

COMMUNICATION

Rapid Methylation of Chlorophenoxyacetic Acid Herbicides with Dimethyl Sulfate for Gas Chromatographic Analyses

A mixture of dimethyl sulfate in methanol is an efficient methylating reagent for the chlorophenoxyacetic acid herbicides. Its efficiency is compared

with methylation by diazomethane and acid-catalyzed reactions.

The use of 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) as herbicides in agriculture and forestry is firmly established. Residue analyses for these compounds are common. Gas-liquid chromatography provides accurate qualitative and quantitative analyses. Esterification is necessary to reduce the polarity of the carboxylic acid group to separate compounds on many columns. The methyl esters are preferred because of ease of preparation, short retention times, and sharp symmetrical peaks that may be quantitated by peak height. Rapid methylation is desirable for processing a large number of samples.

Diazomethane has been recognized by Kirkland (1961) and Schlenk and Gellerman (1960) as an efficient methylating reagent for the carboxylic acids. Erickson and Hield (1962) and Yip (1962) have used it for the methylation of 2,4-D. Apparently no side reactions as reported by Chanin *et al.* (1958) or Muller (1957) occur with the chlorophenoxyacetic acids. However, diazomethane requires long preparation time, has a short shelf life, is toxic, and is explosive. It is undesirable for occasional analyses and teaching laboratories. To avoid these difficulties, other workers (McGinnis and Dougan, 1965; Radin *et al.*, 1959; Stoffel *et al.*, 1959; Wynne *et al.*, 1965) have used acid-catalyzed reactions. Woolson and Harris (1967) have compared the efficiency of several methylating reagents on a number of herbicides. They did not include dimethyl sulfate, which has been adapted for gas chromatographic analysis in this laboratory. Methylation with dimethyl sulfate yields excellent qualitative and more quantitative results than the acid-catalyzed reactions. Although highly toxic, it is inexpensive, available in stock containers, has a long shelf life, and is not explosive.

MATERIALS AND METHODS

Reagents. Ethereal solution of diazomethane (Kirkland, 1961), 90%; methanol, 10% (v./v.).

Dimethyl sulfate, Eastman Organic, practical, 5%; methanol, 95% (v./v.) stored over anhydrous sodium sulfate.

Perchloric acid (62 to 72%), analytical reagent grade, 5%; methanol, 95% (v./v.).

Saturated solution of sodium chloride in distilled water.

Hexane, redistilled over metallic sodium.

Standard Solution. γ -Hexachlorocyclohexane, internal standard, $4.1 \times 10^{-5} M$; 2,4-D, $5.0 \times 10^{-4} M$; 2,4,5-T, $9.0 \times 10^{-5} M$ in methanol.

Instrument. F&M 810 gas chromatograph equipped with an electron-capture detector. Chromatographic column: 6-foot stainless steel, $\frac{1}{8}$ -inch O.D., packed with 10% SE 30 on 80-to-100-mesh Diatoport S. Parameters: injection port temperature, 230° C.; oven, 170° C.; detector, 212° C.; attenuation, 4; range, 10. Carrier gas, helium; purge gas, argon 5% in methane 95%; flow rates of 50 ml. per minute for both gases.

PROCEDURE

Diazomethane. Pipet a series of 1-ml. aliquots of standard solution into 16 \times 150 mm. test tubes. Evaporate under a vacuum of 25 mm. of mercury at room temperature to near dryness. Add 3 ml. of diazomethane reagent and shake thoroughly on a vortex stirrer. Let the series of standards react at room temperature for intervals of 1 to 10 minutes. Evaporate the diethyl ether under vacuum to near dryness. Add 3 ml. of saturated sodium chloride solution and 1 ml. of hexane, and mix thoroughly. Allow the mixture to partition and chromatograph 1 μ l. of the hexane layer.

Acid-Catalyzed Methylation. Pipet a series of 1-ml. aliquots of the standard solution into 16 \times 150 mm. test tubes. Add 3 ml. of the perchloric-methanol reagent and shake thoroughly on a vortex stirrer. Place the test tubes in a 55° C. water bath for 1 to 10 minutes. Remove, cool under a water stream, and add 3 ml. of saturated sodium chloride solution and 1 ml. of hexane. Shake thoroughly, allow to partition, and chromatograph 1 μ l. of the hexane fraction.

Dimethyl Sulfate. Add 1 ml. of standard solution and 1 gram of anhydrous sodium sulfate to a series of 16 \times 150 mm. test tubes. Shake thoroughly on a vortex stirrer. Add 3 ml. of the dimethyl sulfate reagent and shake thoroughly. Place test tubes in a 55° C. water bath for intervals of 1 to 10 minutes. Remove, cool in a water stream, add 3 ml. of saturated sodium chloride solution and 1 ml. of hexane, allow to partition, and chromatograph 1 μ l. of the hexane layer.

RESULTS AND DISCUSSION

Figure 1 shows the results of a typical methylation by the three methods for 2,4-D and 2,4,5-T. The dimethyl sulfate reagent approaches the quantitative methylation of diazomethane and has the advantages listed above. Diazomethane and dimethyl sulfate react rapidly with a linear

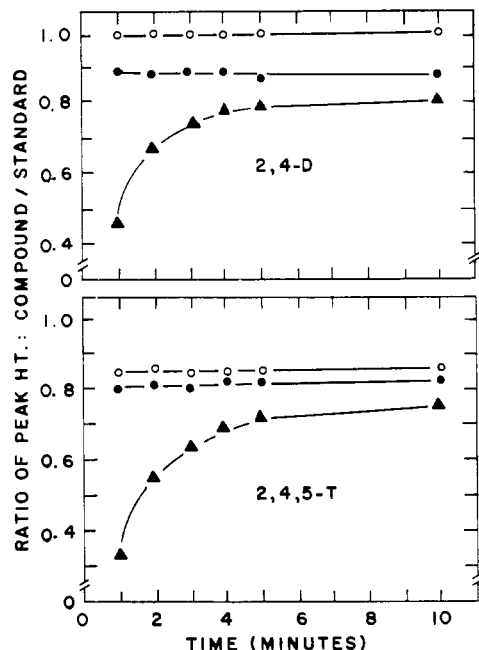


Figure 1. Methylation of 2,4-D and 2,4,5-T

- By diazomethane
- By dimethyl sulfate in methanol
- ▲ By 5% perchloric acid in methanol

response from 1 to 10 minutes. Acid-catalyzed reactions are slower and less quantitative.

Thermodynamic and kinetic curves for the dimethyl sulfate reagent indicate that the maximum reaction occurs between 55° and 60° C. and at a concentration of 5%.

Similar results are obtained from the methylation of *p*-chlorophenoxyacetic, *o*-chlorophenoxyacetic, and *m*-chlorophenoxyacetic acids. The method using dimethyl sulfate is adaptable to herbicide residue analyses.

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