

# Benzene-1,3,5-tricarboxylic Acid-Functionalized Cherry Gum as a Novel and Recoverable Nanocatalyst for Efficient Synthesis of 1,4-polyhydroquinoline Derivatives

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**Abstract:** In this study, Benzene-1,3,5-tricarboxylic acid (BTA)-functionalized gum (Cherry gum) (gum-Pr-BTA), as a novel nanocatalyst was prepared. This novel nanocatalyst was used for the expeditious and efficient synthesis of 1,4-polyhydroquinoline derivatives, as an important pharmaceutical scaffold, in ethanol reflux conditions. This method has several advantages such as high yields, low catalyst loading, short reaction times, and simple workup and could be used up to five reaction cycles without a noticeable decrease in catalytic activity.

**Keywords:** Benzene-1,3,5-tricarboxylic acid (BTA); cherry gum; nanocatalyst; 1,4-polyhydroquinoline derivatives

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## 1. Introduction

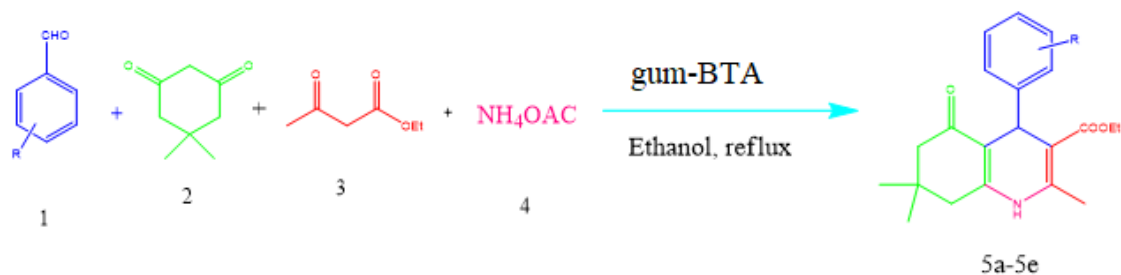
During recent years, scientists have been using multicomponent reactions to synthesize complex organic compounds due to their high efficiency [1]. These reactions have attracted a lot of attention due to their many applications in various fields, such as agriculture, and medicine [2]. Significant advantages of MCRs are the elimination of intermediates, short reaction times, high reaction yield, and easy separation of products, hantzsch reaction is one of this reactions that use for synthesis of 1,4-dihydropyridine derivatives. These compounds are an important class of antihypertensive drugs [3], vasodilators [4], hypnotic, anti-tumor [5].

Heterogeneous catalysts have a crucial role in determining the chemical reactions conditions, especially in multicomponent reactions. The two of their significant advantages are easy separation and reusability [6,7].

These days, using an appropriate compound to prepare the heterogeneous catalyst is an essential factor that 1,3,5-Benzenetricarboxylic acid with properties such as nontoxicity, ability to easily bind to catalytic support, and low cost for the preparation of acidic catalysts can be a perfect selection for this task. Also, acidic catalysts are really beneficial in the synthesis of various heterocyclic compounds.

Cherry gum is a branched-chain polysaccharide that can be used as catalyst support due to its excellent properties and exceptional performance. In addition, using this class of material can be harmless for the environment [8].

In this paper, we reported the synthesis of gum-BTA a heterogeneous catalyst for the preparation of 1,4-dihydropyridine derivatives through one multicomponent reaction, as shown in Scheme 1:



**Scheme 1.** Synthesis of 1,4-dihydropyridine derivatives using gum-BTA nanocatalyst.

## 2. Experimental

### 2.1. General Procedure for Preparation of Nanocatalyst (gum-BTA)

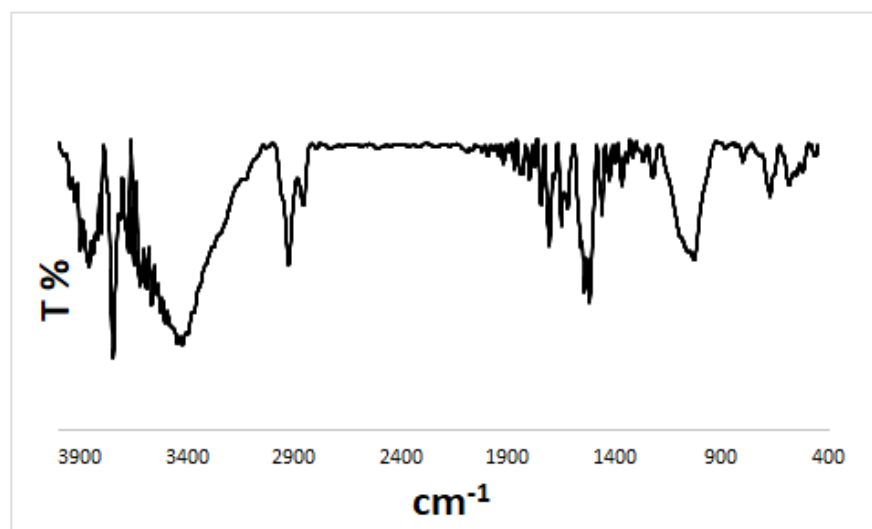
gum-BTA (0.1 g) and KI (0.01 g) were dispersed in DMSO (30 mL), and stirred for 10 h at room temperature, then 1,3,5-Benzenetricarboxylic acid (BTA) (0.1 g) and  $\text{K}_2\text{CO}_3$  (0.055 g) were added to the resulting mixture and stirred for 1 h. Then the resulting white solid was filtered and washed with water (2.5 mL) and ethanol (2.5 mL). Finally, it was dried in a vacuum oven.

### 2.2. General Procedure for Synthesis 1,4-dihydropyridine Derivatives

A mixture of aldehyde (1 mmol), ammonium acetate (1 mmol), ethylacetoacetate (1 mmol), and dimedone (1 mmol), in the presence of the catalytic amount of gum-BTA (0.02 g) was refluxed in EtOH (7 mL). The development of the reaction was monitored by TLC. The precipitated solid was washed with n-hexane and was dried.

## 3. Results and Discussion

FTIR spectrum of the synthesized gum-Pr-BTA is shown in Figure 1. The absorption band at  $3424\text{ cm}^{-1}$  is attributed to OH stretching. Two sharp absorption bands at  $2928\text{ cm}^{-1}$  and  $2856\text{ cm}^{-1}$  are assigned to the asymmetric and symmetric stretching of aliphatic C-H bonds, respectively. The absorption bands at  $1746$  and  $1706\text{ cm}^{-1}$  correspond to C=O bond stretching of ester and acid. The band at  $1520\text{ cm}^{-1}$  can be assigned to the stretching vibration of the C=C bond.



**Figure 1.** FTIR of the gum-Pr-BTA.

EDX analysis confirms the presence of C, O and Si elements in the gum-Pr-BTA structure (Figure 2).

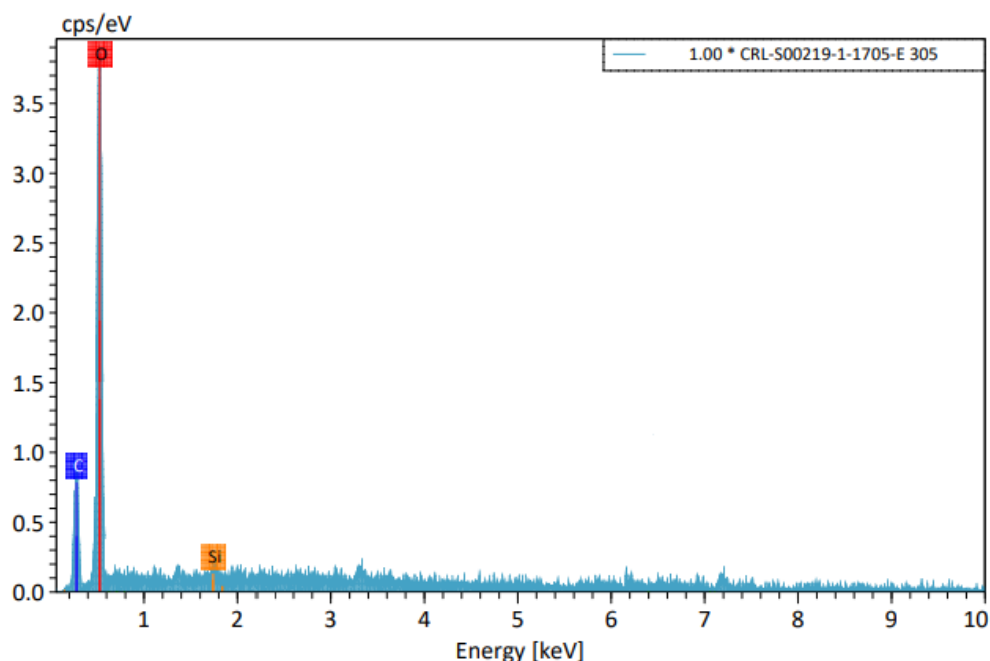


Figure 2. EDX analysis of the gum-Pr-BTA.

In the following, various aldehydes were applied for the synthesis of 1,4-dihydropyridine under optimal reaction conditions.

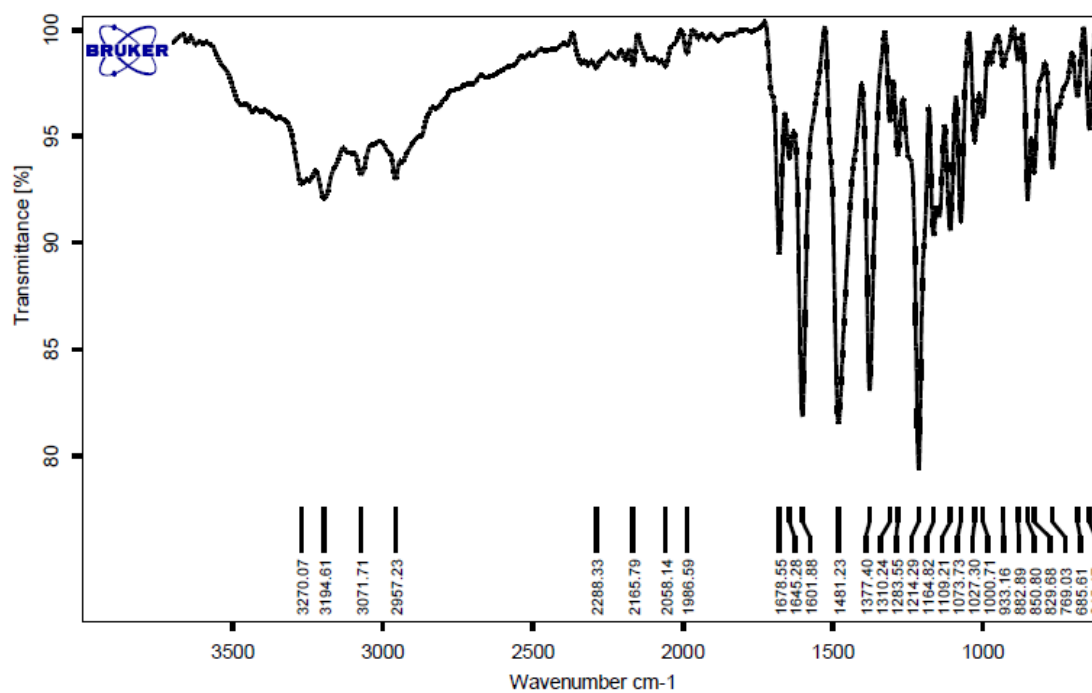
Table 1. Synthesis of 1,4-dihydropyridine derivatives using gum-BTA nanocatalyst.

Entry	R	Product	Time (min)	Mp (°C)	Yield (%)
1	H	5a	10	217–219	95
2	4-Cl	5b	15	240–242	94
3	4-OH	5c	20	230–232	89
4	4-NO <sub>2</sub>	5d	15	239–241	90
5	4-Me	5e	25	254–256	87

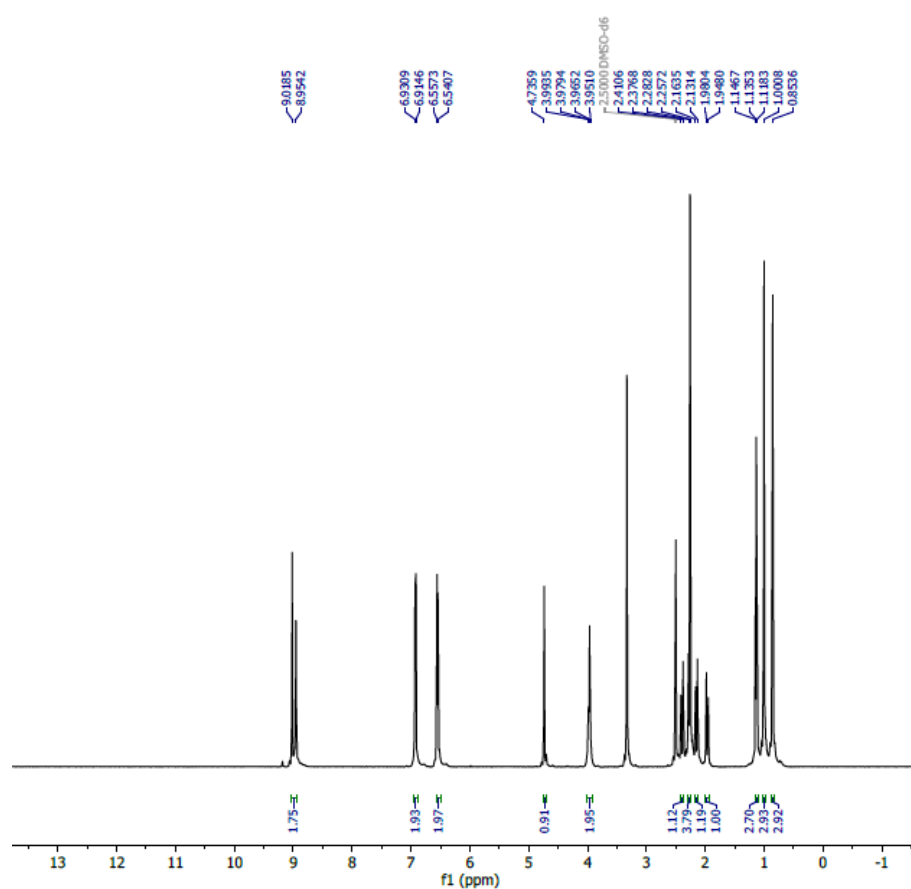
**Reaction conditions:** benzaldehyde (1 mmol), ethyl acetoacetate (1 mmol), dimedone (1 mmol), and ammonium acetate (1 mmol), gum-BTA (0.02 g) and ethanol (7 mL) under reflux conditions.

**Ethyl 2, 7, 7-trimethyl-5-oxo-4-(4-hydroxyphenyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate (5c)**

FTIR (KBr, cm<sup>-1</sup>): 3270, 3194, 3071, 2957, 1678, 1645, 1481, 1377, 1214 cm<sup>-1</sup>. <sup>1</sup>H NMR (500 MHz, DMSO): δ H (ppm)= 0.85(s, 3H, CH<sub>3</sub>), 1.0(s, 3H, CH<sub>3</sub>), 1.13(t, 3H, CH<sub>3</sub>), 1.9–2.41(m, 4H, 2CH<sub>2</sub>), 2.25(s, 3H, CH<sub>3</sub>), 3.95–3.99(q, 2H, OCH<sub>2</sub>), 4.73(s, 1H, Ar-CH), 6.54(d, 2H, Ar-H), 6.93(d, 2H, Ar-H), 8.95(s, 1H, NH), 9.01(s, 1H, OH).



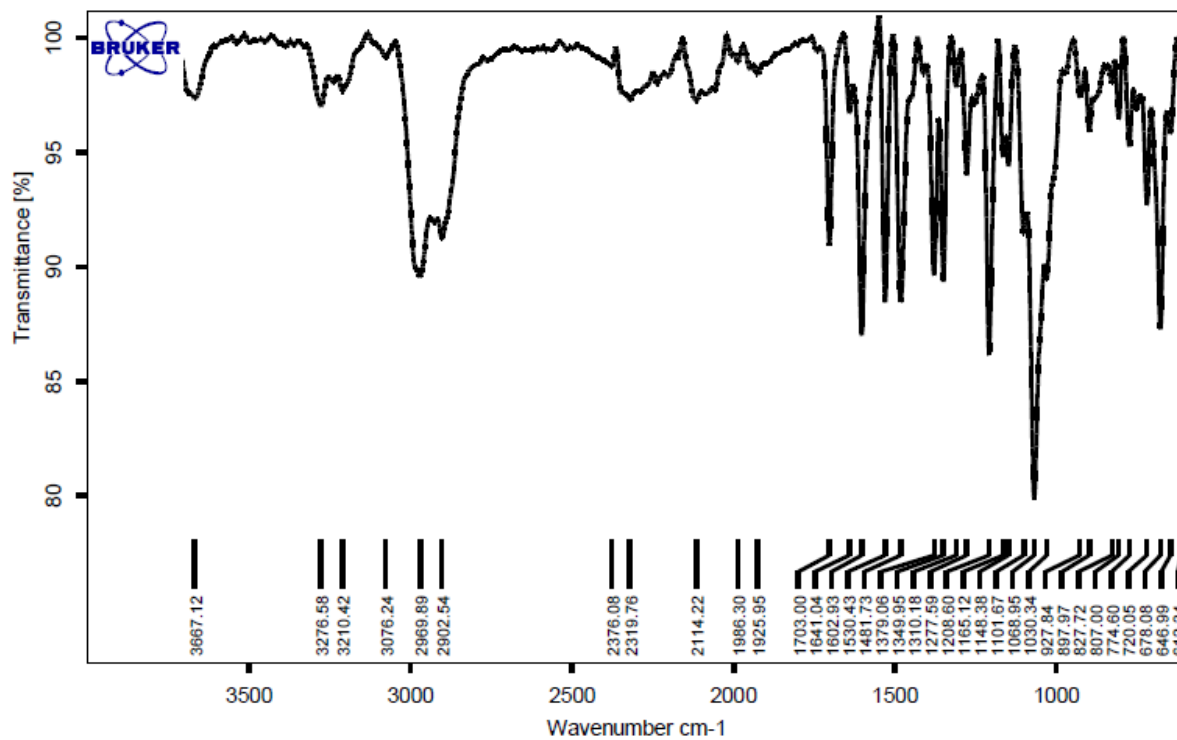
**Figure 3.** FT-IR spectrum of the Ethyl 2, 7, 7-trimethyl-5-oxo-4-(4-hydroxyphenyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate (5c).



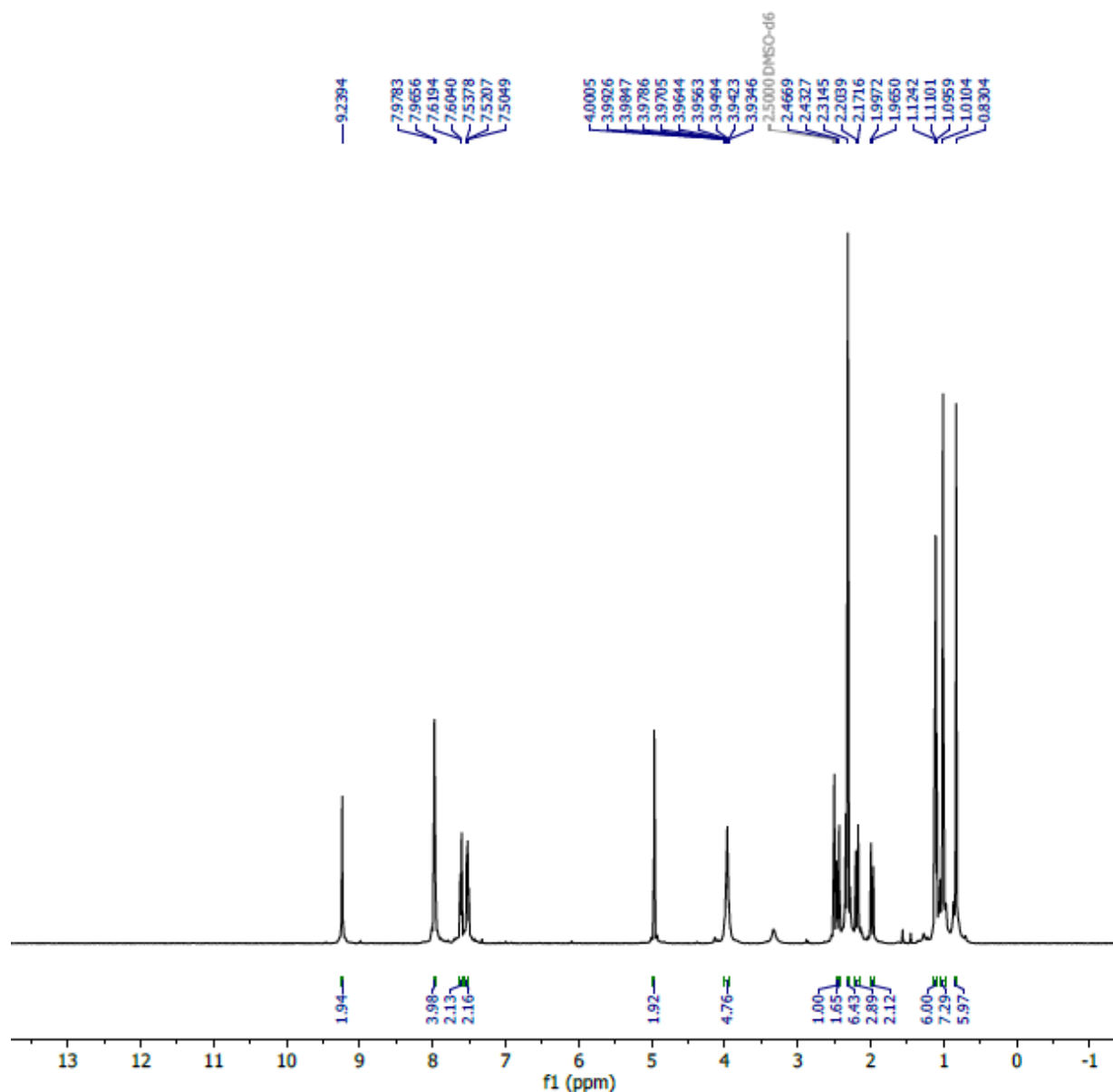
**Figure 4.** <sup>1</sup>H NMR spectrum of the Ethyl 2, 7, 7-trimethyl-5-oxo-4-(4-hydroxyphenyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate (5c).

**Ethyl 1,4,7,8-tetrahydro-2,7,7-trimethyl-4-(4-nitrophenyl)-5(6H)-oxoquinoline-3-carboxylate (5d)**

FTIR (KBr,  $\text{cm}^{-1}$ ): 3276, 3210, 3076, 2969, 2902, 1703, 1641, 1530, 1379  $\text{cm}^{-1}$ .  $^1\text{H NMR}$  (500 MHz, DMSO):  $\delta\text{H}$  (ppm)= 0.83(s, 3H, CH<sub>3</sub>), 1.01(s, 3H, CH<sub>3</sub>), 1.11(t, 3H, CH<sub>3</sub>), 1.96–2.46(m, 4H, 2CH<sub>2</sub>), 2.31(s, 3H, CH<sub>3</sub>), 3.93–4.0(m, 2H, OCH<sub>2</sub>), 4.97(s, 1H, Ar-CH), 7.5–7.61 (m, 4H, Ar-H), 7.97(s, 1H, NH), 9.23(s, 1H, OH).



**Figure 5.** FT-IR spectrum of the Ethyl 1,4,7,8-tetrahydro-2,7,7-trimethyl-4-(4-nitrophenyl)-5(6H)-oxoquinoline-3-carboxylate (5d).



**Figure 6.** <sup>1</sup>H NMR spectrum of the Ethyl 1,4,7,8-tetrahydro-2,7,7-trimethyl-4-(4-nitrophenyl)-5(6H)-oxoquinoline-3-carboxylate (5d).

#### 4. Conclusions

Briefly, the heterogeneous gum-BTA catalyst was synthesized and used for the synthesis of 1,4-dihydropyridine derivatives as a significant product in pharmacologically active compounds. The important advantages of this catalyst are its reusability, simple separation from the reaction mixture, short reaction time, and the synthesis of 1,4-dihydropyridine derivatives with high yield. In general, preparation and use of this simple catalyst is noticeable over other reported catalysts.

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### Conflicts of Interest:

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