# Synthesis and spectral properties of 3-dimethylamino-6-X-7-Y--8-Z-2*H*-1-benzopyran-2-ones

[a]P. HRNČIAR, [b]A. GÁPLOVSKÝ, and [b]J. DONOVALOVÁ

[a]*Department of Organic Chemistry, Faculty of Natural Sciences, Comenius University, CS-842 15 Bratislava*

[b]*Institute of Chemistry, Faculty of Natural Sciences, Comenius University, CS-842 15 Bratislava*

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The reaction of salicylaldehyde, betaine, and acetic anhydride gives 3-dimethylamino-2*H*-1-benzopyran-2-one, in contrast with the published 2-dimethylamino-1,3-indandione. Substituted salicylaldehydes give in the same conditions 3-dimethylamino-6-X-7-Y-8-Z-2*H*-1-benzopyran-2-ones. The structure of the prepared compounds was determined by IR, $^1$H NMR, $^{13}$C NMR, MS, and UV spectroscopy.

Реакция салицилового альдегида, бетаина и уксусного ангидрида приводит к образованию 3-диметиламино-2*H*-1-бензопиран-2-она, в отличие от опубликованного 2-диметиламино-1,3-индандиона. Из замещенных салициловых альдегидов в тех же условиях образуются 3-диметиламино-6-X-7-Y-8-Z-2*H*-1-бензопиран-2-оны. Строение полученных соединений было установлено с помощью ИК, $^1$H ЯМР, $^{13}$C ЯМР, масс- и УФ-спектроскопии.

In 1981 *Masaaki* [1] patented 2-dimethylamino-1,3-indandione (*I*) as an efficient UV absorber and considered the synthesis of *I* to be a new type reaction of salicylaldehyde, betaine, and acetic anhydride. Requiring *I* for a photochemical study [2—4], we attempted to repeat its preparation. The isolated compound was identical by melting point, elemental analysis, IR, $^1$H NMR, and mass spectra with the reported one. All mentioned spectra did not refute the proposed structure of *I* and were comparable with the spectra of analogous derivatives — 2-dimethylamino-2-methyl-1,3-indandione (*II*) and 2-dimethylamino-2--phenyl-1,3-indandione (*III*).

It is worth mentioning that Masaaki established the structure of *I* on the basis of IR spectra (doublet ν(C=O) at $\tilde{\nu} = 1705$ and 1710 cm$^{-1}$ (KBr) which he attributed to vibrationally coupled 1,3-dicarbonyl system). From $^1$H NMR spectra he pointed out the presence of 1,2-disubstituted benzene ring, dimethylamino group and >CH hydrogen ($\delta = 6.3$ ppm), and from the mass spectra he mentioned the molecular ion $M^{+\bullet} = 189$.

However, we found significant discrepancies in electronic absorption (hexane) of the prepared compound ($\lambda_{max} = 340$ nm), *II* and *III* ($\lambda_{max} = 220$ and

230 nm, respectively) and in emission spectra (hexane) of the prepared compound ($\lambda_{max}$ = 460 nm), *II* and *III* (no emission). Also electronic spectra of other 1,3-indandione derivatives, bearing only one substituent in position 2, differed very much from the spectra of the prepared compound.

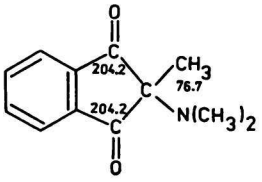
At the photolysis derivatives of 1,3-indandione [5, 6] (including those with dimethylamino group in position 2 [3]) give the corresponding phthalides. Phthalides originate from the Norrish $\alpha$-splitting of *I* which is characteristic of ketones with the lowest $n$—$\pi^*$ transition. At the same conditions by photolysis of the prepared compound its demethylated product was formed ($\alpha$-splitting was not observed) [7].

Discrepancies in electronic spectra, in photochemical and chemical (impossibility to substitute hydrogen by an alkyl group) properties, as well as the fact that the reaction conditions used by Masaaki resemble very much those of the Perkin synthesis of coumarin and its derivatives, prompted us to compare all available spectral data of the prepared compound not only with those of 1,3-indandione derivatives but also with the spectral data of coumarin and its derivatives. As 3-dimethylamino-2*H*-1-benzopyran-2-one (*VI*) isomeric to 2-dimethylamino-1,3-indandione (*I*) has not been prepared yet, we compared the spectral data of the prepared compound with the spectral data of coumarin (2*H*-1-benzopyran-2-one) (*IV*).

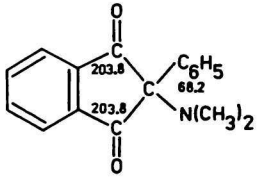
By comparison of the IR spectra (measured in chloroform) of the prepared compound ($\tilde{\nu}$ = 1714 and 1756 $cm^{-1}$ ν(C═O)), *II* ($\tilde{\nu}$ = 1710 and 1746 $cm^{-1}$ ν(C═O)), and *IV* ($\tilde{\nu}$ = 1731 and 1757 $cm^{-1}$ ν(C═O) [8]) it was impossible to say at first sight whether the prepared compound has coumarin or indandione skeleton. Nevertheless, more detailed study showed that the prepared compound behaves differently in the region of $\tilde{\nu}$ = 1700—1800 $cm^{-1}$ from compounds *II*, *III* and other derivatives of 1,3-indandione, as its change of wavenumber of ν(C═O) depends very much on the used solvent [9]. Derivatives of 1,3-indandione exhibit in the same conditions almost constant $\Delta\tilde{\nu}$(ν(C═O)). Furthermore, the position of the wavenumber of the ν(C═O) of the prepared compound deviates significantly from the linearity (more than 10 $cm^{-1}$) obtained for derivatives of 1,3-indandione [10]. Nonetheless, these findings we did not consider sufficient enough to have doubt about the structure of the compound *I* proposed by Masaaki.

Very similar splitting in the mass spectra of *II*, *IV* and the prepared compound did not help to solve the problem, neither did $^1$H NMR spectra (for comparison we needed compound *VI*, not known as yet). Fortunately, we found useful discrepancies in $^{13}$C NMR spectra. While all indandione derivatives exhibit only two signals for three nonaromatic carbons (*i.e.* both carbonyl carbons have the same chemical shift: $\delta$ = 204.2 and 76.7 ppm (*II*); $\delta$ = 203.8 and 68.2 ppm (*III*)), coumarin derivatives exhibit for three nonaromatic car-

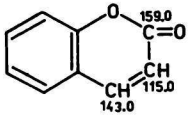
bons three signals ($\delta = 159.0$, 115.0, 143.0 ppm (*IV*), see also Table 2 and Scheme 1). Equal chemical shifts for both carbonyl carbons are due to the plane of symmetry through C-2 atom of the indandione skeleton and substituents on this carbon (Scheme 1). In $^{13}C$ NMR spectra of the prepared compound three signals were present for three nonaromatic carbons ($\delta = 157.9$, 137.2, 120.3 ppm). Reversed values of the chemical shifts for C-3 and C-4 (in comparison with *IV*) are due to the electron-donating effect of the dimethylamino group. This claim can be supported by $^{13}C$ NMR spectrum of 3-methyl-2*H*-1--benzopyran-2-one (*V*), where the values of the chemical shifts are proportional to electron-donating properties of the substituent (Scheme 1) [11, 12].



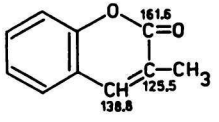

*II*



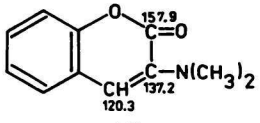

*III*




*IV*




*V*

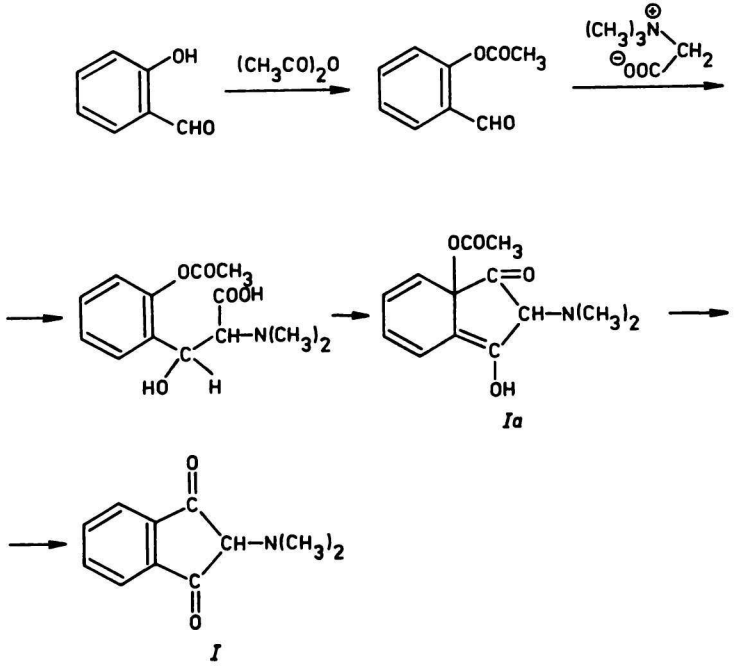



*VI*

*Scheme 1*

Fairly good agreement in $^{13}C$ NMR, UV, and other spectra of the compound in question and coumarin derivatives enables us to conclude that by the reaction of salicylaldehyde, betaine, and acetic anhydride 3-dimethylamino-2*H*-1--benzopyran-2-one (*VI*) is formed instead of 2-dimethylamino-1,3-indandione (*I*) as *Masaaki* claimed incorrectly [1]. The structure *VI* was lately unambiguously confirmed by an X-ray diffraction study [13].

As a final part of this study we should like to make some comments on the reaction scheme (Scheme 2) presented in *Masaaki's* patent [1]. Electrophilic attack of the aromatic carbon (bearing acetoxy group) by the carbonyl carbon is not very feasible (formation of intermediate *Ia*). The reaction should then take place also with other substituted benzaldehydes (mainly with electron-donating group in position 2). Not a small amount of the assumed product was isolated when we run the reaction with 2-methoxybenzaldehyde or 2-chlorobenzaldehyde.




*Scheme 2*

As it was noted earlier, the reaction conditions used by Masaaki very much resemble those of the classical Perkin reaction. By that reaction coumarin was firstly prepared from salicylaldehyde, acetic anhydride, and sodium acetate [14]. The only difference in Masaaki's procedure was that he did not use basic catalyst. Nevertheless, such a catalyst can be formed in the reaction medium due to the following equilibria

$$(CH_3CO)_2O + (CH_3)_3\overset{\oplus}{N}CH_2COO^{\ominus} \rightleftarrows$$

$$\rightleftarrows \quad CH_3CO{-}O{-}CO{-}CH_2{-}\overset{\oplus}{N}(CH_3)_3 + CH_3COO^{\ominus}$$

$$(CH_3)_3\overset{\oplus}{N}—CH_2—COOCOCH_3 + CH_3COO^{\ominus} \rightleftarrows$$

$$\rightleftarrows (CH_3)_3\overset{\oplus}{N}—\underline{\overset{\ominus}{C}}H—COOCOCH_3 + CH_3COOH$$

First equilibrium leads to the formation of a mixed anhydride. In the next step acetate anion removes the proton from $CH_2$ and the corresponding ylide is formed. The ylide reacts with the carbonyl carbon of the formyl group of salicylaldehyde. Nonetheless, no experimental evidence is available for these equilibria. These conclusions have been backed up by the fact that the reaction proceeds only in one way — only $\alpha$-carbon of betaine reacts (*i. e.* acetate anion removes more acidic hydrogen and more stable C-anion is formed). Formation of the C-anion from acetic anhydride would lead to the synthesis of coumarin (*IV*), which, however was not detected in the reaction mixture. Cleavage of the methyl group from the nitrogen follows most probably the C-anion formation or the reaction of this anion with the formyl group of salicylaldehyde. If demethylation takes place earlier, C-anion would not be formed so easily. In such a case another equilibrium (leading to coumarin) should take place, as formation of C-anion from $(CH_3)_2N—CH_2—COO—$ is energetically more demanding than formation of C-anion from $CH_3COO—$.

$$(CH_3)_2NCH_2COOCOCH_3 + CH_3COO^{\ominus} \rightleftarrows$$

$$\rightleftarrows (CH_3)_2N—\underline{\overset{\ominus}{C}}H—COOCOCH_3 + CH_3COOH$$

$$(CH_3CO)_2O + CH_3COO^{\ominus} \rightleftarrows \underline{\overset{\ominus}{C}}H_2—COOCOCH_3 + CH_3COOH$$

For completeness sake some experiments have been made for preparation of substituted coumarins (3-dimethylamino-6-X-7-Y-8-Z-2*H*-1-benzopyran-2--ones) from substituted salicylaldehydes, betaine, and acetic anhydride. The results indicate that salicylaldehydes with electron-donating substituents decrease, while those with electron-withdrawing substituents increase the reaction rate, as it was supposed earlier. The course of the reactions was monitored by TLC.

## Experimental

UV spectra were measured on a Perkin—Elmer PE 450 spectrophotometer, IR spectra on a Perkin—Elmer PE 180 spectrophotometer, $^1$H NMR spectra on a Tesla BS 487 instrument at 80 MHz, $^{13}$C NMR spectra on a Jeol FX-100 instrument at 25.05 MHz, mass spectra on MS-902 S instrument and emission spectra on a RELS-5-fluorometer ($\lambda_{exc}$ = 366 nm).

*Table 1*

Characteristic data for 3-dimethylamino-6-X-7-Y-8-Z-2*H*-1-benzopyran-2-ones

| Compound | X | Y | Z | Formula $M_r$ | $w_i$(calc.)/% $w_i$(found)/% | | | | Yield | M. p./°C Solvent |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | C | H | N | Halogen | % | |
| *VI* | H | H | H | $C_{11}H_{11}NO_2$ | 69.84 | 5.82 | 7.41 | | 90 | 84—85 |
| | | | | 189 | 70.10 | 5.70 | 7.62 | | | Hexane |
| *VII* | H | H | $CH_3O$ | $C_{12}H_{13}NO_3$ | 65.75 | 5.94 | 6.39 | | 70 | 92—93 |
| | | | | 219 | 65.68 | 5.67 | 6.20 | | | Hexane |
| *VIII* | H | $CH_3O$ | H | $C_{12}H_{13}NO_3$ | 65.75 | 5.94 | 6.39 | | 69 | 101—102.5 |
| | | | | 219 | 65.82 | 5.83 | 6.45 | | | Hexane |
| *IX* | H | Br | H | $C_{11}H_{10}BrNO_2$ | 49.25 | 3.73 | 5.22 | 29.85 (Br) | 84 | 153—154 |
| | | | | 268 | 49.61 | 4.05 | 5.10 | 29.76 | | Ethanol |
| *X* | Cl | H | Cl | $C_{11}H_9Cl_2NO_2$ | 51.16 | 3.49 | 5.43 | 27.52 (Cl) | 82 | 190—192 |
| | | | | 258 | 51.28 | 3.22 | 5.63 | 27.15 | | Ethanol |
| *XI* | $NO_2$ | H | H | $C_{11}H_{10}N_2O_4$ | 56.41 | 4.27 | 11.96 | | 61 | 245—247 |
| | | | | 234 | 56.62 | 4.35 | 11.73 | | | Hexane |

*Table 2*

IR and $^{13}C$ NMR characteristics for 3-dimethylamino-6-X-7-Y-8-Z-2*H*-1-benzopyran-2-ones

| Compound | $\tilde{\nu}$/cm$^{-1}$ (chloroform) | | | | $\delta$/ppm ($C^2HCl_3$) | | |
|---|---|---|---|---|---|---|---|
| | ν(CO) | ν(C=C) | ν(C—O—C) | ν($NO_2$) | C-2 | C-3 | C-4 |
| *VI* | 1741 | 1610 | 1075 | | 157.9 | 137.2 | 120.3 |
| | 1756 | | 1115 | | | | |
| *VII* | 1730 | 1612 | 1075 | | 159.7 | 136.1 | 119.1 |
| | 1755 | | 1115 | | | | |
| *VIII* | 1735 | 1625 | 1075 | | 157.6 | 137.6 | 116.2 |
| | 1750 | | 1165 | | | | |
| *IX* | 1730 | 1610 | 1080 | | 157.9 | 138.4 | 122.4 |
| | 1750 | | 1123 | | | | |
| *X* | 1720 | 1610 | 1070 | | 156.9 | 138.7 | 113.3 |
| | 1750 | | 1165 | | | | |
| *XI* | 1720 | 1605 | 1065 | 1335 | 156.6 | 143.2 | 116.5 |
| | 1755 | | 1115 | 1520 | | | |

## *Preparation of 3-dimethylamino-6-X-7-Y-8-Z-2H-1-benzopyran-2-ones VI—XI*

X,Y,Z-Salicylaldehyde (0.01 mol), betaine (0.02 mol), and acetic anhydride (0.03 mol) were heated under reflux condenser for 7 h at 180—200 °C. The mixture was

then cooled to the room temperature and 70 $cm^3$ of 50 % ethanol were added. After the mixture was set aside for 12 h, the precipitate was filtered off and crystallized from ethanol or hexane. The yields and other characteristics of the prepared compounds *VI*—*XI* are given in Table 1. IR and $^{13}C$ NMR characteristics are given in Table 2.

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