

357. *Studies in Qualitative Organic Analysis. Identification of Alkyl Halides, Amines, and Acids.*

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Methods for the identification and detection of certain classes of compounds are given. Alkyl bromides and iodides are identified as *S*-alkylisothioureas; aliphatic amines by means of 4-diphenyl isothiocyanate,  $\beta$ -naphthyl isothiocyanate, and 2 : 4 : 5-trinitrotoluene; monobasic aliphatic acids as 2-alkylbenzimidazole picrates. Alkyl nitrites are detected by means of 2-phenylindole.

An improved method for the preparation of 2 : 4-dinitrobenzoic acid is given.

IN this work the reagents yielding derivatives suitable for the identification of certain classes of organic compounds can be readily prepared in the laboratory or purchased at small cost, and the derivatives are easily obtained and purified.

The methods used for the identification of the alkyl halides are often tedious. For example, their identification by means of potassium 3-nitrophthalimide (Sah and Ma, *Ber.*, 1932, 65, 1630) requires ten hours' heating. The conversion of alkyl halides into alkyl mercuric halides (Marvel, Gauerke, and Hill, *J. Amer. Chem. Soc.*, 1925, 47, 3009) by means of the Grignard reaction is much more satisfactory, but has the drawback that it can be used only with the primary alkyl halides, and the preparation of the Grignard reagent does not always proceed smoothly. We have found that thiourea is a suitable reagent for the identification of the alkyl bromides and iodides. *S*-Alkylisothioureas are formed and these yield picrates whose melting points are sharp. Their crystalline structure is also characteristic (for photomicrographs, see Brown, Thesis, Edinburgh, 1937). By this method compounds can be identified in a few minutes, but the method has the disadvantage that it is not applicable to alkyl chlorides or to tertiary compounds. Phenylthiourea is much less satisfactory than thiourea, as it reacts only with the straight-chain compounds.

Phenyl isothiocyanate is often used for the identification of amines, but in the case of some aliphatic amines the thioureas have low melting points and are difficult to crystallise. We therefore tried other isothiocyanates. 4-Diphenyl isothiocyanate proved to be very satisfactory, the resulting thioureas separating quickly. Their melting points are convenient and sharp.  $\beta$ -Naphthyl isothiocyanate also gave good results. Suter and Moffett (*J. Amer. Chem. Soc.*, 1933, 55, 2497) found  $\alpha$ -naphthyl isothiocyanate to be satisfactory. We also found *p*-tolyl isothiocyanate, used by Whitmore and Otterbacher (*J. Amer. Chem. Soc.*, 1929, 51, 1909) for aromatic amines, and *p*-chlorophenyl isothiocyanate to be useful reagents, but *m*-nitrophenyl isothiocyanate, used by Sah and Lei (*Centr.*, 1934, 3015) for aromatic amines, frequently yielded oily products with the aliphatic amines (for detailed results with the last three reagents, see Brown, *loc. cit.*).

Barger and Tutin (*Biochem. J.*, 1918, 12, 402) used 2 : 4 : 5-trinitrotoluene as a reagent for amino-acids, the 5-nitro-group being replaced. The reagent was found to be excellent for the identification of small quantities of certain amines, a 10% alcoholic solution yielding instantly a clean precipitate of the substituted alkylaniline. The use of the reagent is, however, limited, as it reacts only with the primary amines, and in the case of the higher amines gives oily products.

Monobasic aliphatic acids react with *o*-phenylenediamine to form 2-substituted benzimidazoles, and this method has been used for their identification (Seka and Muller, *Monatsh.*, 1931, 57, 97). The method is not completely satisfactory, as it requires considerable time, and the melting points of many of the substituted benzimidazoles lie close together. We have used the method of Phillips (*J.*, 1928, 2393) and have formed the 2-alkylbenzimidazole picrates, which have convenient melting points. While the work was in progress Pool, Harwood, and Ralston (*J. Amer. Chem. Soc.*, 1937, 59, 178) reported the use of the 2-alkylbenzimidazoles for identifying monobasic acids, and indicated that they may examine salts such as the picrates. We have therefore discontinued the work, and merely report what we have already accomplished.

Alkyl nitrites quickly form 3-oximino-2-phenylindole when treated with 2-phenylindole. This is a good method for detecting small quantities of nitrite, a 1% alcoholic solution yielding a precipitate without any difficulty. Attempts to apply the method quantitatively have so far met with little success, but the matter is being further investigated.

2:4-Dinitrobenzoic acid can be used for the identification of amines [Buehler and Calfee, *Ind. Eng. Chem. (Anal.)*, 1934, 6, 351]. We have obtained a more suitable method for the preparation of this acid than that used by Curtius and Bollenbach (*J. pr. Chem.*, 1907, 76, 288).

## EXPERIMENTAL.

The m. p.'s recorded were all obtained with a thermometer standardised with pure compounds of known m. p. Most of the nitrogen analyses were obtained by the semi-micro Dumas method, but a few were done by Dr. Weiler, Oxford.

*Preparation of S-Alkylisothiourea Picrates.*—Finely powdered thiourea (0.2 g.) and an equal quantity of alkyl bromide or iodide were heated with alcohol (2 c.c.) for 2 minutes. Picric acid (0.2 g.), dissolved in the minimum quantity of boiling alcohol, was then added; on cooling, the picrate separated. It was crystallised from alcohol until a constant sharp m. p. was obtained.

<i>S-Alkylisothiourea picrates.</i>									
Alkyl halide.	Formula.	M. p.	% N found.	% N calc.	Alkyl halide.	Formula.	M. p.	% N found.	% N calc.
Methyl .....	—	224°	—	—	isoAmyl .....	C <sub>12</sub> H <sub>17</sub> O <sub>7</sub> N <sub>5</sub> S	179°	18.8	18.7
Ethyl.....	—	188	—	—	sec.-Amyl.....	—	143	18.9	—
n-Propyl ...	C <sub>10</sub> H <sub>13</sub> O <sub>7</sub> N <sub>5</sub> S	181	20.6	20.2	n-Hexyl .....	C <sub>13</sub> H <sub>19</sub> O <sub>7</sub> N <sub>5</sub> S	157	18.3	18.0
isoPropyl ...	—	148	20.4	—	Ethylene di-	—	—	—	—
n-Butyl ...	C <sub>11</sub> H <sub>16</sub> O <sub>7</sub> N <sub>5</sub> S	180	19.7	19.4	bromide ...	C <sub>10</sub> H <sub>13</sub> O <sub>7</sub> N <sub>7</sub> S <sub>2</sub>	270	23.9	24.1
isoButyl ...	—	174	19.7	—	Allyl .....	—	155	—	—
sec.-Butyl...	—	190	19.5	—	Benzyl.....	C <sub>14</sub> H <sub>13</sub> O <sub>7</sub> N <sub>5</sub> S	188	17.6	17.7
n-Amyl.....	C <sub>12</sub> H <sub>17</sub> O <sub>7</sub> N <sub>5</sub> S	154	18.8	18.7					

The picrates were obtained in yellow needles or prisms. Benzyl chloride also can be identified by this method.

*Thiocarbanilides.*—The thiocarbanilides necessary for the preparation of the isothiocyanates were prepared by Fry's method (*J. Amer. Chem. Soc.*, 1913, 35, 1544). pp'-*Diphenylthio-*

<i>4-Diphenylthioureas.</i>					<i>β-Naphthylthioureas.</i>				
Amine.	Formula.	M. p.	% N found.	% N calc.	Formula.	M. p.	% N found.	% N calc.	
Methyl .....	C <sub>14</sub> H <sub>14</sub> N <sub>2</sub> S	142°	11.6	11.6	C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> S	127°	12.8	13.0	
Ethyl .....	C <sub>15</sub> H <sub>16</sub> N <sub>2</sub> S	165	10.9	10.9	C <sub>13</sub> H <sub>14</sub> N <sub>2</sub> S	142	12.2	12.2	
n-Propyl .....	C <sub>16</sub> H <sub>18</sub> N <sub>2</sub> S	156	10.2	10.4	C <sub>14</sub> H <sub>16</sub> N <sub>2</sub> S	114	11.5	11.5	
n-Butyl .....	C <sub>17</sub> H <sub>20</sub> N <sub>2</sub> S	155	9.8	9.9	C <sub>15</sub> H <sub>18</sub> N <sub>2</sub> S	119	11.2	10.9	
isoButyl .....	—	157	10.0	—	—	137	11.2	—	
n-Amyl .....	C <sub>18</sub> H <sub>22</sub> N <sub>2</sub> S	147	9.3	9.4	C <sub>16</sub> H <sub>20</sub> N <sub>2</sub> S	114	10.6	10.3	
isoAmyl .....	—	130	9.6	—	—	116	10.1	—	
n-Heptyl .....	C <sub>20</sub> H <sub>26</sub> N <sub>2</sub> S	149	8.7	8.6	C <sub>18</sub> H <sub>22</sub> N <sub>2</sub> S	115	9.7	9.3	
Dimethyl .....	C <sub>15</sub> H <sub>16</sub> N <sub>2</sub> S	225	11.3	10.9	C <sub>13</sub> H <sub>14</sub> N <sub>2</sub> S	173	12.2	11.4	
Diethyl .....	C <sub>17</sub> H <sub>20</sub> N <sub>2</sub> S	114	9.8	9.9	C <sub>15</sub> H <sub>18</sub> N <sub>2</sub> S	90	10.7	10.9	
Dipropyl .....	C <sub>19</sub> H <sub>24</sub> N <sub>2</sub> S	117	8.9	9.0	C <sub>17</sub> H <sub>22</sub> N <sub>2</sub> S	109	9.9	9.8	
Diisobutyl .....	C <sub>21</sub> H <sub>28</sub> N <sub>2</sub> S	160	8.5	8.5	C <sub>16</sub> H <sub>20</sub> N <sub>2</sub> S	136	9.2	8.9	
Di-n-amyl .....	C <sub>22</sub> H <sub>30</sub> N <sub>2</sub> S	118	7.7	7.6	C <sub>21</sub> H <sub>30</sub> N <sub>2</sub> S	126	6.6	6.5	
Benzyl .....	C <sub>23</sub> H <sub>32</sub> N <sub>2</sub> S	147	9.0	8.8	C <sub>18</sub> H <sub>16</sub> N <sub>2</sub> S	173	9.7	9.6	
cycloHexyl .....	C <sub>20</sub> H <sub>18</sub> N <sub>2</sub> S	180	9.3	9.0	C <sub>18</sub> H <sub>16</sub> N <sub>2</sub> S	172	10.1	9.9	
Bornyl .....	C <sub>19</sub> H <sub>22</sub> N <sub>2</sub> S	167	7.8	7.7	—	—	—	—	
Camphyl .....	C <sub>23</sub> H <sub>28</sub> N <sub>2</sub> S	138	7.6	7.7	C <sub>21</sub> H <sub>26</sub> N <sub>2</sub> S	127	8.3	8.6	
Ethylenediamine .....	C <sub>28</sub> H <sub>26</sub> N <sub>4</sub> S <sub>2</sub>	237	15.3	15.5	C <sub>24</sub> H <sub>22</sub> N <sub>4</sub> S <sub>2</sub>	223	17.4	17.1	

*carbanilide* was purified by boiling the crude product with alcohol and separating the white amorphous residue, m. p. 233—235° (Found: C, 78.8; H, 5.6; N, 7.4. C<sub>25</sub>H<sub>20</sub>N<sub>2</sub>S requires C, 78.9; H, 5.3; N, 7.3%).

*isothiocyanates.*—These are best prepared by Steudemann's method (*Ber.*, 1883, 16, 549, 2334). 4-Diphenyl isothiocyanate formed light brown needles from glacial acetic acid and on recrystallisation from alcohol was obtained in colourless needles, m. p. 70° (Found: C, 73.4; H, 4.6; N, 6.7; S, 14.2. C<sub>13</sub>H<sub>9</sub>NS requires C, 73.9; H, 4.3; N, 6.6; S, 15.2%).

*Preparation of Thioureas.*—The amine (0.2 g.) and the isothiocyanate (0.2 g.) were heated together for about 20 seconds, and 50% alcohol (2 c.c.) added. The thiourea deposited on cooling was recrystallised from 50% alcohol (table on p. 1700).

*Preparation of 4:6-Dinitro-N-alkyl-m-toluidines.*—2:4:5-Trinitrotoluene (0.1 g.) was dissolved in alcohol (1 c.c.), and 3 or 4 drops of the amine added. The compound separated immediately, and on crystallisation from alcohol yielded yellow or orange needles.

## 4:6-Dinitro-N-alkyl-m-toluidines.

Amine.	Formula.	M. p.	% N found.	% N calc.	Amine.	Formula.	M. p.	% N found.	% N calc.
Methyl .....	—	173°	—	—	<i>n</i> -Heptyl .....	C <sub>14</sub> H <sub>21</sub> O <sub>4</sub> N <sub>3</sub>	50°	14.4	14.2
Ethyl .....	C <sub>9</sub> H <sub>11</sub> O <sub>4</sub> N <sub>3</sub>	126	18.7	18.7	Ethylenedi- amine .....	C <sub>16</sub> H <sub>16</sub> O <sub>8</sub> N <sub>6</sub>	280	20.2	20.0
<i>n</i> -Propyl .....	C <sub>10</sub> H <sub>13</sub> O <sub>4</sub> N <sub>3</sub>	101	17.4	17.6	Benzyl .....	C <sub>14</sub> H <sub>13</sub> O <sub>4</sub> N <sub>3</sub>	100	14.4	14.6
<i>n</i> -Butyl .....	C <sub>11</sub> H <sub>15</sub> O <sub>4</sub> N <sub>3</sub>	96	16.6	16.6	Dipropyl .....	—	Oil	—	—
<i>iso</i> Butyl .....	„	112	„	„	Diamyl .....	—	Oil	—	—
<i>n</i> -Amyl .....	C <sub>12</sub> H <sub>17</sub> O <sub>4</sub> N <sub>3</sub>	99	15.4	15.7					
<i>iso</i> Amyl .....	C <sub>12</sub> H <sub>17</sub> O <sub>4</sub> N <sub>3</sub>	87	15.6	„					

*Preparation of 2-Alkylbenziminazole Picrates.*—*o*-Phenylenediamine (0.5 g.), the organic acid (0.5—1 g.), and 4*N*-hydrochloric acid (4 c.c.) were refluxed for 15 minutes. The solution was cooled, and aqueous ammonia added until the alkylbenziminazole separated. It was washed with water, dissolved in the minimum quantity of boiling alcohol, and added to a solution of picric acid (0.5 g.) in the minimum quantity of boiling alcohol. The picrate separated on cooling and was recrystallised from alcohol.

## 2-Alkylbenziminazole picrates.

Acid.	Formula.	M. p.	% N found.	% N calc.	Acid.	Formula.	M. p.	% N found.	% N calc.
Formic .....	—	230°	—	—	Hexoic .....	C <sub>18</sub> H <sub>19</sub> O <sub>7</sub> N <sub>5</sub>	282°	16.6	16.8
Acetic .....	C <sub>14</sub> H <sub>11</sub> O <sub>7</sub> N <sub>5</sub>	214	19.6	19.4	Lactic .....	C <sub>15</sub> H <sub>13</sub> O <sub>8</sub> N <sub>5</sub>	131	17.8	17.9
Propionic .....	C <sub>15</sub> H <sub>13</sub> O <sub>7</sub> N <sub>5</sub>	120	18.6	18.7	Glycollic .....	C <sub>14</sub> H <sub>11</sub> O <sub>8</sub> N <sub>5</sub>	214	18.5	18.6
Butyric .....	C <sub>16</sub> H <sub>15</sub> O <sub>7</sub> N <sub>5</sub>	124	18.1	18.0	Mandelic .....	C <sub>20</sub> H <sub>15</sub> O <sub>8</sub> N <sub>5</sub>	209	15.2	15.5
<i>iso</i> Butyric ...	„	136	17.8	„					

*o*-Phenylenediamine picrate prepared in the usual way was obtained in yellow needles, m. p. 208° (decomp.) (Found: N, 25.4. Calc. for C<sub>12</sub>H<sub>11</sub>O<sub>7</sub>N<sub>5</sub>: N, 25.9%).

*3-Oximino-2-phenylindole.*—2-Phenylindole (0.1 g.) was dissolved in boiling alcohol, and the alkyl nitrite (0.1 g.) added. The oximino-compound separated on cooling and crystallised from amyl acetate in orange diamond-shaped needles, m. p. 280° (decomp.).

*2:4-Dinitrobenzoic Acid.*—Fuming nitric acid (500 c.c.) was added slowly to phenylacetic acid (50 g.), the mixture being cooled with running water. The solution was then refluxed for 1 hour and poured into water. The precipitate was washed with cold water. 2:4-Dinitrobenzoic acid (55 g., 70%) thus obtained was nearly pure, m. p. 180—182°. When recrystallised from water (4 parts) and alcohol (1 part), it was obtained in colourless needles, m. p. 181—182° (lit., 182—183°): yield, 45 g.

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