

STUDYING OF THE CONDITIONS OF ERYTHRITOL, MANNITOL, SORBITOL, XYLITOL, TARTARIC AND CITRIC ACIDS ESTERIFICATION BY USING HIGH ALIPHATIC CARBOXYLIC ACIDS AND ALCOHOLS

G. S. GRIGORYAN *, A. Ts. MALKHASSYAN **

Chair of Organic Chemistry, YSU, Armenia

A comparative study of the esterification reactions of erythritol, mannitol, sorbitol, xylitol, citric and tartaric acids with higher aliphatic acids and alcohols without catalysts and under conditions for acid catalysis at temperatures of 150–200°C has been carried out. Optimum temperatures and conditions for the expediency of using solvents and acid catalysts to increase the yields of esters were determined.

Keywords: esterification, erythritol, 1,2,4-butanetriol, mannitol, sorbitol, xylitol, decyl, dodecyl, pentadecyl alcohols, citric, tartaric, stearic, palmitic acids.

Introduction. In previous studies we studied the esterification reactions of polyatomic alcohols (erythritol, mannitol, sorbitol and others) with higher fatty acids (HFA): stearic, palmitic, oleic, etc., as well as polyatomic acids (citric, tartaric, grape) with higher aliphatic alcohols (HAA): decyl, pentadecyl, etc. [1–5]. As a result, the properties of various non-glyceride oils and fats were obtained and described. During the research it was observed that the optimal reaction conditions were strongly dependent on each alcohol-acid pair, which cannot be combined into a standard esterification procedure. For example, when esterifying in a toluene solution of 1,4-butanediol with stearic, palmitic and oleic acids, the efficiency of the reaction increased with the addition of acid catalysts [1]. However, during the esterification of mannitol and sorbitol the use of acids and solvents was inexpedient [2]. And in the case of esterification of erythritol and isomeric butanetriols with the same carboxylic acids, with or without catalysts, the use of solvent N-methylpyrrolidone (N-MP) was required [3]. The esterification of tartaric and grape acids with HFA acids smoothly proceeds without catalysts and solvent [4]. However, in the case of citric acid, the reaction does not proceed without the solvent [5]. Out of solvents used, only aprotic dipolar solvents, in particular N-methylpyrrolidone, turned out to be effective. Dimethylformamide or dimethyl sulfoxide can also be used [3–5].

The variety of optimal reaction conditions for different polyols and carboxylic acids requires a rational explanation. It also seems desirable to substantiate the general recommendations regarding the advisability of using solvents and acid catalysts, as well as the optimal temperature regimens, for the preparation of esters of polyols.

* E-mail: grigor-1955@mail.ru

** E-mail: amalkhasyan@ysu.am

Thus, in scope of the experimental work of obtaining non-glyceride oils and fats, it becomes expedient to conduct a study targeting to improve and unify the experimental procedures of the esterification reactions. For this study, polyols (mannitol, sorbitol, xylitol, erythritol and 1,2,3-butanetriol), as well as HFA (stearic and palmitic) were taken. Conditions close to the optimal were taken for the esterification. The reaction temperature ranged from 150–200°C in a solution of N-MP, either without a solvent, without a catalyst, or in the presence of 0.01–0.1 wt.% 4-toluenesulfonic acid (TSA). The reaction time was 10 h.

A similar approach was used to study the esterification of polyacids (tartaric and citric) with HFA (decyl, dodecyl and pentadecyl).

Experimental Part.

General Method of Esterification. The reaction is carried out on a combined reactive distillation unit, including a thermostatically controlled magnetic stirrer reactor and a distillation column with a Dean-Stark packing for condensation of water vapor. 10 mmol of polyol and 30 mmol (butanetriols) or 40 mmol (xylitol, mannitol, sorbitol) of HFA are placed in the reactor. For the esterification of citric or tartaric acids, 10 mmol of acid per each and 30 or 20 mmol of HAA are added, respectively. The reaction unit is pumped out of air (4 mm Hg) and heated with stirring. When the set temperature is reached, nitrogen is passed into the reactor (10–15 mL/min, 20–30 mm Hg).

Table 1

Esterification of C₄ polyols with palmitic and stearic acids, reaction time is 10 h

№	Polyol	Acid	Polyol, ratio to acid, mol	T, °C	Presence of N-MP, w/w	Presence of TSA, wt. %	Yield, mol %	Melt. point, °C, physical state
1	erythritol	palmitic	1 : 4.1	150	1 : 3	absent	90	97–99, solid
2		palmitic	1 : 4.1	180	1 : 3	absent	96	68–71, solid
3		palmitic	1 : 4.1	200	1 : 3	absent	95	99–102, solid
4		palmitic	1 : 4.1	150	absent	absent	17	55–63, soft
5		palmitic	1 : 4.1	180	absent	absent	20	50–59, soft
6		palmitic	1 : 4.1	200	absent	absent	24	63–76, soft
7		stearic	1 : 4.1	150	1 : 3	absent	97	98–100, solid
8		stearic	1 : 4.1	180	1 : 3	absent	96	98–102, solid
9		stearic	1 : 4.1	200	1 : 3	absent	96	98–103, solid
10		palmitic	1 : 4.1	180	1 : 3	0.01%	96	98–103, solid
11		palmitic	1 : 4.1	180	1 : 3	0.1%	97	98–103, solid
12		palmitic	1 : 4.1	180	absent	0.1%	42	77–79, soft, burnt, blackened
13	stearic	1 : 4.1	180	1 : 3	0.1%	97	98–105, solid	
14	1,2,4-butanetriol	palmitic	1 : 3.1	150	1 : 3	absent	86	55–58, soft
15		palmitic	1 : 3.1	180	1 : 3	absent	96	68–71, soft
16		palmitic	1 : 3.1	200	1 : 3	absent	95	77–79, solid
17		palmitic	1 : 3.1	150	absent	absent	20	72–76, soft
18		palmitic	1 : 3.1	180	absent	absent	32	80–83, solid
19		palmitic	1 : 3.1	200	absent	absent	29	83–86, solid
20		stearic	1 : 3.1	150	1 : 3	absent	84	90–96, solid
21		stearic	1 : 3.1	180	1 : 3	absent	96	92–96, solid
22		stearic	1 : 3.1	200	1 : 3	absent	96	92–96, solid
23		palmitic	1 : 3.1	180	1 : 3	0.01	96	74–79, soft
24		palmitic	1 : 3.1	180	1 : 3	0.1	97	77–79, solid
25		palmitic	1 : 3.1	180	absent	0.1	30	77–79, solid
26	stearic	1 : 3.1	180	1 : 3	0.1	94	94–97, solid	

The experiments in the solvent are carried out with the addition of N-MP, taken in a threefold weight excess relative to the amount of reagents. The experiments with a catalyst are performed by adding to the reaction mixture 0.01– 0.1 wt.% TSA.

Table 2

Esterification of C₅₋₆ polyols with palmitic and stearic acids, reaction time is 10 h

№	Polyol	Acid	Polyol, ratio to acid, mol	T, °C	Presence of N-MP, w/w	Presence of TSA, wt.%	Yield, mol %	Melt. point, °C, physical state
1	mannitol	palmitic	1 : 6.1	150	1 : 3	absent	90	97–99, solid
2		palmitic	1 : 6.1	180	1 : 3	absent	96	68–71, solid
3		palmitic	1 : 6.1	200	1 : 3	absent	95	99–102, solid
4		palmitic	1 : 6.1	150	absent	absent	17	55–63, soft
5		palmitic	1 : 6.1	180	absent	absent	20	50–59, soft
6		palmitic	1 : 6.1	200	absent	absent	24	63–76, soft
7		stearic	1 : 6.1	150	1 : 3	absent	97	98–100, solid
8		stearic	1 : 6.1	180	1 : 3	absent	96	98–102, solid
9		stearic	1 : 6.1	200	1 : 3	absent	96	98–103, solid
10		palmitic	1 : 6.1	180	1 : 3	0.01	96	98–103, solid
11		palmitic	1 : 6.1	180	1 : 3	0.1	97	98–103, solid
12		palmitic	1 : 6.1	180	absent	0.1	42	77–79, soft, burnt
13		stearic	1 : 6.1	180	1 : 3	0.1	97	98–105, solid
14	sorbitol	palmitic	1 : 6.1	150	1 : 3	absent	86	55–58, soft
15		palmitic	1 : 6.1	180	1 : 3	absent	96	68–71, soft
16		palmitic	1 : 6.1	200	1 : 3	absent	95	77–79, solid
17		palmitic	1 : 6.1	150	absent	absent	20	72–76, soft
18		palmitic	1 : 6.1	180	absent	absent	32	80–83, solid
19		palmitic	1 : 6.1	200	absent	absent	29	83–86, solid
20		stearic	1 : 6.1	150	1 : 3	absent	84	90–96, solid
21		stearic	1 : 6.1	180	1 : 3	absent	96	92–96, solid
22		stearic	1 : 6.1	200	1 : 3	absent	96	92–96, solid,
23		palmitic	1 : 6.1	180	1 : 3	0.01	96	74–79, soft
24		palmitic	1 : 6.1	180	1 : 3	0.1	97	77–79, solid
25		palmitic	1 : 6.1	180	absent	0.1	30	77–79, solid
26		stearic	1 : 6.1	180	1 : 3	0.1	94	94–97, solid
27	stearic	1 : 6.1	180	1 : 3	0.1	97	98–105, solid	
28	xylytol	palmitic	1 : 5.1	150	1 : 3	absent	86	55–58, soft
29		palmitic	1 : 5.1	180	1 : 3	absent	96	68–71, soft
30		palmitic	1 : 5.1	200	1 : 3	absent	95	77–79, solid
31		palmitic	1 : 5.1	150	absent	absent	20	72–76, soft
32		palmitic	1 : 5.1	180	absent	absent	32	80–83, solid
33		palmitic	1 : 5.1	200	absent	absent	29	83–86, solid
34		stearic	1 : 5.1	150	1 : 3	absent	84	90–96, solid
35		stearic	1 : 5.1	180	1 : 3	absent	96	92–96, solid
36		stearic	1 : 5.1	200	1 : 3	absent	96	92–96, solid,
37		palmitic	1 : 5.1	180	1 : 3	0.01	96	74–79, soft
38		palmitic	1 : 5.1	180	1 : 3	0.1	97	77–79, solid
39		palmitic	1 : 5.1	180	absent	0.1	30	77–79, solid
40	stearic	1 : 5.1	180	1 : 3	0.1	94	94–97, solid	

The course of the reaction is monitored by the release of water in the Dean-Stark trap; in addition, a sample is taken every 3 h and the content of starting materials and products is determined chromatographically. Then the reaction mixture is cooled down, purged with nitrogen to remove the moisture, dissolved in 25 mL of diisopropyl ether, the remaining acid is separated, washed with 4×20 mL of water to remove residual reagents, N-MP and dried to constant weight. The product is re-precipitated from 50 mL of 80°C ethanol, the resulting oil is dried to constant weight, weighed and analyzed. Product yields are shown in Tabs. 1–4.

Table 3

Esterification of citric acid with aliphatic alcohols, reaction time 10 h

№	Alcohol	Ratio of HAA to acid, mol	T, °C	Presence of N-MP, w/w	Presence of TSA, wt. %	Yield, mol %	Melt. point, °C, physical state
1	pentadecyl	1 : 3.3	150	1 : 3	absent	90	53–56, soft
2	pentadecyl	1 : 3.3	180	1 : 3	absent	96	54–58, soft
3	pentadecyl	1 : 3.3	200	1 : 3	absent	95	55–58, solid
4	pentadecyl	1 : 3.3	150	absent	absent	93	52–53, soft
5	pentadecyl	1 : 3.3	180	absent	absent	97	56–59, solid
6	pentadecyl	1 : 3.3	200	absent	absent	97	55–58, solid
7	pentadecyl	1 : 3.3	150	1 : 3	0.01	96	54–58, solid
8	pentadecyl	1 : 3.3	180	1 : 3	0.1	90	56–59, solid
9	pentadecyl	1 : 3.3	200	absent	0.1	80	57–60, solid
10	dodecyl	1 : 3.3	150	1 : 3	absent	96	39–41, soft
11	dodecyl	1 : 3.3	180	1 : 3	absent	98	39–41, soft
12	dodecyl	1 : 3.3	200	1 : 3	absent	97	41–43, solid
13	dodecyl	1 : 3.3	150	absent	absent	96	40–43, soft
14	dodecyl	1 : 3.3	180	absent	absent	98	39–41, soft
15	dodecyl	1 : 3.3	200	absent	absent	97	39–41, solid
16	dodecyl	1 : 3.3	150	1 : 3	0.01	97	39–41, soft
17	dodecyl	1 : 3.3	180	1 : 3	0.1	95	39–41, solid
18	dodecyl	1 : 3.3	200	1 : 3	0.1	89	39–41, solid
19	decyl	1 : 3.3	150	1 : 3	absent	94	36–38, soft
20	decyl	1 : 3.3	180	1 : 3	absent	96	36–40, soft
21	decyl	1 : 3.3	200	1 : 3	absent	98	38–41, soft
22	decyl	1 : 3.3	150	absent	absent	96	35–39, soft
23	decyl	1 : 3.3	180	absent	absent	98	35–41, soft
24	decyl	1 : 3.3	200	absent	absent	97	38–41, soft
25	decyl	1 : 3.3	150	1 : 3	0.01	96	34–38, soft
26	decyl	1 : 3.3	180	1 : 3	0.1	98	36–39, soft
27	decyl	1 : 3.3	200	absent	0.1	98	37–40, solid

The Tab. 1 shows the results of experiments on the esterification of C₄ polyols with palmitic and stearic acids.

A similar study was carried out on the esterification of polyols of the C₆ series: mannitol, sorbitol and xylitol with palmitic and stearic acids (Tab. 2).

The Tab. 3 shows the results of experiments on the esterification of citric acid with pentadecyl, dodecyl and decyl alcohols.

The Tab. 4 shows the results of experiments on the esterification of tartaric acid with pentadecyl and dodecyl alcohols.

Table 4

Esterification of tartaric acid palmitic and stearic acid, reaction time 10 h

№	Alcohol	Ratio of HAA to acid, mol	T, °C	Presence of N-MP, w/w	Presence of TSA, wt. %	Yield, mol %	Melt. point, °C, physical state
1	palmitic	1 : 2.1	150	1 : 3	absent	95	71–74, soft
2	palmitic	1 : 2.1	180	1 : 3	absent	96	73–76, soft
3	palmitic	1 : 2.1	200	1 : 3	absent	95	73–78, solid
4	palmitic	1 : 2.1	150	absent	absent	93	81–84, soft
5	palmitic	1 : 2.1	180	absent	absent	97	83–86, solid
6	palmitic	1 : 2.1	200	absent	absent	97	85–88, solid
7	palmitic	1 : 2.1	150	1 : 3	0.01%	96	84–68, solid
8	palmitic	1 : 2.1	180	1 : 3	0.1%	90	76–79, soft
9	palmitic	1 : 2.1	200	absent	0.1%	80	77–80, solid
10	stearic	1 : 2.1	150	1 : 3	absent	96	78–81, solid
11	stearic	1 : 2.1	180	1 : 3	absent	98	79–84, solid
12	stearic	1 : 2.1	200	1 : 3	absent	97	78–84, solid
13	stearic	1 : 2.1	150	absent	absent	96	75–80, solid
14	stearic	1 : 2.1	180	absent	absent	98	78–82, solid
15	stearic	1 : 2.1	200	absent	absent	97	81–84, solid
16	stearic	1 : 2.1	150	1 : 3	0.01%	97	76–80, solid
17	stearic	1 : 2.1	180	1 : 3	0.1%	95	79–82, solid
18	stearic	1 : 2.1	200	absent	0.1%	89	79–84, solid
19	dodecyl alcohol + stearic acid	1 : 2 : 2	180	1 : 3	0.1%	89	96–100, solid
20	dodecyl alcohol + stearic acid	1 : 2 : 2	180	absent	0.1%	90	96–100, solid
21	pentadecyl alcohol + stearic acid	1 : 2 : 2	180	1 : 3	absent	98	116–120, solid
22	pentadecyl alcohol + palmitic acid	1 : 2 : 2	180	absent	absent	96	113–118, solid

Results and Discussion. In order to perform a synthesis of non-glyceride oils and fats, we should address the following complex issues. First, polyols, polyacids, HAA and HFA are usually solid and mutually insoluble substances. Secondly, when heated, polyols, polyacids, HAA and HFA do not dissolve entirely and, therefore, the esterification reactions usually proceed under heterogeneous conditions. Thirdly, there are restrictions for increasing the reaction temperature due to side reactions causing splitting of polyols and polyol esters. Therefore, in contrast to monohydric alcohols, esters of polyhydric alcohols are obtained (using an excess of HFA) in order to complete the esterification reaction. A method for removing the excess acid after the reaction should also be developed, to eliminate the possibility of contamination of the obtained oil with chemicals or solvents. Conversely, during preparation of esters of polyatomic acids, a slight excess of HAA and an effective method of removing excess alcohol from the oil are required.

In addition, special conditions are necessary for simultaneous removal of water by heating the reaction mixture.

Azeotropic Esterification. The theoretical amounts of polyol and fatty acid are heated in the presence of a boiling solvent (for example toluene or xylene), which carries away the water formed during the reaction. For collecting water in laboratory preparations, a simple trap such as Dean-Stark is used. Measuring the amount of distilled water during the reaction offers a convenient way to monitor the progress of the reaction. The temperature of the azeotropic distillation can be precisely controlled by the amount of solvent. The azeotropic solvent (usually toluene or xylene) is washed and the sublimate is returned to the reaction vessel. In our works, azeotropic distillation of water with toluene was effectively used in the esterification of 1,4-butanediol with stearic, palmitic and oleic acids [1].

Esterification Using Bubbling Inert Gases. The rate and degree of esterification of polyols are improved by purging inert gases such as carbon dioxide or nitrogen through the reaction mixture [6]. Water is carried away by a gas stream, which results in a loss of polyol and fatty acids. When producing oils from 1,4-butanediol, we used nitrogen as an inert gas to facilitate the stripping of water vapor and to supply the gaseous HCl and HBr catalysts to the reactor [1]. During the esterification of mannitol and sorbitol, the reaction mixture was purged with helium [2].

Vacuum Esterification. Esterification under reduced pressure offers the most efficient and practical method of esterification with polyatomic alcohols [6]. The moderately fast reaction rate is maintained at a lower temperature, than for other processes with good color retention. The most important polyols used for esterification are moderately volatile at the temperatures of vacuum esterification. A reflux condenser mounted above the reactor minimizes the reagent losses. Erythritol was esterified under reduced pressure (20–40 mm Hg), which significantly speeded up the reaction and brightened the product [3]. The combination of vacuum esterification and bubbling of an inert gas appeared to be the most practical reaction in terms of speed, maximum yield and color of the product.

The Use of Acid Catalysts. There is an extremely voluminous literature on the catalysis of the product esterification reaction [7]. The majority of catalysts that have been described are acids, such as sulfuric, hydrochloric, phosphoric, sulfonic, trifluoroacetic, boron trifluoride, alkyl phosphoric acids, etc. [6, 7]. Catalysts can be used to accelerate the esterification of polyols, but they usually impair the color of the product [1–5].

We also noticed difficulties during the esterification reaction conducted by classical methods using acid catalysts [1, 7]. In many experiments abundant tarring was observed. There were also difficulties related to cleaning the reaction products from the starting materials. It was concluded that the mineral acids are ineffective as catalysts for production of high-boiling oils. In further studies we abandoned the use of acid catalysts.

According to the source [6], studying the esterification of unsaturated acids with some polyols, it was concluded that in a “sufficiently extensive study of catalysts, none was found to give sufficiently good results to justify the use either commercially or in a laboratory. In all cases, the catalyst increased the initial rate of esterification; but eventually, if a low acid value was needed, time required for

achieving the acid number was the same as without the catalyst". The results of our studies largely coincide with this conclusion, except for the esterification reaction of 1,4-butanediol BAC [1]. The relatively low-boiling glycol restricts the use of high temperature and very low pressure during the synthesis. Therefore, only in this case the acceleration of synthesis by acid catalysts is justified.

Homogenization of the Reaction Mixture. It is very important to assure good mixing of the reaction mixture during the esterification reactions, especially in large-scale experiments. Normally, polyols with HFA and polyatomic acids with HAA do not mix even in the molten state. Ordinary propeller-type stirrers do not mix solid polyols with viscous, heavy fatty acids adhering to the bottom of the reaction vessel [2–5]. We used magnetic stirrers in flat-bottomed flasks to ensure scraping of reagents from the bottom. In addition, the reactions were carried out in oil baths, avoiding local overheating. This is especially important to avoid splitting and even charring of polyols. In cases when the reaction did not proceed due to the mutual insolubility of the reactants, molten reactants were dissolved in high-boiling polar solvents: DMF, DMSO and, especially, N-MP. As a result, the reaction mixture successfully got homogenized and the target products in high yields, i.e. non-glyceride oils were obtained. In particular, this method of homogenizing the reaction mixture was used during acquisition of oils of erythritol, isomeric butanetriols, citric, tartaric and grape acids [2–5].

The Reaction Temperature. Temperature is another important parameter of the esterification reaction. Sometimes the first signs of a reaction are observed at 100–120°C. But in reality, the esterification of polyols is carried out in the temperature range of 150–220°C. The choice of temperature also depends on the pair of polyol+HAA, since during the synthesis it is necessary to ensure a balance between high product yield and its quality (according to chemical analysis, the absence of bitter taste and light color). For example, in the esterification of 1,4-butanediol with stearic, palmitic and oleic acids in the presence of a solvent – toluene, the reaction temperature could not be above its boiling point of 108°C. In the absence of toluene, the reaction can be carried out at 120–180°C. Due to the impossibility of raising the reaction temperature above the boiling point of 1,4-butanediol, the reaction proceeds slowly. Acceleration of the reaction was achieved by the addition of acids HCl, HBr, H₂SO₄, CuCl₂, p-toluenesulfonic acid and others, as well as by azeotropic distillation with nitrogen purging.

Mannitol and sorbitol are solids with melting points of 167–170°C and 98–100°C, respectively. When heated above 140°C and stirring, a homogeneous melt forms and the reaction proceeds at an optimum temperature of 190–200°C for 6–20 h with yields of about 90–93%. Heating to 220°C leads to a noticeable pitch.

Erythritol is a solid with a melting point of 121°C, 1,2,3-butanetriol and 1,2,4-butanetriol are thick transparent liquids (m.p. near –20°C). Heating and mixing of polyols with HFA do not ensure the homogenization of the reaction mixture. The esterification reaction of polyols becomes possible only in the presence of N-MP solvent and successfully proceeds at a temperature of 160–190°C with yields of 92–96% in 8–20 h. When heated to 200°C, the reaction products darken, indicating a decrease in oil quality.

The esterification of citric acid with HAA (pentadecyl, dodecyl, decyl, nonyl, octyl, hexyl, etc.) is also performed in solvents – N-MP, DMF or DMSO. The reaction proceeds successfully at a temperature of 150–180°C for 8–20 h. The yield is up to 97%. An increase in temperature leads to deterioration of the product's color. In a DMSO solvent with prolonged heating, the product acquires an unnatural smell of mercaptans. For purification, the product is recrystallized from ethanol.

The esterification of tartaric acid by higher aliphatic alcohols proceeds according to the same patterns. The reaction proceeds smoothly in N-MP at 150–180°C in two stages, 10 h each. The first stage is the azeotropic esterification of the hydroxyl groups of tartaric acid with stearic, palmitic and oleic acids. The yields of disubstituted ether acids are $93 \pm 3\%$. In the second stage, performed *in situ*, the ester acids obtained are esterified at 150–180°C with dodecyl, pentadecyl and other alcohols. In the second stage, the yields of tetra-substituted esters are $84 \pm 8\%$.

Conclusion. Thus, for carrying out the esterification reaction of polyols with higher aliphatic acids or polyacids with higher aliphatic alcohols, the following patterns can be formulated. The following conditions are optimal: a temperature range of 150–200°C, azeotropic distillation using reduced pressure or an inert gas flow, a homogeneous reaction medium, which is achieved by efficient mixing of the molten or dissolved reagents. For most solid or liquid polyols, polyacids, HAA and HFA used, a homogeneous medium is achieved using a high-boiling polar solvent. Under these conditions, for each pair of the reagents (polyols+HFA or polyacid + HAA) yields from 90% to quantitative are achieved. When using low-boiling reagents, when the required process temperature is not achievable (in the case of 1,4-butanediol), a positive effect is achieved by adding acid catalysts.

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Գ. Ս. ԳՐԻԳՈՐՅԱՆ, Ա. Ց. ՄԱԼԽԱՍՅԱՆ

ԷՐԻՏՐԻՏԻ, ՄԱՆԻՏԻ, ՍՈՐԲԻՏԻ, ՔՍԻԼԻՏԻ, ԳԻՆԵԹՕՎԻ ԵՎ
ԿԻՏՐՈՆԱԹՕՎԻ ԲԱՐՉՐ ԱԼԻՖԱՏԻԿ ԿԱՐԲՈՆԱԹՕՈՒՆԵՐՈՎ
ԷՏԵՐԻՖԻԿԱՑՄԱՆ ՌԵԱԿՑԻԱՅԻ ՊԱՅՄԱՆՆԵՐԻ
ՈՒՍՈՒՄՆԱՍԻՐՈՒԹՅՈՒՆ

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Իրականացվել է բարձր ալիֆատիկ կարբոնաթթուներով և սպիրտներով էրիթրիտի, մաննիտի, սորբիտի, քսիլիտի, գինեթթվի և լիմոնաթթվի էթերիֆիկացման համեմատական հետազոտությունը թթվային կատալիզի պայմաններում $150\text{--}200^\circ\text{C}$ ջերմաստիճանային ինտերվալում: Բարդ էթերների ելքերի ավելացման նպատակով որոշվել են ռեակցիաների օպտիմալ ջերմաստիճանները, ինչպես նաև լուծիչների և թթվային կատալիզատորների կիրառման նպատակահարմարության հարցերը:

Г. С. ГРИГОРЯН, А. Ц. МАЛХАСЯН

ИЗУЧЕНИЕ УСЛОВИЙ РЕАКЦИЙ ЭТЕРИФИКАЦИИ ЭРИТРИТА,
МАННИТА, СОРБИТА, КСИЛИТА, ВИННОЙ И ЛИМОННОЙ КИСЛОТ
ВЫСШИМИ АЛИФАТИЧЕСКИМИ КАРБОНОВЫМИ КИСЛОТАМИ
И СПИРТАМИ

Резюме

Проведено сравнительное исследование реакций этерификации эритрита, маннита, сорбита, ксилита, винной и лимонной кислот высшими алифатическими карбоновыми кислотами и спиртами без катализаторов и в условиях кислотного катализа при температурах $150\text{--}200^\circ\text{C}$. Определены оптимальные температуры и условия целесообразности использования растворителей и кислотных катализаторов для повышения выходов сложных эфиров.