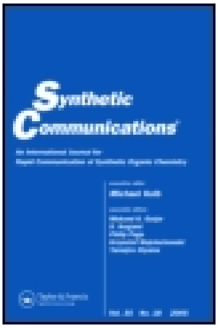

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AMMONIUM ACETATE-BASIC ALUMINA CATALYZED KNOEVENAGEL CONDENSATION UNDER MICROWAVE IRRADIATION UNDER SOLVENT-FREE CONDITION

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***Abstract**: Ammonium acetate and basic alumina catalyzed efficiently the Knoevenagel condensation of aldehydes and ketones with active methylene compounds under solvent-free condition where olefinic products were obtained in high yields.*

The Knoevenagel condensation is one of the most important methods for the preparation of alkenes.[1,2] The reaction is catalyzed by primary and secondary amines or their corresponding ammonium salts in harmful solvents, or with Lewis acids, as $TiCl_4$/base,[3] $ZnCl_2$,[4] CdI_2.[5] Recently using inorganic solid supports under homogenous conditions have been reported as a suitable method for Knoevenagel condensation; The examples are alumina,[6,7] Al_2O_3-$AlPO_4$,[8] xonotlite,[9] basic anion exchange resins,[10] functionalized silica gel with alkyl amines,[11] montmorillonite K-10, silyl propylethylene diamine[12] and zeolites.[13,14]

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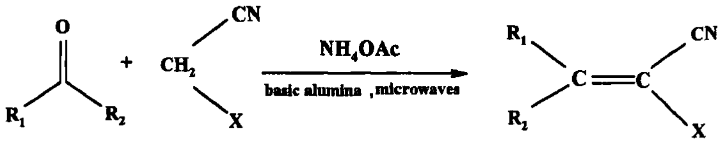
Microwave irradiation under solvent-free condition has also shown it's utility in Knoevenagel condensation by using Piperidine,[15] clays,[16-18] silica gel[19] and other catalysts.[20,24]

In this work, we wish to report the ammonium acetate-basic alumina as highly effiecient catalyst for condensation of aldehydes and ketones with active methylene compounds under solvent-free condition by microwave irradiation. The aldehydes and ketones reacted with malononitrile, methyl cyanoacetate and cyanoacetamide according to Scheme. The resulting alkenes **3**, reaction conditions and yields are shown in Table.



Scheme

In all cases, the products **3a-p** were identified as *E* isomers by the IR, ^{1}H-NMR spectra and the previously reported melting points. The absence of carbonyl groups of aldehydes in IR spectra with appearance of olefinic hydrogen in ^{1}H-NMR spectra at δ 7.7-8.3 region are indicative of the reaction products. Cinnamaldehyde reacted with malononitrile to give 1,1-dicyano 4-phenylbuta-1,3-diene without Michael addition . The reactions were completed within 3-8 min. with improved yields. The electron donating groups (OCH_3, CH_3) in aromatic rings did not retard the Knoevenagel condensation under this condition. As shown in Table, compounds **3b, 3l** gave high yields, which could be due to high electron withdrawing effect of nitro group. It seems that under our experimental conditions the base abstracts a proton from the active methylene compounds, then addition of resulting nucleophile to the carbonyl group of aldehydes or ketones after dehydration give the final products.

In conclusion, microwave irradiation catalyzed by ammonium acetate and basic alumina improve the condensation of methylene active compounds such as

Table 1. Synthesis of alkenes via Knoevenagel condensation catalyzed by ammonium acetate - basic alumina under microwave irradiation.

Product	R_1	R_2	X	Power (watt)	Time (min)	Yield* %
a	C_6H_5	H	CN	850	6	80
b	3- $NO_2C_6H_4$	H	CN	850	3	85
c	4-$NO_2C_6H_4$	H	CN	425	6	64
d	2-furyl	H	CN	425	3	82
e	Ph - C=C-	H	CN	425	5	74
f	4-$CH_3OC_6H_4$	H	CN	850	8	83
g	4- $CH_3C_6H_4$	H	CN	850	3	87
h	C_6H_5	CH_3	CN	850	6	93
i	iso-propyl	H	CN	r.t	5	88
j	CH_3	CH_3	CN	r.t	5	80
k	C_6H_5	H	COOMe	850	7	82
l	3 - $NO_2C_6H_4$	H	COOMe	850	6	90
m	2-furyl	H	COOMe	850	2	70
n	Ph -C=C -	H	COOMe	850	2	70
o	C_6H_5	H	$CONH_2$	850	8	70
p	4- $CH_3OC_6H_4$	H	$CONH_2$	850	8	46

* Isolated yield

All products were charactized by IR,^{1}H-NMR spectroscopic data and melting points.

methyl cyanoacetate, malononitrile, cyanoacetamide with aldehydes and ketones. This methodology is fast, clean and applicable for the preparation of tri-substituted alkenes; It has simple set-up and work-up and is environmentally friendly and comparible to other methods.

EXPERIMENTAL SECTION

Melting points were measured on a Electrothermal melting point apparatus and are uncorrected. IR spectra were recorded with a Shimadzu IR-408 spectrometer (KBr). ^{1}H-NMR spectra were determined in chloroform-d solution on a FT-NMR Bruker AC-80 (80MHz) and reported in δ ppm. We used a domestic microwave oven (Moulinex 2735A) at 2450 MHz (100% Power 850 W) under the conditions shown in Table.

General Procedure for preparation of alkenes 3a-p

Aldehyde or ketone (3mmole), ammonium acetate (3mmole, 231mg), basic alumina (3g) and active methylene compound **2** (3mmole) were mixed thoroughly in a mortar.The reaction mixture was placed in a beaker and irradiated under the conditions shown in Table. The progress of reaction was monitored by TLC using petroleum ether: CH_2Cl_2=30:70 as eluent. The mixture was extracted into methylene chloride then filtered and washed with water. The solvent was removed under reduced pressure by rotatory evaporator. Further purification by column chromatography on silica gel gave the desired product.

1,1–**Dicyano-2-phenylethylene (3a):** mp=84 °C (lit[15]= 82, 87 °C). ^{1}H-NMR ($CDCl_3$, δ ppm): 7.90 (s, 1H, H-C=C), 7.50-8.15 (m, 5H, Ar). IR (KBr, cm^{-1}): 3020 (HC=C), 2250 (CN), 1590(C=C).

1,1-Dicyano-2-(3-nitrophenyl)ethylene (3b): mp=100 °C (lit[25]=104-105 °C). ^{1}H- NMR ($CDCl_3$, δ ppm): 7.85 (s, 1H, HC=C), 8.60 (t, 1H, J=1.8 Hz, H-2'), 8.3-8.4 (dd, 1H, J=0.8, J=9 Hz, H-4'), 8.30 (d, 1H, H-6'), 7.7 (t, 1H, J=8Hz, H-5'). IR (KBr, cm^{-1}): 3010 (HC=C), 2225 (CN), 1590 (C=C); 1530 (C=C), 1350 (NO_2).

1,1-Dicyano-2-(4nitrophenyl)ethylene (3c): mp=159 °C (lit[15]=159 °C). ^{1}H-NMR ($CDCl_3$, δ ppm): 8.39 (d, 2H, J= 7.2, H-2′, H-6′), 8.1 (d, 2H, J= 7.2 Hz, H-3′, H-

5′), 7.88 (s, 1H, H-C=C). IR (KBr, cm^{-1}): 3010 (H-C=C), 2250 (CN),1600, (C=C); 1530, 1350, (NO_2).

1,1-Dicyano-2-furylethylene (3d): mp=72 °C (lit[5]=72 °C). ^{1}H-NMR ($CDCl_3$, δ ppm): 7.75 (d, 1H, J= 1.6, H-5′), 7.45 (s,1H, HC=C), 7.3 (d, 1H, J= 3.8, H-3′), 6.65 (dd, 1H, H-4′, J=1.8, J=3.8). IR (KBr, cm^{-1}): 3020 (H-C=C); 2250 (CN),1610 (C=C).

1,1-Dicyano-4-Phenylbuta-1,3diene (3e): mp=128 °C (lit[27]=128 °C). ^{1}H-NMR ($CDCl_3$, δ ppm): 7.1-7.6 (m, 8H, H-C=C, Ar). IR (KBr, cm^{-1}): 3020 (H-C=C), 2225 (CN),.1610 (C=C).

1,1-Dicyano-4-(*p*-methoxyphenyl)ethyle (3f): mp=114 °C (lit[19]=114 °C). ^{1}H-NMR ($CDCl_3$, δ ppm): 7.90 (d, 2H, J= 9.2, H-2′, H-6′), 7.65 (s, 1H, HC=C), 6.92 (d, 2H, J=9.2, H-3′, H-5′), 3.91(s, 3H, OCH_3). IR (KBr, cm^{-1}): 3020 (H-C=C), 2250 (CN), 1605 (C=C).

1,1-Dicyano-2-(p-methylphenyl)ethylene(3g): mp=135 °C (lit[26]=135 °C). ^{1}H-NMR 2H, ($CDCl_3$, δ ppm): 7.75 (d, 2H, J=8.2, H-2′, H-6′), 7.65 (s, 1H, HC=C), 7.27 (d, J=8.2 Hz, H-3′, H-5′), 2.40 (s, 3H, CH_3). IR (KBr, cm^{-1}): 3020 (H-C=C), 2250 (CN), 1590 (C=C).

1,1-Dicyano-2-phenyl-1-propene (3h): mp=92 ° C (lit[15]= 92 °C). ^{1}H-NMR ($CDCl_3$, δ ppm): 7.45 (s, 5H, Ar), 3.6 (s, 3H, CH_3). IR (KBr, cm^{-1}):2250 (CN), 1650 (C=C).

1,1-Dicyano-3-methyl-1-butene (3i): mp=76 °C (lit[5]=77 °C). ^{1}H-NMR ($CDCl_3$, δ ppm): 1.15 (d, 6H, 2 Me, J=6.6 Hz), 2.75-3.25 (m, 1H, -CH),7.15 (d, 1H, J=10.6, H-C=C). IR (KBr, cm^{-1}): 1640 (C=C), CN (2225), 2950 (HC=C).

1,1-Dicyano-2-methyl-1-propene (3j): mp=170 °C (lit[30]=171.5°C). ^{1}H-NMR ($CDCl_3$, δ ppm): 3.50 (s, 6H, 2 Me). IR (KBr, cm^{-1}): 2970 (H-C=C), 2250(CN), 1650 (C=C).

2-Cyano-3-phenyl-2-propenoic acid methylester (3k): mp=89 °C (lit[15]= 89,90 °C). ^{1}H-NMR ($CDCl_3$, δ ppm): 8.25 (s, 1H , H-C=C), 7.30-8.15 (m, 5H, Ar), 3.9(s, 3H, OCH_3). IR (KBr, cm^{-1}): 3010 (H-C=C), 1730 (C=O), 2250 (CN), 1090 (C-O), 1605 (C=C).

2-Cyano-3-(m-nitrophenyl)-2-propenoic acid methylester (3l): mp=135 °C, (lit[28] = 135 °C). ^{1}H-NMR ($CDCl_3$, δ ppm): 8.6 (t, 1H, J=1.7 Hz, H-2′), 8.4 (d, 2H, J= 7Hz, H-6′, H-4′), 8.2 (s, 1H, H-C=C), 7.7 (t, 1H, J= 7.5 Hz, H-5′), 3.9 (s, 3H, OCH_3). IR (KBr, cm^{-1}): 3020 (H-C=C), 2250 (CN); 1350, 1530 (NO_2), 1730 (C=O), 1610 (C=C)

2-Cyano-3-furyl-2-propenoic acid methylester (3m): mp=95 °C (lit[15]= 95 °C). ^{1}H-NMR ($CDCl_3$, δ ppm): δ 7.95 (s, 1H, H-C=C), 7.70 (d, 1H, J=1.6 Hz, H-5′), 7.35 (d,1H, J=3.8 Hz, H-3′), 6.65 (dd, 1H, J=3, 1.7 Hz, H-4′). IR (KBr, cm^{-1}): 3010 (C=C), 2225 (CN), 1730 (C=O), 1080 (C-O), 1610 (C=C).

2-Cyano-5-phenyl-2,4-pentadien carboxilic acid methylester (3n): mp=145 °C (lit[29]=145 °C).[29] ^{1}H-NMR ($CDCl_3$, δ ppm): 7.90 (t, 1H, J= 5 Hz, H-C=C), 7.15-7.60 (m, 7H, H-C=C, Ar), 3.9 (s, 3H, OCH_3). IR (KBr, cm^{-1}): 3040 (H-C=C), 2250 (CN), 1610 (C=C),1080 (C-O).

2-Cyano-3-phenyl-2-propenamide (3o):mp=123°C (lit[15]=121, 124 °C). ^{1}H-NMR ($CDCl_3$, δ ppm): 8.25 (s, 1H, H-C=C), 7.9 (m, 2H, J=8.1Hz, H-2′, H-6′), 7.5 (m, 3H, H-3′, H-4′, H-5′), 6.5 (brs, 2H, NH_2). IR (KBr, cm^{-1}): 3490 (NH_2), 2225 (CN), 1690 (C=O), 1590 (C=C).

2-Cyano-3-(p-methoxyphenyl)-2-propenamide (3p): mp= 214 °C (lit[4]=216 °C). ^{1}H-NMR ($CDCl_3$, δ ppm): 8.2 (s, 1H, H-C=C), 7.9 (d, 2H, J=8.8Hz, H-3′, H-5′), 6.9 (d, 2H, J=8.8 Hz, H-2′, H-6′), 3.85 (s, 3H, OCH_3), 6.1 (brs, 2H, NH_2). IR (KBr, cm^{-1}): 3500 (NH_2), 2225 (CN), 1690 (C=O), 1580 (C=C).

REFERENCES

1. Jones, G. *Organic Reactions* 1967, **15,** 204.
2. Tietze, L.; Beifuss, V. *Comprehensive Organic Synthesis* (Eds.: Trost, B.M.; Fleming, I.), Pergamon Press, Oxford, 1991, Vol II, 341.
3. Lehnert, W. *Synthesis*, 1974, 667.
4. Rao, P.S.; Venkataratnam, R.V. *Tetrahedron Lett.*, 1991, **32**, 5821.
5. Parajatapati, D.; Sandhu, J.S. *J.Chem.Soc. Perkin Trans. 1* , 1993 , 739.
6. Texier-Boulett, F.; Foucod, A. *Tetrahedron Lett.*, 1982, **23,** 4927.
7. Cooke, G.; Schulz, O. *Synth.Commun.*, 1996, **26,** 2549.
8. Cabello, J.A.; Campelo, J.M.; Garcia, A.; Luna, D.; Marians, J.M. *J.Org.Chem.,* 1984, **41,** 5195.
9. Chalais, S.; Laszlo, P.; Mathy, *Tetrahedron Lett.*, 1985, **26,** 4453.
10. Hein, R.W.; Astle, M.J.; Shelton, J.R. *J.Org.Chem*, 1961, **26**, 1874.
11. Angeletti, E.; Canepa, C.; Martinetti, G.; Venturello, P. *J.Chem.Soc.Perkin Trans.1* 1989, 105.

12. Subba Rao, Y.U.; Choudary, B.M.; *Synth.Commun.*, 1991, **21**, 1163.

13. Reddy, T.I.; Varema, R.S. *Tetrahedron Lett.*, 1997, 38, 1721.

14. Wang, Q.L; Yudao Ma., Zua, B. *Synth.Commun.*, 1997, **27**, 4107.

15. Abdallah-El Ayoubi, S.; Texier-Boullet, F.;Hamelin, J. *Synthesis,* 1994, 258.

16. Abdallah-El Ayoubi, S.; Texier-Boullet, F. *J.Chem.Res.*,1995, 208.

17. Villemin, D.; Labiad, B. *Synth.Commun.*, 1990, **20**, 3207.

18. Villemin, D.; Diez-Barra, E.; Loupy, A.; Langa, F. *Tetrahedron Lett.*, 1996, **37**, 1113.

19. Kim, S.Y.; Kwon, P.S.; T.W.Kwon, T.W. *Synth.Commun.*, 1997, **27**, 533.

20. P.S.Kwon, Y.M.Kim, C.J.Kang, Kwon, *Synth. Commun.*, 1997, **27**, 4091.

21. Kim, S.Y.; Kwon, P.S.; Kwon, T.W. *Synth.Commun.*, 1997, **27**, 533.

22. Obrador, E.; Castro, M.; Tamariz, J.; Zepeda, G; Miranda, R.; Delgado, F. *Synth. Commun.*, 1998, **28**, 4649.

23. Kumar, H.M.S.; Subbareddy, B.V.; Anjaneyulu, S.; Yadav, J.S. *Synth.Commun.*, 1998, **28**, 3811.

25.Beilstein, Handbuch der Organischen Chemie, Band *9,* II, 641.

26.The Aldrich Library of Infrared Spectra, 1981.

27.Beilstein, Handbuch der Organischen Chemie, Band *9*, 913.

28.Beilstein, Handbuch der Organischen Chemie, Band *9*, 4383.

29.Beilstein, Handbuch der Organischen Chemie, Band *9*, 913, I, 397.

30.Beilstein, Handbuch der Organischen Chemie, Band *2*, II, 662.

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