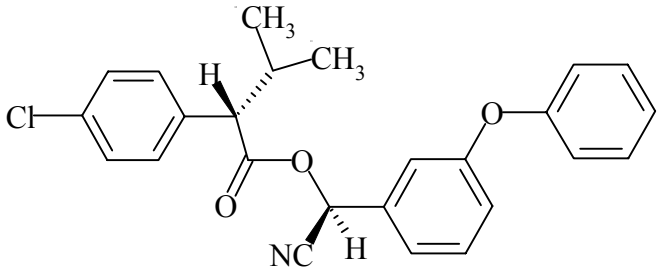
ESFENVALERATE
481



ISO common name	Esfenvalerate
Chemical name	*(S)*-*α*-Cyano-3-phenoxybenzyl *(S)*-2-(4-chlorophenyl)-3-methylbutyrate (IUPAC); [*S*-(*R**,*R**)]-cyano(3-phenoxyphenyl)methyl 4-chloro-α-(1-methylethyl)-benzeneacetate (CA; *66230-04-4*)
Empirical formula	$C_{25}H_{22}ClNO_3$
RMM	419.9
m.p.	48.9 – 55.7 °C
v.p.	$< 1 \times 10^{-5}$ Pa (25 °C)
Solubility	In water: 10 µg/l (20 °C); soluble in organic solvents
Description	Yellow viscous liquid to dull yellow solid
Stability	Hydrolysed in alkaline solution
Formulations	Ultra-low volume liquids

ESFENVALERATE TECHNICAL
*481/TC/(M)/-

1 Sampling. Take at least 100 g.

2 Identity tests

2.1 GLC. Use the GLC method below. The relative retention time of esfenvalerate with respect to the internal standard for the sample solution should not deviate by more than 1% from that for the calibration solution.

2.2 HPLC. Use the HPLC method below. The retention time of esfenvalerate for the sample solution should not deviate by more than 2% from that for the esfenvalerate working standard solution and the intensities of the esfenvalerate isomers should give the same pattern as in the working standard solution.

3 Esfenvalerate

3.1 Gas chromatographic method

SCOPE In this method the total content of esfenvalerate (*S,S* isomer) and the *R,R* isomer is obtained. The method is intended for the determination of esfenvalerate content, when the influence of *R,R* isomer is negligible.

OUTLINE OF METHOD Esfenvalerate is determined by capillary gas chromatography using flame ionisation detection and di-*n*-octyl phthalate as internal standard.

REAGENTS

Acetone

Esfenvalerate working standard technical product of certified purity. Store at room temperature.

Di-n-octyl phthalate internal standard. Must not show a peak with the same retention time as esfenvalerate.

Formic acid

Internal standard solution. Dissolve di-*n*-octyl phthalate (2 g) and formic acid (3 g) in acetone (200 ml). Ensure that a sufficient quantity of this solution is prepared for all samples and calibration standards to be analysed.

Calibration solution. When the esfenvalerate working standard is crystalline or partly crystalline homogenise it by warming it to melting and by stirring. Prepare calibration solutions in duplicate. Weigh (to the nearest 0.1 mg) 110 to 130 mg (corresponding to 90 to 100 mg of esfenvalerate) (*s* mg) of esfenvalerate working standard into a vial or stoppered flask (200 ml). Add by

* Provisional CIPAC method 2002. Prepared by the Japanese Committee (JAPAC). Chairman: N Tamori. Based on a method supplied by Sumitomo Chemical Co. Ltd, Japan.

pipette internal standard solution (10 ml). Add by measuring cylinder acetone (90 ml) and dissolve completely (Solutions C_A and C_B).

Phosphoric acid

Water purified

APPARATUS

Gas chromatograph equipped with a split/splitless injection and a flame ionisation detector. Clean the injection port before use to prevent esfenvalerate from decomposing during analysis, as follows:

- Remove the removable parts of the injection port.
- Wash the inner wall of the injection port with acetone followed by water and 1 % (v/v) aqueous phosphoric acid solution in this order.
- Rub carefully the inner wall using a cotton or soft paper wiper wet with 1 % (v/v) aqueous phosphoric acid solution.
- Rinse it with 1 % (v/v) aqueous phosphoric acid solution, water and acetone in this order.
- Clean the removed parts in the similar manner if possible.
- Assemble the parts.

Capillary column fused silica, 30 m × 0.25 mm (i.d.), film thickness: 0.25 µm, coated with crosslinked dimethyl polysiloxane (DB-1 or equivalent)

Injection liner Clean the liner before use according to the following procedures:

- Remove the glass wool.
- Wash the liner with acetone, water and 1 % (v/v) aqueous phosphoric acid solution in this order.
- Soak it in 1 % (v/v) % aqueous phosphoric acid solution for 10 minutes.
- Rinse it with water.
- Rinse and dry it with acetone and pack deactivated glass wool.

Electronic integrator or *data system*

PROCEDURE

(a) Gas chromatographic conditions (typical):

Column	fused silica, 30 m × 0.25 mm (i.d.), film thickness: 0.25 µm, coated with crosslinked dimethyl polysiloxane (DB-1 or equivalent)
Injection system	
Injector	split injection
Split flow	approximately 100 ml/min
Injection volume	1 µl
Detector	flame ionisation
Temperatures	
Column oven	265 °C
Injection port	290 °C
Detector	290 °C

Carrier gas	helium, 30 cm/s
Retention times	di-*n*-octyl phthalate: about 8.0 min esfenvalerate (*S,S* isomer + *R,R* isomer): about12.5 min

(b) System check. Prepare a sample solution. Inject a 1 µl portion of the sample solution. The peak area of a degradation product (retention time: about 9.6 min, see fig.16) should be less than 1.0 % of the peak area of esfenvalerate, otherwise clean the injection port again and/or replace the injection liner.

(c) Linearity check. Check the linearity of the detector response by injecting 1 µl of solutions with esfenvalerate concentrations 0.5, 1 and 2 times that of the calibration solution before conducting analysis.

(d) System equilibration. Prepare two calibration solutions. Inject 1 µl portions of the first one until the response factors obtained for two consecutive injections differ by less than 1.0 %. Then inject a 1 µl portion of the second solution. The response factor for this solution should not deviate by more than 1.0 % from that for the first calibration solution, otherwise prepare new calibration solutions.

(e) Preparation of sample solution. Homogenise the sample. When the sample is crystalline or partial crystalline homogenise it by warming it to melting and by stirring. Prepare sample solutions in duplicate. Weigh (to the nearest 0.1 mg) sufficient sample to contain 90 to 110 mg (*w* mg) of esfenvalerate into a vial or stoppered flask (200 ml). Add by pipette internal standard solution (10 ml). Add by measuring cylinder acetone (90 ml) and dissolve completely (Solutions S_A and S_B).

(f) Determination. Inject in duplicate 1 µl portions of each sample solution bracketing them by injections of the calibration solutions as follows; calibration solution C_A, sample solution S_A, sample solution S_A, calibration solution C_B, sample solution S_B, sample solution S_B, calibration solution C_A, and so on. Measure the relevant peak areas.

(g) Calculation. Calculate the mean value of each pair of response factors bracketing the two injections of a sample and use this value for calculating the esfenvalerate contents of the bracketed sample injections.

$$f_i = \frac{I_r \times s \times P}{H_s}$$

$$\text{Content of esfenvalerate} = \frac{f \times H_w}{I_q \times w} \quad \text{g/kg}$$

where:
f_i = individual response factor
f = mean response factor
H_s = peak area of esfenvalerate in the calibration solution
H_w = peak area of esfenvalerate in the sample solution
I_r = peak area of the internal standard in the calibration solution
I_q = peak area of the internal standard in the sample solution
s = mass of esfenvalerate working standard in the calibration solution (mg)
w = mass of sample taken (mg)
P = purity of esfenvalerate working standard (g/kg)

Repeatability r = 14 g/kg at 850 g/kg active ingredient content
= 11 g/kg at 855 g/kg active ingredient content
Reproducibility R = 16 g/kg at 850 g/kg active ingredient content
= 22 g/kg at 855 g/kg active ingredient content

3.2 Liquid chromatographic method

SCOPE The method is intended for the determination of the *R,R* isomer fraction.

OUTLINE OF METHOD The *R,R* isomer fraction is determined by normal phase high performance liquid chromatography using a chiral stationary phase and UV detection at 278 nm.

REAGENTS
Hexane HPLC grade
2-Propanol HPLC grade
Mobile phase hexane – 2-propanol, 500 + 1 (v/v); degas before use
Sample solvent hexane – 2-propanol, 39 + 1 (v/v)

APPARATUS
High performance liquid chromatograph with a detector suitable for operation at 278 nm and an injector capable of delivering 10 µl. Preferably equipped with a column oven capable of controlling at around 25 °C.
Column 250 × 4 (i.d.) mm, stainless steel, packed with Sumichiral OA-2000 (5µm) obtainable from Sumika Chemical Analysis Service.
Electric integrator or data system

PROCEDURE

(a) Liquid chromatographic conditions (typical):

Column	250 × 4 mm (i.d.), stainless steel, packed with Sumichiral OA-2000, 5µm
Mobile phase	hexane – 2-propanol, 500 + 1 (v/v)
Flow rate	1.0 ml/min
Column temperature	ambient, preferably at a constant temperature around 25 °C
Injection volume	10 µl
Detector wavelength	278 nm
Retention times	*S,S* isomer: about 27 min *R,R* isomer: about 30 min

(b) System equilibration. Inject 10 µl portions of a sample solution until the *R,R* isomer fraction obtained for two consecutive injections differ by less than 0.3% calculated by subtracting a smaller value from a larger value.

(c) Preparation of sample solution. Homogenise the sample. When the sample is crystalline or partial crystalline homogenise it by warming it to melting and by stirring. Prepare sample solutions in duplicate for each sample. Weigh (to the nearest 0.1 mg) sufficient sample to contain 8 to 12 mg of esfenvalerate into a vial or stoppered flask (50 ml). Add by measuring cylinder the sample solvent (20 ml) and dissolve completely.

(d) Determination. Inject in duplicate 10 µl portions of each sample solution. Measure the relevant peak areas.

(e) Calculation

$$R,R \text{ isomer fraction percentage} = \frac{H_{rr}}{H_{ss} + H_{rr}} \times 100\ \%$$

where:

H_{ss} = peak area of the *S,S* isomer

H_{rr} = peak area of the *R,R* isomer

Repeatability r = 0.3 % at a 1.1 % *R,R* isomer fraction and 850 g/kg active ingredient content

= 0.2 % at a 1.4 % *R,R* isomer fraction and 855 g/kg active ingredient content

Reproducibility R = 0.7 % at a 1.1 % *R,R* isomer fraction and 850 g/kg active ingredient content

= 0.4 % at a 1.4 % *R,R* isomer fraction and 855 g/kg active ingredient content

ESFENVALERATE ULTRA-LOW VOLUME LIQUID
*481/UL/(M)/-

1 Sampling. Take at least 100 g.

2 Identity tests
2.1 GLC. As for esfenvalerate technical **481/**TC/(M)/2.1**.**
2.2 HPLC. As for esfenvalerate technical **481/**TC/(M)/2.2**.**

3 Esfenvalerate
3.1 Gas chromatographic method

SCOPE The method can also be used for the determination of esfenvalerate in mixed formulations with fenitrothion.

Continue as for esfenvalerate technical **481/**TC/(M)/3.1 except add at *(a) Gas chromatographic conditions*:

Temperatures	
Column oven	265 °C (use a short temperature program to remove formulation components, if necessary)
Retention times	fenitrothion: more than 20 min

and substitute *(e) Preparation of sample solution.* for:
(e) Preparation of sample solution. Prepare sample solutions in duplicate for each sample. Weigh (to the nearest 0.1 mg) sufficient sample to contain 90 to 110 mg (*w* mg) of esfenvalerate into a vial or stoppered flask (200 ml). Add by pipette internal standard solution (10 ml). Add by measuring cylinder acetone (90 ml) and mix thoroughly.

Repeatability r	= 0.3 g/kg at 5.5 g/kg active ingredient content
	= 0.2 g/kg at 9.9 g/kg active ingredient content
	= 0.3 g/kg at 17.1 g/kg active ingredient content
Reproducibility R	= 0.6 g/kg at 5.5 g/kg active ingredient content
	= 0.4 g/kg at 9.9 g/kg active ingredient content
	= 1.0 g/kg at 17.1 g/kg active ingredient content

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3.2 Liquid chromatographic method

SCOPE The method can also be used for the determination of esfenvalerate in mixed formulations with fenitrothion.

Continue as for esfenvalerate technical **481**/TC/(M)/3.2 except add at *(a) Liquid chromatographic conditions* :

Retention times fenitrothion: about 17 min

and substitute for *(c) Preparation of sample solution*:

(c) Preparation of sample solution. Prepare sample solutions in duplicate for each sample. Weigh (to the nearest 0.1 mg) sufficient sample to contain 8 to 12 mg of esfenvalerate into a vial or stoppered flask (50 ml). Add by measuring cylinder the sample solvent (20 ml) and mix thoroughly. Filter the solution through a 0.45 µm filter.

Repeatability r = 0.2 % at a 0.9 % *R,R* isomer fraction and 5.5 g/kg active ingredient content
= 0.1 % at a 0.9 % *R,R* isomer fraction and 9.9 g/kg active ingredient content
= 0.2 % at a 0.9 % *R,R* isomer fraction and 17.1 g/kg active ingredient content

Reproducibility R = 0.3 % at a 0.9 % *R,R* isomer fraction and 5.5 g/kg active ingredient content
= 0.3 % at a 0.9 % *R,R* isomer fraction and 9.9 g/kg active ingredient content
= 0.4 % at a 0.9 % *R,R* isomer fraction and 17.1 g/kg active ingredient content

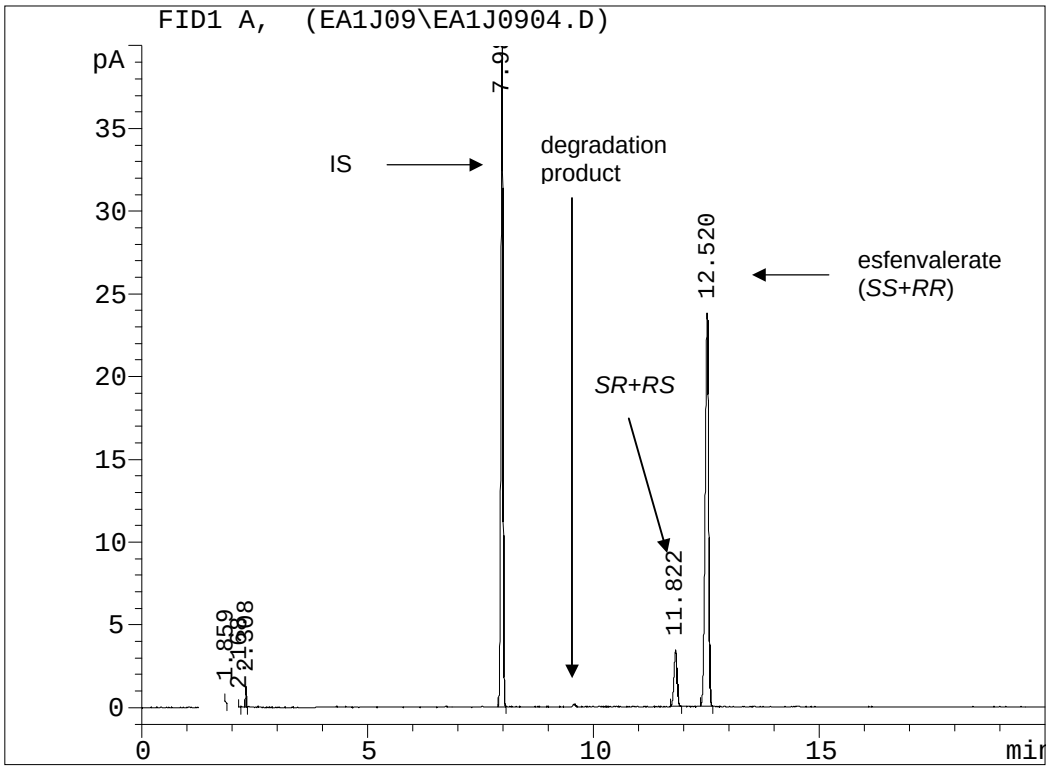

Fig. 16 Gas chromatogram of esfenvalerate technical

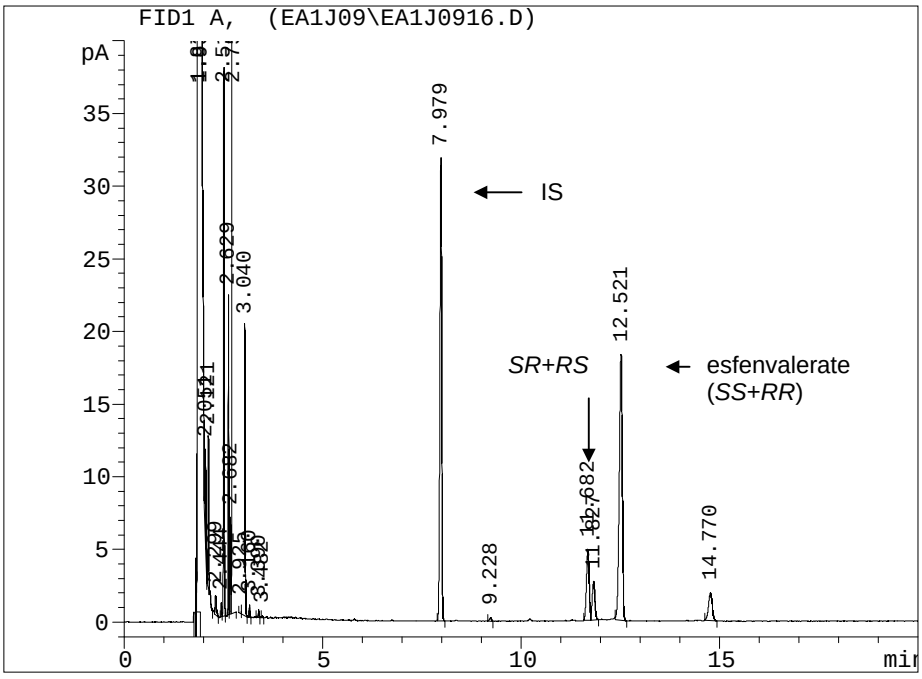

Fig. 17 Gaschromatogram of esfenvalerate + fenotrothion UL formulation
Peaks other than IS, *SR*+*RS* and *SS*+*RR* are formulants or impurities of fenitrothion

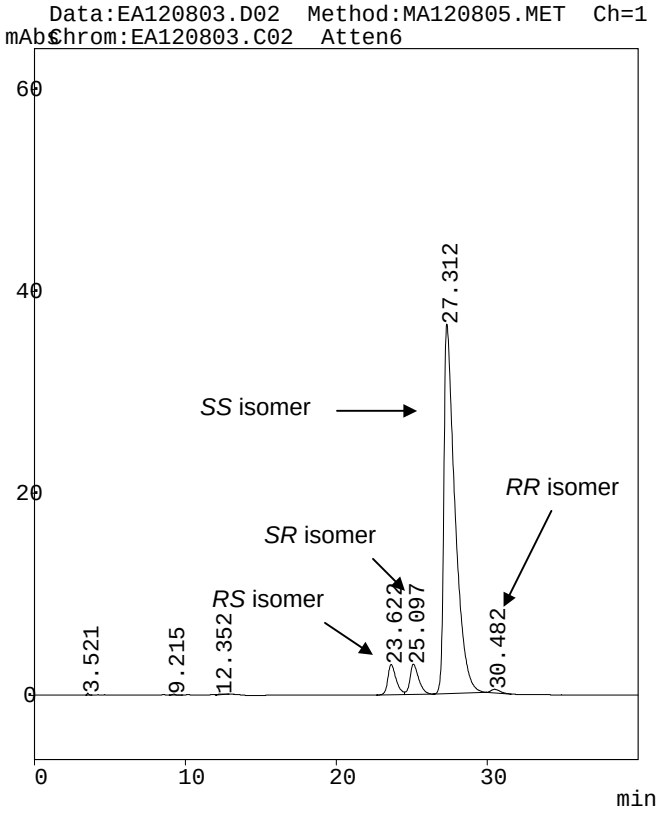

Fig. 18 HPLC chromatogram of esfenvalerate technical

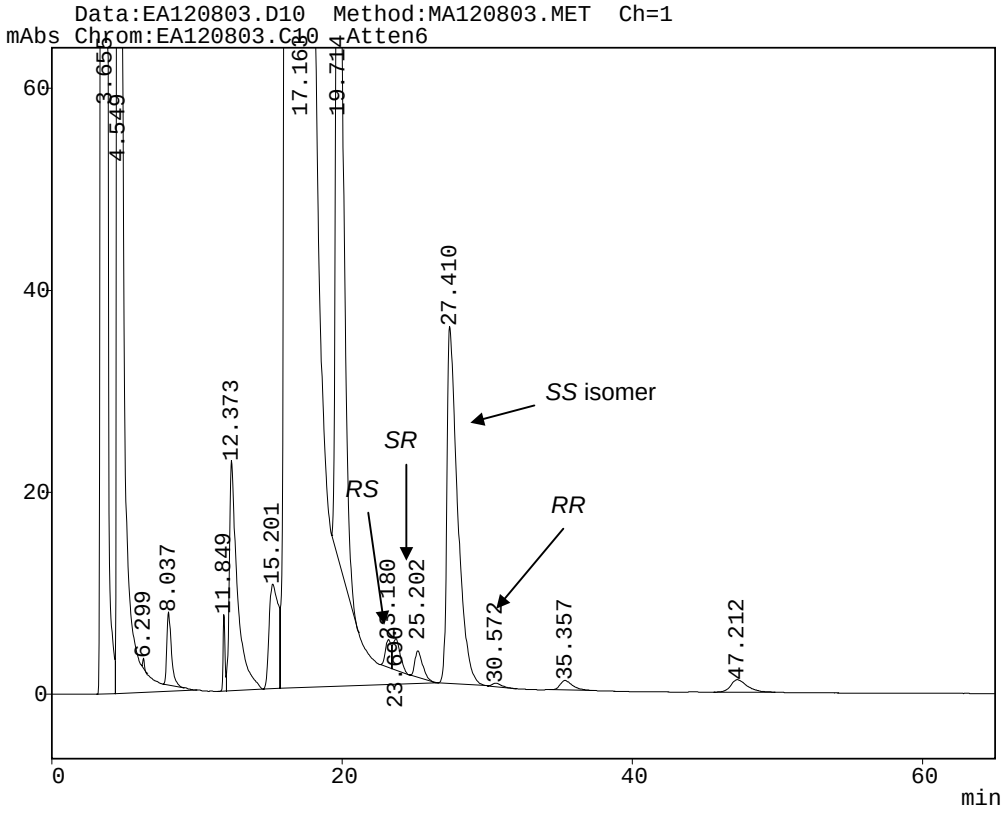

Fig. 19 HPLC chromatogram of esfenvalerate + fenotrothion UL formulation
Peaks other than IS, *SR*+*RS* and *SS*+*RR* are formulants or impurities of fenitrothion. A peak of a fenitrothion impurity elutes at about 70-80 min.