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Reactions between Azolium Salts and Nucleophilic Reagents

III. Base-catalyzed Interhalogenation and *cine*-Substitution of Bromopyrazolium Salts with Formation of 1,2-Dimethyl-pyrazol-4-in-3-ones

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1,2-Dimethyl-3,4-dibromo-pyrazolium tosylate (IIa) in basic solution reacts to give 1,2-dimethyl-3,4,5-tribromo-pyrazolium tosylate (XVII) and 1,2-dimethyl-4-bromo-pyrazolium tosylate (Ia) as primary products. (IIa) and (XVII) yield 1,2-dimethyl-4-bromo-pyrazol-4-in-3-one (VIIIa) and the 5-bromo-derivative (XX) *via* nucleophilic attack by hydroxide ion. 1,2-Dimethyl-4-bromo-pyrazolium tosylate (Ia), or its 3-methyl-derivative (Ib), react with 1 N sodium hydroxide or -methoxide at 190° with *cine*-substitution giving the 1,2-dimethyl-pyrazol-4-in-3-ones (VIIa) or (VIIb). The *cine*-substitution to a minor extent follows an interhalogenation route (1, Scheme 1), and to a major extent follows an intrahalogenation route (2) and/or an AE_a-mechanism (4).

C-Halogen substituted pyrazoles are very unreactive toward nucleophilic attack.[1] Thus 3- or 4-halopyrazoles react only by prolonged reflux with lithium dimethylamide in ether to give ring-opened products.[2] Quaternization of the pyrazole ring is expected to increase the reactivity of the halogen atoms toward nucleophilic reagents. In fact, 1,2-disubstituted 3-halogeno-pyrazolium salts, when treated under mild conditions with hydroxylic ions, hydrogen sulphide ions, ammonia, dimethylamine, or aniline, undergo substitution to give 1,2-disubstituted 3-pyrazolones, -thiones, or imines, respectively.[3,4] No data on the reactivity of halogen in the 4-position of 1,2-disubstituted pyrazolium salts are available. The present paper deals with the reactivity of 1,2-dimethyl-4-halogeno-pyrazolium salts toward nucleophilic reagents.

1,2-Dimethyl-4-bromo-pyrazolium *p*-toluenesulfonate (Ia) was prepared from 1-methyl-4-bromo-pyrazole (XVIa) and methyl tosylate. Other pyrazolium tosylates mentioned in the present paper were prepared in the same way (see Experimental).

NUCLEOPHILIC SUBSTITUTIONS

Reactions with hydroxyl ion. (Ia) was heated with 1 N sodium hydroxide in order to produce 1,2-dimethyl-pyrazolio-4-oxide (Xa). Complete conversion of the starting material required 70 h at 100° or, alternatively, 3 h at 190°.

The NMR-spectrum of the major product, obtained in 53 % yield, showed two methyl group signals at δ 3.36 and 3.38. Besides, two protons forming an AB-system were present at δ 5.45 and 7.22 (J_{AB} 3.6 Hz). This NMR-spectrum is not in accordance with the expected pyrazolio-oxide (Xa), but rather indicates that 1,2-dimethyl-pyrazol-4-in-3-one (VIIa) is the product obtained. Thus *N*-methyl groups of the known 1,2-disubstituted pyrazol-4-in-3-ones absorb at δ 3.0 – 3.3, and ring protons at 4-position in these pyrazolones absorb at δ 5.1 – 5.4.[5] The product showed a characteristic absorption at 1605 cm^{-1} in infrared; authentic 1,2,5-trimethyl-pyrazol-4-in-3-one absorbs at 1630 cm^{-1}. 1-Methyl-4-bromo-pyrazole (XVIa), 1-methyl-pyrazole (XVa), formic acid, and minor amounts of destruction products were established as by-products. (XVIa) is probably formed by dequaternization of the starting material (Ia). (XVa) may be formed by dequaternization of the salt (IIIa) formed as an intermediate during the reaction (see later). Formic acid and destruction products may be formed *via* ring-opening.

1,2-Dimethyl-4-chloro-pyrazolium tosylate (Ia, X = Cl), with sodium hydroxide gave the same products as the bromo salt (Ia) in almost the same yields.

Similarly, 1,2,3-trimethyl-4-bromo-pyrazolium tosylate (Ib), when heated with 1 N sodium hydroxide to 190° for 3 h, gave 1,2,5-trimethyl-pyrazol-4-in-3-one (VIIb) as the main product. The structure of (VIIb) was proved by its identity with an authentic sample prepared by methylation of 1,3-dimethyl-pyrazol-4-in-5-one. (VIIb) was also formed in 85 % yield when 1,2,5-trimethyl-3-bromo-pyrazolium tosylate (IVb) was heated to 100° for three hours with 1 N sodium hydroxide. This proves that the 4-halogen substituted salts (Ia and Ib) react with hydroxide ion with *cine*-substitution. In addition to the pyrazolone (VIIb), the 4-bromo substituted salt (Ib) gave 1,3-dimethyl-4-bromo-pyrazole, 1,5-dimethyl-4-bromo-pyrazole (XVIb) 1,3-dimethyl- pyrazole, 1,5-dimethyl-pyrazole (XVb), formic acid, acetic acid, and destruction products. The two bromo-pyrazoles are probably formed by dequaternization of the starting material. (XVb) and its isomer may arise by dequaternization of 1,2,3-trimethyl-pyrazolium tosylate (IIIb) formed as an intermediate during the reaction (see later).

1,2,3,5-Tetramethyl-4-bromo-pyrazolium tosylate (Ic), when heated with sodium hydroxide, gave unchanged starting material (65 %), the dequaternization product (XVIc) (20 %), and minor amounts of formic and acetic acid. This experiment indicates that the halogen in the 4-position of this particular type of 1,2-disubstituted pyrazolium salts does not react with hydroxylic ion under the severe conditions used.

Reactions with methoxide. 1,2-Dimethyl-4-bromo-pyrazolium tosylate (Ia) when heated with sodium methoxide afforded the pyrazolone (VIIa) as the main product. In addition, minor amounts of 5,5′-bi-1-methyl-pyrazole (XXIV) and 1-methyl-5-(1′-methyl-3′-pyrazolyl)-pyrazole (XXV) were formed (see

Experimental), probably arising by dequaternization of (XXIII), the formation of which has not been rationalized. The presence of 1-methyl-pyrazole (XVa) or 1-methyl-4-bromo-pyrazole (XVIa) could not be demonstrated as these compounds are lost by the isolation procedure. No bromo-pyrazolone (VIIIa) was observed. Similarly, 1,2,3-trimethyl-4-bromo-pyrazolium tosylate (Ib) gave 1,2,5-trimethyl-pyrazol-4-in-5-one (VIIb) (9 %) and the 4-bromo-derivative (VIIIb) (5 %). The structure of (VIIIb) appeared from its formation by bromination of the pyrazolone (VIIb). The presence of 1,3-dimethyl-4-bromo-pyrazole, 1,5-dimethyl-4-bromo-pyrazole (XVIb), 1,3-dimethyl-pyrazole, or 1,5-dimethyl-pyrazole (XVb) could not be demonstrated since these compounds are lost during the isolation procedure. 1,2,5-Trimethyl-3-bromo-pyrazolium tosylate (IVb) and sodium methoxide, under similar conditions, afforded the pyrazolone (VIIb) in quantitative yield.

MECHANISM

Several mechanisms are possible for *cine*-substitution of 4-bromo- or -chloro-pyrazolium salts which have no substituents in the 3-position. One of the possibilities could involve an interhalogenation reaction similar to that observed in the triazolium salt series (route 1, Scheme 1).[6,7] Further mechanisms leading to *cine*-substitution is anomalous addition-elimination, denoted AE_a[11] (route 4, Scheme 1), or elimination-addition, denoted EA[11] (route 3, Scheme 1). These mechanisms will be discussed in detail below.

Another possible mechanism for the formation of the pyrazolones is ring-opening followed by rearrangement, ring-closure and substitution. However, base-catalyzed ring-opening of 1,2-disubstituted pyrazolium salts [8,9] (and 1,2-disubstituted pyrazol-4-in-3-ones [10]) are reported to occur with rupture of the two C–N bonds with subsequent formation of *N*,*N*'-disubstituted hydrazines. Therefore, pyrazolone formation *via* ring-opening is highly unlikely. Radical mechanisms may be excluded as the reaction proceeds readily when hydroquinone is present. A carbene-like intermediate is highly unlikely as no such intermediate could be trapped with cyclohexene.

4-Bromo-1,2,3-triazolium salts are reactive brominating agents in basic solution and interbromination in 5-position has been reported.[6,7] Thus a similar interhalogenation of the 4-halo-pyrazolium salt (I) appears reasonable. If so, (II) and (III) would be formed and interact to produce the 5-halo substituted salt (IV). This then might react with hydroxylic ions to give (V) furnishing, by deprotonation, the pyrazolone (VII). Analogously, reaction with methoxide ions might give (VI) which by dequaternization and loss of an *O*-methyl group might produce the pyrazolone (VII).[7] All of the conceivable brominations may proceed by bromonium ion transfer to carbanions formed by abstraction of a ring hydrogen atom.[6] Consequently, the rate of the interhalogenation should be proportional to the rate of the proton abstraction from the acceptor and proportional to the rate of the halonium ion abstraction from the donor. Furthermore, it would be reasonable to assume, that the rate of halonium ion abstraction of a given halo-substituted salt should be proportional to the rate of the proton abstraction of a similar salt with halogen replaced by hydrogen.

According to the exchange rates (Table 1), the 3,4-dibromo pyrazolium salt (IIa) should be similar to 1,3-dimethyl-4-bromo-1,2,3-triazolium tosylate with regard to reactivity.[6] The latter, when dissolved in 1 N sodium hydroxide at room temperature, partly undergoes nucleophilic substitution followed by proton abstraction, thereby forming a triazolio-oxide, and partly undergoes an interhalogenation reaction forming an unsubstituted salt and a dibromo salt. The latter then, by substitution and proton abstraction, affords a bromo-triazolio-oxide.[6]

Quite similarly, the 3,4-dibromo-pyrazolium salt (IIa), when dissolved in 1 N sodium hydroxide at room temperature (Scheme 2), partly undergoes nucleophilic substitution of the most reactive halogen, namely that in the 3-position, to give (XVIII) which then by proton abstraction affords 1,2-dimethyl-4-bromo-pyrazol-4-in-3-one (VIIIa). The structure of the latter follows from its NMR-spectrum, which shows a signal in the region where 5-protons absorb and lacks signals in the 4-proton region (Table 2). Furthermore, (VIIIa) was formed by the reaction of (VIIa) with bromine analogous to the formation of (VIIIb) by bromination of (VIIb). In contrast, (VIIIa) did not react with bromine, indicating that only the 4-positions of pyrazolones (VII) and (VIII) are accessible to electrophilic attack. The remainder of the starting material (IIa) undergoes interhalogenation forming the 1,2-dimethyl-3,4,5-tribromo-pyrazolium salt (XVII) and the 1,2-dimethyl-4-bromo-pyrazolium salt (Ia). The formation of the latter is in agreement with the exchange rates of 1,2-dimethyl-pyrazolium tosylate (IIIa), which indicates, that halogen in the 3-position is much more readily abstracted as a halonium ion, than halogen in the 4-position. The 4-bromo-salt formed does not react with sodium hydroxide at room temperature. The initially formed 3,4,5-tribromo salt, on the other hand, reacts readily with nucleophilic substitution of the most reactive halogen in the 3-position, thereby forming (XIX), which by proton abstraction affords 1,2-dimethyl-4,5-dibromo-pyrazol-4-in-3-one (XX). The structure of (XX) was confirmed by infrared- and NMR-spectra which showed absorptions in the regions where other 1,2-dimethyl-pyrazol-4-in-3-ones absorb (see Table 2).

The bromo-pyrazolone (VIIIa) was heated to 100° for 1 h with 1 N sodium hydroxide saturated with sodium bromide. Provided equilibration took place, the dibromo-pyrazolone (XX) would be present, formed *via* the salts (XVIII), (XVII), and (XIX). However, only starting material was recovered unchanged indicating kinetic control of the above reaction. Hence, the ratio between the products (VIIIa) and (XX) reflects the ratio between the velocity constants of the rate limiting steps 5 and 6.

The exchange rate of the 4-proton in 1,2-dimethyl-pyrazolium tosylate (IIIa) was unmeasurably low in aqueous solution. (No exchange after 60 days at pD 12). Consequently, 1,2-dimethyl-4-bromo-pyrazolium tosylate (Ia) should be a very poor bromonium ion donor. However, the formation of 1-methyl-pyrazole (XVa) by the reaction between (Ia) and sodium hydroxide suggests, that 1,2-dimethyl-pyrazolium tosylate (IIIa) is formed by an interhalogenation reaction of (Ia), yielding, in addition, (IIa) possibly through an equilibrated system a. According to the exchange rates, the 3-position of the unsubstituted salt (IIIa) is attacked much more readily by a halonium

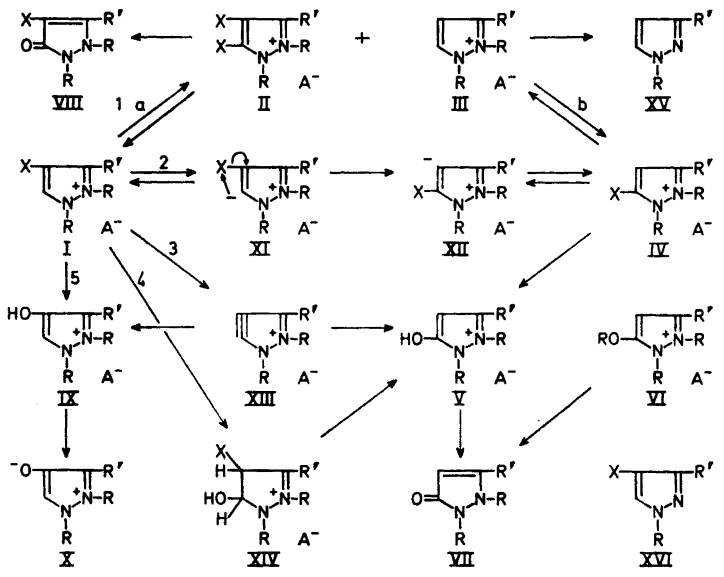
ion, than the 4-position. Consequently, the equilibrium b should be established much faster. Since the dibromo-salt (IIa) according to exchange rate studies is considerably more reactive toward halonium ion attack than the unsubstituted salt (IIIa), equilibrium c should be established even faster. Nucleophilic substitution of the 3-halogen in the salts (IIa), (IVa) and (XVII) by hydroxylic ion may then occur, giving the pyrazolones (VIIIa), (VIIa) and (XX). However, no bromo-pyrazolones (VIIIa) or (XX) could be detected from the reaction of the 4-bromo- salt (Ia) with sodium hydroxide. The lack of the dimethyl-bromo-pyrazolones may be explained by the fact that the dibromo salt (IIa), when heated with sodium hydroxide, gave only destruction products and no bromo-pyrazolones. Traces of pyrazolone (VIIa) were detected, probably formed from the 4-bromo salt (Ia), which, in its turn, is formed by interhalogenation of (IIa) according to c (Scheme 2). Furthermore, the pure bromo-pyrazolones (VIIIa) and (XX) when heated with sodium hydroxide were destroyed completely. Consequently, the pyrazolone (VIIa) is the only product expected to survive by reaction of the 4-bromo-pyrazolium salt (Ia) with sodium hydroxide *via* the proposed interhalogenation mechanism. The formation of the trimethyl-bromo-pyrazolone (VIIIb) by the reaction of the 4-bromo-pyrazolium salt (Ib) with sodium methoxide can be explained by the fact that the dibromo salt (IIa) affords the bromo-pyrazolone (VIIIa) in 26 % yield when treated with sodium methoxide under similar conditions. This indicates, that the dibromo salt (IIb) is formed during the reaction of (Ib) with sodium methoxide, thus confirming contributions from the proposed interhalogenation mechanism.

As a byproduct from the reaction between (IIa) and sodium methoxide, the pyrazolone (VIIa) was isolated in 11 % yield. Its formation may be explained by a primary reduction of some of the starting material by the methanol used as the solvent, thereby forming the 4-bromo salt (Ia) which then affords (VIIa) as before. A similar reduction of dibromo-salts was observed in the 1,2,3-triazole series.[7] Alternatively, (VIIa) may arise from substitution and dequaternization of the 4-bromo-salt (Ia), formed by interhalogenation of the starting material (IIa) according to c (Scheme 2).

In order to investigate the brominating power of the 4-bromo-pyrazolium salt (Ia), it was heated with 1,3-dimethyl-1,2,3-triazolium tosylate and sodium hydroxide. According to the exchange rates,[6] the triazolium salt should be similar to (Ia) in reactivity toward halonium ion attack. However, no triazolio-oxides were formed. Consequently, no bromination of the triazolium salt has taken place.[6] Again, attempts to brominate 1,3-dimethyl-1,2,3-triazolium tosylate with 1,2,3-trimethyl-4-bromo-pyrazolium tosylate (Ib), and 1,2,3,5-tetramethyl-4-bromo-pyrazolium tosylate (Ic) were of no avail. Equally unsuccessful was the application of sodium methoxide. These experiments do not support the proposed interhalogenation mechanism a (Scheme 1).

The bromination of 1,2-dimethyl-4-bromo-pyrazolium tosylate (Ia) with *N*-bromoacetamide in 1 N sodium hydroxide was now investigated. According to exchange rates, the 4-bromo-pyrazolium salt (Ia) should behave similarly to 1,3-dimethyl-1,2,3-triazolium tosylate towards halonium ion attack.[6] In fact, (Ia) with *N*-bromoacetamide afforded the dibromo-pyrazolone (XX) in high yield. Most likely the 3,4-dibromo salt (IIa) is initially formed and

halogenated to give the 3,4,5-tribromo-pyrazolium salt (XVII), which subsequently gives (XX).



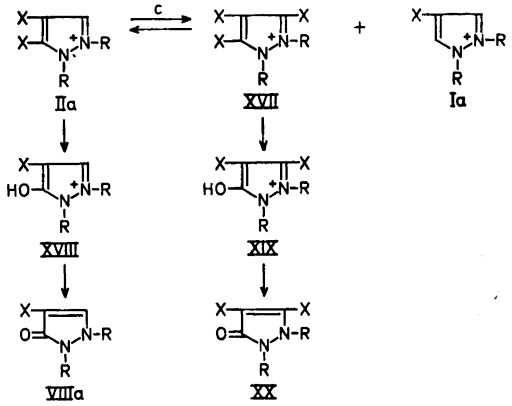
	R	R'
a	CH_3	H
b	CH_3	CH_3

X=Br, and $A^- = p\text{-}CH_3C_6H_4SO_3^-$, when not otherwise stated

Scheme 1

In order to investigate the second step in the proposed interhalogenation mechanism b (Scheme 1), a 1:1 mixture of 1,2-dimethyl-pyrazolium tosylate (IIIa) and the dibromo derivative (IIa) was heated with sodium hydroxide to 190°. Only starting material (IIIa), 1-methyl-pyrazole (XVa) (formed by dequaternization of (IIIa)), and destruction products were obtained together with no more than a minor amount of the expected pyrazolone (VIIa), the latter probably formed *via* the 4-bromo salt (Ia) which in turn arises by interhalogenation of (IIa) according to c (Scheme 2). When the same reaction was carried out at 100°, (IIIa) was recovered unchanged, whereas (IIa) was converted into the bromo-pyrazolones (VIIIa) and (XX) according to c (Scheme 2). This confirms that the dibromo salt (IIa) halogenates itself much more readily than it does the unsubstituted salt (IIIa). Again these experiments are not in keeping with the interhalogenation mechanism b (Scheme 1).

In order to study the susceptibility of (III) to bromination, 1,2-dimethyl-pyrazolium tosylate (IIIa), was reacted with *N*-bromoacetamide in 1 N sodium hydroxide. According to exchange rates (IIIa) should be attacked *ca.* 275 times slower by *N*-bromoacetamide in 1 N sodium hydroxide, than the 4-bromo-derivative (Ia). In fact, no conversion of (IIIa) was detected after 14



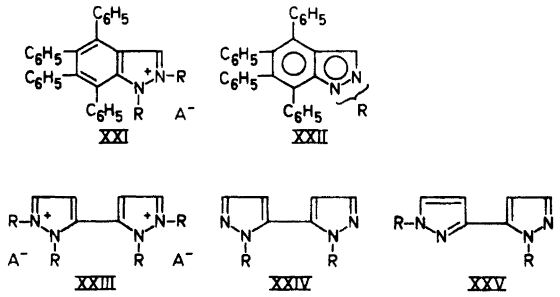
Scheme 2

days at room temperature. To conclude, the formation of 1-methyl-pyrazoles (XV) in the reaction of 4-bromo-pyrazolium salts (I) with sodium hydroxide, as well as the production of the bromo-pyrazolone (VIIIb) in the reaction of the 4-bromo salt (Ib) with sodium methoxide, indicates that the interhalogenation a (Scheme 1) does take place to a certain extent. However, all attempts to substantiate the step b failed, since the dibromo salt (IIa) halogenates itself much more readily than it halogenates the unsubstituted salt (IIIa). Consequently, the interhalogenation mechanism 1 (Scheme 1) can only account to a minor extent for the formation of the pyrazolones (VII) from the 4-halo-pyrazolium salts (I). The fact that the 4-bromo-pyrazolium salt (Ia) does not halogenate a competing halonium ion acceptor (such as the 1,2,3-triazolium salt) indicates, that (Ia) is not a halonium ion donor. The interesting possibility, that the halonium ion migrates directly to the 3-position *via* a 1,2-halonium shift (route 2, Scheme 1) cannot be excluded on the basis of the present evidence.

Base competiton studies has been utilized in the investigation of AE_a- and EA-mechanisms.[12] Amines, phenolates, or benzoates may conceivably be used as competing nucleophilic reagents. However, 1,2-dimethyl-4-bromo-pyrazolium tosylate (Ia) when treated with methylamine or piperidine in water, methanol, or dimethylformamide dequaternized forming 1-methyl-4-bromo-pyrazole (XVIa) accompanied by some decomposition. Unfortunately, no substitution products could be detected. Sodium phenolate, -benzoate, -thiobenzoate, -methylmercaptide (a potent aryne trapping agent in liquid ammonia[13]), -*p*-thiocresylate, or -azide gave similar results. Sodium sulfide in water afforded 1-methyl-pyrazole (XVa) (60 %) formed *via* reduction of the starting material. Otherwise, only destruction products and no substitution products were obtained. This lack of substitution reactions prevents the use of base competition experiments in the present case. The

above mentioned reaction with sodium methoxide cannot be used either, since sodium methoxide and hydroxide give the same products.

Trapping of an intermediate hetaryne with tetraphenylcyclopentadienone has been traditionally used as a proof of the EA-mechanism.[11] Recently, however, this method has been shown to be of limited value since tetraphenylcyclopentadienone may give an identical adduct by an AEa-mechanism.[14] In the present case the tetraphenyl-indazolium salt (XXI) (Scheme 3) would



$R = CH_3$, $A^- = p\text{-}CH_3C_6H_4SO_3^-$

Scheme 3

be formed in either case undergoing, partly or entirely, dequaternization to the tetraphenyl-indazole(s) (XXII). However, neither (XXI) nor (XXII) could be detected as products from the reaction of 1,2-dimethyl-4-bromopyrazolium tosylate and sodium methoxide with tetraphenylcyclopentadienone. Only *cis*-2,3,4,5-tetraphenylcyclopent-2-ene-1-one was isolated, in 75 % yield, a known compound from the reaction of tetraphenylcyclopentadienone with ethanol or sodium ethoxide alone at elevated temperature.[15,16] Consequently, this experiment cannot be used to support neither an EA- nor an AE_a-mechanism.

1,3-Dimethyl-triazolio-4-oxide is an excellent 1,3-dipole which reacts readily with benzyne.[17] Furthermore, the triazolio-oxide is stable even on prolonged heating to 200° in acids or bases. Therefore it should be a potent trapping agent for an intermediate hetaryne (XIII). However, the triazolio-oxide was recovered unchanged when reacted with the 4-bromo-pyrazolium salt (Ia) and sodium methoxide.

5-Membered hetarynes are expected to have high energy contents and are consequently not expected to show high specificity in the product determining addition step.[18] With an EA-mechanism operating, (VIIa) and (Xa) should therefore be formed in nearly equal amounts. By the reaction of the pyrazolium salt (Ia) with sodium hydroxide or sodium methoxide a high specificity was found. This fact is certainly not in favour of an EA-mechanism.

To conclude, the reaction(s) leading to the formation of the pyrazolones (VII), when 1,2-disubstituted 4-halogeno-pyrazolium salts (I) are treated

with sodium hydroxide or -methoxide, probably proceed(s) to a minor extent *via* an interhalogenation mechanism 1 (Scheme 1) and to a major extent *via* an intrahalogenation mechanism 2 and/or an AE_a-mechanism 4. No choice between the last two possibilities can be made on the basis of the available data.

EXPERIMENTAL

Thin layer and column chromatography were carried out as described previously.[19] NMR-spectra were obtained on Varian A-60 or HA 100 instruments. Position of signals are given in ppm (δ-values) relative to TMS. Deuteriochloroform was used as a solvent. Mass-spectra were obtained on a Perkin Elmer 270 instrument. Melting points are uncorrected.

1,2-Dimethyl-4-bromo-pyrazolium tosylate (Ia). To ensure purity, 1-methyl-4-bromo-pyrazole (XVIa) [20] was chromatographed on a column of silica gel (5.2 g per 100 mg of (XVIa)) using ether-hexane 1:4 as eluent. (XVIa) (1.33 g) and methyl tosylate (1.54 ml) were heated to 100° for 3 h. The product was washed with ether (3 × 10 ml) and recrystallized from methanol-ether. This gave 2.48 g (86 %) of 1,2-dimethyl-4-bromo-pyrazolium tosylate (Ia) as colourless crystals, m.p. 153°. (Found: C 41.31; H 4.36; N 8.21; S 9.18; Br 22.97. Calc. for $C_{12}H_{15}N_2O_3SBr$: C 41.49; H 4.36; N 8.07; S 9.23; Br 23.01).

1,2,3-Trimethyl-4-bromo-pyrazolium tosylate (Ib). Similarly, pure 1,5-dimethyl-4-bromo-pyrazole (XVIb) (1.84 g) [21] and methyl tosylate (1.96 ml) gave 3.60 g (95 %) of 1,2,3-trimethyl-4-bromo-pyrazolium tosylate (Ib) as colourless crystals, m.p. 182°. (Found: C 43.06; H 4.87; N 7.73; S 8.70; Br 22.10. Calc. for $C_{13}H_{17}N_2O_3SBr$: C 43.21; H 4.75; N 7.76; S 8.88; Br 22.12).

1,2,5-Trimethyl-3-bromo-pyrazolium tosylate (IVb). Similarly, 1,3-dimethyl-5-bromo-pyrazole (563 mg) [21] and methyl tosylate (0.60 ml) gave 1.15 g (99 %) of 1,2,5-trimethyl-3-bromo-pyrazolium tosylate (IVb) as colourless crystals, m.p. 179—180°. (Found: C 43.06; H 4.65; N 7.81; S 8.70; Br 22.40).

1,2,3,5-Tetramethyl-4-bromo-pyrazolium tosylate (Ic). Similarly, 1,3,5-trimethyl-4-bromo-pyrazole (XVIc) (1.25 g) [20] and methyl tosylate (1.23 ml) gave 2.31 g (94 %) of 1,2,3,5-tetramethyl-4-bromo-pyrazolium tosylate (Ic) as colourless crystals, m.p. 182—184°. (Found: C 44.65; H 5.19; N 7.65; S 8.45; Br 21.08. Calc. for $C_{14}H_{19}N_2O_3SBr$: C 44.81; H 5.11; N 7.47; S 8.56; Br 21.29).

1,2-Dimethyl-4-chloro-pyrazolium tosylate (Ia, X=Cl). To ensure purity, 1-methyl-4-chloro-pyrazole (XVIa, X=Cl) [22] was chromatographed on a column of silica gel (5.8 g per 100 mg of pyrazole) using ether-hexane 1:4 as eluant. (XVIa, X=Cl) (120 mg) was

Table 1. Deuterium exchange rates of 1,2-dimethyl-pyrazolium tosylates.

Compound	Proton	pD	$T_{\frac{1}{2}}$[d] min	Relative rate
1,2-Dimethyl-pyrazolium tosylate (IIIa)	H_3 H_4	11.55[a]	63.5 [e]	1.00
1,2-Dimethyl-4-bromo-pyrazolium tosylate (Ia)	H_3	9.86[b]	11.3	2.75×10^2
1,2-Dimethyl-3,4-dibromo-pyrazolium tosylate (IIa)	H_5	7.96[c]	20.4	1.21×10^4

[a] Phosphate-hydroxide buffer.
[b] Borate buffer.
[c] Phosphate buffer.
[d] The rates were measured by NMR analysis at 34°.
[e] No exchange after 60 days at room temperature.

treated with methyl tosylate (0.20 ml) in the usual manner and the product was purified as above. This gave 309 mg (99 %) of 1,2-dimethyl-4-chloro-pyrazolium tosylate (Ia, X=Cl) as colourless crystals, m.p. 120–123°. (Found: C 47.80; H 5.09; N 9.15; S 10.78; Cl 11.58. Calc. for $C_{12}H_{15}N_2O_3SCl$: C 47.59; H 4.99; N 9.26; S 10.59; Cl 11.71).

1,2-Dimethyl-pyrazolium tosylate (IIIa). Similarly, 1-methyl-pyrazole (XVa) (492 mg) [23] and methyl tosylate (1.12 ml) gave 1.53 g (95 %) of 1,2-dimethyl-pyrazolium tosylate (IIIa) as colourless crystals, m.p. 159–161°. (Found: C 53.59; H 5.89; N 10.60; S 11.79. Calc. for $C_{12}H_{16}N_2O_3S$: C 53.72; H 6.02; N 10.44; S 11.95).

1,2-Dimethyl-3,4-dibromo-pyrazolium tosylate (IIa). To ensure purity, 3,4-dibromo-pyrazole [20] was chromatographed on a column of silica gel (6.5 g per 100 mg of dibromo-pyrazole) using benzene-ether 4:1 as eluant. 3,4-Dibromo-pyrazole (817 mg) was methylated with excess of diazomethane using the procedure described previously.[19] Cautious evaporation of the solvent left 871 mg (100 %) of a colourless oil. An NMR-spectrum showed signals at δ 7.50, 7.35, 3.92, and 3.88 indicating a mixture of 1-methyl-3,4-dibromo-pyrazole and 1-methyl-4,5-dibromo-pyrazole in the ratio 1.00:1.37. This mixture, when heated with methyl tosylate (0.68 ml) to 100° for 6 h gave 1.38 g (89 %) of 1,2-dimethyl-3,4-dibromo-pyrazolium tosylate (IIa) as colourless crystals, m.p. 196–197°. Recrystallization from methanol-ether did not raise the melting point. (Found: C 33.83; H 3.35; N 6.73; S 7.76; Br 37.33. Calc. for $C_{12}H_{14}N_2O_3SBr_2$: C 33.82; H 3.31; N 6.58; S 7.53; Br 37.51).

1,2-Dimethyl-4-bromo-pyrazolium tosylate (Ia) and sodium hydroxide. (Ia) (300 mg) and 1 N aqueous sodium hydroxide (2.70 ml) were heated to 190° for 3 h in a sealed tube. The mixture was extracted with a known amount of deuteriochloroform to which a known amount of methylene chloride was added. An NMR-spectrum of the extract showed signals due to 1-methyl-pyrazole (XVa) (7 %) and 1-methyl-4-bromo-pyrazole (XVIa) (5 %). The yields were determined by comparing the integrals of the NMR-signals with the integral of signal due to methylene chloride. The presence of (XVa) and (XVIa) was proved by adding, one by one, the pure substances to the solution. When hexafluorobenzene was used instead of deuteriochloroform the expected upfield shifts of the 5-protons were observed.[24] Furthermore, the pure substances were added one by one to the mixture as before. An NMR-spectrum of the water phase showed signals due to pyrazolone, destruction products, sodium tosylate, and two signals due to sodium formate and -acetate. The solution was acidified with hydrochloric acid and evaporated to dryness *in vacuo*. The distillate was collected in a cooled reciever containing 0.1 N sodium hydroxide. The distillate was evaporated to dryness. An NMR-spectrum of the residue dissolved in D_2O showed two signals due to sodium formate and -acetate. The presence of these compounds were proved by adding, one by one, the pure substances to the solution.

The residue from the first evaporation was extracted with boiling chloroform (3 × 10 ml). Removal of the chloroform left a yellow oil which was extracted with boiling ethyl acetate (5 × 5 ml). Removal of the solvent gave 52 mg (53 %) of a yellow oil. TLC using ethyl acetate-methanol 1:1 as the eluent, indicated one spot. No bromo-pyrazolone was present. Reprecipitations from ethyl acetate-hexane with cooling in dry-ice gave a colourless, crystalline, very hygroscopic material, m.p. 47–63°. (Found: C 53.42; H 7.29; N 24.83. Calc. for $C_5H_8N_2O$: C 53.55; H 7.19; N 24.99). Spectral data are given in Table 2.

1,2-Dimethyl-4-chloro-pyrazolium tosylate (Ia, X=Cl) and sodium hydroxide. (Ia, X = Cl) (99 mg) and 1 N sodium hydroxide (1.10 ml) were heated to 190° for 3 h in a sealed tube. The solution was extracted with deuteriochloroform as described above. An NMR-spectrum of the extract showed signals corresponding to 1-methyl-4-chloro-pyrazole (XVIa, X = Cl) (11 %), identified as described above. No 1-methyl-pyrazole (XVa) could be observed. An NMR-spectrum of the water phase showed the presence of pyrazolone, destruction products, sodium tosylate, and -formate. The formate was identified as above. The water phase was worked up as above giving 12 mg (33 %) of 1,2-dimethyl-pyrazol-4-in-3-one (VIIa), identified by NMR- and IR-spectra. No impurities could be detected by TLC.

1,2,3-Trimethyl-4-bromo-pyrazolium tosylate (Ib) and sodium hydroxide. (Ib) (120 mg) and 1 N sodium hydroxide (1.10 ml) were heated to 190° for 3 h. The solution was extracted with carbon tetrachloride containing methylene chloride as an integration standard. An 100 MHz NMR-spectrum of the extract showed signals corresponding to 1,3-

dimethyl-pyrazole (5 %), 1,5-dimethyl-pyrazole (XVb) (1 %), 1,3-dimethyl-4-bromo-pyrazole (8 %), and 1,5-dimethyl-4-bromo-pyrazole (XVIb) (12 %). The compounds were identified as described above. When hexafluorobenzene was used instead of carbon tetrachloride the expected shifts were observed.[24] Furthermore, the two bromo-pyrazoles were identified by gas-chromatography and subsequent mass-spectrometry of the fractions obtained. The water phase contained sodium formate and -acetate as shown by NMR. Working up as described above gave 10 mg (24 %) of 1,2,5-trimethyl-pyrazol-4-in-3-one (VIIb) as a colourless oil. TLC showed that no bromo-pyrazolone (VIIIb) was present. IR- and NMR-spectra were identical with those of an authentic sample prepared from 1,3-dimethyl-pyrazol-4-in-5-one [25] and purified by preparative thin layer chromatography using methylethyl ketone saturated with water as eluent.

1,2,5-Trimethyl-3-bromo-pyrazolium tosylate (IVb) and sodium hydroxide. (IVb) (116 mg) and 1 N sodium hydroxide (1.00 ml) were heated to 100° for 3 h. Evaporation of the solvent, extraction with boiling chloroform (5 × 10 ml), and evaporation of the chloroform left 35 mg (85 %) of 1,2,5-trimethyl-pyrazol-4-in-3-one (VIIb), identical with the material prepared above.

1,2,3,5-Tetramethyl-4-bromo-pyrazolium tosylate (Ic) and sodium hydroxide. (Ic) (76 mg) and 1 N sodium hydroxide (0.65 ml) were heated to 190° for 3 h. The solution was extracted with deuteriochloroform. An NMR-spectrum of the chloroform solution showed the presence of 1,3,5-trimethyl-4-bromo-pyrazole (XVIc) (20 %), identified by addition of the pure substance to the solution. An NMR-spectrum of the water phase showed the presence of starting material (Ic) (65 %), sodium tosylate, traces of sodium formate and -acetate, and minor amounts of destruction products. No pyrazolio-oxide (Xc) could be detected.

1,2-Dimethyl-3,4-dibromo-pyrazolium tosylate (IIa) and sodium hydroxide. A. (IIa) (99 mg) and 1 N sodium hydroxide (0.75 ml) were heated to 190° for 3 h. The solvent was then removed and the residue was extracted with chloroform (5 × 10 ml). Removing of the chloroform gave 5 mg of a yellow oil. An NMR-spectrum indicated the presence of several products. Only traces of pyrazolone (VIIa) could be detected.

B. (IIa) (150 mg) and 1 N sodium hydroxide (1.50 ml) were kept at room temperature for 5 h. (NMR-spectra indicated complete conversion after 3 ½ h). The solvent was then removed *in vacuo* at 50° and the residue was extracted with boiling chloroform (5 × 10 ml). Removing of the solvent gave 54 mg of colourless crystals, which was chromatographed on silica gel (5 g) using ethyl acetate as the eluent. The first fraction contained 38 mg (33 %) of 1,2-dimethyl-4,5-dibromo-pyrazol-4-in-3-one (XX) as colourless crystals, m.p. 169—171°. Recrystallization from ethyl acetate-hexane did not raise the melting point. (Found: C 22.34; H 2.32; N 10.27; Br 59.07. Calc. for $C_5H_6N_2OBr_2$: C 22.24; H 2.24; N 10.38; Br 59.20). Spectral data are given in Table 2. The column was then eluted with ethyl acetate-methanol 1:1. This gave 18 mg (22 %) of 1,2-dimethyl-4-bromo-pyrazol-4-in-3-one (VIIIa) as a colourless, semicrystalline mass. IR- and NMR-spectra were identical with those of the material prepared as decribed below. The residue from the chloroform extraction was extracted with acetonitrile. The solvent was removed and the residue was dissolved in water and passed through 5 ml of Amberlite IRA 400 regenerated with p-toluene sulfonic acid. Evaporation of the water and recrystallization from methanol-ether gave 28 mg (30 %) of 1,2-dimethyl-4-bromo-pyrazolium tosylate (Ia) as colourless crystals, m.p. 148—154°. IR- and NMR-spectra were identical with those of the material prepared above.

1,2-Dimethyl-pyrazolium tosylate (IIIa), 1,2-dimethyl-3,4-dibromo-pyrazolium tosylate (IIa) and sodium hydroxide. A. (IIIa) (37 mg), (IIa) (59 mg), and 1 N sodium hydroxide (0.90 ml) were heated to 190° for 3 h. The solution was extracted with deuteriochloroform. An NMR-spectrum of the extract showed the presence of 1-methyl-pyrazole (XVa) (18 %), identified in the usual way. An NMR-spectrum of the water phase showed, among others, the presence of starting material (IIIa) (75 %) and of pyrazolone (VIIa) (16 % based on (IIa)). Working up the water phase as described above gave 5 mg of a colourless oil. An NMR-spectrum indicated the presence of pyrazolone (VIIa).

B. (IIIa) (56 mg), (IIa) (88 mg), and 1 N sodium hydroxide (1.30 ml) were heated to 100° for 1 h. The water was then removed and the residue was extracted with chloroform. Removal of the chloroform gave a brown oil (89 mg). An NMR-spectrum showed the presence of the bromo-pyrazolones (VIIIa) and (XX) and of a minor amount of starting material (IIIa). No pyrazolone (VIIa) could be detected. An NMR-spectrum

Table 2. Spectroscopic data of 1,2-dimethyl-pyrazol-4-in-3-ones.

Compound	Infrared[a]	NMR[b]								
	cm^{-1}	H_4 ppm	H_5 ppm	$J_{H_4H_5}$ Hz	NCH_3 ppm	$J_{^{13}C-H}$ Hz	NCH_3 ppm	$J_{^{13}C-H}$ Hz	CCH_3 ppm	$J_{^{13}C-H}$ Hz
1,2-Dimethyl--pyrazol-4-in-3-one (VIIa)	1605	5.45	7.22	3.6	3.38	140.6	3.36	140.6		
1,2-Dimethyl-4-bromo--pyrazol-4-in-3-one (VIIIa)	1627		7.35		3.42	141.4	3.42	141.4		
1,2-Dimethyl-4,5-dibromo--pyrazol-4-in-3-one (XX)	1640				3.40	141.7	3.38	142.4		
1,2,5-Trimethyl--pyrazol-4-in-3-one (VIIb)	1630	5.25			3.34	139.4	3.27	139.4	2.17	130.8
1,2,5-Trimethyl-4-bromo--pyrazol-4-in-3-one (VIIIb)	1628				3.38		3.32			

[a] IR-spectra were obtained in potassium bromide discs.
[b] NMR-spectra were obtained in deuteriochloroform.

Table 3. NMR-data of bi-pyrazoles.

Compound	Solvent	NCH_3 ppm	NCH_3' ppm	H_4 ppm	H_4' ppm	H_3 ppm	H_3' ppm	H_5' ppm	$J_{H_3H_4}$ Hz	$J_{H_3'H_4'}$ Hz	$J_{H_4'H_5'}$ Hz
5,5′-Bi-1-methyl-pyrazole	$CDCl_3$	3.96	3.96	6.57	6.57	7.35	7.35		2.1	2.1	
(XXIV)	C_6F_6	3.98	3.98	6.09	6.09	7.32	7.32				
1-Methyl-5-(1′-methyl-3′-	$CDCl_3$	3.95	4.14	6.43	6.40	7.45		7.39	2.0		2.2
pyrazolyl)-pyrazole (XXV)	C_6F_6	3.92	4.15	6.32	6.12	7.50		7.00			

of the residue from the chloroform extraction showed the presence of starting material (IIIa) and of a minor amount of 1,2-dimethyl-4-bromo-pyrazolium tosylate (Ia).

1,2-Dimethyl-pyrazolium tosylate (IIIa), 1,2,3,5-tetramethyl-4-bromo-pyrazolium tosylate (Ic) and sodium hydroxide. (IIIa) (60 mg), (Ic) (85 mg), and sodium hydroxide (0.72 ml) were heated and extracted with deuteriochloroform. An NMR-spectrum of the extract showed the presence of 1-methyl-pyrazole (XVa) (11 %) and 1,3,5-trimethyl-4-bromo-pyrazole (XVIc) (24 %). An NMR-spectrum of the water phase showed the presence of the starting materials (IIIa) (64 %) and (Ic) (76 %). No pyrazolone (VIIa) could be detected.

1,2-Dimethyl-4-bromo-pyrazolium tosylate (Ia), 1,3-dimethyl-1,2,3-triazolium tosylate, and sodium hydroxide. Similarly, (Ia) (62 mg), 1,3-dimethyl-1,2,3-triazolium tosylate (49 mg),[6] and 1 N sodium hydroxide (1.00 ml) were heated and extracted with deuteriochloroform. An NMR-spectrum of the extract showed the presence of 1-methyl-pyrazole (XVa) (7 %) and 1-methyl-1,2,3-triazole (4 %). An NMR-spectrum of the water phase showed the presence of unchanged 1,3-dimethyl-1,2,3-triazolium tosylate (84 %) and of 1,2-dimethyl-pyrazol-4-in-3-one (VIIa). No triazolio-oxides could be observed.[6] Working up the water phase as described above afforded 12 mg (60 %) of the pyrazolone, identified by IR- and NMR-spectra.

1,2,3,5-Tetramethyl-4-bromo-pyrazolium tosylate (Ic), 1,3-dimethyl-1,2,3-triazolium tosylate, and sodium hydroxide. Similarly, (Ic) (65 mg), 1,3-dimethyl-1,2,3-triazolium tosylate (47 mg), and sodium hydroxide (0.55 ml) were heated and extracted with deuteriochloroform. An NMR-spectrum of the extract showed the presence of 1-methyl-triazole (7 %) and 1,3,5-trimethyl-4-bromo-pyrazole (XVIc) (18 %). An NMR-spectrum of the water phase showed the presence of unchanged 1,3-dimethyl-1,2,3-triazolium tosylate (60 %), (Ic) (60 %), and 1-methyl-1,2,3-triazole (7 %). No triazolio-oxides could be detected.[6]

1,2-Dimethyl-4-bromo-pyrazolium tosylate (Ia), N-bromo acetamide, and sodium hydroxide. (Ia) (113 mg) and *N*-bromoacetamide (230 mg) were dissolved in 1 N sodium hydroxide (2.00 ml) and the solution was kept at room temperature for 14 days. Sodium thiosulfate (2.0 g) and 2 ml of water was then added and the mixture was extracted with methylene chloride (2 × 15 ml). After drying, the methylene chloride was removed giving 77 mg (88 %) of 1,2-dimethyl-4,5-dibromo-pyrazol-4-in-3-one (XX) as colourless crystals, m.p. 159–162°. Recrystallization from ethyl acetate-hexane raised the melting point to 170°. IR- and NMR-spectra were identical with those of the material prepared as described below.

1,2-Dimethyl-pyrazolium tosylate (IIIa), N-bromoacetamide, and sodium hydroxide. (IIIa) (184 mg) and *N*-bromoacetamide (236 mg) were dissolved in 1 N sodium hydroxide (3.10 ml) and the solution was kept at room temperature for 14 days. An NMR-spectrum indicated, that no conversion of the starting material had taken place.

1,2-Dimethyl-4-bromo-pyrazolium tosylate (Ia) and sodium methoxide. (Ia) (301 mg) and 1 N sodium methoxide in methanol (2.70 ml) were heated to 190° for 3 h in a sealed tube. The methanol was then removed and the residue was extracted with boiling chloroform (5 × 10 ml). Removal of the chloroform left an oil which was extracted with boiling ethyl acetate (5 × 5 ml). Evaporation of the solvent gave 55 mg of a yellow oil. TLC, using ethyl acetate-methanol 1:1 as the eluent, indicated that no bromopyrazolone was present. The crude product was chromatographed on a column of silica gel (10 g) using ethyl acetate as the eluent. The first fraction contained 10 mg (11 %) of 1-methyl-5-(1′-methyl-3′-pyrazolyl)-pyrazole (XXV) as a yellow oil. The mass spectrum showed a parent ion at *m/e* 162. (Calc. Mw.: 162). NMR-data are given in Table 3.

The doublets at δ 6.40 and 6.43 are in the region where 4-protons absorb. The doublets were sharp in agreement with the fact that 4-proton signals are negligible broadened by quadropole interaction from nitrogen or coupling to NCH_3-groups.[24] The doublets at δ 7.39 and 7.45 are in the region where 3- and 5-protons absorb. The doublets were broadened due to quadropole interaction from nitrogen and/or coupling to NCH_3. The doublet at δ 7.45 is attributed to a 3-proton since it shows no upfield shift when hexafluorobenzene is used as the solvent. The doublet at δ 7.39 is shifted upfield in this solvent and is therefore a 5-proton signal.[24] These assignments were confirmed by the fact, that $J_{H_4H_5}$ was larger than $J_{H_3H_4}$.[24] The next fraction to leave the column contained 11 mg (12 %) of 5,5′-bi-1-methyl-pyrazole (XXIV) as colourless crystals, m.p. 132–144°.

Two recrystallizations from ether-hexane raised the melting point to 144–146°. (Found: C 59.06; H 6.22. Calc. for $C_8H_{10}N_4$: C 59.24; H 6.21). The mass spectrum showed a parent ion at *m/e* 162. (Calc. Mw.: 162). NMR-data are given in Table 3. As before, the sharp doublet at δ 6.57 is attributed to H_4 and H_4' and the broadened doublet at δ 7.35 is attributed to H_3 and H_3' since it shows no upfield shift when hexafluorobenzene is used as the solvent. The coupling constant is in the region characteristic for $J_{H_3H_4}$.[24] The column was then eluted with ethyl acetate-methanol 1:1. This gave 71 mg (54 %) of 1,2-dimethyl-pyrazol-4-in-3-one (VIIa) which crystallized on drying in a desiccator, m.p. 61–64°. Recrystallization from ethyl acetate-hexane with cooling in dry-ice did not raise the melting point. IR- and NMR-spectra proved the identity with the material prepared above.

1,2,3-Trimethyl-4-bromo-pyrazolium tosylate (Ib) and sodium methoxide. Similarly, (Ib) (824 mg) and 1 N sodium methoxide (7.30 ml) after heating, evaporation, extraction with chloroform and ethyl acetate, gave 99 mg of a brown oil which was chromatographed on a column of silica gel (50 g) using ethyl acetate-methanol 1:1 as the eluent. The first fraction contained 36 mg of a brown greasy mass, which was not identified further. The next fraction contained 26 mg (5 %) of 1,2,5-trimethyl-4-bromo-pyrazol-4-in-3-one (VIIIb) m.p. 68–73°. Recrystallization from ethyl acetate-hexane raised the melting point to 123–124°. Melting point, IR- and NMR-spectra proved the identity with the material prepared by bromination of the pyrazolone (VIIb) (see later). The last fraction contained 27 mg (9 %) of 1,2,5-trimethyl-pyrazol-4-in-3-one (VIIb), identical with the material prepared above. The residue from the chloroform extraction was dissolved in D_2O. An NMR-spectrum indicated the presence of sodium formate, -acetate and -tosylate. No starting material, pyrazolones (VII), or pyrazolio-oxides (X) were present.

1,2,5-Trimethyl-3-bromo-pyrazolium tosylate (IVb) and sodium methoxide. Similarly, (IVb) (100 mg) and 1 N sodium methoxide (0.90 ml) after heating, evaporation, and extraction with chloroform and ethyl acetate, gave 1,2,5-trimethyl-pyrazol-4-in-3-one (VIIb) in quantitative yield as a yellow oil, identical with the material prepared above.

1,2,3,5-Tetramethyl-4-bromo-pyrazolium tosylate (Ic) and sodium methoxide. (Ic) (65 mg) and 1 N sodium methoxide (0.57 ml) were heated to 190° for 3 h. Working up the mixture as described above gave 16 mg (34 %) of a colourless oil. IR- and NMR-spectra proved the identity with 1,3,5-trimethyl-4-bromo-pyrazole (XVIc). The residue from the chloroform extraction was dissolved in D_2O. An NMR-spectrum showed the presence of sodium formate, -acetate, and -tosylate. No starting material, or pyrazolio-oxide (Xc) was present.

1,2-Dimethyl-3,4-dibromo-pyrazolium tosylate (IIa) and sodium methoxide. Similarly, (IIa) (303 mg) and 1 N sodium methoxide (2.30 ml) gave 50 mg crude product, which was chromatographed on a column of silica gel (10 g) using ethyl acetate-methanol 1:1 as an eluent. The first fraction contained 39 mg (26 %) of 1,2-dimethyl-4-bromo-pyrazol-4-in-3-one (VIIIa) as a yellow oil. Reprecipitation from ethyl acetate-hexane with cooling in dry-ice gave colourless crystals, m.p. 100–102°. (Found: C 31.21; H 4.84; N 14.52; Br 41.53. Calc. for $C_5H_7N_2OBr$: C 31.43; H 3.69; N 14.67; Br 41.83). IR- and NMR-spectra proved the identity with the material prepared by bromination of the pyrazolone (VIIa) (see later). The second fraction contained 9 mg (11 %) of 1,2-dimethyl-pyrazol-4-in-3-one (VIIa) as a yellow oil, which crystallized on drying. The identity was proved by IR- and NMR-spectra.

1,2-Dimethyl-pyrazolium tosylate (IIIa), 1,2-dimethyl-3,4-dibromo-pyrazolium tosylate (IIa), and sodium methoxide. Similarly, (IIIa) (34 mg), (IIa) (53 mg), and 1 N sodium methoxide (0.40 ml) gave a brown oil (25 mg). An NMR-spectrum showed the presence of 1,2-dimethyl-pyrazol-4-in-3-one (VIIa) and the bromoderivative (VIIIa). (Yields: 12 and 88 %, respectively, based on starting material (IIa)).

1,2-Dimethyl-pyrazolium tosylate (IIIa), 1,2,3,5-Tetramethyl-4-bromo-pyrazolium tosylate (Ic), and sodium methoxide. Similarly, (IIIa) (60 mg), (Ic) (85 mg), and 1 N sodium methoxide (0.72 ml) gave a brown oil (15 mg) (35 %). IR- and NMR-spectra proved the identity with 1,3,5-trimethyl-4-bromo-pyrazole (XVIc). The residue from the chloroform extraction was dissolved in D_2O. An NMR-spectrum showed that none of the starting material was present. The pyrazolone (VIIa) could be detected, neither in the chloroform, nor in the water phase.

1,2-Dimethyl-4-bromo-pyrazolium tosylate (Ia), 1,3-dimethyl-1,2,3-triazolium tosylate, and sodium methoxide. Similarly, (Ia) (65 mg), 1,3-dimethyl-1,2,3-triazolium tosylate (51 mg), and 1 N sodium methoxide (0.60 ml) gave a brown oil (27 mg). An NMR-spectrum showed the presence of 1-methyl-1,2,3-triazole and 1,2-dimethyl-pyrazol-4-in-3-one (VIIa). (Yields: 79 and 69 %, respectively, based on the starting materials). No triazolio-oxides were observed.[6]

1,2,3,5-Tetramethyl-4-bromo-pyrazolium tosylate (Ic), 1,3-dimethyl-1,2,3-triazolium tosylate, and sodium methoxide. Similarly, (Ic) (66 mg), 1,3-dimethyl-1,2,3-triazolium tosylate (47 mg), and 1 N sodium methoxide (0.55 ml) gave a brown oil (20 mg). An NMR-spectrum showed the presence of 1-methyl-1,2,3-triazole and 1,3,5-trimethyl-4-bromo-pyrazole (XVIc). (Yields: 35 and 39 %, respectively, based on the starting materials). No triazolio-oxides could be detected.

1,2-Dimethyl-4-bromo-pyrazolium tosylate (Ia), tetraphenylcyclopentadienone, and sodium methoxide. Similarly, (Ia) (61 mg), tetraphenylcyclopentadienone (69 mg), and 1 N sodium methoxide (0.56 ml) gave a violet oil (86 mg), which was purified by preparative TLC (20 × 20 cm plate, 1 mm layer of silica gel) using ether-hexane 1:9 as eluent. Two minor zones with high R_F-values were not identified further. The third zone contained 2.5 mg (4 %) of unchanged tetraphenylcyclopentadienone, identified by the IR-spectrum. Then followed two minor zones which were not identified further. The 6th zone contained 52 mg (75 %) of *cis*-2,3,4,5-tetraphenyl-cyclopent-2-ene-1-one as colourless crystals; m.p. 155° after one recrystallization from ethyl acetate-hexane with cooling in dry-ice. (Reported m.p. 162° [16]). The NMR-spectrum showed 20 aromatic protons and 4 protons in an AB-pattern at δ 4.66 and 3.79; J_{AB} was 2.6 Hz, indicating *cis*-configuration. The mass spectrum gave a parent ion at *m/e* 386. (Calc. Mw: 386). The IR-spectrum was identical with that of the material described previously.[16] A microanalysis was in agreement with the proposed structure. The last zone contained 23 mg (71 %) of 1,2-dimethyl-pyrazol-4-in-3-one, identified by IR- and NMR-spectra. None of the unindentified zones showed *N*-methyl group signals in NMR. Similarly, the residue from the chloroform extraction when dissolved in D_2O showed no *N*-methyl group signals in NMR. Therefore, presence of the tetraphenylindazole-derivatives (XXI) and (XXII) may be excluded.

1,2-Dimethyl-4-bromo-pyrazolium tosylate (Ia), 1,3-dimethyl-1,2,3-triazolio-4-oxide, and sodium methoxide. Similarly, (Ia) (188 mg), 1,3-dimethyl-1,2,3-triazolio-4-oxide (61 mg),[6] and sodium methoxide (1.73 ml) gave a brown oil (97 mg). An NMR-spectrum showed the presence of 1,2-dimethyl-pyrazol-4-in-3-one (VIIa) and unchanged triazolio-oxide. (Yield: 38 and 100 %, respectively, based on the starting materials). 1,3-Dipolar adducts could not be detected.

Table 4.

Nucleophilic reagent	Chloroform phase		Water phase	
	1-Methyl-4-bromo-pyrazole (XVIa) %	1-Methyl-pyrazole (XVa) %	Starting material (Ia) %	Pyrazolone (VIIa)[a] %
Sodium azide	56	0	28	0
» benzoate	23	0	41	0
» thiobenzoate	73	0	0	4
» phenolate	36	0	0	10
» *p*-thiocresylate	43	0	0	25
» sulfide	0	60	0	0
» hydrogencarbonate	49	0	25	0
Methylamine	0	0	85	0

[a] No other substitution products could be detected.

1,2-Dimethyl-4-bromo-pyrazolium tosylate (Ia) and other nucleophilic reagents. A 10 % solution of (Ia) in the appropriate solvent and 3.2 equivalents of the nucleophilic reagent were heated to 190° for 3 h in a sealed tube. When water was used as a solvent the solution was extracted with deuteriochloroform containing methylene chloride as integration standard. NMR-spectra of the chloroform- and the water phase were run. Results are given in Table 4.

When methanol was used as the solvent, the methanol was removed and the residue was extracted with boiling chloroform. The chloroform was removed and NMR-spectra were run. The residue from the chloroform extraction was dissolved in D_2O and NMR-spectra were run. With sodium hydrogensulfide, -methylmercaptide, or piperidine no substitution products could be detected, neither in the chloroform, nor in the water phase. In some cases dimethylformamide, acetonitrile, or dimethylsulfoxide were tried as the solvent. However, no substitution products could be detected.

Bromination of 1,2-dimethyl-pyrazol-4-in-3-one (VIIa). (VIIa) (14 mg) was dissolved in 1 N sodium hydroxide (0.12 ml) and bromine (6.5 µl) was added. The mixture was kept one hour at room temperature. The solvent was then removed *in vacuo* and the residue was extracted with ethyl acetate (4×5 ml). Removal of the ethyl acetate gave 15 mg (63 %) of chromatographically pure 1,2-dimethyl-4-bromo-pyrazol-4-in-3-one (VIIIa) identical with the material prepared above.

Bromination of 1,2,5-trimethyl-pyrazol-4-in-3-one (VIIb). Similarly, (VIIb) (25 mg), 1 N sodium hydroxide (0.20 ml), and bromine (10.2 µl) gave 26 mg (63 %) of 1,2,5-trimethyl-4-bromo-pyrazol-4-in-3-one (VIIIb) as colourless crystals, m.p. 67—73°. Recrystallization from ethyl acetate-hexane raised the melting point to 123—124°. (Found: C 35.26; H 4.54; N 13.59; Br 38.83. Calc. for $C_6H_9N_2OBr$: C 35.13; H 4.43; N 13.66; Br 38.96).

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