

**NMR AND MS SPECTRA OF ISOMERIC
 α - AND β -ARYL(INDOL-3-YL)BENZOINS**

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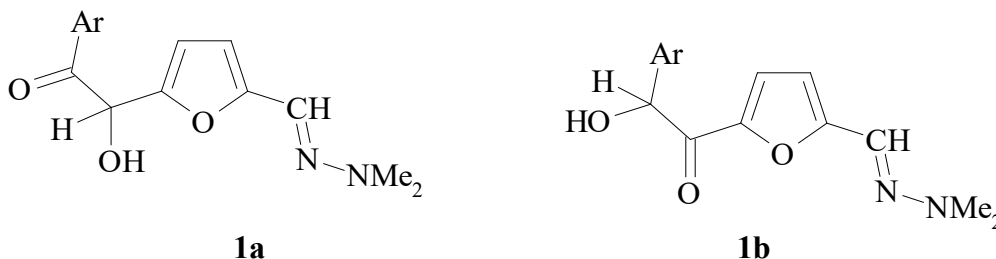
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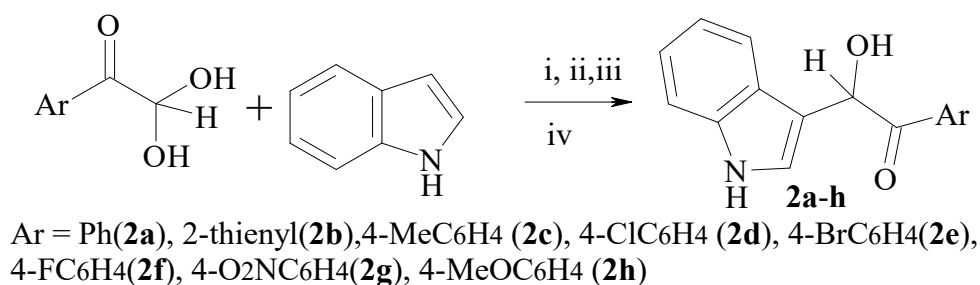
Unsymmetrical benzoin and aryl(hetaryl)benzoin exist in two isomeric forms, α -benzoin and β -benzoin for example aryl(furyl)benzoin **1a** and **1b** (Scheme 1, Ar = 4-ClC₆H₄), possess different stability.



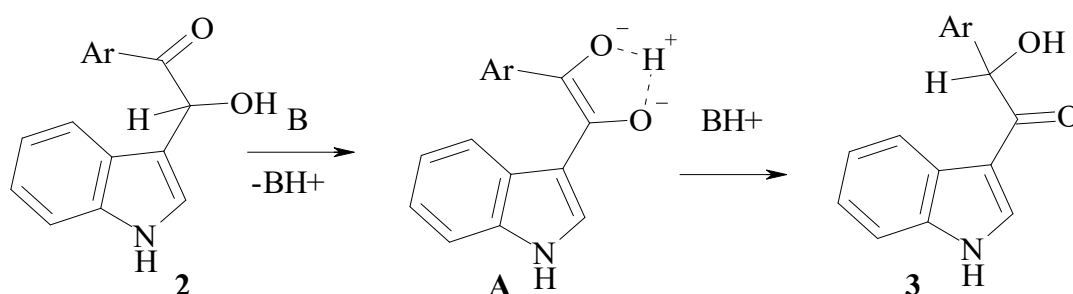
The development of efficient and general methodology for the synthesis of α -functionalized α -(indol-3-yl) ketones is highly desirable now. These compounds become relevant precursors for the preparation of biologically active molecules.

We had synthesized known α -benzoin **2a** and **2b** with moderate yields by reaction of indole with proper arylglyoxals in PhH at r.t. (ii) or in AcOH at rt (iv). α -Aryl(indolyl)benzoin **2c** has been synthesized in boiling PhH according to Zhungietu (i). α -Aryl(indolyl)benzoin **2d,e** had been synthesized as by known method (i), as in AcOH at r.t. during 1 h (iv). α -(4-Fluorophenyl)(indolyl)benzoin **2f** was obtained by 4-fluorophenylglyoxal interaction with indole in PhH at r.t. (ii). α -(4-Nitrophenyl)(indolyl)benzoin **2g** was obtained by interaction of 4-nitrophenylglyoxal hydrate with indole in acetic acid at 19°C during no more than

1 h. α -(4-Methoxyphenyl)(indolyl)benzoin **2h** was synthesized with moderate yield by 4-methoxyphenylglyoxal hydrate interaction with indole in boiling PhMe.



We have found that some α -benzoins **2** readily isomerise into β -benzoins **3** in presence of bases (Et₃N (i,**3a,3b,3d,3e**), EtONa in EtOH (ii,**3d,3e**)):



(Ar = Ph (**a**), 2-thienyl (**b**), 4-ClC₆H₄(**d**), 4-Br-C₆H₄ (**e**)).

Structure of isomeric α -aryl(indolyl)benzoins **2** and β -aryl(indolyl)benzoins **3** was confirmed by data of ¹H and ¹³C NMR spectra and mass spectra. In ¹H NMR spectra of compounds **3** the chemical shifts of C(2)H indolyl proton and NH proton lie in more low field then chemical shifts of proper protons of α -benzoins **2**. Probably, this phenomenon is caused by conjugation of indol-3-yl moiety with carbonyl group in β -benzoins **3** (Table 1).

Table 1. The characteristic ¹H NMR chemical shifts (ppm) of α -aryl(indolyl)benzoins **2** and β -aryl(indolyl)benzoins **3** in (CD₃)₂SO

α -benzoins			β -benzoins		
Ar	C(2) _{ind} H	NH	Ar	C(2) _{ind} H	NH
Ph (2a)	7.355	11.075	Ph (3a)	8.544	11.984
2-C ₄ H ₃ S (2b)	7.411	11.085	2-C ₄ H ₃ S (3b)	8.563	12.042
4-ClC ₆ H ₄ (2d)	7.334	11.077	4-ClC ₆ H ₄ (3d)	8.58	12.04
4-BrC ₆ H ₄ (2e)	7.3285	11.073	4-BrC ₆ H ₄ (3e)	8.564	12.025

In ¹³C MR spectra of α -aryl(indolyl)benzoins **2** and β -aryl(indolyl)benzoins **3** the characteristic carbon shifts are shifts of CHOH carbon and C=O carbon atoms

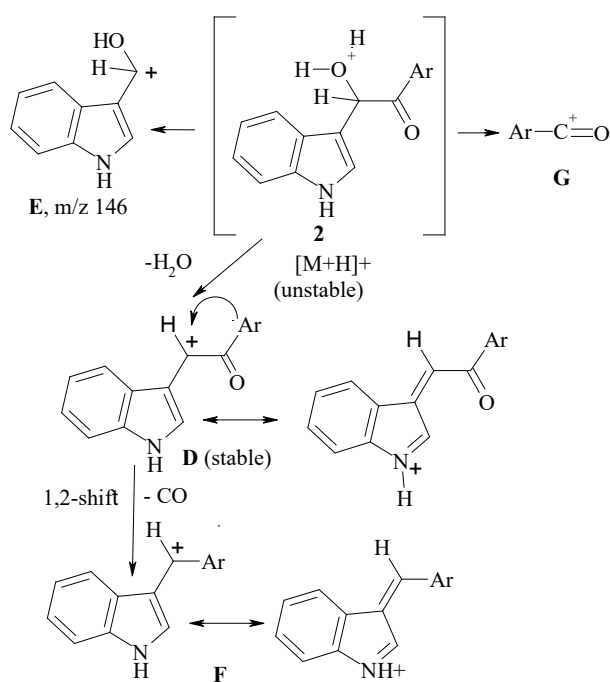
(Table 2). In compounds **3** shift of C=O carbon lies in some upper field than of C=O carbon of α -benzoin **2** due to more conjugation of C=O group with 3-indolyl moiety. Shift of CHO carbon for β -aryl(indolyl)benzoin **3** is observed in some lower field than that of α -aryl(indolyl)benzoin **2**.

Table 2. The characteristic ^{13}C NMR chemical shifts (ppm) of α -aryl(indolyl)benzoin **2** and β -aryl(indolyl)benzoin **3** in $(\text{CD}_3)_2\text{SO}$

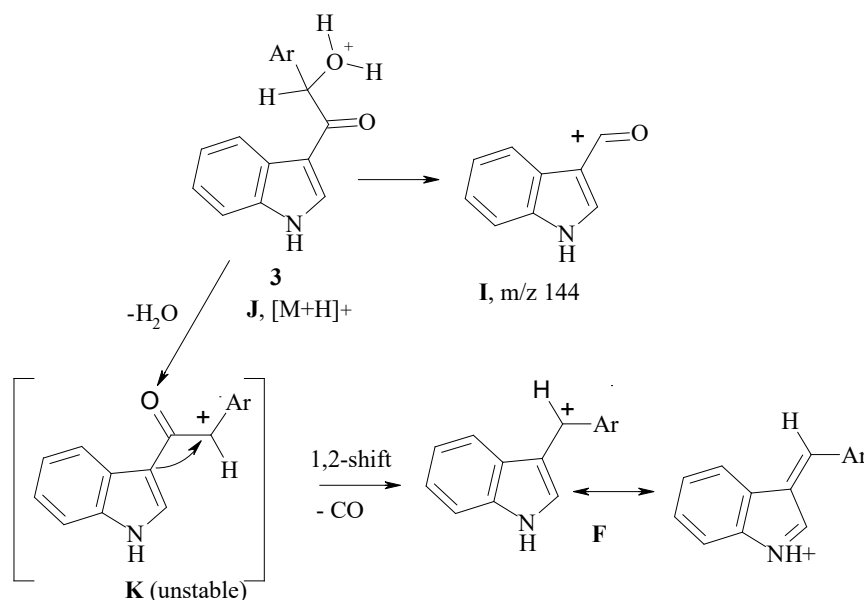
α -benzoin			β -benzoin		
Ar	CHOH	C=O	Ar	CHOH	C=O
Ph (2a)	69.5	199.0	Ph (3a)	76.2	194.3
2-C ₄ H ₃ S (2b)	70.8	192.3	2-C ₄ H ₃ S (3b)	72.4	193.1
4-ClC ₆ H ₄ (2d)	69.7	197.8	4-ClC ₆ H ₄ (3d)	75.5	194.1
4-BrC ₆ H ₄ (2e)	69.7	198.2	4-BrC ₆ H ₄ (3e)	75.5	194.0
4-O ₂ NC ₆ H ₄ (2g)	70.3	198.2			

MS spectra of α - and β -aryl(indol-3-yl)benzoin also have some substantial distinctions.

Protonation of aryl(3-indolyl)benzoin molecules in FAB-MS conditions causes substantial difference of their FAB-MS spectra relatively to their EI-MS spectra. In FAB-MS spectra of α -aryl(indolyl)benzoin **2** peaks of $[\text{M}+\text{H}]^+$ ions are absent, but KI addition to the samples yields peaks of $[\text{M}+\text{K}]^+$ ions, whereas in FAB-MS spectra of β -aryl(indolyl)benzoin **3** $[\text{M}+\text{H}]^+$ peaks of cations **J** are observed.



In MS spectra (FAB regime) of α -aryl(indolyl)benzoins **2** peaks of stable indolyl ions **D** $[M+H-H_2O]^+$ and “benzylic” ion **E** with m/z 146 are dominated. In this case of α -aryl(indolyl)benzoins **2** the cations $[M+H-H_2O-CO]^+$ **F** are observed, presumably obtaining from cations **D** by synchronous 1,2-shift of aryl moiety to cation center and CO elimination. Acyl cations **G** are observed, too.



And vice versa, in MS spectra of β -aryl(indolyl)benzoins **3** peaks of ions $[M+H]^+$ **J**, $[M+H-H_2O-CO]^+$ **F** and acyl cation **I** with m/z 144 are dominated (Scheme 5). In this case aryl(indolyl)cations $[M+H-H_2O-CO]^+$ **F** are observed too, presumably obtaining from cations **J** by H_2O elimination and the yielding unstable cations **K**. Further cations **K** by synchronous 1,2-shift of indolyl moiety to cation center and CO elimination convert into stable cations **F**. Peaks ions $[M+H-H_2O]^+$ **K** have low intensity. As shown, the water molecule elimination from protonated molecules benzoins **2** and **3** yields to forming of ions, having cation center in α -position to the indolyl moiety in the case of α -aryl(indolyl)benzoins **2** and in α -position to the aryl moiety in the case of β -aryl(indolyl)benzoins **3**. Seemingly, the indolyl moiety much effectively stabilized the positive charge than the aryl moiety. This phenomenon causes the high stability of ions **D** and low stability of ions **K**. Probably, the first causes the absence of $[M+H]^+$ ions in FAB-MS spectra of α -aryl(indolyl)benzoins **2**.