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THE INTERMOLECULAR SELF-CONDENSATION OF 2,4-PENTANEDIONE UNDER THE INFLUENCE OF POTASSIUM FLUORIDE IN DIMETHYLFORMAMIDE

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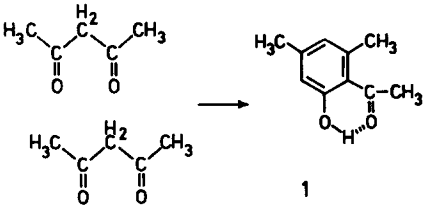
Clark and Miller [1,2] reported recently on the self-condensation of enolizable carbonyl compounds in the presence of potassium fluoride in N,N-dimethylformamide. In a typical experiment, refluxing of acetylacetone (0.1 mol) and KF (0.2 mol) in DMF (40 g) for 16 h furnished 64 % of 2-hydroxy-4,6-dimethylacetophenone (1). The structure originally considered [1] and later revised [3-5] was 3-hydroxy-2,5,7-trimethyltropone. A hydrogen bonded species from fluoride anion and enol was conjectured as reactive intermediate.[1,2] We want to discuss the possible role of KF and to correct some inconsistent nmr observations.



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We repeated Clark and Miller's experiment in freshly distilled DMF (Merck, Uvasol quality) and obtained the yellow needles of 1, mp. 56 - 57°C, in only 6 % yield; a corresponding experiment with addition of 2 ml water increased the yield to 10 %. Heterogenous reactions - the bulk of the KF remains undissolved - give often erratic results and depend on dispersion state and pretreatment of the solid.

The alleged "significant solubility"[1,2] of KF in DMF is very small. Refluxing 0.2 mol KF in 40 g DMF, filtering the hot suspension and evaporating in vacuo left <10 mg of solid residue. A larger amount of residue (0.33 g) was obtained when 0.2 mol KF, 40 g DMF and 0.2 mol acetylacetone were stirred at 25°C for a week. The residue of the filtered solution contains 5 % (16 mg) of KF as determined by complexometric titration of fluoride. The ^{1}H-nmr spectrum (D_2O) of the residue is that of potassium acetylacetonate; the aqueous solution showed pH $\approx$ 14.

Is it conceivable that the self-condensation of the diketone by KF is due to the formation of some potassium acetylacetonate ? On refluxing 0.10 mol acetylacetone with potassium acetylacetonate (0.024

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mol) in 40 g DMF for 16 h, we isolated indeed 5.24 g (51 %) of crude 1 (mp 52 - 56°C) and, after recrystallization, 4.32 g (42 %) of pure material, mp 56 - 57°C; the conditions await optimization.

If potassium acetylacetonate is formed from acetylacetone and KF, one mol of HF must be set free. The stoichiometry

$$\text{acetylacetone} + 2\,\text{KF} \rightarrow \text{K-acetylacetonate} + \text{KHF}_2$$

is conceivable, since KHF_2 is virtually insoluble in DMF; <2 mg were dissolved after 16 h stirring of 1 g KHF_2 in 20 g DMF at 20°C. Possibly the system contains more HF acceptors. After refluxing acetylacetone (10 g) with KHF_2 (15 g) and DMF (40 g) for 12 h we isolated 0.7 g 1. It is imaginable that KHF_2 is converted to $KF \cdot 2\,HF$ or $KF \cdot 3\,HF$; these fluorides are known. Our preliminary results do not confirm the importance of the hydrogen bonded species invoked by the Canadian authors.[1,2] The polar aprotic medium (DMF) may be responsible for the successful self-condensation of acetylacetone which gives poor yields in aqueous alkaline medium.[6]

Clark and Miller[1,2] claimed that acetylacetone is converted to 100 % enol on treatment with KF in DMF at room temperature (^1H-nmr analysis). The low solubility of KF rules that out, because a catalytic conversion of the equilibrium mixture to one tautomer would violate fundamental principles. In a 33 vol% solution of pentanedione in DMF the singlets of the enol form appear at δ 2.02 (2 CH_3), 5.69 (CH) and the broad hump of chelated OH at 14.7, whereas the singlets at 2.17 (2 CH_3) and 3.74 (CH_2) are attributed to the keto tautomer; the equilibrium mixture contains 69 % enol at 35°C. After shaking with powdered KF, one singlet at δ 2.07 for the methyl groups of both tautomers indicates a highly mobile equilibrium. The signals of CH and CH_2 of enol and keto form, respectively, are missing; due to their larger $\Delta\delta$ in keto and enol form as well as to their equilibration with OH, they are still in the state of coalescence. The same phenomenon can be brought about by triethylamine catalysis. Temperature-dependent spectra reveal that the keto enol equilibration is faster than DMF rotation.

What is the tautomerization catalyst in the KF system? Neither a hot-filtered solution of KF in DMF, nor a trace of HF, changes the normal ^1H-nmr spectrum of acetylacetone. However, a small amount of potassium acetylacetonate generates the characteristic pattern of the rapidly equilibrating mixture.

References

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2. J.H. Clark and J.M. Miller, J.C.S. Perkin I, 2063 (1977).
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5. Independent of lit.[3,4] we found the reported spectral data[1] consistent with 1, but not with the 3-hydroxytropone structure for which we saw no reasonable mechanism of formation.
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