

probably not due to the different type of surface balance used (for comparative data obtained with the Wilhelmy-Dervichian and the Mikrokator surface-balances, see Ref.¹⁵), but due to the fact that the samples of rosin acids used in the present study had been purified by chromatography and were exceptionally pure.

In contrast to the pressure-area curves for the other pimaric acids, the curve for isodextropimaric acid exhibits an ascending part due to a relatively rapid solidification of the film under further compression after the collapse of the monolayer (Fig. 3). For further details relating to this interesting phenomenon, which is obviously related to some peculiarity in the structure of the isodextropimaric acid molecule, see Ref.¹⁶

Experimental part. The pressure-area curves were obtained with the recording Mikrokator Balance¹⁴. The rate of compression was approximately 2 cm/min. The substrate was a solution of 3 M sodium chloride (Merek, pro analysi, ignited) brought to pH 2 by addition of hydrochloric acid. The importance of these conditions, which reduce the solubilities of the acid monolayers and the tendency of the monolayers to undergo collapse, has been demonstrated earlier¹. The area values were reproducible within $\pm 0.2 \text{ \AA}^2$. Spreading from benzene and from light petroleum (b.p. 60–80°) gave identical results.

For the physical properties of the rosin acids studied, the reader is referred to Ref.¹¹

Acknowledgements. The authors are indebted to Mrs. Karin Nilsson for skilled assistance in the monolayer work.

1. Bruun, H. H. *Acta Acad. Aboensis, Math. & Phys.* **19** (1954).
2. Harris, G. G. and Sanderson, T. F. J. *Am. Chem. Soc.* **70** (1948) 2081.
3. Brossi, A. and Jeger, O. *Helv. Chim. Acta* **33** (1950) 722.
4. Harris, G. C. in Wiese, L. E. and Jahn, E. C. *Wood Chemistry*, New York 1952, p. 590.
5. Harper, S. H. *Annual Rep. Chem. Soc. London* **45** (1948) 174.
6. Barton, D. H. R. *Quart. Revs. London* **3** (1949) 46.
7. Simonsen, J. and Barton, D. H. R. *The Terpenes III*, Cambridge 1952, p. 374.
8. Wenkert, E. *Chem. & Ind. London* **1955** 282.
9. Green, B., Harris, A. and Whalley, W. B. *Chem. & Ind. London* **1958** 1084.

10. Green, B., Harris, A. and Whalley, W. B. *J. Chem. Soc.* **1958** 4715.
11. Bruun, H. H., Ryhage, R. and Stenhagen, E. *Acta Chem. Scand.* **12** (1958) 789.
12. Bruun, H. H., Fischmeister, I. and Stenhagen, E. *Acta Chem. Scand.* **13** (1959) 379.
13. Keimatsu, S., Ishiguro, T. and Fukui, G. *J. Pharm. Soc. Japan* **57** (1957) 92.
14. Stållberg-Stenhagen, S. and Stenhagen, E. *Nature* **159** (1947) 814.
15. Stållberg-Stenhagen, S. and Stenhagen, E. *Acta Chem. Scand.* **3** (1949) 1035.
16. Bruun, H. H. *Arkiv Kemi* **8** (1955) 412.

Received March 20, 1959.

Isolation of Polynuclear Aromatic Hydrocarbons from the Roots of *Chrysanthemum vulgare* Bernh.

ERLING GUDDAL*

Institutt for organisk kjemi, Norges tekniske høgskole, Trondheim, Norway

During the investigation of the roots of tansy (*Chrysanthemum vulgare* Bernh.) for the presence of acetylenic compounds¹, one sample collected in the vicinity of the local Gas Works gave a small hydrocarbon fraction with a characteristic ultraviolet spectrum and strong fluorescence, which turned out to be a complex mixture of polynuclear aromatic hydrocarbons.

15 kg of fresh roots were extracted with acetone, and the extracted lipids transferred to light petroleum. From the petroleum soluble material a mixture of sparingly soluble compounds were removed by crystallisation from ether at -10°C . The mother liquor was evaporated to dryness and the residue dissolved in a minimum of hot methanol. This was added to a hot saturated solution of trinitrotoluene in methanol. A yellow crystalline precipitate was formed immediately, and the crystallisation was completed by cooling to -10°C . The mixture of addition compounds was dissolved in benzene and filtered through a

* Present address: Research Dept., Leo Pharmaceutical Products, Copenhagen, Denmark.

column of highly activated alumina. Evaporation of the benzene left 185 mg of a slightly yellow crystalline mixture of aromatic hydrocarbons. This mixture was dissolved in light petroleum and chromatographed on deactivated alumina.

The mixture showed strong fluorescence even when adsorbed, and the zones could readily be made visible by irradiating the column with an ultraviolet lamp. The fractions obtained were rechromatographed several times, and by this procedure it was possible to obtain spectroscopically pure fractions of anthracene, pyrene, and fluoranthene, the ultraviolet spectra of which were identical with those given in the literature³. 2.5 mg of anthracene was obtained as colourless plates with a strong violet fluorescence. It melted at 212–213°C in a sealed tube, not depressed on admixture with authentic anthracene. Further evidence of their identity was furnished by their infrared spectra.

To ensure that these compounds did not originate from adhering soil, a sample of 10 kg of the soil of the same location was extracted with acetone and treated as above. In this case, the splitting of the trinitrotoluene-complexes left 200 mg of a yellow oil, showing no tendency of crystallisation even after prolonged cooling to –10°C. Its ultraviolet spectrum, however, was very similar to that of the crude mixture of aromatic hydrocarbons isolated from the plant material. Since the contamination of the plant material with soil hardly exceeds a few per cent by weight, these findings indicate that some polynuclear aromatic hydrocarbons, although highly toxic to most higher organisms, are actually resorbed by the plant. By extraction of material from areas which are not polluted by the smoke from the Gas Works, it has been shown that these compounds are not normal metabolites of the plant.

Polynuclear aromatic hydrocarbons have previously been isolated from animal tissues in a few cases. Zechmeister and Koe³ isolated a great number of these compounds from the barnacle *Tetraclita squarosa rubescens*, and Cahnmann and Kuratsune⁴ reported similar results from oysters growing in polluted waters. Sula⁵ isolated anthracene and benzo[a]pyrene from human lung tissue.

The occurrence of naphthalene in plant material has been reported in several cases. Soden and Rojahn⁶ found "appreciable amounts" of naphthalene in oil of cloves and storax oil, and Schimmel & Co. isolated the same compound from iris oil⁷, and from two samples of Indian costus root oil⁸. These findings have not been confirmed, and may have arisen as a result of a roasting of the roots before distillation⁹. Stoll and Scherrer isolated naphthalene from oakmoss from several localities, and noticed accompanying changes in the amount and composition of terpenes in the lichens¹⁰. Treibs¹¹ found naphthalene as a normal constituent of oil of leaf buds of *Betula lenta*, and Sebe¹² found it in rice embryo together with methyl substituted homologues. Regarding the two last findings, nothing can be said concerning the possibilities of smoke contamination, as nothing is said of the origin of the material. It appears that the isolation of higher aromatic hydrocarbons from plant material has not been reported previously.

The author is glad to thank Professor N. A. Sørensen for his interest in this work and for his constant encouragement. This work was carried out under the tenure of a Research Fellowship from *Norges tekniske høyskole*.

1. Guddal, E. and Sørensen, N. A. *Acta Chem. Scand.* **13** (1959). *In press*.
2. Friedel, R. H. and Orchin, M. *Ultraviolet Spectra of Aromatic Compounds*. New York 1951.
3. Zechmeister, L. and Koe, B. K. *Arch. Biochem. Biophys.* **69** (1952) 1.
4. Cahnmann, H. J. and Kuratsune, M. *Anal. Chem.* **29** (1957) 1312.
5. Sula, J. *Chem. Abstr.* **49** (1955) 486.
6. Soden, H. v. and Rojahn, W. *Chem. Zentr.* **1907 I** 1117.
7. Schimmel & Co., *Berichte* **1907** 55.
8. Gildemeister, E. and Hoffmann, F. *Die Ätherischen Öle*. Dritte Aufl. Schimmel & Co. Leipzig 1931, **III** 1047.
9. Guenther, E. *The Essential Oils*, D. Van Nostrand, New York 1952, **Vol. 5** 446.
10. Stoll, M. and Scherrer, W. *Chem. Zentr.* **1958 II** 2512.
11. Treibs, W. *Ber.* **71** (1938) 612, p. 616.
12. Sebe, Y. *Chem. Abstr.* **41** (1947) 3510.

Received March 11, 1959.