Supporting Information for

A bipyridine ligand embedded in polysiloxane gel which soaks up CuCl to form a reusable gel-catalyst active for ATRC

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Contents

1. General Methods P-S2
2. Preparation of 2,2’-Bipyridine Derivatives P-S2
3. Synthesis of [Cu]@[SiC6-DABipy] P-S3
4. Spectral Data of the Substrates P-S4
5. Spectral Data of the Products P-S5
6. References P-S6
7. NMR Spectra of Pyridine Derivatives P-S7
8. NMR Spectra of the Substrates P-S8
9. NMR Spectra of the Products P-S12

Supplementary Material (ESI) for Chemical Communications
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1. General Methods

Karstedt’s catalyst in 0.1 M xylene solution was purchased from Aldrich. Polymethylhydrosiloxane (PMHS, n = 25) was purchased from AZmax Co. Ltd. Chemical shifts for $^1$H, $^{13}$C, and $^{29}$Si NMR spectra were measured on JEOL ECA 400 (396 MHz) and ECA 600 (600 MHz) spectrometers. Chemical shifts for $^1$H NMR were described in parts per million downfield from tetramethylsilane as an internal standard ($\delta = 0$) in CDCl$_3$, unless otherwise noted. Chemical shifts for $^{13}$C NMR were expressed in parts per million in CDCl$_3$ as an internal standard ($\delta = 77.1$), unless otherwise noted. Chemical shifts for $^{29}$Si NMR were described in parts per million downfield from tetramethylsilane as an external standard. IR spectra were measured on JASCO FT/IR-550 and 4200 spectrometers. ICP-MS and HRMS analyses were performed at the Analytical Center in Institute for Materials Chemistry and Engineering, Kyushu University. Analytical thin-layer chromatography (TLC) was performed on aluminum sheets precoated with aluminum oxide (Merck, aluminum oxide 150 F$_{254}$, neutral) and glass plates precoated with silica gel (Merck, Kieselgel 60 F$_{254}$). Visualization was accomplished by UV light (254 nm), anisaldehyde, and phosphomolybdic acid.

2. Preparation of 2,2’-Bipyridine Derivatives

4,4’-Di(methoxycarbonyl)-2,2’-bipyridine. This compound was prepared from 2,2’-bipyridine-4,4’-dicarboxylic acid (1.16 g, 4.75 mmol) and conc. H$_2$SO$_4$ (2.3 mL) in methanol (20 mL) according to the literature method; 1 1.11 g (86%); Mp 209.2-210.4 °C; IR (KBr): $\nu$ 1731, 1558, 1466, 1437, 1359, 1295, 1246, 1191, 1126, 959, 758 cm$^{-1}$; $^1$H NMR (396 MHz, CDCl$_3$): $\delta$ 4.00 (s, 6H), 7.91 (d, $J = 4.8$ Hz, 2H), 8.87 (d, $J = 4.8$ Hz, 2H), 8.97 (bs, 2H); $^{13}$C NMR (150 MHz, CDCl$_3$): $\delta$ 52.9, 120.7, 123.4, 138.7, 150.3, 156.6, 165.7. This compound was used in the next step without further purification.

4,4’-Bis(hydroxymethyl)-2,2’-bipyridine. This compound was prepared from 4,4’-di(methoxycarbonyl)-2,2’-bipyridine (1.11 g, 4.07 mmol) and NaBH$_4$ (3.34 g, 88.3 mmol) in ethanol (81 mL) according to the literature method; 1,2 725 mg (82%); Mp 170.6-171.4 °C; IR (KBr): $\nu$ 3366, 3064, 2883, 1601, 1557, 1456, 1388, 1060, 997, 816 cm$^{-1}$; $^1$H NMR (396 MHz, CD$_3$OD): $\delta$ 4.79 (s, 4H), 7.48 (d, $J = 4.8$ Hz, 2H), 8.31 (bs, 2H), 8.63 (d, $J = 4.8$ Hz, 2H); $^{13}$C NMR (150 MHz, CD$_3$OD): $\delta$ 63.6, 120.2, 122.7, 150.1, 154.4, 157.2. This compound was used in the next step without further purification.

4,4’-Bis[(2-propenyloxy)methyl]-2,2’-bipyridine (DABipy). To a suspension of NaH (60 wt%; 523 mg, 8.7 mmol) in DMF (5 mL) was added a solution of 4,4’-bis(hydroxymethyl)-2,2’-bipyridine (725 mg, 3.35 mmol) in DMF (11 mL) at 0 °C. After it was stirred at that temperature for 40 min, allyl bromide (760 $\mu$L, 8.71 mmol) was added and the resultant mixture was stirred at room temperature overnight. Purification by silica gel chromatography (CHCl$_3$/MeOH = 20:1) gave 2 in 77% yield (770 mg); IR (neat) $\nu$ 2855, 1597, 1557, 1459, 1367, 1105, 1092, 991, 926, 826 cm$^{-1}$; $^1$H NMR (396 MHz, CDCl$_3$): $\delta$ 4.11 (d, $J = 5.3$ Hz, 4H), 4.64 (s, 4H), 5.25 (d, $J = 10.1$ Hz, 2H), 5.35 (d, $J = 16.9$ Hz, 2H), 5.98 (ddd, $J = 16.9, 10.1, 5.3$ Hz, 2H), 7.39 (d, $J = 4.8$ Hz, 2H), 8.38 (bs, 2H), 8.67 (d, $J = 4.8$ Hz, 2H); $^{13}$C NMR (99.5 MHz, CDCl$_3$): $\delta$ 70.6, 71.9, 117.7, 119.4, 122.0, 134.4, 148.8, 149.5, 156.2; HRMS (FAB) calcd for C$_{18}$H$_{20}$N$_2$O$_2$+H 297.1603, found 297.1603.
3. Synthesis of [Cu/bipy]@Si

[bipy]@Si: To a stirred solution of DABipy (2) (14.8 mg, 0.05 mmol) and PMHS (\(M_w = 1500–1900; n = 25.6\) (average); 140 µL, Si–H = 2 mmol) in tetrahydrofuran (0.5 mL) was added a xylene solution of Karstedt’s catalyst (0.1 M solution, 100 µL, 0.01 mmol). After it was stirred for 30 min, 1,5-hexadiene (180 µL, 1.5 mmol) was added to the solution. Hydrosilylation proceeded at 40 °C and [bipy]@Si was formed as a wet gel within 2 h. Finally, the formed wet gel was treated with ethylene (balloon) in ether (2 mL) for 1 h for complete consumption of the unreacted Si–H moieties in the gel. The resultant wet gel was washed with ether (20 mL) and then dried under reduced pressure to afford the dry gel. \(^{29}\)Si NMR (CP/MAS; 10 kHz) \(\delta 9.9\) (Me\(_3\)SiO–), -21.0 [–CH\(_2\)SiMe(O–)].

A: \(^{29}\)Si NMR; before ethylene treatment

B: \(^{29}\)Si NMR; after ethylene treatment

C: \(^{13}\)C NMR; after ethylene treatment

Figure S1. \(^{29}\)Si NMR (CP/MAS; 10 kHz) (A and B) and \(^{13}\)C NMR (CP/MAS; 10 kHz) spectra (C) of [bipy]@Si.

[Cu/bipy]@Si: CuCl (2.0 mg, 0.02 mmol and [Pt]@SiC\(_6\)-Dabipy obtained as above were measured into a flask, and the atmosphere was replaced by argon. Then freshly distilled, carefully degassed dichloromethane (1.5 mL) was added. After it was stirred for 1 h at ambient temperature, the resultant wet gel was washed with dichloromethane (20 mL) and then dried under reduced pressure to afford [Cu]@SiC\(_6\)-DABipy as a dry gel. ICP-MS analysis revealed that the dichloromethane solution contained 102 µg of copper; which means that 92% of the charged CuCl was entrapped in the gel.

\[\text{CuCl} \quad \text{CH}_2\text{Cl}_2 \quad \text{air} \]

D: [bipy]@Si

E: [Cu/bipy]@Si

F

Figure S2. Photos of [bipy]@Si (D), [Cu/bipy]@Si (E: as prepared; F: exposure to air).
4. Spectral Data of the Substrates

**N,N-Diallyl-α,α,α-trichloroacetamide (1a):**

\[
\text{IR (neat): v: 3084, 2986, 1681, 1435, 1409, 1232, 1183, 992, 929, 844, 810, 670 \text{ cm}^{-1}; } \\
\text{H NMR (396 MHz, CDCl}_3\text{): } \delta 4.01 \text{ (bs, 2H), 4.32 (bs, 2H), 5.10-5.39 (m, 4H), 5.80 (bs, 2H); } \\
\text{13C NMR (99.5 MHz, CDCl}_3\text{): } \delta 49.6, 51.5, 92.9, 117.9, 119.2, 130.9, 131.8, 160.0.
\]

**N- Allyl-N-benzyl-α,α,α-trichloroacetamide (1b):**

\[
\text{mp: 43.9-44.6 °C; IR (KBr): v: 3065, 2986, 1678, 1496, 1414, } \\
\text{1229, 991, 937, 847, 738 \text{ cm}^{-1}. Spectroscopic data of this amide were obtained as a mixture of two } \\
\text{rotational isomers. major isomer: } \text{H NMR (396 MHz, CDCl}_3\text{): } \delta 4.28 \text{ (bs, 2H), 4.67 (bs, 2H), } \\
\text{5.26 (bd, } J = 17.4 \text{ Hz, 1H), 5.35 (bd, } J = 9.7 \text{ Hz, 1H), 5.84 (bs, 1H), 7.21-7.41 (m, 5H); } \\
\text{13C NMR (99.5 MHz, CDCl}_3\text{): } \delta 49.9, 51.1, 93.0, 119.7, 127.7, 127.8, 128.7, 131.8, 135.7, 160.6;} \\
\text{minor isomer: } \text{H NMR (396 MHz, CDCl}_3\text{): } \delta 3.94 \text{ (bs, 2H), 4.98 (bs, 2H), 5.13 (bd, } J = 16.9 \text{ Hz, 1H), 5.23 (bd, } J = 9.2 \text{ Hz, 1H), 5.77 (bs, 1H), } \\
\text{7.21-7.41 (m, 5H); } \text{13C NMR (99.5 MHz, CDCl}_3\text{): } \delta 49.9, 52.2, 93.0, 118.3, 127.0, 127.8, 128.7, 130.7, 135.0, \\
\text{160.6.}
\]

**N- Allyl-N-tosyl-α,α,α-trichloroacetamide (1c):**

\[
\text{IR (neat): v: 72.5-73.0 °C; IR (KBr): v: 3057, 2988, 1712, 1596, 1365, } \\
\text{1322, 1267, 1222, 1173, 1086, 840, 817, 674 \text{ cm}^{-1}; } \text{H NMR (396 MHz, CDCl}_3\text{): } \delta 2.45 \text{ (s, 3H), } \\
\text{4.92 (dm, } J = 5.3 \text{ Hz, 2H), 5.38 (dm, } J = 10.6 \text{ Hz, 1H), 5.46 (dm, } J = 17.4 \text{ Hz, 1H), 5.96 (ddt, } J \\
\text{= 17.4, 10.6, 5.3 Hz, 1H), 7.34 (d, } J = 8.2 \text{ Hz, 2H), 7.93 (d, } J = 8.2 \text{ Hz, 2H); } \text{13C NMR (99.5 MHz, CDCl}_3\text{): } \delta 21.8, 51.2, 92.1, 119.6, 129.5, 129.6, 132.3, 134.7, 145.7, 159.0.
\]

**N- Allyl-N-phenyl-α,α,α-trichloroacetamide (1d):**

\[
\text{IR (neat): v: 3082, 2934, 1683, 1594, 1493, 1385, 1258, 930, } \\
\text{835, 699 \text{ cm}^{-1}; } \text{H NMR (396 MHz, CDCl}_3\text{): } \delta 4.38 \text{ (bs, 2H), 5.13 (dm, } J = 16.9 \text{ Hz, 1H), 5.21 } \\
\text{(dm, } J = 10.1 \text{ Hz, 1H), 5.93 (ddt, } J = 16.9, 10.1, 6.3 \text{ Hz, 1H), 7.28-7.43 (m, 5H); } \text{13C NMR (99.5 MHz, CDCl}_3\text{): } \delta 57.8, 93.1, 119.6, 128.6, 128.8, 129.6, 131.1, 141.1, 160.1.
\]

**N-Prenyl-N-tosyl-α,α,α-trichloroacetamide (1e):**

\[
\text{mp: 99.7-100.3 °C; IR (KBr): v: 3061, 2975, 1709, 1596, 1446, } \\
\text{1365, 1311, 1171, 1085, 844, 814, 704 \text{ cm}^{-1}; } \text{H NMR (396 MHz, CDCl}_3\text{): } \delta 1.78 \text{ (bs, 3H), 1.80 } \\
\text{(bs, 3H), 2.45 (s, 3H), 4.90 (d, } J = 6.3 \text{ Hz, 2H), 5.22 (m, 1H), 7.33 (d, } J = 8.7 \text{ Hz, 2H), 7.91 (d, } \\
\text{J = 8.7 Hz, 2H); } \text{13C NMR (99.5 MHz, CDCl}_3\text{): } \delta 18.3, 21.8, 25.8, 47.9, 92.3, 119.3, 129.4, \\
\text{129.6, 135.2, 137.4, 145.5, 159.3; HRMS (FAB) caled for } C_{14}H_{16}\text{NO}_2\text{Cl}_3\text{S}+H \text{ 383.9995, found 383.9995.}
\]

**N- Allyl-N-tosyl-α,α,α-dimethyl-α-bromooacetamide (1f):**

\[
\text{mp: 83.2-84.6 °C; IR (KBr): v: 2982, 2934, 1682, 1596, } \\
\text{1458, 1392, 1352, 1317, 1240, 1168, 1086, 927, 813, 775, 716 \text{ cm}^{-1}; } \text{H NMR (396 MHz, CDCl}_3\text{): } \delta 1.89 \text{ (s, 6H), 2.44 (s, 3H), 4.96 } \\
\text{(dm, } J = 4.8 \text{ Hz, 2H), 5.32 (dm, } J = 10.6 \text{ Hz, 1H), 5.42 } \\
\text{(dm, } J = 16.9 \text{ Hz, 1H), 5.99 (ddt, } J = 16.9, 10.6, 4.8 \text{ Hz, 1H), 7.31 (d, } J = 8.2 \text{ Hz, 2H), 7.88 (d, } \\
\text{J = 8.2 Hz, 2H); } \text{13C NMR (99.5 MHz, CDCl}_3\text{): } \delta 21.7, 32.0, 50.6, 57.0, 118.2, 128.9, 129.2, 133.6, 136.1, 144.7, \\
\text{170.4.}
\]

**N- Allyl-N-tosyl-α,α,α-dichloroacetamide (1g):**

\[
\text{mp: 95.3-96.0 °C; IR (KBr): v: 3057, 2986, 1715, 1596, 1366, } \\
\text{1266, 1172, 1087, 811, 739 \text{ cm}^{-1}; } \text{H NMR (396 MHz, CDCl}_3\text{): } \delta 2.47 \text{ (s, 3H), 4.42 (dm, } J = 5.3 \text{ Hz, 2H), 5.21-}
\]
5. Spectral Data of the Products

3,3-Dichloro-4-chloromethyl-1-allylpyrroridin-2-one (2a): IR (neat): 2923, 1728, 1482, 1446, 1418, 1273, 956, 916, 835 cm\(^{-1}\); \(^1\)H NMR (396 MHz, CDCl\(_3\)): \(\delta 3.11 (m, 1H), 3.22 (dd, J = 10.1, 8.2 Hz, 1H), 3.58 (dd, J = 10.1, 7.2 Hz, 1H), 3.74 (dd, J = 10.6, 10.1 Hz, 1H), 3.92-4.05 (m, 3H), 5.27 (dm, J = 16.9 Hz, 1H), 5.30 (dm, J = 10.1 Hz, 1H), 5.74 (ddt, J = 16.9, 10.1, 6.3 Hz, 1H); \(^{13}\)C NMR (99.5 MHz, CDCl\(_3\)): \(\delta 41.1, 46.4, 47.4, 51.6, 83.7, 119.7, 130.4, 165.7\).

3,3-Dichloro-4-chloromethyl-1-benzylpyrroridin-2-one (2b): mp: 129.3-130.0 °C; IR (KBr): 3030, 2927, 1725, 1482, 1430, 1360, 1273, 957, 911, 834, 701 cm\(^{-1}\); \(^1\)H NMR (396 MHz, CDCl\(_3\)): \(\delta 3.03-3.14 (m, 2H), 3.47 (m, 1H), 3.68 (dd, J = 11.1, 9.7 Hz, 1H), 3.98 (dd, J = 11.1, 3.9 Hz, 1H), 4.45 (d, J = 14.5 Hz, 1H), 4.64 (d, J = 14.5 Hz, 1H), 7.24 (d, J = 7.7 Hz, 2H), 7.31-7.40 (m, 3H); \(^{13}\)C NMR (99.5 MHz, CDCl\(_3\)): \(\delta 41.1, 47.3, 47.9, 51.6, 83.7, 119.7, 130.4, 166.1\).

3,3-Dichloro-4-chloromethyl-1-(p-toluenesulfonyl)pyrroridin-2-one (2c): mp: 159.5-160.9 °C; IR (KBr): 3054, 1763, 1376, 1265, 1176, 985, 748, 730 cm\(^{-1}\); \(^1\)H NMR (396 MHz, CDCl\(_3\)): \(\delta 2.46 (s, 3H), 3.08 (dddd, J = 10.1, 8.7, 6.8, 4.3 Hz, 1H), 3.56 (dd, J = 10.1, 8.7 Hz, 1H), 3.68 (dd, J = 11.1, 3.9 Hz, 1H), 4.45 (d, J = 14.5 Hz, 1H), 4.64 (d, J = 14.5 Hz, 1H), 7.24 (d, J = 7.7 Hz, 2H), 7.31-7.40 (m, 3H); \(^{13}\)C NMR (99.5 MHz, CDCl\(_3\)): \(\delta 21.9, 40.2, 47.5, 50.7, 82.7, 128.3, 130.1, 133.3, 146.5, 163.1\).

3,3-Dichloro-4-chloromethyl-1-phenylpyrroridin-2-one (2d): mp: 139.9-140.8 °C; IR (KBr): 3054, 1763, 1376, 1265, 1176, 985, 748, 730 cm\(^{-1}\); \(^1\)H NMR (396 MHz, CDCl\(_3\)): \(\delta 3.26 (dddd, J = 10.6, 8.7, 7.2, 4.3 Hz, 1H), 3.74 (dd, J = 10.1, 8.7 Hz, 1H), 3.85 (dd, J = 11.1, 10.1 Hz, 1H), 3.94 (dd, J = 11.1, 4.3 Hz, 1H), 4.25 (dd, J = 10.1, 6.8 Hz, 1H), 7.38 (d, J = 8.2 Hz, 2H), 7.93 (d, J = 8.2 Hz, 2H); \(^{13}\)C NMR (99.5 MHz, CDCl\(_3\)): \(\delta 21.9, 40.2, 47.5, 50.7, 82.7, 128.3, 130.1, 133.3, 146.5, 163.1\).

3,3-Dichloro-4-[(1-chloro-1-methyl)ethyl]-1-(p-toluenesulfonyl)pyrroridin-2-one (2e): mp: 118.6-119.5 °C; IR (KBr): 3054, 1763, 1494, 1409, 1305, 1184, 1123, 1052, 817, 761, 684 cm\(^{-1}\); \(^1\)H NMR (396 MHz, CDCl\(_3\)): \(\delta 1.87 (s, 3H), 1.89 (s, 3H), 2.47 (s, 3H), 3.10 (dd, J = 10.1, 7.2 Hz, 1H), 3.88 (t, J = 10.1 Hz, 1H), 4.25 (dd, J = 10.1, 7.2 Hz, 1H), 7.39 (d, J = 8.2 Hz, 2H), 7.95 (d, J = 8.2 Hz, 2H); \(^{13}\)C NMR (99.5 MHz, CDCl\(_3\)): \(\delta 21.9, 30.2, 33.7, 45.9, 58.3, 67.8, 81.9, 128.4, 130.1\).
3,3-Dimethylo-4-bromomethyl-1-(p-toluenesulfonyl)pyrroridin-2-one (2f): $^5$ mp: 130.9-131.2 °C; IR (KBr): $\nu$ 3057, 2973, 1736, 1366, 1266, 1173, 1115, 744 cm$^{-1}$; $^1$H NMR (396 MHz, CDCl$_3$): $\delta$ 0.89 (s, 3H), 1.16 (s, 3H), 2.43 (s, 3H), 2.44 (dd, $J = 10.1$, 8.7, 7.2, 4.8 Hz, 1H), 3.60 (dd, $J = 10.1$, 8.7 Hz, 1H), 3.43 (dd, $J = 10.1$, 8.7 Hz, 1H), 4.14 (dd, $J = 10.1$, 7.2 Hz, 1H), 7.33 (d, $J = 8.2$ Hz, 2H), 7.91 (d, $J = 8.2$ Hz, 2H); $^{13}$C NMR (99.5 MHz, CDCl$_3$): $\delta$ 21.7, 23.4, 29.9, 45.0, 45.4, 48.8, 128.0, 129.8, 134.8, 145.4, 176.9.

3-Chloro-4-chloromethyl-1-(p-toluenesulfonyl)pyrroridin-2-one (2g): $^6$ mp: 125.3-126.9 °C; IR (KBr): $\nu$ 3055, 1753, 1372, 1265, 1174, 1129, 1089, 964, 741 cm$^{-1}$; $^1$H NMR (396 MHz, CDCl$_3$): $\delta$ 2.46 (s, 3H), 2.83 (m, 1H), 3.69-3.81 (m, 3H), 4.11 (dd, $J = 10.6$, 7.7 Hz, 1H), 4.35 (d, $J = 8.7$ Hz, 1H), 7.37 (d, $J = 8.7$ Hz, 2H), 7.94 (d, $J = 8.7$ Hz, 2H); $^{13}$C NMR (99.5 MHz, CDCl$_3$): $\delta$ 21.8, 42.3, 44.2, 46.9, 56.1, 128.3, 130.01, 134.2, 146.1, 166.7. cis-4h: $\delta$ 2.46 (s, 3H), 2.95 (m, 1H), 3.53 (dd, $J = 11.6$, 7.2 Hz, 1H), 3.63-3.74 (m, 2H), 4.13 (dd, $J = 10.1$, 7.3 Hz, 1H), 4.44 (d, $J = 6.3$ Hz, 1H), 7.37 (d, $J = 8.7$ Hz, 2H), 7.92 (d, $J = 8.7$ Hz, 2H); $^{13}$C NMR (99.5 MHz, CDCl$_3$): $\delta$ 21.8, 40.3, 41.1, 47.9, 57.5, 128.2, 129.96, 134.0, 146.0, 166.8.

3,3-Dichloro-4-[(1-chloro-1-methyl)ethyl]-1-benzylazetidin-2-one (2h): mp: 89.6-90.3 °C; IR (KBr): $\nu$ 3064, 2937, 1792, 1394, 1265, 1111, 805, 739 cm$^{-1}$; $^1$H NMR (396 MHz, CDCl$_3$): $\delta$ 1.75 (s, 3H), 1.81 (s, 3H), 4.23 (s, 1H), 4.33 (d, $J = 15.0$ Hz, 1H), 5.00 (d, $J = 15.0$ Hz, 1H), 7.29-7.40 (m, 5H); $^{13}$C NMR (99.5 MHz, CDCl$_3$): $\delta$ 26.3, 29.1, 46.3, 68.6, 81.2, 128.4, 128.6, 129.0, 134.0, 161.8; HRMS (FAB) calcd for C$_{13}$H$_{14}$NOCl$_3$+H 306.0219, found 306.0219.

6. References

7. NMR Spectra of Pyridine Derivatives

4,4'-Di(methoxycarbonyl)-2,2'-bipyridine

4,4'-Bis(hydroxymethyl)-2,2'-bipyridine
4,4'-Bis(2-propenoxymethyl)-2,2'-bipyridine (DABipy)

NMR Spectra of the Substrates

$N,N$-Diallyl- $\alpha,\alpha,\alpha$-trichloroacetamide (1a)
N-Allyl-N-benzyl-α,α,α-trichloroacetamide (1b)

N-Allyl-N-tosyl-α,α,α-trichloroacetamide (1c)
N-Allen-N-phenyl-α,α,α-trichloroacetamide (1d)

N-Prenyl-N-tosyl-α,α,α-trichloroacetamide (1e)
N-Allyl-N-tosyl-α,α-dimethyl-α-bromoacetamide (1f)

N-Allyl-N-tosyl-α,α-dichloroacetamide (1g)
N-Benzyl-N-(2-methyl-1-propenyl)-α,α,α-trichloroacetamide (1h)

NMR Spectra of the Products

3,3-Dichloro-4-chloromethyl-1-allylpyrrolidin-2-one (2a)
3,3-Dichloro-4-chloromethyl-1-benzylpyrroloidin-2-one (2b)

3,3-Dichloro-4-chloromethyl-1-(p-toluenesulfonyl)pyrroloidin-2-one (2c)
3,3-Dichloro-4-chloromethyl-1-phenylpyrroolidin-2-one (2d)

3,3-Dichloro-4-[(1-chloro-1-methyl)ethyl]-1-(p-toluenesulfonyl)pyrroolidin-2-one (2e)

PS- 14
3,3-Dimethylo-4-bromomethyl-1-(p-toluenesulfonyl)pyrroridin-2-one (2f)

3-Chloro-4-chloromethyl-1-(p-toluenesulfonyl)pyrroridin-2-one (2g)
3,3-Dichloro-4-[(1-chloro-1-methyl)ethyl]-1-benzylazetidin-2-one (2h)