ISSN: 0974 - 7516 Volume 9 Issue 12

Organic CHEMISTRY

An Indian Journal

Microreview

OCAIJ, 9(12), 2013 [500-503]

Effects of different reaction conditions on the synthesis of propylene carbonate

Xiaoli Zhang

Chemical Department, Liaoning Shihua University, Fushun, (CHINA)

E-mail: zhangxl6650223@outlook.com

ABSTRACT

The main properties of propylene carbonate have been introduced. Different catalysts that consist of inorganic salt like basic zinc carbonate-activated carbon, metal matrix composites of Al_2O_3 and MgO with loading Cu and magnaliumhydrotalcite with loading Snhave also been introduced. Effects of different reaction conditions such as the calcination temperature, the calcination time, the reaction temperature and the number of reusable catalyston the synthesis of propylene carbonate fromurea and propylene glycolare discussed. The optimum calcination temperature, the calcination time, the reaction temperature and the number of reusable catalystare beneficial to improve the yield of the product, propylene carbonate.

KEYWORDS

Overview;
Reaction conditions;
Propylene carbonate.

INTRODUCTION

Propylene carbonate (PC) is one kind of organic solvents witha high performance such as a high boiling point and a high polarity, etc[1]. Propylene carbonate as a major feedstock is widely used in different fields such as organic synthesis[2], gas separation[3] and the battery electrolyte[4], etc. There are four synthetic methods listed as follows, such as phosgenation[5], transesterification method[6], chlorine/propanol method[7] and the synthetic method of carbon dioxide and propylene oxide[8], etc. The synthetic method of carbon dioxide and propylene oxide gradually takes the places of other methods due to poor product performance. These advantages of propylene carbonate instead of carbon dioxide are written as follows, decreasing the greenhouse effect in the atmosphere, high value chemical productsand energy utilization rate, so the synthetic methods of propylene carbonate is gradually focused on.

In the present paper, different catalysts such as inorganic salt like basic zinc carbonate-activated carbon, metal matrix composites of $Al_2O_3$and MgO with loading Cu and magnaliumhydrotalcite with loading Snhave been evaluated inthe synthesis of propylene carbonate. Effects of differentreaction conditions, such as the calcination temperature, the calcination time, the reaction temperature and the number of reusable catalyst, on the synthetic method of propylene carbonate have been reviewed. Furthermore, theoptimized reaction conditions are also pointed out.

RESULTS AND DISCUSSION

The properties of propylene carbonate

TABLE 1 shows the properties of propylene carbonate[9].

TABLE 1 : The properties of propylene carbonate

Items	Properties
Molecular formula	$C_4H_6O_3$
Molecular weight	102.9
Refractive index	1.4218
Melting point (°C)	-49.2
Boiling point (°C)	238.4
Flash point (°C)	128
Relative density	1.2047
Vapor pressure (20°C /pa)	17.33
Appearance	Colorless and tasteless liquid under the room temperature
Solubility	Easily mix with diethyl ether, acetone, benzene, trichloromethane, ethyl acetate, etc.

EFFECTS OF DIFFERENT CONDITIONS ON YIELDS OF PROPYLENE CARBONATE

Effects of the calcination temperature on yields of propylene carbonate

Du Weichao[10] developed a method for the preparation of propylene carbonate and effects of reaction conditions on its yield were discussed. Using basic zinc carbonate-activated carbon as a catalyst andurea and propylene glycol as feedstocks, propylene carbonate was generated. It was observed that the molarratio of propylene glycol to urea and the amount ofbasic zinc carbonate-activated carbonwere 2.5:1.0 and 1.0 %of total reactant weight, respectively. Furthermore, the reaction temperature, the reaction time, the reaction pressure and the calcination time were 170 °C, 2 hr, 0.04 Mpa and 2 hr, respectively. Effects of the calcination temperature on yields of propylene carbonate had also beendiscussed. Figure 1 showed the effect of the calcination temperature on yields of propylene carbonate. The experimental resultsshowed that the yield of propylene carbonate increased withan increase of the calcination temperature. When the calcination temperature was 220°C,the maximum yield of propylene carbonate was 94.5%, sothe optimized calcination temperature was proved to be 220°C.

Effects of the calcination time on yields of propylene carbonate

Du Weichao[10] explained why basic zinc carbonate - activated carbon as a catalyst generatedpropylene carbonate. It was observed that the molar ratio of propylene glycol to urea and the amount of basic zinc carbonate-activated carbon were 2.5:1.0 and 1.0 % of total reactant weight, respectively. Furthermore, the reaction temperature, the reaction time, the reaction pressure and the calcination temperature were 170 °C, 2 hr, 0.04 Mpa and 220 °C, respectively. Effects of thecalcination time on yields of propylene carbonate hadbeen discussed. TABLE 2 showed the effect of the calcination time on yields of propylene carbonate. The yield of propylene carbonate firstincreased and then decreased with an increase of the calcination time. When the calcination time was 2hr, the maximum yield of propylene carbonate reached 94.5%, so the optimized calcination time was 2 hrs.

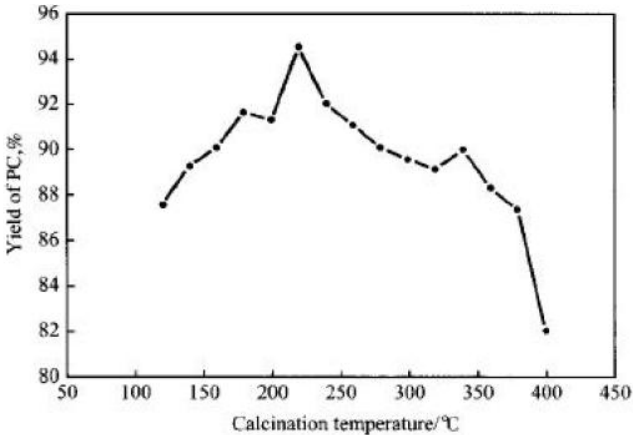

Figure 1: The effect of the calcination temperature on yields of propylene carbonate

TABLE 2 : The effect of the calcination time on yields of propylene carbonate

Calcination time, hr	Yield of PC, %
0	84.5
1	91.9
2	94.5
3	91.7
4	89.8
5	85.8

Effects of the reaction temperature on yields of propylene carbonate

Liu Yuan[11] used metal matrix composites of Al_2O_3 and MgO with loading Cuas a catalyst while the molar ratio of propylene glycol to urea(4.0:1.0), the reaction time (3hr) and the weight ratio of metal matrix composites of Al_2O_3 and MgO with loading Cuto to-

tal reactant (1.0 %) were kept constants. Effects of the reaction temperature on yields of propylene carbonate, TABLE 3, indicated that the yield of propylene carbonate first increased and then decreased withan increase in the reaction temperature. It was observed that the maximum yield of propylene carbonate reached 95.2 % when the reaction temperature was 170 °C.

TABLE 3 : The effect of the reaction temperature on yields of propylene carbonate

Reaction temperature, °C	Yield of PC, %
140	85.6
150	88.7
160	93.7
170	95.2
180	89.3

Effects of the reaction time on yields of propylene carbonate

Liu Yuan[11] described the synthesis of propylene carbonate and studied effects of different reaction conditions on yields of propylene carbonate using metal matrix composites of Al_2O_3 and MgO with loading Cu as the catalyst. The molar ratio of propylene glycol to urea (4.0:1.0) and the reaction temperature (170 °C) and the weight ratio of metal matrix composites of Al_2O_3 and MgO with loading Cuto total reactant (1.0 %) were kept constants while studying effects of the reaction time on yields of propylene carbonate. TABLE 4 showed that the yield of propylene carbonate first increased and thendecreased with an increase in the reaction time. It was observedthat the maximum yield of propylene carbonate 95.2 % was attained when the reaction time was 3 hr.

TABLE 4 : The effect of the reaction time on yields of propylene carbonate

Reaction time, hr	Yield of PC, %
2	86.3
3	95.2
4	92.5
5	86.9
6	72.5
7	69.1
8	68.2

Effects of the number of reusable catalyston yields of propylene carbonate

Liu Yuan[12] introduced a synthetic method of propylene carbonate and evaluated effects of reactionconditions on the yield of propylene carbonate. Propylene glycol was reacted with urea to produce propylene carbonate with magnaliumhydrotalcite with loading Sn as the catalyst. The reactiontime, the reaction temperature, the molar ratio of propylene glycol to urea and theamount of the catalyst were kept to be constants at 3 hr, 170 °C, 4.0:1.0 and 1.5 % of total reactant weight, respectively. Magnaliumhydrotalcite with loading Snas the catalyst was reused five times. Figure 2showed the relationship between the yield of propylene carbonate and the number of magnaliumhydrotalcite with loading Sn reusing. Whenmagnaliumhydrotalcite with loading Sn was reused 5 times, the yield of propylene carbonate still kept at above 81.07 %, somagnaliumhydrotalcite with loading Snwasproved to be the best catalyst.

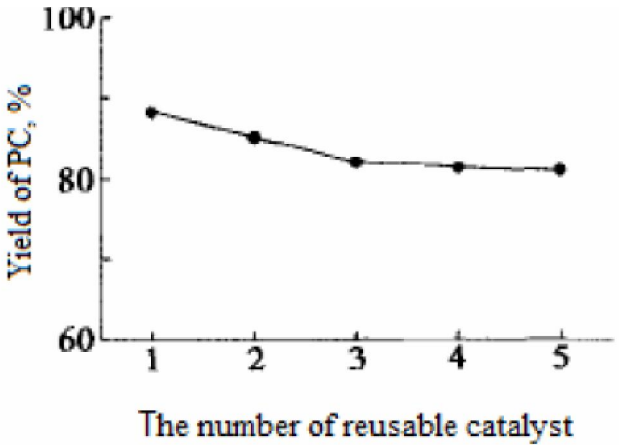

Figure 2 : The relationship between the yield of propylene carbonate and the number of magnaliumhydrotalcite with loading Sn reusing

CONCLUSION

Based on the above discussion and review, using urea and propylene glycol as feedstocks and basic zinc carbonate - activated carbon, metal matrix composites of Al_2O_3 and MgO with loading Cu and magnaliumhydrotalcite with loading Snas catalysts, effects of the calcination temperature, the calcination time, the reaction temperature and the number of reusable

catalyston yields of propylene carbonate have been discussed. The experimental results obtained are the following:

(1) The maximum yield of propylene carbonate was 94.5% when the calcination temperature was 220°C.
(2) When the calcination time was 2hr, the maximum yield of propylene carbonate reached 94.5%.
(3) The maximum yield of propylene carbonate reached 95.2 % when the reaction temperature was 170 °C.
(4) The maximum yield of propylene carbonate 95.2 % was attained when the reaction time was 3 hr.
(5) The maximum yield of propylene carbonate was still kept 81.07% even after 5 recycling of magnaliumhydrotalcite with loading Sn catalyst.

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