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2,3,5-TRITHIAHEXANE IN THE ESSENTIAL OIL OF *HUMULUS LUPULUS*

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In the course of our work [1] on the identification of sulphur compounds in hop oil and the investigation of their effect upon hop flavour in beer, we isolated a fraction from the oil of a growth of the Wye Northdown variety which contained an unusually high level of an unknown sulphur compound. The compound had the properties of a sulphide or polysulphide; thus it could be quantitatively removed from the oil by shaking with aqueous mercuric chloride or hydrogen peroxide, but not with sodium hydroxide (which removes thiols) or hydroxylamine (which removes thioesters) [2]. A GC–MS study of the fraction revealed significant ions at *m/e* (rel. int.) 140 (M^+, 33), 61 (100), and 45 (20), a pattern which closely resembles the published data [3, 4] for 2,3,5-trithiahexane (**1**).

We synthesized 2,3,5-trithiahexane by iodine oxidation of a mixture of methanethiol and methylthiomethanethiol [5] in 5 N NaOH. Compound **1** was separated from the by-products of the reaction (dimethyl disulphide and 2,4,5,7-tetrathiaoctane) by preparative GC and shown to be identical (GLC on polar and non-polar phases and GC–MS) to the unknown hop oil component.

2,3,5-Trithiahexane has recently been identified in *Lentinus edodes* Sing [6], Beaufort [7] and Camembert [8] cheeses, and in cooked cabbage, broccoli and cauliflower [9]. However, this is the first report of its occurrence in hop oil. In this particular batch of Northdown hops, the level in the oil was 240 ppm, but 2,3,5-trithiahexane was found (GLC) in most other hop oils, typically in the range 40–120 ppm. The mode of formation of this unusual sulphide in hop oil is unknown, but it may be produced by oxidation of methylthiomethanethiol in the presence of methanethiol which occurs widely in hops; it is relevant to note that we have recently identified [10] methylthiomethyl 2-methylbutanethiolate (**2**) in the same hop oil, and this thioester can be formally derived from methylthiomethanethiol and 2-methylbutanoic acid.

EXPERIMENTAL

Hop oils were obtained by steam distillation according to the procedure recommended by the Institute of Brewing [11] and stored in glass vials at 0°. Analytical GLC employed synchronous flame ionization and flame photometric detection. In micro-preparative GLC work, fractions of interest were collected at −77° in glass U-tubes. Stationary phases used were 10% Carbowax 20M and 10% SE 30 on Chromosorb A AW. GC–MS was performed on a mass spectrometer which was coupled to a data system. MS were scanned at 75 eV ionization voltage, and data were collected at 2 sec intervals from *m/e* 33 to 600.

$$MeSSCH_2SMe$$

1

$$MeCH_2\underset{\displaystyle Me}{\underset{|}{C}}H \cdot CO \cdot SCH_2SMe$$

2

Synthesis of 2,3,5-*trithiahexane*. Methylthiomethanethiol (4 mmol), prepared from *S*-methylthiomethylisothiuronium chloride as described in ref. [5], was treated at 0° with a soln of methanethiol (4 mmol) in 5 N NaOH (2.7 ml). I_2 (4 mmol) was added in portions with shaking, and the mixture was kept at room temp. for 2 hr. Et_2O extracts (2 × 5 ml) were washed with H_2O, dried ($MgSO_4$), and evapd to give a yellow oil (770 mg). Pure 2,3,5-trithiahexane was obtained by preparative GLC as a pale yellow oil (Found: C, 25.90; H, 5.80; Calc. for $C_3H_8S_3$: C, 25.69; H, 5.75%) which exhibited the following physical properties. GC–MS *m/e* (rel. int.): 142 ($M^+ + 2$, 4), 141 ($M^+ + 1$, 2), 140 (M^+, 31), 61 ($MeS^+ = CH_2$, 100), 45 (CHS^+, 18). ^1H NMR (60 MHz, CCl_4): δ 2.20 (3 H, *s*, CH_3SCH_2), 2.46 (3 H, *s*, MeS_2), 3.75 (2 H, *s*, SCH_2S).

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