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Synthesis of oxathiolanes using the reaction of alkenes with carbondisulfide in the presence of H_2O_2 and KF/Clinoptilolite

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Abstract: An efficient one-pot synthesis of functionalized oxathiolanes is described via the reaction of carbondisulfide with alkenes in the presence of hydrogen peroxide and KF/Clinoptilolite in MeOH as solvent at room temperature.

Keywords: Oxazole; Aziridine; Carbon dioxide; Sodium hydride; Methoxide ion.

Introduction

KF/CP that is employed as a new natural and economical solid base system synthesized from depositing Potassium fluoride on Clinoptilolite [1-9]. Clinoptilolite is a natural zeolite with a high internal surface area. It is much more valuable due to its high exchange capability for cations mainly for K^+. Therefore, more free fluoride anions act as an effective base. In contrast, the preparation of clinoptilolite (KF/CP) is very easy without the need for any pre-activation [10-12]. Multicomponent reactions (MCRs), with three or more reactants join in a one-pot procedure to afford a single product [13-15]. They are economically and environmentally useful because multi-step synthesis produce large amounts of trash frequently because of complex isolation actions frequently involving comfortable, toxic, and hazardous solvents after each step [16-19]. MCRs are absolutely suited for combinatorial library synthesis and increased utilize in the finding procedure for new drugs and agrochemicals [20].

They supply a dominant tool toward the one-pot synthesis of diverse and complex compounds as well as small and drug-like heterocycles [21]. Green chemistry move towards hold out significant potential not only for reduction of byproducts, waste produced, and lowering of energy but also in the expansion of new methodologies toward before exclusive materials, using existing technologies [22]. Between existing part of chemistry, medicinal and pharmaceutical chemistry are possibly developed for greening [23]. It should be mentioned, heterocyclic compounds are a highly valuable and unique class of compounds. These compounds demonstrate a broad spectrum of physical, chemical and biological characteristics [24, 25]. In nature, heterocyclic compounds are widely distributed and display an important part in metabolism owing to their structural nucleus occurring in various natural products, including hormones, antibiotics, alkaloids, vitamins and many others. Among them, oxathiolane derivatives demonstrate a broad spectrum of biological activities such as anti-tubercular, anti-AIDS, anti-malarial, anti-microbial, antitumor, anticancer and antifungal. Herein, we report an efficient synthesis of functionalized oxathiolanes **3a-i** in good yields through the reaction of alkenes **2**, carbon disulfide **1** and methanol in the presence of hydrogen peroxide and

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KF/CP (NPs) in methanol as the solvent at room temperature (Scheme **1**).

Results and discussion

Our studies were initiated by treating a solution of alkenes **2**, carbon disulfide **1** and methanol in the presence of hydrogen peroxide and KF/CP (NPs) in methanol as the solvent at room temperature (Scheme 1). Our studies were initiated by treating a solution of carbon disulfide containing an oxirane derivative in the presence of hydrogen peroxide and KF/CP. The nucleophile derived from methanol and carbondisulfide in the presence of hydrogen peroxide and KF/CP (NPs) in methanol as the solvent at room temperature. was found to undergo a clean and facile reaction with oxiranes at room temperature to afford in excellent yields (Scheme 2). We used 0.02 g catalyst for selecting best amount of catalyst. By increasing the amount of catalyst from 0.02 g isn't seen any change in the yield of reaction. The amount of catalyst is 0.02 g in optimized condition. After each run, the catalyst was separated from the mixture of reaction and washed with ethylacetate, then dried under vacuum at room temperature.

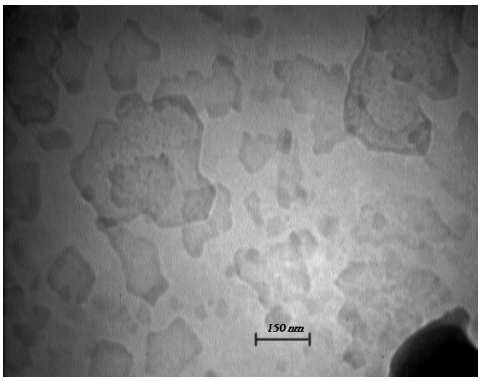


Figure 1. SEM image of KF/CP nanoparticles.

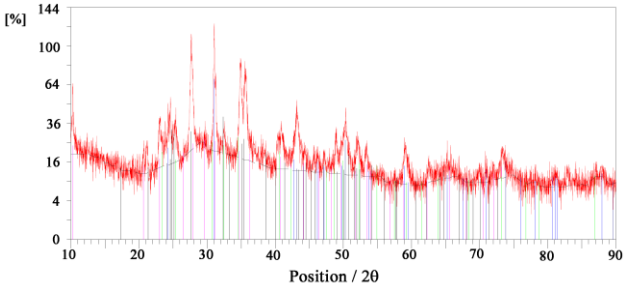
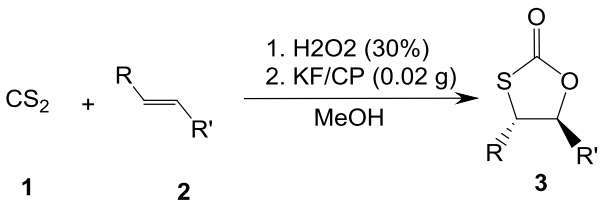


Figure 2. XRD spectra of KF/CP nanoparticles.

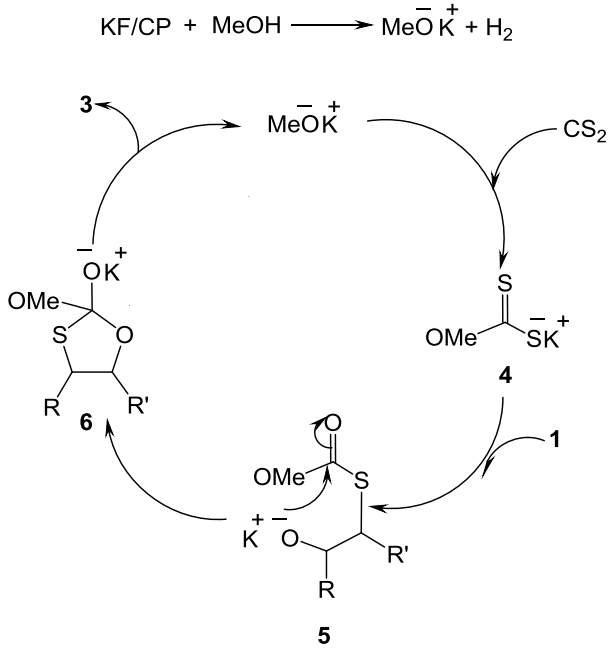


1, 3	R	R'	Yield (%) of **3**
a	Me	H	96
b	Et	H	94
c	R, R' = $(CH_2)_4$		96
d	Ph	H	95
e	$PhOCH_2$	H	94
f	$CH_2CHCH_2OCH_2$	H	94
g	$(CH_3)_2CHOCH_2$	H	96
h	Ph	Ph(*cis*)	88
i	Ph	Ph(*trans*)	86

Scheme 1: Synthesis of oxathiolane **3**

Structures of compounds **3a–3i** were confirmed by IR, ^{1}H NMR, ^{13}C NMR, and mass spectral data. For example, the ^{1}H NMR spectrum of **3a** exhibited a triplet at 1.56 (^3J = 6.7) for the methyl proton, two doublet doublets at 3.62 (2J = 11.9, ^3J = 7.4) and 3.98 (^2J = 11.9, ^3J = 6.4) for the CH_2 moiety and a multiplet at 4.45-4.51 ppm for the CH group. The ^{13}C NMR spectrum of **3a** shows a signal at 228.5 ppm for the C=O group. The mass spectrum of 3a displayed the molecular ion peak at m/z = 145. A tentative mechanism for this transformation is proposed in Scheme 2. The first step may involve addition of

methoxide ion to CS_2 and formations of the 1:1 adduct 3. Subsequent nucleophilic attack of **4** to oxirane **1** that are produced from the reaction of alkene and hydrogen peroxide, which is converted to **3** by elimination of potasium methoxide.



Scheme 2: Proposed mechanism for the formation of **3**.

Conclusion

In conclusion, the reaction of methanol and carbon disulfide with alkenes in the presence of hydrogenperoxide and KF/CP NPS (0.02 g) led to oxathiolane derivatives in excellent yields.

Experimental

General

Melting points were measured on an *Electrothermal 9100* aparatus. further purification. IR Spectra: *Shimadzu IR-460* spectrometer. ^{1}H-and ^{13}C-NMR spectra: *Bruker DRX-500 AVANCE* instrument; in $CDCl_3$ at 500.1 and 125.7 MHz, resp; δ in ppm, *j* in Hz. EI-MS (70 eV): *Finnigan-MAT-8430* mass spectrometer, in m/z. Elemental analyses (C, H, N) were performed with a *Heraeus CHN-O-Rapid* analyzer.

General Procedure for the Preparation of Compounds **3.**

To a stirred solution of CS_2 (0.35 g, 5 mmol) in MeOH (0.064 g, 2 mmol) containing KF/CP NPs (0.02 g), was added the oxirane derivative **1** (2 mmol) that are produces as in situ from the reaction of alkenes with H_2O_2 at r.t. The mixture was stirred for 12 h, and filtered to remove KOMe. The residue was purified by extraction with Et_2O to afford pure **3**.

5-Methyl-1,3-oxazole-2-one (3a):

Yellow oil, yield: 0.26 g (96%). IR (KBr) (ν_{max}/cm^{-1}): 1700, 1439, 1414, 1370, 1143, and 1073 cm^{-1}. ^{1}H NMR (500.1 MHz, $CDCl_3$): δ 1.56 (3 H, *d*, ^3J = 6.7, Me), 3.62 (1 H, *dd*, ^2J = 11.9, ^3J = 7.4, CH), 3.98 (1 H, *dd*, ^2J = 11.9, ^3J = 6.4, CH), 4.45-4.51 (1H, *m*, CH). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ 19.1 (Me), 50.3 (CH_2), 55.5 (CH), 228.5 (C=S). EI-MS: EI-MS: 134 (M^+, 15), 119 (78), 92 (100), 76 (64), 58 (48), 42 (56). Anal. Calcd for $C_4H_6OS_2$ (134.21): C, 35.80; H, 4.51; found: C, 35.90; H, 4.55%.

5-Ethyl-1,3-oxazole-2-one (3b):

Yellow oil, yield: 0.28 g (94%). IR (KBr) (ν_{max}/cm^{-1}): 1711, 1627, 1507, 1431, 1327, and 1273 cm^{-1}. ^{1}H NMR (500.1 MHz, $CDCl_3$): δ 1.07 (3 H, *t*, ^3J = 7.4, Me), 1.91-1.97 (2 H, *m*, CH_2), 3.71 (1 H, *dd*, ^2J = 11.9,

^3J = 7.5, CH), 3.98 (1 H, *dd*, ^2J = 11.9, ^3J = 5.5, CH), 4.29-4.33 (1 H, *m*, CH). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ 13.1 (Me), 27.2 (CH_2), 48.3 (CH_2), 62.9 (CH), 228.5 (C=S). EI-MS: 148 (M^+, 10), 119 (68), 92 (100), 76 (84), 56 (42), 29 (24). Anal. Calcd for $C_5H_8OS_2$ (148.24): C, 40.51; H, 5.44; found: C, 40.41; H, 5.49%.

Hexahydro-1,3-benzoxazole-2-one (3c):

Yellow crystals, yield: 0.33 g (96%); mp 176-178°C. IR (KBr) (ν_{max}/cm^{-1}): 1628, 1431, 1326, 1272, and 1094 cm^{-1}. ^{1}H NMR (500.1 MHz, $CDCl_3$): δ 1.43-1.48 (2 H, *m*, CH_2), 1.68-1.75 (2 H, *m*, CH_2), 1.93-1.97 (2 H, *m*, CH_2), 2.17-2.22 (2 H, *m*, CH_2), 4.08-4.09 (1 H, *m*, CH), 4.09-4.11 (1 H, *m*, CH). ^{13}C NMR (125.7 MHz, $CDCl_3$); δ 25.5 (2 CH_2), 29.5 (2 CH_2), 65.0 (2 CH), 227.6 (C=S). EI-MS: 174 (M^+, 5), 118 (78), 92 (100), 82 (64), 76 (48), 56 (45). Anal. Calcd for $C_7H_{10}OS_2$ (174.27): C, 48.24; H, 5.78; found: C, 48.18; H, 5.79%.

5-Phenyl-1,3-oxazole-2-one (3d):

Yellow crystals, yield: 0.30 g (95%); mp 115-117°C. IR (KBr) (ν_{max}/cm^{-1}): 1568, 1470, 1438, 1413, 1357, and 1048 cm^{-1}; ^{1}H NMR (500.1 MHz, $CDCl_3$): δ 4.03 (1 H, *dd*, ^2J = 12.0, ^3J = 5.7, CH), 4.17 (1 H, *dd*, ^2J =12.0, ^3J = 11.8, CH), 5.65 (1 H, *dd*, ^2J = 10.3, ^3J = 5.7, CH), 7.37-7.44 (3 H, *m*, 3 CH), 7.50 (2 H, *d*, ^3J = 7.2, 2 CH). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ 49.8 (CH_2), 64.2 (CH), 127.5 (2 CH), 129.2 (2 CH), 129.3 (CH), 135.3 (C), 227.2 (C=S). EI-MS: 196 (M^+, 10), 119 (76), 104 (46), 92 (25), 77 (100). Anal. Calcd for $C_9H_8OS_2$ (196.28): C, 55.07; H, 4.11; found: C, 55.03; H, 4.08%.

5-(Phenoxymethyl)-1,3-oxazole-2-one (3e):

Yellow crystals, yield: 0.42 g (94%); mp 55-57°C. IR (KBr) (ν_{max}/cm^{-1}): 1584, 1481, 1448, 1238, 1165, and 1063 cm^{-1}. ^{1}H NMR (500.1 MHz, $CDCl_3$): δ 4.06 (1 H, *dd*, ^2J = 12.3, ^3J = 4.0, CH), 4.18-4.23 (2 H, *m*, CH_2), 4.36 (1 H, *dd*, ^2J = 12.2, ^3J = 4.5, CH), 4.61-4.66 (1 H, *m*, CH), 6.93 (2 H, *d*, ^3J = 7.9, 2 CH), 7.02 (1 H, *t*, ^3J = 7.3, CH), 7.33 (2 H, *t*, ^3J = 7.5, 2 CH). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ 45.0 (CH_2), 57.4 (CH), 66.7 (CH), 114.7 (2 CH), 121.9 (CH), 129.7 (2 CH), 157.8 (C), 225.4 (C=S). EI-MS: 226 (M^+, 5), 149 (78), 134 (64), 107 (94), 92 (46), 77 (100). Anal. Calcd for $C_{10}H_{10}O_2S_2$ (226.31): C, 53.07; H, 4.45; found: C, 53.05; H, 4.40%.

5-(Vinyloxymethyl)-1,3-oxazole-2-one (3f):

Yellow oil, yield :0.36 g (94%). IR (KBr) (ν_{max}/cm^{-1}): 1702, 1630, 1451, 1414, and 1348 cm-1. ^{1}H NMR (500.1 MHz, $CDCl_3$): δ 3.64 (1 H, *dd*, ^2J = 9.8, ^3J = 5.8, CH), 3.79-3.81 (1 H, *m*, CH), 3.94 (1 H, *dd*, ^2J = 12.1, ^3J = 4.7, CH), 4.04 (2 H, *d*, ^3J = 5.6, 2 CH), 4.07 (1 H, *dd*, ^2J = 12.1, ^3J = 5.7, CH), 4.44-4.49 (1 H, *m*, CH), 5.20-5.30 (2 H, *m*, 2 CH), 5.83-5.91(1 H, *m*, CH). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ 45.4 (CH_2), 58.7 (CH), 69.4 (CH_2), 72.8 (CH_2), 118.4 (CH_2), 134.3 (CH), 227.9 (C=S). EI-MS: 190 (M^+, 15), 133 (74), 114 (58), 92 (46), 57 (100). Anal. Calcd for $C_7H_{10}O_2S_2$ (190.27): C, 44.19; H, 5.30; found: C, 44.15; H, 5.36%.

5-(Isopropoxymethyl)-1,3-oxazole-2-one (3g):

Pall yellow oil, yield: 0.37 g (96%). IR (KBr) (ν_{max}/cm^{-1}): 1703, 1643, 1452, 1417, 1372, and 1332 cm^{-1}. ^{1}H NMR (500.1 MHz, $CDCl_3$): δ 1.12 (6 H, *d*, ^3J = 6.1, 2 Me), 3.53-3.62 (2 H, *m*, CH_2), 3.73 (1 H, *m*, CH), 3.89 (1 H, *dd*, ^2J = 12.0, ^3J = 4.9, CH), 4.01 (1 H , *dd*, ^2J = 12.0, ^3J = 5.7, CH), 4.36-44.40 (1 H, *m*, CH). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ 21.7 (Me), 21.8 (Me), 44.7 (CH_2), 58.6 (CH_2), 67.0 (CH), 72.3 (CH), 227.3 (C=S). EI-MS: 192 (M^+, 5), 149 (84), 119 (25), 116 (52), 92 (32), 43 (42), 73 (100). Anal. Calcd for $C_7H_{12}O_2S_2$ (192.29): C, 43.72; H, 6.29; found: C, 43.85; H, 6.26%.

4,5-Diphenyl-1,3-oxazole-2-one (3h):

Yellow crystals, yield: 0.48 g (88%); mp 123-125°C. IR (KBr) (ν_{max}/cm^{-1}): 1475, 1435, 1140, and 1050 cm^{-1}. ^{1}H NMR (500.1 MHz, $CDCl_3$): δ 4.41 (1 H, *s*, CH), 5.74 (1 H, *s*, CH), 7.13-7.17 (5 H, *m*, 5 CH), 7.31-7.33 (5 H, *m*, 5 CH). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ 44.5 (CH), 70.6 (CH), 127.6 (CH), 128.1 (2 CH), 128.5 (2 CH), 129.5 (2 CH), 129.6 (CH), 129.8 (2 CH), 133.6 (C), 135.5 (C), 225.3 (C=S). EI-MS: 272 (M^+, 15), 196 (78), 180 (64), 92 (58), 77 (100). Anal. Calcd for $C_{15}H_{12}OS_2$ (272.38): C, 66.15; H, 4.44; found: C, 66.08; H, 4.39%.

4,5-Diphenyl-1,3-oxazole-2-one (3i):

Yellow crystals, yield: 0.47g(86%); mp 127-129°C. IR (KBr) (ν_{max}/cm^{-1}): 1479, 1439, 1142, and 1056 cm^{-1}. ^{1}H NMR (500.1 MHz, $CDCl_3$): δ 4.08 (1 H, *s*, CH), 5.76 (1 H, *s*, CH), 7.00 (2 H, *d*, ^3J = 7.4, 2 CH), 7.18 (2 H, *t*, ^3J = 7.8, 2 CH), 7.27-7.30 (3 H, *m*, 3 CH), 7.38 (2 H, *t*, ^3J = 7.5, 2 CH), 7.54 (1 H, *d*, ^3J = 7.4, CH). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ 45.9 (CH), 68.4 (CH), 126.9 (2 CH), 128.0 (CH), 128.8 (2 CH), 129.1 (2 CH), 129.2 (2 CH), 129.3 (CH), 133.5 (C), 137.7 (C), 227.9 (C=S). EI-MS: 272 (M^+, 15), 196 (76), 180 (62),

92 (62), 77 (100). Anal. Calcd for $C_{15}H_{12}OS_2$ (272.38): C, 66.15; H, 4.44; found: C, 66.08; H, 4.46%.

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