
K C Majumdar*, T K Das & B Chattopadhyay
Department of Chemistry, University of Kalyani, Kalyani 741 235, India
E-mail: kcm_ku@yahoo.co.in

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Thermal rearrangement of 6-[N-(4′-aryloxybut-2-ynyl) N-methylamino]coumarins in refluxing N,N-DEA has led to Claisen rearrangement at the aryloxypropargyl segment resulting in the formation of N-(4′-coumarinylmethyl),N-methylcoumarins in excellent yield.

Keywords: 6-Aminocoumarin, Claisen rearrangement, benzopyran, 1,4-dichlorobut-2-yn, sigmatropic rearrangement

Coumarin1 and its derivatives2 are interesting due to their physiological activity1. The biological activity3,4 of 4-alkyl and 3-alkyl coumarins has made their synthesis5 an important target. Recently, the synthesis of a new tricyclic pyrrolocoumarin system has been reported by the amine oxide rearrangement, a [2,3] Meisenheimer rearrangement followed by a [3,3] Claisen rearrangement6 of the substrate 7. We have also reported the thermal [3,3] sigmatropic rearrangement of 6-prop-2-ynyloxycoumarins7 to furnish a number of pyrano [3,3-f] chromen-2(7H)-ones. Extensive work has been reported on the aza-Claisen rearrangement of allyl aryl amines8 and aryl propargyl amines9. There is also report on the sequential Claisen rearrangement of 1,4-(bis)aryloxybut-2-ynes 10 and related systems 2-511 etc. However, there is no report on the successful Claisen rearrangement of substrates of the type 612. When attempted, only decomposition occurred even under nitrogen atmosphere. This prompted the study of the thermal [3,3] sigmatropic rearrangement of the substrates 7. Herein are reported the results (Figure 1).

Results and Discussion
The starting materials 6-[N-(4-aryloxybut-2-ynyl)-N-methylamino] coumarins 7a-d were synthesized in good yields by refluxing 6-(N-methylamino) coumarin 8 and 1-aryloxy-4-chlorobut-2-ynes 9a-d in dry acetone in the presence of anhydrous potassium

![Figure 1](image-url)
carbonate and a small amount of sodium iodide\(^{13}\) (Scheme I). Compounds 7a-d were characterized from their elemental analysis and spectroscopic data. The IR spectrum of 7a showed \(\nu_{\text{max}}\) at 1721 cm\(^{-1}\) due to the presence of a carbonyl group. The \(^1\text{H}\) NMR spectrum of 7a revealed a three proton singlet at \(\delta\ 2.94\) due to the \(N\)-CH\(_3\) and two sets of two proton singlets at \(\delta\ 3.74\) and 4.07 due to the \(N\)-CH\(_2\) and O-CH\(_2\) respectively. Another two sets of one proton doublets appeared at \(\delta\ 6.37\) (\(J = 9.50\) Hz) and 7.56 (\(J = 9.50\) Hz) respectively due to the C\(_3\)-H and C\(_4\)-H proton of the coumarin moiety. The mass spectrum of 7a showed a molecular ion peak at \(m/z\ 349\) (M\(^{+}\)).

The starting materials are unique as the system is tailored to possess aryloxy propynyl moiety as well as \(N\)-vinyl and \(N\)-methylpropynyl amine moiety (Scheme I). Therefore, these substrates provide an excellent scope for studying the competition between oxy Claisen versus amino Claisen \(i.e\). Claisen rearrangement of substrates aryl propargyl amine \(\textit{versus}\) aryl propargyl ether in the same molecule. It is well-known that the oxy Claisen is favoured over amino Claisen due to the higher energy of activation\(^{14}\) for nitrogen containing substrates. It is also an established phenomenon that the activation energy needed for the propargyl vinyl ether rearrangement\(^{15}\) is much less than the aryl propargyl ether rearrangement\(^{16}\). Apparently three products 10, 11 and 12 are easily expected from the specially tailored substrates 7a-d, by a single [3,3] sigmatropic rearrangement (Scheme II).

The formation of products 10a-d from the substrates 7a-d may be explained by the occurrence of the thermal [3,3] sigmatropic rearrangement at the aryloxy propynyl moiety of substrates 7a-d followed by enolisation, [1,5] hydrogen shift and electrocyclic ring closure to give product 10. The occurrence of the same sequence of reactions at the aryl propargyl amine part of the substrates 7 may have afforded the products 11 and or 12 which were actually not obtained (Scheme III).

The substrates 7a-d present a scope for two [3,3] sigmatropic rearrangements and the preference for the first rearrangement in these substrates is not easily predictable at first sight. Hence, the reaction has been carried out in \(N,N\)-DEA and experimentally it has been found that instead of the amino-Claisen products 11 and/or 12, the oxy-Claisen product 10 is being formed probably due to the high energy of activation for the amino-Claisen rearrangement as compared to the oxy-Claisen rearrangement. Product 10, a crystalline solid was obtained in 88% yield. From its elemental analysis and spectral data this was characterized as 10a. The IR spectrum of 10a gives a band at 1719 cm\(^{-1}\) due to the lactone carbonyl group of the coumarin moiety. The \(^1\text{H}\) NMR spectrum of 10a showed a three proton singlet at \(\delta\ 3.06\) and two proton singlets at \(\delta\ 4.25\) due to the presence of \(N\)-CH\(_3\) and \(N\)-CH\(_2\) group. A one proton multiplet and a two proton doublets appeared at \(\delta\ 5.59\) and 4.70 respectively due to the presence of vinyl proton and O-CH\(_2\) protons of the benzopyran moiety of the compound 10a. Its molecular ion peak appeared at \(m/z\ 349\) (M\(^{+}\)). \(^{13}\text{C}\) NMR spectrum of this compound revealed signals at \(\delta\ 161.7,\ 154.5,\ 148.5,\ 146.7,\ 146.5,\ 144.1,\ 129.1,\ 123.2,\ 119.2,\ 117.8,\ 117.2,\ 117.0,\)

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\begin{array}{cccccc}
R^1 & R^2 & R^3 & R^4 & \text{Yield} \\
7a & H & H & OMe & H & 92\% \\
7b & H & Me & H & Me & 90\% \\
7c & H & Me & H & H & 84\% \\
7d & Me & H & H & Me & 90\% \\
\end{array}
\]

Scheme I—Reagents and reaction condition: (i) dry Me\(_2\)CO-K\(_2\)CO\(_3\), NaI, reflux, 12-15 hr
116.9, 114.2, 109.0, 108.9, 65.7, 56.1, 54.1, 39.2. Other substrates 7b-d were similarly treated to give the products 10b-d in 79-86% yield.

The compounds 10a-d which have been synthesized by a single Claisen rearrangement, still possess an allyl aryl amine moiety for a second Claisen rearrangement. Therefore, the compounds 10a-d were allowed to undergo further Claisen rearrangement by treating with boron trifluoride etherate in dry dichloromethane. However, no change of starting material was observed. Attempts to achieve the second Claisen rearrangement of product 10 with anhydrous AlCl₃ in dichloromethane, benzene and toluene caused decomposition of the starting material. Attempts to carry out the reaction in the presence of anhydrous zinc chloride in dry toluene/ethanolic H₂SO₄ gave back the starting material.

Experimental Section

Melting points were determined in open capillaries and are uncorrected. UV-Vis absorption spectra were recorded in ethanol solution on a Shimadzu UV-240 IPC spectrometer (λmax in nm), IR spectra were run on a Perkin-Elmer 120-000A apparatus (νmax in cm⁻¹) for solid samples (KBr discs) and are liquid samples (neat). ¹H and ¹³C NMR spectra were determined for solutions in CDCl₃ with TMS as internal standard on a Brucker DPX-400. Elemental analyses and MS data were collected on a Leco 932 CHNS analyzer and on a JEOL-JMS-600 instrument respectively. Progress of the reaction was monitored by TLC run on silica gel-G (E-Merck, India). Silica gel (60-120 mesh) was used for column chromatographic separation. 1-aryloxy-4-chlorobut-2-yne products are obtained by eluting the column with ethyl acetate: petroleum ether (1:4).

Compound 7a: Yield 92%, gummy mass; UV-Vis (EtOH): nm 387, 254; IR (neat): 1721 cm⁻¹; ¹H NMR (CDCl₃): δ 2.94 (s, 3H), 3.74 (s, 3H), 4.07 (s, 2H), 4.59 (t, 2H, J=1.69 Hz), 6.37 (d, 1H, J=9.50 Hz), 6.72-6.82 (m, 5H), 7.00-7.03 (dd, 1H, J=2.93 Hz, J=2.99 Hz), 7.20-7.22 (d, 1H, J=9.08 Hz), 7.56 (d, 1H, J=9.50 Hz); ¹³C NMR (CDCl₃): δ 161.6, 154.7, 151.9, 147.5, 146.3, 144.1, 119.5, 119.4, 117.6, 117.1, 116.4, 114.8, 111.9, 82.6, 80.2, 57.1, 56.0, 43.6, 39.5; MS: m/z 349 (M⁺). Anal. Calcd. for C₂₁H₁₉NO₄: C, 72.20; H, 5.44; N, 4.01. Found: C, 72.29; H, 5.40; N, 3.97%.

Compound 7b: Yield 90%, gummy mass; UV-Vis (EtOH): nm 381, 254; IR (neat): 1715 cm⁻¹; ¹H NMR (CDCl₃): δ 2.92 (s, 3H), 2.95 (s, 3H), 4.07 (s, 2H), 4.60 (t, 2H, J=1.51 Hz), 6.35 (d, 1H, J=9.50 Hz), 6.49 (s, 2H), 6.57 (s, 1H), 6.74-6.75 (d, 1H, J=2.91 Hz), 7.00-7.03 (dd, 1H, J=2.94 Hz, J=2.99 Hz), 7.18-7.20 (d, 1H, J=9.07 Hz), 7.53-7.55 (d, 1H, J=9.50 Hz); MS: m/z 347 (M⁺); Anal. Calcd. for C₂₂H₂₁NO₃: C, 76.08; H, 6.05; N, 4.03. Found: C, 76.01; H, 6.15; N, 4.17%.

Compound 7c: Yield 84%, gummy mass; UV-Vis (EtOH): nm 377, 254; IR (neat): 1729 cm⁻¹; ¹H NMR (CDCl₃): δ 2.26 (s, 3H), 2.95 (s, 3H), 4.08 (d, 2H, J=1.42 Hz), 4.62-4.63 (t, 2H, J=1.68 Hz), 6.36-6.38 (d, 1H, J=9.50 Hz), 6.66-6.76 (m, 4H), 7.01-7.03 (dd, 1H, J=2.95 Hz, J=2.95 Hz), 7.07-7.10 (m, 1H), 7.19-7.21 (m, 1H), 7.54-7.56 (d, 1H, J=9.50 Hz); MS: m/z 333 (M⁺); Anal. Calcd. for C₂₂H₂₁NO₄: C, 75.67; H, 5.70; N, 4.20. Found: C, 75.49; H, 5.61; N, 4.03%.

Compound 7d: Yield 90%, gummy mass; UV-Vis (EtOH): nm 381, 254; IR (neat): 1722 cm⁻¹; ¹H NMR (CDCl₃): δ 2.24 (s, 3H), 2.23 (s, 3H), 2.94 (s, 3H), 4.06 (s, 2H), 4.62 (t, 2H, J=1.70 Hz), 6.36-6.38 (d, 1H, J=9.50 Hz), 6.68-6.70 (m, 1H), 6.78 (d, 1H, J=2.84 Hz), 6.79-6.81 (m, 1H), 6.91 (s, 1H), 7.00-7.03 (dd, 1H, J=2.89 Hz, J=2.91 Hz), 7.18-7.21 (m, 1H), 7.53-7.56 (m, 1H, J=9.50 Hz); MS: m/z 347 (M⁺); Anal. Calcd. for C₂₂H₂₁NO₄: C, 75.67; H, 5.70; N, 4.20. Found: C, 75.49; H, 5.61; N, 4.03%.

General procedure for the synthesis of the compounds, 10a-d

Compounds 7a-d (0.2 g) was refluxed in N,N-diethylaniline (3 mL) for 15 hr. The reaction mixture
was cooled, poured into ice cold (1:1) aqueous HCl solution and kept aside overnight. The mixture was then extracted with dichloromethane (3×25 mL). The dichloromethane extract was washed with dil. HCl (3×20 mL) and brine, dried (anhyd. Na₂SO₄). Dichloromethane was distilled off and the residual mass was chromatographed over silica-gel (60-120 mesh). Compounds 10a-d were eluted with ethyl acetate:petroleum ether (1:4).

**Compound 10a**: Yield 88%, solid, m.p. 139°C. UV-Vis (EtOH): nm 398, 257; IR (KBr): 1719 cm⁻¹; ¹H NMR (CDCl₃): δ 3.06 (s, 3H), 3.74 (s, 3H), 4.25 (s, 2H), 4.70 (s, 2H), 5.59 (s, 1H), 6.35 (d, 1H, J=9.50 Hz), 6.64-6.73 (m, 3H), 6.79-6.92 (m, 2H), 7.19 (m, 1H), 7.60 (d, 1H, J=9.50 Hz); ¹³C NMR (CDCl₃): δ 161.7, 154.5, 148.5, 146.7, 146.5, 144.1, 129.1, 123.2, 119.2, 117.8, 117.2, 117.0, 116.9, 114.2, 109.0, 108.9, 65.7, 56.1, 54.1, 39.2; MS: m/z 349 (M⁺); Anal. Calcd. for C₂₁H₁₉NO₄: C, 72.20; H, 5.44; N, 4.01.

**Compound 10b**: Yield 85%, gummy mass. UV-Vis (EtOH): nm 398, 257; IR (KBr): 1706 cm⁻¹; ¹H NMR (CDCl₃): δ 2.20 (s, 3H), 2.45 (s, 3H), 3.04 (s, 3H), 3.93 (d, 2H, J=1.6 Hz), 4.44 (m, 2H), 5.67-5.68 (m, 1H), 6.35 (d, 1H, J=9.50 Hz), 6.60 (t, 2H, J=3.22 Hz), 6.65 (s, 1H), 6.85-6.88 (dd, 1H, J=2.9 Hz, J=2.9 Hz), 7.18 (d, 1H, J=9.10 Hz), 7.60 (d, 1H, J=9.50 Hz); MS: m/z 347 (M⁺); Anal. Calcd. for C₂₁H₁₉NO₃: C, 76.08; H, 6.05; N, 4.03. Found: C, 76.03; H, 5.29; N, 4.18%.

**Compound 10c**: Yield 82%, solid, m.p. 120°C. UV-Vis (EtOH): nm 398, 257; IR (KBr): 1717 cm⁻¹; ¹H NMR (CDCl₃): δ 2.11 (s, 3H), 2.44 (s, 3H), 3.04 (s, 3H), 4.38 (d, 2H, J=1.6 Hz), 4.44 (m, 2H), 5.67-5.68 (m, 1H), 6.35 (d, 1H, J=9.50 Hz), 6.60 (t, 2H, J=3.22 Hz), 6.65 (s, 1H), 6.85-6.88 (dd, 1H, J=2.9 Hz, J=2.9 Hz), 7.17 (d, 1H, J=9.50 Hz), 7.60 (d, 1H, J=9.50 Hz); MS: m/z 347 (M⁺); Anal. Calcd. for C₂₁H₁₉NO₃: C, 76.08; H, 6.05; N, 4.03. Found: C, 76.03; H, 6.25; N, 4.08%.

**Compound 10d**: Yield 82%, solid, m.p. 151°C. UV-Vis (EtOH): nm 398, 257; IR (KBr): 1706 cm⁻¹; ¹H NMR (CDCl₃, 500 MHz): δ 2.20 (s, 3H), 2.45 (s, 3H), 3.06 (s, 3H), 4.25 (d, 2H, J=1.87 Hz), 4.74 (t, 2H, J=1.73 Hz), 5.74-5.76 (m, 1H), 6.36 (d, 1H, J=9.50 Hz), 6.63 (d, 1H, J=2.94 Hz), 6.69-6.83 (m, 2H), 6.91 (d, 1H, J=2.98 Hz), 6.99 (d, 1H, J=7.73 Hz), 7.17 (d, 1H, J=8.74 Hz), 7.60 (d, 1H, J=9.50 Hz); MS: m/z 333 (M⁺); Anal. Calcd. for C₂₂H₂₁NO₃: C, 75.67; H, 5.70; N, 4.20. Found: C, 75.89; H, 5.83; N, 4.40%.

**Conclusion**

In conclusion, the successful Claisen rearrangement of the substrates containing both the arloxy propargyl ether moiety and aryl propargyl amine moiety has been achieved. The rearrangement occurred only at the propargyl ether part of the substrate to afford benzopyran derivatives.

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**References**


