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# Gas Chromatographic Enantiomer Separation of Cyclopropane Derivatives on Three 2, 6-Di-*O*-allyl-3-*O*-acylated-β-cyclodextrins Chiral Stationary Phases

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**Abstract:** Eight pairs of enantiomers of cyclopropane derivatives were resolved on capillary gas chromatographic columns using three new 2, 6-di-*O*-allyl-3-*O*-acylated-β-cyclodextrins as chiral stationary phases. It was found that the three β-CDs can separate some of the racemic cyclopropane derivatives well.

**Keywords:** β-Cyclodextrin derivatives (β-CDs), enantioseparation, cyclopropane derivatives.

The chiral cyclopropyl group is found as a basic structural element in many medicines and pesticides. The chiral separation of cyclopropane derivatives, which plays a crucial role in the evaluation of asymmetry synthesis and identification of optically active compounds. Among the chiral stationary phases used in gas chromatography, β-CDs possess high enantioselectivity towards a variety of chiral compounds. It is found that the CDs with different substituteds has different enantioseparation abilities, so it is significant to synthesize new CDs and use them as CGC chiral stationary phases.

So far, there are many reports about the alkyl or acyl substituted CDs, however, the allyl substituted CDs used as stationary phase is less studied. In our study, we synthesized three new β-CDs with allyl substitutes in 2, 6 positions and three acyl groups (valeryl, heptanonyl, octanoyl) were substituted the 3-OH groups CD. The product was used as gas chromatography chiral stationary phases. Eight pairs of enantiomers of cyclopropane derivatives were well resolved on capillary gas chromatography using these β-CDs as chiral stationary phases.

## Experimental

The procedures of synthesis and characterization of three new 2,6-di-*O*-allyl-3-acylated-β-cyclodextrins are as described in the reference[1, 2], and the characterization data are as follows: 2, 6-Di-*O*-allyl-3-*O*-valeryl-β-CD: $^1$H NMR ($CDCl_3$, δ ppm), 0.91(m, 3H, $CH_3$), 1.25-1.33 (m, 2H, $CH_3CH_2$), 1.60(m, 2H, $COCH_2CH_2$), 2.31(m, 2H, $COCH_2$),

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3.34-4.52 (m, 11H, CD(H)，2×$OCH_2$)，5.07-5.28 (m, 4H, 2×$CH_2$)，5.87-6.02 (m, 2H, 2×CH). IR (film, $cm^{-1}$): 3400, 3080, 2990, 2870, 2820, 2760, 1740, 1460, 1420, 1340, 1155-1045, 925.

2, 6-Di-*O*-allyl-3-*O* -heptanonyl-β-CD: $^1$H NMR ($CDCl_3$, δ ppm), 0.88(m, 3H, $CH_3$)，1.29[m, 6H, $CH_3(CH_2)_3$], 1.61(m, 2H, $COCH_2CH_2$), 2.32-2.37 (m, 2H, $COCH_2$), 3.34-4.46 (m, 11H, CD(H)，2×$OCH_2$)，5.07-5.28 (m, 4H, 2×$CH_2$)，5.90 (m, 2H, 2×CH). IR (film, $cm^{-1}$): 3400, 3080, 2990, 2900, 2820, 2760, 1740, 1455, 1420, 1350, 1160-1045, 925.

2, 6-Di-*O*- allyl -3-*O*-octanoyl-β-CD: $^1$H NMR ($CDCl_3$, δ ppm), 0.85-0.88 (m, 3H, $CH_3$)，1.28[m, 8H, $CH_3(CH_2)_4$], 1.61-1.63(m, 2H, $COCH_2CH_2$), 2.29-2.36(m, 2H, $COCH_2$), 3.33-4.30 (m, 11H, CD(H)，2×$OCH_2$)，5.07-5.29 (m, 4H, 2×$CH_2$)，5.84-5.98 (m, 2H, 2×CH). IR (film, $cm^{-1}$): 3400, 3080, 2990, 2870, 2800, 2750, 1740, 1150-1040, 925.

**Table 1** Column properties

| Col No. | Stationary phase | Col. dimension m×mm I.D. | Film thickness μm* | Retention factor *k* | Col. temp.℃ | Col. efficiency plates /m |
|---|---|---|---|---|---|---|
| 1# | 2,6-di-*O*-allyl-3-*O*-valeryl-β-CD | 20×0.25 | 0.31 | 1.37 | 120 | 2301 |
| 2# | 2,6-di-*O*-allyl-3-*O*-heptanonyl-β-CD | 20×0.25 | 0.31 | 1.25 | 120 | 3181 |
| 3# | 2,6-di-*O*-allyl-3-*O*-octanoyl-β-CD | 20×0.25 | 0.31 | 1.50 | 120 | 3440 |

*Film thickness is calculated assuming that the density of the stationary phases is equal to 1.000.
**Column efficiency is determined using *n*-dodecane as the test solute.

**Figure 1** Chromatogram of methyl *trans*-3-(2, 2-dichlorovinyl)-2,2-dimethyl-cyclopropanecarboxylate on column 2 at 100℃.

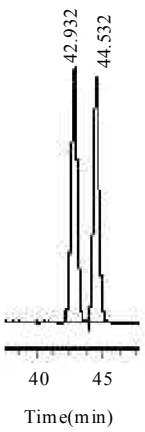
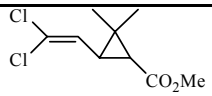
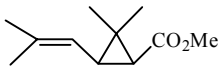
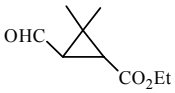
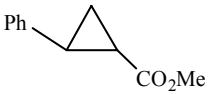
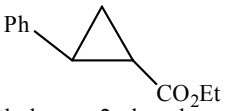
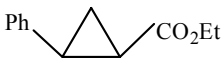



**Figure 2** Chromatogram of ethyl *trans*-3-formyl-2, 2-dimethyl cyclopropa-necarboxylate on column 1 at 100℃.

**Table 2** The retention factor (*k*) and relative retention (α) values of some racemic compounds on three columns

| Solutes | Col. No. | Temp. ℃ | Retention factor *k* | | Relative retention values α |
|---|---|---|---|---|---|
|  methyl *trans*-3-(2, 2-dichlorovinyl)-2, 2-dimethylcyclopropanecarboxylate | 1# | 100 | 27.23 | 28.37 | 1.04 |
| | 2# | 100 | 23.32 | 24.24 | 1.04 |
| | 3# | 100 | 23.88 | 24.60 | 1.03 |
|  methyl *cis*-2, 2-dimethyl-3-(2-methyl propenyl)cyclopropanecarboxylate | 1# | 100 | 19.30 | 20.06 | 1.04 |
| | 2# | 100 | 15.01 | 15.58 | 1.04 |
| | 3# | 100 | 15.83 | 16.26 | 1.03 |
|  ethyl *trans*-3-formyl-2, 2-dimethyl cyclopropanecarboxylate | 1# | 100 | 13.45 | 13.88 | 1.03 |
| | 2# | 100 | 11.01 | 11.35 | 1.03 |
| | 3# | 100 | 10.97 | 11.22 | 1.02 |
|  ethyl *cis*-3-formyl-2, 2-dimethyl cyclopropanecarboxylate | 1# | 100 | 23.24 | 23.89 | 1.03 |
| | 2# | 100 | 18.79 | 19.25 | 1.02 |
| | 3# | 100 | 18.52 | 18.95 | 1.02 |
|  methyl *trans*-2-phenyl-cyclopropanecarboxylate | 1# | 120 | 26.24 | 26.55 | 1.01 |
| | 2# | 120 | 21.84 | 22.13 | 1.01 |
| | 3# | 120 | 22.21 | 22.21 | 1.00 |
|  methyl *cis*-2-phenyl-cyclopropanecarboxylate | 1# | 120 | 18.70 | 18.97 | 1.01 |
| | 2# | 120 | 15.51 | 15.78 | 1.02 |
| | 3# | 120 | 15.76 | 15.95 | 1.01 |
|  ethyl *trans*-2-phenyl-cyclopropanecarboxylate | 1# | 120 | 24.87 | 25.11 | 1.01 |
| | 2# | 120 | 20.82 | 21.09 | 1.01 |
| | 3# | 120 | 22.35 | 22.35 | 1.00 |
|  ethyl *cis*-2-phenyl-cyclopropanecarboxylate | 1# | 120 | 17.83 | 18.08 | 1.01 |
| | 2# | 120 | 14.13 | 15.01 | 1.02 |
| | 3# | 120 | 15.85 | 16.05 | 1.01 |

*Column preparation*

Fused-silica capillary tubes were treated by depositing sodium chloride onto their inner wall. The columns were then statically coated at 35℃ with a 0.5% (*w/v*) solution of the cyclodextrin derivative in dichloromethane. Then, the columns were conditioned under a slow nitrogen flow at 40°C, 80℃, 120℃, 160℃ for 1 h, respectively, finally at 180℃ for 4 h for each.

All three columns were prepared by this method, and their properties are listed in **Table 1**.

## Results and Discussion

The chromatographic data obtained are summarized in **Table 2**. The results show that the three β-CDs can separate the racemic compounds of methyl *trans*-3- (2, 2-dichlorovinyl)-2, 2-dimethylcyclopropanecarboxylate **(Figure 1)**, methyl *cis*-2, 2- dimethyl-3-(2-methyl propenyl) cyclopropanecarboxylate, ethyl 3-formyl-2, 2-dimethylcyclopropanecarboxy late**(Figure 2)**, methyl 2-phenyl cyclopropanecarboxylate and ethyl 2-phenylcyclo propanecarboxylate with satisfactory result. It appears that the β-CDs possess enatio separation ability for some cyclopropane derivatives.

## Conclusion

Three new β-CDs have been prepared by substituting allyl groups on the 2, 6-OH groups of β-CD and acyl groups on the 3-OH groups as stationary phase. Eight pairs of enantiomers of cyclopropane derivatives were resolved by using these β-CDs. The separation results are satisfactory.

## References

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