Overcoming the Challenge of Complete Isomeric Separation of Allethrin: A Three-Column Approach

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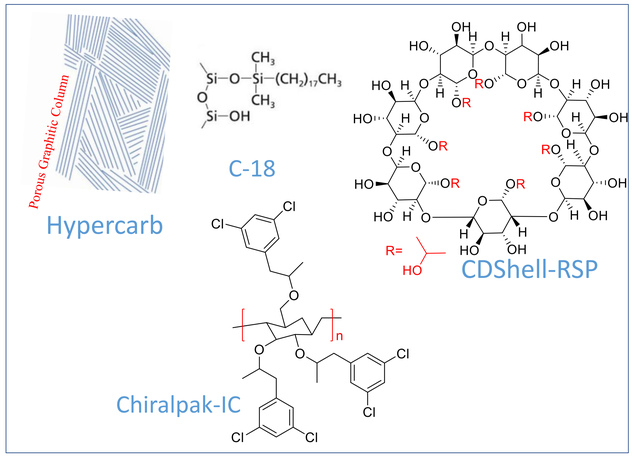
Introduction

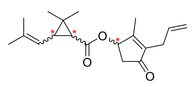
Insects are a widespread and diverse group of organisms, comprising approximately 72% of all animal species. Even though only around 1% of these species account for significant pests, the use of insecticides plays a major role in protecting crops and livestock from insect attacks. However, the pervasive use of these chemicals can leave behind residues that can be harmful to human health and the environment. Synthetic pyrethroids, a class of insecticide, are predominantly used worldwide and account for about 30% of the world's trade in insecticides. Commercially available synthetic pyrethroids, such as allethrin, contain up to eight stereoisomers. As these stereoisomers exhibit significantly different biological activity and toxicity as shown in the table below it is crucial for industries involved in their synthesis and distribution to accurately control the stereoisomeric composition of their products. In this article, we will explore the methods to separate the stereoisomeric composition of allethrin.

Allylrethronyl portion	Chrysanthemate portion	Percentage Abundace	Relative Toxicity
L-	D-trans-	12.4	0.58
D-	L-trans-	12.4	0.14
D-	D-trans-	22.8	3.37
L-	L-trans-	22.8	0.02
L-	D-cis-	8.0	0.33
D-	L-cis-	8.0	0.14
D-	D-cis-	6.8	1.77
L-	L-cis-	6.8	0.06

Structure of Stationary Phase



Structure of Allethrin



*=Chiral Center

- Three chiral centers.
- Eight enantiomers.

Experimental

All separations were done on a JASCO RHPLC equipped with a binary pump, active mixer, auto-sampler, injection port with a 5uL sample loop, temperature controller and a photodiode array detector (λ= 200-650 nm).

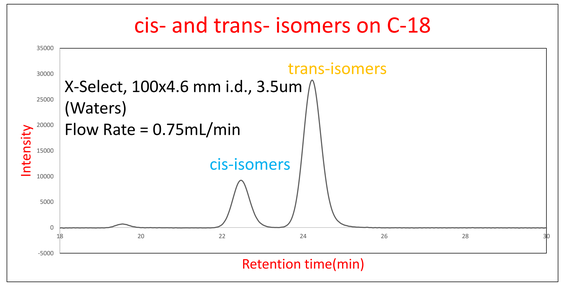
Temperature= 25°c
Wavelength= 254nm
Injection volume= 1uL

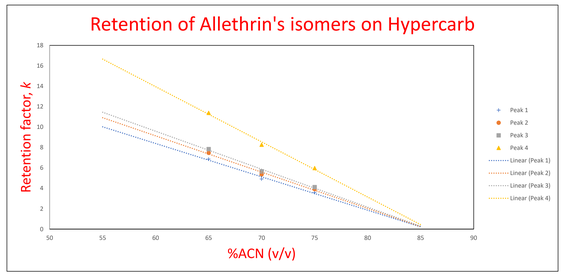
Allethrin sample was purchased from SIGMA-ALDRICH and sample concentration was 1mg/mL.

Goals

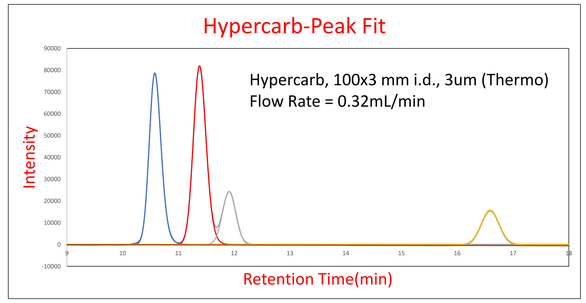
Develop an analytical separation method to separate the diastereomers and a method that can be employed in a 2-D HPLC for the separation of all 8 enantiomers.

Diastereomeric Separation

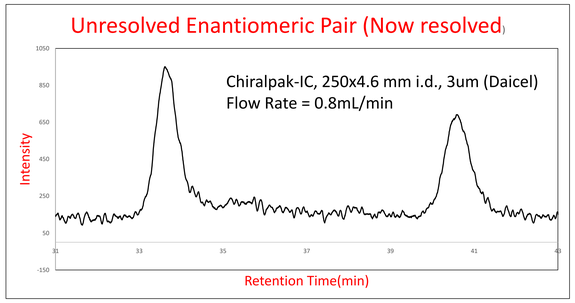




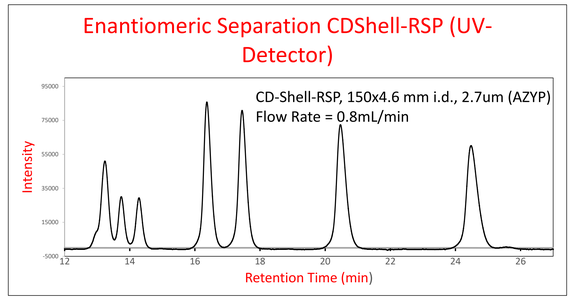
- Hypercarb column shows excellent diastereomeric selectivity.
- *k* vs %ACN graph shows baseline separation is impossible.
- Peak fit solves this issue.

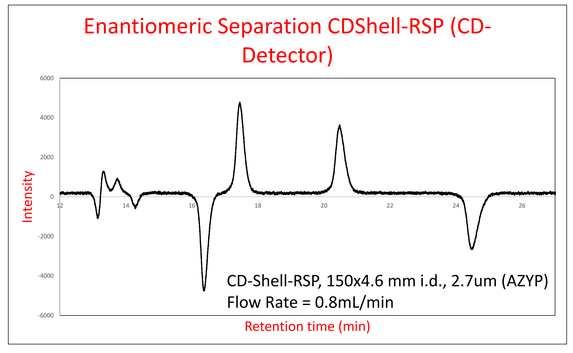


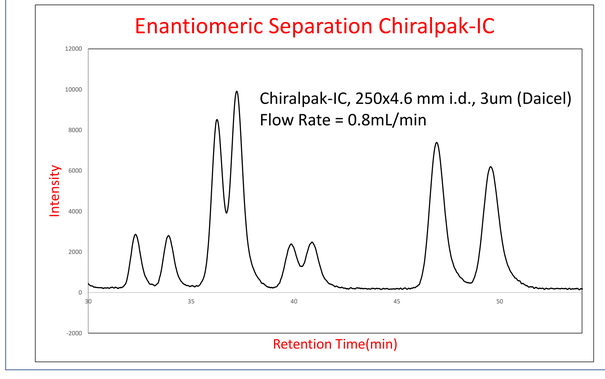
- The first unresolved peak on CDShell-RSP is collected and passed through a Chiralpak-IC column to attain complete isomeric separation.



Enantiomeric Separation







Conclusions

- ❖ Three columns were used to separate all isomers of allethrin.
- ❖ Hypercarb column achieved diastereomeric separation.
- ❖ CDShell-RSP column achieved enantiomeric separation except for the first enantiomeric pair.
- ❖ Chiralpak-IC was able to resolve the first enantiomeric pair.

Acknowledgements

- The authors would like to thank JASCO inc., USA for providing the RHPLC.
- We would like to thank AZYP, LLC for providing CDShell columns.
- I would like to thank Dr. M. Farooq Wahab and Dr. J.T. Lee for guidance and supervision.

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