Synthesis and Characterization of Mikanecic acid diesters using different Catalysts and Their Comparison study

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Abstract: Catalysts are used to make changes easier in the organic synthetic mechanism. Catalysts are involved in the process of chemical changes by reducing time and making it faster to get things done. Catalysts play a vital role in organic synthesis with a novel method for the synthesis of a terpenoid, Mikanecic acid diester. In this research we are using kaolin clay catalyst, potassium carbonate and Potassium iodide to synthesis Baylis-Hillman adducts (alkyl-3-hydroxy-2-methylenepropanoates reacts with aldehyde with a variety of acrylates catalyzed in presence of $TiCl_4$). Mikanecic acid diesters obtained from 1,3-butadiene-2-carboxylate of (Diels-Alder type) self-dimerization occur in the presence of different catalysts. The yield which we obtained is in good ratio. However K_2CO_3 Catalyst gave good yield and reduces the reaction time. In this study, Tertiary butyl acrylate resulted with good yield than the others.
Key Words: Mikanecic acid diester, K_2CO_3, KI, Kaolin clay, Comparison study.

1. Introduction

Synthetic organic chemistry is the paramount developing, expanding and successful branches of Science. During the past years, synthetic organic research has seen massive growth.[1-4] Development of new methods for the synthesis of heterocyclic compound, novel reagents, catalysts, strategies, and transformations is used. In synthetic organic chemistry, the constructions of quaternary carbon center have been one of the demanding and most attractive field due to a number of biologically active natural compounds consisting structural sub-units.[5-8] Terpenoid dicarboxylic acid and Mikanecic acid have attracted our attention due to its special feature of having vinylic quaternary carbon center. In 1936, Manske[9] isolated Mikanecic acid from the alkaloid Mikanoidine obtained by base hydrolysis of *Senecio mikakioides otto*. In literature[10] many research papers have been published based on the synthesis and characterization of Mikanecic acid.[11] Inorganic catalyzed organic reactions are obtaining importance owing to their low-cost nature and special catalytic attributes in various reactions. In this view, our research is focused to develop environmentally benign protocols. Herein, we report, K_2CO_3[12-17], KI[18-21] and Kaolin clay[22-26] catalyzed synthesis of Mikanecic acid diesters results in fairly good yields.

In past years, many researchers developed the Baylis-Hillman reaction. In literature, DABCO[27] was used to perform this reaction and it resulted with the slow reaction rates. A Lewis acid ($TiCl_4$) reaction of acetaldehyde with appropriate acrylates successfully resulted with Baylis-Hillman adducts[28-30] (**1a-1c**). Then these adducts on treatment with suitable catalysts yielded with Mikanecic acid diesters (**2a-2c**) by Diels-Alder

type (i.e. self-dimerization of 1,3-butadiene-2-carboxylate) (Scheme **I II III Table 1**). Mikanecic acid diesters on hydrolysis gave Mikanecic acid. (**3**)

2. Experimental

2.1 Materials and Methods

For this research, the use of chemical, reagents and solvent were bought from the real scientific company, India and used as such. Melting points were found out in an open capillary tube with a Buchi melting point apparatus. Elemental analyses were done by using Perkin-Elmer 240C CHN-analyzer. Perkin Elmer IR spectrophotometer records the ^{1}H- NMR spectra .This was run in (CDCl$_3$) solvent at 200 MHz NMR spectrophotometer. In the same way ^{13}CNMR Spectra records the spectrum at 50 MHz.

2.2 Synthesis of Mikanecic Acid

2.2a. K$_2$CO$_3$ Catalyst

The synthetic procedure is very simple method. As shown in **Scheme I**. 0.01 Mole Baylis-Hillman adducts with Methanol in the presence of base catalyst (K$_2$CO$_3$, 0.2 equiv.) were refluxed for 1 hr. Then completion of their action (monitored by TLC), common workup and column chromatographic purification (hex/ether, 5:1) gave products, which were characterized by IR, NMR spectral data. The outcomes obtained are very much consistent with literature report. The spectral and analytical data of the compound **2a**:

IR (neat): 1713, 1641 cm^{-1}; ^{1}H-NMR (200 MHz, CDCl$_3$): δ 1.70-1.91 (1H, m), 2.08-2.15 (1H, m), 2.29-2.43 (3H, m), 2.73-2.91 (1H, m), 3.70 (3H, s), 3.71 (3H,s), 5.11-5.21 (2H, m), 5.79-5.98 (1H, m), 6.98 (1H, m); Anal. Calcd for C$_{12}$H$_{16}$O$_4$: C, 64.26; H, 7.15 %.Found: C, 63.33; H, 6.91%.

Spectral data for Mikanecic acid: IR (KBr): 1690, 1640 cm^{-1}; ^{1}H-NMR (200 MHz, CDCl$_3$): δ 1.68-2.81(6H, m), 5.01-5.30 (1H, m), 5.76-6.03 (1H, m), 6.86(1H, m), 12.43 (2H, s, br); ^{13}C-NMR (50 MHz,CDCl$_3$): δ 21.59, 29.10, 31.72, 46.52, 114.56, 129.30, 136.78, 140.28, 167.65, 175.22; EI-MS: *m/z* 196 (M·); Anal. Calcd for C$_{10}$H$_{12}$O$_4$: C, 61.23; H, 6.13 %. Found: C, 57.49; H, 6.51 %.

2.2b. KI catalyst

As shown in **Scheme II**, the reaction can be carried out with 0.01 mole scale of Baylis-Hillman adduct in acetone in accordance with KI (0.2 equiv.) were refluxed for 1 hr. After completion of their action (checked by TLC), usual refine and column chromatographic purification (hex/ether, 5:2) obtained products. The end compounds were characterized by IR, NMR spectra. The product gave good yield with literature report. The spectral data of the compound **2a**:

IR (neat): 1715, 1645 cm^{-1}; ^{1}H-NMR (200 MHz, CDCl$_3$): δ 1.76-1.95 (1H, m), 2.09-2.19 (1H, m), 2.27-2.45 (3H, m), 2.76-2.93 (1H, m), 3.68 (3H, s), 3.76 (3H,s), 5.12-5.27 (2H, m), 5.78-5.95 (1H, m), 6.95 (1H, m); Anal. Calcd for C$_{12}$H$_{16}$O$_4$: C, 64.28; H, 7.14 %.Found: C, 63.32; H, 6.90%.

Spectral data for Mikanecic acid: IR (KBr): 1690, 1640 cm^{-1}; ^{1}H-NMR (200 MHz, CDCl$_3$): δ 1.65-2.85(6H, m), 5.01-5.30 (1H, m), 5.80-6.05 (1H, m), 6.90(1H, m), 12.45 (2H, s, br); ^{13}C-NMR (50 MHz,CDCl$_3$): δ 21.60, 29.11, 31.72, 46.54, 114.58, 129.33, 136.80, 140.33, 167.65, 175.25; EI-MS: *m/z* 196 (M·); Anal. Calcd for C$_{10}$H$_{12}$O$_4$: C, 61.20; H, 6.10 %. Found: C, 57.45; H, 6.45 %.

2.2c. Kaolin clay catalyst

Scheme III, the reaction can be carried out with 0.01 mole scale of Baylis-Hillman adduct with acetone in the presence of, 1 gram of kaolin clay were refluxed for 2 hr. After completion of their action (monitored by TLC), typical workup and column chromatographic cleansing (hex/ether, 5:1) gave products, which were characterized by IR, NMR spectral data. The outcomes obtained are more consistent with literature report. The spectral and analytical data of the compound **2a**:

IR (neat): 1710, 1641 cm-[1]; ^{1}H-NMR (200 MHz, CDCl3): δ 1.72-1.91 (1H, m), 2.04-2.11 (1H, m), 2.22-2.44 (3H, m), 2.70-2.92 (1H, m), 3.67 (3H, s), 3.70 (3H,s), 5.11-5.26 (2H, m), 5.75-5.95 (1H, m), 6.94 (1H, m); Anal. Calcd for $C_{12}H_{16}O_4$: C, 64.25; H, 7.10 %.Found: C, 63.30; H, 6.89%.

Spectral data for Mikanecic acid: IR (KBr): 1690, 1640 cm-[1]; ^{1}H-NMR (200 MHz, CDCl₃): δ 1.65-2.75(6H, m), 5.10-5.35 (1H, m), 5.80-6.10 (1H, m), 6.90(1H, m), 12.40 (2H, s, br); ^{13}C-NMR (50 MHz,CDCl₃): δ 21.52, 29.02, 31.75, 46.50, 114.50, 129.30, 136.80, 140.35, 167.60, 175.15; EI-MS: *m/z* 196 (M·); Anal. Calcd for $C_{10}H_{12}O_4$: C, 61.20; H, 6.15 %. Found: C, 57.50; H, 6.55 %
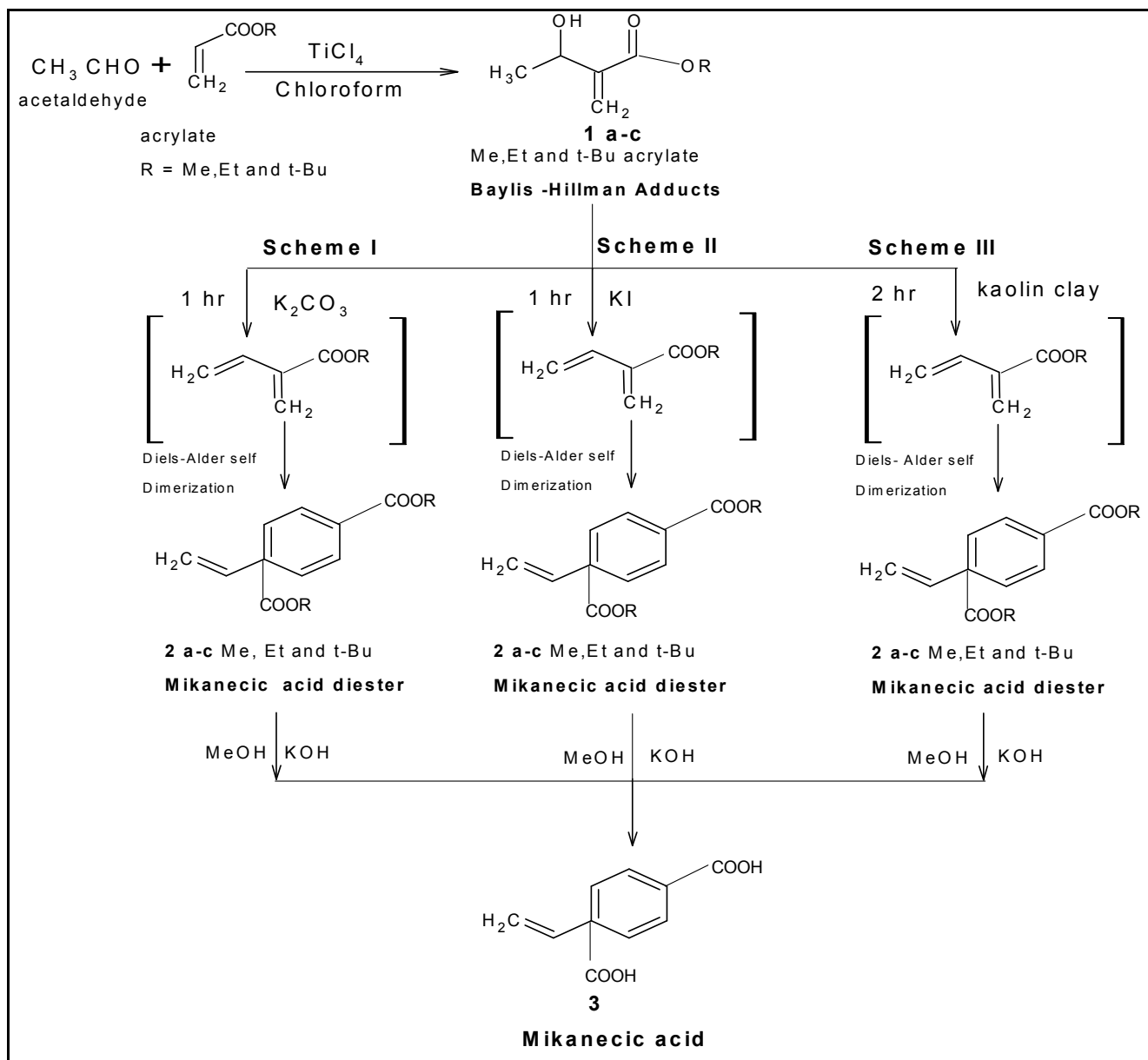
Scheme: Synthesis of Mikanecic acid diester using different catalysts.

3. Result and Discussion

3.1. Synthesis and Characterization

The synthesis of Mikanecic acid diester from Baylis Hillman adducts using three different catalysts that is two chemical catalysts, K_2CO_3 and KI. Another one is natural catalyst, kaolin. In this study first we prepared different Baylis Hillman adducts **(1 a-c)** by using acetaldehyde with different acrylates (Me, Et and t-Bu) in the presence of TiCl₄. Chloroform is used as solvent. Further these different Baylis Hillman adducts react with

K_2CO_3, KI and Kaolin to give Mikanecic acid diesters (**2a-c**) and which on hydrolysis gives Mikanecic acid (**3**). **(Scheme I, II, III)**. All the synthesized compounds were characterized by IR, NMR and mass spectral analysis. In general all the three catalysts were resulted with good yields.

3.2 Comparison of study of the catalyst

The three different Mikanecic acid diester products (**2a-c**) viz. methyl, ethyl and tertiary butyl were synthesized. It results with the reaction time of 2 hours by using natural catalyst and the chemical catalysts were resulted with about 1 hr. In these three adducts, the tertiary butyl acrylate gave good yield for all these three catalysts. Hence, the K_2CO_3 and KI catalysts were offered less reaction time and good yield than kaolin catalyst. **(Shown in the figure.1 shown in the figure.2 and figure.3 Table 1)** The compounds **2 a-c & 3** were characterized by IR, NMR and mass spectroscopy.
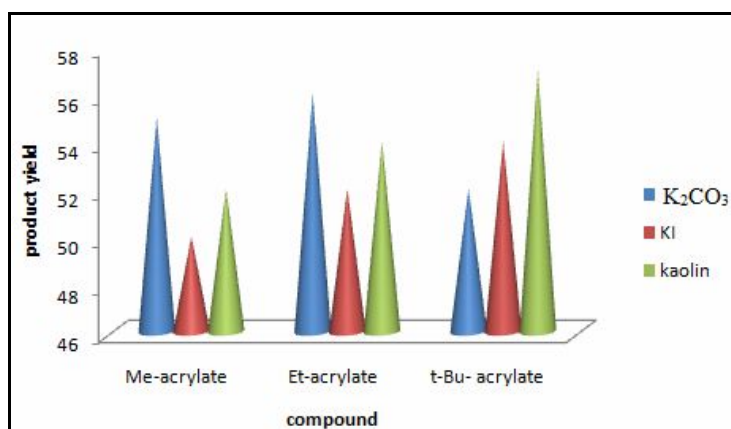

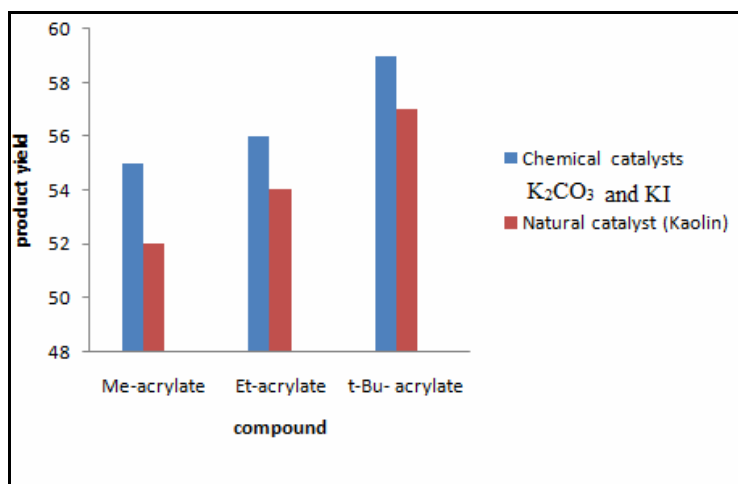**Figure.1 Comparision of Catalytic activity on synthesis of Mikanecic acid diester.**

Figure.2 Comparison of Chemical and Natural Catalytic activity on Synthesis of Mikanecic acid Diester.
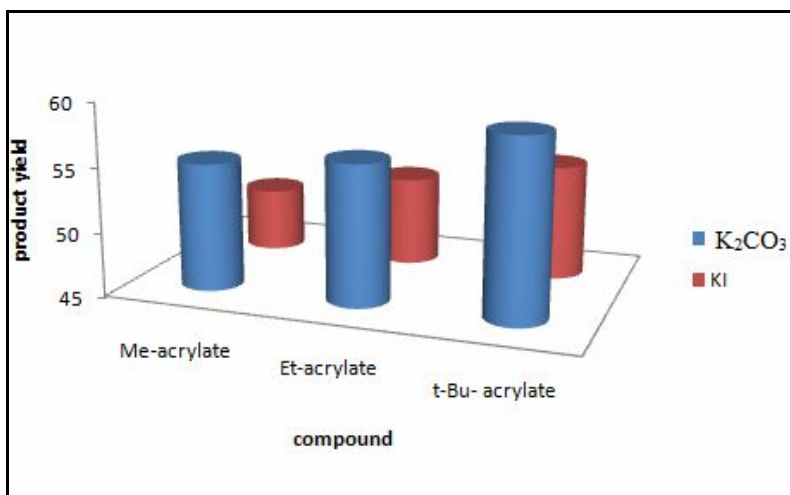
Figure.3 Comparison of Pottasium carbonate and Pottasium Iodide Catalytic activity on Synthesis of Mikanecic acid Diester.

Table .1 Synthesis of Mikanecic acid diesters a, b and c (a-Me, b-Et and c-t-Bt acrylate).

Substrate	Reaction time / catalyst	Product	Yield (%)
1a	1h /K_2CO_3	2a	55
1b	1h /K_2CO_3	2b	56
1c	1h /K_2CO_3	2c	59
1a	1h /KI	2a	50
1b	1h /KI	2b	52
1c	1h /KI	2c	54
1a	2h /Kaolin	2a	52
1b	2h /Kaolin	2b	54
1c	2h /Kaolin	2c	57

4. Conclusions

As a conclusion, this research describes a facile synthesis of Mikanecic acid diesters from Baylis-Hillman compounds, react with three catalysts (K_2CO_3, Kaolin clay and KI) and gives Mikanecic acid diesters, during Diels-Alder type self-dimerization of adducts (1, 3-Butadiene-2-carboxylate). The process represented was the indirect way of performing the Diels-Alder type method. In this method equal molecule of diene and dienophile react and resulted in Baylis-Hillman molecule. Pottasium carbonate is used in versatile industries in the manufacture of catalysts. Synthesis of Mikanecic acid derivatives is obtained from different catalysts with reactant. However the potassium carbonate catalysts gave good yield and reduced reaction time compared to others. In these three acrylates, tertiary butyl acrylate offered good results with all the three catalysts used in our research.

Acknowledgment

References

1. K. Reshetova and Y.A Ustynyuk, *Russ.Chem*., Bull., 53, 335 (2004).
2. G. Zhao, T. Jiang, H. Gao, J. Huang, and D. Sun, *Green Chem.*, 6 , 75 (2004).

3.   A. Zoupy, A. Petit, F. Hamelin and D. Mathe, *Synthesis*., 1213 (1998).
4.   B.Gangadasu, P.Narender, B. Chinna Raju and V. Jeyathirtha Rao, *Ind. J. Chem*., 45B, 1259 (2006).
5.   S.F Martin *Tetrahedron*. 36, 419 (1980).
6.   D. Romo, and A.I. Mayer, *Tetrahedron*., 47, 9503 (1991).
7.   J. Angelo, F. Dumas and A. Guingant *Tetrahedron Asymmetry*., 3, 459 (1992).
8.   B. Das, J. Banerjee and N. Ravindranath, *Tetrahedron*., 60, 8357 (2004).
9.   R.H.F. Manske, Canad. *J. Res*., 14B, 6 (1936).
10.   K. Fuji, *Chem. Rev*., 93, 2037 (1993).
11.   L.K. Sydnes, L.Skattbol and.D.G.Lappord Helv., *Chim . Acta*., 58, 2061 (1975).
12.   Swati Ojha, Usha Ameta, Neelam Dhakar and G.L.Talesara, *Ind.J.Chem*., 46B, 860-865. (2007).
13.   V. Singh and S. Batra *Tetrahedron*., 64, 4511-4574 (2008).
14.   Sumathi Bhatia, Sukhdev Singh, Rajesh Kumar, Amit Kumar, Carl.E.Olsen and K. Ashok Prasad, *Ind. J. Chem*.,52B, 379-386(2013).
15.   Urvasi Tiwari, Chetna Ameta ,Manish.K.Rawal, Rakshit Ameta and B. Pinki Punjabi, *Ind. J. chem.*, 52B, 42-439(2013).
16.   P. R. Kawel, P. R. Deohate and B.N. Berad , *Ind. J. Chem.*, 54B, 833-836(2015).
17.   N. Ralph, Salvatore, Cheol. H.wan Yoon and Kyung Woon Jung, *Tetrahedron*., 57, 7785- 7811(2001).
18.   Chao-Jun Li, *Chem.Rev*., 105, 3095-3165 (2005).
19.   Saikat Das Sarma, Pallab Pahari, Swapnali Hazarika, Parasa Hazarika,Manash Jyoti Borah and Dilip Konwar, *ARKIVOC*., 243-263 (2013).
20.   Tom. D. Sheppared, *Organic and Biomol.Chem.*, DOI: 10.1039/b818155a (2009).
21.   Jun-fa-wei, Li-hui Zhang, Zhan-quo Chen, Xian-ying and Jing-Ling Cao, Org. *Biomol Chem*., 7 , 3280-3284(2009).
22.   M. Balogh and P. Laszolo, *Organic Chem. using Clays*., 106 2316-2317 (1993).
23.   Ponnusamy Shanmugam and Paramasivan Raja Singh, *Synlett*., 8 , 1314-1316 (2001).
24.   Eman. A. Emam, *APRN Jour of Sci and Tech*., 3 , 4 (2013).
25.   Dilipkonwar, K. Pradp, Gogoi, Pranjal Gogoi, GeetikaBorah, Ruby Baruah Neelaksi Hazarika and Rituraj Borgohain , *Ind. J. Chem Tech*., 15 , 75-78(2008).
26.   Gopalpur Nagendrapp, *Applied Clay Sci*., 53 , 106-138(2011).
27.   Deevi Basavaiah, Anumolu Jaganmohan Rao and Tummanapalli Satyanarayana, *Chem.Rev*., 103 , 811-891(2003).
28.   Jeong Beom Park, Seung Ho Ko, Wan Pyo Hong and Kee-Jung Lee, *Angew.chem.Int.Ed.*, 42, 5054-5056(2003).
29.   R. Alan, Katritzky, Myong Sang Kim and Khalid Widyan, *ARKIVOC*. 3, 91-101(2008).
30.   H. Firouzabadi and M. Jafarpour *J.Iran.Chem.Soc*., 5 , 159-183 (2008).

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