C₂H₄]⁺).

Literature

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