

CATALYSIS OF THE KNOEVENAGEL CONDENSATION

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Abstract : Xonotlite alone or made more basic by doping of potassium *t*-butoxide catalyses the title reaction between aromatic aldehydes and malononitrile or alkyl cyanoacetates. At ambient temperatures, this procedure specifically gives high yields of E olefinic Knoevenagel products.

INTEREST of preparative organic chemistry for the carbonyl group verges on prurience ! One of the first conversions of the carbonyl group into an olefin, dozens of years before the Wittig¹ or the McMurry² routes, was devised by Knoevenagel³. This reaction, now nearly a century-old, thus assumes continued importance.

As part of a more general renovation program for important organic reactions⁴⁻⁸, we looked for a catalyst enabling Knoevenagel condensations to occur smoothly and quantitatively at room temperature. This is a reaction known to be catalysed by weak bases⁹ under homogeneous conditions, and our recent successes with the Michael reaction⁸ under heterogeneous conditions, via a basic catalyst (xonotlite-*t*-butoxide) that we had devised, encouraged us to try homologous procedures for the Knoevenagel condensation.

The illustrative results achieved so far (Table 1) show that this is a promising method for stereospecific preparation of E olefins by the Knoevenagel route. No effort was made at isolation of the intermediate aldols.

Reaction time were arbitrarily set to 1 h. and 24 h. but in some instances, such as between $H_2C(CN)_2$ and *p*-NO₂-C₆H₄-CHO, the reaction needs only a few minutes.

For alkyl cyanoacetates, high yields of olefins are obtained in 1 h by the use of *t*-BuOK doped xonotlite whereas for the more activated malononitrile or the rather unstable 2-furaldehyde, this catalyst appears to be too aggressive, and to give rather poor yields. However, in such cases, high yields are also obtained by a combination of the use of untreated xonotlite with a longer reaction time.

The main advantages of the method described hereabove compared to the other recently described heterogeneous (solid/liquid) procedures^{10,11} are that it is truly catalytic and its very low cost. Let us also point out its versatility with the possibility of modulating catalytic activity by slight modification of the doping.



R ₁	R ₂ =CN				R ₂ =COOEt			R ₂ =COOMe		
	A	B	C	D	A	B	C	A	B	D
R-C ₆ H ₄ -										
p.H	43	81	80	96	82	--	74	84	--	100
p.Me	57	70	79	--	80	60	62	80	53	54
p.OMe	77	86	79	--	86	--	52	81	--	--
p.NMe ₂	35	60	--	--	78	7	--	73	8	--
p.Cl ²	34	65	--	--	82	85	47	86	--	--
p.CN	--	75	--	--	92	--	--	88	--	--
m.CN	60	56	--	--	--	--	--	--	--	--
p.NO ₂	40	80	82	--	83	94	85	79	87	--
2-naphtaldehyde	60	65	--	--	89	--	--	95	--	--
2-furaldehyde	--	84	56	--	--	85	89	--	94	98

- A : reaction (1 h) with xonotlite-*t*-butoxide potassium (15/12)¹³ as catalyst (100 mg for 10 mM)
 B : reaction (24 h) with untreated xonotlite¹³ as catalyst (100 mg for 10 mM).
 C : literature¹⁰ yields for reaction (30 min. to 1 h) with AlPO₄-Al₂O₃ as catalyst (1.5 to 3 g for 10 mM).
 D : literature¹¹ yields for reaction (a few minutes) with Al₂O₃ as catalyst (3 g for 10 mM)

Table 1. Isolated yields (%) for selected catalysed Knoevenagel condensations.

Standard procedure :

To a mixture of the aromatic aldehyde (10 mM) and of the methylene compound (10 mM), at ambient temperature¹², 100 mg of the catalyst¹³ is added. The mixture is stirred for 1 or 24 h (see above). The solid mixture formed is then dissolved in CH₂Cl₂, or any other suitable organic solvent, and filtered. After solvent evaporation, the solid residual material is recrystallized from methanol.

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- When the mixture of reagents was not liquid at ambient temperature, it was carefully melted, the catalyst added and heating stopped.
- a) For runs B the catalyst used was dried overnight in an oven at 120°C.
 b) For runs A the catalyst used was prepared by adding 15 g of dried P60 xonotlite to a solution of 12 g of potassium *t*-butoxide in *t*-BuOH under vigorous stirring. Stirring was maintained for a few minutes, the solvent was evaporated under reduced pressure using a rotatory evaporator and the residual solid dried in an oven at 120°C. The catalyst may be stored and will remain efficient for several months.

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