2-HYDROXY-5 (1-METHYLTYCLOHEXYL)-SYNTHESIS REAGENT OF ACETOPHENONE

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Abstract: The article is devoted to 2-hydroxy-5(1-methylcyclohexyl)-reagent for the synthesis of acetophenone. The purpose of this study is to expand the scope of scientific research related to the synthesis of acetophenone. The research of this work was carried out on the basis of the experimental method.
Keywords: hydroxy-5 (1-methyltyclohexyl)-synthesis reagent, catalytic acylation, Y-type zeolite

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Introduction:

Recent literature reviews indicate that chemical additives and compounds added to the production of polymer materials, oils, and various goods receive considerable attention. Among these chemical compounds, alkylphenols and their derivatives possess distinct advantages. One of their noteworthy features is their enduring resistance to light, atmospheric conditions, and temperature fluctuations. Consequently, approximately 70-75% of the chemical additives currently used in the industry are constituted of compounds based on alkylphenols (Armstrong, 1966).

Depending on their composition and structure, these chemical additives can serve functions like antioxidants, stabilizers, brighteners, oxygenators, and more. Therefore, the multifunctional characteristics of chemical additives created through the combination of various components are of great interest. It's worth noting that chemical additives with acetyl and hydroxyl fragments, as found in the literature, are widely utilized as photostabilizers and thermostabilizers (Bijelic, 2019).

Objective:

The goal of this study is to expand the scope of scientific research related to acetophenone synthesis. Specifically, the study focuses on the production of 2-hydroxy-5 (1-methylcycloalkyl) acetophenones through acylation reactions using para-(1-methylcyclopentyl) - and para-(1-methylcyclohexyl) phenols in conjunction with pickling vinegar and a Zn-based nanocatalytic system. The aim is to extend the range of scientific investigations and determine new areas of application for these compounds.

Materials and methods:

The experimental section details the initial substances employed for obtaining methylcycloalkylacetophenones, including para-(1-methylcyclopentyl)- and para-(1-methylcyclohexyl) phenols, along with the use of pickling vinegar as a chemical component. The pickling vinegar used is characterized by the following physical-chemical properties: Boiling Point = 118°C, Melting Point = 16.7°C, Molar Mass = 60 g/mol. Additionally, a catalyst is prepared in nano-scale with ZnCl2.

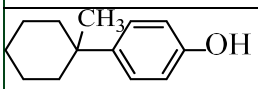
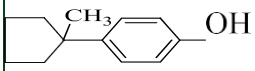
Para-(1-methylcyclopentyl) and para-(1-methylcyclohexyl) phenols undergo catalytic cycloalkylation with the participation of Y-type zeolite catalysts impregnated with a mixture of phenol, 1-methylcyclopentene, 1-methylcyclohexene, KU-23 (DUST 20298-74), and phosphate pickling vinegar (Bijelic, 2019).

Table 1 outlines the physical and chemical properties of para-(1-methylcycloalkyl) phenols. The structure of the synthesized compounds is determined using IQ and 1H NMR analysis methods. IQ spectra are recorded using the Bruker ALPA IQ-FurYE spectrometer, while 1H NMR spectra are

recorded at 300.13 MHz using the Bruker TOPSPIN apparatus in CDCl3 solution.

The reaction involving para-(1-methylcyclohexyl) phenol and pickling vinegar is described as follows:

Table1. Physico-chemical properties of para- (1-methylcycloalkyl) phenols

Structural formulas	Melting Point, °C/10 mm	T_m,°C	M.Wt	Element composition, %			
				Hesablanıb		Tapılıb	
				C	H	C	H
	161-164	96	190	82.1	9.5	81.4	8.9
	145-148	90	176	81.8	9.1	81.3	9.6

Results and discussions:

The provided reaction is carried out using the following procedure: 16.5 g (0.12 mol) of anhydrous nano-weighed ZnCl2 and 16.5 g (0.27 mol) of iced vinegar are placed in a flask and heated. When the temperature reaches 100°C, 19.0 g (0.1 mol) of para-(1-methylcyclohexyl) phenol is gradually added to the mixture, and the temperature is raised to 120-160°C. The mixing of components continues for 20-60 minutes. Then, the mixed chloride solution is rinsed with a 10% aqueous sodium hydroxide solution and filtered under reduced pressure. The intended product is washed with ethanol, and its physicochemical properties are determined. (Bijelic, 2019)

One of the key factors influencing the direction of the acylation reaction of para-(1-methylcyclohexyl) phenol with vinegar is the reaction temperature. The yield of the reaction product depending on temperature and time is shown in Figure 1.

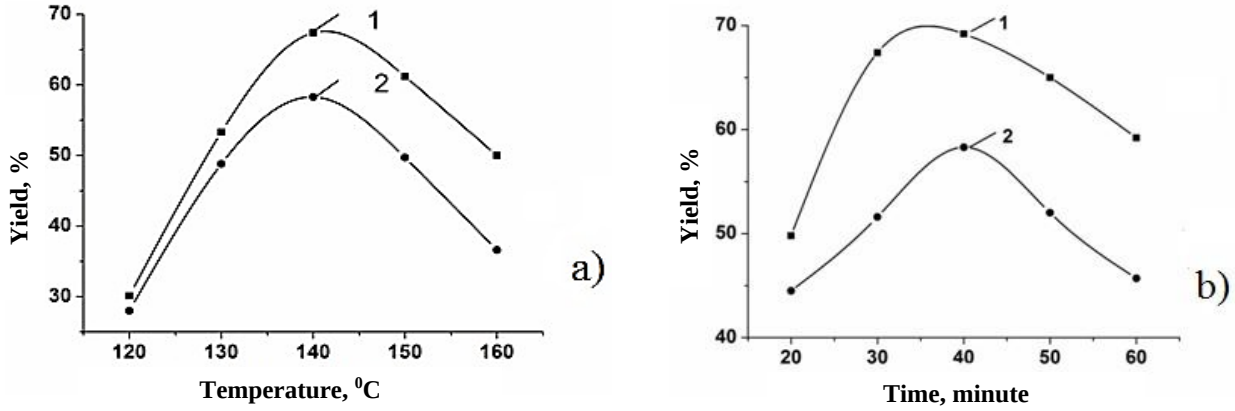


Figure 1. Temperature (a) and time (b) dependence of the yields of 2-hydroxy-5(1-methylcyclohexyl)-(1) and 2-hydroxy-5 (1-methylcyclopentyl)-(2) acetophenones.

As can be seen from Figure 1 (curve 1, a), at lower temperatures, below 120°C, the yield of 2-hydroxy-5(1-methylcyclohexyl) acetophenone decreases significantly, reaching 30.1% (relative to the initial cycloalkylphenol). By increasing the temperature from 120°C to 140°C, the purposeful action increases the yield of the product from 30.1% to 67.4%. Raising the temperature to 160°C is not favorable and results in a decrease in the yield to 57.5%. This drop at higher temperatures is attributed to the formation of undesirable by-products.

The purposeful reaction time significantly affects the yield of the target product. The reaction time was studied within a range of 20 to 60 minutes. (Bijelic, 2018)

As shown in Figure 1 (curve 1, b), when the initial components of the reaction are allowed to interact for 30 minutes, the yield of 2-hydroxy-5(1-methylcyclohexyl) acetophenone

reaches 67.4% relative to the initial para-(1-methylcyclohexyl) phenol. Changing the reaction time, whether increasing or decreasing, does not lead to significant variations in the product yield.

Thus, under the given conditions of the acylation reaction involving para-(1-methylcyclohexyl) phenol with pickling vinegar and a nano-sized ZnCl2 catalyst at 140°C for 30 minutes, the yield of the target product, 2-hydroxy-5 (1-methylcyclohexyl) acetophenone, is 67.4% relative to the initial para-(1-methylcyclohexyl) phenol.

Once the target product is obtained, its IR and 1H NMR spectra are recorded to determine its chemical structure and physicochemical properties.

Figures 2 and 3 provide the IR and 1H NMR spectra of 2-hydroxy-5(1-methylcyclohexyl) acetophenone, respectively**.**

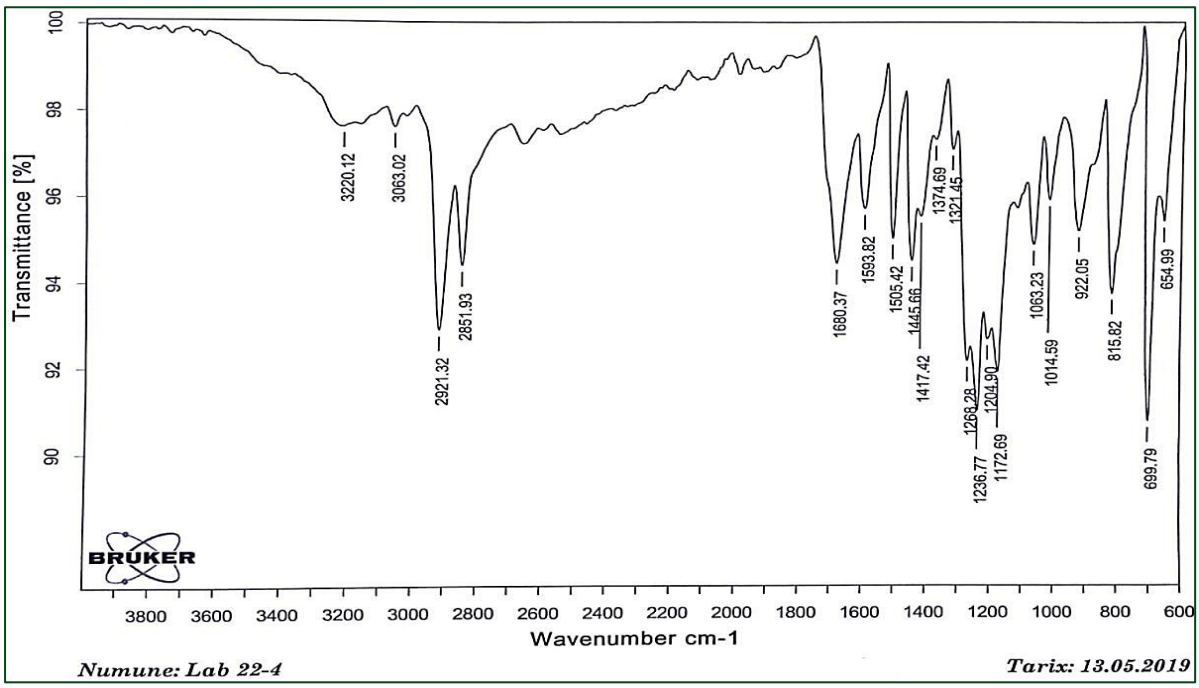


Figure 2. IR-spectrum of 2.2-Hydroxy-5 (1-methylcyclohexyl) acetophenone

The IR spectrum results of 2-Hydroxy-5(1-methylcyclohexyl) acetophenone are presented in

The 1H NMR spectrum of 2-Hydroxy-5(1-methylcyclohexyl) acetophenone consists of four signals with intensity ratios of 3:10:1:4.

- The singlet at 1.2 ppm corresponds to the methyl (CH3) group.
- The multiple at 1.77 ppm is associated with the 1.5 ppm saturated hydrocarbon group.
- The OH group appears as a singlet at 8 ppm.
- The protons of the aromatic ring can be observed in the range of 6.5-7 ppm.

This confirms the chemical structure of 2-Hydroxy-5(1-methylcyclohexyl) acetophenone**.**

The reaction is carried out using the method described above: 16.5 g (0.12 mol) of anhydrous nano-weighed ZnCl2 and 16.5 g (0.27 mol) of icy vinegar are placed in a flask and heated. When the temperature reaches 90°C, 17.6 g (0.1 mol) of para-(1-methylcyclopentyl) phenol is gradually added to the mixture, and the temperature is raised to 120-160°C. The mixing of the components continues for 20-60 minutes, and then the resulting chloride solution is washed with a 10% aqueous solution of chloride under reduced pressure. The intended product is washed with ethyl alcohol, and its chemical structure and physicochemical properties are

determined. (Bhatt& etc, 2017)

Table 2. The results of the IQ-spectroscopic analysis of 2-Hydroxy-5 (1-methylcyclohexyl) acetophenone

Signals, cm-1	Location in the structural formula
654	Information of the group of phenol
699,815	substituted benzene core
922,1014	C-H bond in a cycle
1063	O-H bond
1204, 1236,1268	C-O bond
1374	Deformation vibration of the C-H bond in the CH3 group
1417,1445	Deformation vibration of the C-H bond in the C(O)CH2 group
1505	Benzene nucleus
1593	C bond in aromatic hydrocarbons
1680	C=O
2851,2921	Valence vibration of the C-H bond in the CH3 group
3063	H-C=C-H
3220	O-H bond in the OH group

Chemical structure of the substance:

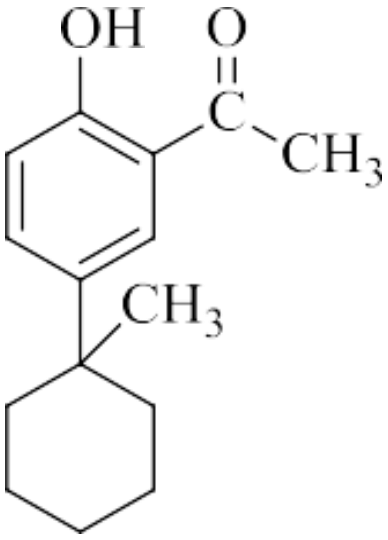


Figure 3. 21H NMR spectrum of 2-Hydroxy-5 (1-methylcyclohexyl) acetophenone

Empirical formula: C15H20O2, Molar mass: 232
Boiling point: 166-168 °C (at 10 mm of mercury pressure)
Melting point: 114.8 °C

Additionally, a catalytic acylation reaction was carried out with para-(1-methylcyclopentyl) phenol and vinegar:

The results of the catalytic acylation reactions of para-(1-methylcyclopentyl) phenol with vinegar are shown in Figure 1.

Increasing the temperature of the acylation reaction from 120°C to 140°C, as shown in Figure 1 (line 2,a), results in an increase in the yield of the desired product from 28.0% to 58.3%. However, when the temperature is

further raised above 150-160°C, the yield of the desired product begins to decrease. At 150-160°C, the yield of acetophenone obtained from para-(1-methylcyclopentyl) phenol ranges from 36.6% to 49.7%.

The duration of the reaction in the reaction zone also plays a significant role in the yield of the desired product. For instance, when the reaction time is 20 minutes, the yield of the desired product is 44.5% (see Figure 1, line 2, b). Increasing the time to 40 minutes raises the yield of the desired product to 58.3%. However, further extension of the mixing time in the subsequent increment reduces the yield of the desired product to 45.7%. The decrease in the yield of the desired product with excessive mixing time in the reaction zone can be attributed to the formation of unwanted byproducts.

Therefore, the acylation reaction with vinegar was carried out purposefully in the presence of anhydrous nano-weighed ZnCl2 catalyst as follows: at a temperature of 135-140°C, for a reaction time of 30-40 minutes, the yield of 2-hydroxy-5 (1-methylcycloalkyl) acetophenones for the target product was found to be 58.3-67.4% compared to para-(1-methylcycloalkyl) phenol (Bluestone & etc, 2010)

After the removal and separation of 2-hydroxy-5(1-methylcycloalkyl) acetophenones from the reaction products, their chemical structures were confirmed using IR and 1H NMR spectroscopic techniques.

In the 1H NMR spectrum of 2-hydroxy-5(1-methylcycloalkyl) acetophenones, a singlet CH3 group is observed at 1.22 ppm, and a singlet from the saturated hydrocarbon group is observed at δ=1.77 ppm. The singlet OH group proton at 5-6 ppm matches with the proton of 2-hydroxy-5(1-methylcyclohexyl) acetophenone in the previous spectra. The 1,2,4-trisubstituted benzene ring manifests itself in the chemical shifts at 6.87 ppm.

In the IR spectrum of the substance, the stretching bands of the para-substituted benzene ring are found at 825, 1240, 1510, and 1592-1610 cm-1, and a maximum band of the associated OH group is observed at 3220 cm-1.

The unmovable bands characterizing the methyl group are found at 2920, 2850 cm-1 (the valence vibration of the OH group) and 1440 cm-1 (the valence vibration of the CH2 group). Bands at 1365 and 2940 cm-1 correspond to the methyl group. The C=O band of the C(O)CH2 group is observed at 1242, 1265, 1276, and 1335 cm-1, and the deformation band of the C-H group is found at 1440, 1460 cm-1 in the unmovable bands.

Thus, the chemical composition of 2-hydroxy-5(1-methylcycloalkyl) acetophenones is substantiated with evidence.

Chemical composition of 2-hydroxy-5 (1-methylcycloalkyl) acetophenones:

Empirical formula: C14H18O2

Molar mass: 218

Boiling point: 150-152 °C (at 10 mm of mercury pressure)

Melting point: 113.3 °C

Conclusion:

Catalytic acylation reactions with vinegar were studied in the presence of anhydrous nano-weighed ZnCl2 catalyst for para-(1-methylcycloalkyl)- and para -(1-methylcyclohexyl) phenols.

It was determined that at a reaction temperature of 135-140°C, for a duration of 30-40 minutes, the yield of 2-hydroxy-5(1-methylcycloalkyl) acetophenones for the target product ranges from 58.3% to 67.4% compared to para-(1-methylcycloalkyl) phenol.

The physicochemical properties of 2-hydroxy-5 (1-methylcycloalkyl) acetophenones were determined, and their chemical compositions were confirmed using IR and 1H NMR spectroscopic methods.

References:

Armstrong JM, Myers DV, Verpoorte JA, Edsall JT (1966) Purification and properties of human erythrocyte carbonic anhydrases. J Biol Chem 241:5137–5149

Bhatt A, Mahon BP, Cruzeiro VWD et al (2017) Structure-activity relationships of benzenesulfonamide-based inhibitors towards carbonic anhydrase isoform specificity. ChemBioChem 18:213–222. https://doi.org/10.1002/cbic.201600513

Bijelic A, Aureliano M, Rompel A (2018) The antibacterial activity of polyoxometalates: structures, antibiotic effects and future perspectives. Chem Commun 54:1153–1169.https://doi.org/10.1039/C7CC07549A

Bijelic A, Aureliano M, Rompel A (2019) Polyoxometalates as potential next-generation metallodrugs in the combat against cancer. Angew Chemie Int Ed 58:2980–2999. https://doi.org/10.1002/anie.201803868

Bluestone JA, Herold K, Eisenbarth G (2010) Genetics, pathogenesis and clinical interventions in type 1 diabetes. Nature 464:1293–1300. https://doi.org/10.1038/nature08933