

Supporting Information  
for

# Enantioselective addition of diphenyl phosphonate to ketimines derived from isatins catalyzed by binaphthyl-modified organocatalysts

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## Experimental and analytical data

### 1. General

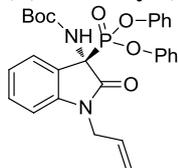
All commercial reagents and solvents were used without purification. TLC analyses were carried out on pre-coated silica gel plates with F<sub>254</sub> indicator. Visualization was accomplished by UV light (254 nm), I<sub>2</sub>, *p*-anisaldehyde, ninhydrin, and phosphomolybdic acid solution as an indicator. Purification of reaction products was carried out by flash chromatography using E. Merck silica gel 60 (230–400 mesh). <sup>1</sup>H NMR and <sup>13</sup>C NMR spectra were recorded on a Jeol 400 MHz NMR (400 MHz for <sup>1</sup>H, 100 MHz for <sup>13</sup>C). Chemical shift values (δ) are reported in ppm relative to Me<sub>4</sub>Si (δ 0.0 ppm). Optical rotations were measured on a JASCO-DIP-1000 digital polarimeter with a sodium lamp. The enantiomeric excesses (ees) were determined by HPLC. HPLC analyses were performed on Younglin M930 Series and Younglin M9100 Series machines and were measured at 254 nm using the indicated chiral column.

### 2. General procedure for the enantioselective addition of diphenyl phosphonate (**2**) to ketimines derived from isatins **1**.

To a solution of ketimine **1** (0.3 mmol), diphenyl phosphonate (**2**, 0.45 mmol), 4 Å MS (150 mg) in ethyl acetate (3 mL), the catalyst (**III**, 7.5 μmol) was added at 0 °C. The reaction mixture was stirred for 12–48 h. After completion of the reaction, the resulting solution was concentrated in vacuo and the obtained residue was purified by flash chromatography (EtOAc–hexane) to afford the corresponding adducts **3**. Products **3** are known compounds, and their data were identical to those reported in the literature [1,2].

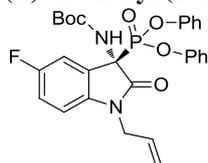
### 3. Characterization data of products 3.

#### (*R*)-*tert*-Butyl (1-allyl-3-(diphenoxyphosphoryl)-2-oxoindolin-3-yl)carbamate (3a)



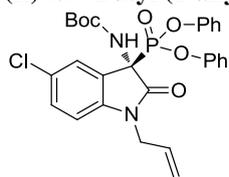
$[\alpha]_{\text{D}}^{24} = -15.92$  ( $c = 1$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 1.29 (s, 9H), 4.24 (d,  $J = 13.2$  Hz, 1H), 4.64 (d,  $J = 15.6$  Hz, 1H), 5.18 (d,  $J = 10.4$  Hz, 1H), 5.38 (d,  $J = 17.6$  Hz, 1H), 5.80–5.91 (m, 2H), 6.69 (d,  $J = 8.9$  Hz, 2H), 6.867 (d,  $J = 8.0$  Hz, 1H), 7.07–7.26 (m, 7H), 7.31–7.40 (m, 3H), 7.53 (dd,  $J = 1.4$  and 7.4 Hz, 1H);  $^{13}\text{C NMR}$  ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 28.0, 43.0, 81.3, 109.3, 117.7, 120.2 (d,  $J = 3.8$  Hz), 120.9 (d,  $J = 3.8$  Hz), 122.9 (d,  $J = 3.8$  Hz), 125.2 (d,  $J = 3.9$  Hz), 125.6, 125.8, 129.6, 129.8, 130.0 (d,  $J = 3.1$  Hz), 130.8, 143.6 (d,  $J = 7.7$  Hz), 150.0 (dd,  $J = 10.6$  and 19.3 Hz), 153.5 (d,  $J = 18.4$  Hz), 170.7;  $^{31}\text{P NMR}$  ( $\text{CDCl}_3$ , 162 MHz)  $\delta$ : 7.25; HPLC (90 : 10, *n*-hexane : *i*-PrOH, 254nm, 1mL/min) Chiralpak IB column,  $t_{\text{R}} = 7.8$  (major),  $t_{\text{R}} = 11.4$  (minor), 93% ee.

#### (*R*)-*tert*-Butyl (1-allyl-3-(diphenoxyphosphoryl)-5-fluoro-2-oxoindolin-3-yl)carbamate (3b)



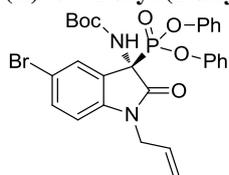
$[\alpha]_{\text{D}}^{25} = -11.08$  ( $c = 1$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 1.32 (s, 9H), 4.24 (d,  $J = 14.8$  Hz, 1H), 4.60 (d,  $J = 15.6$  Hz, 1H), 5.19 (d,  $J = 10.8$  Hz, 1H), 5.37 (d,  $J = 17.2$  Hz, 1H), 5.78–5.90 (m, 2H), 6.78 (m, 3H), 6.91–7.40 (m, 8H), 7.28–7.36 (m, 3H);  $^{13}\text{C NMR}$  ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 28.1, 43.2, 81.6, 110.0 (d,  $J = 6.8$  Hz), 113.1 (d,  $J = 3.8$  Hz), 113.3 (d,  $J = 4.8$  Hz), 116.2 (d,  $J = 2.9$  Hz), 116.5 (d,  $J = 2.8$  Hz), 117.8, 120.1 (d,  $J = 3.8$  Hz), 120.8 (d,  $J = 3.9$  Hz), 125.7, 126.0, 129.7, 129.9, 130.6, 149.8 (d,  $J = 9.6$  Hz), 153.5 (d,  $J = 19.3$  Hz), 170.6;  $^{31}\text{P NMR}$  ( $\text{CDCl}_3$ , 162 MHz)  $\delta$ : 6.57; HPLC (70 : 30, *n*-hexane : *i*-PrOH, 254nm, 1mL/min) Chiralpak IC column,  $t_{\text{R}} = 5.6$  (minor),  $t_{\text{R}} = 7.1$  (major), 94% ee.

#### (*R*)-*tert*-Butyl (1-allyl-5-chloro-3-(diphenoxyphosphoryl)-2-oxoindolin-3-yl)carbamate (3c)



$[\alpha]_{\text{D}}^{27} = 5.64$  ( $c = 1$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 1.32 (s, 9H), 4.26 (s, 1H), 4.59 (d,  $J = 15.6$  Hz, 1H), 5.19 (d,  $J = 10.8$  Hz, 1H), 5.37 (d,  $J = 17.2$  Hz, 1H), 5.78–5.90 (m, 2H), 6.80 (t,  $J = 8.6$  Hz, 2H), 7.12–7.23 (m, 6H), 7.29–7.43 (m, 3H), 7.50 (s, 1H);  $^{13}\text{C NMR}$  ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 28.1, 43.2, 81.7, 110.4, 117.9, 120.1 (d,  $J = 4.8$  Hz), 120.7 (d,  $J = 3.8$  Hz), 125.4 (d,  $J = 3.8$  Hz), 125.7, 125.9, 128.3 (d,  $J = 3.8$  Hz), 129.7, 129.9, 130.5, 142.2 (d,  $J = 6.7$  Hz), 149.9 (dd,  $J = 10.1$ , 13.0 Hz), 153.4 (d,  $J = 18.3$  Hz), 170.4;  $^{31}\text{P NMR}$  ( $\text{CDCl}_3$ , 162 MHz)  $\delta$ : 6.38; HPLC (70 : 30, *n*-hexane : *i*-PrOH, 254nm, 1mL/min) Chiralpak IC column,  $t_{\text{R}} = 6.5$  (minor),  $t_{\text{R}} = 8.6$  (major), 94% ee.

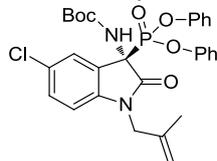
#### (*R*)-*tert*-Butyl (1-allyl-5-bromo-3-(diphenoxyphosphoryl)-2-oxoindolin-3-yl)carbamate (3d)



$[\alpha]_{\text{D}}^{26} = 16.36$  ( $c = 1$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 1.32 (s, 9H), 4.24 (d,  $J = 15.2$  Hz, 1H), 4.58 (d,  $J = 14.8$  Hz, 1H), 5.19 (d,  $J = 11.2$  Hz, 1H), 5.37 (d,  $J = 16.8$  Hz, 1H), 5.77–5.90 (m, 2H), 6.74 (d,  $J = 8.4$  Hz, 1H), 6.82 (d,  $J = 6.8$  Hz, 2H), 7.11–7.24 (m, 6H), 7.32–7.51 (m, 3H), 7.63 (t,  $J = 2.4$  Hz, 1H);  $^{13}\text{C NMR}$  ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 28.1, 43.2, 81.7, 110.8, 115.4 (d,  $J = 3.8$  Hz), 117.9, 120.1 (d,  $J = 3.8$  Hz), 120.7 (d,  $J = 3.8$  Hz), 125.6,

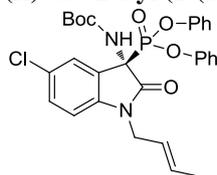
126.0, 128.1 (d,  $J = 3.8$  Hz), 129.7, 129.9, 130.4, 132.8 (d,  $J = 2.8$  Hz), 142.7 (d,  $J = 6.8$  Hz), 149.9 (dd,  $J = 9.6$ , 13.5 Hz), 153.4 (d,  $J = 17.3$  Hz), 170.3;  $^{31}\text{P}$  NMR ( $\text{CDCl}_3$ , 162 MHz)  $\delta$ : 6.36; HPLC (70 : 30, *n*-hexane : *i*-PrOH, 254nm, 1mL/min) Chiralpak IC column,  $t_{\text{R}} = 6.1$  (minor),  $t_{\text{R}} = 7.8$  (major), 97% ee.

**(R)-tert-Butyl (5-chloro-3-(diphenoxyphosphoryl)-1-(2-methylallyl)-2-oxoindolin-3-yl)carbamate (3e)**



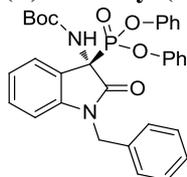
$[\alpha]_{\text{D}}^{28} = 9.84$  ( $c = 1$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 1.32 (s, 9H), 1.77 (s, 3H), 4.14 (s, 1H), 4.53 (d,  $J = 13.2$  Hz, 1H), 4.92 (s, 1H), 5.04 (s, 1H), 5.89 (d,  $J = 2.9$  Hz, 1H), 6.79–6.82 (m, 3H), 7.10–7.14 (m, 1H), 7.19–7.23 (m, 5H), 7.28–7.36 (m, 3H), 7.50 (t,  $J = 2.4$  Hz, 1H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 19.9, 28.1, 46.9, 81.7, 110.4, 113.2, 120.2 (d,  $J = 4.8$  Hz), 120.8 (d,  $J = 3.8$  Hz), 125.3 (d,  $J = 4.8$  Hz), 125.8, 126.0, 128.2 (d,  $J = 3.8$  Hz), 129.7, 129.9, 138.6, 142.5 (d,  $J = 6.8$  Hz), 149.9 (t,  $J = 10.6$  Hz), 153.4 (d,  $J = 17.4$  Hz), 170.6;  $^{31}\text{P}$  NMR ( $\text{CDCl}_3$ , 162 MHz)  $\delta$ : 6.54; HPLC (70 : 30, *n*-hexane : *i*-PrOH, 254nm, 1mL/min) Chiralpak IC column,  $t_{\text{R}} = 7.0$  (major),  $t_{\text{R}} = 10.0$  (minor), >99% ee.

**(R)-tert-Butyl (1-(trans-but-2-en-1-yl)-5-chloro-3-(diphenoxyphosphoryl)-2-oxoindolin-3-yl)carbamate (3f)**



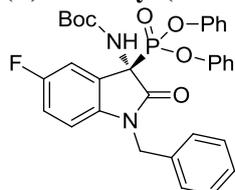
$[\alpha]_{\text{D}}^{26} = 12.24$  ( $c = 1$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 1.32 (s, 9H), 1.61 (s, 3H), 4.10–4.33 (m, 1H), 4.50–4.63 (m, 1H), 5.39–5.46 (m, 1H), 5.69–5.88 (m, 1H), 6.75–6.83 (m, 3H), 7.10–7.13 (m, 1H), 7.19–7.23 (m, 5H), 7.28–7.44 (m, 3H), 7.48–7.50 (m, 1H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 17.6, 28.1, 42.2, 42.6, 53.4, 81.7, 110.1, 110.3, 120.1 (d,  $J = 4.8$  Hz), 120.7 (d,  $J = 3.8$  Hz), 123.5, 123.6, 125.4 (d,  $J = 3.8$  Hz), 125.7, 125.9, 128.1, 129.0, 129.5, 129.7, 129.9, 141.5, 142.3 (d,  $J = 6.7$  Hz), 149.9 (t,  $J = 11.6$  Hz), 153.5 (d,  $J = 17.2$  Hz), 170.3;  $^{31}\text{P}$  NMR ( $\text{CDCl}_3$ , 162 MHz)  $\delta$ : 6.38; HPLC (70 : 30, *n*-hexane : *i*-PrOH, 254nm, 1mL/min) Chiralpak IA column,  $t_{\text{R}} = 16.6$ , 19.4 (minor),  $t_{\text{R}} = 22.7$ , 35.15 (major), 88, 85% ee.

**(R)-tert-Butyl (1-benzyl-3-(diphenoxyphosphoryl)-2-oxoindolin-3-yl)carbamate (3g)**



$[\alpha]_{\text{D}}^{25} = -3.32$  ( $c = 1$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 1.30 (s, 9H), 4.76 (d,  $J = 13.6$  Hz, 1H), 5.30 (d,  $J = 15.6$  Hz, 1H), 5.93 (d,  $J = 11.6$  Hz, 1H), 6.61 (d,  $J = 7.6$  Hz, 1H), 6.72 (d,  $J = 7.6$  Hz, 1H), 7.03–7.24 (m, 10H), 7.30–7.40 (m, 5H), 7.54 (d,  $J = 7.2$  Hz, 1H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 28.0, 44.6, 81.4, 109.5, 120.1 (d,  $J = 3.8$  Hz), 120.9 (d,  $J = 4.7$  Hz), 122.9, 125.2 (d,  $J = 3.8$  Hz), 125.5, 125.8, 127.2, 127.5, 129.6, 129.8, 130.0, 135.4, 143.6 (d,  $J = 4.7$  Hz), 149.9 (dd,  $J = 10.6$ , 21.6 Hz), 153.8 (d,  $J = 18.3$  Hz), 171.1;  $^{31}\text{P}$  NMR ( $\text{CDCl}_3$ , 162 MHz)  $\delta$ : 7.27; HPLC (70 : 30, *n*-hexane : *i*-PrOH, 254nm, 1mL/min) Chiralpak IC column,  $t_{\text{R}} = 8.0$  (minor),  $t_{\text{R}} = 10.6$  (major), >99% ee.

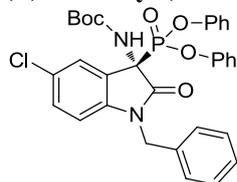
**(R)-tert-Butyl (1-benzyl-3-(diphenoxyphosphoryl)-5-fluoro-2-oxoindolin-3-yl)carbamate (3h)**



$[\alpha]_{\text{D}}^{25} = -5.40$  ( $c = 1$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 1.34 (s, 9H), 4.79 (d,  $J = 16.0$  Hz, 1H), 5.25 (d,  $J = 15.2$  Hz, 1H), 5.94 (d,  $J = 11.6$  Hz, 1H), 6.62 (dd,  $J = 4.0$  and 8.8 Hz, 1H), 6.71 (d,  $J = 8.4$  Hz, 2H), 6.91–6.95 (m, 1H), 7.08–7.24 (m, 8H), 7.27–7.39 (m, 6H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 28.1, 44.8, 81.7, 110.1 (d,  $J =$

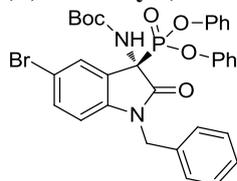
9.6 Hz), 113.1, 116.3, 116.5, 120.1 (d,  $J = 3.8$  Hz), 120.8 (d,  $J = 4.7$  Hz), 125.7, 126.0, 127.2, 127.6, 128.8, 128.9, 129.7, 130.0, 135.1, 149.9 (dd,  $J = 9.6, 13.0$  Hz), 153.5 (d,  $J = 17.4$  Hz), 171.0;  $^{31}\text{P}$  NMR ( $\text{CDCl}_3$ , 162 MHz)  $\delta$ : 6.63; HPLC (70 : 30, *n*-hexane : *i*-PrOH, 254nm, 1mL/min) Chiralpak IC column,  $t_{\text{R}} = 6.5$  (minor),  $t_{\text{R}} = 8.2$  (major), >99% ee.

**(*R*)-tert-Butyl (1-benzyl-5-chloro-3-(diphenoxyphosphoryl)-2-oxoindolin-3-yl)carbamate (3i)**



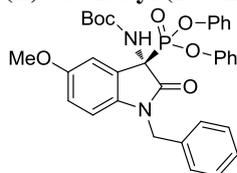
$[\alpha]_{\text{D}}^{26} = 17.48$  ( $c = 1$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 1.34 (s, 9H), 4.79 (d,  $J = 8.8$  Hz, 1H), 5.23 (d,  $J = 15.2$  Hz, 1H), 5.93 (d,  $J = 11.2$  Hz, 1H), 6.62 (d,  $J = 8.8$  Hz, 1H), 6.74 (d,  $J = 8.4$  Hz, 2H), 7.17–7.25 (m, 10H), 7.31–7.38 (m, 4H), 7.50 (t,  $J = 2.2$  Hz, 1H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 28.1, 44.7, 81.8, 110.5, 120.1 (d,  $J = 4.8$  Hz), 120.8 (d,  $J = 4.8$  Hz), 125.4 (d,  $J = 3.9$  Hz), 125.7, 126.0, 127.2, 127.7, 128.4 (d,  $J = 3.9$  Hz), 128.8, 129.7, 130.0, 134.9, 142.1 (d,  $J = 6.8$  Hz), 149.8 (dd,  $J = 9.7, 13.5$  Hz), 153.5 (d,  $J = 17.4$  Hz), 170.8;  $^{31}\text{P}$  NMR ( $\text{CDCl}_3$ , 162 MHz)  $\delta$ : 6.44; HPLC (70 : 30, *n*-hexane : *i*-PrOH, 254nm, 1mL/min) Chiralpak IC column,  $t_{\text{R}} = 5.8$  (minor),  $t_{\text{R}} = 7.2$  (major), 98% ee.

**(*R*)-tert-Butyl (1-benzyl-5-bromo-3-(diphenoxyphosphoryl)-2-oxoindolin-3-yl)carbamate (3j)**



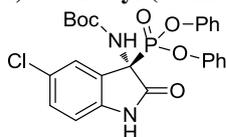
$[\alpha]_{\text{D}}^{26} = 34.28$  ( $c = 1$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 1.34 (s, 9H), 4.80 (s, 1H), 5.22 (d,  $J = 15.6$  Hz, 1H), 5.94 (d,  $J = 11.2$  Hz, 1H), 6.57 (d,  $J = 8.0$  Hz, 1H), 6.74 (d,  $J = 8.4$  Hz, 2H), 7.09–7.24 (m, 10H), 7.29–7.38 (m, 6H), 7.63 (t,  $J = 2.0$  Hz, 1H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 28.1, 44.7, 81.8, 111.0, 115.5 (d,  $J = 3.8$  Hz), 120.1 (d,  $J = 3.8$  Hz), 120.8 (d,  $J = 3.8$  Hz), 125.7, 126.0, 127.2, 127.7, 128.1 (d,  $J = 4.8$  Hz), 128.8, 129.7, 129.9, 132.8, 134.9, 142.6 (d,  $J = 7.8$  Hz), 149.9 (dd,  $J = 10.6, 13.5$  Hz), 153.5 (d,  $J = 18.3$  Hz), 170.7;  $^{31}\text{P}$  NMR ( $\text{CDCl}_3$ , 162 MHz)  $\delta$ : 6.41; HPLC (70 : 30, *n*-hexane : *i*-PrOH, 254nm, 1mL/min) Chiralpak IC column,  $t_{\text{R}} = 6.5$  (minor),  $t_{\text{R}} = 8.1$  (major), >99% ee.

**(*R*)-tert-Butyl (1-benzyl-3-(diphenoxyphosphoryl)-5-methoxy-2-oxoindolin-3-yl)carbamate (3k)**



$[\alpha]_{\text{D}}^{26} = 35.28$  ( $c = 1$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 1.32 (s, 9H), 3.69 (s, 3H), 4.76 (s, 1H), 5.26 (d,  $J = 15.6$  Hz, 1H), 5.93 (d,  $J = 12.0$  Hz, 1H), 6.57–6.80 (m, 4H), 7.05–7.40 (m, 15H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 28.1, 44.7, 55.8, 81.8, 110.0, 111.9, 115.0, 120.1 (d,  $J = 4.8$  Hz), 120.9 (d,  $J = 3.8$  Hz), 125.5, 125.8, 127.2, 127.4, 128.7, 129.5, 129.8, 135.4, 137.0 (d,  $J = 6.8$  Hz), 150.0 (dd,  $J = 9.7, 18.3$  Hz), 153.6 (d,  $J = 18.3$  Hz), 156.1 (d,  $J = 3.9$  Hz), 170.8;  $^{31}\text{P}$  NMR ( $\text{CDCl}_3$ , 162 MHz)  $\delta$ : 7.19; HPLC (70 : 30, *n*-hexane : *i*-PrOH, 254nm, 1mL/min) Chiralpak AD-H column,  $t_{\text{R}} = 17.0$  (minor),  $t_{\text{R}} = 24.9$  (major), >99% ee.

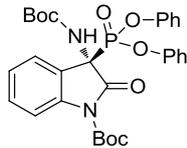
**(*R*)-tert-Butyl (5-chloro-3-(diphenoxyphosphoryl)-2-oxoindolin-3-yl)carbamate (3l)**



$[\alpha]_{\text{D}}^{26} = -1.92$  ( $c = 1$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 1.39 (s, 9H), 5.85 (s, 1H), 5.98 (d,  $J = 10.8$  Hz, 1H), 6.74 (t,  $J = 9.4$  Hz, 1H), 6.83 (d,  $J = 7.6$  Hz, 2H), 7.10–7.23 (m, 6H), 7.32–7.57 (m, 3H), 8.00–8.26 (m, 1H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 28.2, 81.5, 111.4 (d,  $J = 12.5$  Hz), 120.2 (d,  $J = 3.8$  Hz), 120.7 (d,  $J = 4.7$  Hz), 125.6 (d,  $J = 3.8$  Hz), 125.8, 126.0, 126.4, 128.2 (d,  $J = 3.8$  Hz), 129.7, 129.9, 140.1 (d,  $J = 7.8$  Hz), 149.9 (dd,  $J = 6.8, 9.6$  Hz), 154.0, 171.8;  $^{31}\text{P}$  NMR ( $\text{CDCl}_3$ , 162 MHz)  $\delta$ : 5.98; HPLC (70 : 30, *n*-hexane : *i*-PrOH,

254nm, 1mL/min) Chiralpak AD-H column,  $t_R = 11.7$  (major),  $t_R = 29.0$  (minor), 73% ee.

**(R)-tert-Butyl 3-((tert-butoxycarbonyl)amino)-3-(diphenoxyphosphoryl)-2-oxoindoline-1-carboxylate (3m)**

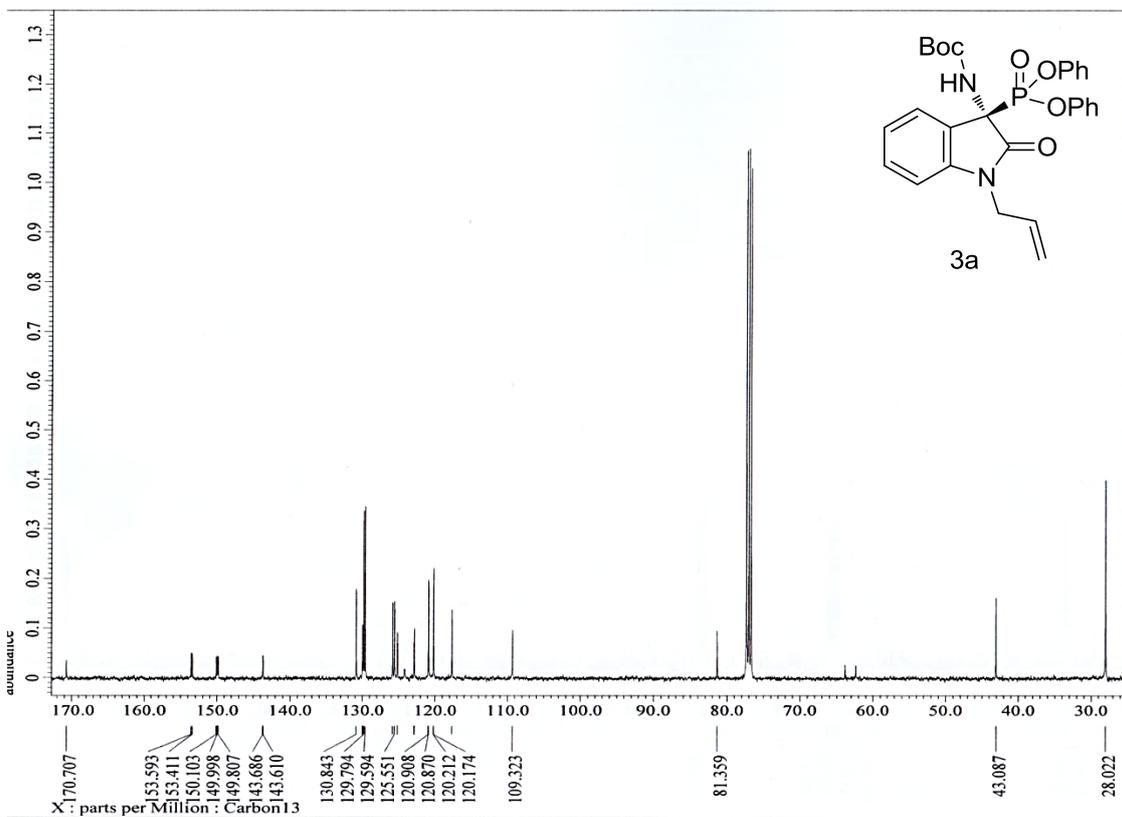
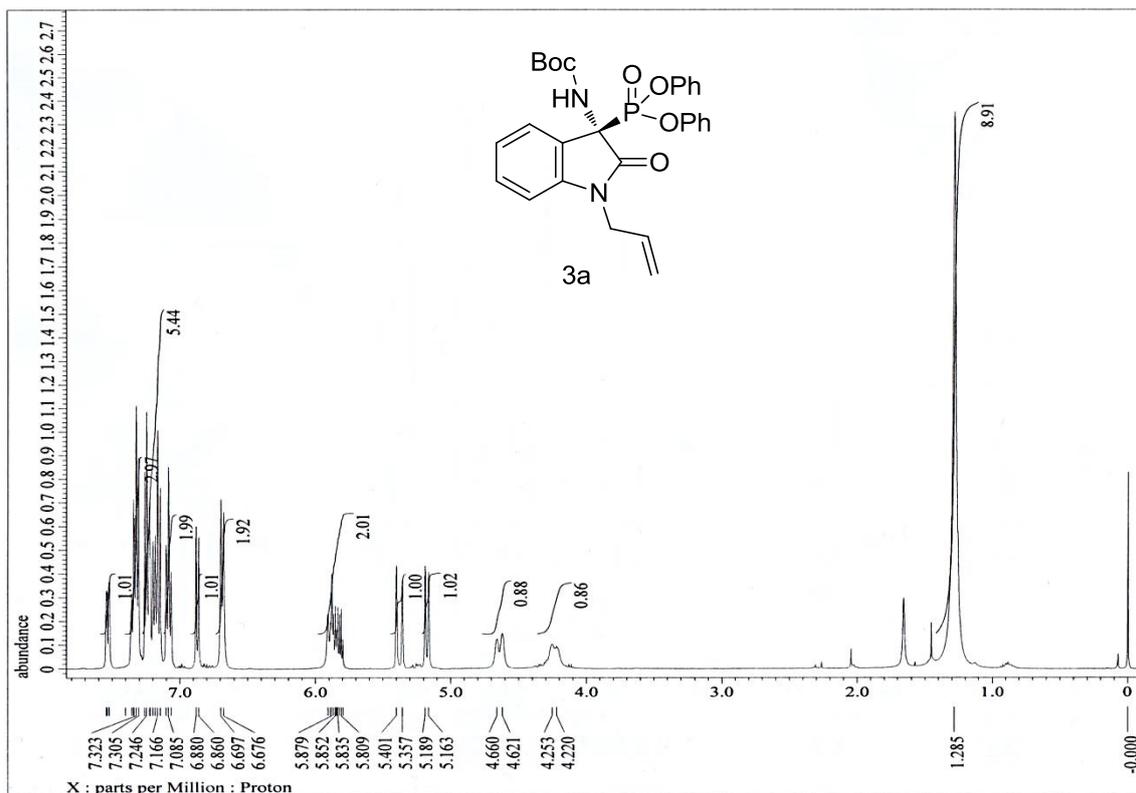


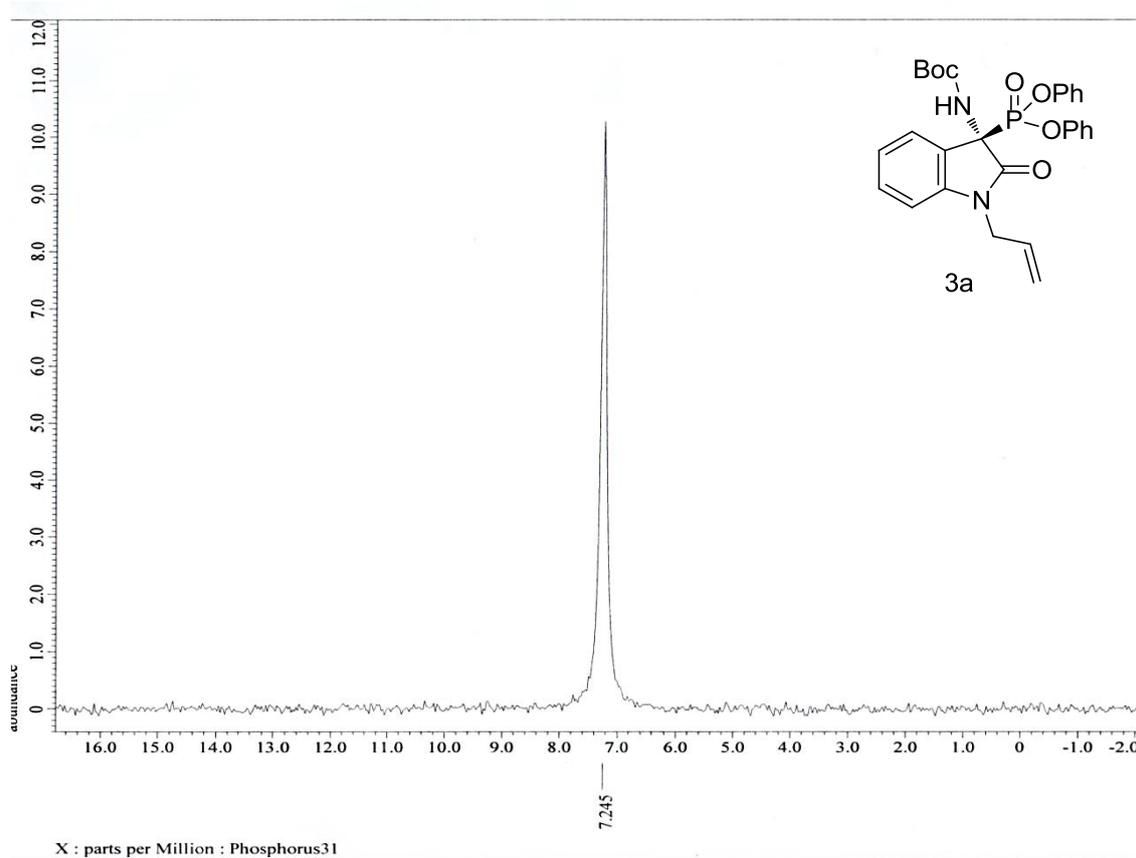
$[\alpha]_D^{29} = -17.4$  ( $c = 1$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 1.40 (s, 9H), 1.51 (s, 9H), 5.87 (d,  $J = 8.8$  Hz, 1H), 6.96–7.12 (m, 4H), 7.18–7.24 (m, 2H), 7.29–7.44 (m, 7H), 7.88 (d,  $J = 7.6$  Hz, 1H);  $^{13}\text{C NMR}$  ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 27.5, 28.0, 80.2, 83.8, 119.7 (d,  $J = 4.8$  Hz), 120.1 (d,  $J = 4.8$  Hz), 122.3, 123.3, 125.2, 125.3, 128.3, 129.4, 129.5, 129.8, 149.7 (d,  $J = 7.6$  Hz), 150.1 (d,  $J = 7.6$  Hz), 166.6 (d,  $J = 5.7$  Hz);  $^{31}\text{P NMR}$  ( $\text{CDCl}_3$ , 162 MHz)  $\delta$ : -12.50; HPLC (97 : 3, *n*-hexane : *i*-PrOH, 254nm, 0.2mL/min) Chiralpak IC column,  $t_R = 83.4$  (minor),  $t_R = 96.3$  (major), 26% ee.

#### 4. References

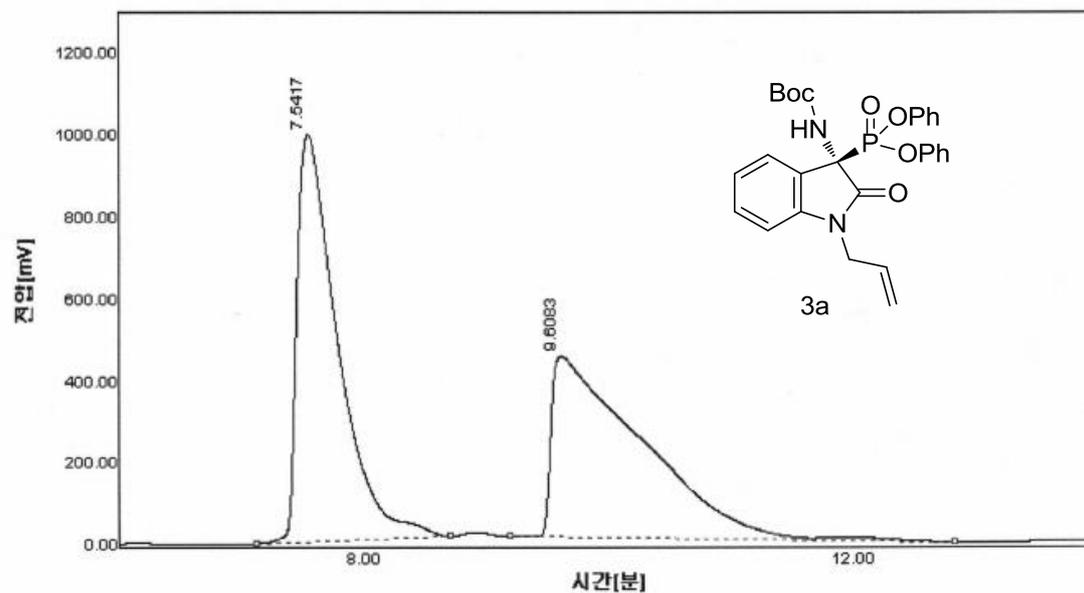
- George, J.; Sridhar, B.; Reddy, B. V. S. *Org. Biomol. Chem.* **2014**, *12*, 1595–1602.  
doi:10.1039/C3OB42026D
- Kumar, A.; Sharma, V.; Kaur, J.; Kumar, V.; Mahajan, S.; Kumar, N.; Chimni, S. S. *Tetrahedron* **2014**, *70*, 7044–7049. doi:10.1016/j.tet.2014.06.013

## 5. NMR spectra and HPLC chromatograms of 3.





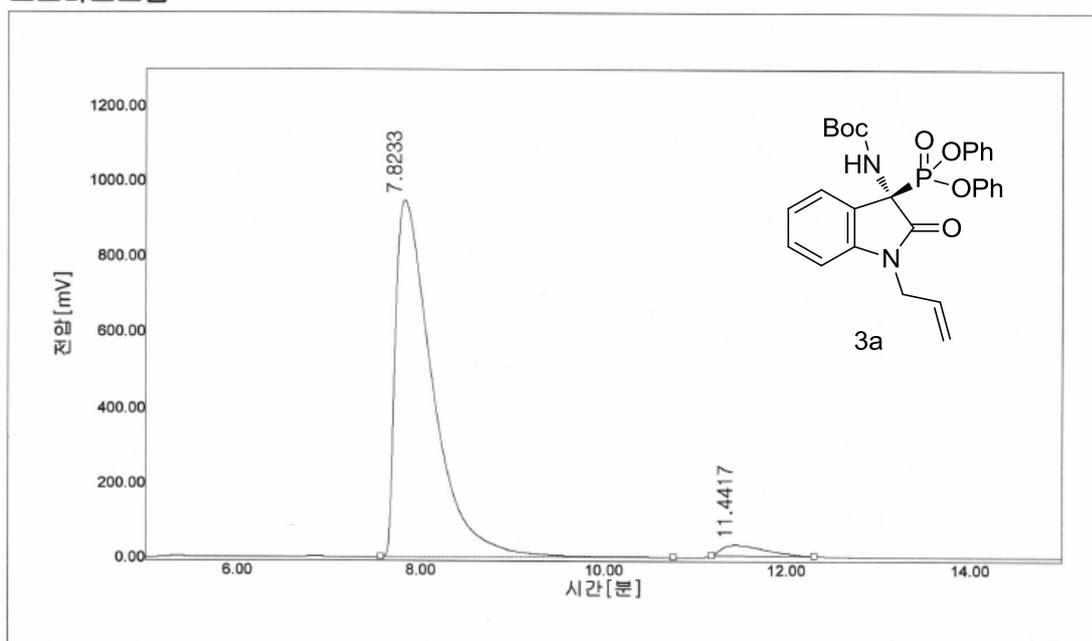
## 크로마토그램



## 적분 결과

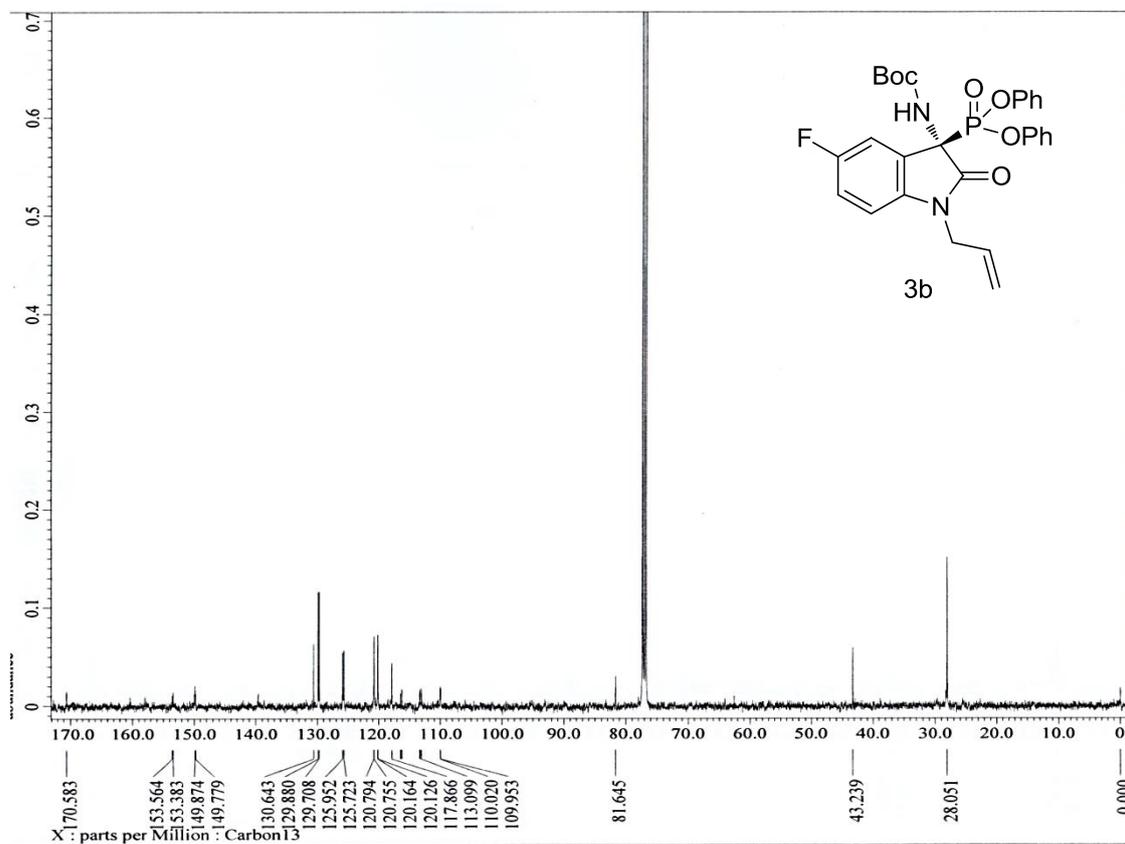
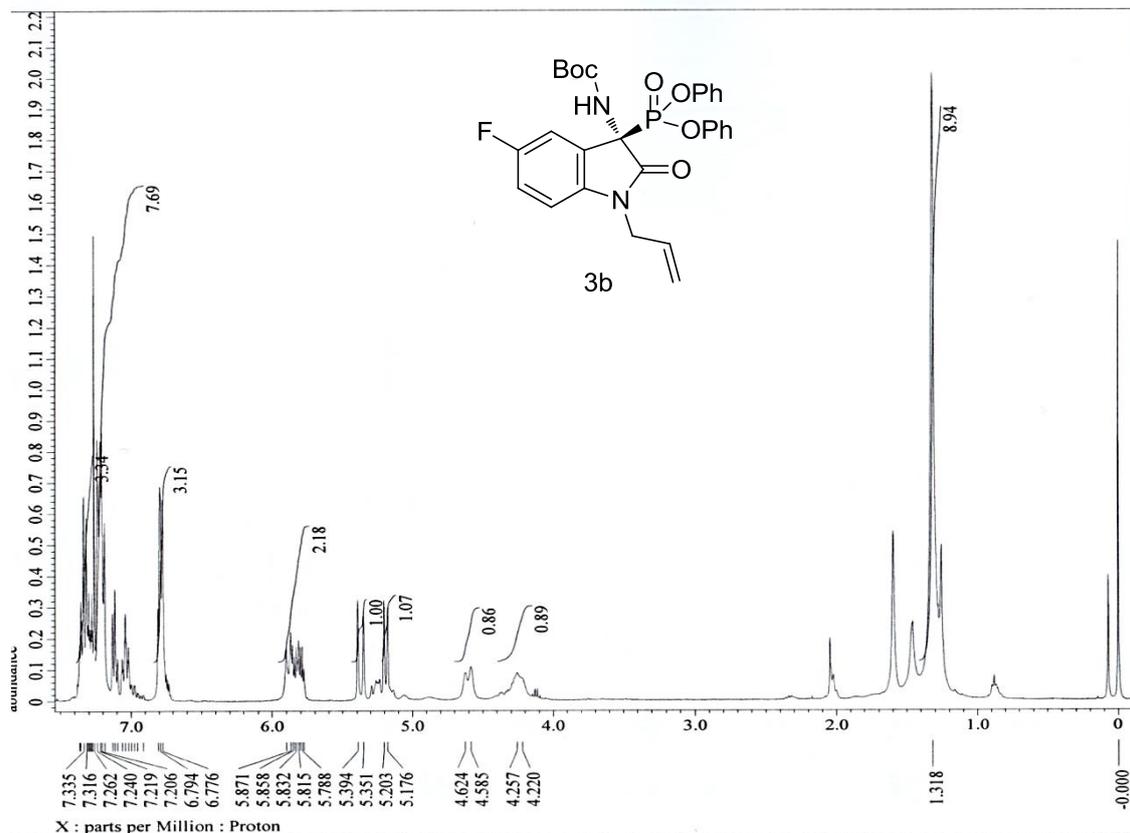
번호	RT[분]	면적비[%]	면적[mV*s]	폭[초]	형태
1	7.5417	50.02	22894.0781	31.35	FF
2	9.6083	49.98	22880.1125	99.39	FF
합계			45774.1906		

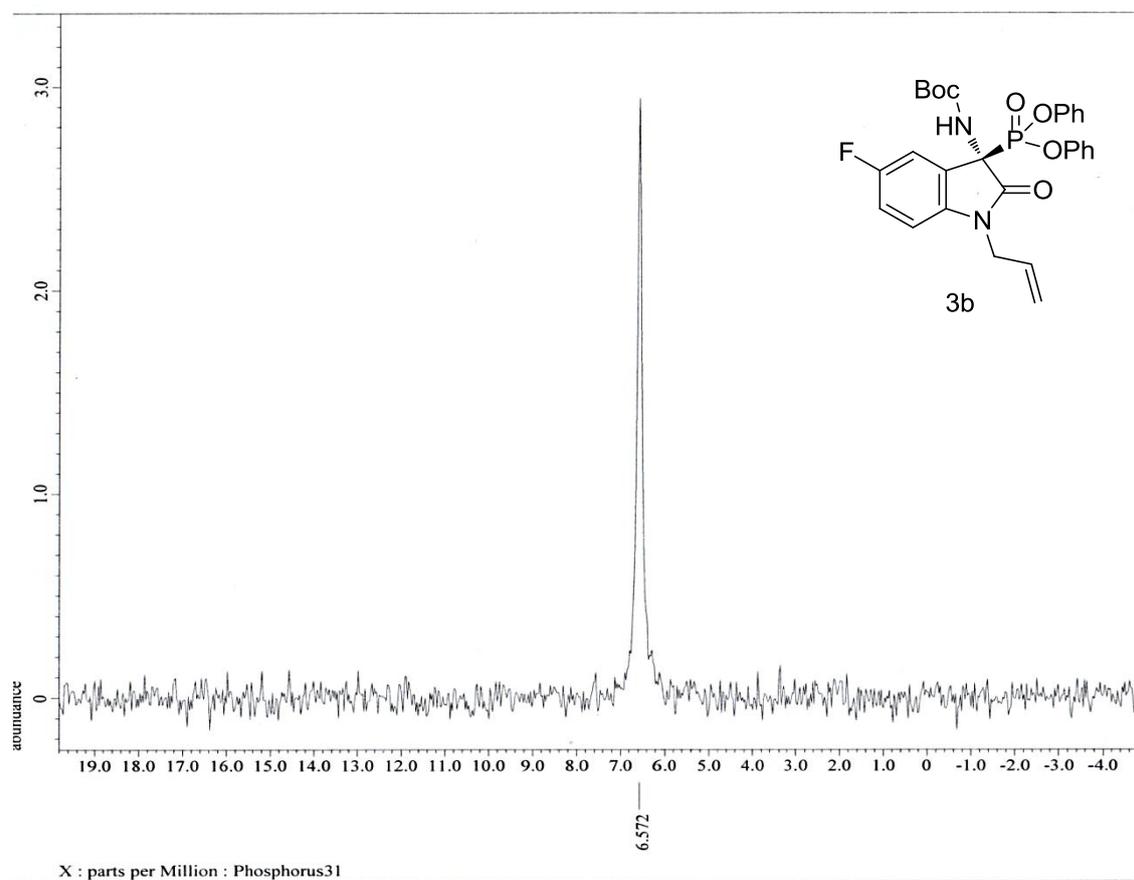
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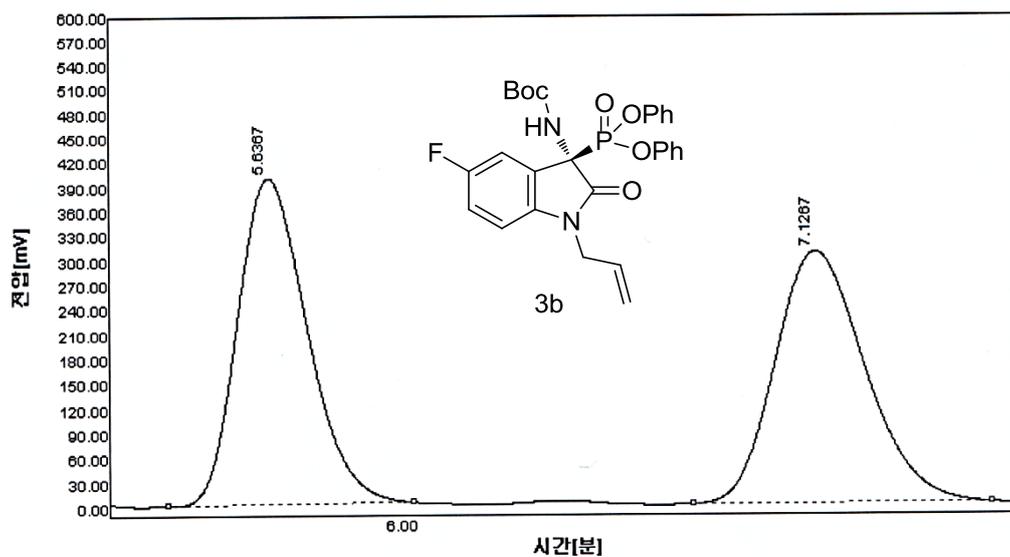


## 적분 결과

번호	RT[분]	면적비[%]	면적[mV*s]	폭[초]	형태
1	7.8233	96.52	26705.6469	37.48	FF
2	11.4417	3.48	964.2119	53.79	FF
합계			27669.8594		

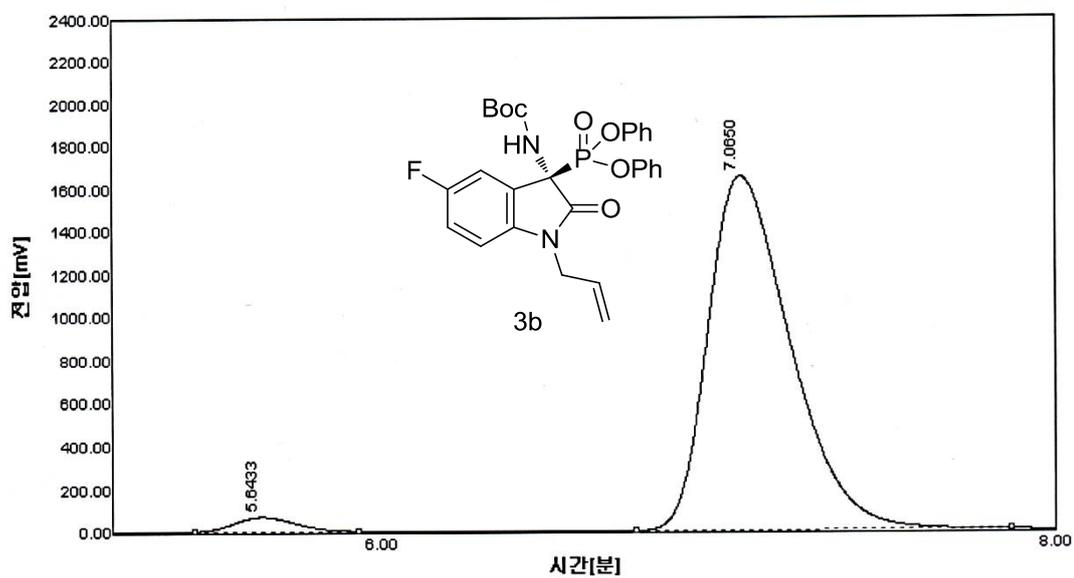






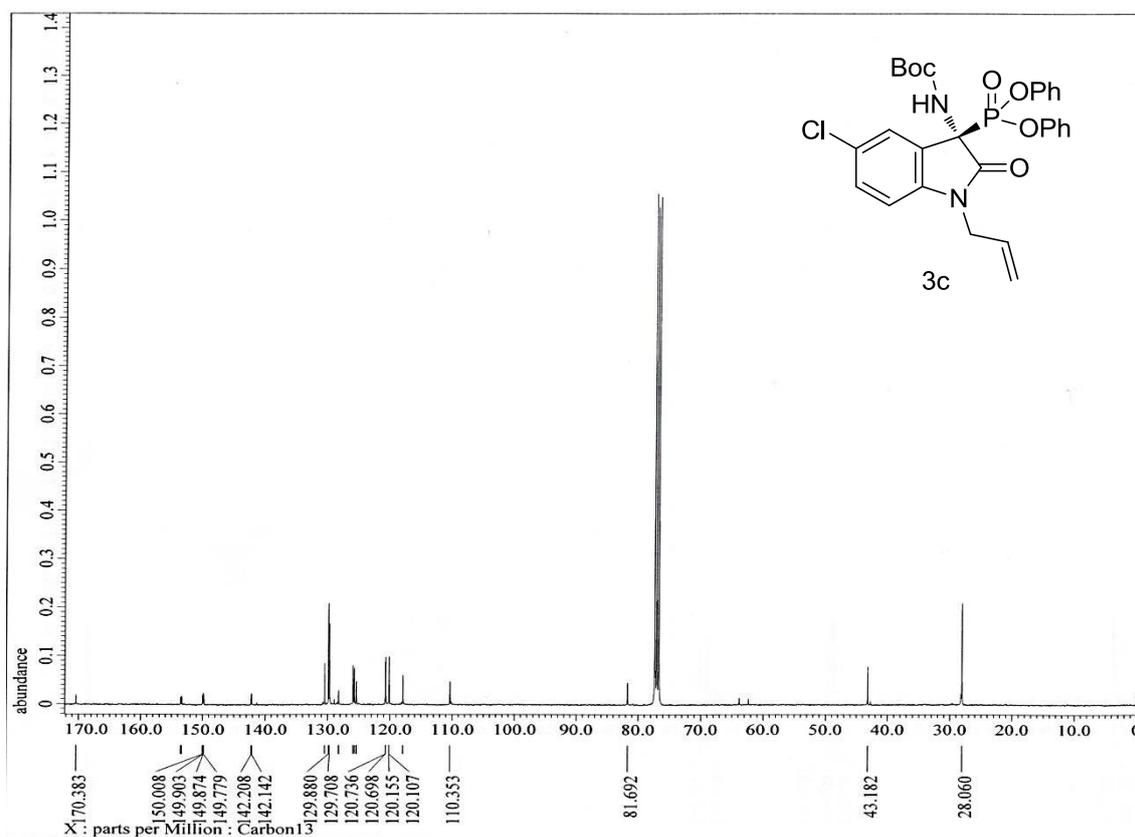
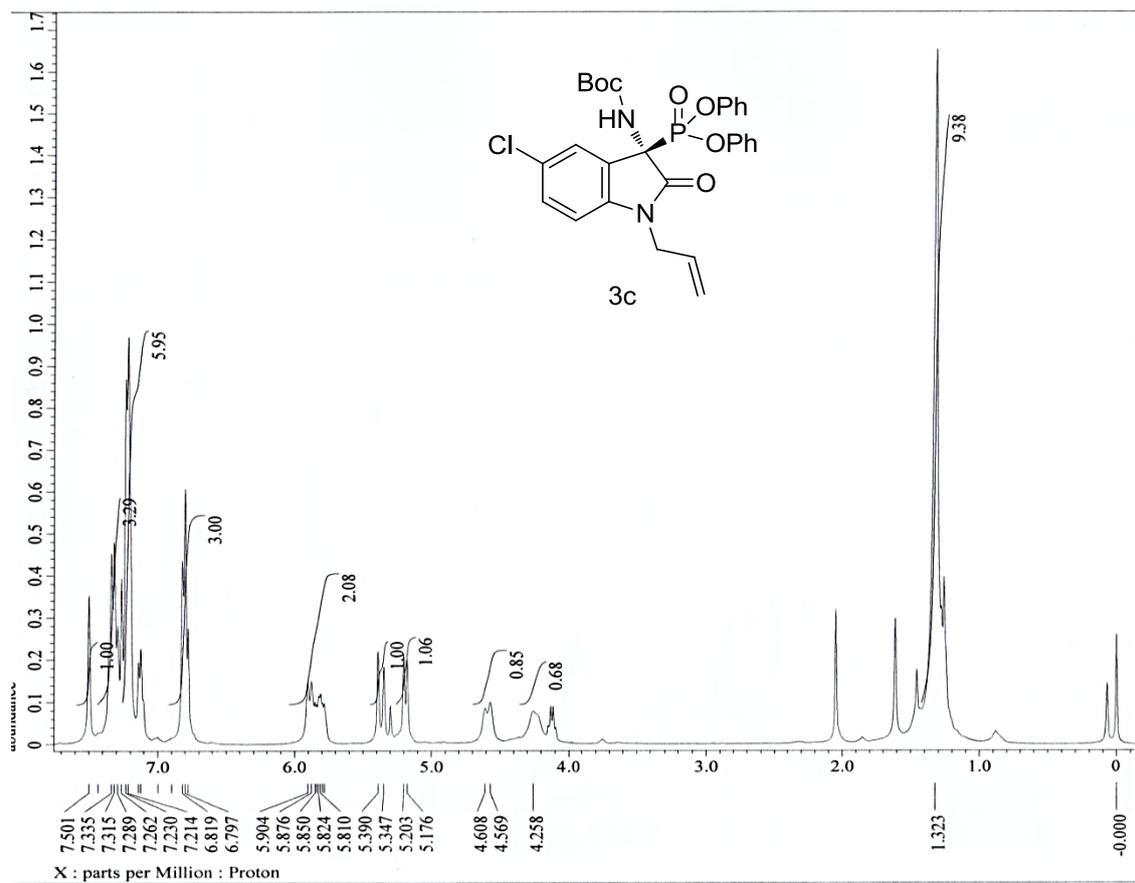
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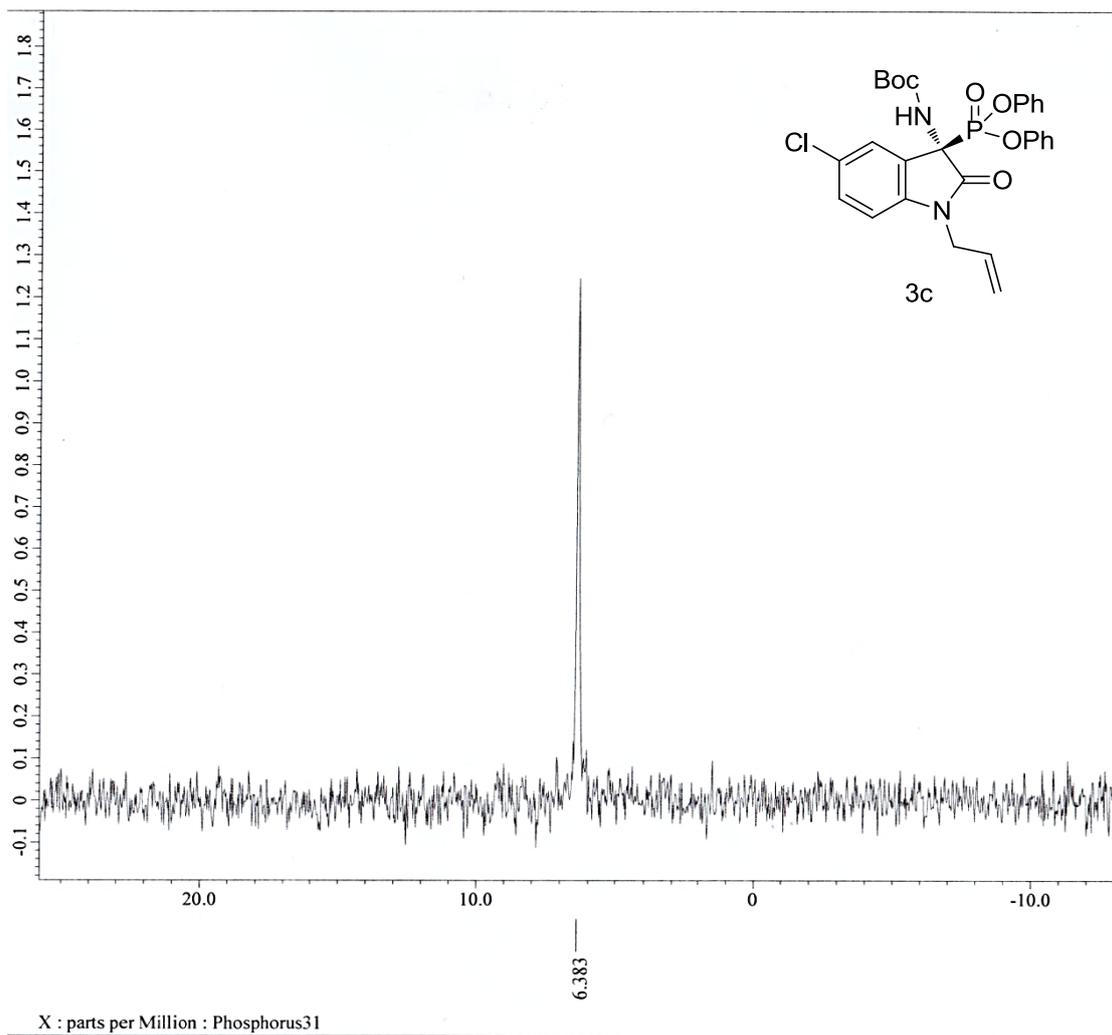
번호	RT[분]	면적비[%]	면적[mV*s]	폭[초]	형태
1	5.6367	49.94	5179.4809	20.63	FF
2	7.1267	50.06	5191.4945	26.82	FF
합계			10370.9754		



### 적분 결과

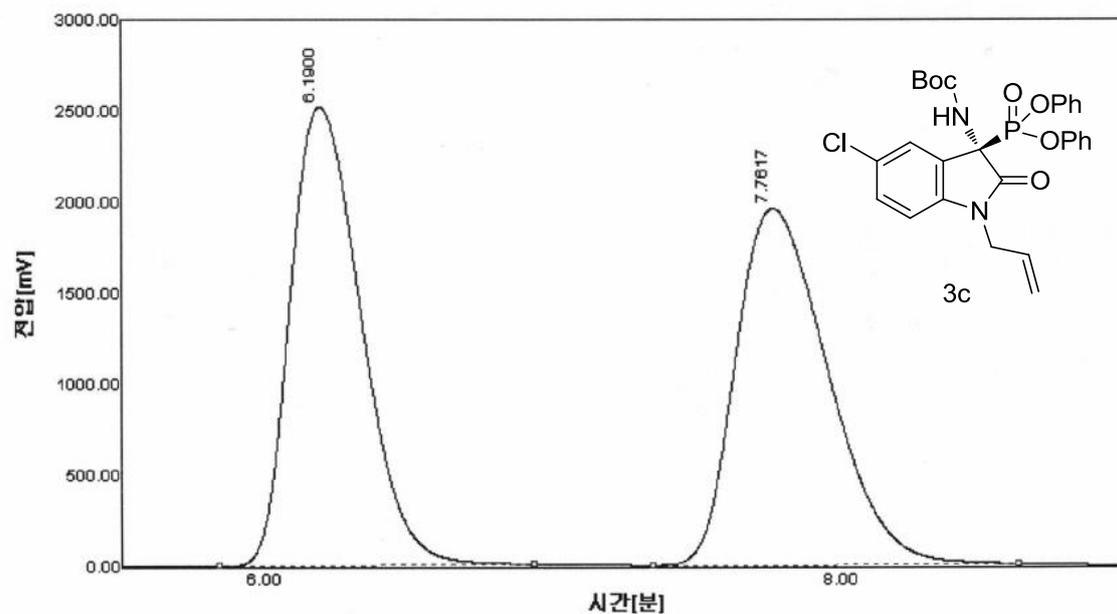
번호	RT[분]	면적비[%]	면적[mV*s]	폭[초]	형태
1	5.6433	2.85	816.2968	19.57	FF
2	7.0650	97.15	27816.0687	23.99	FF
합계			28632.3655		





X : parts per Million : Phosphorus31

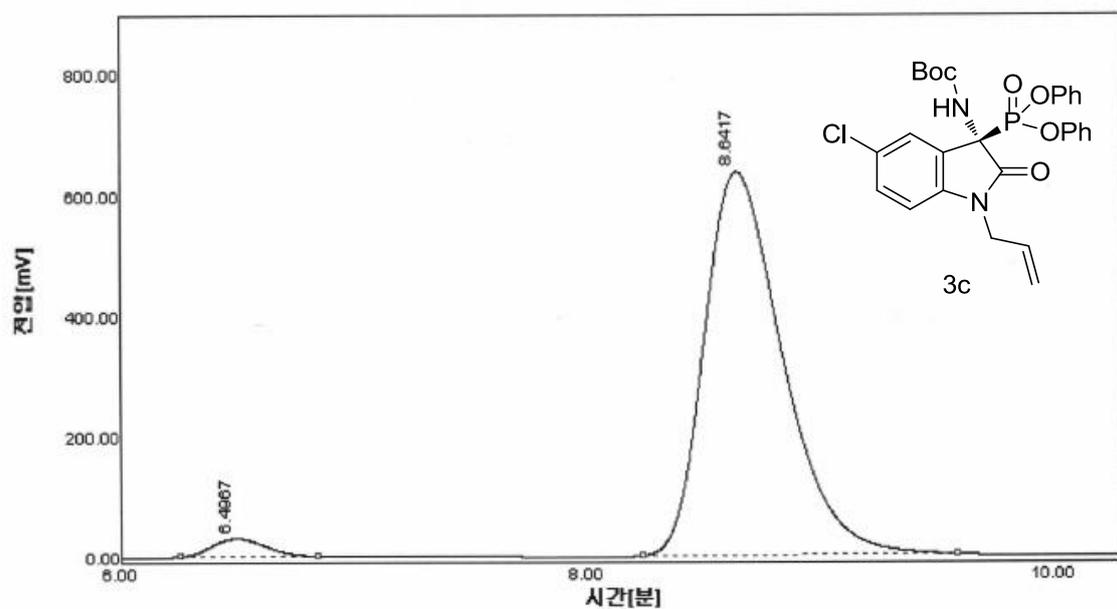
## 크로마토그램



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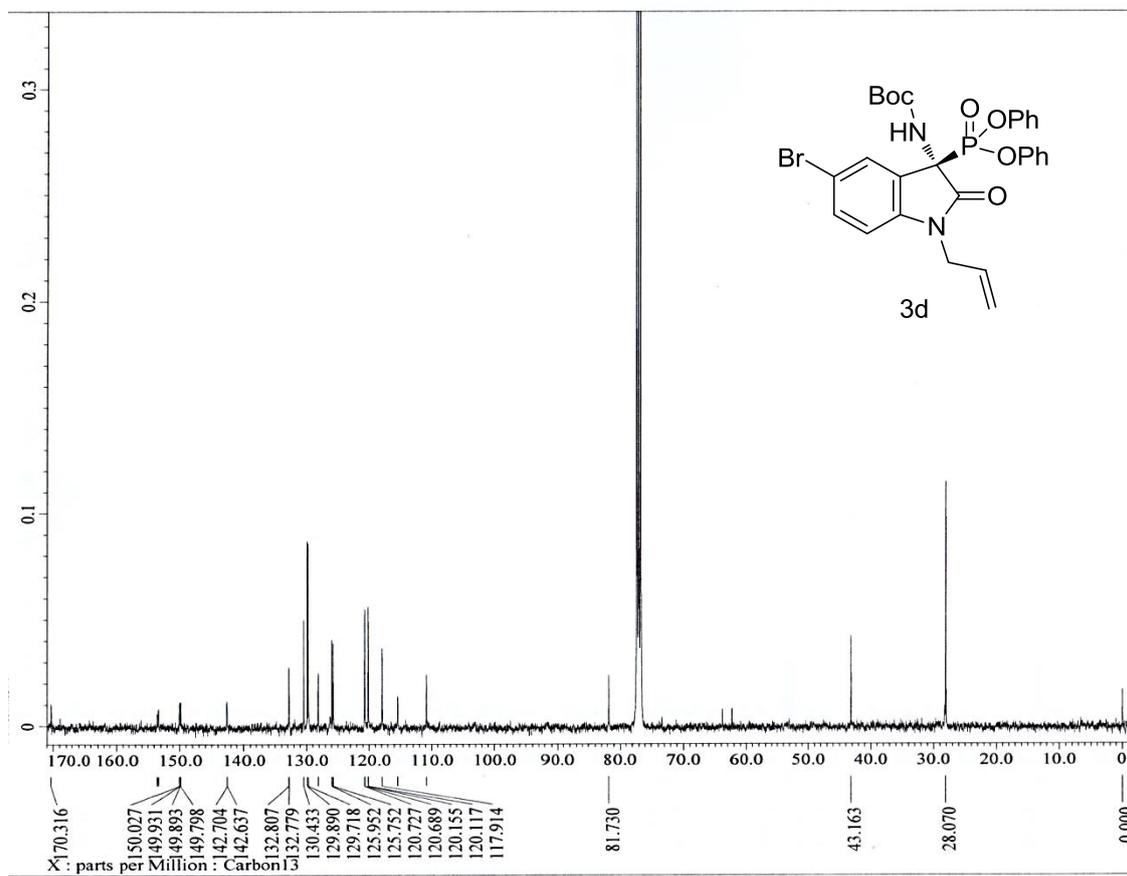
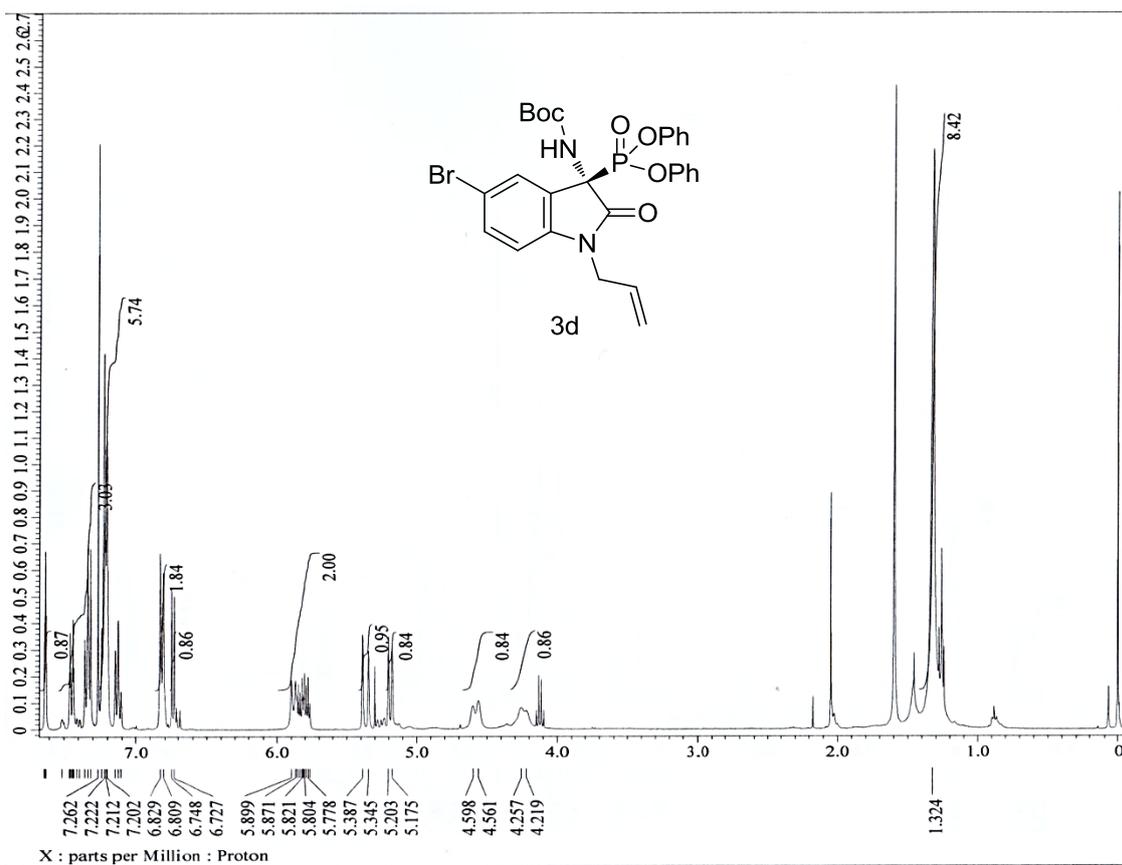
번호	RT[분]	면적비[%]	면적[mV*s]	폭[초]	형태
1	6.1900	49.70	42639.7531	26.60	FF
2	7.7617	50.30	43155.6281	35.05	FF
합계			85795.3812		

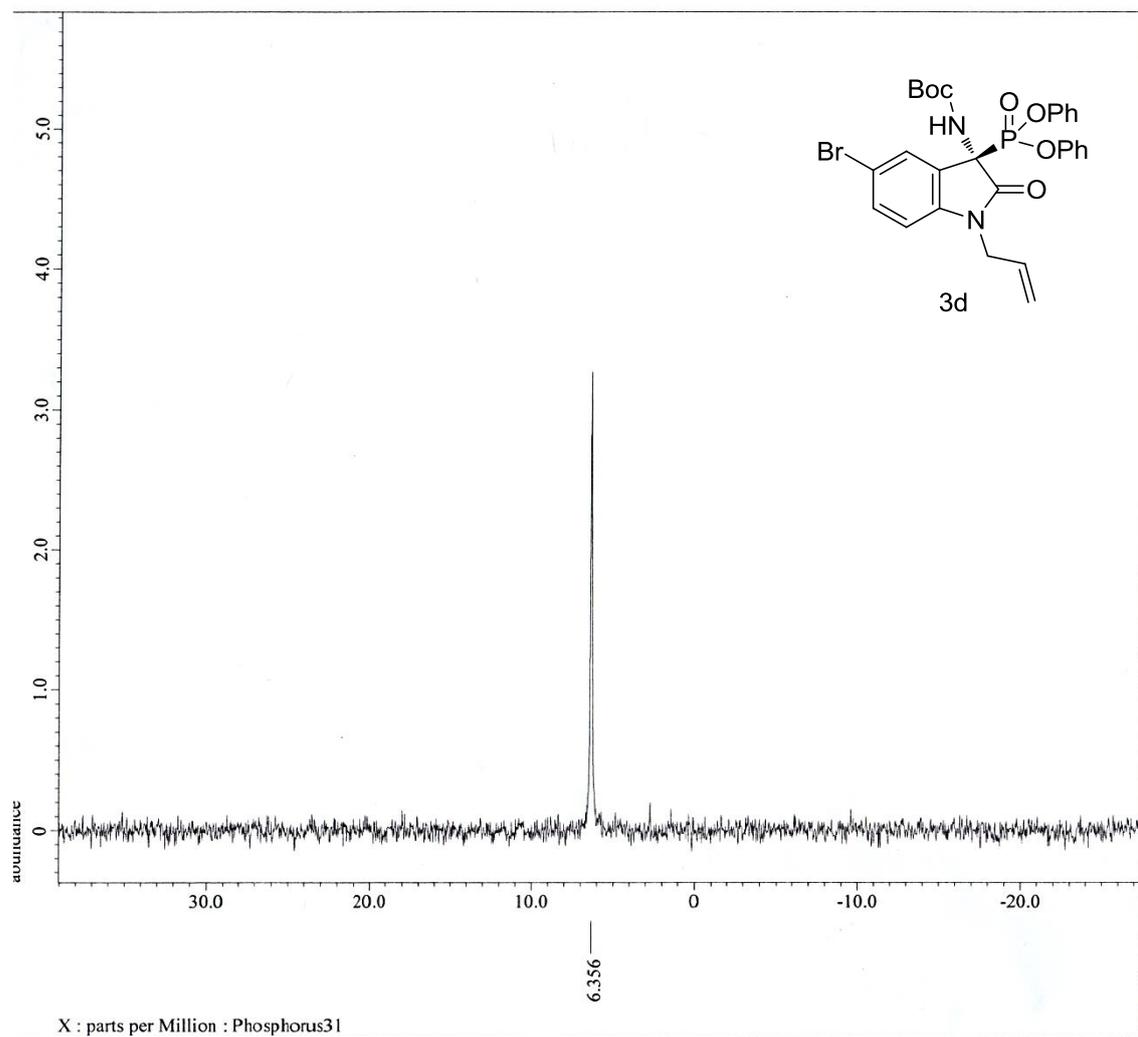
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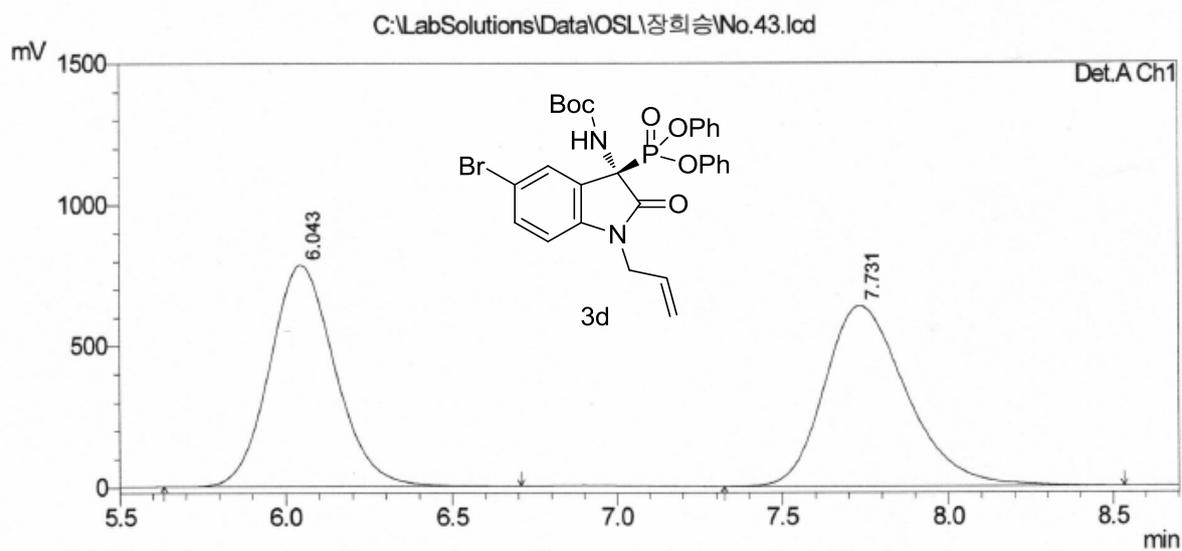
## 적분 결과

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1	6.4967	3.07	466.6148	25.28	FF
2	8.6417	96.93	14752.4875	33.05	FF
합계			15219.1023		





## &lt;Chromatogram&gt;

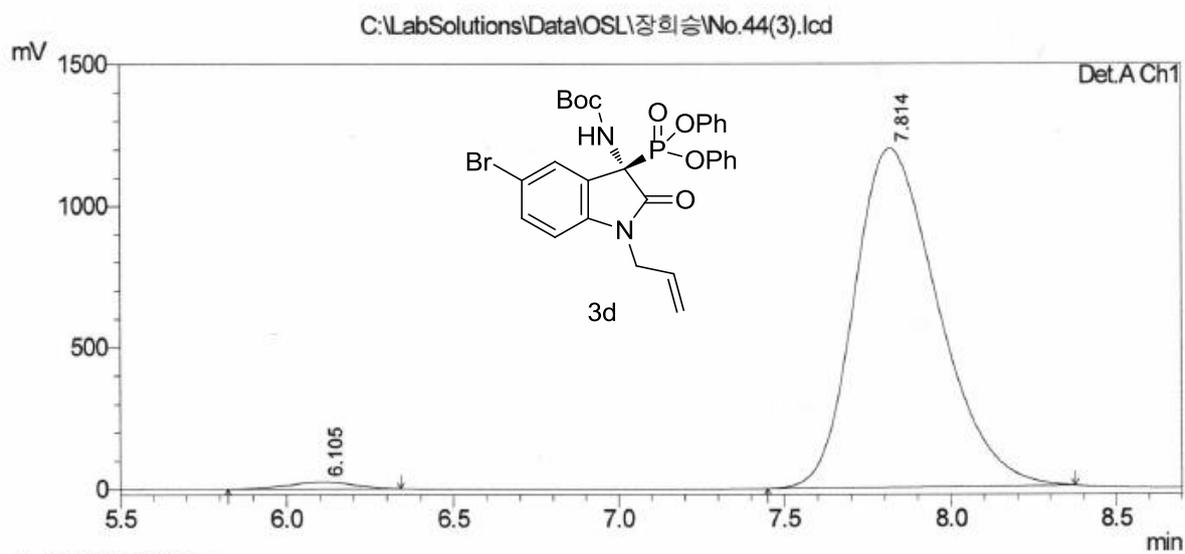


PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	6.043	10625675	782521	49.329	55.120
2	7.731	10914619	637152	50.671	44.880
Total		21540293	1419672	100.000	100.000

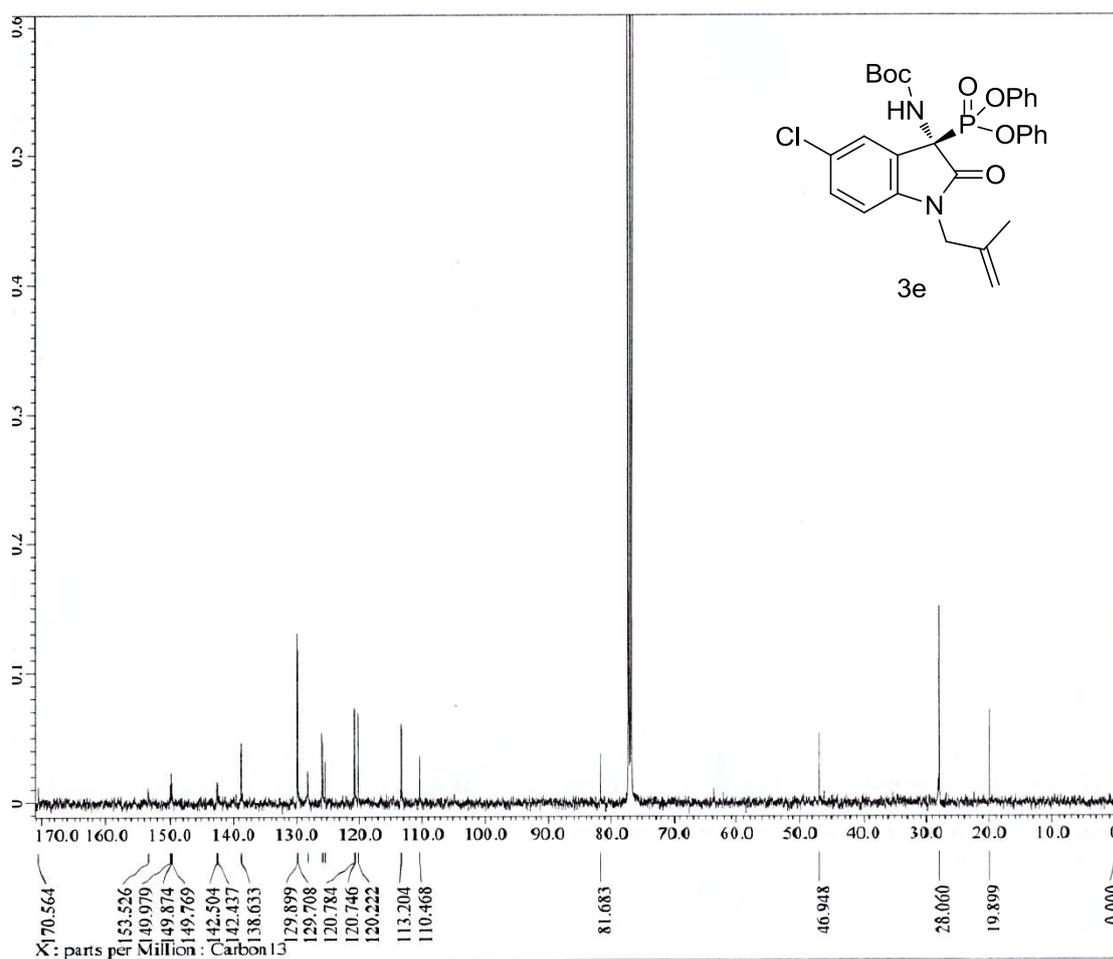
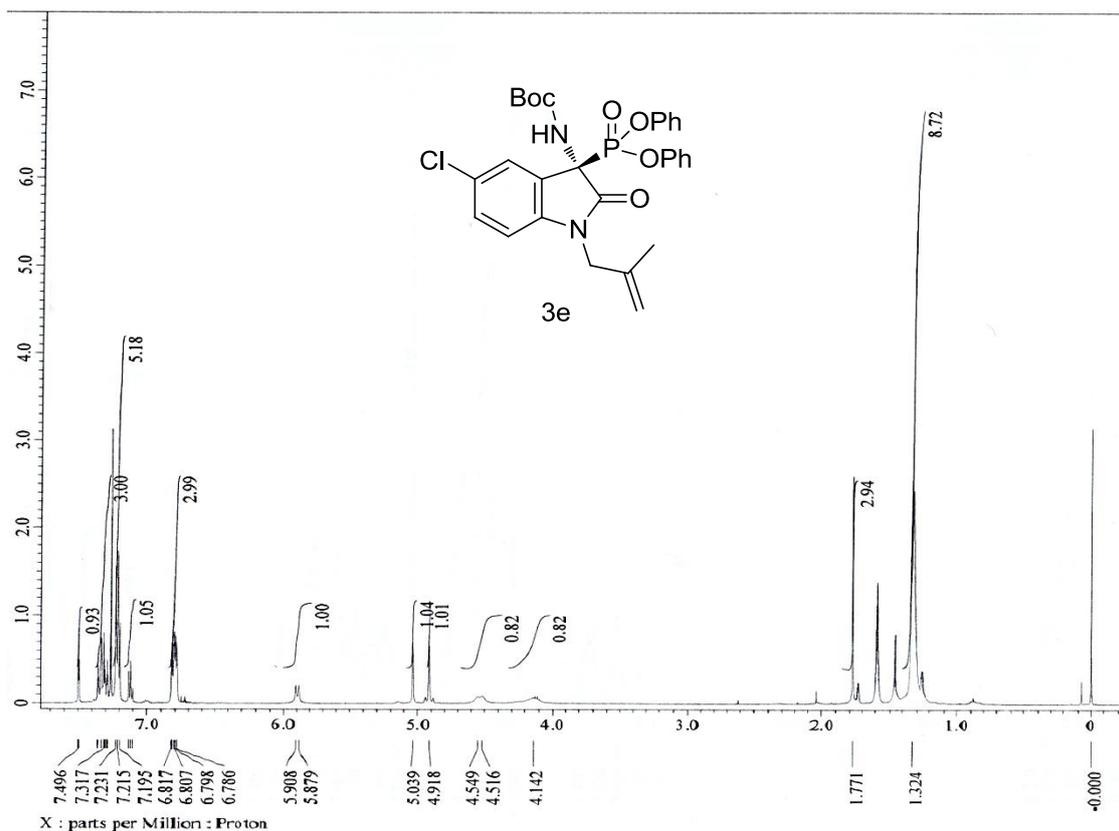
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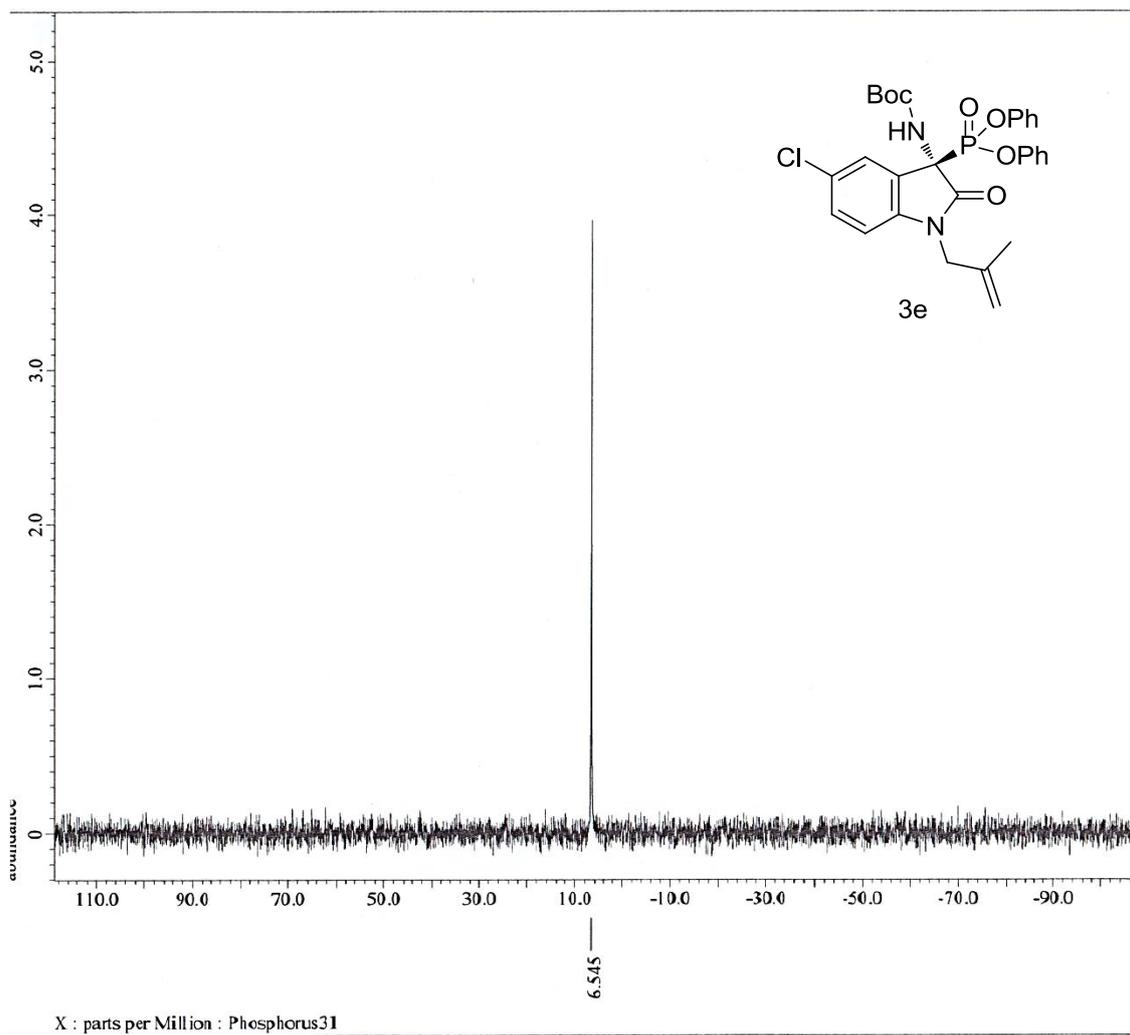


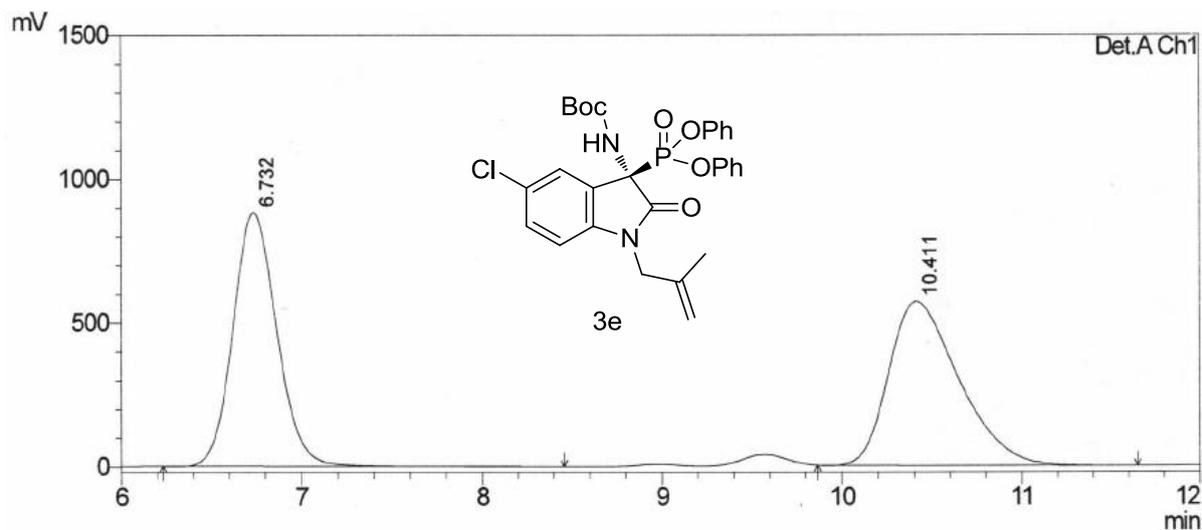
PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	6.105	339344	24603	1.592	2.014
2	7.814	20972794	1196913	98.408	97.986
Total		21312137	1221516	100.000	100.000





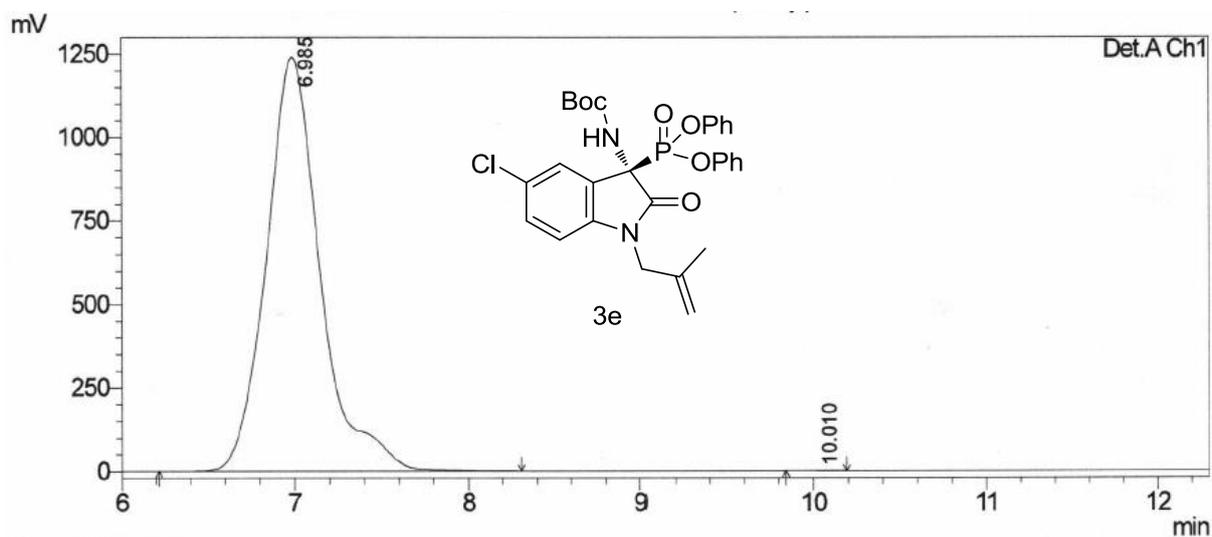


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	6.732	14823700	881646	49.020	60.728
2	10.411	15416559	570157	50.980	39.272
Total		30240259	1451803	100.000	100.000

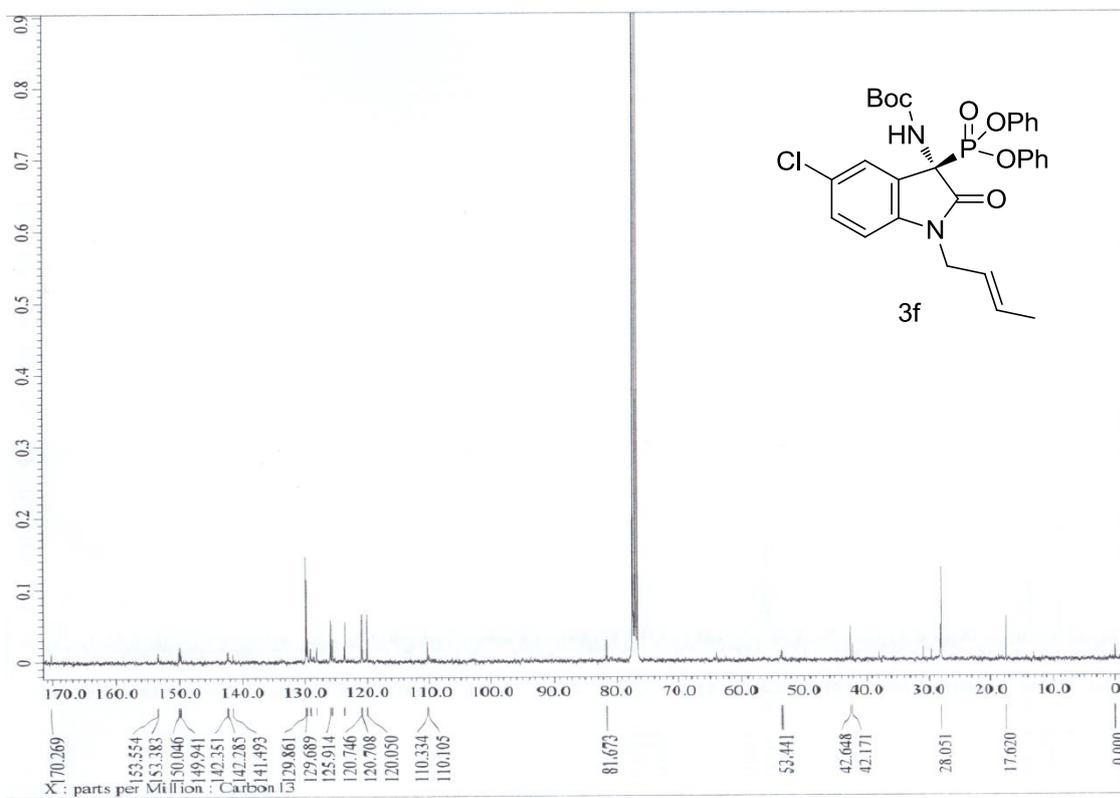
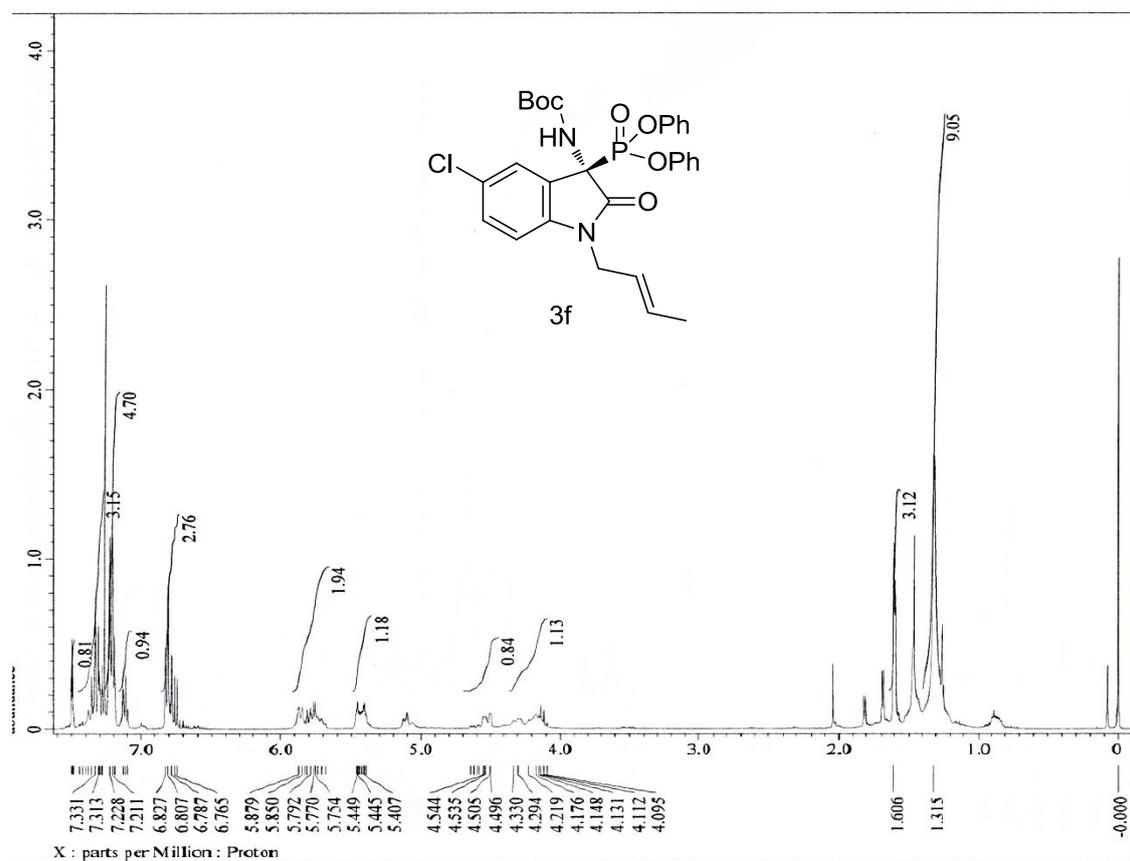


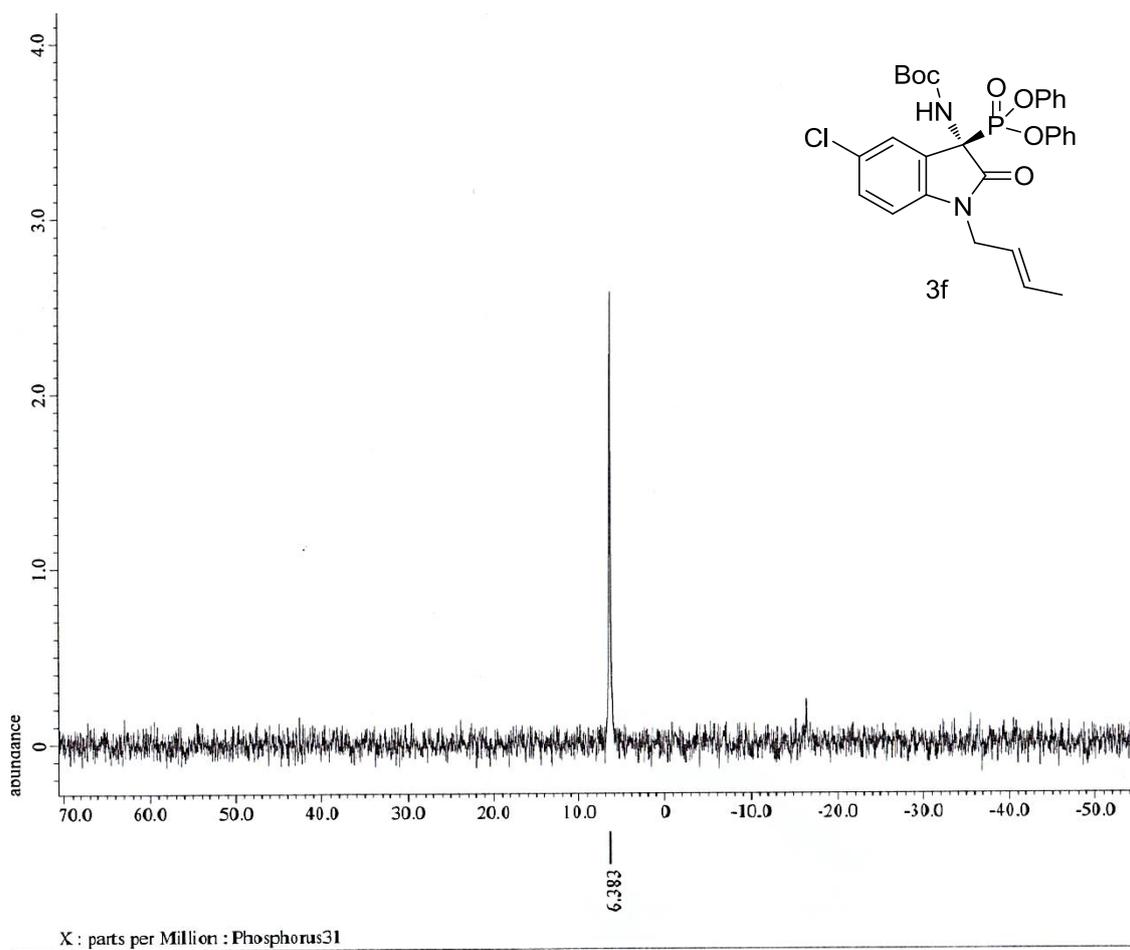
1 Det.A Ch1/254nm

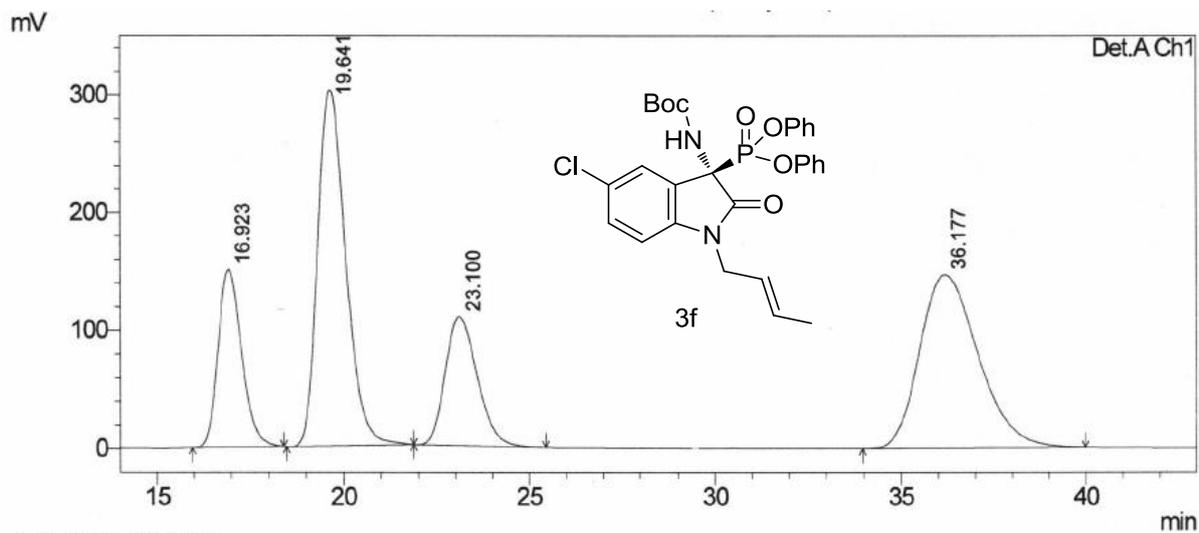
PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	6.985	26576366	1239137	99.963	99.936
2	10.010	9919	788	0.037	0.064
Total		26586285	1239925	100.000	100.000





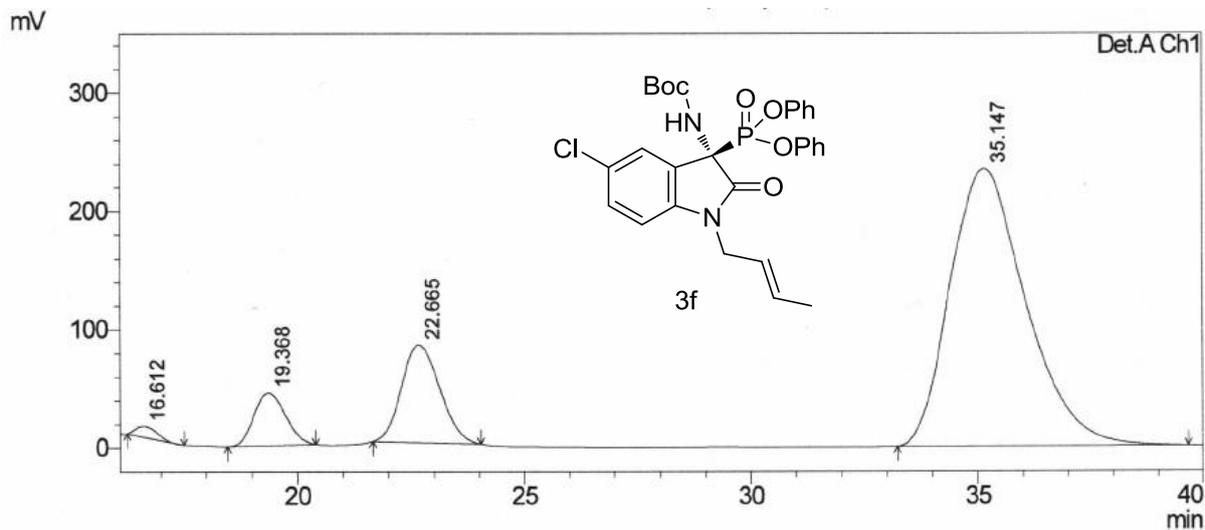


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	16.923	6618401	150146	14.733	21.219
2	19.641	15729707	302048	35.017	42.686
3	23.100	6510334	108858	14.493	15.384
4	36.177	16062385	146560	35.757	20.712
Total		44920827	707612	100.000	100.000

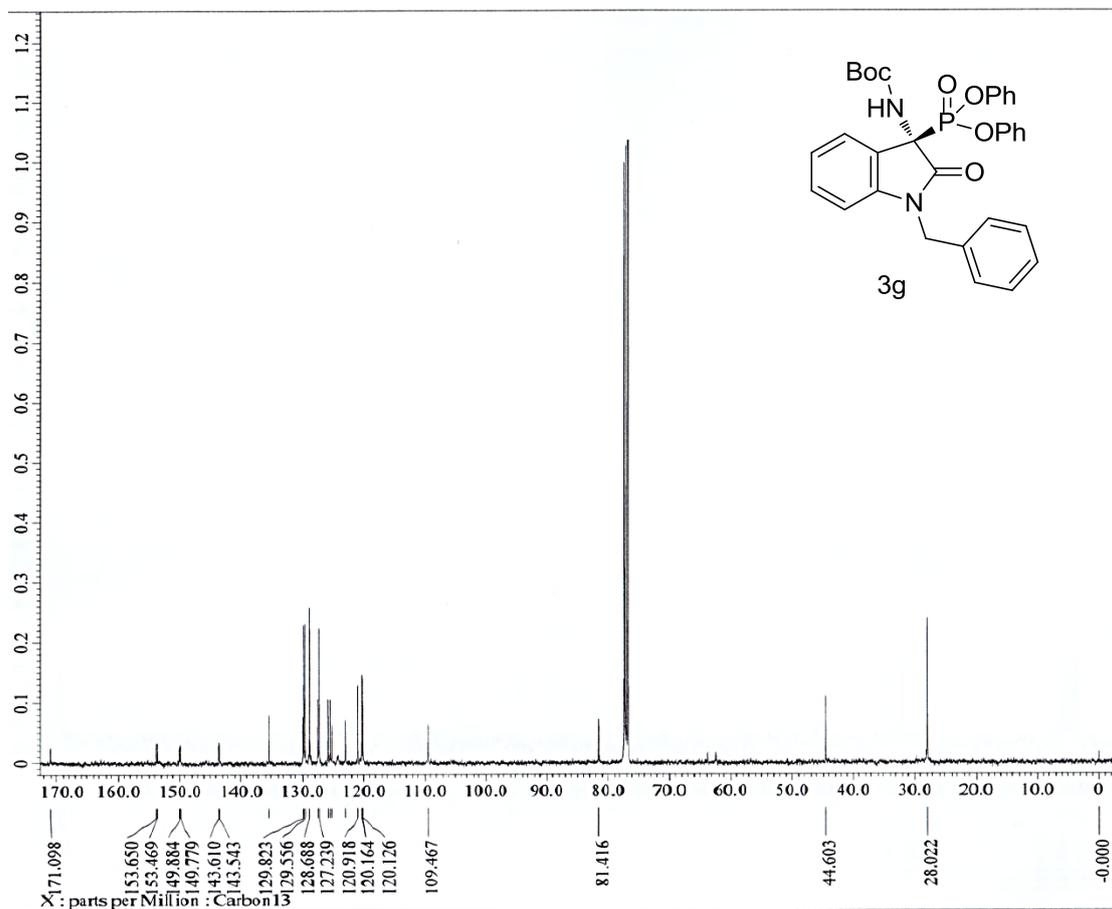
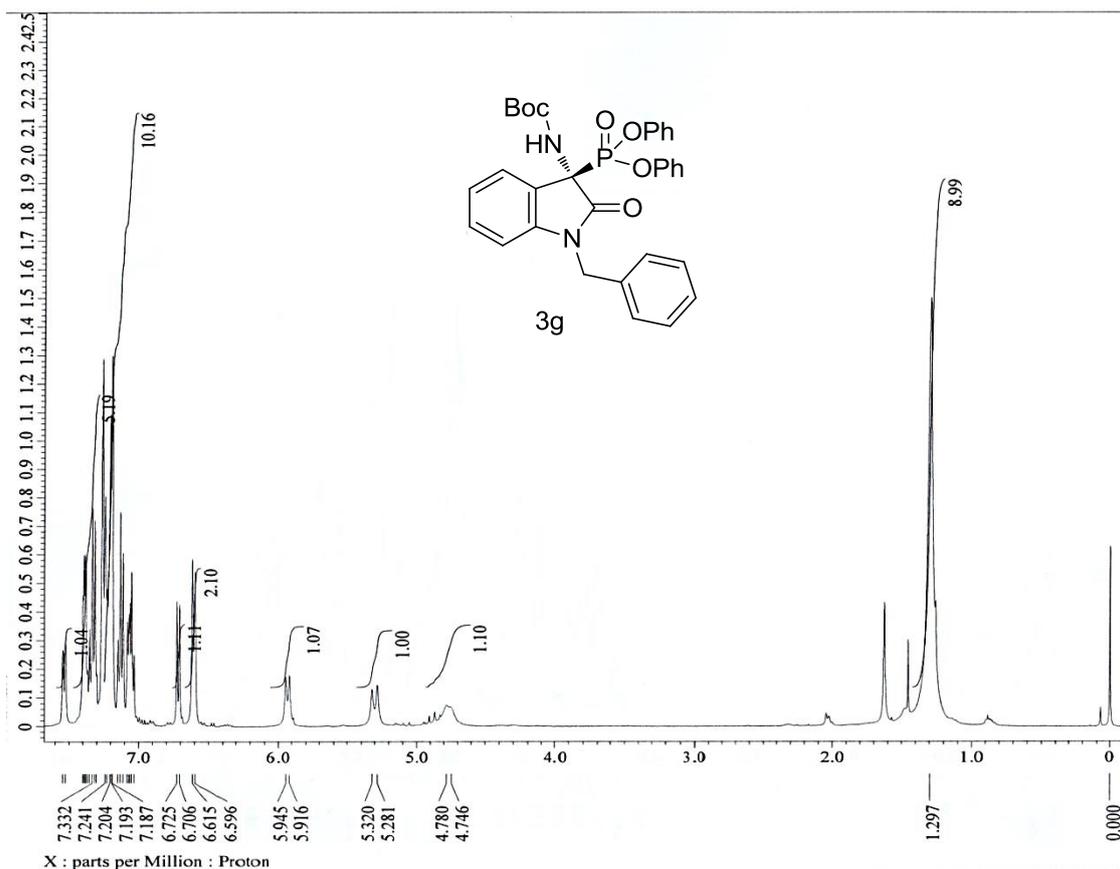


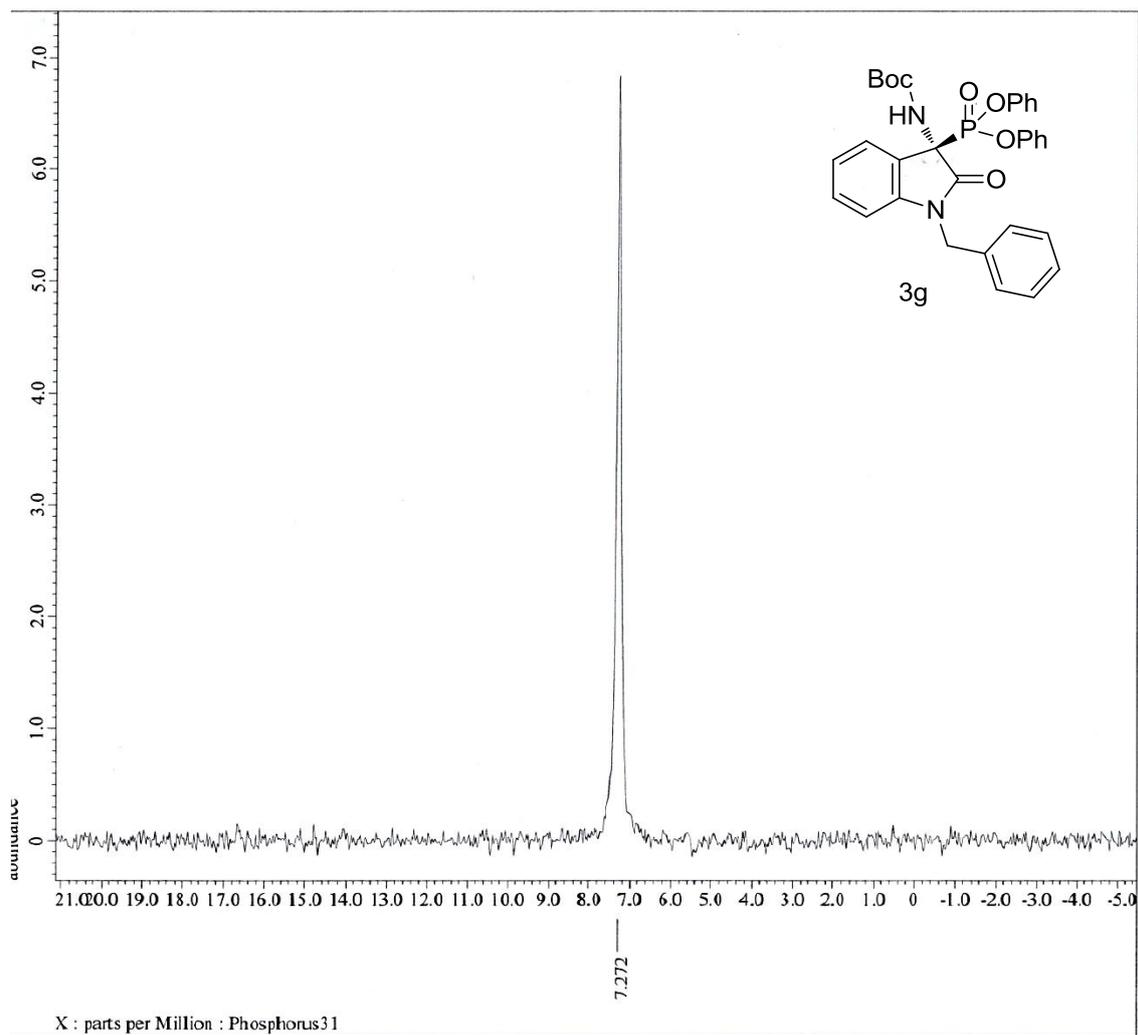
1 Det.A Ch1/254nm

PeakTable

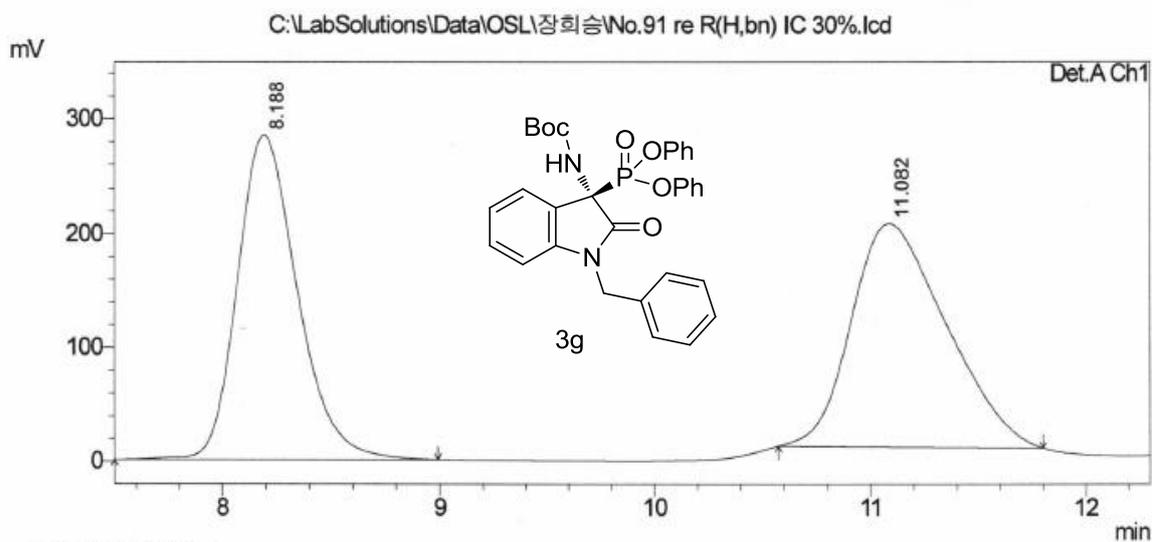
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	16.612	299402	9121	0.868	2.461
2	19.368	2142934	44614	6.210	12.039
3	22.665	4822768	82563	13.976	22.279
4	35.147	27243200	234288	78.947	63.221
Total		34508304	370587	100.000	100.000





## &lt;Chromatogram&gt;

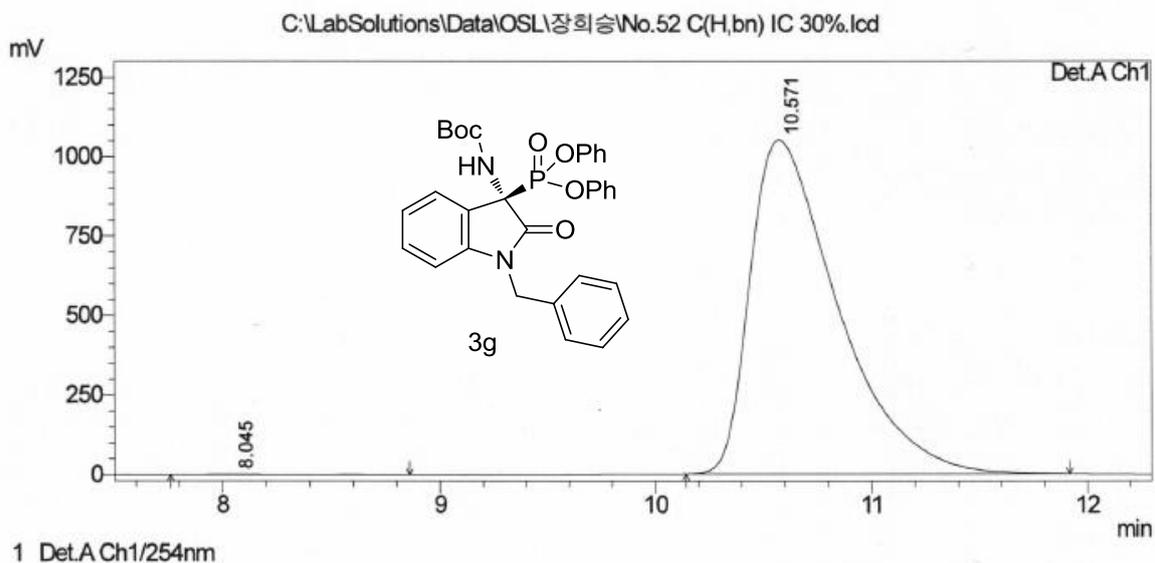


PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	8.188	5442520	284068	47.579	59.071
2	11.082	5996464	196821	52.421	40.929
Total		11438985	480889	100.000	100.000

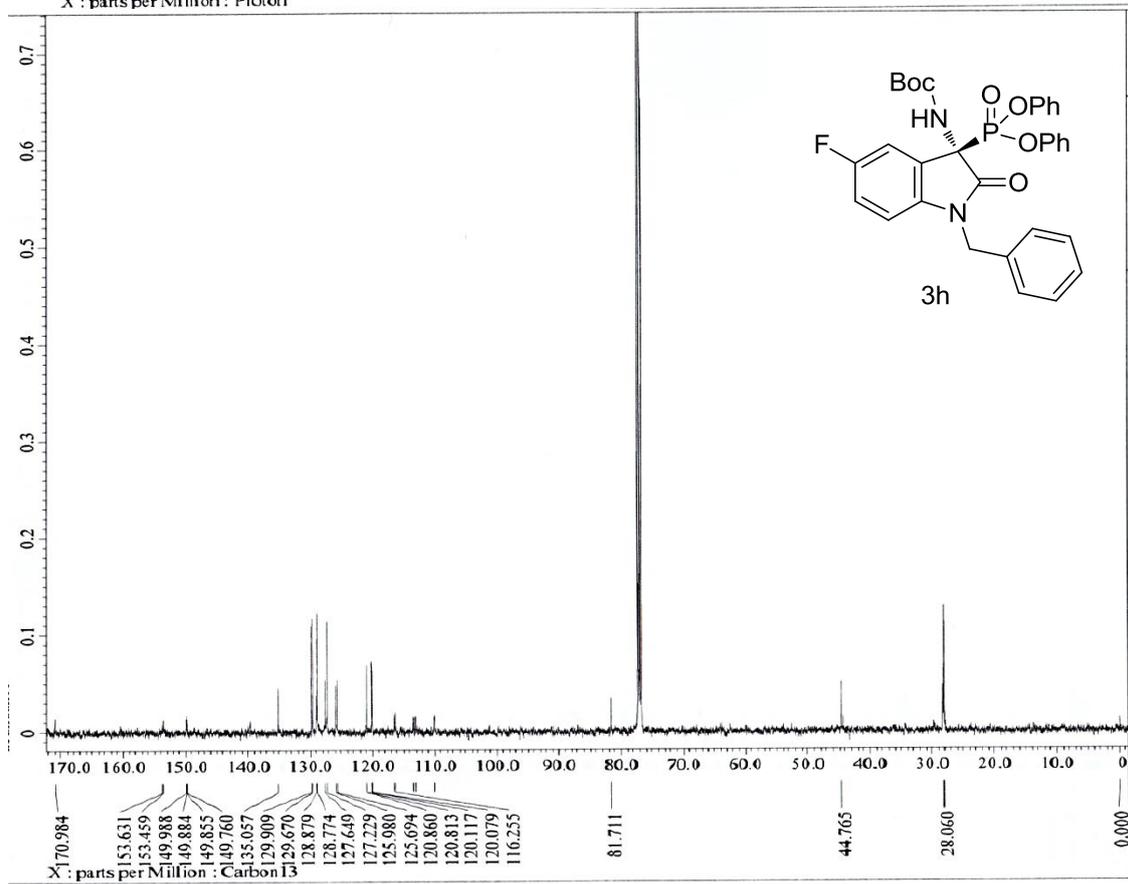
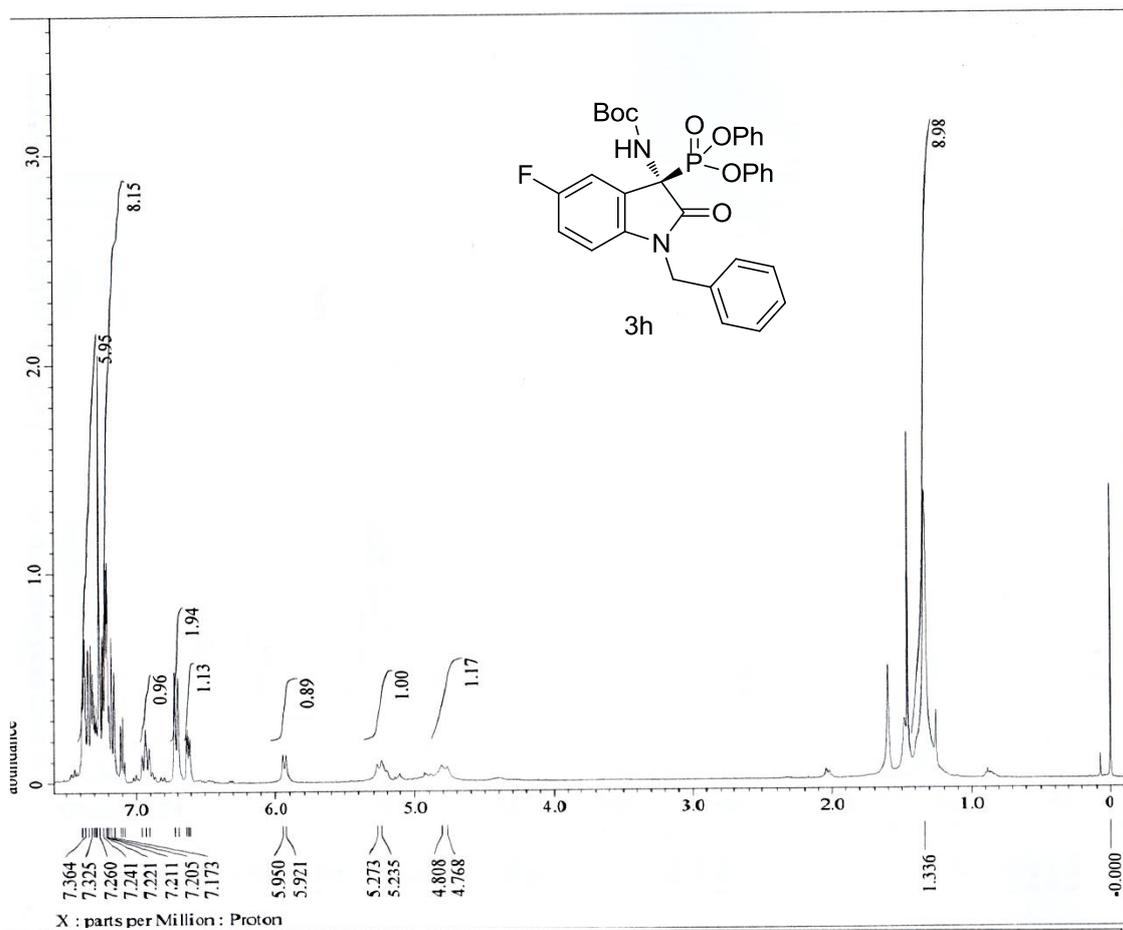
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PeakTable

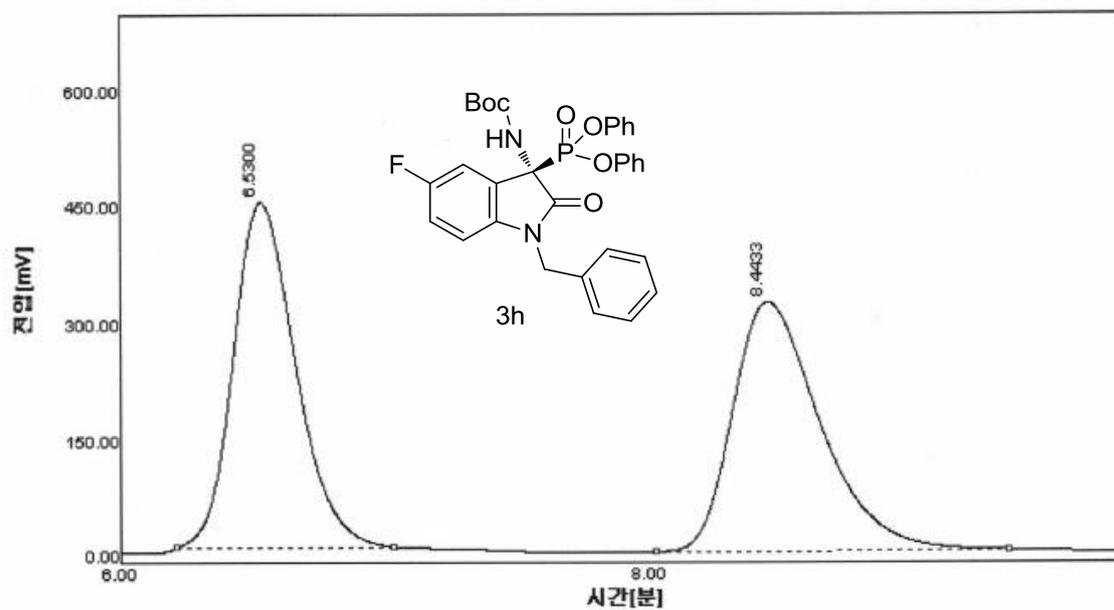
Detector A Ch1 254nm

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1	8.045	30260	1005	0.103	0.096
2	10.571	29425567	1049787	99.897	99.904
Total		29455827	1050792	100.000	100.000





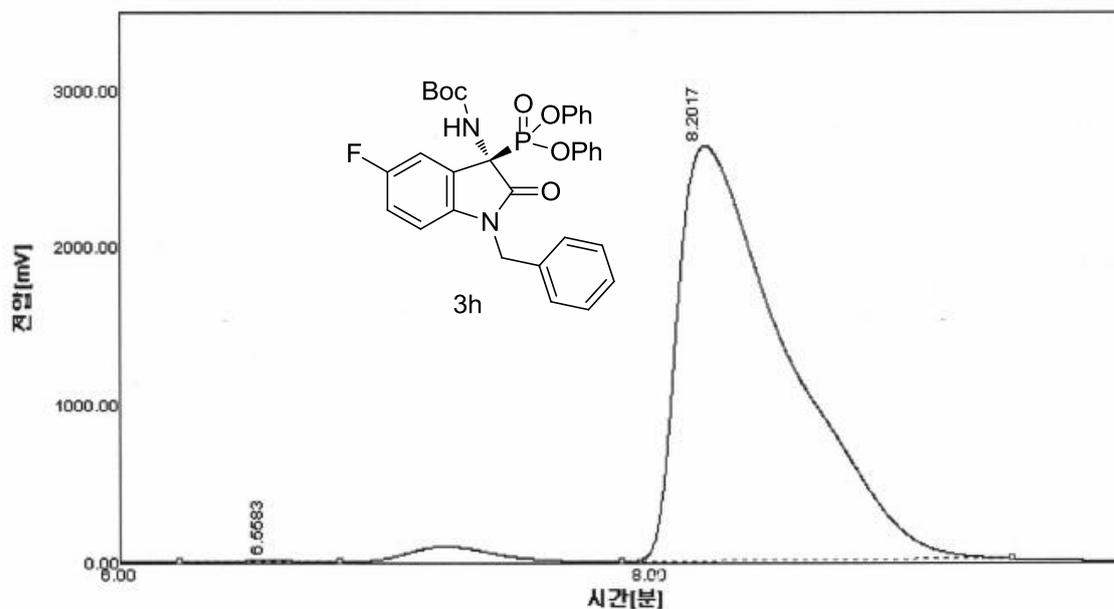
## 크로마토그램



## 적분 결과

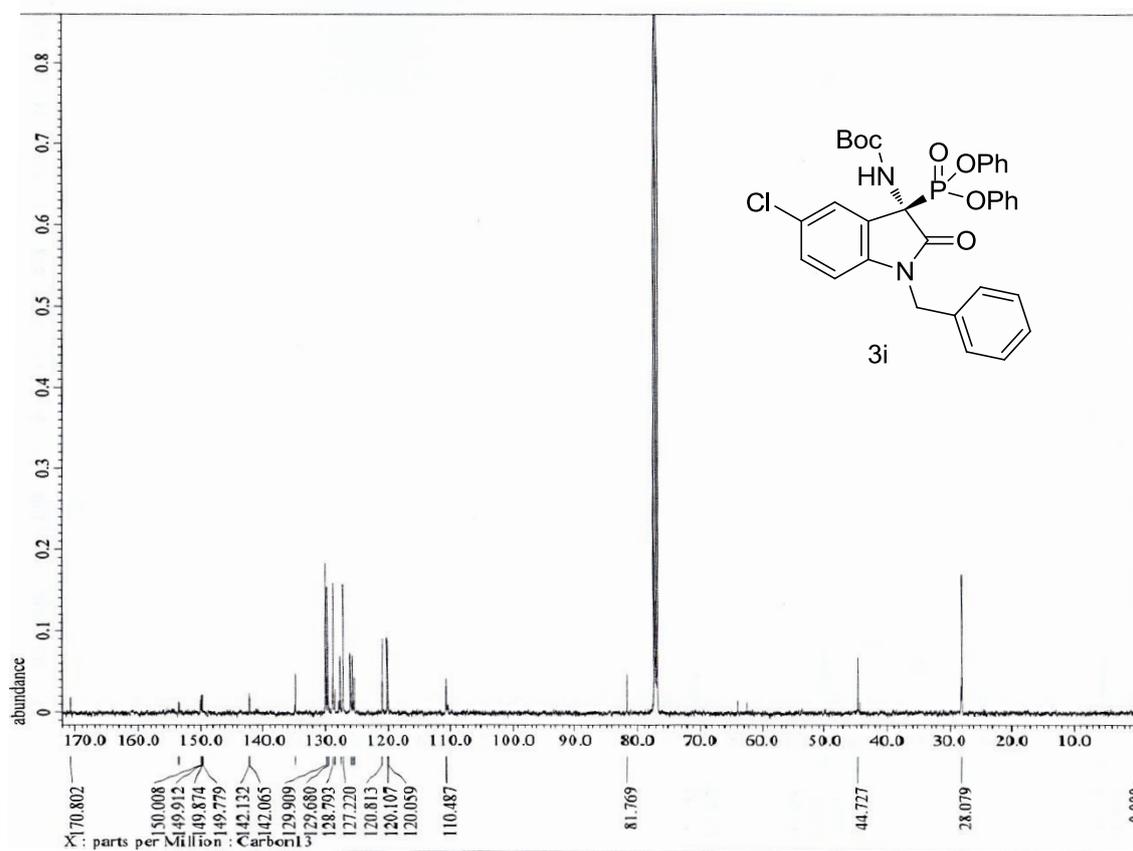
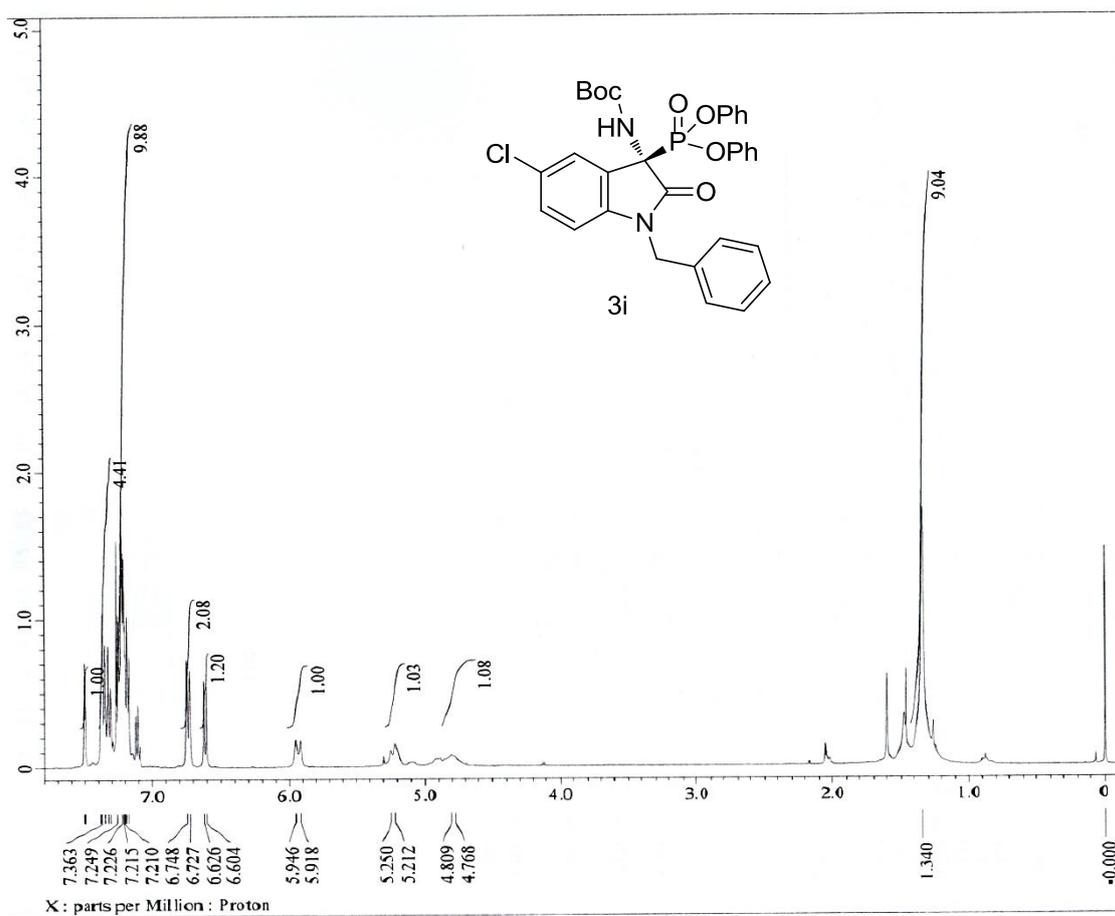
번호	RT[분]	면적비[%]	면적[mV*s]	폭[초]	형태
1	6.5300	49.64	7226.5016	25.29	FF
2	8.4433	50.36	7330.8398	32.61	FF
합계			14557.3414		

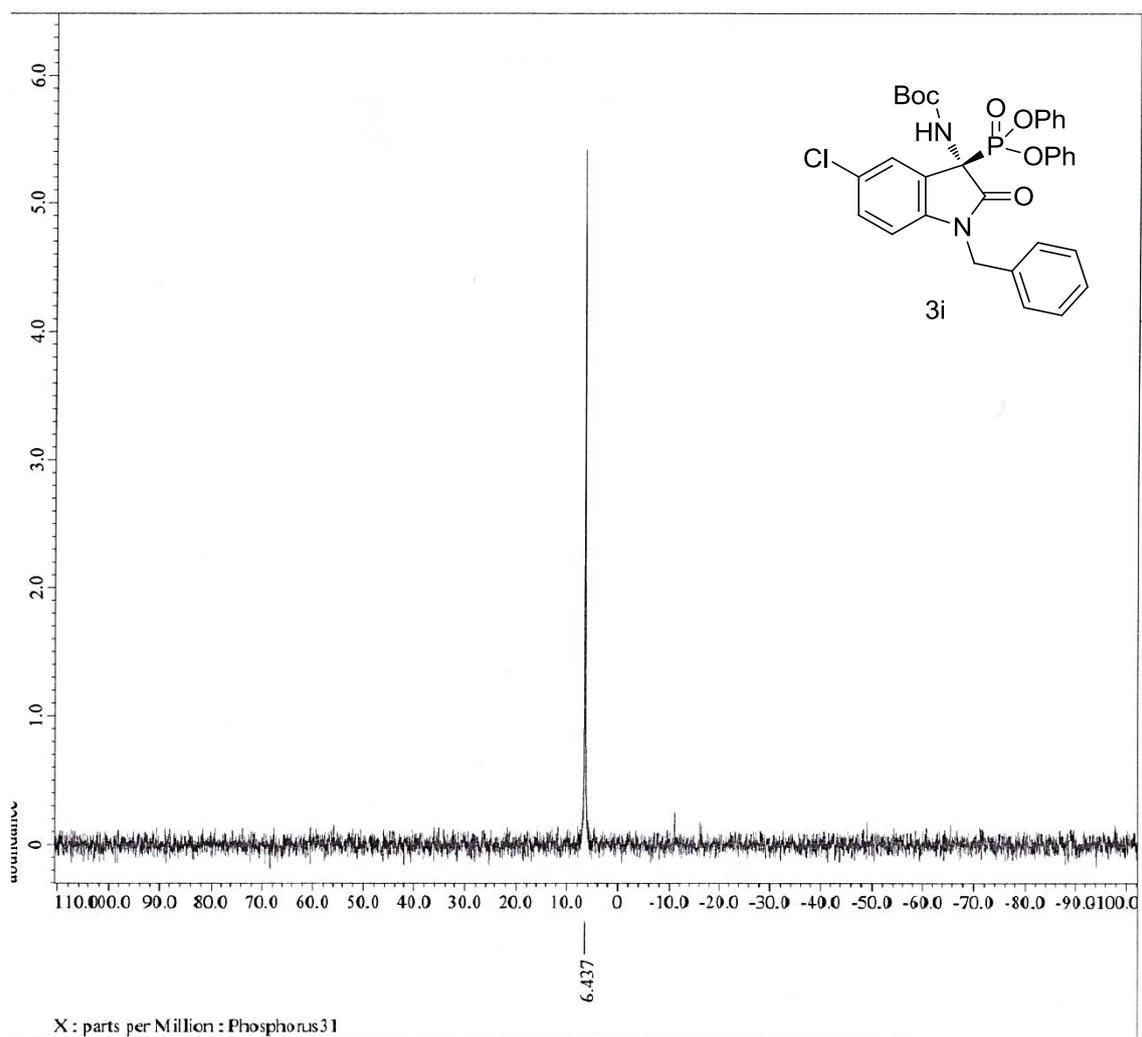
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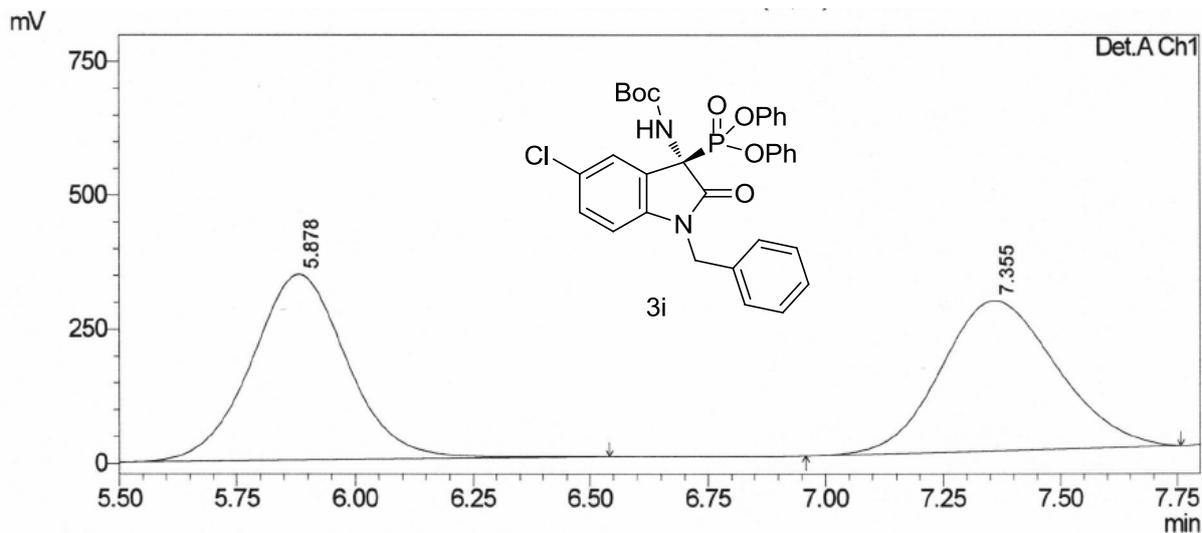


## 적분 결과

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2	8.2017	99.77	2643.9487	58.09	FF
합계			2816.1125		



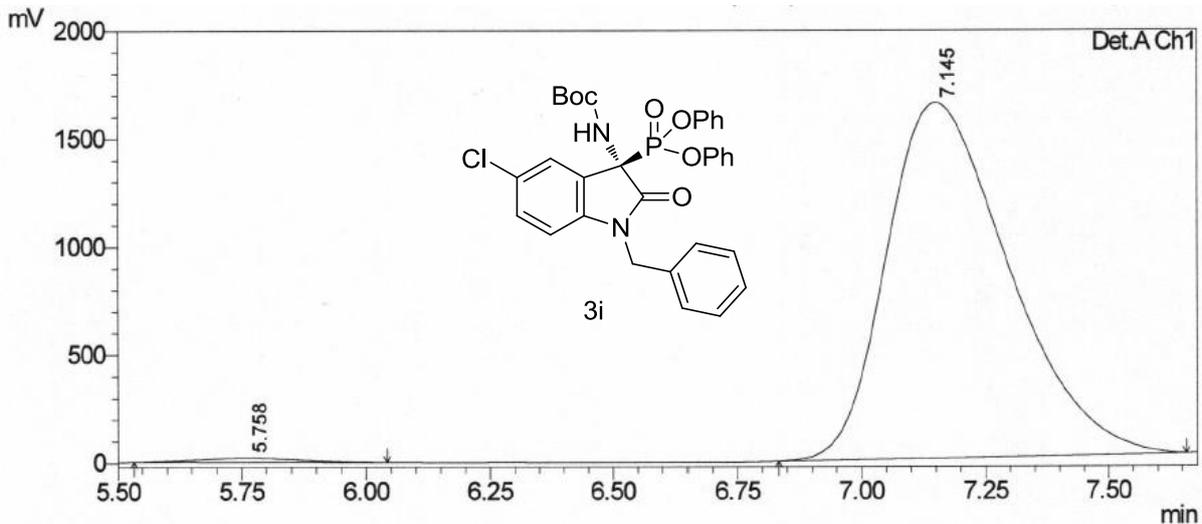




PeakTable

Detector A Ch1 254nm

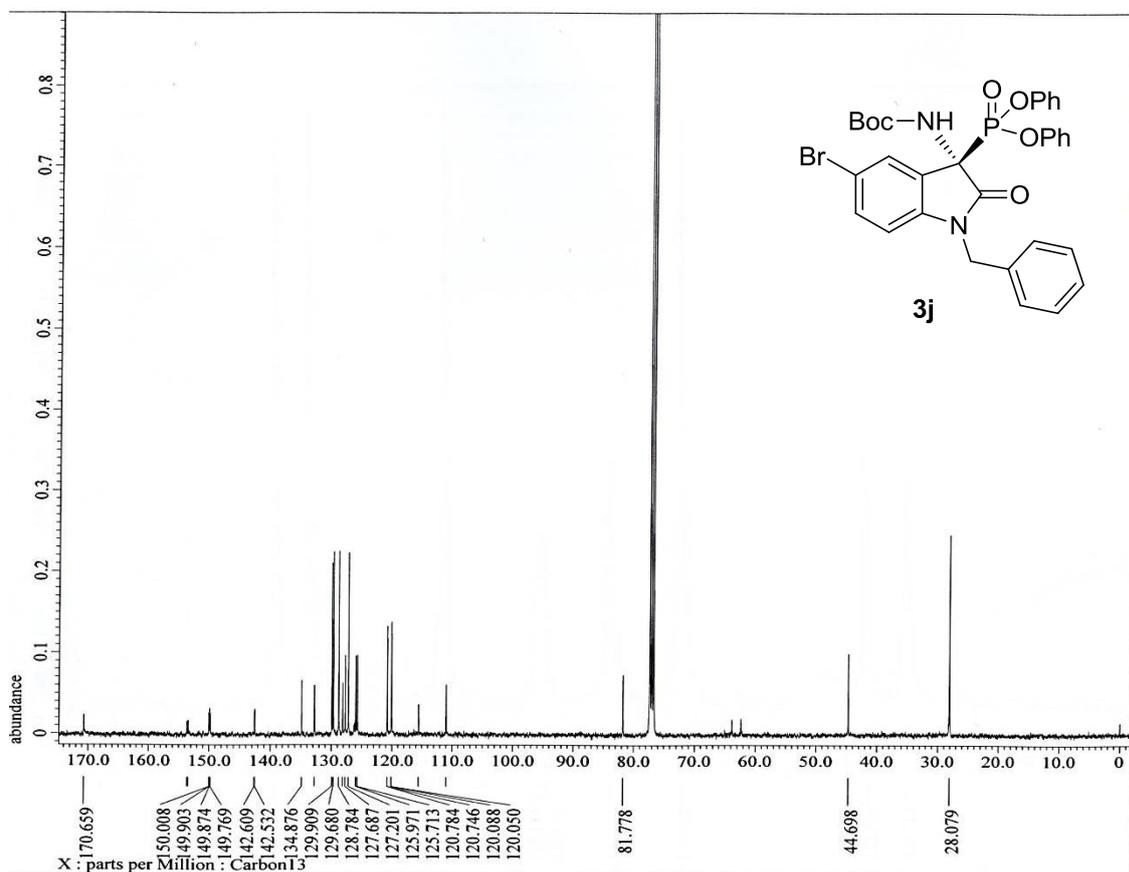
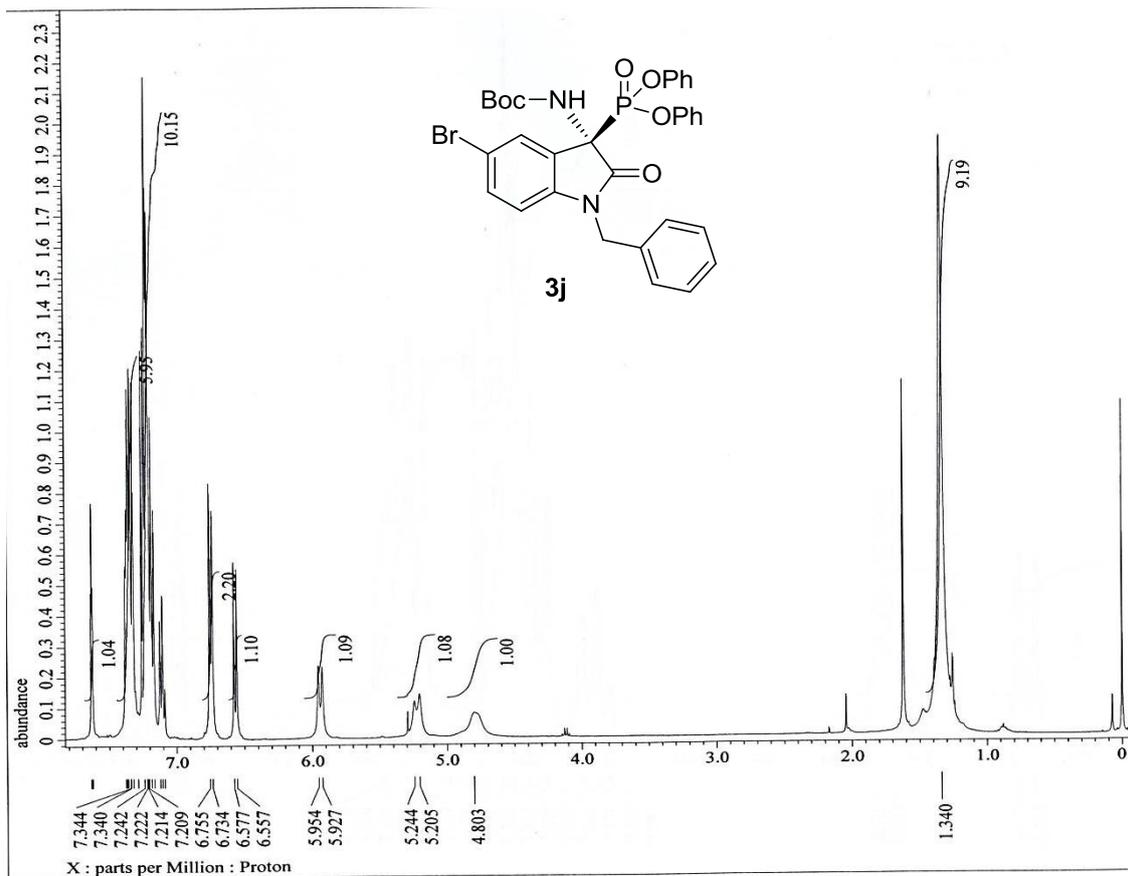
Peak#	Ret. Time	Area	Height	Area %	Height %
1	5.878	4868166	346176	50.302	55.263
2	7.355	4809797	280235	49.698	44.737
Total		9677964	626411	100.000	100.000

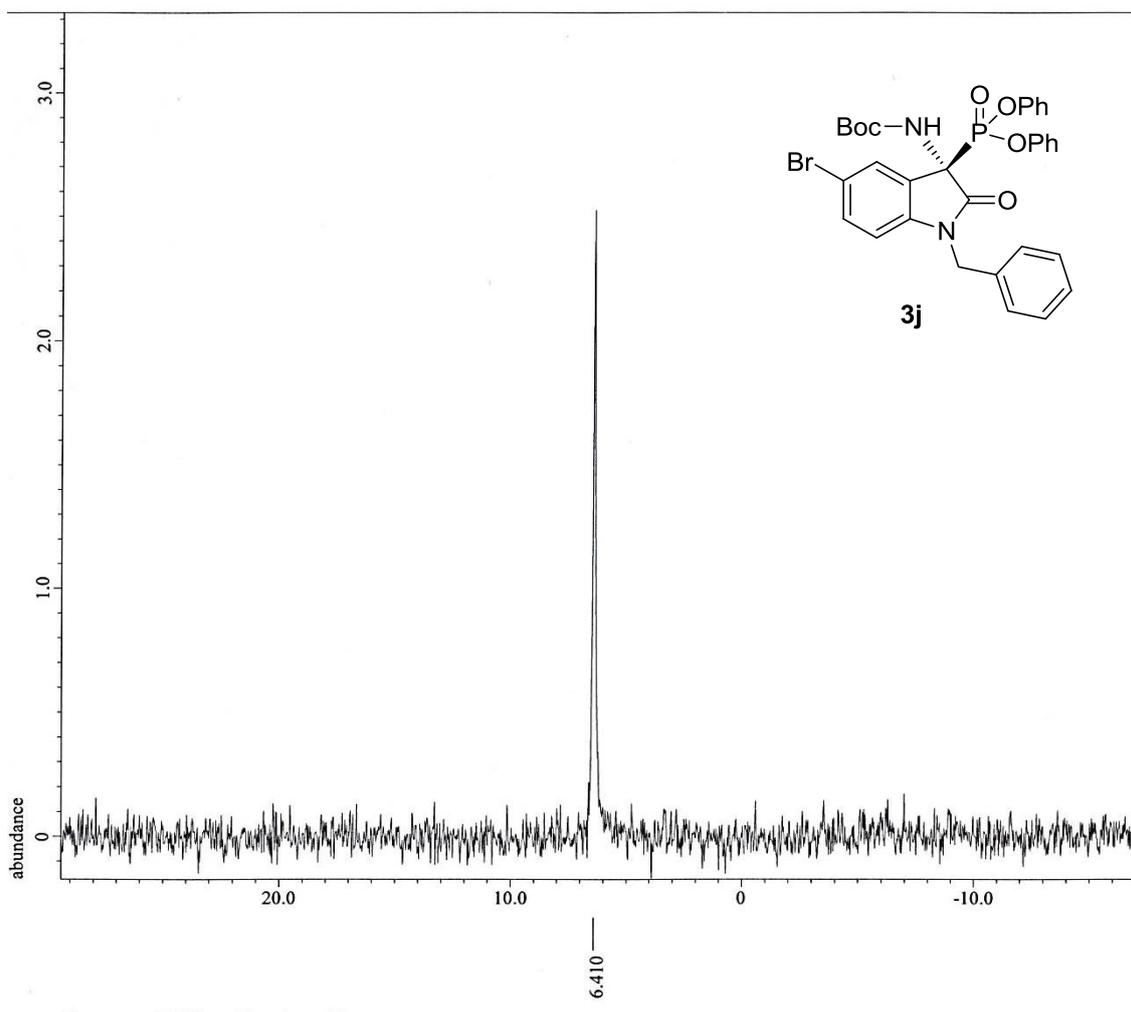


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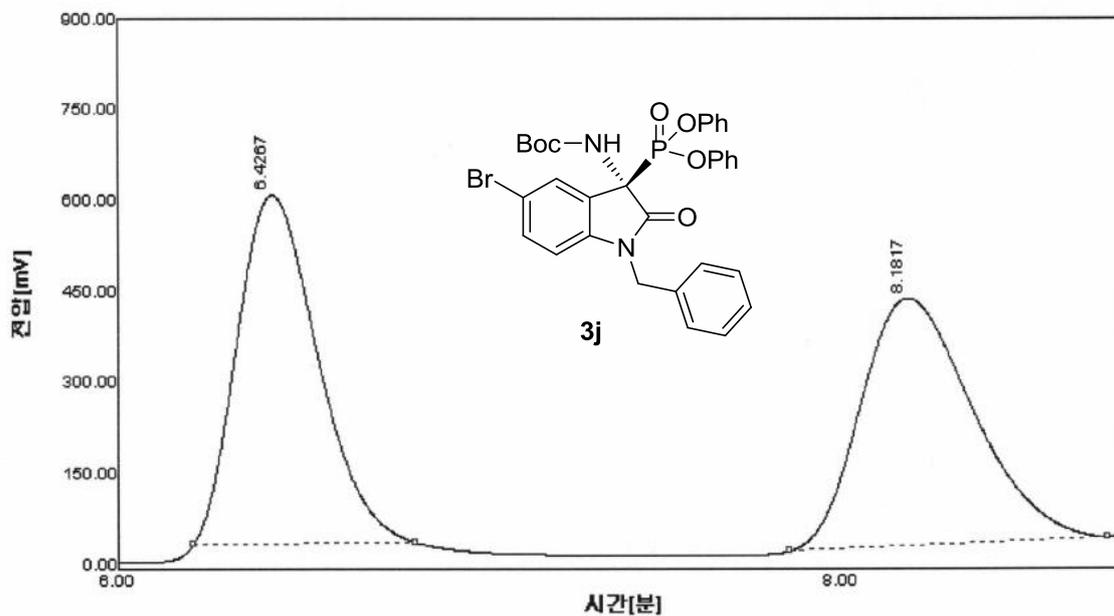
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	5.758	261958	18236	0.920	1.095
2	7.145	28213493	1646431	99.080	98.905
Total		28475450	1664667	100.000	100.000





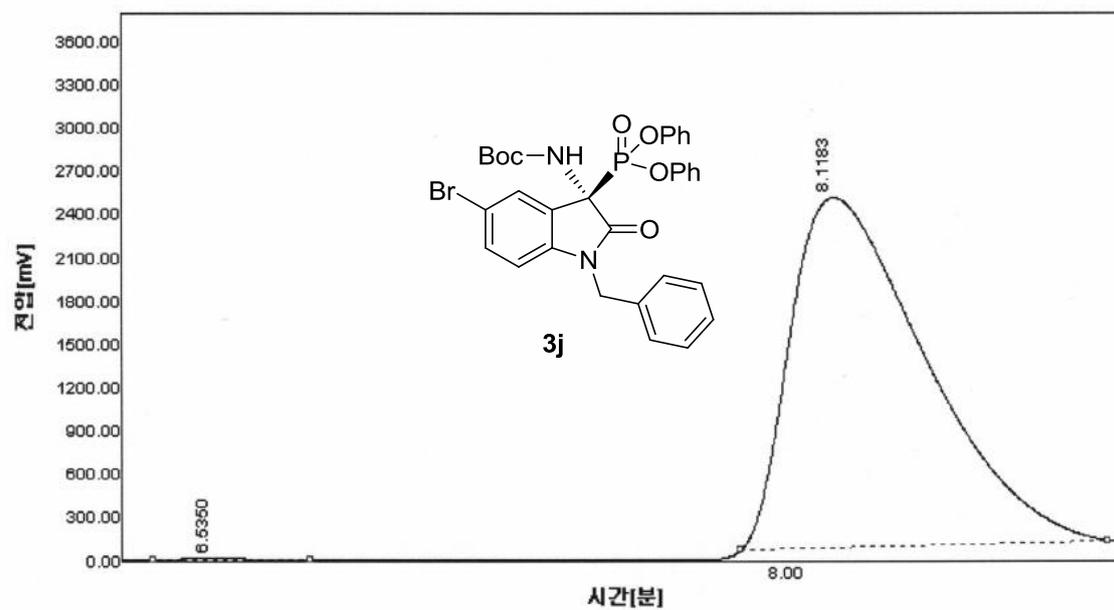
## 크로마토그램



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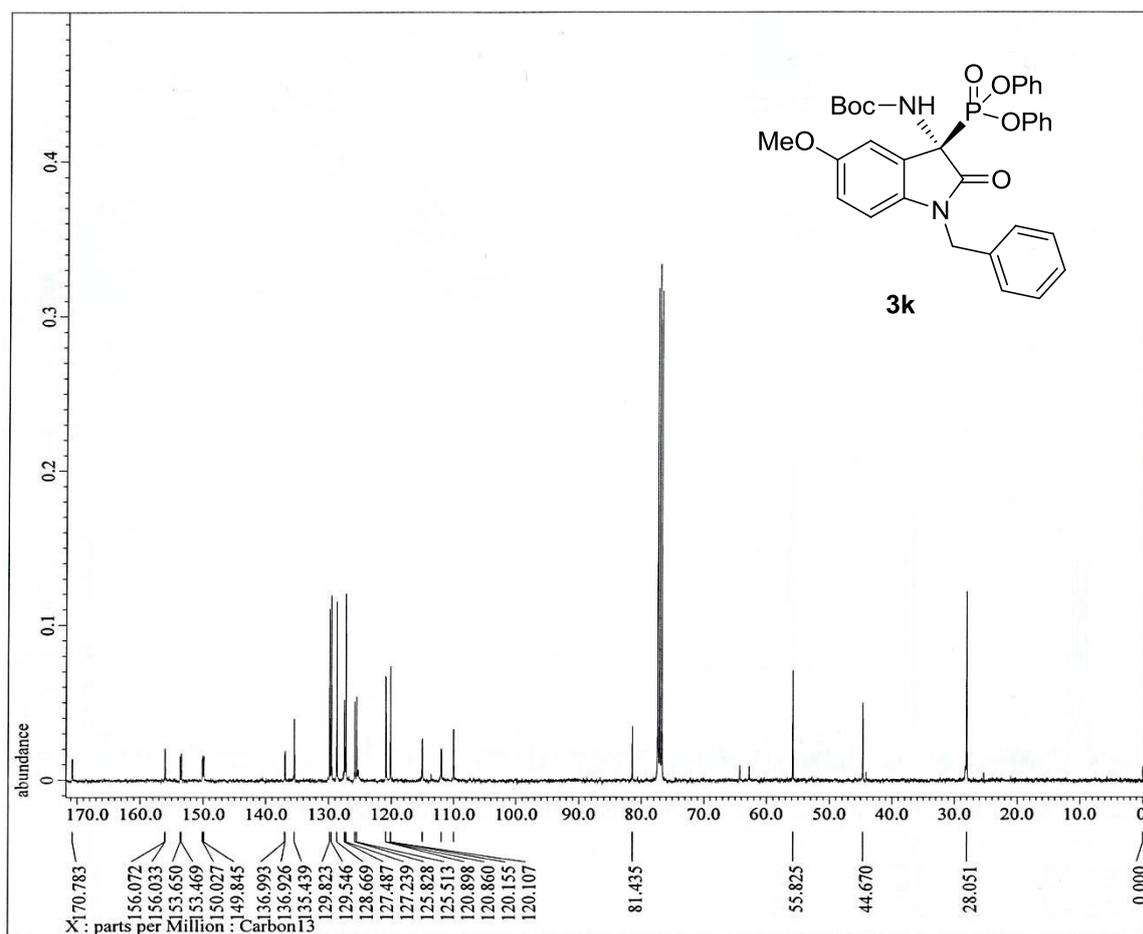
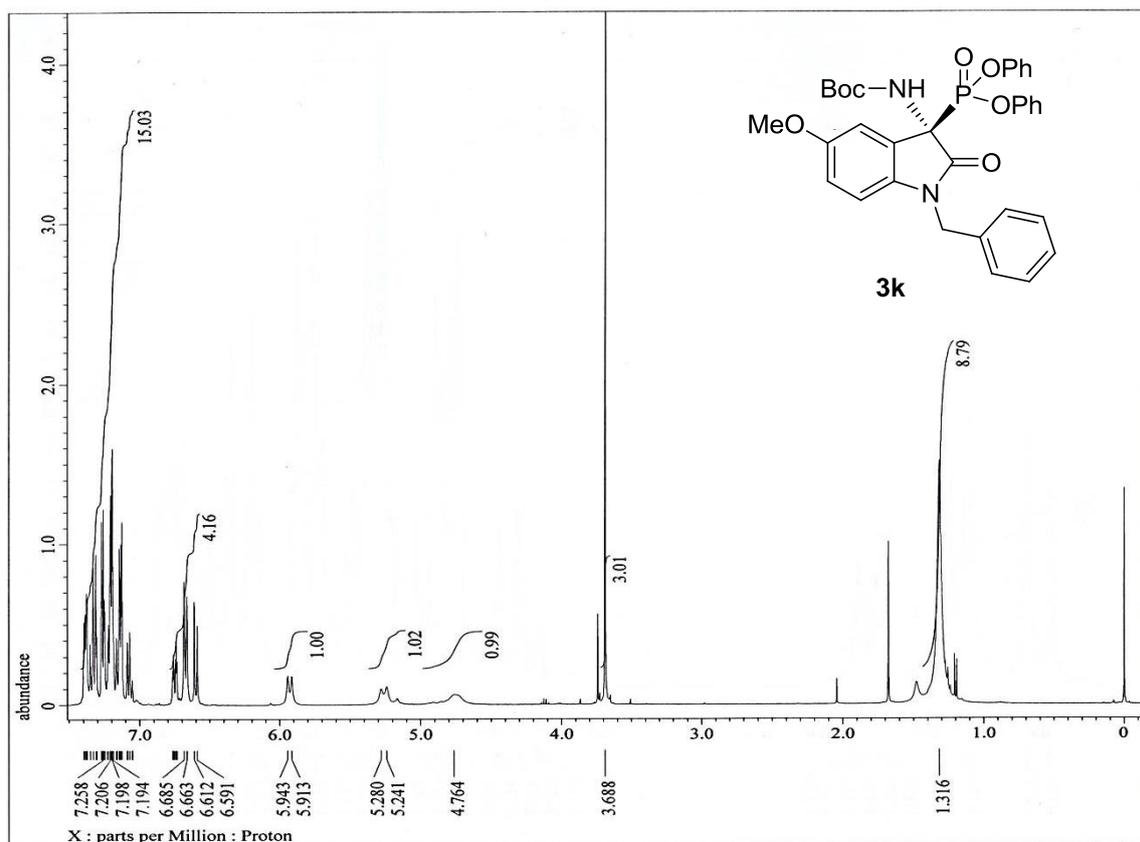
번호	RT[분]	면적비[%]	면적[mV*s]	폭[초]	형태
1	6.4267	50.26	8794.6422	24.45	FF
2	8.1817	49.74	8703.8578	31.17	FF
합계			17498.5000		

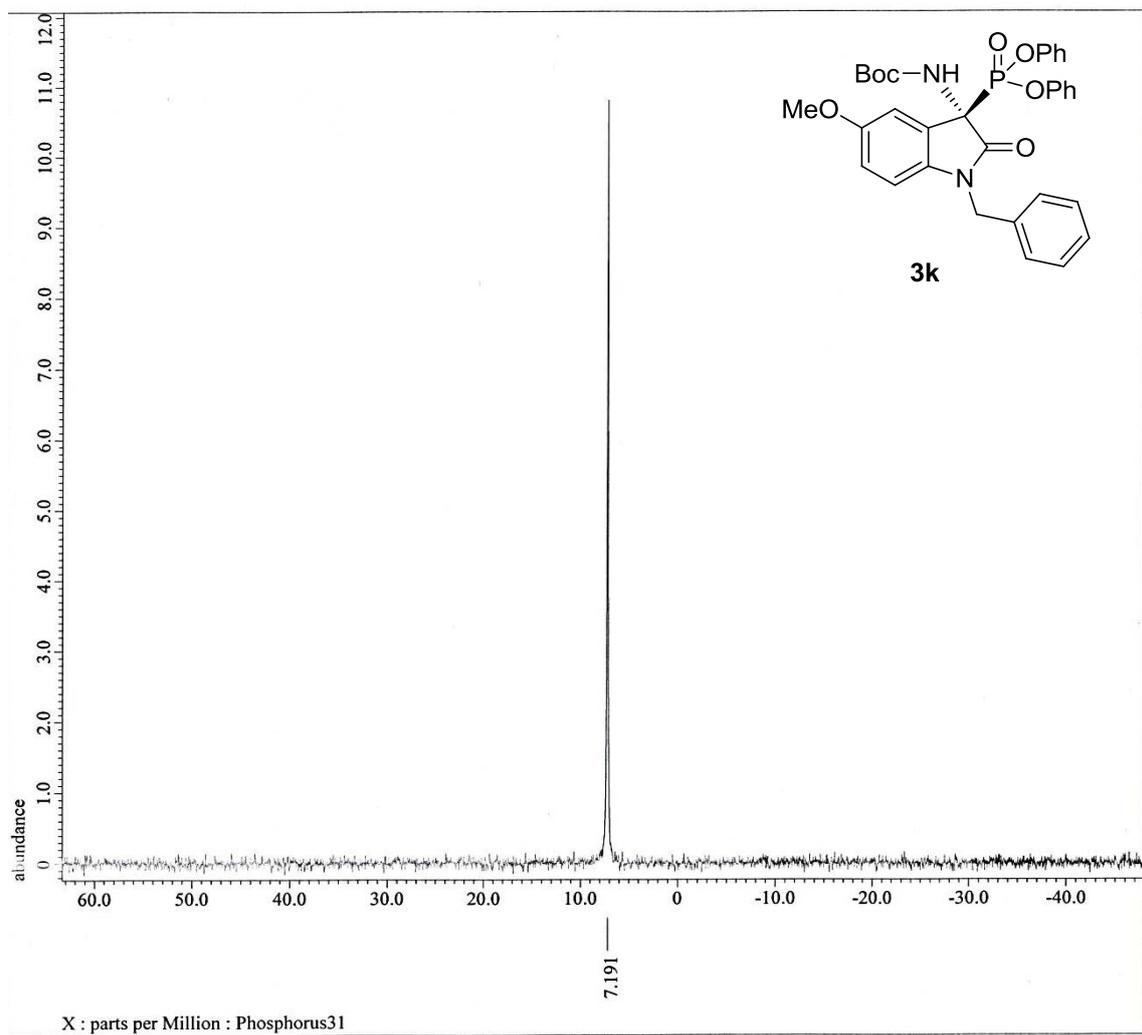
## 크로마토그램



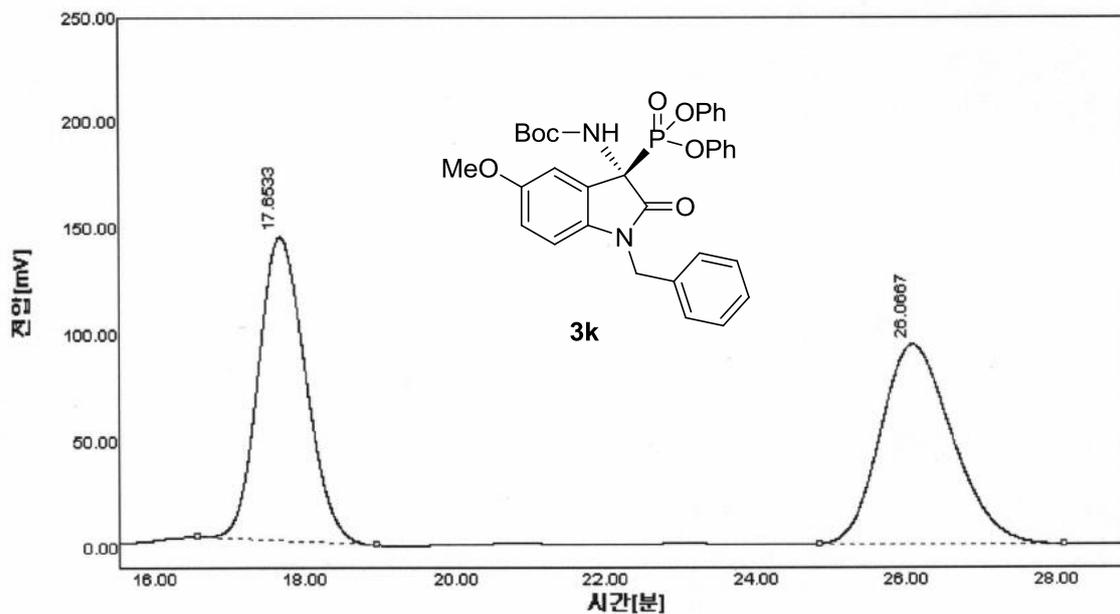
## 적분 결과

번호	RT[분]	면적비[%]	면적[mV*s]	폭[초]	형태
1	6.5350	0.23	131.4502	21.01	FF
2	8.1183	99.77	58057.2375	34.22	FF
합계			58188.6877		





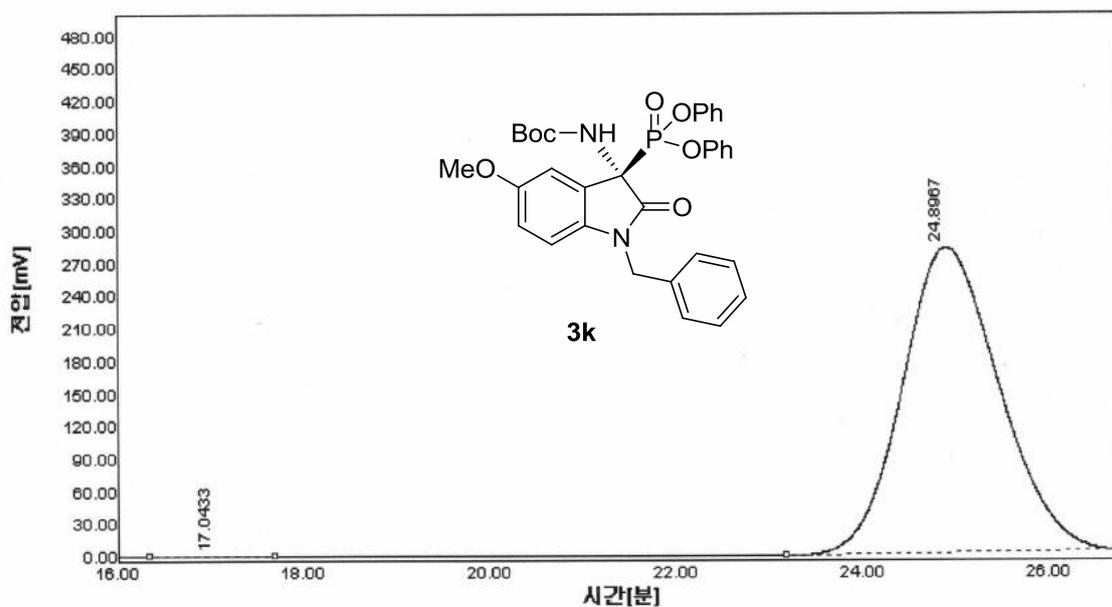
## 크로마토그램



## 적분 결과

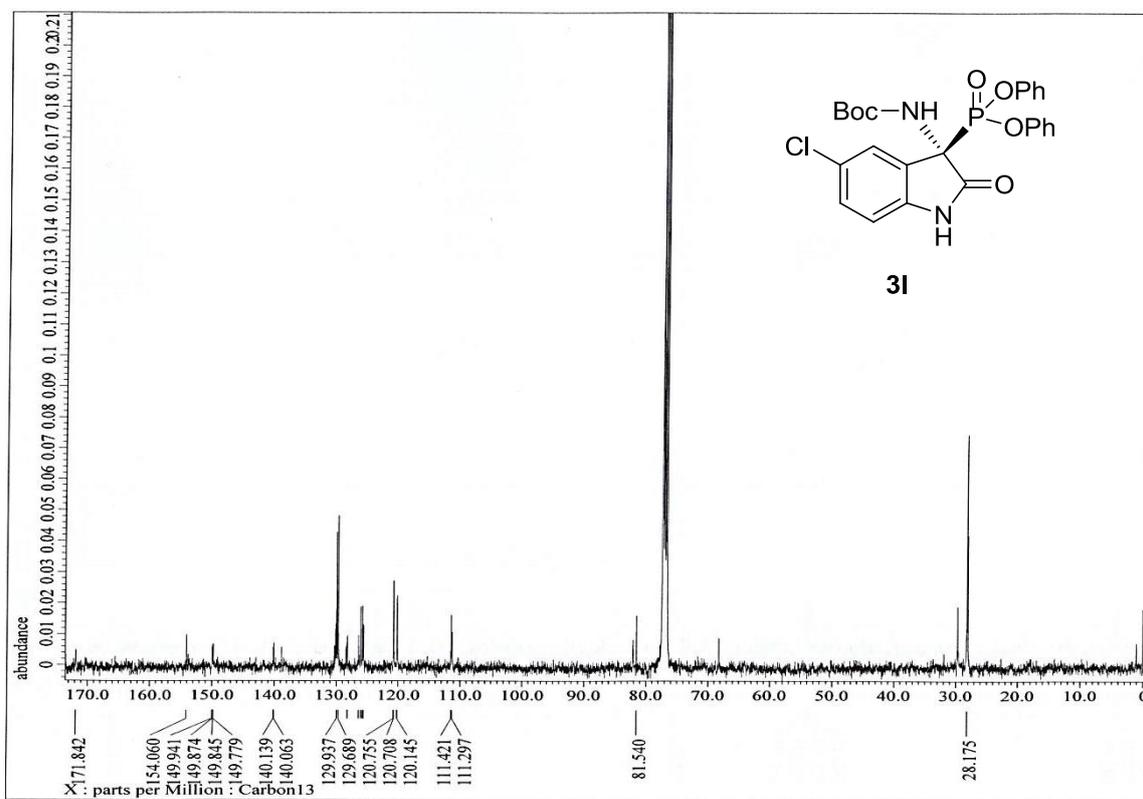
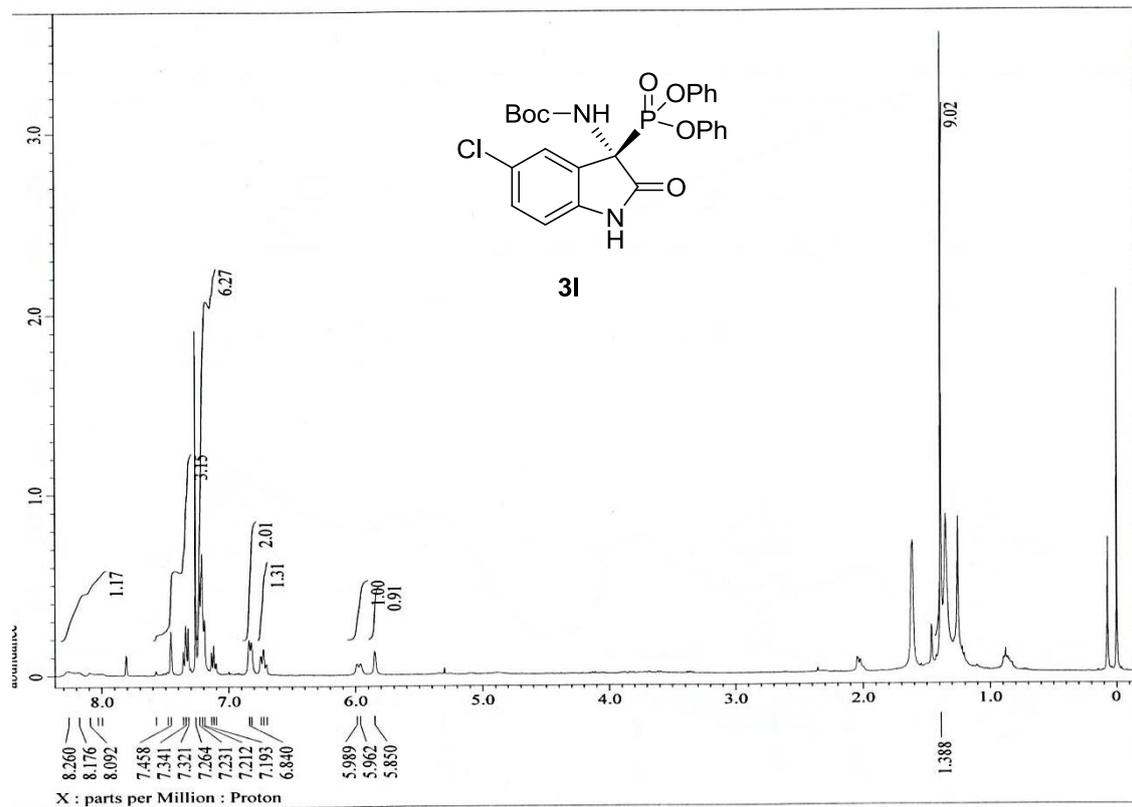
번호	RT[분]	면적비[%]	면적[mV*s]	폭[초]	형태
1	17.6533	49.95	6188.3461	68.90	FF
2	26.0667	50.05	6201.3781	105.46	FF
합계			12389.7242		

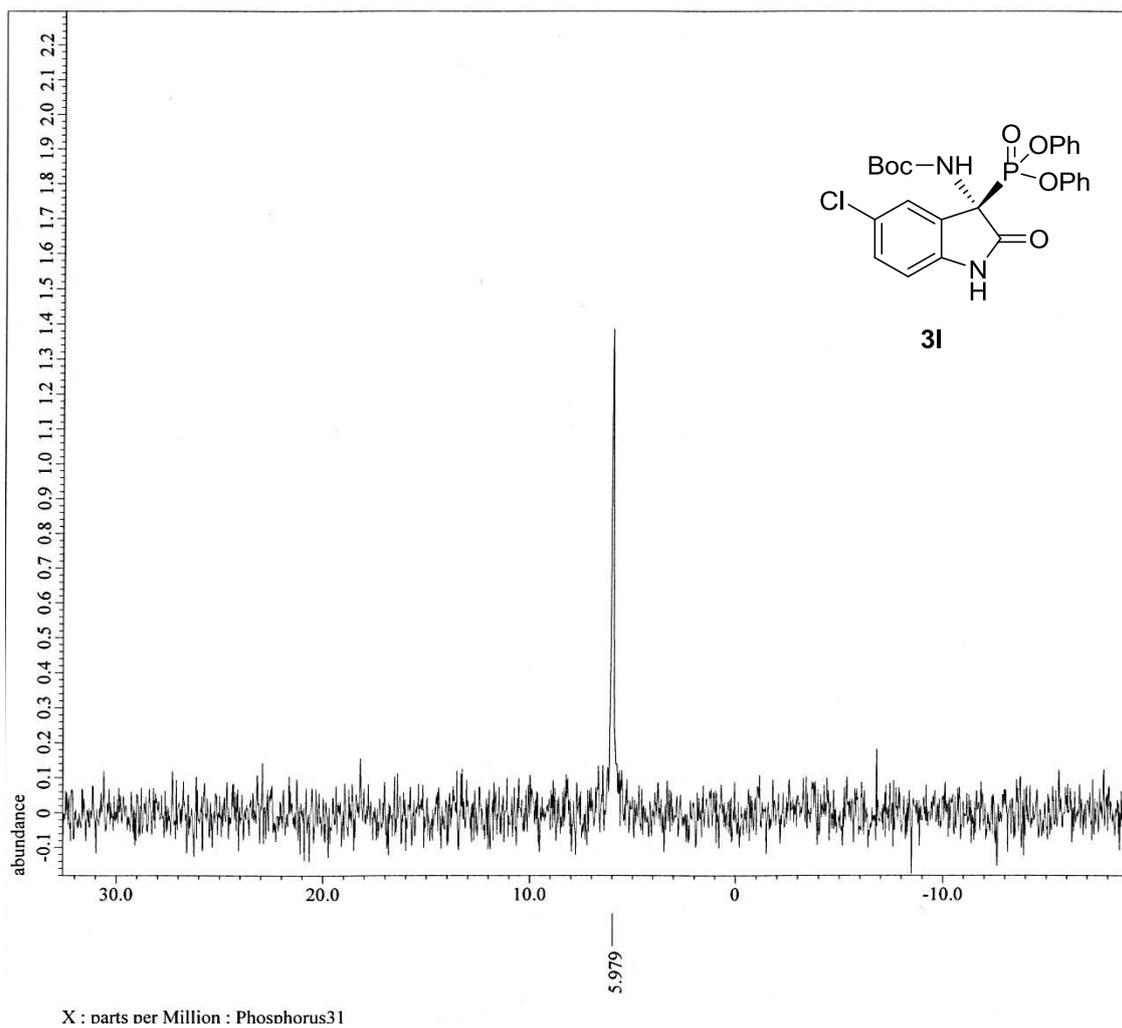
## 크로마토그램



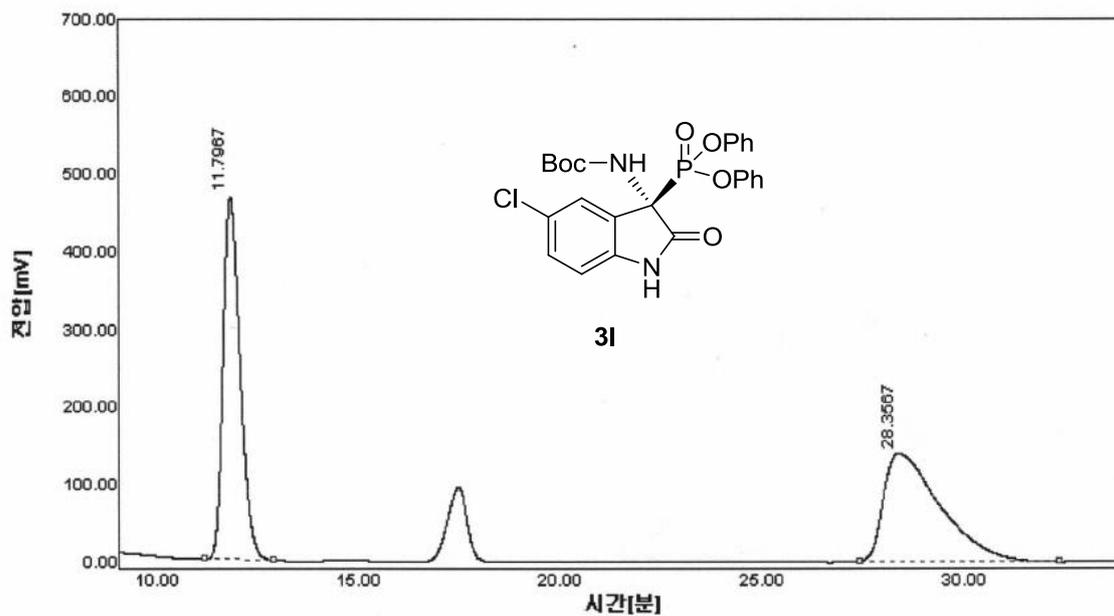
## 적분 결과

번호	RT[분]	면적비[%]	면적[mV*s]	폭[초]	형태
1	17.0433	0.22	45.3051	61.73	FF
2	24.8967	99.78	20232.5344	115.18	BB
합계			20277.8395		





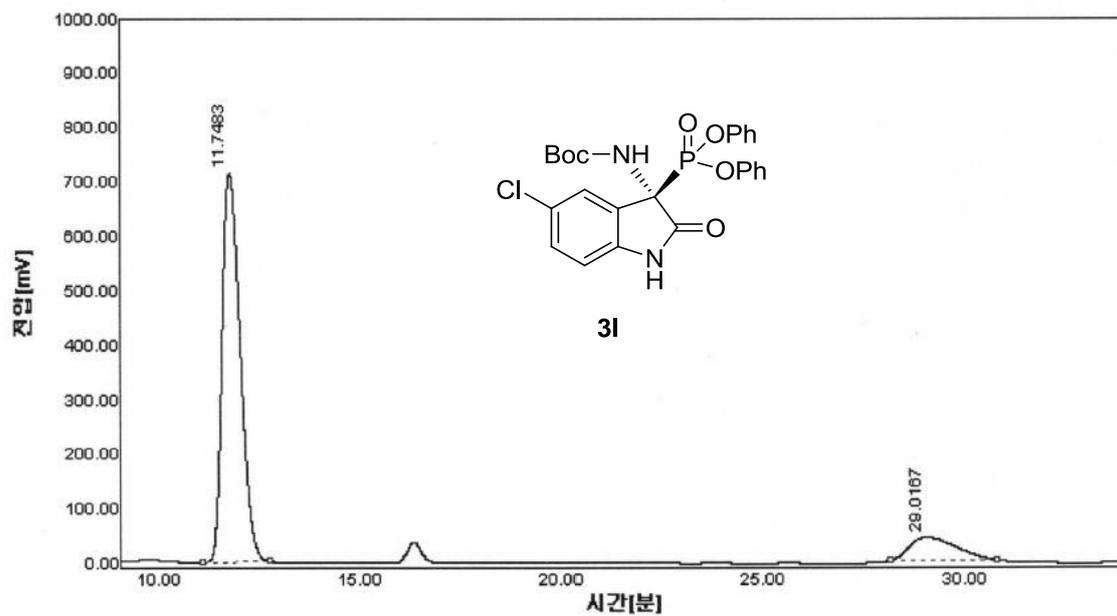
## 크로마토그램



## 적분 결과

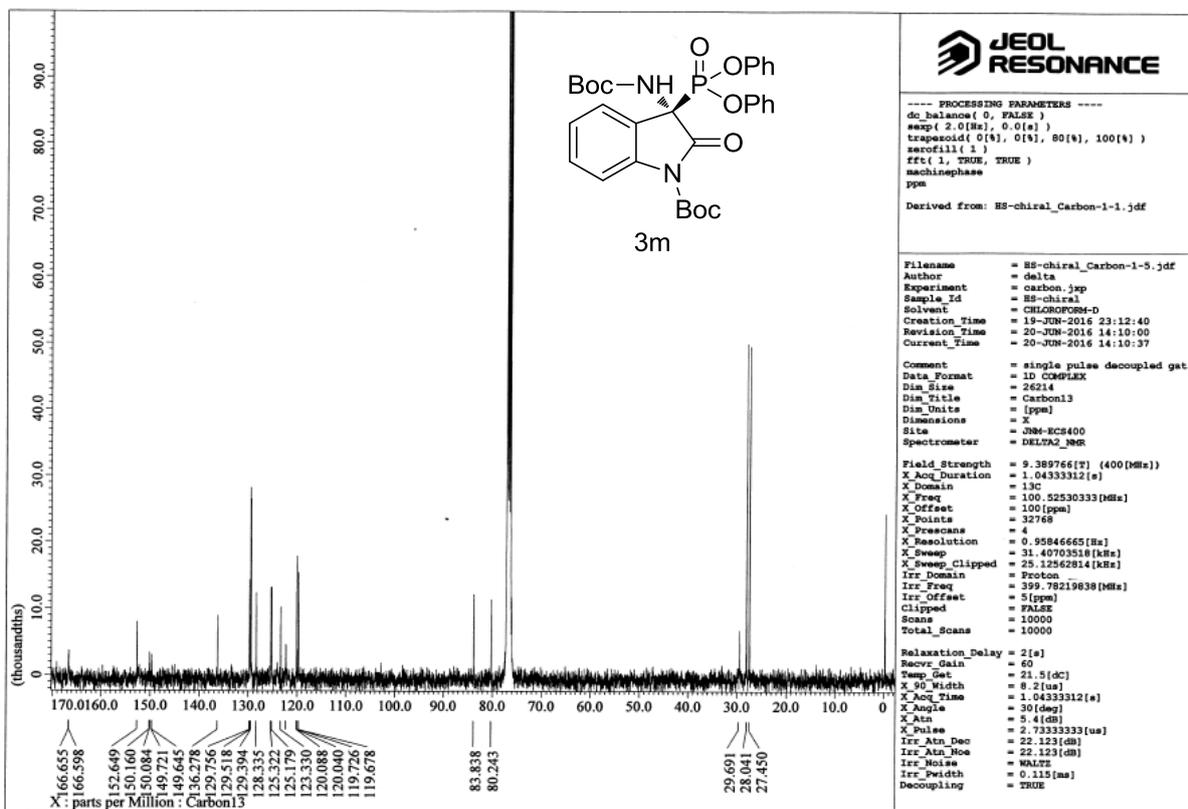
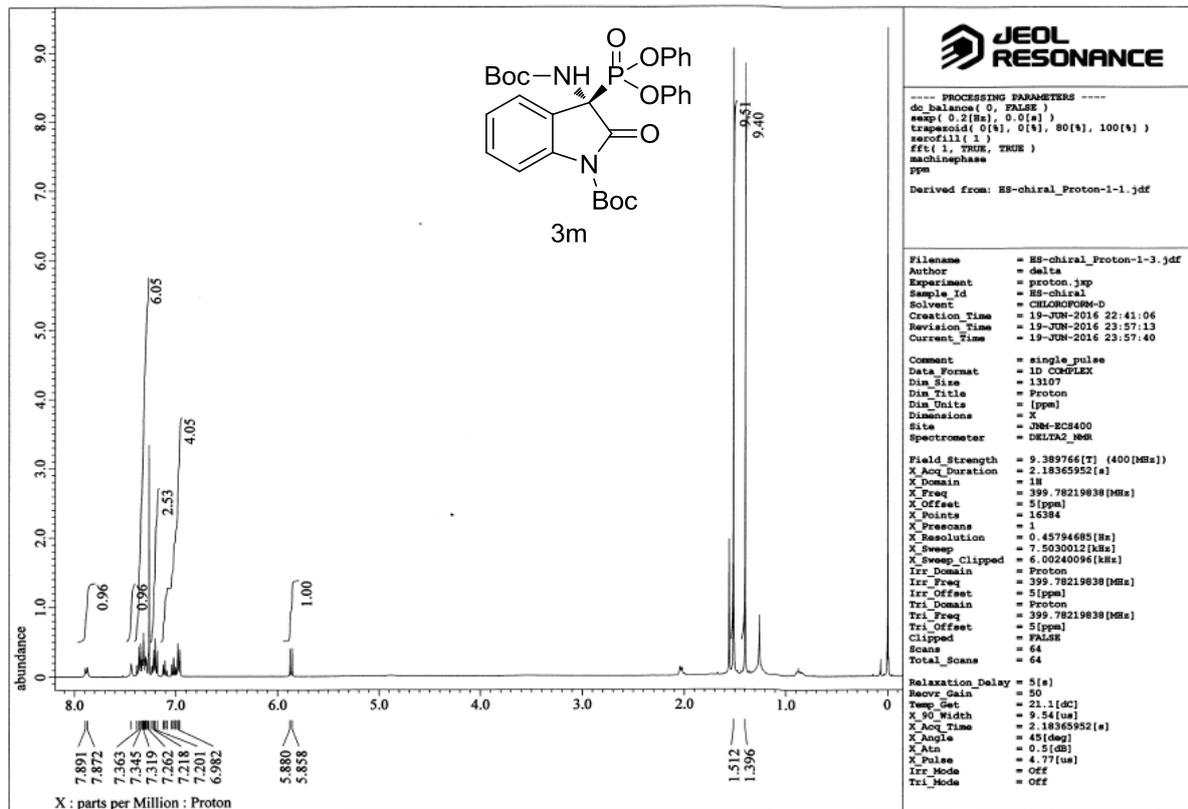
번호	RT[분]	면적비[%]	면적[mV*s]	폭[초]	형태
1	11.7967	50.01	13597.0187	45.74	FF
2	28.3567	49.99	13591.6969	137.88	FF
합계			27188.7156		

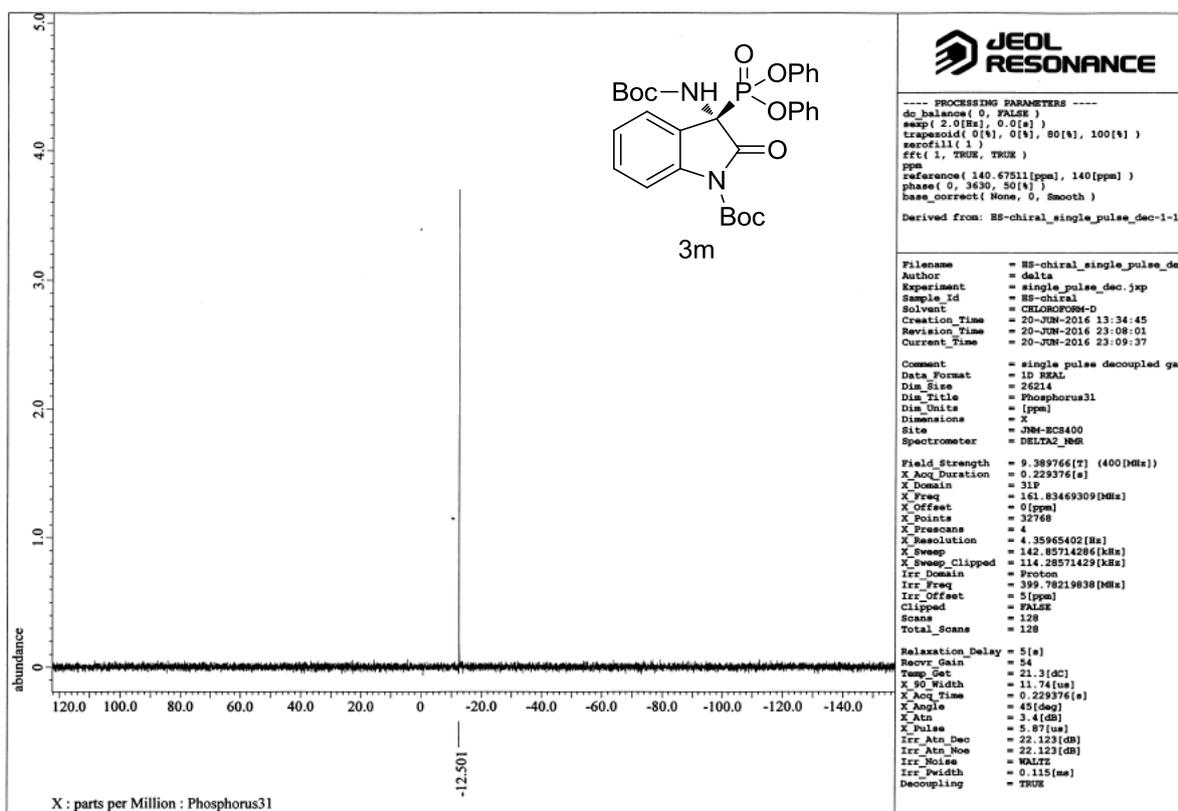
## 크로마토그램



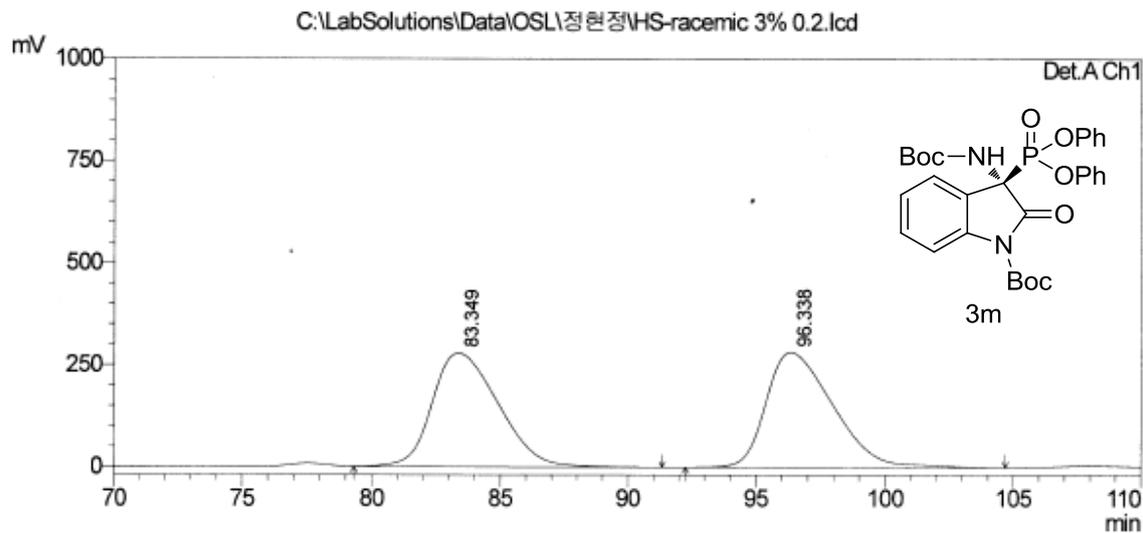
## 적분 결과

번호	RT[분]	면적비[%]	면적[mV*s]	폭[초]	형태
1	11.7483	86.66	22079.3812	49.21	FF
2	29.0167	13.34	3397.9391	130.30	FF
합계			25477.3203		





## &lt;Chromatogram&gt;

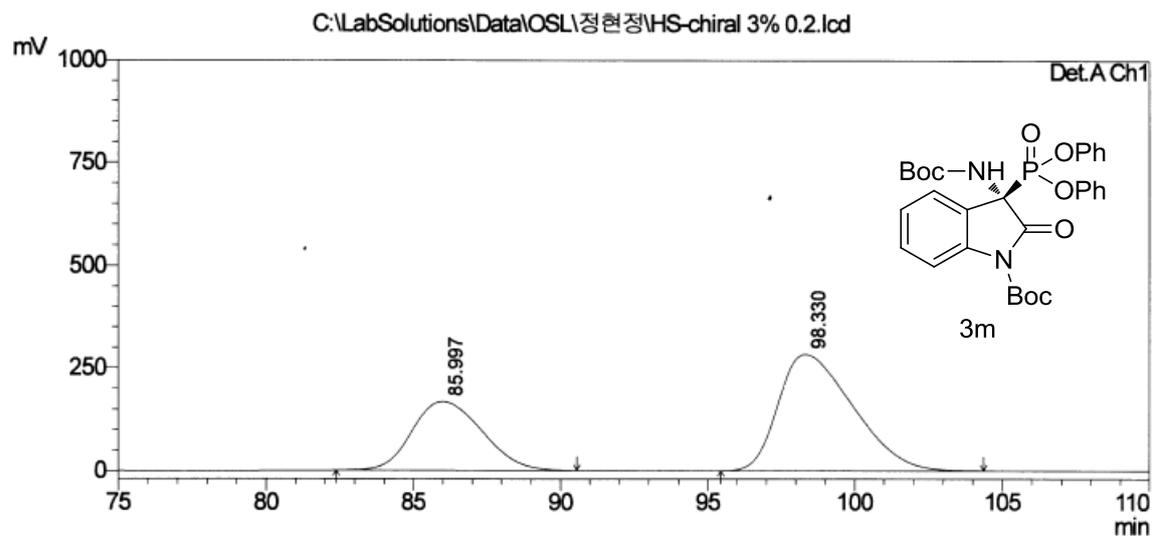


PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	83.349	49728671	278460	49.625	49.665
2	96.338	50480778	282215	50.375	50.335
Total		100209449	560676	100.000	100.000

## &lt;Chromatogram&gt;



PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	85.997	27756936	166772	35.720	37.080
2	98.330	49950735	282993	64.280	62.920
Total		77707671	449766	100.000	100.000