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Identification of Normal Higher Aliphatic Aldehydes by Means of the Melting Point Data of Their Thiosemicarbazones

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The step-like alternations in melting points of both series of the aldehyde thiosemicarbazones, containing an even and an odd number of carbon atoms, are on average 10° for higher members of the homologous series. This lends itself well to an easy identification of higher aliphatic aldehydes.

The aldehydes are usually identified by conversion into crystalline derivatives and determination of the physical constants. The derivatives commonly used for this purpose are 2,4-dinitrophenylhydrazones, oximes and semicarbazones. However, care is required in their use since this way of identification when extended to higher aliphatic aldehydes can lead to erroneous conclusions. Malkin and Tranter[1] revised the melting points of 2,4-dinitrophenylhydrazones of *n*-pentanal up to *n*-tridecanal and found that they lie within too narrow a range of only 1.5° to be readily distinguished. However, long X-ray spacings — which are dependent on the number of carbon atoms — are found to be suitable for this purpose. No X-ray data are recorded for the members from tridecanal upwards. There also exist chromatographic methods for the separation and identification of 2,4-dinitrophenylhydrazones.[2-7]

In the course of our investigation of the aldehydes formed by the periodate oxidations of yeast cerebrin bases, sphingolipide bases and similar compounds we were unable to identify them by virtue of the melting point data of the above mentioned derivatives.

We have found that step-like alternations in melting points are shown by the thiosemicarbazones of the higher lipide aldehydes of both series, containing an even and an odd number of carbon atoms. It has been found that these alternations in melting points — the fact being attributed to the difference in crystal structure[8] — are on average 10° for higher members of the homologous series. Therefore, we consider the thiosemicarbazones as particularly suitable for the identification of the fatty aldehydes. On basis of the melting point determination it can be established without difficulty whether an aldehyde belongs to the even or odd series.

To our experience, the identification by means of oximes, semicarbazones and 2,4-dinitrophenylhydrazones is entirely unsuitable for following reasons: 1. The melting points of the neighbouring derivatives are too close to each other. For example, the semicarbazones C_{13} to C_{18} melt over a range of only 3° (106—109°), the six oximes melt over a range of 8° (81—89°) and the corresponding 2,4-dinitrophenylhydrazones melt over a range of only 2° (105—107°).

2. There is no alternation in melting points of both even and odd series. 3. The melting point depression of the mixed neighbouring derivatives is either minute (2,4-dinitrophenylhydrazones) or does not occur at all (semicarbazones).

Since the majority of the homologous thiosemicarbazones up to C_{18} were unknown, we prepared them from the corresponding aldehydes in the usual manner. The aldehydes have been obtained either by heating 2-methoxy fatty acids to the boiling point according to Darzens and Levy[9] — for odd members — or by the Rosenmund reduction of the acid chlorides[10] — for even members. The melting points and nitrogen analyses of normal fatty aldehyde thiosemicarbazones are listed in Table I. Fig. 1. represents the

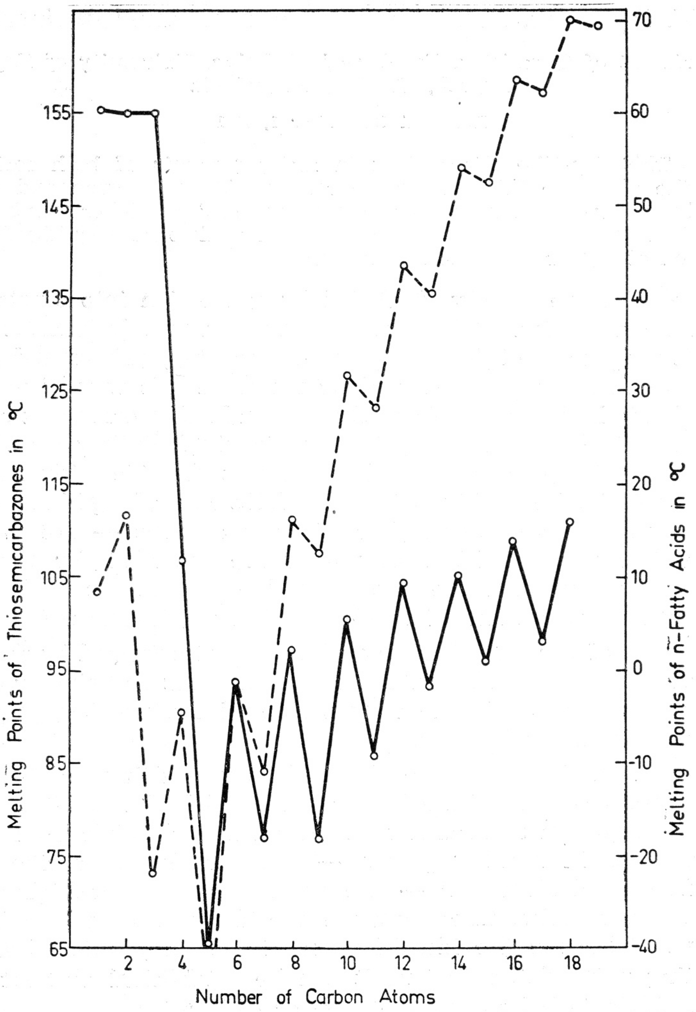

Fig. 1. Melting Points of Aldehyde Thiosemicarbazones and Fatty Acids

melting point alternations of the thiosemicarbazones. For comparison, the melting points of normal fatty acids are also given and are represented by the discontinuous curve. The curves in Fig. 2. represent the melting points of the binary mixtures of some higher aldehyde thiosemicarbazones.

From these data it becomes evident, that the melting point and the mixed melting point determination of a thiosemicarbazone with an authentic sample, combined occassionally with the carbon — hydrogen elemental analysis, offers a ready means of identification of higher aliphatic aldehydes.[11,12] Other reported derivatives are of little value for identification purposes.

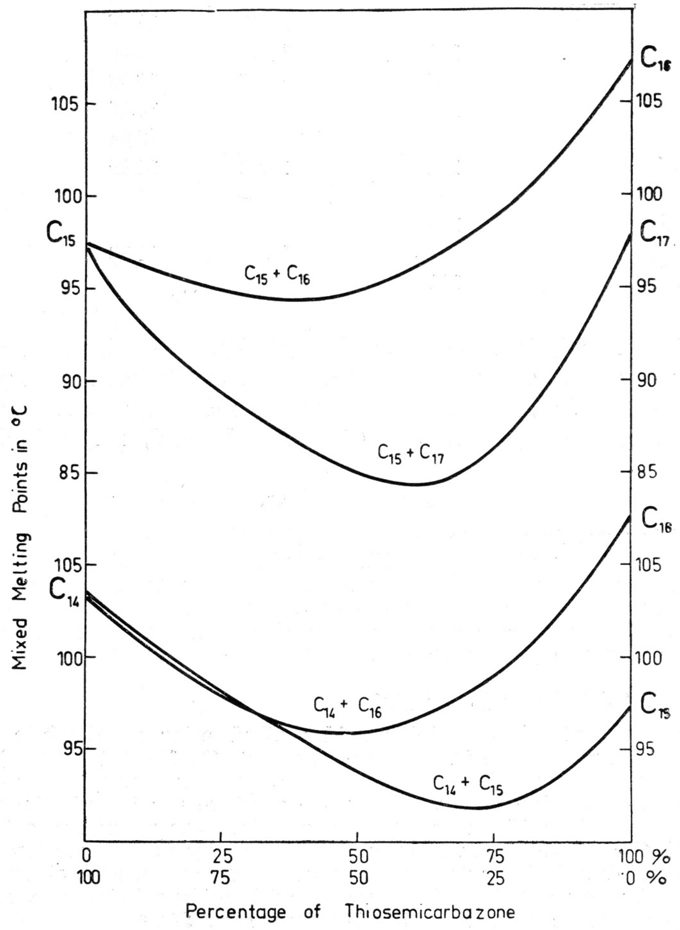

Fig. 2. Melting Points of Binary Mixtures of Aldehyde Thiosemicarbazones

TABLE I

Melting Points and Analyses of the Normal Fatty Aldehyde Thiosemicarbazones

Aldehyde	M. p. in °C	Analysis		Reference
		Calc'd. N	Found N	
Methanal	155—156			14
Ethanal	154—156			15
Propanal	155			16
Butanal	108—109			15
Pentanal	65			17
Hexanal	92—93	24,25	24.02	
Heptanal	78—79			14
Octanal	97	20.87	20.78	
Nonanal	79	19.52	19.86	
Decanal	101	18.32	18.60	
Undecanal	87	17.27	16.98	
Dodecanal	105	16.32	16.15	
Tridecanal	94	15.48	15.84	
Tetradecanal	104	14.72	14.89	
Pentadecanal	98			18
Hexadecanal	109			19
Heptadecanal	99	12.37	12.58	
Octadecanal	111			19

The nitrogen analyses are given preferentially for the hitherto undescribed substances. Exceptions are octanal and decanal, which have been prepared by Bénezet, Favro, Igolen, and Pallaud.[13] Their melting points are somewhat lower: 94—95° for octanal and 99—99.5° for decanal, respectively.

EXPERIMENTAL

The melting points reported are uncorrected values.

The normal fatty aldehydes with an odd number of carbon atoms were prepared — with the exception of *n*-nonanal — by thermal decomposition of 2-methoxy fatty acids according to the method of Darzens and Levy.[9] The aldehydes with an even number of carbon atoms were obtained starting with the fatty acid chlorides following the procedure of Rosenmund.[10]

Preparation of 2-Methoxy Fatty Acids

To a mixture of 2-bromo fatty acid methyl ester in absolute methanol a solution of sodium methoxide in absolute methanol (in 10—15% excess) was added dropwise. The reaction mixture was then refluxed for 3 hrs. After addition of aqueous sodium hydroxide and refluxing the mixture for an additional 1 hr., the hydrolysis was complete. Upon cooling, the solution was poured into 10% aqueous sulphuric acid, the precipitated methoxy acid filtered by suction, washed with water, dried and recrystallized either from petroleum ether or from 95% ethanol. The yield of the pure acid was 75—80%. In this manner following substances were prepared:

a) 2-Methoxydodecanoic acid, m.p. 55—56° (ref. m.p. 52°).[9]

b) 2-Methoxytetradecanoic acid, m.p. 63—64°.

Anal. $C_{15}H_{30}O_3$ (258.39) calc'd.: C 69.72; H 11.70%
found : C 69.79; H 11.86%

c) 2-Methoxyhexadecanoic acid, m.p. 73—74^0 (ref. m.p. 73—74^0).[9]
d) 2-Methoxyoctadecanoic acid, m.p. 77—78^0 (ref. m.p. 75—76^0).[9]

Preparation of Aldehydes by Thermal Decomposition of 2-Methoxy Fatty Acids

A sample of 2-methoxy fatty acid was heated in a modified Hickmann flask to the boiling point for 30 min., using a free flame. The content of the flask was then distilled slowly at atmospheric pressure. The aldehyde which contained one carbon atom less than the starting methoxy acid was redistilled to give a colourless, viscous oil which crystallized soon. Thus, the following normal aldehydes were prepared: undecanal, b.p. 272^0, tridecanal, b.p. 280^0, pentadecanal, b.p. 286^0, and heptadecanal, b.p. 318^0.

Preparation of Aldehydes by the Rosenmund Reduction of Fatty Acid Chlorides

The acid chlorides were prepared in the usual manner by heating the acids with thionyl chloride at 70^0 for 1 hr. and distillation of the crude product *in vacuo.* The reduction of the latter with hydrogen at 150^0 and in the presence of palladium on barium sulphate catalyst gave the following normal aldehydes: hexanal, octanal, decanal, dodecanal, tetradecanal, and hexadecanal. The crude products were converted into thiosemicarbazones without further purification.

Other Methods of Preparation

Nonanal has been prepared by the oxidation of 9,10-dihydroxyoctadecanoic acid with periodic acid.[20]

Preparation of Thiosemicarbazones

A solution of aldehyde and thiosemicarbazide (in 20% excess) in a mixture ethanol: water (1:1) was refluxed for 1 hr. After cooling the separated crystals were filtered off and recrystallized from methanol with addition of some water. The thiosemicarbazones crystallized in colourless platelets.

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IZVOD

Identifikacija normalnih viših alifatskih aldehida s pomoću određivanja tališta tiosemikarbazona

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Viši masni aldehidi mogu se lagano identificirati na temelju alternacija tališta, koje pokazuju tiosemikarbazoni s parnim i neparnim brojem C-atoma. Te su alternacije relativno visoke — u prosjeku oko 10⁰ kod viših članova homolognog niza. Tališta tiosemikarbazona aldehida C_1—C_{18}, od kojih je veći broj sada prvi put opisan, prikazana su u tablici I i slici 1. Grafički su prikazana i tališta binarnih smjesa, koje tvore tiosemikarbazoni aldehida C_{14}—C_{17} (sl. 2.). Identifikacija viših masnih aldehida s pomoću općenito upotrebljavanih derivata oksima i 2,4-dinitro-fenilhidrazona, sasvim je nepouzdana.

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