DERIVATIVES OF 4-AZA-9-FLUORENONE

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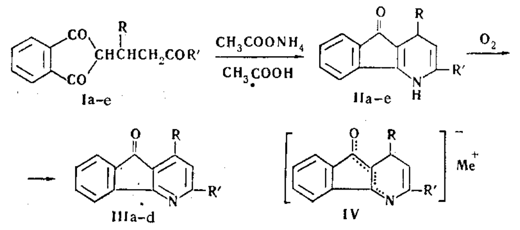
Derivatives of 1,3-indandione containing in position 2 a carbon chain with a δ-carbonyl group cyclize on heating with ammonium acetate in glacial acetic acid to form derivatives of 1,4-dihydro-4-aza-9-fluorenone. The latter are readily oxidized to the corresponding 4-aza-9-fluorenones. The IR and UV spectra of the compounds obtained are discussed.

In one of the variants of the Hantzsch synthesis of dihydropyridines [1,2], 1,5-diketones and ammonia or amino compounds are used as the starting materials [3–6]. 1,3-Indandiones containing in position 2 a carbon chain with a δ-carbonyl group are simultaneoulsy 1,3- and 1,5-diketones. As such, on being heated with ammonium acetate in glacial acetic acid they cyclize to form derivatives of 1,4-dihydro-4-aza-9-fluorenone or 2,3(CO)-benzoylene-1,4-dihydropyridine (II). The cyclization of 2-(α-phenacylbenzyl)-1,3-indandione (Ia) into the corresponding compound IIa has been effected by us previously [7]. In the present work we used some triketones (Ib–d) that we obtained by the Michael reaction [8] and the triketone Ie [9].

When 2-(α-phenacyl-p-methoxybenzyl)-1,3-indandione (Ib), 2-(α-phenacylfurfuryl)-1,3-indandione (Ic), 2,2-dimethyl-5-(1',3'-indandion-2'-yl)-5-phenyl-3-pentanone (Id) and 4-(1',3'-indandion-2'-yl)-4-phenyl-2-butanone (Ie) were heated with ammonium acetate in glacial acetic acid they yielded, respectively, 1-(p-methoxyphenyl)-3-phenyl- (IIb), 1-(α-furyl)-3-phenyl- (IIc), 3-tert-butyl-1-phenyl- (IId), and 3-methyl-1-phenyl- (IIe) -1,4-dihydro-4-aza-9-fluorenones. The basic properties of the amino group of the 1,4-dihydro-4-aza-9-fluorenone derivatives are strongly suppressed because of conjugation with the carbonyl group. On the contrary, they possess weakly acidic properties and dissolve in ethanolic alkali with a deepening of the coloration. This is due to the splitting off of a proton and the formation of the conjugated anion IV with an equalized electron density. The 1,4-dihydroazafluorenones IIb, c are very readily oxidized, particularly in alkaline solutions, to the corresponding 4-aza-9-fluorenones (IIIb, c). Oxidation takes place so readily that under the cyclization conditions the 4-aza-9-fluorenones are formed in addition to the dihydro derivatives. The solubility of the latter in ethanolic alkalies enables them to be separated from the former, which are incapable of dissolving in alkalies. Compounds IId and IIe form exceptions, proving to be more stable to oxidation. The dihydro derivative IId can be oxidized to IIId only with concentrated nitric acid.



a	$R = R' = C_6H_5$	
b	$R = C_6H_4OCH_3\text{-}p$	$R' = C_6H_5$
c	$R = \alpha$-furyl	$R' = C_6H_5$
d	$R = C_6H_5$	$R' = C(CH_3)_3$
e	$R = C_6H_5$	$R' = CH_3$

The basic properties that are characteristic for the pyridine ring are considerably weakened in the 4-aza-9-fluorenones IIIb–d.

The identification of the individual bands in the IR spectra of the 1,4-dihydro-4-aza-9-fluorenones presents considerable difficulties in view of the presence in their molecules of a β-aminovinyl ketone system. The presence of aromatic structures and of intermolecular hydrogen bonds complicates the spectra still further.

β-Aminovinyl carbonyl compounds are structural vinylogs of amides [10]. Recently, the bands of amides have been considered as composite, and calculations of the participation of each bond in the given vibration have been carried out [11,12]. It is assumed that in the spectra of the β-aminovinyl ketones vibrations are exhibited not of the individual C=O and C=C groups but composite bands in which the whole conjugated system makes its contribution to a greater or smaller degree [13–15]. The attempt to ascribe individual bands to vibrations of definite groups has led various authors to different conclusions. Some hold the view that the carbonyl absorption has the highest-frequency bands, although they are strongly lowered and are not always the most intense bands in the spectrum. Thus, for example, in 3-benzoylindoles the absorption at 1595 cm^{-1} is ascribed to the carbonyl group and the absorption at 1515 cm^{-1} to the C=C bond [16]. In β-morpholinobenzylideneacetophenone, the carbonyl absorption is found at 1628 cm^{-1} [10], and in 5,5-dimethyl-3-pyrrolidylcyclohex-2-en-1-one it is located at 1610 cm^{-1} [17]. Other authors consider that the carbonyl absorption can be found between 1500 and 1600 cm^{-1} [18]. Bellamy, in a study of the IR spectra of the N-methyl-4-pyridinones established that the carbonyl absorption appears in the 1580–1600 cm^{-1} region and the absorption of the C=C bond at 1650 cm^{-1} [19].

Table 1

IR Spectra* of the 1,4-Dihydro-4-aza-9-fluorenones II-d

Compound	Medium	Vibrations in the 1500-1700 cm^{-1} region	ν_{NH}, cm^{-1}
IIa^7	Nujol	$\frac{1508}{65}$, $\frac{1572}{52}$, $\frac{1598}{22}$, $\frac{1642}{50}$, $\frac{1672}{31}$	3290
	Dichloroethane	$\frac{1494}{45}$, $\frac{1580}{57}$, $\frac{1600}{30}$, $\frac{1616}{22}$, $\frac{1651}{48}$, $\frac{1684}{46}$	3395
IIb	Nujol	$\frac{1500}{82}$, $\frac{1571}{72}$, $\frac{1602}{41}$, $\frac{1639}{70}$. $\frac{1672}{48}$	3263
	Dichloroethane	$\frac{1508}{51}$, $\frac{1580}{66}$, $\frac{1604}{50}$, $\frac{1649}{49}$, $\frac{1682}{46}$	3395
IIc	Nujol	$\frac{1522}{83}$, $\frac{1572}{75}$, $\frac{1600}{40}$, $\frac{1618}{40}$, $\frac{1640}{73}$, $\frac{1672}{53}$	3210
	Dichloroethane	$\frac{1500}{48}$, $\frac{1584}{63}$, $\frac{1595}{33}$, $\frac{1611}{26}$, $\frac{1648}{54}$, $\frac{1680}{50}$	3390
IId	Nujol	$\frac{1516}{88}$, $\frac{1568}{67}$, $\frac{1605}{45}$, $\frac{1642}{74}$, $\frac{1662}{42}$,	3250
	Dichloroethane	$\frac{1502}{46}$, $\frac{1578}{64}$, $\frac{1601}{28}$, $\frac{1616}{23}$, $\frac{1658}{72}$, $\frac{1682}{43}$	not recorded

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*The IR spectra were taken on an IKS-14 instrument. The denominator of the fraction gives the relative intensity of the band.

Table 2

IR Spectra* of the 4-Aza-9-fluorenones IIIa-d

Compound	ν_{CO}, cm^{-1}	$\nu_{C=C,\ C=N}$, cm^{-1}
IIIa^7	$\frac{1709}{77}$	$\frac{1590}{49}$, $\frac{1572}{51}$, $\frac{1551}{71}$
IIIb	$\frac{1710}{79}$	$\frac{1606}{60}$, $\frac{1586\text{ sh.}}{54}$, $\frac{1575}{62}$, $\frac{1546}{72}$, $\frac{1509}{60}$
IIIc	$\frac{1705}{76}$	$\frac{1591}{68}$, $\frac{1552}{73}$
IIId	$\frac{1709}{72}$	$\frac{1604}{45}$, $\frac{1582}{68}$, $\frac{1555}{74}$

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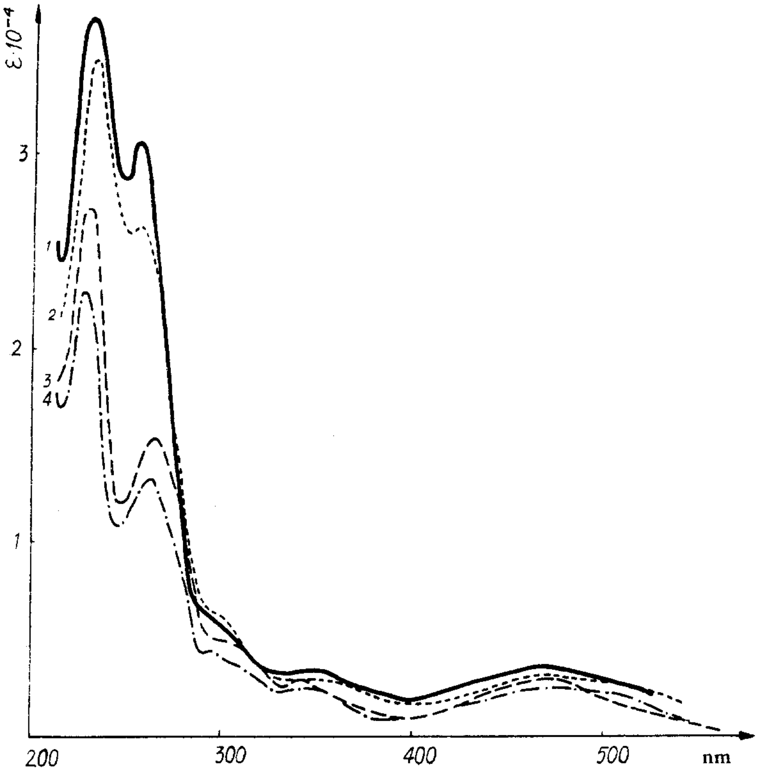
*The spectra were taken for IIIa-c on an IKS-14 instrument in dichlorothethane and for IIId on a UR-10 instrument in Nujol. The denominator of the fraction gives the relative intensity of the band.

Table 3

UV Spectra of Some Compounds (in Ethanol)

Compound	λ_{max}, nm ($\varepsilon \cdot 10^{-4}$)
IIa[7]	232(4.19), 235(4.15), 259(3.10), 300(0.52), 348(0.32), 475(0.38)
IIb	236(3.51), 258(2.64), 300(0.62), 350(0.30), 467(0.33)
IIc	233(3.76), 258(3.07), 300(0.60), 350(0.34), 465(0.37)
IId	228(2.30), 264(1.34), 295(0.44), 345(0.25), 470(0.26)
IIe	229(2.71), 265(1.56), 300(0.55), 341(0.33), 478(0.31)
V[25]	238(2.00), 260(2.64), 302(0.62), 343(0.64), 467(0.34)
VI[25]	232(2.23), 254(2.49), 300(0.76), 346(0.46)



UV spectra of 1,4-dihydro-4-aza-9-fluorenones in ethanol: 1) **IIc**, 2) **IIb**, 3) **IIe**, 4) **IId**.

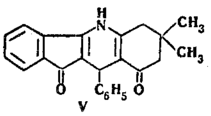
In the 1,4-dihydroazafluorenones that we have synthesized (Table 1), there are five bands in the 1500–1700 cm^{-1} region—at about 1672, 1639–1642, 1598–1605, 1568–1572 and 1500–1522 cm^{-1} in Nujol and 1680–1684, 1648–1658, 1595–1605, 1578–1584 and 1494–1508 cm^{-1} in dichloroethane. The vibrations in the 1600–1618 cm^{-1} region are ascribed by some authors to the deformation vibrations of the N—H bond [13–15]. Since we have no N-substituted or deuterated 1,4-dihydroazafluorenones available, we cannot determine unambiguously what bands are due to the deformation vibrations of the N—H bond and what to the vibrations of the aromatic structure. So far as concerns the other absorption bands, they are composite and cannot be assigned to a definite bond. For example, the assignment of the band at 1672 cm^{-1} to the vibrations of the carbonyl group and the band in the 1640–1650 cm^{-1} range to the vibrations of the double carbon-carbon bond will be purely formal, since the former is less intense than the latter.

A comparison of the IR spectra of the 1,4-dihydroazafluorenones IIa-d with those for related compounds likewise does not permit general conclusions to be drawn. For example, while 2,3-benzoylene-5-oxo-4-phenyl-1,4,5,6,7,8-hexahydroquinoline has absorption bands at 1683, 1642, and 1605 cm^{-1}, 2-cyano-3-methyl-1,4-dihydro-4-aza-9-fluorenone has only two bands, at 1645 and 1584 cm^{-1} [15].

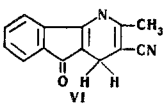
In the 3-micron region for the 1,4-dihydroazafluorenones IIa-d in Nujol there is a broad band in the 3210–3290 cm^{-1} range ascribed to the stretching vibrations of an intermolecularly bound N—H group. In solution, the intermolecular hydrogen bonds disappear and in place of the above-mentioned broad band a band of the free vibrations of the N—H bond appears in the 3390–3395 cm^{-1} region, which agrees with the literature [13, 20].

In fluorenone and its derivatives, the carbonyl absorption is found between 1711 and 1720 cm^{-1} [21, 22]. 4-Aryl-2, 3(CO),6, 5(CO)-dibenzoylenepyridines [23] and 11-oxo-11H-indeno[1, 2-b]quinoline [24] have the characteristic band of the carbonyl group of a five-membered ring at about 1720 cm^{-1}. The carbonyl groups of the 4-aza-9-fluorenones that we have obtained (Table 2) are characterized by an intense absorption band in the range from 1705 to 1710 cm^{-1}.

The 1,4-dihydro-4-aza-9-fluorenones that we obtained have UV spectra very similar to the spectra of related compounds described in the literature [25] such as, for example, 2, 3(CO)-benzoylene-5-oxo-7, 7-dimethyl-4-phenylhexahydroquinoline (V) and 2-cyano-3-methyl-1,4-dihydro-4-azafluorenone (VI).



V



VI

The spectrum (Table 3) is complex, and has a large number of absorption bands. It can be stated strictly only that the maxima at 465–475 nm correspond to electronic transitions in the conjugated system $-\overset{|}{N}-\overset{|}{C}=\overset{|}{C}-\overset{|}{C}=O$.

EXPERIMENTAL

1-(p-Methoxyphenyl)-3-phenyl-1,4-dihydro-4-aza-9-fluorenone (IIb) and 1-(p-methoxyphenyl)-3-phenyl-4-aza-9-fluorenone (IIIb). A mixture of 2 g (0.0052 mole) of **Ib**, 1.5 g (0.02 mole) of ammonium acetate, and 10 ml of glacial acetic acid was heated in the water bath for 50 min. On cooling, 1.2 g of a mixture of red and yellow crystals deposited. The mixture was treated with ethanolic alkali and 0.55 g (29%) of yellow **IIIb** was filtered off; acidification of the filtrate with concentrated hydrochloric acid precipitated 0.45 g (24%) of **IIb**. By recrystallization from ethanol, the **IIb** was obtained in the form of red crystals with mp 193° C. The substance dissolved in ethanolic alkali with a violet red coloration which disappeared on standing in the air because of the formation of **IIIb**. Found, %: C 82.45; H 5.42; N 3.89. Calculated for $C_{25}H_{19}NO_2$: %, C 82.17; H 5.24; N 3.83.

The precipitate of **IIIb** was recrystallized from acetic acid, giving yellow crystals with mp 206° C. Found, %: C 83.00; H 4.50; N4.12. Calculated for $C_{25}H_{17}NO_2$, %: C 82.62; H 4.72; N 3.86.

1-(α-Furyl)-3-phenyl-1,4-dihydro-4-aza-9-fluorenone (IIc) and 1-(α-furyl)-3-phenyl-4-aza-9-fluorenone (IIIc). A mixture of 2 g (0.0058 mole) of **Ic**, 1.5 g (0.02 mole) of ammonium acetate, and 10 ml of acetic acid was heated in the water bath for 1 hr. On cooling, 1.2 g of a mixture of red and yellow crystals was obtained. The mixture was treated with ethanolic alkali and 0.47 g (25%) of **IIIb** was filtered off. When the solution was neutralized with dilute acetic acid, 0.47 g (25%) of **II** was obtained in the form of red crystals with mp 175–176° C (from ethanol). Found, %: C 81.17; H 4.60; N 4.28. Calculated for $C_{22}H_{15}NO_2$, %: C 81.21; H 4.65; N 4.31.

The precipitate of **IIIc** was recrystallized from acetic acid, giving yellow crystals with mp 184–185° C. Found, %: C 81.52; N 4.06; N 4.52. Calculated for $C_{22}H_{13}NO_2$, %: C 81.72; H 4.05; N 4.33.

3-tert-Butyl-1-phenyl-1,4-dihydro-4-aza-9-fluorenone (IId). A mixture of 2 g (0.006 mole) of **Id**, 1.5 g (0.02 mole) of ammonium acetate, and 10 ml of glacial acetic acid was heated in the water bath for 1 hr. On cooling, 1.1 g (58%) of **IId** deposited in the form of dark red crystals with mp 203° C (from ethanol or acetic acid). Found, %: C 83.60; H 6.70; N 4.62. Calculated for $C_{22}H_{21}NO$, %: C 83.75; H 6.71; N 4.44.

3-tert-Butyl-1-phenyl-4-aza-9-fluorenone (IIId). Compound IId (0.95 g; 0.003 mole) was treated with a mixture of 1 ml of glacial acetic acid and 2 ml of concentrated nitric acid. The yellow solution was poured into water and the precipitate was recrystallized from ethanol to give 0.9 g (95%) of **IIId** in the form of yellow crystals with mp 110–111° C. Found, %: C 84.43; H 6.18; N 4.78. Calculated for $C_{22}H_{19}NO$, %: C 84.29; H 6.10; N 4.47.

3-Methyl-1-phenyl-1,4-dihydro-4-aza-9-fluorenone (IIe). A mixture of 2.93 g (0.001 mole) of **Ie**, 2.7 g (0.035 mole) of ammonium acetate, and 10 ml of glacial acetic acid was heated in the water bath for 40 min. On cooling, 1.88 g (69%) of **IIe** deposited in the form of dark red crystals, mp 233° C (from ethanol). Found, %: C 83.45; H 5.63; N 5.26. Calculated for $C_{19}H_{15}NO$, %: C 83.49; H 5.53; N 5.13.

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