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The identification of barbiturates by attenuated total reflectance

Robert Lewis
University of the Pacific

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THE IDENTIFICATION OF BARBITURATES BY ATENUATED TOTAL REFLECTANCE

A Thesis
Presented to
the Faculty of the Graduate School
University of the Pacific

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Robert Lewis
December 1972
This thesis, written and submitted by

Robert Lewis

is approved for recommendation to the Committee on Graduate Studies, University of the Pacific.

Department Chairman or Dean:

Thesis Committee:

[Signatures]

Chairman

Dated June 14, 1973
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The use of Attenuated Total Reflectance as an analytical technique in infrared spectroscopy has become increasingly important in the past few years. ATR (Attenuated Total Reflectance) is a relatively new analytical method. Producing spectra of compounds by this method requires no solvent for dissolving the sample and no salts for making pellets. The only requirements for spectra production, similar in quality to those produced by conventional methods, are that there is enough sample to cover both sides of the reflector and that the indices of refraction of the sample and reflector be similar. The index of the sample is fixed; therefore, the index of the reflector is controlled by selecting a reflector with one similar to the sample. Reflectors with indices from 1.2 to 4.12 are commercially produced. Since no solvents or salts are used in ATR, this method allows complete recovery of the sample without using separation or abstraction processes. The elimination of solvents and salts should also lower the cost of spectra production. The ATR method eliminates the weighing and measuring of samples and salts and the time consuming process of pellet making; therefore, it should be a quicker method than any of the conventional methods.

The principles of ATR have been applied to several fields of infrared analysis. Harris and Svoboda used ATR as a means of determination of Alkyl and Monomer Modified Resins; Katlaksky and Keller used ATR to study aqueous solutions. Ahliyah and Mooney used ATR.
in preparing spectra of Polyatomic Anions, and Deley and Liotti used ATR as a means of identifying coating on paper. Materials for which ATR has been useful in analysis include fabrics, polymers which cannot be easily prepared for other types of analysis, and surfaces of semiconductors. In this project, spectra of several pure barbiturates, drug compositions containing barbiturates, and several related compounds were prepared using ATR; these were compared to spectra produced by the conventional pellet method.
ATTENUATED TOTAL REFLECTANCE

Attenuated Total Reflectance is defined as a beam of light entering a prismatic material and penetrating the sample just once before being reflected out of the prismatic material (Fig. 1). In Attenuated Total Reflectance, the angle of incidence -- the angle at which the light enters the prism -- can be varied and matched to the sample.

Figure 1 — Single Reflection. The beam of light is shown penetrating the sample just once before being reflected back through the prism.

Attenuated Total Reflectance is a variation of attenuated radiation which results from reflection at the surface of a chemical material. The beam entering the material is reflected internally when the angle of incidence at the interface between sample and prism is greater than the critical angle. (A beam with an angle of incidence $i$ and angle of reflection of $90^\circ$ will not penetrate a less dense medium but will travel along the surface of the less dense medium. The angle that the beam makes with the perpendicular is called the cr-
tical angle\(^6\)). (Fig. 2).

The reflection is total in the region between the critical angle and the grazing incidence; it is total from the surface of the prismatic material. Total reflection occurs at all wavelengths where the absorption is zero\(^7\).

Multiple Attenuated Total Reflectance (MATR) differs from Attenuated Total Reflectance (ATR) in that the beam penetrates the sample many times. As many as 25 to 50 penetrations may occur, (Fig. 3). It has the advantage over ATR in that the weakly absorbing samples give good spectra due to the many penetrations. Such samples give poor ATR spectra or none at all.

Figure 3 -- Multiple Attenuated Total Reflectance. The beam penetrates the sample several times before it is reflected out of the prismatic material.
In Attenuated Total Reflectance and Multiple Attenuated Total Reflectance, a beam of radiation loses energy when a material that selectively absorbs radiation is placed in contact with the reflecting surface. The energy is lost at wavelengths where the material absorbs due to interaction between the material and the penetrating beam. The penetration of the radiation in the sample depends on the wavelength of light, the refractive indices of the reflector and sample, and the angle of incidence of the radiation.

A graph of penetration versus angle of incidence in the region of absorption shows that penetration increases more rapidly when the angle of incidence at the interface is near the critical angle, (Fig. 4).

Figure 4 — Relationship of angle of incidence to depth of penetration.

A plot of the index of refraction versus wavelength near an absorption band (Fig. 5) shows that the index of refraction undergoes a radical change in this region. If a reflector of index \( n_1 \) is selected,
there is a point at which the index of the sample is greater than that of the reflector. At this wavelength there is no angle of incidence where reflection can take place. Nearly all of the energy passes into the sample. A reflector with index \( n_2 \) has no point at which the index of the sample exceeds it but has a region on the long wavelength side of the band where the index of the sample comes close to that of the plate. This reflector gives more absorption on the long wavelength side and total absorption is reduced. A reflector with an index of \( n_3 \) that is considerably greater than the index of the sample has no point where the index of the sample is greater than the reflector. Under such condition the index variation of the sample has no effect on the shape of the band although total absorption is small.

The quality of Attenuated Total Reflectance spectra depends on the ratio between the refractive indices of the sample and prism. The quality of the spectra decreases as the index of the reflector approaches that of the sample. Prisms (reflectors) with different indices have been used in ATR so that the index of the prism can be matched to the index of the material using several prism materials. Polchlopek produced spectra of polystyrene (refractive index 1.6), polytetrafluoroethylene (refractive index between 1.3 to 1.4), polymethyl-methacrylate (refractive index 1.5). He reported approximate minimum angles of incidence at which samples with various refractive indices may be used with different prism materials. Table I contains the angles for critical reflection of the three samples and the prism material. Table II indicates the quality of the spectra
Figure 5 — shows the changes the refractive index undergoes near an absorption frequency.

The dotted line represents the absorption when taken by transmission. The heavy line shows the radical change it undergoes. \( n_1 \) shows the absorption when a reflector with a refractive index is smaller than the sample that is used. \( n_2 \) has a refractive index that is the same as the refractive index of the sample. \( n_3 \) has a refractive index that is larger than the refractive index of the sample.
Table I. Angles for Critical Reflection of Seven Prisms with Refractive Indices Ranging from 1.43 to 4.02

<table>
<thead>
<tr>
<th>Prism Material</th>
<th>Refractive Index</th>
<th>Refractive index of sample</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>1.3</td>
</tr>
<tr>
<td>CaF$_2$</td>
<td>1.43</td>
<td>66°</td>
</tr>
<tr>
<td>NaCl</td>
<td>1.52</td>
<td>60°</td>
</tr>
<tr>
<td>AgCl</td>
<td>2.0</td>
<td>40°</td>
</tr>
<tr>
<td>KRS-6</td>
<td>2.19</td>
<td>36°</td>
</tr>
<tr>
<td>IRTRAN-2</td>
<td>2.25</td>
<td>35°</td>
</tr>
<tr>
<td>KRS-5</td>
<td>2.38</td>
<td>33°</td>
</tr>
<tr>
<td>Ge</td>
<td>4.02</td>
<td>19°</td>
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</tbody>
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Table II. Quality of ATR Spectra with Various Prisms

<table>
<thead>
<tr>
<th>Refractive index of samples</th>
<th>Good Spectra</th>
<th>Fair Spectra</th>
<th>Poor Spectra</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KRS-5</td>
<td>KRS-6</td>
<td>AgCl</td>
</tr>
<tr>
<td>1.3-1.4</td>
<td>40-65°</td>
<td>50-65°</td>
<td>60-65°</td>
</tr>
<tr>
<td>1.5</td>
<td>40-65°</td>
<td>50-65°</td>
<td>60-65°</td>
</tr>
<tr>
<td>1.6</td>
<td>40-65°</td>
<td>50-65°</td>
<td>65°</td>
</tr>
</tbody>
</table>
obtained over several angles with the three samples. Polchlopek listed three prisms good enough for general ATR work. The three prisms are KRS-5 (42 mole % Thallous bromide, 58 mole % Thallous iodide), KRS-6 (40 mole % Thallous bromide, 60 mole % Thallous Chloride), and AgCl; AgCl has a more limited range than KRS-5 or KRS-6 and also shows a larger amount of distortion outside its effective range than the others. Of the three materials the AgCl prism produced the best spectra when used in its effective domain.
INFRARED SPECTROSCOPY

The infrared region of the spectrum extends from the visible region until it overlaps the micro-wave region. Its wavelength limits are between 0.7 micron to 500 microns with the most useful part of the spectrum occurring in the narrow region 2.5 microns to 15 microns\textsuperscript{11}. The infrared region between .8 microns and 50 microns can be explored with modern instruments; spectra obtained in this region are due primarily to vibration, stretching and bending modes within molecules\textsuperscript{12}.

The basic characteristic of this region is that the principle source of radiation is thermal emission from a source. The radiant energy is absorbed by a natural vibration mode when the frequency of the radiation is the same as the natural frequency of vibration and when there is a change in the dipole moment of the molecule. The amount of radiation absorbed is proportional to the square of the rate change of the dipole moment with respect to displacement of the atom\textsuperscript{13}.

There are two types of molecular vibration observed when infrared radiation is absorbed: stretching and bending. Stretching vibration is the rhythmic movement of the atoms back and forth along the bond axis. Bending may be of two types. One is a change in bond angles between two atoms each bonded to a third atom. A second type involves movement of a group of atoms with respect to the rest of the molecule. The terms scissoring, rocking, wagging, and
twisting are used to describe the various types of bending motions\textsuperscript{14}.

The instrument used in this research project was a Perkin-Elmer Model 337 infrared spectrometer. It is a double beam recording spectrometer with an optical null and a Littrow type grating monochromator that gives one percent accuracy in transmission and $\pm 6 \text{ cm}^{-1}$ accuracy in wave number in the moderate wavelength of the first region. The second region has an accuracy of $\pm 2 \text{ cm}^{-1}$ in transmission\textsuperscript{15}.

The Wilks Model 12 Doublebeam Attenuated Total Reflectance attachment (Figure 6) was used in analysis of the barbiturates by ATR.

Installation and adjustment of the attachment are described in the operators' manual\textsuperscript{16}. The unit mounts directly to the spectrometer with the reference prism and sample in the reference and sample side respectively. The mirrors on both optical systems need to be carefully aligned.

KRS-5 prisms were used in the analysis of the barbiturates. KRS-5 is insoluble in most organic solvents as well as cold water. It is non-hydroscopic and has a high enough refractive index to produce good spectra.

The reflector in the reference side of the Model 12 was held in a Teflon Internal Plate Holder (Figure 7). The prism is supported on its edges with the portion penetrated by the beam from the spectrometer being held "free in air"\textsuperscript{17}. The reflector in the sample side is held in a stainless steel sample holder (Fig. 8). The holder presses solid samples in contact with the reflector and applies uniform pressure. There are four screws in the sample holder which are tightened in a diagonal manner to prevent a wedge between the body and pressure plate\textsuperscript{18}.
Figure 6 -- The Wilds Model 12 Attenuated Total Reflector
Figure 7 -- Teflon Internal Plate Holder
Figure 8 — Stainless Steel Sample Holder
The clinically important barbiturates are colorless crystalline solids that melt from 96 to 205°C; other barbiturates melt at higher temperatures and many have color. Barbiturates are not very soluble in water and are unstable under acidic conditions; many are used as hypnotic drugs in medicine\textsuperscript{19}.

The barbiturates are considered to be one of the most important groups of pyrimidine derivatives. The parent compound, barbituric acid (2,4,6, trihydroxypyrimidine), is formed by heating a mixture of malonic ester and urea under pressure in alcohol\textsuperscript{20}.

\[ \text{O} \]
\[ \text{C} \text{--OR} \]
\[ \text{CH}_2 \]
\[ \text{C} \text{--OR} \]
\[ \text{O} \]
\[ \text{H} \]
\[ \text{N} \text{-- H} \]
\[ \text{C} \text{= O} \]
\[ \text{N} \text{-- H} \]
\[ \text{H} \]

ETOH
\[ \Delta \]

Any of the 5,5 disubstituted barbituric acids can be prepared by this method when a urea derivative is heated with a malonic ester.
Infrared spectra of the barbiturates were first taken by Umberger and Adam\textsuperscript{21} in a chloroform solution. Only a few of the barbiturates gave an absorption between 8 microns and 12 microns (1250 cm\textsuperscript{-1} to 8 cm\textsuperscript{-1}). Solid spectra of the barbiturates\textsuperscript{22,23,24} have shown that the barbiturates do absorb in this region. Hubley\textsuperscript{25} listed an absorption peak near 850 cm\textsuperscript{-1} (11.7 microns) as being characteristic of all barbiturates.

Spectra of the barbiturates show absorption that can be assigned to special functional groups. Except for the band at 500 cm\textsuperscript{-1}, the assignments are those of Hubley\textsuperscript{25}. Absorptions between 3250-3000 cm\textsuperscript{-1} are in the spectral region in which N-H stretch occurs. The spectra of the barbiturates show a strong and a weak absorption peak in this band region; the strong band is near 3200 cm\textsuperscript{-1} and the weak band is near 3000 cm\textsuperscript{-1}. 5-Amino barbital, unlike the others, shows absorption above 3300 cm\textsuperscript{-1}.

There are three absorption peaks in most of the barbiturate spectra, between 1750 cm\textsuperscript{-1} and 1660 cm\textsuperscript{-1}. Sodium barbital showed two absorption peaks in this region; these are at a much lower frequency (1680 cm\textsuperscript{-1} and 1610 cm\textsuperscript{-1}) than the other barbiturates. The sodium barbital peaks are more in agreement with peaks of barbiturate complexes as reported by Hubley\textsuperscript{25}.

Several absorption bands, caused by C-H deformation and C-H stretching vibration, are present in the barbiturate spectra between 1475 cm\textsuperscript{-1} and 1250 cm\textsuperscript{-1}. An absorption band near 500 cm\textsuperscript{-1} appeared in the spectra of all of the barbiturates.
EXPERIMENTAL

Spectra of the barbiturates, pharmaceuticals containing barbiturates, street drugs, and related compounds were produced by the conventional KBr pellet method for comparison with the ATR spectra. In obtaining these spectra a small sample of the material, well mixed with ground KBr, was placed in an evacuable die and pressed into a transparent pellet. Spectra of the samples were recorded on the Perkin-Elmer 337 infrared spectrometer at normal slit width and fast scanning speed between 4,000 cm\(^{-1}\) and 400 cm\(^{-1}\).

Caution had to be taken to assure maximum contact between the sample and reflector when spectra of the compounds were taken by ATR, because the better the contact, the greater the amount of absorption. The samples were ground to reduce the size of the particles, and then placed on the gummy side of a transparent tape. The tape offers a method of getting a uniform distribution of the samples on the reflector without scratching it. Care has to be taken to cover the tape completely; any part of the tape exposed to the reflector will produce its own characteristic spectrum. A piece of the sample-covered tape was placed on each side of the reflector and the holder was fastened by tightening the screws diagonal to each other to assure uniform pressure. Spectra were recorded at normal slit width and fast scanning speed.

Some of the barbiturates, drugs, and related compounds required a greater amount of sample than could be picked up by the tape to
give good ATR spectra. In such cases additional sample was added to the sample holder by laying one piece of the tape on the bottom section of the holder and spreading the sample across it with a Q-Tip. The reflector was then placed over the sample and a small amount of the sample was spread across the reflector in the same manner. The reflector was covered with the second piece of tape and the top section of the holder was fastened. In placing the sample on the reflector in this manner, extreme care must be taken to prevent scratching the reflector. Experience is necessary to obtain a uniform spread of the sample using this technique.

The barbiturates were the best grade available commercially. The street drug sample was obtained locally. The urea derivatives were chosen because of the large number of 5-5 disubstituted barbiturates made from them.

Spectra of the following compounds and drugs were prepared in the manner described:

Urea - (m.p. 132.7°C)
\[
\text{NH}_2 - \text{C} - \text{NH}_2
\]

Thiourea - (m.p. 180-182°C).
\[
\text{S}
\]
\[
\text{NH}_2 - \text{C} - \text{NH}_2
\]

Diethylthiourea - (m.p. 68-71°C).
\[
\text{CH}_3 - \text{CH}_2 - \text{N} - \text{C} - \text{N} - \text{CH}_2 - \text{CH}_3
\]
Uric Acid - (decomposes)

Malonic Acid - (m.p. 135.6°C).

Barbituric Acid - (m.p. 243°C).

Sodium barbital -

2-Thiobarbital - (m.p. 235°C).
Secobarbital - (m.p. 82°C).

Amobarbital - (m.p. 156-158°C).

5-Amino barbituric acid - (m.p. above 400°C).

Phenobarbital - (m.p. 174-178°C).

The following proprietary preparations were also analyzed by ATR:

Dexamyl capsule (SKF) - contains amobarbital and d-amphetamine.

Dexamyl tablet (SKF) - contains amobarbital and d-amphetamine.

Sodium amyotal (Lilly) - contains sodium amobarbital.
Tuinal (Lilly) - contains sodium secobarbital and sodium amobarbital.
Nembutal (McNeil) - contains sodium pentobarbital.
Carbital (Parke-Davis) - contains sodium phenobarbital.

In addition, a typical "street drug" containing a barbiturate was subjected to ATR analysis. Spectra of this illicit preparation and the authentic compounds and mixtures are presented in the Appendix.
RESULTS

There is no great difference in the barbiturate spectra obtained by the different methods. The basic difference occurs in the 3300 cm$^{-1}$ and 2900 cm$^{-1}$ region. Generally the ATR spectra of the barbiturates in the 3300 cm$^{-1}$ region show fewer peaks than the transmission spectra. The peaks in the 2900 cm$^{-1}$ region of the transmission spectra are separated better than in the ATR spectra. The difference in quality is best pointed out by the analysis of the spectra of the individual compounds.

Amytal - There is very little difference in the two spectra. The most noticeable difference is the sharpness of the ATR peaks in the 3300 cm$^{-1}$ region; they are much sharper than the same peaks in the transmission spectrum. One less absorption peak between 900 cm$^{-1}$ and 800 cm$^{-1}$ occurs in the ATR spectrum.

Secobarbital - The spectra are similar except in the 2900 cm$^{-1}$ where the C-H peaks are separated better in the transmission spectra.

Sodium Barbital - Absorbance in the 3300 cm$^{-1}$ of the ATR spectrum is less intense than expected from the amount of sample used. The peaks in this region are not separated as well as they are in the transmission spectrum. The remainder of the spectra are quite similar.

Phenobarbital - The transmission spectrum shows more absorption above the 3300 cm$^{-1}$ region than ATR spectrum; however, there is better
separation of the absorption peaks in the $1700 \text{ cm}^{-1}$ region of the ATR spectrum.

5-Amino barbital - The ATR spectrum shows weak absorption in the $3300 \text{ cm}^{-1}$ region and very little separation of the absorption peaks. The transmission spectrum peaks are very well separated. The remainder of the spectra are quite similar.

2-thio-barbital - A transmission spectrum of this barbiturate was not obtainable since the compound was changed under pressure.

The quality of the spectra of the pharmaceuticals differ more than the quality of the spectra of the pure barbiturates. This difference could be caused by the diluent used. Very little of a colored pharmaceutical such as Dexamyl could be used for the transmission spectra. The greatest differences occur in the $3300 \text{ cm}^{-1}$ region where a broad band appears in most of the ATR spectrum.

Individual analysis of the urea derivatives, malonic acid, pharmaceuticals, and street drugs are discussed in the following to compare the positions of absorption peaks in the spectra.

Table three lists the absorption peaks of the barbiturates.

Urea - Four absorption peaks in the $3300 \text{ cm}^{-1}$ region are seen in the KBr tablet spectrum of urea. The four peaks ($3460 \text{ cm}^{-1}, 3400 \text{ cm}^{-1}, 3340 \text{ cm}^{-1}, \text{ and } 3255 \text{ cm}^{-1}$) are due to N-H stretching. Two peaks are near $1700 \text{ cm}^{-1}$ (at 1680 and 1670 cm$^{-1}$). These two peaks are due to C=O stretching. A peak caused by C-N stretching vibrations at $1152 \text{ cm}^{-1}$
is also seen in the spectrum. The ATR spectrum of urea gives a broad peak in the 3300 cm\(^{-1}\) region. Several absorption peaks are distinguishable in this broad peak. They are at 3420 cm\(^{-1}\), 3310 cm\(^{-1}\), and 3115 cm\(^{-1}\). The C=O stretch absorption peaks are at 1680 cm\(^{-1}\) and 1635 cm\(^{-1}\). The C-N stretching vibration peak is near 1190 cm\(^{-1}\). The change in the position of the C=O peak in the two spectra could be caused by interaction of the salt and urea in the pellet.

Thiourea - Four absorption peaks in the 3300 cm\(^{-1}\) regions are also seen in the KBr tablet spectrum of thiourea. These four peaks (3375 cm\(^{-1}\), 3340 cm\(^{-1}\), 3270 cm\(^{-1}\) and 3155 cm\(^{-1}\)) are due to N-H stretching. A sharp peak at 1610 cm\(^{-1}\) is also seen in the spectrum. An absorption peak is seen at 1185 cm\(^{-1}\). That is due to C=S stretching. Another one caused by N-H stretching is seen at 730 cm\(^{-1}\). The peak seen at 630 cm\(^{-1}\) is due to C-S stretching. The spectrum of urea prepared by ATR is quite similar to the pellet spectrum. Three N-H stretching peaks are seen in the 3300 cm\(^{-1}\) region. The three peaks are near 3340 cm\(^{-1}\), 3240 cm\(^{-1}\), and 3150 cm\(^{-1}\). A sharp peak at 1590 cm\(^{-1}\), also due to N-H stretching, is seen. The absorption peak near 1180 cm\(^{-1}\) is caused by C=S stretching. The ATR spectrum of thiourea, like the ATR spectrum of urea, shows one less peak in the 3300 cm\(^{-1}\) region than is shown in the pellet spectrum. The peaks in the ATR spectrum are also at different wavelengths. The changes in position of absorption peaks could be caused by the salt used.
N,N-diethylthiourea - Only two N-H absorption peaks are seen in the spectrum of N,N-diethylthiourea. These peaks are at 3225 cm\(^{-1}\) and 3075 cm\(^{-1}\). Two sharp peaks are also seen at 1550 cm\(^{-1}\) and 1500 cm\(^{-1}\). A C=S stretching peak appears at 1055 cm\(^{-1}\). A N-H stretch peak is seen at 800 cm\(^{-1}\). The spectrum of N,N-diethylthiourea prepared by ATR is the same quality as that of the pellet.

Uric Acid - The KBr spectrum of uric acid has a broad band from 3300 cm\(^{-1}\) to 2610 cm\(^{-1}\), but several peaks are distinct. Relatively sharp peaks are at 3000 cm\(^{-1}\) and 2810 cm\(^{-1}\). Two moderate peaks are at 2695 cm\(^{-1}\) and 2610 cm\(^{-1}\). Two sharp peaks due to N-H stretching are seen at 1660 cm\(^{-1}\) and 1580 cm\(^{-1}\). A moderate peak at 870 cm\(^{-1}\) is also caused by N-H stretching.

The ATR spectrum of uric acid is similar to the pellet spectrum. A broad band is found between 3175 cm\(^{-1}\) and 1560 cm\(^{-1}\). The N-H stretching absorption peaks in the fingerprint region are near the same wave number - as they appear in the pellet spectrum.

Malonic Acid - The KBr spectrum of malonic acid has a broad band from 3500 cm\(^{-1}\) to 2325 cm\(^{-1}\). This band includes the absorption peaks of C-H in the 2900 cm\(^{-1}\) region and the C-OH absorption peaks in the 2500 cm\(^{-1}\). A sharp absorption peak caused by C=O stretch is seen at 1705 cm\(^{-1}\). Sharp peaks caused by C-H deformation are seen between 1425 cm\(^{-1}\) and 1300 cm\(^{-1}\). Two broad bands characteristic of carboxylic acid are seen at 942 cm\(^{-1}\) and 890 cm\(^{-1}\). The ATR spectrum of malonic
Acid is quite different from the pellet spectrum. Distinct sharp peaks at 3340 cm\(^{-1}\), 3250 cm\(^{-1}\), and 3130 cm\(^{-1}\) are shown in the ATR spectrum. A broad band is shown that goes from 2900 cm\(^{-1}\) to 2150 cm\(^{-1}\). The two absorption peaks due to C=O stretching are near 1670 cm\(^{-1}\) and 1585 cm\(^{-1}\). The difference in the spectra of the compound could be caused by structural changes that malonic acid undergoes when pressed into a pellet.

Dexamyl - The ATR spectrum of Dexamyl gives a broad band in the 3300 cm\(^{-1}\) region. There are no distinct peaks in the band. The medium size peak at 1610 cm\(^{-1}\) in the KBr spectrum is very weak in the ATR spectrum. Below 1200 cm\(^{-1}\), the spectra are quite similar.

Carbital contains sodium phenobarbital and carbomal. Its spectrum shows absorption above 3300 cm\(^{-1}\). Also, absorption peaks are seen at 3390 cm\(^{-1}\), 3360 cm\(^{-1}\), 3320 cm\(^{-1}\), 3225 cm\(^{-1}\), and 3052 cm\(^{-1}\). Three C=O absorption peaks are seen at 1715 cm\(^{-1}\), 1698 cm\(^{-1}\), and 168 cm\(^{-1}\). A sharp peak similar to the one seen in the spectrum of the street drug is seen at 1560 cm\(^{-1}\) in the carbital spectrum. C-H deformation and C-N stretching vibrational absorption peaks are seen between 1470 cm\(^{-1}\) and 1250 cm\(^{-1}\). The characteristic absorption peaks of barbiturates near 850 cm\(^{-1}\) is at 850 cm\(^{-1}\). Several weak absorption peaks are given in the area where the characteristic barbiturate peak occurs near 500 cm\(^{-1}\).

The ATR spectrum of carbital gives a broad band in the 3300 cm\(^{-1}\) region. The band goes from 3380 cm\(^{-1}\) to 3150 cm\(^{-1}\). Several peaks
are somewhat distinct in this region. These peaks are near $3220 \text{ cm}^{-1}$ and $3090 \text{ cm}^{-1}$. The C=O peaks are near $1750 \text{ cm}^{-1}$, $1725$, and $1690 \text{ cm}^{-1}$. These peaks are at higher frequencies than they are in the KBr spectrum. The spectra are quite similar.

Nembutal - Nembutal contains pentobarbital. Its KBr spectrum shows a broad band in the $3300 \text{ cm}^{-1}$ region. The broad band goes from $3300 \text{ cm}^{-1}$ to $3090 \text{ cm}^{-1}$. A medium absorption peak is given at $3040 \text{ cm}^{-1}$.

Only two C=O absorption peaks are given in the spectrum. They are near $1700 \text{ cm}^{-1}$ and $1650 \text{ cm}^{-1}$. A broad peak is given in the area of the characteristic barbiturate peak near $850 \text{ cm}^{-1}$. The peak extends from $865 \text{ cm}^{-1}$ to $830 \text{ cm}^{-1}$. The characteristic absorption peak near $500 \text{ cm}^{-1}$ is at $515 \text{ cm}^{-1}$.

The ATR spectrum of Nembutal is quite different from the KBr spectrum. One broad band is seen in the $3300 \text{ cm}^{-1}$ region. The band is between $3550 \text{ cm}^{-1}$ and $3080 \text{ cm}^{-1}$. Three C=O absorption peaks are given. They are near $1720 \text{ cm}^{-1}$, $1690 \text{ cm}^{-1}$, and $1645 \text{ cm}^{-1}$. A broad band similar to the one in the KBr spectrum is seen between $865 \text{ cm}^{-1}$ and $832 \text{ cm}^{-1}$. The absorption peak near $500 \text{ cm}^{-1}$ is at $515 \text{ cm}^{-1}$.

Dexamyl - The Dexamyl tablet contained 5 mg of d-amphetamine sulfate and 5 mg of amobarbital. Its spectrum (KBr) shows absorption above $3300 \text{ cm}^{-1}$. Absorption peaks are seen at $3540 \text{ cm}^{-1}$, $3490 \text{ cm}^{-1}$, $3200 \text{ cm}^{-1}$ and $3070 \text{ cm}^{-1}$. The two absorption peaks at $3200$ and $3020$ corresponds to the N-H absorption peaks of amobarbital in this region. This position has been shifted which could be due to the other compounds in the tablet. The C=O absorption peaks in the $1700 \text{ cm}^{-1}$ region
are very close to the position of the C=O peaks in amytal. A medium-sized peak that does not occur in amytal spectrum is located at 1610 cm$^{-1}$ in the Dexamyl spectrum. This peak corresponds to $\text{-NH}_2$ stretching$^{25}$. The amount of absorption due to C-H deformation and C-N stretching between 1470 cm$^{-1}$ and 1250 cm$^{-1}$ is larger in the Dexamyl spectrum than in amytal. The characteristic barbiturate absorption peak near 850 cm$^{-1}$ is near 847 cm$^{-1}$ in the Dexamyl spectrum. A weak peak is also seen at 965 cm$^{-1}$. Only one of these peaks is seen in the amytal spectrum. The characteristic peak near 500 cm$^{-1}$ is at 490 cm$^{-1}$ in the Dexamyl spectrum.

Street Drug - The street drug contained secobarbital (determined by TLC$^{25}$). Its spectrum (KBr) shows absorption above 3300 cm$^{-1}$. Absorption peaks are seen at 3450 cm$^{-1}$, 3420 cm$^{-1}$, 3350 cm$^{-1}$, 3310 cm$^{-1}$, 3245 cm$^{-1}$ and 3075 cm$^{-1}$. Some of these peaks are part of a broad band in the 3300 cm$^{-1}$ region. The two peaks at 3245 cm$^{-1}$ and 3075 cm$^{-1}$ correspond to the N-H stretch peaks of secobarbital (3230 cm$^{-1}$ and 3120 cm$^{-1}$). The shift in position could be caused by influence (interaction) of the other compounds in the mixture. The other peaks in this region are due to absorption by the other compounds. The C=O peaks in the spectrum of the street drug are located at lower frequencies (1700 cm$^{-1}$, 1698 cm$^{-1}$, and 1690 cm$^{-1}$), than they are in the spectrum of secobarbital (1752 cm$^{-1}$, 1730 cm$^{-1}$, and 1695 cm$^{-1}$). A very sharp peak shows up in the street drug spectrum that does not show in the spectrum of secobarbital. This peak is near 1590 cm$^{-1}$. The amount of absorption near 1470 cm$^{-1}$ and 1250 cm$^{-1}$ are about the same in
the spectra of secobarbital and the street drug; however, much more absorption is shown in the spectrum of the street drug below 1200 cm\(^{-1}\) than is shown in the spectrum of secobarbital. The characteristic peak of barbiturates near 850 cm\(^{-1}\) is seen at 845 cm\(^{-1}\) in the street drug; it is near 830 cm\(^{-1}\) in secobarbital. The one near 500 cm\(^{-1}\) is at 522 cm\(^{-1}\); it is at 500 cm\(^{-1}\) in the secobarbital spectrum.

The ATR spectrum of the street drug is of similar quality to the KBr spectrum. In it, the absorption peaks in the 3300 cm\(^{-1}\) region are not as clearly defined as they are in the KBr spectrum. The peaks in this region are part of a broad band. The C=O absorption peaks are shifted and only two are distinct. These two peaks are near 1725 cm\(^{-1}\) and 1675 cm\(^{-1}\).
CONCLUSION

ATR as a method of analysis of anions compounds is a relatively new technique. This method does not require the use of solvent or salts to obtain infrared spectra, and the quality of the spectra can be changed by varying the reflector used thus allowing spectra of the highest quality to be produced for almost any compound.

ATR, when applied to the infrared analyses of barbiturates, provides a very useful technique for identification and study. It is useful in identifying barbiturates in the sense that it provides a method of obtaining spectra of the barbiturates whose structures may change under pressure. 2-Thiobarbital gave a spectrum that showed no distinct absorption peaks above 1300 cm\(^{-1}\) when the pellet technique was used. A spectrum of it prepared by ATR showed absorption peaks in the 3300 cm\(^{-1}\) and 1700 cm\(^{-1}\) regions that are distinct and characteristic of barbiturates.

Spectra of barbiturates whose structure are not altered under pressure can also be prepared this way. Spectra of the barbiturates prepared by ATR do not show any absorption peaks due to solvent or salts. The position of the absorption peaks of the barbiturates would not be shifted due to influence of the solvent or salt. The ATR technique would be useful in barbiturate study in that it would allow the investigation of barbiturates in a mixture and provide a means of determining what compounds made up the mixture. Since many barbiturates used as street drugs are diluted with strychnine, ATR could provide a quick means of identifying the diluent.
The ATR technique provides a faster way of identifying barbiturates by infrared spectroscopy, in that covering both sides of the reflector with the mixture takes less time than it does to make a pellet.

The ATR method also eliminates expensive reagents which should lower the cost of spectrum production; also, anything used in the analysis is completely recovered for confirmatory tests.
### TABLE III

**CHARACTERISTIC ABSORPTION POINTS OF THE BARBITURATES**

<table>
<thead>
<tr>
<th>Compound</th>
<th>N-H Stretch Freq. cm⁻¹</th>
<th>C=O Stretch Freq. cm⁻¹</th>
<th>Characteristic Band at 800±50 cm⁻¹</th>
<th>Characteristic Band at 500±25 cm⁻¹</th>
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<td>490</td>
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<td>1750 1725</td>
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<td>850</td>
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<td>840</td>
<td>515</td>
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<td>ATR 3210 3090</td>
<td>1755 1715</td>
<td>837</td>
<td>592</td>
</tr>
<tr>
<td>Compound</td>
<td>N-H Stretch Freq. cm⁻¹</td>
<td>C=O Stretch Freq. cm⁻¹</td>
<td>Characteristic Band at 800±50 cm⁻¹</td>
<td>Characteristic Band at 500±25 cm⁻¹</td>
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<td>-------------------------</td>
<td>------------------------</td>
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<tr>
<td>Sodium barbital</td>
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<td>842 840</td>
<td>523 520</td>
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<td>ATR 3050</td>
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<tr>
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<td>849 848</td>
<td>500 498</td>
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<tr>
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<td>ATR 3225 3125</td>
<td>1725 1715</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barbituric acid</td>
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<td>1752 1725</td>
<td>A broad peak</td>
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</tr>
<tr>
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<td>ATR 3200 3090</td>
<td>1750 1710</td>
<td>830 492</td>
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<td>1690 1680</td>
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</tbody>
</table>
APPENDIX

INFRARED SPECTRA
N,N-Diethylthiocourea
(ADR)
Sodiumbarbital (ATR)
BIBLIOGRAPHY

17. Ibid., p. 9.
18. Ibid., p. 10.


