CATALYSIS OF THE KNOEVENAGEL CONDENSATION

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

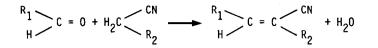
As part of a more general renovation program for important organic reactions⁴⁻⁸, we looked for a catalyst enabling Knoevenagel condensations to occur smoothly and quantitatively at room temperature. This is a reaction known to be catalysed by weak bases⁹ under homogeneous conditions, and our recent successes with the Michael reaction⁸ under heterogeneous conditions, via a basic catalyst (xonotlite-<u>t</u>-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 <u>stereospecific</u> preparation of <u>E</u> 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 $p-NO_2-C_6H_4$ -CHO, the reaction needs only a few minutes.

For alkyl cyanoacetates, high yields of olefins are obtained in 1 h by the use of \underline{t} -BuOK doped xonotlite whereas for the more activated malononitrile or the rather unstable 2-furaldehyde, this catalyst appears to be too agressive, 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 <u>truly catalytic</u> and its very low cost. Let us also point out its <u>versatility</u> with the possibility of modulating catalytic activity by slight modification of the doping.



R ₁ R-C ₆ H ₄ -	R ₂ =CN				R ₂ =COOEt			R ₂ ≖COOMe		
	A	В	С	D	Α	В	С	A	В	þ
p.H	43	81	80	96	82		 74			100
p.Me	57	70	79		80	60	62	80	53	54
p.OMe	77	86	79		86		52	81		
p.NMe,	35	60			78	7		73	8	
p.C1 ²	34	65			82	85	47	86	<u>-</u>	
p.CN		75			92			88		
m.CN	60	56								
p.NO2	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- \underline{t} -butoxide potassium (15/12)¹³ as catalyst (100 mg for 10 mM)

B : reaction (24 h) with untreated xonotlite 13 as catalyst (100 mg for 10 mM).

- C : literature¹⁰ yields for reaction (30 min. to 1 h) with $A1P0_4$ - $A1_20_3$ as catalyst (1.5 to 3 g for 10 mM).
- D : literature¹¹ yields for reaction (a few minutes) with $A1_20_3$ 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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- 11.
- F. Texier-Boullet and A. Foucaud, <u>Tetrahedron Lett.</u>, 23, 4927 (1982). When the mixture of reagents was not liquid at ambient temperature, it was carefully melted, the catalyst added and heating stopped. 12.
- a) For runs B the catalyst used was dried overnight in an oven at 120°C. 13.
 - b) For runs A the catalyst used was or rea overlight in an over 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 other than the solvent for the solvent catalyst may be stored and will remain efficient for several months.