1. SYNONYMS

**CFR:** GHB analogs are treated as controlled substances under Federal law only if intended for human consumption. According to 21 U.S.C. § 813, "a controlled substance analog(ue) shall, to the extent intended for human consumption, be treated, for the purposes of any Federal law as a controlled substance in Schedule I." Thus, authorities can prosecute drug offenses involving 1,4-butanediol in the same manner as offenses involving GHB. See 21 U.S.C. § 802(32) for the definition of a controlled substance analog(ue).

**CAS #:** 110-63-4

**Other Names:**
- 1,4-Dihydroxybutane
- Butylene glycol
- 1,4-Butylene glycol
- 1,4-Tetramethylene glycol
- Tetramethylene 1,4-diol
- Sucol-B

2. CHEMICAL AND PHYSICAL DATA

2.1. CHEMICAL DATA

<table>
<thead>
<tr>
<th>Form</th>
<th>Chemical Formula</th>
<th>Molecular Weight</th>
<th>Melting Point (°C)</th>
<th>Boiling Point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,4-butanediol</td>
<td>C₄H₁₀O₂</td>
<td>90.1</td>
<td>16</td>
<td>230</td>
</tr>
</tbody>
</table>

2.2. SOLUBILITY

<table>
<thead>
<tr>
<th>Form</th>
<th>A</th>
<th>C</th>
<th>E</th>
<th>H</th>
<th>M</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,4-butanediol</td>
<td>VS</td>
<td>S</td>
<td>S</td>
<td>I</td>
<td>VS</td>
<td>VS</td>
</tr>
</tbody>
</table>

A = acetone, C = chloroform, E = ether, H = hexane, M = methanol and W = water, VS = very soluble, FS = freely soluble, S = soluble, PS = sparingly soluble, SS = slightly soluble, VSS = very slightly soluble and I = insoluble
3. SCREENING TECHNIQUES

3.1. COLOR TESTS

Most color tests are inadequate for 1,4-butanediol. There are currently no specific color tests for this compound and most common color tests give little response to 1,4-butanediol. Therefore, the results of both the Marquis and Mandelin’s are subject to interpretation. (Morris, 2001)

<table>
<thead>
<tr>
<th>COLOR TEST</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marquis</td>
<td>Faint brown</td>
</tr>
<tr>
<td>Mandelin’s</td>
<td>Brown</td>
</tr>
</tbody>
</table>

3.2. CRYSTAL TESTS

Currently, there are no reliable crystal tests.

3.3. GAS CHROMATOGRAPHY

Sample Preparation:
1,4-butanediol is soluble in methylene chloride and chloroform and may be extracted from aqueous solutions. It is also soluble in methanol.

Method - 1,4BD-GCS1

Instrument: Gas chromatograph operated in split mode with FID

Column: 5% phenyl/95% methyl silicone 30 m x 0.33 mm x 0.25 µm film thickness

Carrier gas: Hydrogen at 3.0 mL/min

Temperatures:
- Injector: 260°C
- Detector: 300°C

Oven program:
1) 100°C initial temperature for 1.0 min
2) Ramp to 270°C at 15°C/min
3) Hold final temperature for 3.7 min

Injection Parameters: Split Ratio = 30:1, 1 µL injected

<table>
<thead>
<tr>
<th>COMPOUND</th>
<th>RRT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 3.4. HIGH PERFORMANCE LIQUID CHROMATOGRAPHY

**Method - 1,4BD-LCS1**

1,4-Butanediol may be identified in aqueous solutions by LC-MS employing an ammonium acetate buffer (see the electrospray mass spectrum of 1,4-butanediol). The electrospray (+) mass spectrum displays a peak due to a protonated species of 1,4-butanediol (91 amu), as well as a peak for the cationic species (73 amu) that results from the loss of a hydroxide anion. The spectrum may also display a peak for the sodium ion complex with 1,4-butanediol (113 amu) if a sodium salt is present in the sample.

**Standard Solution Preparation:**
Prepare the standard solution of 1,4-butanediol (5-10 mg/mL) in methanol.

**Instrument:** High performance liquid chromatograph with atmospheric pressure ionization electrospray mass selective detector

**Column:** 5 µm Aqua C18, 100 mm x 4.6 mm

**Detector:** Scan mode, positive ion
Capillary voltage: 3000 V
Fragmentor: 30 eV
Nebulizer pressure: 60 psig
Drying gas flow: 13.0 L/min
Drying gas temperature: 350°C

**Flow:** 1.500 mL/min

**Injection Volume:** 5 µL

**Buffer:** 20 mM CH₃COONH₄ (~ pH 7.5)

**Mobile Phase:** 100% Buffer

<table>
<thead>
<tr>
<th>COMPOUND</th>
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<tbody>
<tr>
<td>GHB</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>COMPOUND</th>
<th>RRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2-butanediol</td>
<td>0.808</td>
</tr>
<tr>
<td>1,3-butanediol</td>
<td>0.845</td>
</tr>
<tr>
<td>GBL</td>
<td>0.964</td>
</tr>
<tr>
<td>1,4-butanediol</td>
<td>1.00</td>
</tr>
<tr>
<td>COMPOUND</td>
<td>RRT</td>
</tr>
<tr>
<td>------------------</td>
<td>------</td>
</tr>
<tr>
<td>1,4-Butanediol</td>
<td>1.00</td>
</tr>
<tr>
<td>GHB</td>
<td>1.01</td>
</tr>
<tr>
<td>GBL</td>
<td>1.14</td>
</tr>
</tbody>
</table>

**Method - 1,4BD-LCS2**

**Instrument:**
High performance liquid chromatograph equipped with atmospheric pressure ionization electrospray mass selective detector

**Column:**
5 µm ODS hypersil, 4.6 mm x 100 mm

**Detector:**
Mass selective detector
Nebulizer gas temperature: 350°C
Nebulizer gas flow: 13 L/min
Nebulizer pressure: 55 psig
Capillary voltage: 5 kV

**Flow:**
0.75 mL/min

**Injection Volume:**
5 µL

**Buffer:**
1% acetic acid

**Mobile Phase:**
Buffer: methanol 90:10
Samples are to be dissolved or diluted in mobile phase, then filtered with a 0.45-micron filter.

**3.5 NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY**

**Sample preparation:**
Use typically 5 to 10 mg of sample for proton NMR and 30 mg for carbon NMR. Dissolve sample in chloroform-d (CDCl₃) with the internal reference standard tetramethylsilane (TMS). *Filter all preparation solutions before analysis.

**Method Test - NMRS1**

**Instrument:**
400 MHz Nuclear magnetic resonance spectrometer
Probe

5 mm indirect detection gradient NMR probe

Parameters

$^1H \text{NMR}$:
- Observed frequency: 400.1 MHz
- Pulse angle: $30^\circ$
- Acquisition time: 1.995 s
- Acquisition delay: 1.000 s
- Spectral window: 6410 Hz
- Transmitter power: 57 dB
- Variable temperature set @: $25^\circ$C
- Number of transients: 16

$^{13}C \text{NMR}$:
- Observed frequency: 100.6 MHz
- Pulse angle: $45^\circ$
- Acquisition time: 1.202 s
- Acquisition delay: 1.000 s
- Spectral window: 25062 Hz
- Transmitter power: 61 dB
- Decoupler: on
- Decoupler modulation mode: Waltz
- Decoupler modulation frequency: 10100 Hz
- Variable temperature set @: $25^\circ$C
- Number of transients: 1024

Water-d (D$_2$O) or methanol-d (CD$_3$OH) may be employed as the solvent using 2,2-dimethyl-2-silylpentane-5-sulfonate (DSS or DDS) as the internal reference standard.
4. SEPARATION TECHNIQUES

Relatively pure samples may be examined by infrared spectroscopy for the identification of 1,4-butanediol either directly or by solvent extraction. 1,4-butanediol is also readily separated from aqueous solutions by a liquid-liquid extraction using methylene chloride or chloroform. This is also possible for solutions with a matrix such as carbonated sodas.

Aqueous samples could alternatively be analyzed by allowing a portion of the sample to evaporate at low heat. Because 1,4-butanediol has a relatively high boiling point of 230°C, heating the sample on a surface up to 100°C is safe. Many of these samples contain sugars, dyes, and other components of the matrix. Therefore, a chloroform extraction is recommended to obtain a clean IR spectrum. (Garcia, Catterton, 2003)

5. QUANTITATIVE DATA

5.1 GAS CHROMATOGRAPHY

Method 7 - 1,4BDGC1

Internal Standard Stock Solution:
1.2 mg/mL dodecane in methanol*.

Standard Solution Preparation:
Accurately weigh and prepare a standard solution of 1,4-butanediol at approximately 2.0 mg/mL with methanol*.

Sample Preparation:
Accurately weigh the sample to target a final 1,4-butanediol concentration of approximately 2 mg/mL. Dilute to volume with methanol*.

*Note: Another solvent could be considered when gamma-hydroxybutyrate is present since it reacts with methanol to form the gamma-hydroxy methyl ester of GHB.

Instrument: HP 5890 or 6890 gas chromatograph operated in split mode with FID

Column: HP-1 cross-linked methyl siloxane, 15 m x 0.20 mm x 0.33 µm

Carrier gas: Hydrogen at 2.0 mL/min

Temperatures:
Injector: 180°C
Detector: 300°C
Oven program: 80°C for 0.5 minute, ramp 40°C per minute to 100°C, hold 1.5 min

Injection Parameters: Split Ratio = 30:1, 1 µL injected

Typical Retention Time: 1,4-Butanediol: 0.75 min
Dodecane: 2.33 min
**Linear Range:** 1.0 – 4.0 mg/mL

**Repeatability:** RSD less than 2.5%

**Correlation Coefficient:** 0.999

**Accuracy:** Error less than 2%

<table>
<thead>
<tr>
<th>COMPOUND</th>
<th>RRT</th>
<th>COMPOUND</th>
<th>RRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2-butanediol</td>
<td>0.70</td>
<td>1,4-butanediol</td>
<td>1.0 (0.75 min)</td>
</tr>
<tr>
<td>1,3-butanediol</td>
<td>0.76</td>
<td>gamma-hydroxy methyl ester of GHB</td>
<td>1.14</td>
</tr>
<tr>
<td>GBL</td>
<td>0.85</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 6. QUALITATIVE DATA

See spectra on the following pages for FT-IR, Mass Spectrometry, Nuclear Magnetic Resonance, and Vapor Phase IR.

### 7. REFERENCES


### 8. ADDITIONAL RESOURCES

Wikipedia
Transmission IR: 1,4-Butanediol, sample neat between KBr disks
16 scans, 4.0 cm$^{-1}$ resolution

IR (ATR): 1,4-Butanediol, (3-bounce, diamond device)
16 scans, 4.0 cm$^{-1}$ resolution
Electron Ionization MS: 1,4-Butanediol
Quadrapole Detector

IR (Vapor Phase): 1,4-Butanediol
Proton NMR: 1,4-Butanediol (400 MHz)
10 mg/mL in CDCl$_3$ with TMS

Carbon NMR: 1,4-Butanediol (100 MHz)
50 mg/mL in CDCl$_3$ with TMS