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An efficient procedure for the synthesis of coumarin derivatives by using green catalyst: tetra butyl ammonium bromide

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Abstract:

Under solvent-free conditions at room temperature, the Pechmann condensation reaction of resorcinol and ethyl acetoacetate using tetra butyl ammonium bromide and K_2CO_3 as an effective, environmentally friendly catalyst results in a good yield of 7-hydroxy-4-methylcoumarin. Short reaction durations, good to exceptional yields, ease of workup, and simplicity of operation are just a few benefits of this catalyst.

Keywords: Tetra butylammonium bromide, Solvent-free conditions, chromenes, biological, Pechmann condensation.

Introduction:

Due to their presence as a significant component of natural products [1] and their wide range of medical applications, including as anti-inflammatory [2], anti-convulsant [3], anti-viral [4], anticoagulant [5], antioxidant [6], antibacterial [7], antifungal [8], anti-HIV [9], anti-carcinogenic material [10], and fluorescence sensors, coumarins constitute an important class of compounds. In addition to the numerous biological uses for coumarin and its derivatives, the chemical literature also illustrates some of its material-related uses, including those for cosmetics [12], optical brightening agents [13], and laser dyes [14]. Certain coumarin derivatives can sense anions, according to a recent literature review [15]. The synthesis of coumarin and its derivatives can be accomplished using a number of well-known procedures [16–23]. The field of coumarin synthesis through the catalysis of the von Pechmann reaction by a number of Lewis acids has seen growth during the past few years [24–34]. Many methods, including the Pechmann[35], Perkin[36], Knoevenagel[37], Reformatsky[38], and Wittig reactions[39] as well as flash vacuum pyrolysis, have been used to synthesis coumarins. [40] The Pechmann reaction, which uses straightforward starting materials such phenols and b-ketoesters in the presence of acidic condensing agents, is the technique that is most frequently utilised among them.[41] The usage of numerous chemicals, including phosphoric acid, trifluoroacetic acid, phosphoric acid, H_2SO_4, P_2O_5, $FeCl_3$, $ZnCl_2$, $POCl_3$, $AlCl_3$, PPA, and other clays, is widely documented in the literature.[42] The majority of these techniques have significant limitations, such as the need for several catalysts, occasionally lengthy reaction periods, and frequently temperatures as high as 1500C. The creation of cation exchange resins, a number of solid acid catalysts, metal nitrates, supported polyaniline catalysts, microwave irradiation, and, most recently, the use of ionic liquids as effective catalysts are just a few of the recent developments in the efficient construction of this nucleus.[43]

Materials and Methods:

General All of the chemicals were bought from commercial suppliers and utilised directly. By comparing IR and 1H NMR data as well as melting points to values given in the literature, all products were identified as well as their structures. Using silica gel SILG/UV 254 and 365 plates, thin-layer chromatography (TLC) was used to monitor the reaction's development. As an internal standard, TMS was used to record the ^{1}H NMR and ^{13}C NMR spectra in DMSO at 400 MHz. Using a KBr disc and a Perkin Elmer spectrometer with version 10.03.06, IR spectra of the compounds were produced. Without any additional correction, melting points were measured using an electrothermal capillary melting point device.

General procedure for the preparation of coumarin derivatives:

Resorcinol (5 mmol) and ethyl acetoacetate (5 mmol) were combined with TBAB (5 mol%, 0.05 g), K2CO3, and stirring was performed at 25°C for the proper amount of time. TLC kept track of the reaction's development (thin layer chromatography). Once finished, the mixture was filtered through broken ice before being rinsed with water (10 ml), The desired coumarins were produced in high yields by evaporating the solvent from the filter and recrystallizing the solid residue from hot ethanol. By comparing the analytical data (melting point, IR, and NMR) with those given in the literatures, all the products were recognised.

Characterization of coumarin derivatives:

Based on their 1H NMR, 13C NMR and IR analyses, the numerous coumarin derivatives' structural assignments are determined. The production of coumarin derivatives was discovered by the study of all available spectral and compositional data.

i.6-Hydroxy-4-methylcoumarin. IR (υ in cm-1) 3258 (OH strech), 1514, 1473 (aromatic ring), 1687 (C=O), 1209, 1094 (C-O); 1 H NMR δ 9.3 (s, 1H, OH), 7.2 (d, 1H, H 8 Aromatic), 6.7 (d, 1H, H 7 Aromatic), 6.3 (s, 1H, H 5 Aromatic), 3.1 (s, 1H, H 3 Aromatic), 2.3 (s, 3H, CH3).

ii.7-Hydroxy-4-methylcoumarin. IR (υ in cm-1) 3504 (OH strech), 1504, 1457 (aromatic ring), 1673 (C=O), 1276, 1074 (C-O); 1 H NMR δ 10.4 (s, 1H, OH), 7.4 (s, 1H, H 8 Aromatic), 6.7 (d, 1H, H 6 Aromatic), 6.7 (d, 1H, H 5 Aromatic), 3.5 (s, 1H, H 3 Aromatic), 2.4 (s, 3H, CH3).

iii.6-Amino-4-methylcoumarin. IR (υ in cm-1) 3376, 3234 (NH strech), 1612, 1514, 1493 (aromatic ring), 1635 (C=O), 1287, 1172 (C-O); 1 H NMR δ 10.2 (s, 2H, NH), 8.4 (d, 1H, H 8 Aromatic), 8.2 (d, 1H, H 7 Aromatic), 7.2 (s, 1H, H 5 Aromatic), 3.4 (s, 1H, H 3 Aromatic), 2.4 (s, 3H, CH3).

iv.8-Amino-4-methylcoumarin. IR (υ in cm-1) 3466, 3247 (NH strech), 1517, 1577, 1456 (aromatic ring), 1645 (C=O), 1248, 1155 (C-O); 1 H NMR δ 10.2 (s, 2H, NH), 7.3 (s, 1H, H 8 Aromatic), 6.8 (d, 1H, H 6 Aromatic), 6.6 (d, 1H, H 5 Aromatic), 3.4 (s, 1H, H 3 Aromatic), 2.4 (s, 3H, CH3).

v.6-Formyl-4-methyl coumarin. IR (υ in cm-1) 1597, 1573, 1412 (aromatic ring), 1773,1606 (C=O), 1281, 1263 (C-O); 1 H NMR δ 10.1 (s, 1H, CHO), 8.3 (d, 1H, H 8 Aromatic), 6.7 (d, 1H, H 7 Aromatic), 6.7 (s, 1H, H 5 Aromatic), 4.5 (s, 1H, H 3 Aromatic), 1.8 (s, 3H, CH3).

vi.8-Formyl-4-methylcoumarin. IR (υ in cm-1) 1605, 1556, 1473 (aromatic ring), 1718, 1612 (C=O), 1213, 1091 (C-O); 1 H NMR δ 10.0 (s, 1H, CHO), 7.7 (d, 1H, H 7 Aromatic), 6.9 (d of d, 1H, H 6 Aromatic), 6.7 (d, 1H, H 5 Aromatic), 6.1 (s, 1H, H 3 Aromatic), 2.8 (s, 3H, CH3).

vii.6-Nitro-4-methylcoumarin. IR (υ in cm-1) 1501 1495 (aromatic ring), 1612 (C=O), 1591,1332 (NO2), 1295,1198 (C-O); 1 H NMR δ 8.1 (d, 1H, H 7 Aromatic), 7.2 (s, 1H, H 5 Aromatic), 6.9 (d, 1H, H 8 Aromatic), 6.4 (s, 1H, H 3 Aromatic), 1.9 (s, 3H, CH3).

viii.8-Nitro-4-methylcoumarin. IR (υ in cm-1) 1511, 1451 (aromatic ring), 1602 (C=O), 1592, 1334 (NO2), 1296, 1196 (C-O); 1 H NMR δ 7.8 (d, 1H, H 7 Aromatic), 7.1 (d of d, 1H, H 6 Aromatic), 6.9 (d, 1H, H 5 Aromatic), 3.3 (s, 1H, H 3 Aromatic), 2.5 (s, 3H, CH3).

ix.7,8-Benzo-4-methylcoumarin. IR (υ in cm-1) 1593, 1575, 1473 (aromatic ring), 1633 (C=O), 1277, 1083 (C-O); 1 H NMR δ 8.6 (d, 1H, H Aromatic), 7.8 (d, 1H, H Aromatic), 7.5-7.6 (m, 2H, H Aromatic), 7.5 (d, 1H, H aromatic), 6.9 (d, 1H, H aromatic), 6.5 (s, 1H, H 3 Aromatic), 2.5 (s, 3H, CH3).

x.6,7-Benzo-4-methylcoumarin. IR (υ in cm-1) 1601,1513, 1467 (aromatic ring), 1632 (C=O), 1278, 1217 (C-O); 1 H NMR δ 7.7 (s, 2H, H Aromatic), 7.6 (d, 1H, H Aromatic), 7.2-7.4 (m, 2H, H Aromatic), 7.2 (d, 1H, H aromatic), 5.2 (s, 1H, H 3aromatic), 1.7 (s, 3H, CH3).

Results and Discussion:

Because of how easily they can be purified and how little trash they emit into the environment, the use of solvent-free processes and phase transfer assisted catalysts for organic transformations has been widely documented. Moreover, they have been employed in numerous organic processes. Tetrabutyl ammonium bromide and K_2CO_3 are added to this process at room temperature. First of all, it should be noted that TBAB has a catalytic effect on the condensation process of resorcinol and ethyl acetoacetate under solvent-free circumstances. A combination of different coumarins was synthesised in the presence of TBAB catalyst, whereas under catalyst-free conditions only 5% yield was obtained in 24 hours (Entry 1, Table 1). The greatest results, as shown in Table 1, came from 0.05 g of the TBAB under solvent-free conditions, which produced 7-Hydroxy-4-methyl-2H-chromen-2-one in 92% yield and 18 min (Entry 4, Table 1). Under the same circumstances, increasing the catalyst amount did not result in a further rise in the yield. The reaction took longer to complete and had less yield when 0.1g of TBAB was employed.

Table 1. Optimization of the amount of catalyst in the preparation of 7-hydroxy-4-methyl-2H-chromen-2-one :

Entry	Catalyst	Time (min)	Yield (%)
1	0.00	24	5
2	0.01	160	30
3	0.03	90	65
4	**0.05**	**38**	**92**
5	0.1	65	72

Conclusion:

In conclusion, employing freshly synthesised TBAB with K_2CO_3 as a catalytic reagent, we have devised an effective approach for the synthesis of coumarin derivatives through Pechmann reaction under solvent-free conditions. This process provides a great yield, quick reaction times, non-toxic reagents, is environmentally benign, has a straightforward reaction, and has mild reaction conditions. This approach is advantageous from an economic and environmental standpoint because it generates less waste than previously thought. The catalyst is accessible, reasonably priced, and simple to handle and remove from the reaction mixture. This protocol might be a useful substitution for existing reaction systems.

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