A New and Convenient Synthesis of Alkyl and Aryl Pyrimidines

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Received December 9, 1987

Vinyl triflates **1**, which are obtained easily from the corresponding ketones, react in an excess of pure nitrile (80°/20 hours) to form tri- and tetra-substituted alkyl and arylpyrimidines **4** and **5** in good yields (45-87%). An isomeric mixture of pyrimidines **4** and **5** is formed from triflate **1** when $R^1 \neq R^2 \neq H$. The reaction proceeds by nitrile-catalyzed elimination-addition mechanism.

J. Heterocyclic Chem., **25**, 1237 (1988).

The alkyl and arylpyrimidines have found applications in flavor [1-3] and liquid crystals chemistry [4]. They are also interesting as non-nucleophile bases in chemical reactions [5].

The pyrimidines are generally prepared by the Pinner reaction [6] (condensation of amidines with 1,3-dicarbonyl compounds). However, this method has the disadvantage that the starting materials, especially in the case of unsymmetrically substituted pyrimidines are not easily available [6]. New synthesis of pyrimidines are based on the coupling of Grignard compounds with chloropyrimidines [7] and on the radical alkylation of pyrimidines [5]. The reaction of nitriles lacking hydrogen at the α-position with alkynes in the presence of phosphoric acid and boron trifluoride as catalyst gives the corresponding pyrimidines in moderate to good yield (42-78%) [8].

We have now found that [9], the reaction of secondary vinyl trifluoromethanesulfonates (triflates) **1** with an excess of aliphatic or aromatic nitrile in a mole ratio nitrile/-triflate = 100:20 under mild conditions (80°, 20 hours), affords the alkyl or arylpyrimidines **4** or **5** respectively in good yields (45-87%).

An isomeric mixture of pyrimidines **4** and **5** with slight preferential formation of the isomer with less branching at the α-position is formed from triflates **1** with $R^1 \neq R^2 \neq H$. Accordingly, a mixture of **4** and **5** containing more **4** is obtained from **1** as well as **1'**. It was found that the product composition is more or less independent of the nitrile used.

It looks plausible from our results that a partial setup of an equilibrium between the vinyl cations **2** and **2'** is the responsible factor for the formation of pyrimidines **4** and **5** (see Scheme I). Such an equilibration is however not to be expected, while the rearrangement of vinyl cation across the double bond has high activation energy as the analogous shift to the double bond [10]. Hence, *e.g.* the triflate **1c** should mainly lead to products which could have formed by the neopentyl rearrangement of the corresponding vinyl cations [11].

On the other hand no rearrangement product was found from the solvolysis of **1a** and **1b** in aqueous ethanol [12].

Probably the reaction proceeds by way of a nitrile-catalysed elimination-addition mechanism. The acetylene formed in the slow-step of the reaction is protonated by

Scheme I

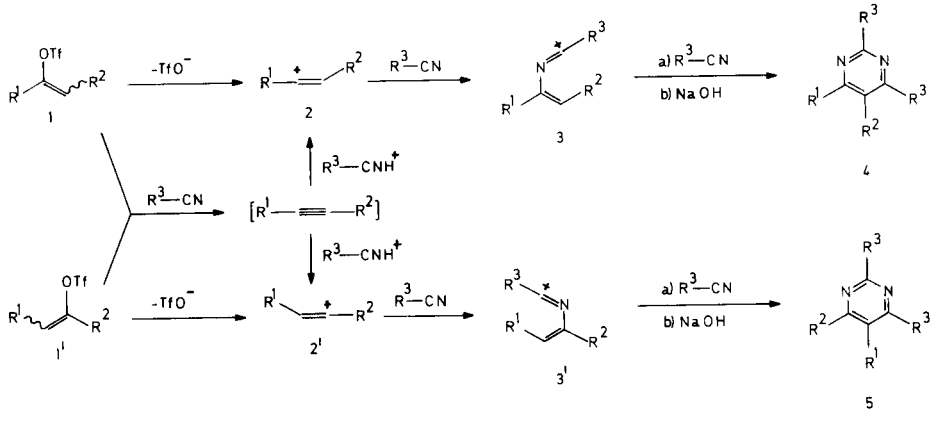

Table I

Alkyl and Arylpyrimidines **4** and **5** Prepared

	Triflate **1**		Nitrile	Products [a] (%)	Yield [b] (%)
	R^1	R^2	R^3		
a [c,d]	C_2H_5	CH_3	CH_3	**4a** (61) [e] + **5a** (39) [e]	87
	C_2H_5	CH_3	C_2H_5	**4b** (50) [e] + **5b** (50) [e]	71
	C_2H_5	CH_3	C_6H_5	**4c** (52) [e] + **5c** (48) [e]	70
b [f,d]	CH_3	C_2H_5	CH_3	**4a** (47) [e] + **5a** (53)	72
c	t-C_4H_9	H	CH_3	**4d**	68
	t-C_4H_9	H	C_2H_5	**4e**	72
	t-C_4H_9	H	t-C_4H_9	**4f**	45
	t-C_4H_9	H	C_6H_5	**4g**	60
d [g,h]	i-C_4H_9	i-C_3H_7	CH_3	**4h** (43) [h] + **5h** (57) [h]	71
	i-C_4H_9	i-C_3H_7	C_2H_5	**4i** (44) [h] + **5i** (56) [h]	70
e	C_6H_5	H	CH_3	**4j**	71
	C_6H_5	H	C_2H_5	**4k**	70
	C_6H_5	H	C_6H_5	**4l**	75
f [i,d]	C_6H_5	C_6H_5	C_6H_5	**4m**	70
g [j,d]	H	C_2H_5	CH_3	No reaction	
h	$(-CH_2-)_4$		CH_3	No reaction	

[a] In the case of mixtures, the composition is given in parenthesis. [b] Yield of isolated products. [c] (*E*)/(*Z*) = 35/65. [d] Determined by ^{1}H-nuclear magnetic resonance. [e] Determined by ^{13}C-nuclear magnetic resonance. [f] (*E*)/(*Z*) = 39/61. [g] (*E*)/(*Z*) = 28/72. [h] Determined by gas chromatography. [i] (*E*)/(*Z*) = 30/70. [j] (*E*)/(*Z*) = 78/22.

the conjugated acid of the nitrile to the vinyl cations **2** and **2'**, which are subsequently captured quickly by nitrile preventing the rearrangement. According to this mechanism, phenylacetylene reacts with acetonitrile in the presence of trifluoromethanesulfonic acid, under the same conditions as **1e**, giving **4j**.

The (*Z*)-triflate reacts faster than the (*E*)-isomer [12], whereby a decrease in *Z*/*E*-ratio is observed when the reaction is discontinued within a short period of time. No reaction is observed when the triflate, due to ring strain (similar to triflate **1h**) or due to the absence of steric acceleration (as in the case of the primary vinyl triflate *E,Z*-**1g** does not show a tendence to eliminate triflic acid.

The relationship of the formation of pyrimidines **4** and **5** should reflect the relative rate of formation and hence the relative stability of the corresponding vinyl cation **2**. It is then expected that pyrimidines **4** are formed preferentially, when the inductive + I-effect of the sustituent R^1 is larger [12] than R^2, which is in agreement with our results. The ratio **4a**:**5a** is higher for **1a** than for **1b**. From this it is seen that the reaction proceeds partially according to a k_c mechanism, whereby the cations are obtained directly from **1** and then react with nitrile before they rearrange or a proton is removed.

The products were analysed by gas chromatography. The pyrimidines **4a,b** and **5a,b** could not be separated by gas chromatography, hence their relative composition were determined by nuclear magnetic resonance. Pyrimidines **4h,i** and **5h,i** were separated by preparative column chromatography.

Pyrimidines **4** and **5** were distinguish[illegible] nuclear magnetic resonance. Thereby the influen[illegible] the substituents R^1 and R^2 on the chemical shift of the corresponding *ipso*-ring proton was taken into account.

The pyrimidines prepared by us have a characteristic odor. Thus, for *e.g.* the pyrimidines **4a** and **5a** smell like biscuits, **4c** like salchichón (Spanish salami-like sausage) and the odor of **4d** resembles Havanna cigars.

EXPERIMENTAL

All boiling and melting points, obtained with a Mel-Temp capillary melting point apparatus, are uncorrected. Nuclear magnetic resonance spectra were recorded on either a Varian T-60 A and Varian FT-80 spectrometer. Chemical shifts were reported in parts per million downfield from internal Tetramethyl silane. The ir spectra were measured with a Perkin-Elmer 781 spectrophotometer. Mass spectra were obtained on a Varian Mat-711 spectrometer at 100 eV. High resolution mass spectra were carried out using PFK as standard. Quantitative gas chromatographic analyses were performed on a Perkin-Elmer Sigma-300 instrument equipped with a 25m glass capillary column of 5% OV 101. Preparative gas chromatography was carried out on a Perkin-Elmer F-21 equipped with a 5m steel column of Carbowax 20M 10% on Chromosorb P-AW-DMCS, 60-80 mesh. Column chromatography was carried out on silica gel 60 (Merck) using pentane or methylene chloride-diethyl ether as the eluent. Microanalyses were performed by the "Centro Nacional de Química Orgánica" de Madrid.

Materials.

Nitriles.

Propionitrile (Merck), pivalonitrile (Merck) and benzonitrile (Merck) were used as received from the commercial source indicated. Acetonitrile (Merck) was used after destillation over calcium hydride.

Ketones and Aldehydes.

Methyl propyl ketone (Fluka), dietyl ketone (Fluka), 3,3-dimethyl-2-butanone (Merck), butyraldehyde (Merck), acetophenone (Merck) and cyclohexanone (Merck) were used as received. Diisobutyl ketone (Merck) was purified by fractional destillation with a spinning Teflon-band column.

Phenylacetylene (Merck) was also used without purification.

Trifluoromethanesulfonic acid anhydride was prepared from trifluromethanesulfonic acid (3M Co) [13].

General Procedure for the Preparation of Vinyltriflates **1** [10].

To a mixture of 10 mmoles of appropriate ketone in 15 ml of dry methylene chloride and 1.7 g of anhydrous sodium carbonate, was added dropwise over 10 minutes at room temperature a solution of 20 mmoles of trifluoromethanesulfonic acid anhydride in 15 ml of methylene chloride. The mixture was stirred over a period of 24 hours. For optimum results the reaction should be monitored by gas chromatography or ir spectra for the disappearance of the starting ketone. After filtration, the organic layer was washed twice with 50 ml of sodium hydrogen carbonate solution, twice with 50 ml of water and dried with sodium sulphate. The solvent was removed *in vacuo* and the crude triflate purified by silica gel column chromatography using pentane as eluent.

General Procedure for the Reaction of Vinyltriflates and Nitriles.

A solution of 20 mmoles of vinyltriflate in 100 mmoles of dry nitrile was stirred at 80° for 20 hours. After the red-brown solution was cooled to room temperature, the excess nitrile removed under vacuum and the residue dissolved in 100 ml of methylene chloride. The organic layer was treated with 2 x 50 ml of 10% sodium hydroxide, 3 x 50 ml water and dried with magnesium sulphate. The solvent was evaporated *in vacuo* and the residual crude products, either **4** or mixture of **4** and **5** depending on the starting triflate, were purified by distillation, crystallation or by silica gel column chromatography using methylene chloride/ether (2:1) as the eluent.

Reaction of Phenylacetylene with Acetonitrile and Trifluoromethanesulfonic Acid.

A solution of 20 mmoles of phenylacetylene and 22.2 mmoles of triflic acid in 100 ml acetonitrile was stirred at 80° for 20 hours. After working up as described in the general procedure, 2,6-dimethyl-4-phenylpyrimidine (**4j**) was obtained in 65% yield.

(*E*/*Z*)-1-Ethyl-1-propenyltriflate (**1a**).

This compound was obtained in 65% yield (lit [12] 41%); ^{1}H-nmr (deuteriochloroform): δ 0.80-1.30 (m, 6H, CH_3), 1.80 (d, J = 7 Hz, 6H, CH_3-CH=), 2.00-2.50 (m, 4H, CH_2-CH_3), 5.10-5.50 (m, 2H, C=C-H); ir (film): 1710, 1420, 1215, 1150 cm^{-1}; ms: m/e 218 (M^+, 46), 68 (M^+ -TfOH, 69), 57 ($C_4H_9^+$, 100).

(*E*/*Z*)-1-Methyl-1-butenyltriflate (**1b**).

This compound was obtained in 55% yield (lit [12] 48%); was purified by preparative gas chromatography; ^{1}H-nmr (deuteriochloroform): δ 1.05 (t, J = 7 Hz, 6H, CH_3CH_2), 2.00 (s, 6H, CH_3-C=C), 2.15 (m, 4H, CH_2), 5.20 (t, J = 7 Hz, 1H, CH=), 5.55 (t, J = 7 Hz, 1H, CH=); ir (film): 1695, 1420, 1225, 1145 cm^{-1}; ms: m/e 218 (M^+, 31), 189 (M^+-C_2H_5, 29), 69 (M^+ -TfO, 100), 68 (M^+ -TfOH, 58), 43 ($C_3H_7^+$, 100).

1-*t*-Butylvinyltriflate (**1c**).

This compound was obtained in 60% yield (lit [11] 40-60%); ^{1}H-nmr (deuteriochloroform): δ 1.15 (s, 9H, CH_3), 5.00 (AB, J = 4 Hz, 2H, $=CH_2$); ir (film): 1655, 1415, 1215, 1145 cm^{-1}; ms: m/e 232 (M^+, 12), 83 (M^+ -TfO, 17), 82 (M^+ -TfOH, 23), 68 (100), 57 ($C_4H_9^+$, 17).

(*E*/*Z*)-1-(2-Methylpropyl)-3-methyl-1-buten-1-yl-triflate (**1d**).

This compound was obtained in 70% yield; ^{1}H-nmr (deuteriochloroform): δ 0.80-1.20 (12H, CH_3), 2.05 (m, 2H, CH_2), 2.10-2.90 (m, 2H, CH), 5.00 (d, J = 6 Hz, 1H, =CH, *Z* isomer), 5.30 (d, J = 6 Hz, 1H, =CH, *E* isomer); ir (film): 1680, 1410, 1205, 1145 cm^{-1}; ms: m/e 274 (M^+, 15), 259 (M^+ -CH_3, 8), 217 (M^+ -C_4H_9, 15), 109 (259 -TfOH, 62), 84 (217 -Tf, 100); hrms: (100 eV) Calcd. for $C_{10}H_{17}F_3O_3S$: 274.0845. Found: 274.0851.

1-Phenylvinyltriflate (**1e**).

This compound was obtained in 54% yield (lit [14] 40%); ^{1}H-nmr (deuteriochloroform): δ 5.50 (AB, J = 2 Hz, 2H, $C=CH_2$), 7.20-7.60 (m, 5H, aromatic); ir (film): 1650, 1420, 1220, 1140 cm^{-1}; ms: m/e 252 (M^+, 25), 119 (M^+ -Tf, 12), 102 (M^+ -TfOH, 100), 77 ($C_6H_5^+$, 75).

(*E*/*Z*)-1,2-Diphenyl-1-ethenyltriflate (**1f**).

This compound was obtained in 61% yield; ^{1}H-nmr (deuteriochloroform): δ 6.40 (s, 1H, *Z* isomer), 6.60 (s, 1H, *E* isomer), 6.80-7.40 (m, 10H, aromatic); ir (film): 1690, 1430, 1230, 1145 cm^{-1}; ms: m/e 328 (M^+, 4), 195 (M^+ -Tf, 6), 194 (M^+ -TfH, 100), 179 (M^+ -TfO, 17); hrms: (100 eV) Calcd. for $C_{15}H_{11}F_3O_3S$: 328.0380. Found: 328.0381.

(*E*/*Z*)-1-Butenyltriflate (**1g**).

Obtained by the general procedure using 2,6-di-*t*-butylpyridine as base in 74% yield (lit [15] 80%); ^{1}H-nmr (deuteriochloroform): δ 0.7-1.10 (m, 6H, 2CH_3-CH_2), 1.90-2.40 (m, 4H, 2CH_2-CH_3), 4.45 (c, J = 5 Hz, 1H, CH_3-CH_2-C*H*=C, *Z* isomer), 5.15 (c, J = 5 Hz, 1H, CH_3-CH_2-C*H*=C *E* isomer), 6.15-6.45 (m, 1H, =CH-OTf, *E* isomer), 6.65-6.70 (m, 1H, =CH-OTf, *Z* isomer); ir (film): 1665, 1425, 1210, 1145 cm^{-1}; ms: m/e 204 (M^+, 51), 71 (M^+ -Tf, 25), 69 (100), 59 (51).

Cyclohexenyltriflate (**1h**).

This compound was obtained in 89% yield (lit [14] 50%); ^{1}H-nmr (deuteriochloroform): δ 1.30-1.60 (m, 4H), 1.90-2.20 (m, 4H), 5.40 (m, 1H, =CH); ir (film): 1690, 1415, 1220, 1140 cm^{-1}; ms: m/e 230 (M^+, 67), 97 (M^+ -Tf, 14), 81 (M^+ -TfO, 40), 80 (M^+ -TfOH, 94), 41 (100).

2,5,6-Trimethyl-4-ethylpyrimidine (**4a**) and 2,4,6-Trimethyl-5-ethylpyrimidine (**5a**).

This mixture was obtained in 87% yield, bp 72-73° (5.0 mm); ^{1}H-nmr (deuteriochloroform): δ 1.10 (t, J = 7 Hz, 3H, CH_3), 2.15 (s, 3H, CH_3), 2.35 (s, 3H, CH_3), 2.45 (s, 3H, CH_3), 2.50 (c, J = 7 Hz, 2H, CH_2); ^{13}C-nmr (deuteriochloroform): 11.1 (CH_3-CH_2, **5a**), 11.7 (CH_3-CH_2, **4a**), 19.8, 20.2, 21.0 (CH_3, **4a** + **5a**), 24.2 (CH_3-CH_2, **5a**), 27.0 (CH_3CH_2, **4a**), 121.3 (C-5, **4a**), 127.9 (C-5, **5a**), 162.6, 162.7, 163.1 (C-2, C-4, C-6, **4a** + **5a**), 167.1 (C-4, **4a**); ir (film): 1560, 1410 cm^{-1}; ms: m/e 150 (M^+, 80) 149 (M^+ -H, 100), 135 (M^+ -CH_3, 25), 122 (M^+ -C_2H_4, 12), 94 (135 -CH_3CN, 7).

Anal. Calcd. for $C_9H_{14}N_2$: C, 72.01; H, 9.32; N, 18.65. Found: C, 72.33; H, 9.14; N, 18.53.

2,4,6-Triethyl-5-methylpyrimidine (**4b**) and 2,5,6-Triethyl-4-methylpyrimidine (**5b**).

This mixture was obtained in 71% yield, bp 94-96° (7.0 mm); ^{1}H-nmr (deuteriochloroform): δ 1.00-1.50 (m, 9H, CH_3), 2.10 (s, 3H, CH_3), 2.30 (s, 3H, CH_3), 2.40-2.90 (m, 6H, CH_2); ^{13}C-nmr (deuteriochloroform): δ 11.4, 12.0, 12.2, 12.8 (CH_3-CH_2, **4b** + **5b**), 19.7 (CH_3, **4b**), 20.6 (CH_3, **5b**), 120.9 (C-5, **4b**), 127.6 (C-6, **5b**), 167.4, 167.7 (C-2, C-4, C-6, **4b** + **5b**); ir (film): 1555, 1415 cm^{-1}; ms: m/e 178 (M^+, 80), 177 (M^+ -H, 100), 163 (M^+ -CH_3, 42), 150 (M^+ -C_2H_4, 12).

Anal. Calcd. for $C_{11}H_{18}N_2$: C, 74.17; H, 10.10; N, 15.72. Found: C, 74.55; H, 9.88; N, 15.55.

2,6-Diphenyl-4-ethyl-5-methylpyrimidine (**4c**) and 2,6-Diphenyl-4-methyl-5-ethylpyrimidine (**5c**).

This mixture was obtained in 70% yield and crystallized from ethanol; ^{1}H-nmr (deuteriochloroform): δ 1.10 (t, J = 7 Hz, 3H, CH_3), 1.35 (t, J = 7 Hz, 3H, CH_3), 2.20 (s, 3H, CH_3, 2.55 (s, 3H, CH_3), 2.95-2.40 (m, 4H, CH_2), 7.10-7.45 (m, 16H, aromatic), 8.00-8.30 (m, 4H, aromatic); ^{13}C-nmr (deuteriochloroform): δ 11.6 (CH_3-CH_2, **5c**), 13.9 (CH_3-CH_2, **4c**), 14.8 (CH_3-CH_2, **5c**), 21.4 (CH_3-CH_2, **4c**), 22.2 (CH_3, **4c**), 28.4 (CH_3, **5c**), 123.0 (C-5, **4c** + **5c**), 127.8, 128.0, 128.1, 128.4, 128.5, 129.0, 129.8, 129.9 (aromatic), 137.8, 138.1, 139.0, 139.2 (aromatic), 160.9, 165.3, 166.1,

170.3 (C-2, C-4, C-6, **4c** + **5c**); ir (potassium bromide): 1550, 1400 cm^{-1}; ms: m/e 274 (M^+, 53), 273 (M^+ -H, 100), 259 (M^+ -CH_3, 4).

Anal. Calcd. for $C_{19}H_{18}N_2$: C, 83.18; H, 6.61; N, 10.21. Found: C, 82.94; H, 6.85; N, 10.26.

2,6-Dimethyl-4-*t*-butylpyrimidine (**4d**).

This compound was obtained in 68% yield, bp 61-62° (4,5 mm); ^{1}H-nmr (deuteriochloroform): δ 1.25 (s, 9H, CH_3), 2.35 (s, 3H, CH_3), 2.50 (s, 3H, CH_3), 6.65 (s, 1H, ring); ^{13}C-nmr (deuteriochloroform): δ 23.8 (CH_3-C-6), 25.7 (CH_3-C-2), 29.0 (CH_3)$_3$-C), 36.7 ((CH$_3$)$_3$-*C*), 112.2 (C-5), 166.0 (C-6), 166.5 (C-2), 177.0 (C-4); ir (film): 1575, 1530, 1390 cm^{-1}; ms: m/e 164 (M^+, 19), 163 (M^+ -H, 39), 149 (M^+ -CH_3, 100).

Anal. Calcd. for $C_{10}H_{16}N_2$: C, 73.18; H, 9.75; N, 17.06. Found: C, 72.98; H, 9.50; N, 16.98.

2,6-Diethyl-4-*t*-butylpyrimidine (**4e**).

This compound was obtained in 72% yield, bp 74-76° (4.0 mm); ^{1}H-nmr (deuteriochloroform): δ 1.25 (t, J = 7 Hz, 3H, CH_3), 1.30 (s, 9H, CH_3), 1.30 (t, J = 7 Hz, 3H, CH_3), 2.62 (c, J = 7 Hz, 2H, CH_2), 2.82 (c, J = 7 Hz, 2H, CH_2), 6.65 (s, 1H, ring); ^{13}C-nmr (deuteriochloroform): δ 12.6 (CH_3-CH_2-C-6), 13.0 (CH_3-CH_2-C-2), 29.1 ((*C*H$_3$)$_3$C), 30.9 (CH_3-*C*H$_2$-C-6), 32.4 (CH_3-*C*H$_2$-C-2), 37.0 ((CH$_3$)$_3$*C*), 111.0 (C-5), 170.1 (C-6), 171.1 (C-2), 177.1 (C-4); ir (film): 1580, 1540, 1385 cm^{-1}; ms: m/e 192 (M^+ -H, 48), 177 (M^+ -CH_3, 100), 150 (191-CH_3CN, 81).

Anal. Calcd. for $C_{12}H_{20}N_2$: C, 75.01; H, 10.41; N, 14.57. Found: C, 74.89; H, 10.49; N, 14.37.

2,4,6-Tri-*t*-butylpyrimidine (**4f**).

This compound was obtained in 45% yield, mp 78-80° (from ethanol/water) (lit [5] mp 79-80°); ^{1}H-nmr (deuteriochloroform): δ 1.30 (s, 18H), 1.35 (s, 9H), 6.75 (s, 1H); ir (film): 1590, 1560, 1545 cm^{-1}; ms: m/e 248 (M^+, 43), 247 (M^+-H, 34), 233 (M^+ -CH_3, 100), 205 (M^+ -C_3H_7, 96).

2,6-Diphenyl-4-*t*-butylpyrimidine (**4g**).

This compound was obtained in 60% yield, mp 83-84° (from ethanol); ^{1}H-nmr (deuteriochloroform): δ 1.40 (s, 9H, CH_3), 7.00-7.40 (m, 7H), 7.80-8.30 (m, 2H), 8.35-8.50 (m, 2H); ^{13}C-nmr (deuteriochloroform): δ 29.3 ((*C*H$_3$)$_3$)C) 37.5 ((CH$_3$)$_3$*C*), 109.4 (C-5), 126.9, 128.0, 128.2, 128.4, 130.1, 137.5, 138.3 (aromatic), 163.3, 163.8 (C-2, C-6), 177.9 (C-4); ir (potassium bromide): 1540, 1375 cm^{-1}; ms: m/e 288 (M^+, 12), 287 M^+ -H, 53), 273 (M^+ -CH_3, 67), 245 (M^+ -C_3H_7, 100), 231 (M^+ -C_4H_9, 6).

Anal. Calcd. for $C_{20}H_{20}N_2$: C, 83.28; H, 6.99; N, 9.71. Found: C, 83.18; H, 7.10; N, 9.90.

2,6-Dimethyl-4-isobutyl-5-isopropylpyrimidine (**4h**) and 2,6-Dimethyl-4-isopropyl-5-isobutylpyrimidine (**5h**).

The mixture **4h** and **5h** was obtained in 70% yield. Compounds **4h** and **5h** were purified by silica gel column chromatography using methylene chloride/ether (2:1) as eluent.

Compound **4h**.

This compound was obtained in 30% yield, bp 71-73° (1.0 mm); ^{1}H-nmr (deuteriochloroform): δ 0.95 (d, J = 7 Hz, 6H, CH_3), 1.30 (d, J = 7 Hz, 6H, CH_3), 2.10 (d, J = 7 Hz, 1H, CH), 2.00-2.60 (m, 2H, CH_2), 2.40 (s, 3H, CH_3), 2.45 (s, 3H, CH_3), 3.00-3.40 (m, 1H, CH); ^{13}C-nmr (deuteriochloroform): δ 20.6 ((*C*H$_3$)$_2$CHCH$_2$), 22.1 ((*C*H$_3$)$_2$CH), 23.5 ((CH$_3$)$_2$*C*HCH$_2$, *C*H$_3$-C-6), 25.0 (*C*H-C-2), 28.2 ((CH$_3$)$_2$*C*H), 43.7 ((CH$_3$)$_2$CH*C*H$_2$), 132.5 (C-5), 163.0 (C-6), 163.9 (C-2), 166.5 (C-4); ir (film): 1550, 1415 cm^{-1}; ms: m/e 206 (M^+ -CH_3, 100), 163 (M^+ -C_3H_7, 44), 149 (M^+ -C_4H_9, 47), 136 (56), 122 (163-CH_3CN, 44).

Anal. Calcd. for $C_{13}H_{22}N_2$: C, 75.74; H, 10.67; N, 13.58. Found: C, 75.60; H, 10.68; N, 13.66.

Compound **5h**.

This compound was obtained in 40% yield, bp 71-73° (1.0 mm); ^{1}H-nmr (deuteriochloroform): δ 0.95 (d, J = 7 Hz, 6H, CH_3), 1.25 (d, J = 6 Hz, 6H, CH_3), 1.70-2.10 (m, 1H, CH), 2.35 (s, 3H, CH_3), 2.45 (d, J = 7 Hz, 2H, CH_2), 2.50 (s, 3H, CH_3), 3.25 (sept, J = 7 Hz, 1H, CH); ^{13}C-nmr (deuteriochloroform): δ 21.6 ((*C*H$_3$)$_2$CH), 22.2 ((*C*H$_3$)$_2$CHCH$_2$), 22.4 (*C*H$_3$-C-6), 25.5 (*C*H$_3$-C-2), 29.5 ((CH$_3$)$_2$*C*HCH$_2$), 30.3 ((CH$_3$)$_2$*C*H), 35.5 ((CH$_3$)$_2$CH*C*H$_2$), 125.3 (C-5), 164.1 (C-6), 164 (C-2), 172 (C-4); ir (film): 1550, 1415 cm^{-1}; ms: m/e 206 (M^+, 45), 191 (M^+ -CH_3, 100), 163 (M^+ -C_3H_7, 45), 149 (M^+ -C_4H_9, 100), 136 (32), 122 (163-CH_3CN, 9).

Anal. Calcd. for $C_{13}H_{22}N_2$: C, 75.74; H, 10.67; N, 13.58. Found: C, 75.60; H, 10.68; N, 13.66.

2,6-Diethyl-4-isobutyl-5-isopropylpyrimidine (**4i**) and 2,6-Diethyl-4-isopropyl-5-isobutylpyrimine (**5i**).

The mixture **4i** and **5i** was obtained in 70% yield; **4i** and **5i** were purified by silica gel column chromatography using methylene chloride/-ether (2:1) as eluent.

Compound **4i**.

This compound was obtained in 31% yield, bp 93-94° (2.0 mm); ^{1}H-nmr (deuteriochloroform): δ 0.95 (d, J = 7 Hz, 6H, CH_3), 1.25 (t, J = 7 Hz, 6H, CH_3), 2.00-2.30 (m, 1H, CH), 2.57 (d, J = 7 Hz, 2H, CH_2), 2.65 (q, 4H, CH_2), 3.25 (sept, J = 7 Hz, 1H, CH); ^{13}C-nmr (deuteriochloroform): δ 12.8 (CH_3CH_2-C-6), 13.7 (CH_3CH_2-C-2), 21.5 ((*C*H$_3$)$_2$CHCH$_2$), 22.3 ((*C*H$_3$)$_2$CH), 26.8 (CH_3*C*H$_2$-C-6), 28.2 (CH_3*C*H$_2$-C-2), 28.9 ((CH$_3$)$_2$*C*H), 31.9 ((CH$_3$)$_2$CHCH$_2$), 44.1 ((CH$_3$)$_2$CH*C*H$_2$), 132.3 (C-5), 167.0 (C-6), 167.5 (C-2), 169.0 (C-4); ir (film): 1540, 1410 cm^{-1}; ms: m/e 234 (M^+).

Anal. Calcd. for $C_{15}H_{26}N_2$: C, 76.93; H, 11.10; N, 11.95. Found: C, 76.79; H, 11.04; N, 12.09.

Compound **5i**.

This compound was obtained in 39% yield, bp 93-94° (2.0 mm); ^{1}H-nmr (deuteriochloroform): δ 0.90 (d, J = 7 Hz, 6H, CH_3), 1.15 (d, J = 7 Hz, 6H, CH_3), 1.20 (t, J = 7 Hz, 3H, CH_3), 1.25 (t, J = 7 Hz, 3H, CH_3), 1.65 (q, J = 7 Hz, 2H, CH_2), 1.70 (q, J = 7 Hz, 2H, CH_2), 1.50-2.10 (m, 1H, CH), 2.40 (d, J = 7 Hz, 2H, CH_2), 3.50 (sept, J = 7 Hz, 1H, CH); ^{13}C-nmr (deuteriochloroform): δ 12.5 (CH_3CH_2-C-6), 13.1 (*C*H$_3$CH$_2$C-2), 21.7 ((*C*H$_3$)$_2$CHCH$_2$), 22.1 ((*C*H$_3$)$_2$CH), 27.7 (CH$_3$*C*H$_2$C-6), 29.9 (CH$_3$C*H$_2$*-C-2), 30.5 ((CH$_3$)$_2$*C*HCH$_2$), 32.0 ((CH$_3$)$_2$*C*H), 34.9 ((CH$_3$)$_2$CH*C*H$_2$), 124.3 (C-5), 168.2 (C-6), 169.0 (C-2), 172.7 (C-4); ir (film): 1540, 1410 cm^{-1}; ms: m/e 234 (M^+).

Anal. Calcd. for $C_{15}H_{26}N_2$: C, 76.93; H, 11.10; N, 11.95. Found: C, 76.79; H, 11.04; N, 12.09.

2,6-Dimethyl-4-phenylpyrimidine (**4j**).

This compound was obtained in 71% yield, bp 95-96° (0.7 mm); ^{1}H-nmr (deuteriochloroform): δ 2.35 (s, 3H, CH_3), 2.60 (s, 3H, CH_3), 6.90-7.30 (m, 4H, aromatic), 7.65-7.90 (m, 2H, aromatic); ^{13}H-nmr (deuteriochloroform): δ 23.0 (*C*H$_3$-C-6), 25.0 (*C*H$_3$-C-2), 111.8 (C-5), 125.9, 127.6, 129.3, 135.9 (aromatic) 162.3 (C-6), 166.0 (C-2), 166.6 (C-4): ir (film): 1590, 1540 cm^{-1}; ms: m/e 184 (M^+, 100), 183 (M^+ -H, 9), 143 (M^+ -CH_3CN, 20), 105 ($C_8H_9^+$, 22).

Anal. Calcd. for $C_{12}H_{12}N_2$: C, 78.27; H, 6.51; N, 15.20. Found: C, 77.93; H, 6.78; N, 15.23.

2,6-Diethyl-4-phenylpyrimidine (**4k**).

This compound was obtained in 70% yield, bp 86-88° (0.1 mm); ^{1}H-nmr (deuteriochloroform): δ 1.15 (t, J = 6 Hz, 3H, CH_3), 1.20 (t, J = 6 Hz, 3H, CH_3), 2.70 (q, J = 6 Hz, 2H, CH_2), 2.95 (q, J = 6 Hz, 2H, CH_2), 7.00-7.30 (m, 4H, aromatic), 7.70-8.00 (m, 2H, aromatic); ^{13}C-nmr (deuteriochloroform): δ 12.3, 12.5 (*C*H$_3$CH$_2$-C2-C-6), 30.6 (CH$_3$*C*H$_2$-C-6), 32.2 (CH$_3$*C*H$_2$-C-2), 111.4 (C-5), 126.5, 128.1, 129.8, 136.9 (aromatic), 163.2 (C-6), 171.3 (C-2), 171.6 (C-4); ir (film): 1580, 1530 cm^{-1}; ms: m/e 212 (M^+, 4), 211 (M^+-H, 5), 135 (M^+-C_6H_5, 6), 105 ($C_8H_9^+$, 15), 94 (100).

Anal. Calcd. for $C_{14}H_{16}N_2$: C, 79.25; H, 7.54; N, 13.10. Found: C, 79.40; H, 7.90; N, 12.78.

2,4,6-Triphenylpyrimidine (**4l**).

This compound was obtained in 75% yield, mp 184-185° (from ethanol) lit [16] mp 185-186°); ^{1}H-nmr (deuteriochloroform): δ 7.10-7.50 (m, 9H, ring), 7.70 (s, 1H, aromatic), 7.90-8.20 (m, 4H, aromatic), 8.35-8.55 (m, 2H, ring); ^{13}C-nmr (deuteriochloroform): δ 110.0 (C-5), 127.0, 128.3, 128.6, 130.4, 130.5, 137.2, 138.0 (aromatic), 164.2, 164.4 (C-2, C-4, C-6); ir (potassium bromide): 1565, 1525 cm^{-1}; ms: m/e 308 (M^+, 24), 307 (M^+-H, 100), 205 (M^+-C_6H_5CN, 71), 102 (205-C_6H_5CN, 43).

2,3,5,6-Tetraphenylpyrimidine (**4m**).

This compound was obtained in 70% yield, mp 185-187° (from ethanol); ^{1}H-nmr (deuteriochloroform): δ 6.60-7.40 (m, 20H, aromatic); ^{13}C-nmr (dimethyl-d_6 sulfoxide): δ 127.46, 127.76, 127.93, 128.03, 128.16, 128.31, 128.53, 128.62, 128.73, 128.92, 129.28, 129.37, 129.53, 130.88 (C-5), phenyl), 136.06, 137.19, 138.51 (C-2, C-4, C-6); ir (potassium bromide): 1520, 1400 cm^{-1}; ms: m/e 384 (M^+, 54), 383 (M^+-H, 89), 178 (M^+-2C_6H_5CN, 100).

Anal. Calcd. for $C_{28}H_{20}N_2$: C, 87.47; H, 5.24; N, 7.29. Found: C, 87.38; H, 5.35; N, 7.15.

Acknowledgment.

We thank Stiftung Volkswagenwerk for financial support of this work.

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