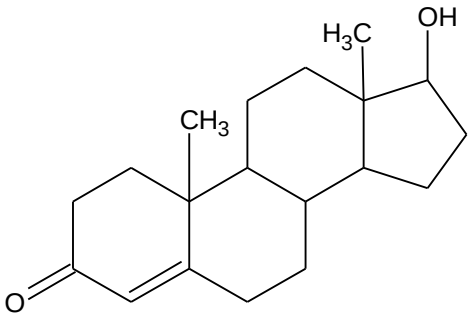
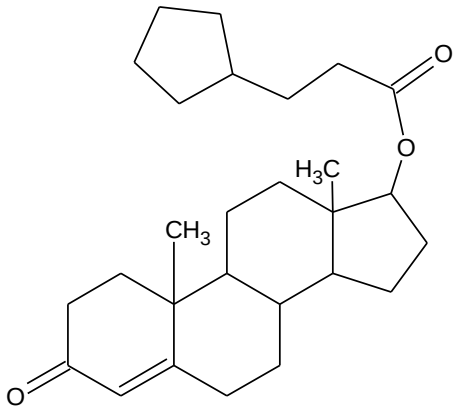
## TESTOSTERONE AND ESTERS*

**Latest Revision: June 23, 2005**

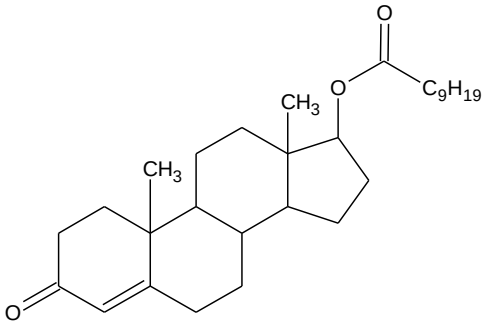
*Other esters of testosterone have been synthesized and identified; however, only the following are treated in this monograph:



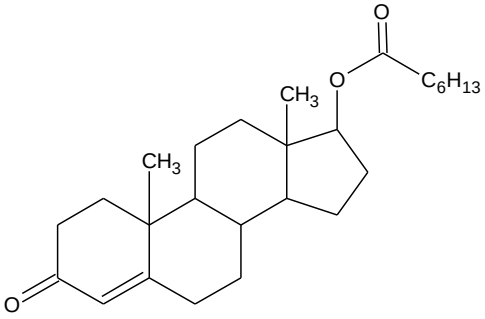

Testosterone



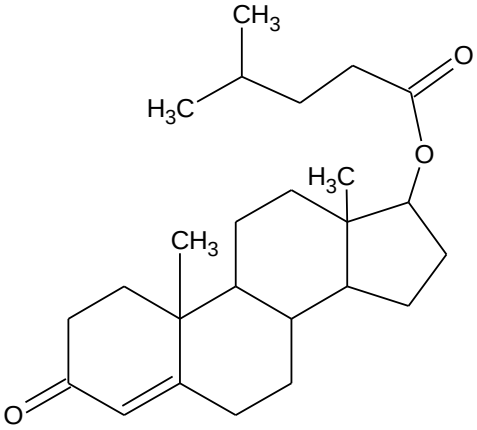

Testosterone Cypionate



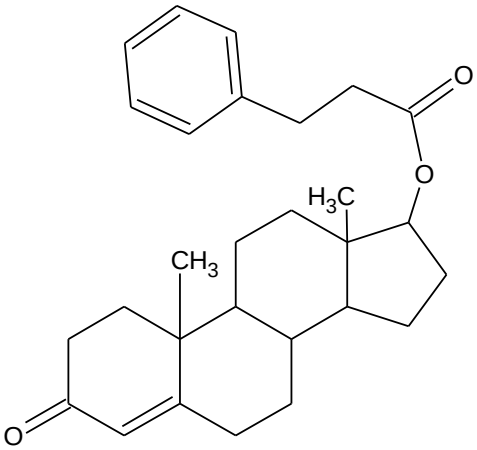

Testosterone Decanoate



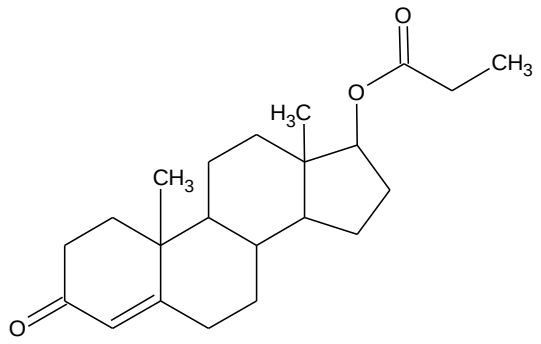

Testosterone Enanthate



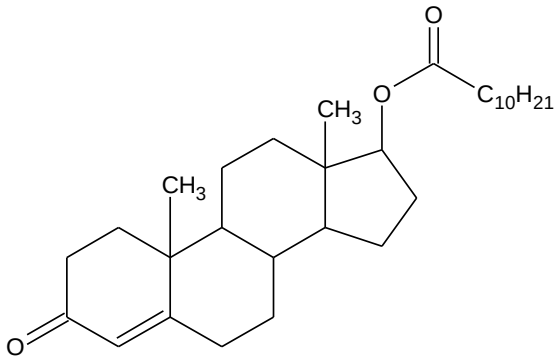

Testosterone Isocaproate




Testosterone Phenylpropionate




Testosterone Propionate




Testosterone Undecanoate

***1. SYNONYMS***

***CFR:***

The Anabolic Steroid Control Act (ASCA) of 1990 amended the Controlled Substances Act to list anabolic steroids as a Schedule III substance. Subsequently, the ASCA of 2003 and 2004 were adopted to clarify the definition of anabolic steroid, listing testosterone and "any salt, ester, or ether of a drug or substance described in this paragraph."

***CAS #:***

| | |
|---|---|
| Testosterone | 58-22-0 |
| Testosterone cypionate | 58-20-8 |
| Testosterone decanoate | 5721-91-5 |
| Testosterone enanthate | 315-37-7 |
| Testosterone isocaproate | 15262-86-9 |
| Testosterone phenylpropionate | 1255-49-8 |
| Testosterone propionate | 57-85-2 |
| Testosterone undecanoate | 5949-44-0 |

***Other Names:***

**Testosterone:**
17β-Hydroxyandrost-4-ene-3-one
4-Androsten-17β-ol-3-one
*trans*-Testosterone
Androst-4-en-17β-ol-one
Andro
Androderm
Androlin
Testoderm
Testred

**Testosterone cypionate:**
17β-Hydroxyandrost-4-ene-3-one cyclopentanepropionate
Testosterone cyclopentylpropionate

Depo-Testosterone
depAndro
Virolon

**Testosterone decanoate:**
17β-Hydroxyandrost-4-ene-3-one decanoate
Testosterone caprate

**Testosterone enanthate:**
17β-Hydroxyandrost-4-ene-3-one enanthate
17β-Hydroxyandrost-4-ene-3-one-17-enanthate
Testosterone heptanoate
Andro LA
Delatestryl
Testinon
Testo-Enant

**Testosterone isocaproate:**
17β-Hydroxyandrost-4-ene-3-one isocaproate
Testosterone 4-methylvalerate

**Testosterone phenylpropionate:**
17β-Hydroxyandrost-4-ene-3-one Phenylpropionate
Testosterone phenpropionate
Testosterone hydrocinnamate
Retandrol

**Testosterone propionate:**
17β-Hydroxyandrost-4-ene-3-one propionate
Testosterone-17-propionate
17-(1-Oxopropoxy)-(17β)-androst-4-en-3-one

**Testosterone undecanoate:**
17β-Hydroxyandrost-4-ene-3-one undecanoate
4-Androsten-17β-ol-3-one undecanoate
17-[(1-Oxoundecyl)oxy]-androst-4-en-3-one

## *2. CHEMICAL AND PHYSICAL DATA*

### *2.1. CHEMICAL DATA*

| COMPOUND | Chemical Formula | Molecular Weight | Melting Point (°C) |
|---|---|---|---|
| Testosterone | $C_{19}H_{28}O_2$ | 288.4 | 154 |
| Testosterone cypionate | $C_{27}H_{40}O_3$ | 412.6 | 101-102 |
| Testosterone decanoate | $C_{29}H_{46}O_3$ | 442.6 | 48-54 |

| | | | |
|---|---|---|---|
| Testosterone enanthate | $C_{26}H_{40}O_3$ | 400.5 | 36-37 |
| Testosterone isocaproate | $C_{25}H_{38}O_3$ | 386.5 | 77-79 |
| Testosterone phenylpropionate | $C_{28}H_{36}O3$ | 420.5 | 116 |
| Testosterone propionate | $C_{22}H_{32}O_3$ | 344.4 | 120 |
| Testosterone undecanoate | $C_{30}H_{48}O_3$ | 456.6 | 61 |

### *2.2. SOLUBILITY*

| COMPOUND | A | C | E | H | M | W |
|---|---|---|---|---|---|---|
| testosterone (T) | S | VS | PS | SS | FS | I |
| T. cypionate | FS | FS | FS | PS | FS | I |
| T. decanoate | VS | VS | VS | VS | VS | I |
| T. enanthate | VS | VS | VS | S | VS | I |
| T. isocaproate | S | VS | VS | PS | S | I |
| T. phenylpropionate | FS | S | PS | I | S | VSS |
| T. propionate | FS | VS | FS | PS | FS | I |
| T. undecanoate | VS | VS | VS | VS | VS | I |

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

| COMPOUND | SULFURIC ACID | MANDELIN'S |
|---|---|---|
| Testosterone | N/R | faint orange |
| Testosterone cypionate | N/R | N/R |
| Testosterone decanoate | slow orange | faint orange |
| Testosterone enanthate | N/R | N/R |
| Testosterone | slow orange | slow orange |

| | | |
|---|---|---|
| isocaproate | | |
| Testosterone phenylpropionate | N/R | faint aqua |
| Testosterone propionate | N/R | N/R |
| Testosterone undecanoate | N/R | N/R |

### *3.2.* CRYSTAL TESTS

Currently, there are no reliable crystal tests.

### *3.3.* THIN-LAYER CHROMATOGRAPHY

**Visualization**

Sulfuric acid: ethanol spray (1:9)

| COMPOUND | RELATIVE R1 SYSTEM TLC19 |
|---|---|
| **testosterone** | 1.00 |
| testosterone undecanoate | 0.17 |
| testosterone decanoate | 0.22 |
| testosterone cypionate | 0.35 |
| testosterone enanthate | 0.40 |
| testosterone isocaproate | 0.50 |
| testosterone phenylpropionate | 0.55 |
| testosterone propionate | 0.72 |

### *3.4.* GAS CHROMATOGRAPHY

***Method Test-GCS1***

***Instrument:*** Gas chromatograph operated in split mode with FID

***Column:*** 5% phenyl/95% methyl silicone 12 m x 0.2 mm x 0.33 µm film thickness

***Carrier gas:*** Helium at 1.0 mL/min

***Temperatures:*** Injector: 250°C

Detector: 280°C
Oven program:
1) 180°C initial temperature for 2.0 min
2) Ramp to 280°C at 25°C/min
3) Hold final temperature for 12.0 min

***Injection Parameters:*** Split Ratio = 60:1, 1 µL injected

Samples are to be dissolved in appropriate solvent (chloroform) and filtered.

| COMPOUND | RRT |
|---|---|
| **testosterone** | **1.0 (5.81 min.)** |
| testosterone propionate | 1.1 |
| testosterone isocaproate | 1.3 |
| testosterone enanthate | 1.5 |
| testosterone cypionate | 1.9 |
| testosterone phenylpropionate | 2.2 |
| testosterone decanoate | 2.3 |
| testosterone undecanoate | 2.6 |

### *3.5 HIGH PERFORMANCE LIQUID CHROMATOGRAPHY*

***Method Test-LCS1***

***Instrument:*** High performance liquid chromatograph equipped with diode array

***Column:*** Phenomenex Aqua C-18 5 µm; 150 mm x 4.6 mm

***Detector:*** UV, 240 nm

***Flow:*** 1.0 mL/min

***Injection Volume:*** 5.0 µL

***Buffer:*** 90:10 MeOH:$H_2O$

***Mobile Phase:*** 90:10 MeOH:$H_2O$

Samples are to be dissolved in methanol and filtered with a 0.45-micron filter.

| COMPOUND | RRT |
|---|---|
| **testosterone** | **1.00 (2.9 min)** |
| testosterone propionate | 1.62 |
| testosterone phenylpropionate | 2.47 |
| testosterone isocaproate | 2.86 |
| testosterone enanthate | 3.45 |
| testosterone cypionate | 3.79 |
| testosterone decanoate | 8.11 |
| testosterone undecanoate | 10.65 |

### *3.6 NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY*

*Sample preparation:*
Use ca. 5 to 10 mg of sample for proton NMR and 30 mg for carbon NMR. Dissolve sample in chloroform-d ($CDCl_3$) 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***

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

*$^{13}C$ NMR:*
Observed frequency: 100.6 MHz
Pulse angle: 45°
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°C
Number of transients: 1024

## *4. SEPARATION TECHNIQUES*

Testosterone and its esters are generally encountered in one of three forms: tablets, suspensions or dissolved in oils. Isolation from tablets is achieved by direct extraction with chloroform or methylene chloride. Following evaporation of the solvent, the residue may be suitable for infrared identification or mass spectrometer identification in the case of multi-entity preparations. Isolation of the steroid(s) from suspensions is achieved by separating the liquid and drying the resultant powder. The powder is then analyzed similarly as above. Testosterone and its esters, when dissolved in an oil matrix, are impossible to identify by infrared and can cause fouling of other types of instrumentation. Solid-phase extraction is a simple and effective means to isolate the steroid(s) for identification. Approximately five to seven drops of the oil solution is dissolved in pet ether or hexanes and added to a solid-phase extraction cartridge filled with silica. After washing the cartridge with the same solvent, the steroid(s) are eluted from the cartridge with acetone and analyzed as above.

## *5. QUANTITATIVE PROCEDURES*

### *5.1* HIGH PERFORMANCE LIQUID CHROMATOGRAPHY

***Method Test-LCQ1***

*Standard Solution Preparation:*
Accurately weigh and prepare a standard solution of the appropriate testosterone ester at approximately 0.5 mg/mL using methanol.

*Sample Preparation*:
For powder or other solid dosage forms, accurately weigh an amount of sample into a volumetric flask and dilute with methanol. For aqueous suspensions, insure that the sample is well mixed, then pipette an aliquot into a volumetric flask and dilute with methanol. If necessary, dilute the sample so the final concentration approximates the standard concentration. Filter sample with a 0.45-micron filter. (Recovery studies have not been performed for steroids dissolved in oil matrices, so this method is not validated for testosterone and/or its esters dissolved in oil. Literature suggests that quantitative recoveries can be obtained by multiple extractions with methanol [Walters, et al].)

| | |
|---|---|
| ***Instrument:*** | High performance liquid chromatograph equipped with diode array |
| ***Column:*** | Phenomenex Aqua C-18 5 µm; 150 mm x 4.6 mm |
| ***Detector:*** | UV, 240 nm |
| ***Flow:*** | 1.00 mL/min |
| ***Injection Volume:*** | 5.0 µL |
| ***Buffer:*** | 90:10 MeOH:$H_2O$ |

***Mobile Phase:*** 90:10 MeOH:$H_2O$

***Typical Retention Time:*** Testosterone: 2.9 min.
Testosterone enanthate: 10.0 min
Testosterone cypionate: 11.0 min
Testosterone propionate: 4.7 min

***Linear Range:*** 0.25 - 1.0 mg/mL

***Repeatability:*** RSD less than 0.5%

***Correlation Coefficient:*** 0.9999

***Accuracy:*** Error less than 5%

| COMPOUND | RRT |
|---|---|
| **testosterone** | **1.00 (2.9 min)** |
| testosterone propionate | 1.62 |
| testosterone enanthate | 3.45 |
| testosterone cypionate | 3.79 |

### *6. QUALITATIVE DATA*

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

### *7. REFERENCES*

Analytical Methods for the Analysis of Steroids; (FFS-630-01); DEA Special Testing and Research Laboratory, February 22, 1991.

Analytical Profiles of Anabolic Steroids; CND Analytical: Auburn, AL, 1989.

Budavari, S., The Merck Index, 13 Edition, Merck and Co., Inc., 2001, p.1638

Chiong DM, Consuegra-Rodriguez E, Almirall JR, “The Analysis and Identification of Steroids”, Journal of Forensic Sciences, Vol. 37, No. 2, October 1987, pp. 488-502.

Colman, P.D.; Hearn, E.A.; Taylor, R.W.; Le, S.D. "Anabolic Steroids-Analysis of Dosage Forms from Selected Case Studies from the Los Angeles County Sheriff's Scientific Services Bureau"; Journal of Forensic Sciences; 1991, Vol. 36, pp 1079-1088.

De Beer, J.O. "On-Line High Performance Liquid Chromatographic Diode Array Spectrometric Analysis of Steroidal Hormones in Illicit Preparations"; Journal of Chromatography; 1989, Vol. 489, pp 139-155.

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Lurie, I.S.; Sperling, A.R.; Meyers, R.P. "The Determination of Anabolic Steroids by MECC, Gradient HPLC, and Capillary GC"; Journal of Forensic Sciences; 1994, Vol. 39, pp 74-85.

Moffat A.C., Sr. Ed., Clarke's Isolation and Identification of Drugs, The Pharmaceutical Press, London, Second Edition 1986, p.1003.

Walters, M.J.; Ayers, R.J.; Brown, D.J. "Analysis of Illegally Distributed Steroid Products by Liquid Chromatography with Identity Confirmation by Mass Spectrometry or Infrared Spectrometry"; JAOAC; 1990, Vol. 73, No.6, pp 904-926.

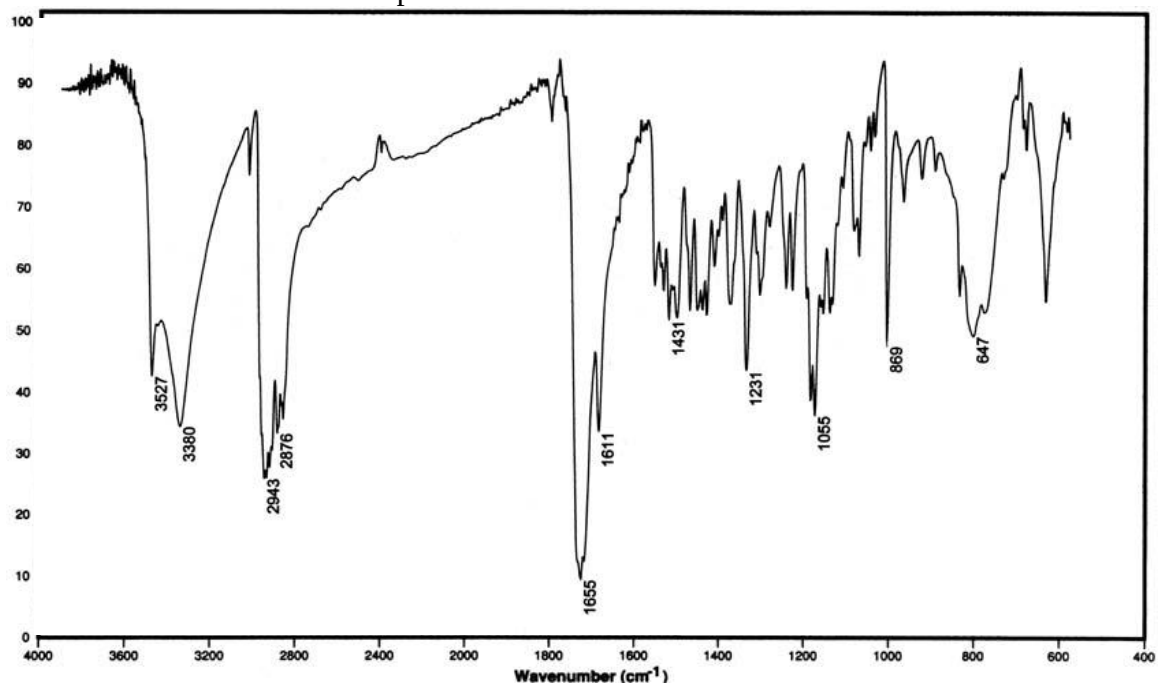
Zaretskii, V.I. Mass Spectrometry of Steroids; New York, Wiley; 1976.

***8. ADDITIONAL RESOURCES***

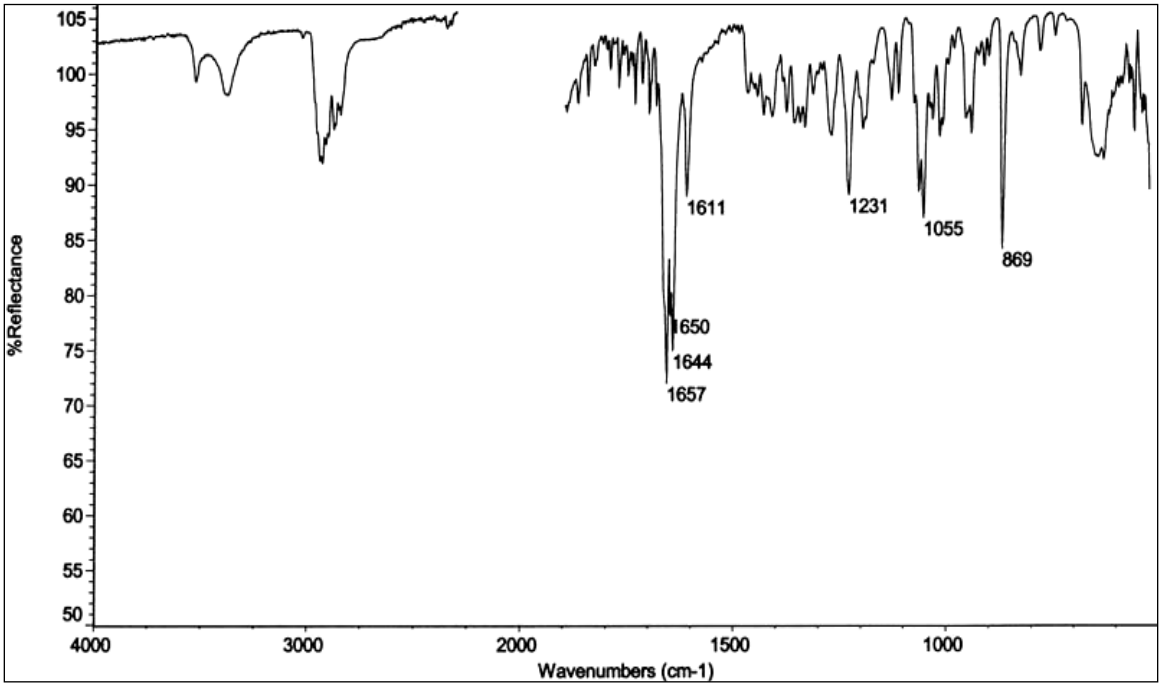
Forendex

Wikipedia

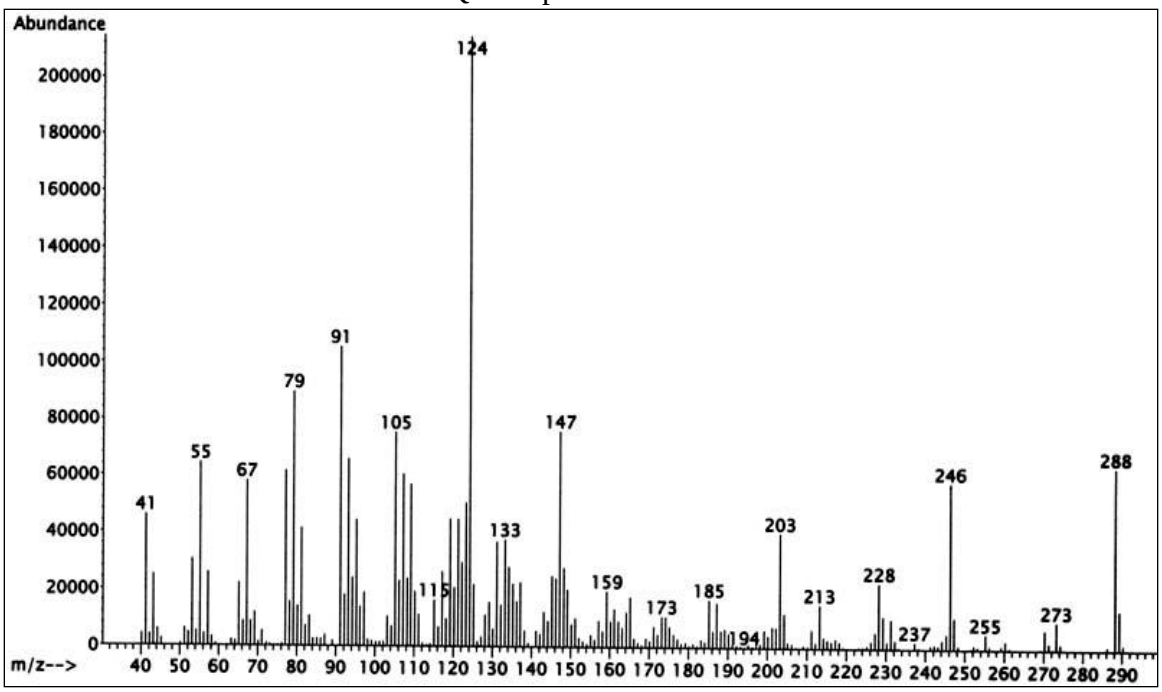
Transmission IR:  Testosterone
16 scans, 4.0 cm-1 resolution
Sample in Potassium Bromide matrix



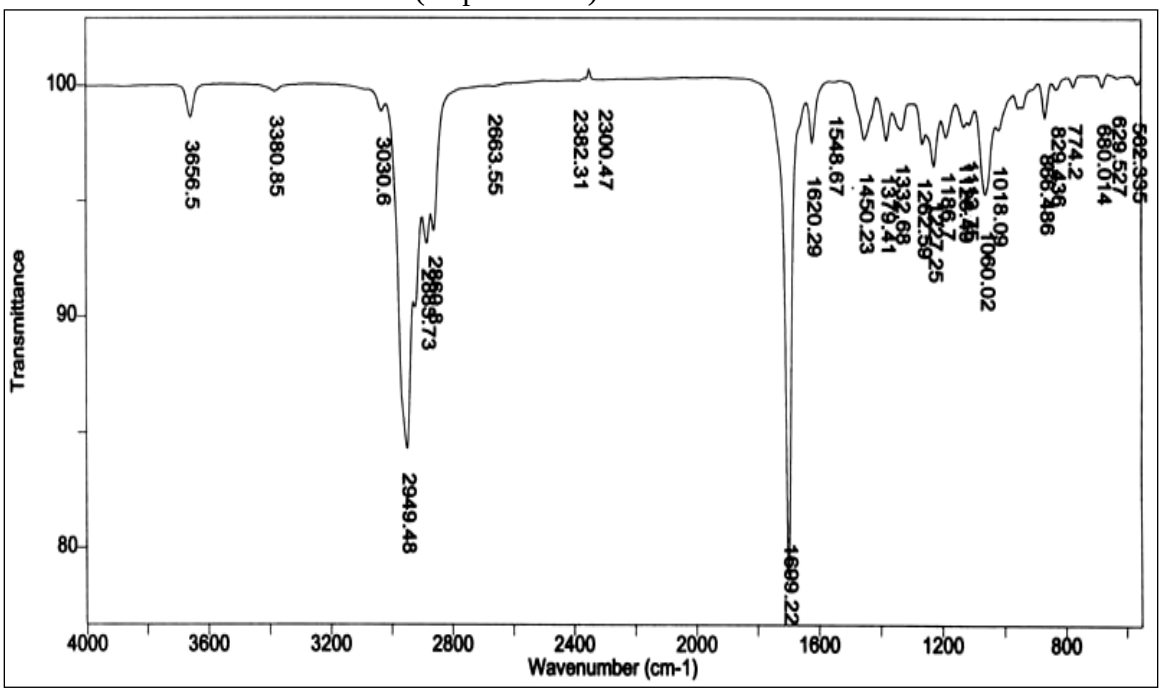

IR (ATR, 3-bounce, diamond device):  Testosterone
16 scans, 4.0 cm-1 resolution



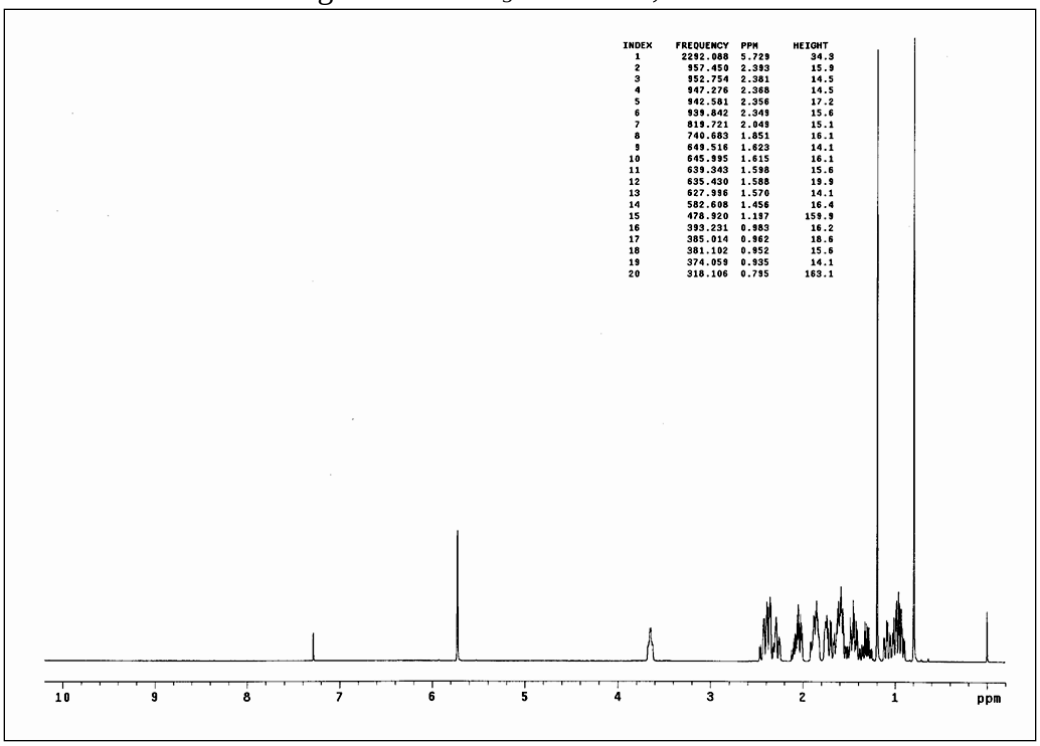
MS (EI): Testosterone
Quadrupole Detector



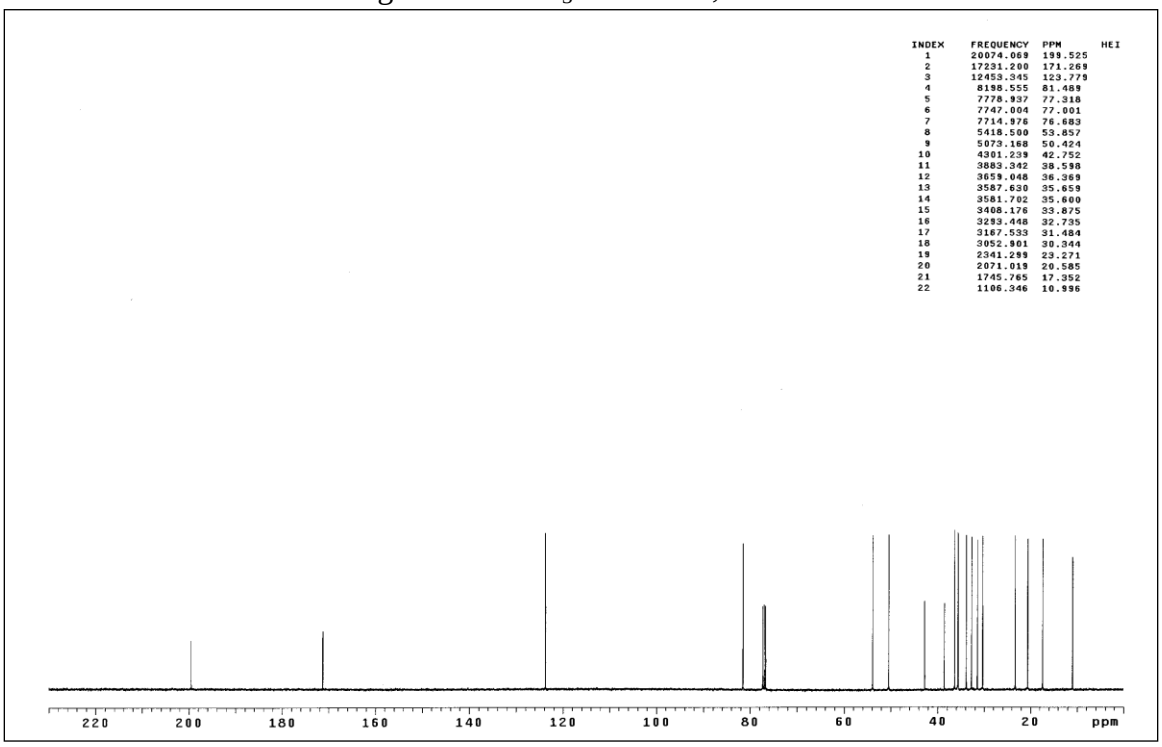

IR (Vapor Phase): Testosterone



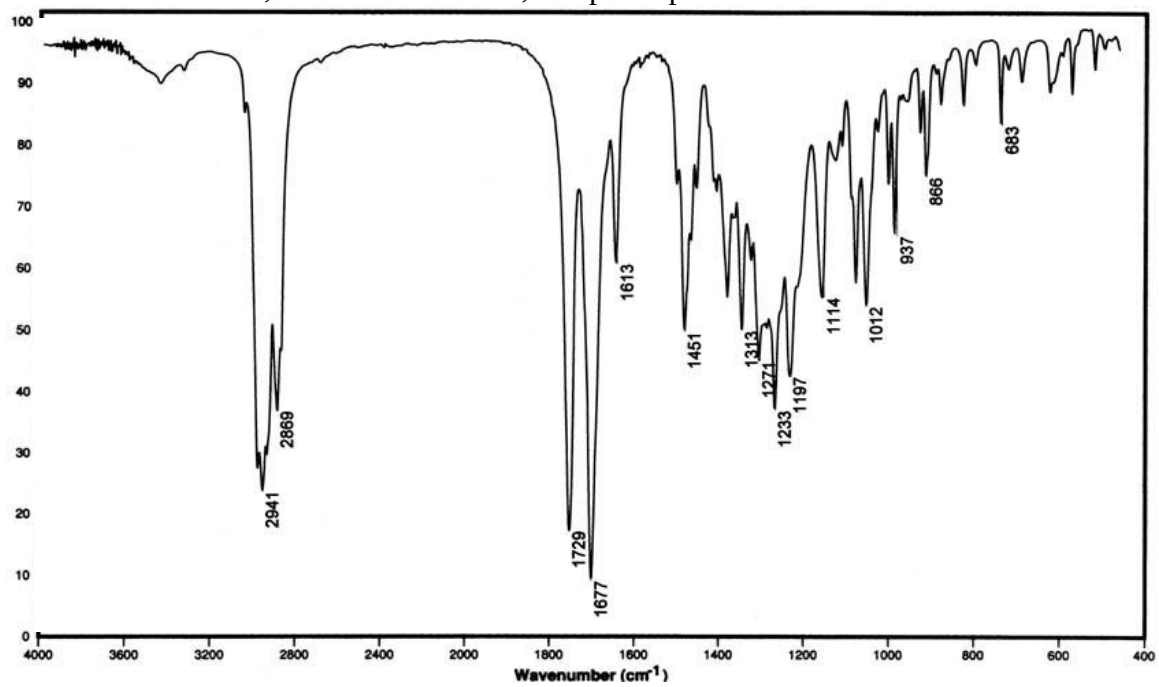
NMR (PROTON):  Testosterone
10 mg/mL in $CDCl_3$ with TMS, 400 MHz



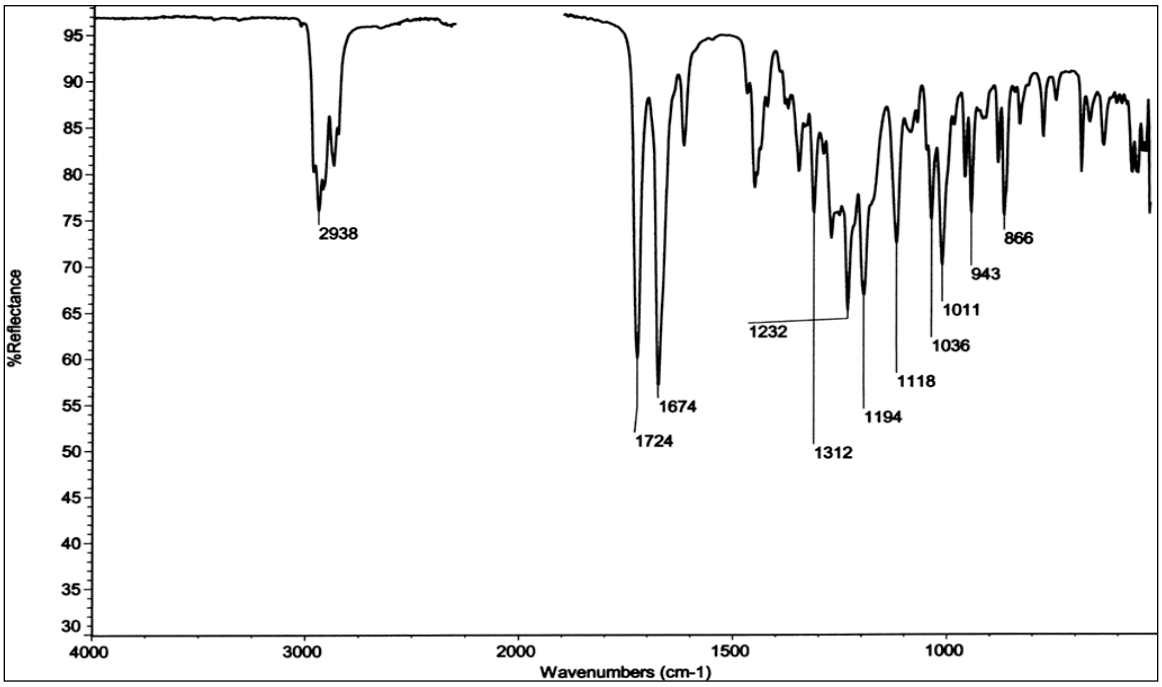

NMR (CARBON):  Testosterone
50 mg/mL in $CDCl_3$ with TMS, 100 MHz



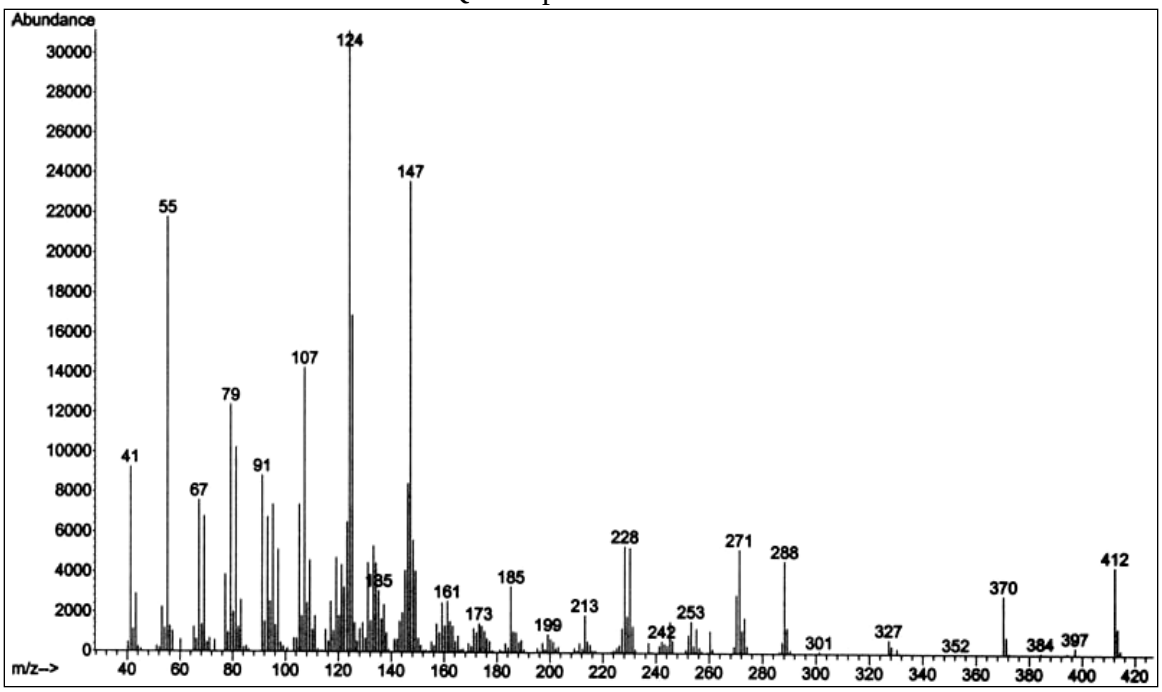
Transmission IR: Testosterone cypionate
16 scans, 4.0 $cm^{-1}$ resolution, sample in potassium bromide matrix



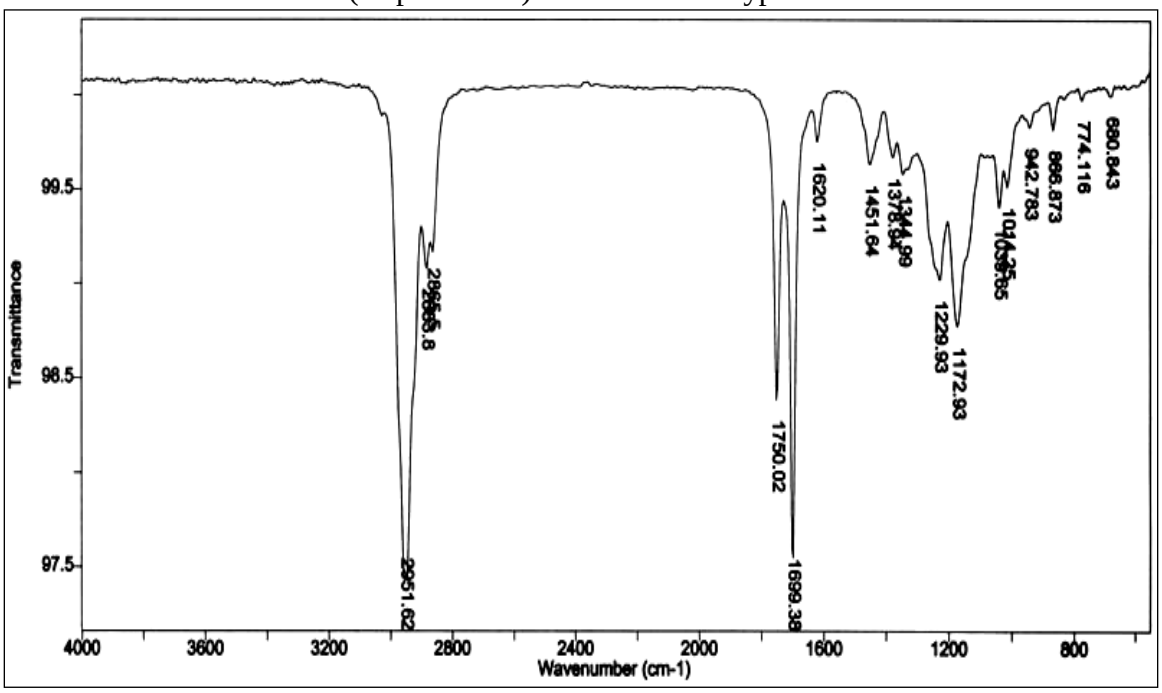

IR (ATR, 3-bounce, diamond device): Testosterone cypionate
16 scans, 4.0 $cm^{-1}$ resolution



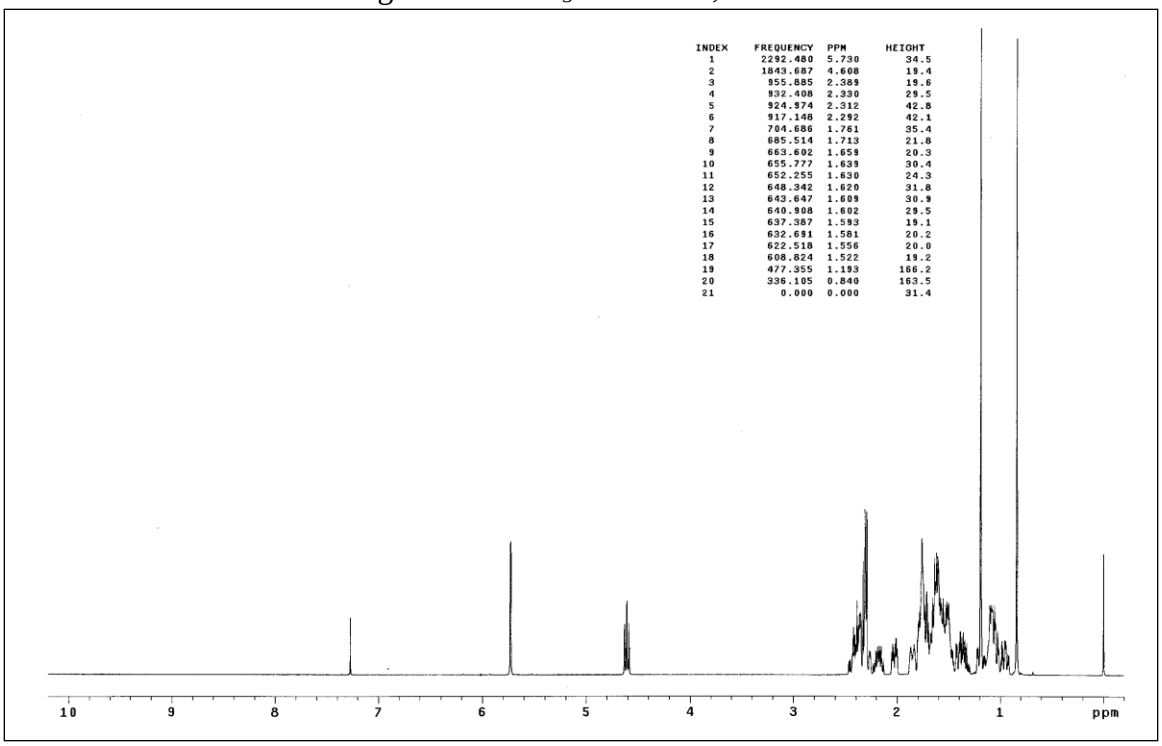
MS (EI):  Testosterone cypionate
Quadrupole Detector




IR (Vapor Phase):  Testosterone cypionate



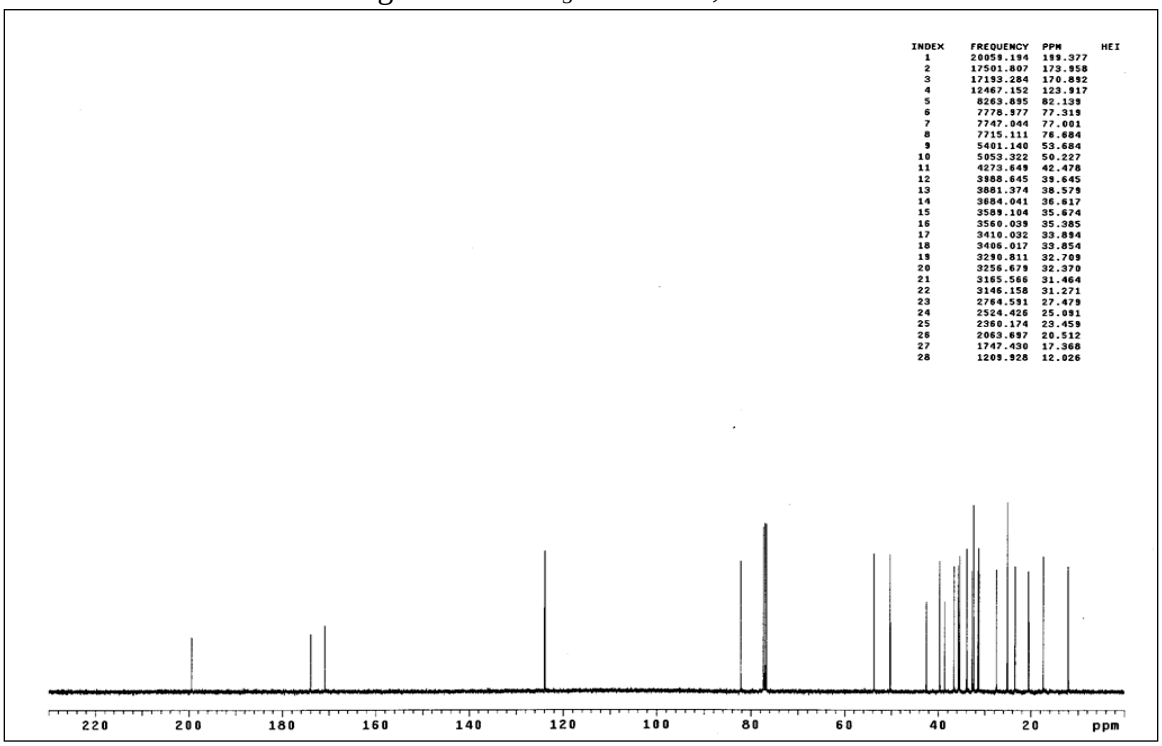
NMR (PROTON): Testosterone cypionate
10 mg/mL in $CDCl_3$ with TMS, 400 MHz



| INDEX | FREQUENCY | PPM | HEIGHT |
|---|---|---|---|
| 1 | 2292.480 | 5.730 | 34.5 |
| 2 | 1843.687 | 4.608 | 19.4 |
| 3 | 955.885 | 2.389 | 19.6 |
| 4 | 932.408 | 2.330 | 29.5 |
| 5 | 924.974 | 2.312 | 42.8 |
| 6 | 917.148 | 2.292 | 42.1 |
| 7 | 704.686 | 1.761 | 35.4 |
| 8 | 685.514 | 1.713 | 21.8 |
| 9 | 663.602 | 1.659 | 20.3 |
| 10 | 655.777 | 1.639 | 30.4 |
| 11 | 652.255 | 1.630 | 24.3 |
| 12 | 648.342 | 1.620 | 31.8 |
| 13 | 643.647 | 1.609 | 30.9 |
| 14 | 640.908 | 1.602 | 29.5 |
| 15 | 637.387 | 1.593 | 19.1 |
| 16 | 632.691 | 1.581 | 20.2 |
| 17 | 622.518 | 1.556 | 20.0 |
| 18 | 608.824 | 1.522 | 19.2 |
| 19 | 477.355 | 1.193 | 166.2 |
| 20 | 336.105 | 0.840 | 163.5 |
| 21 | 0.000 | 0.000 | 31.4 |

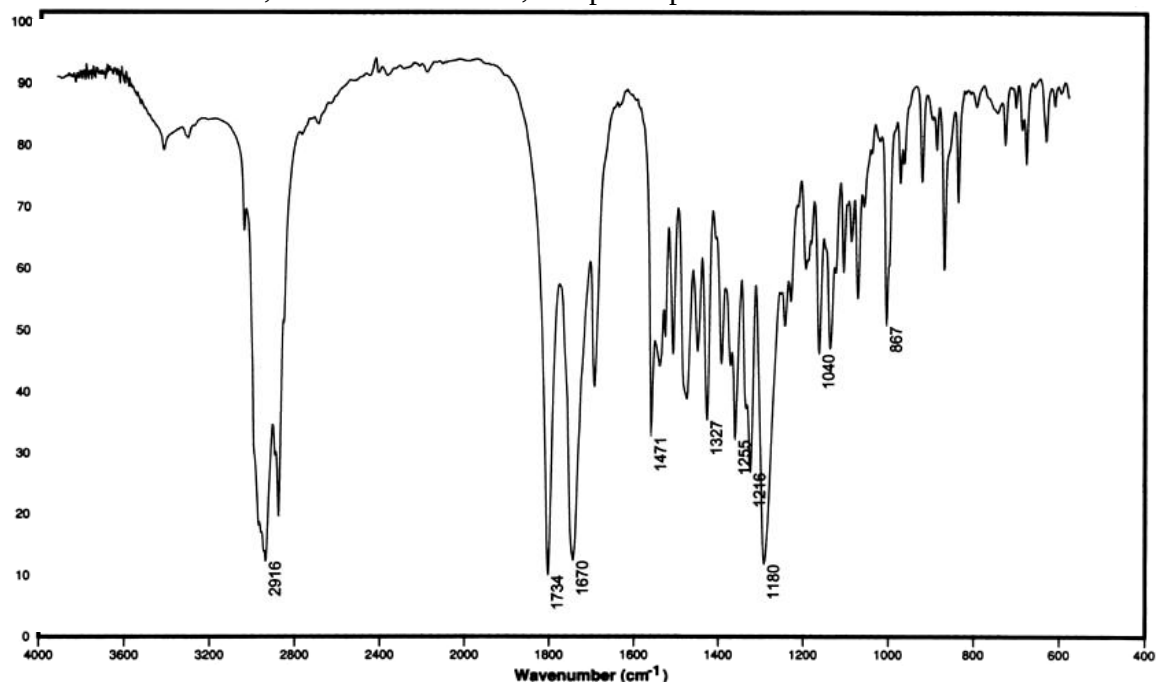


NMR (CARBON): Testosterone cypionate
50 mg/mL in $CDCl_3$ with TMS, 100 MHz

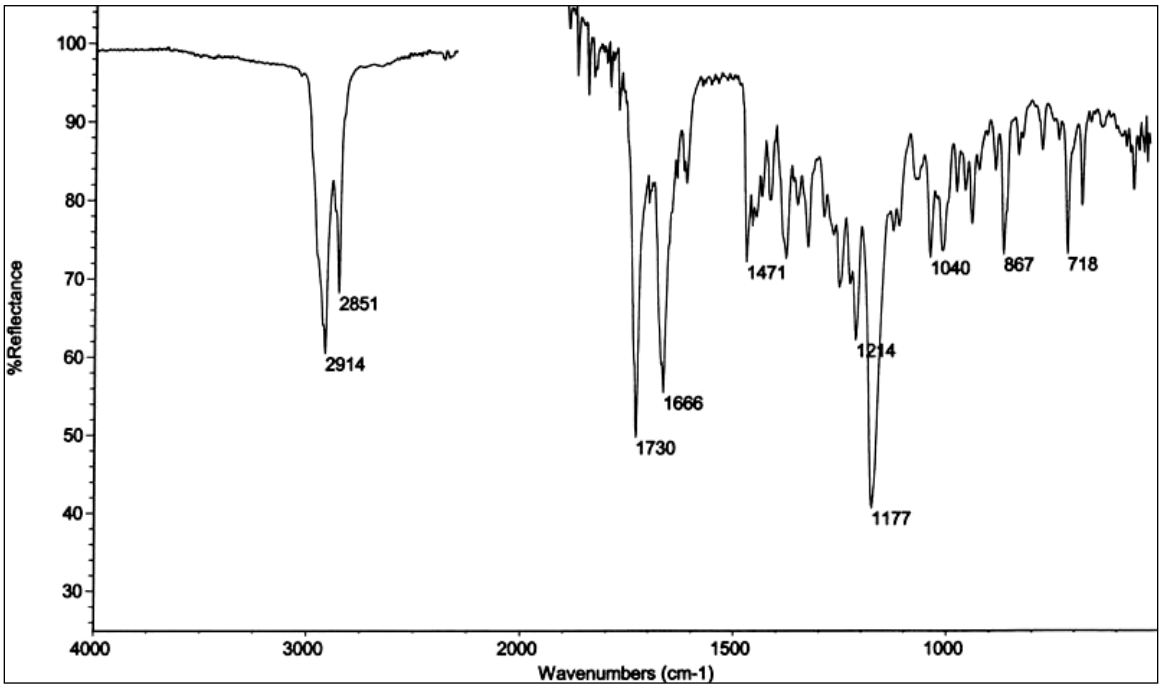


| INDEX | FREQUENCY | PPM | HEI |
|---|---|---|---|
| 1 | 20059.194 | 159.377 | |
| 2 | 17501.807 | 173.958 | |
| 3 | 17193.284 | 170.892 | |
| 4 | 12467.152 | 123.917 | |
| 5 | 8263.895 | 82.139 | |
| 6 | 7778.977 | 77.319 | |
| 7 | 7747.044 | 77.001 | |
| 8 | 7715.111 | 76.684 | |
| 9 | 5401.140 | 53.684 | |
| 10 | 5053.322 | 50.227 | |
| 11 | 4273.649 | 42.478 | |
| 12 | 3868.645 | 38.645 | |
| 13 | 3881.374 | 38.579 | |
| 14 | 3684.041 | 36.617 | |
| 15 | 3589.104 | 35.674 | |
| 16 | 3560.039 | 35.385 | |
| 17 | 3410.032 | 33.894 | |
| 18 | 3406.017 | 33.854 | |
| 19 | 3290.811 | 32.709 | |
| 20 | 3256.679 | 32.370 | |
| 21 | 3165.566 | 31.464 | |
| 22 | 3146.158 | 31.271 | |
| 23 | 2764.591 | 27.479 | |
| 24 | 2524.426 | 25.091 | |
| 25 | 2360.174 | 23.459 | |
| 26 | 2063.697 | 20.512 | |
| 27 | 1747.430 | 17.368 | |
| 28 | 1209.928 | 12.026 | |

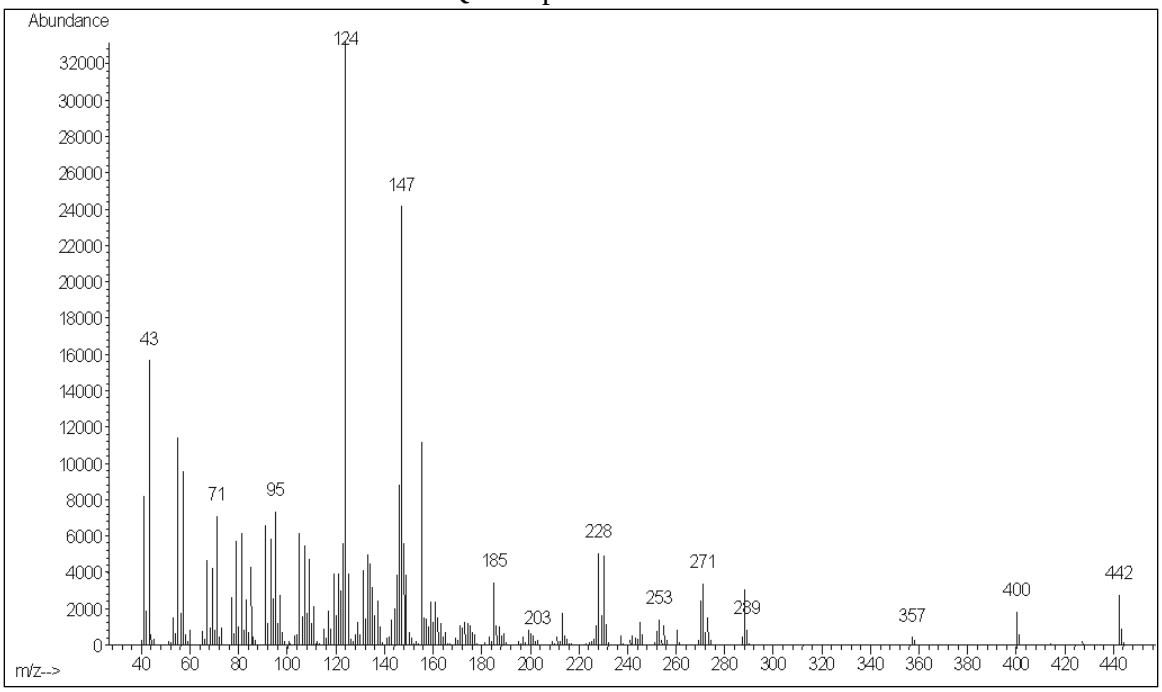
Transmission IR: Testosterone decanoate
16 scans, 4.0 $cm^{-1}$ resolution, sample in potassium bromide matrix



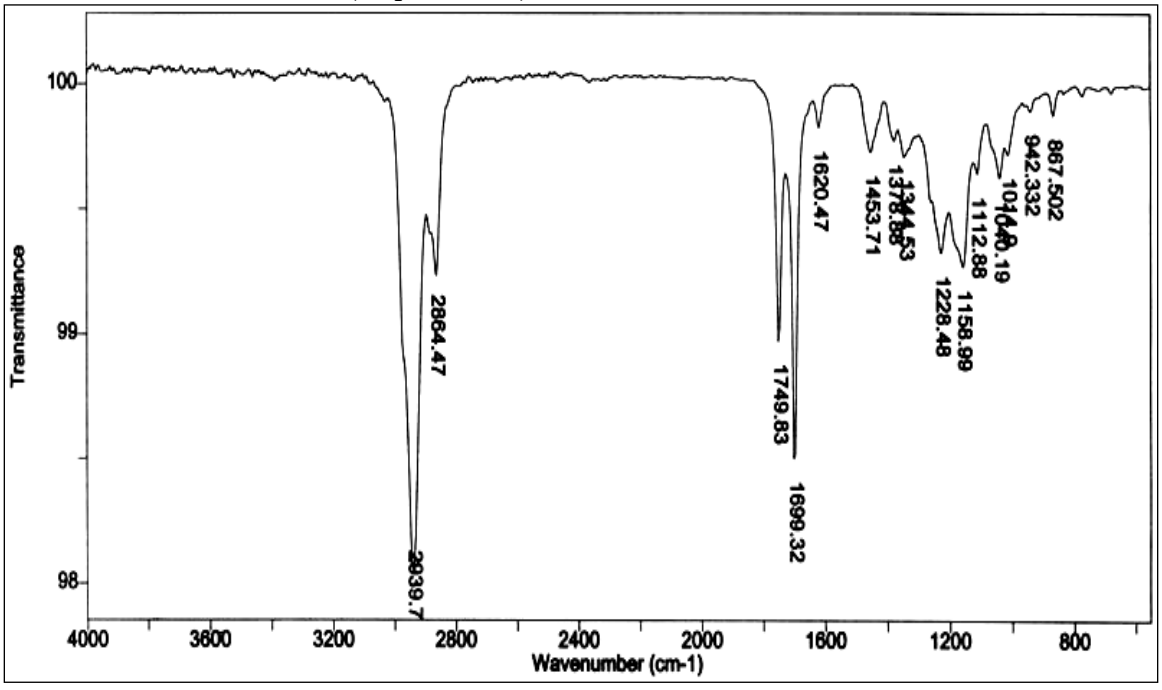

IR (ATR, 3-bounce, diamond device): Testosterone decanoate
16 scans, 4.0 cm-1 resolution



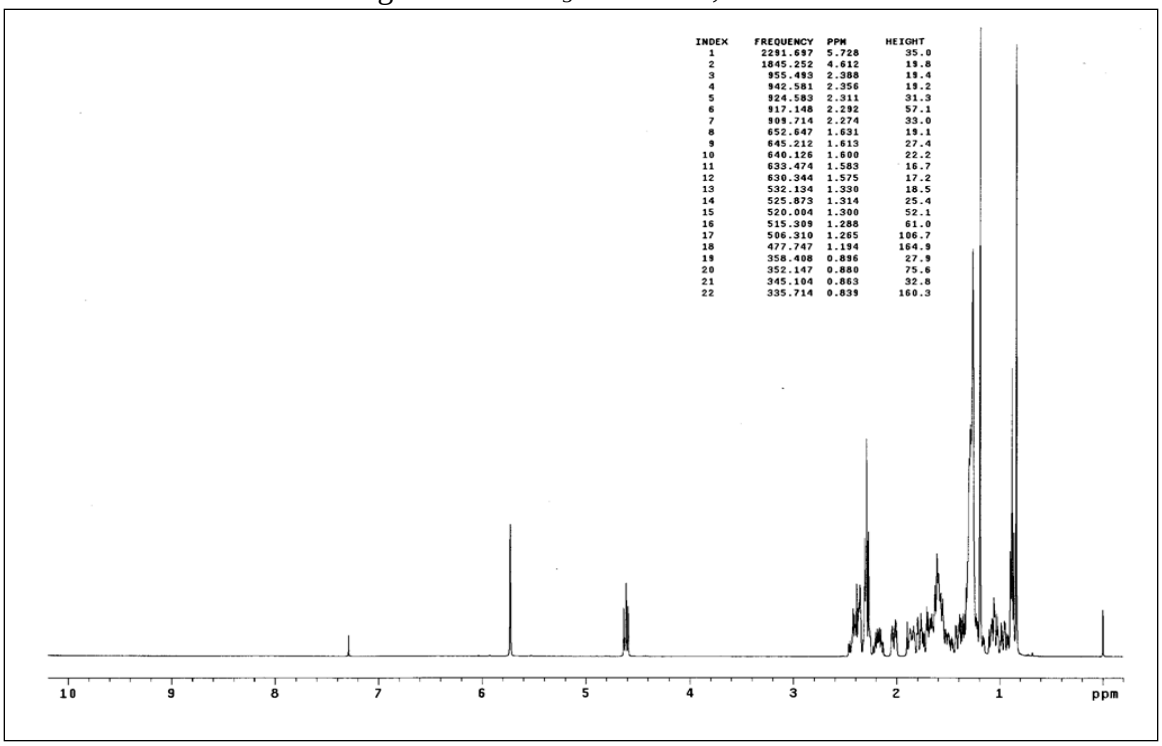
MS (EI): Testosterone decanoate
Quadrupole Detector



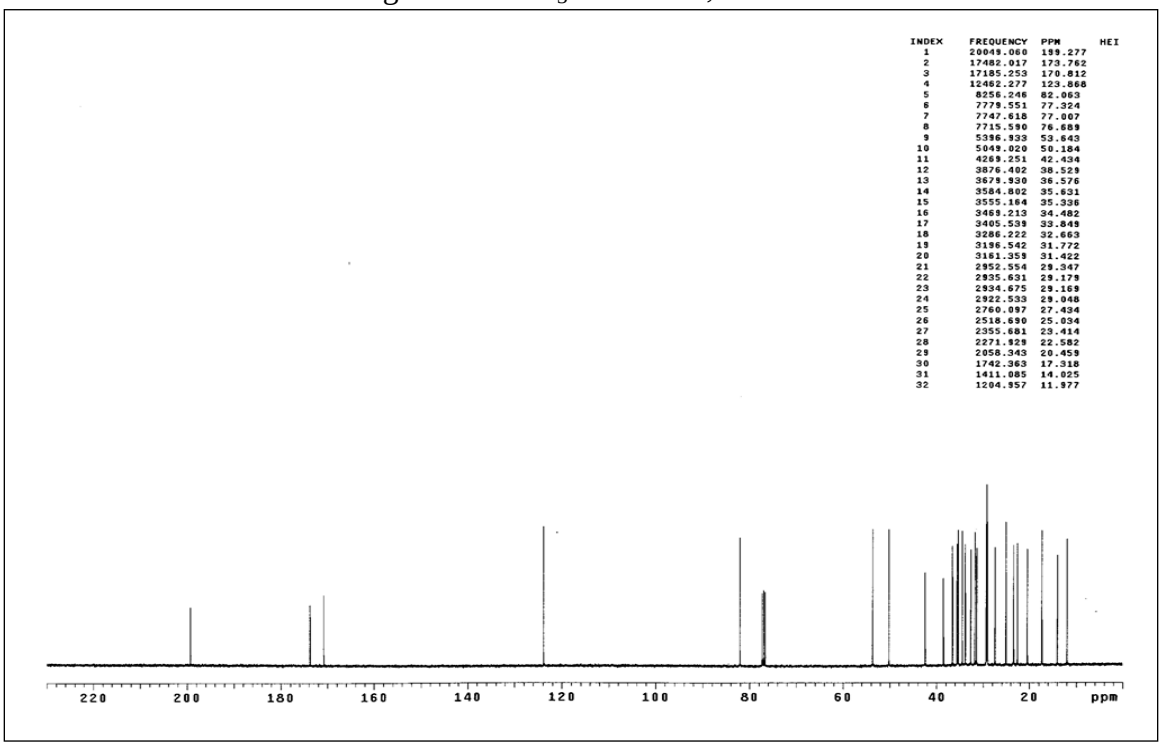

IR (Vapor Phase): Testosterone decanoate



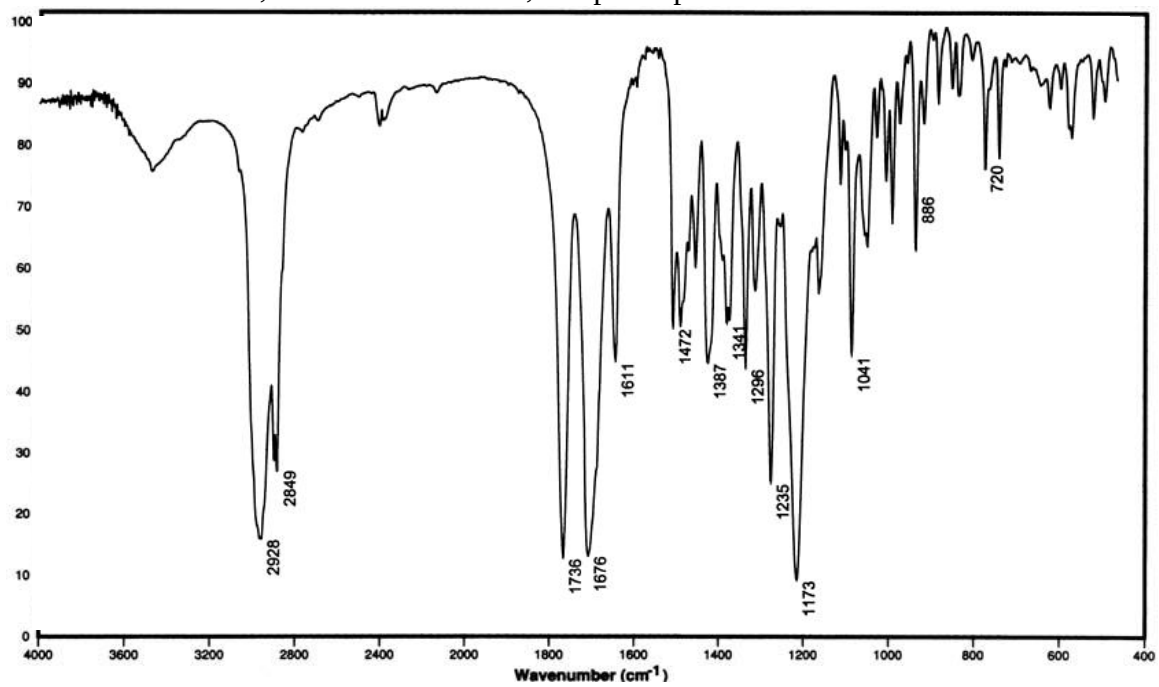
NMR (PROTON): Testosterone Decanoate
10 mg/mL in $CDCl_3$ with TMS, 400 MHz



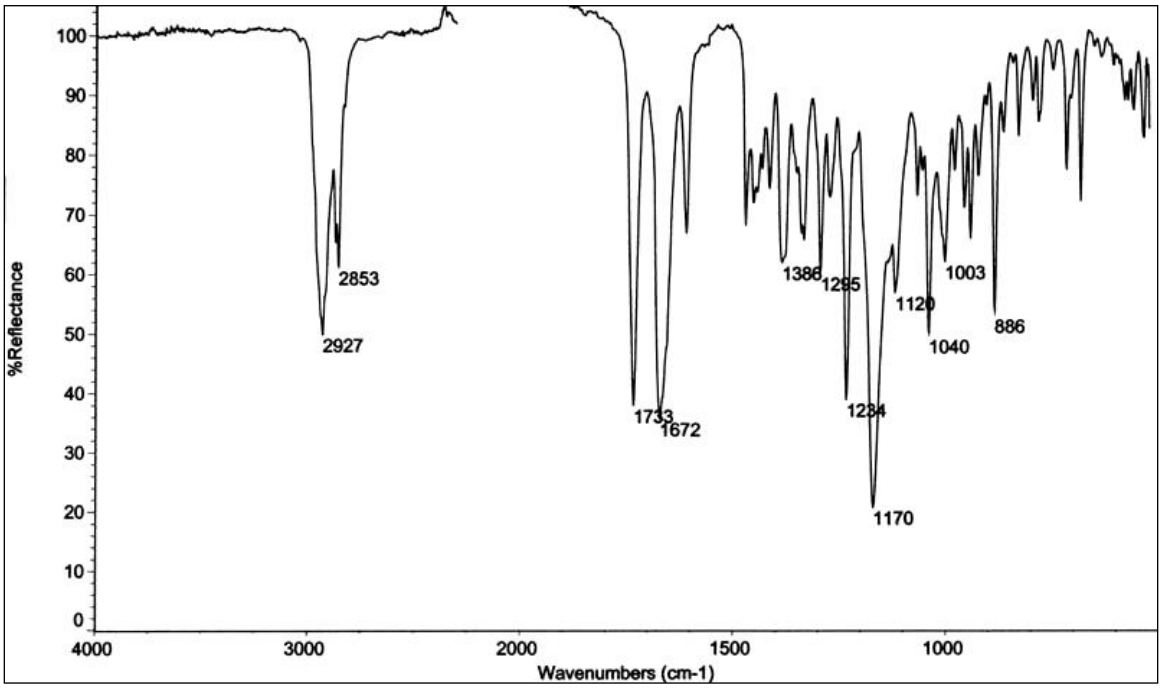

NMR (CARBON) Testosterone decanoate
50 mg/m: in $CDCl_3$ with TMS, 100 MHz



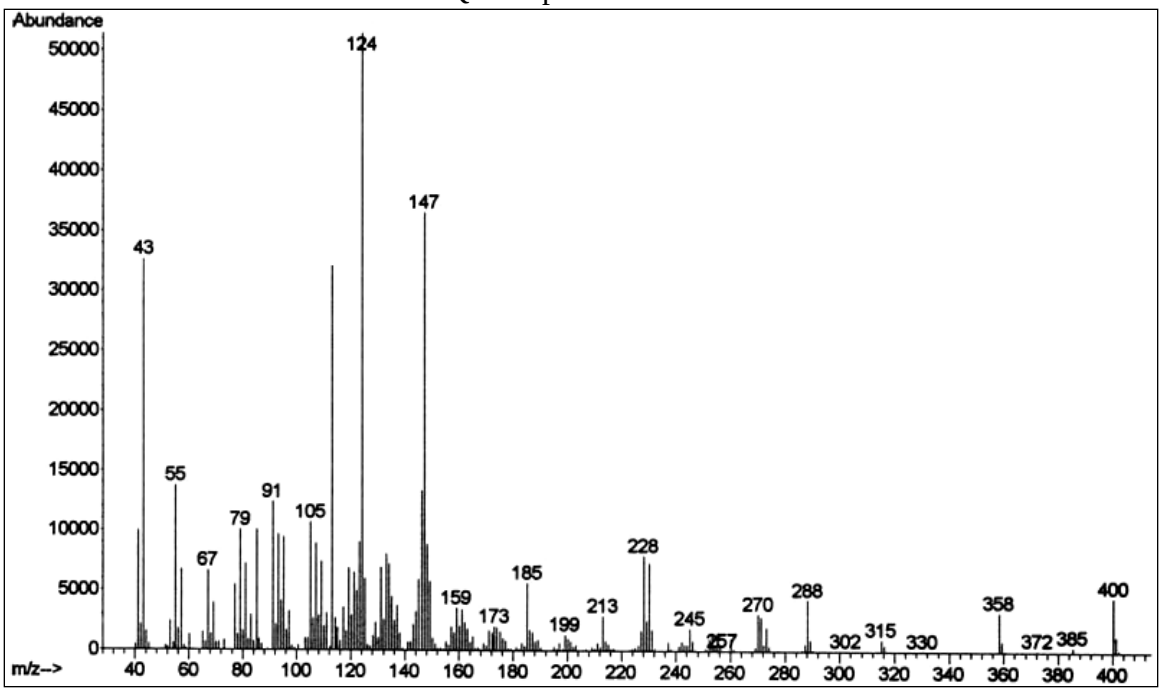
Transmission IR:  Testosterone enanthate
16 scans, 4.0 cm-1 resolution, sample in potassium bromide matrix



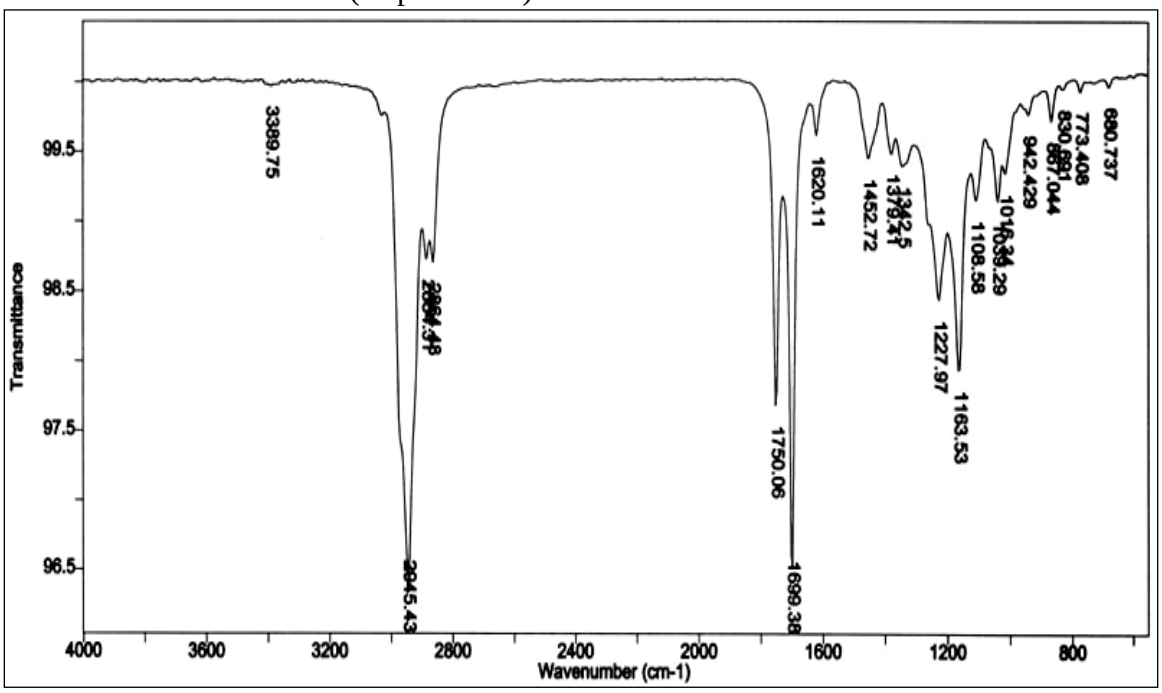

IR (ATR 3-bounce, diamond device):  Testosterone enanthate
16 scans, 4.0 $cm^{-1}$ resolution



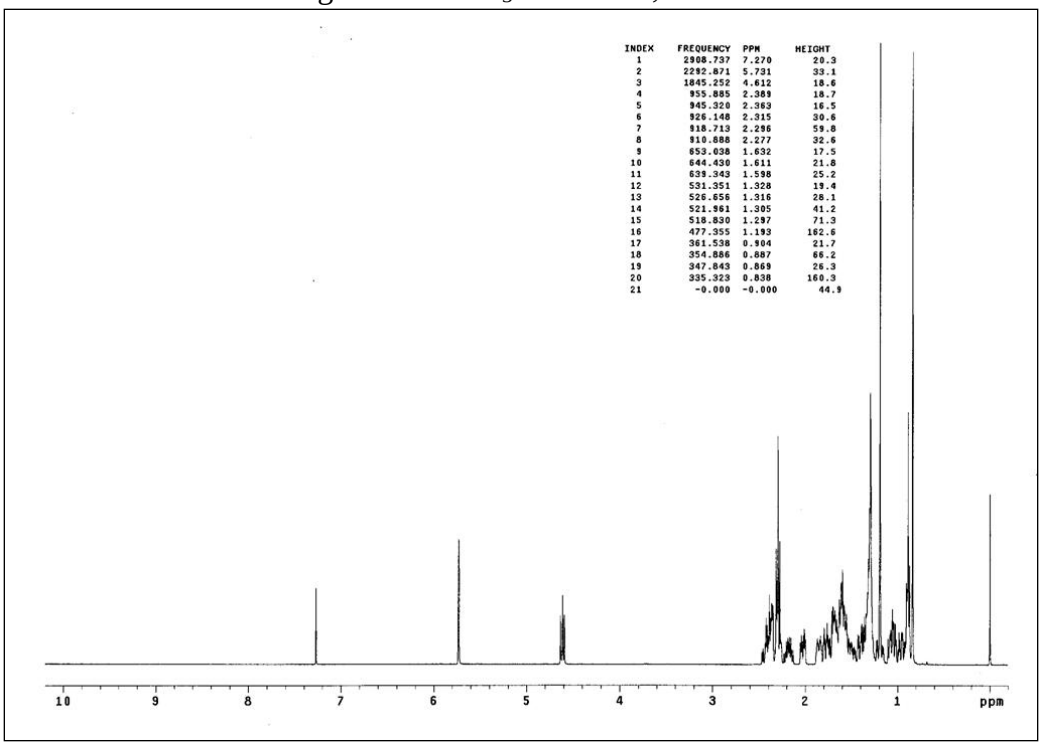
Mass Spectrum (EI): Testosterone enanthate
Quadrupole Detector



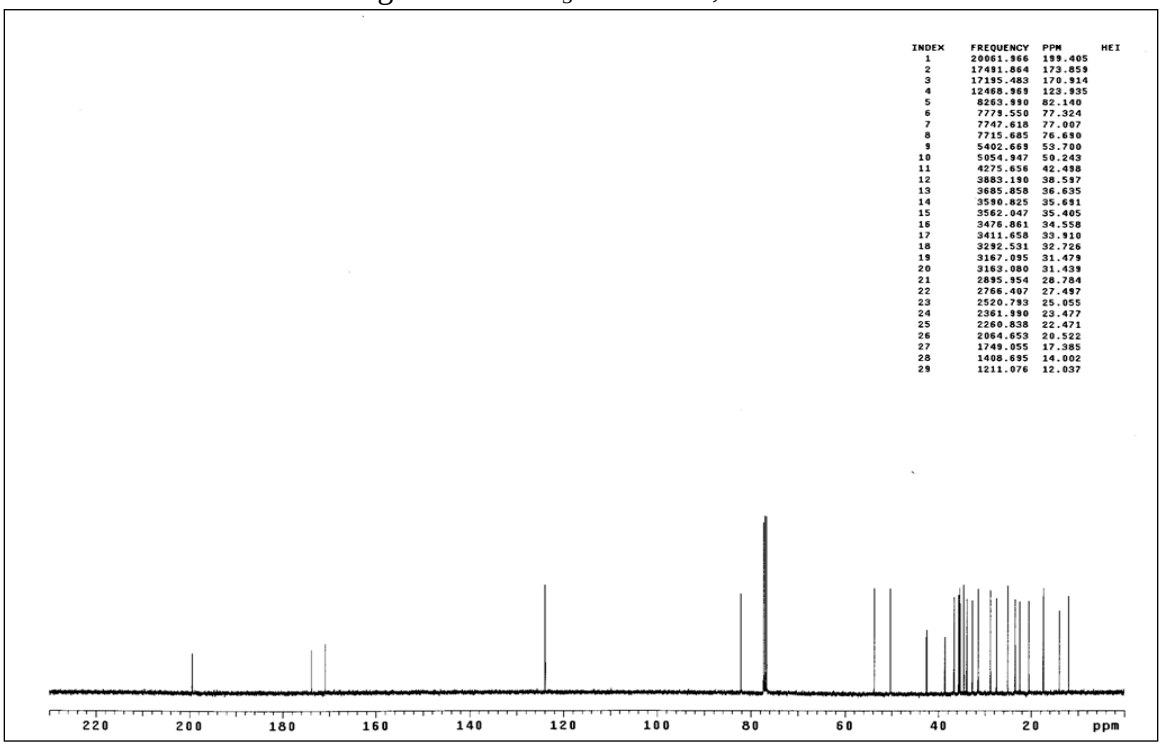

IR (Vapor Phase): Testosterone enanthate



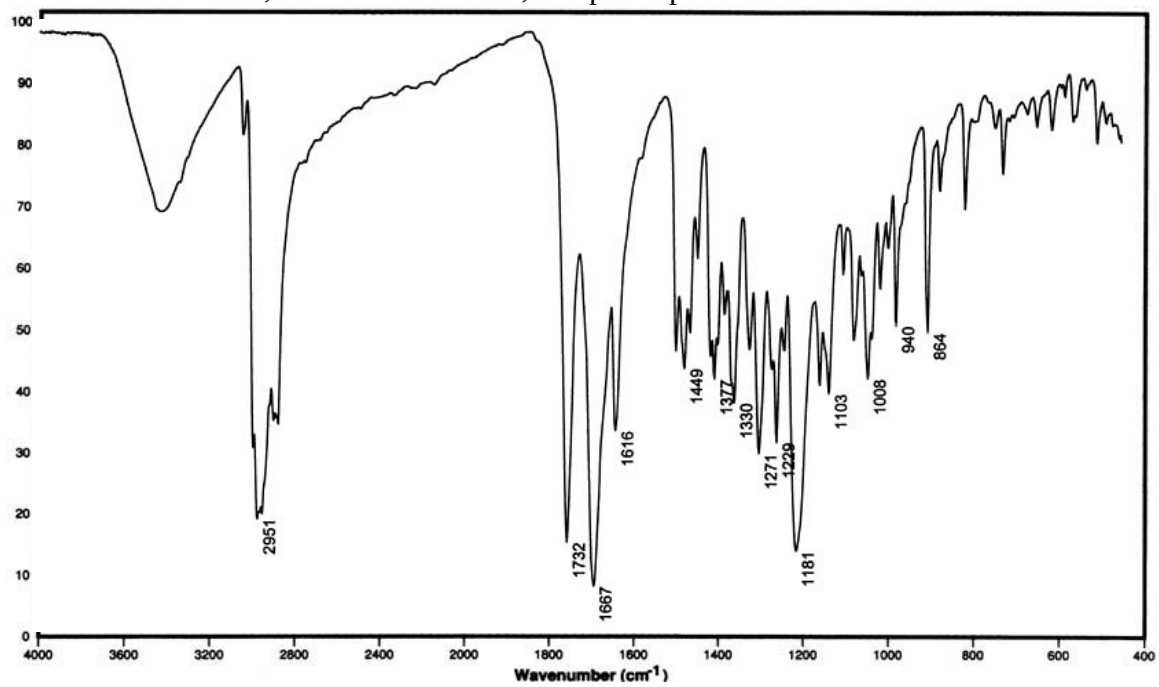
NMR (PROTON): Testosterone enanthate
10 mg/mL in $CDCl_3$ with TMS, 400 MHz



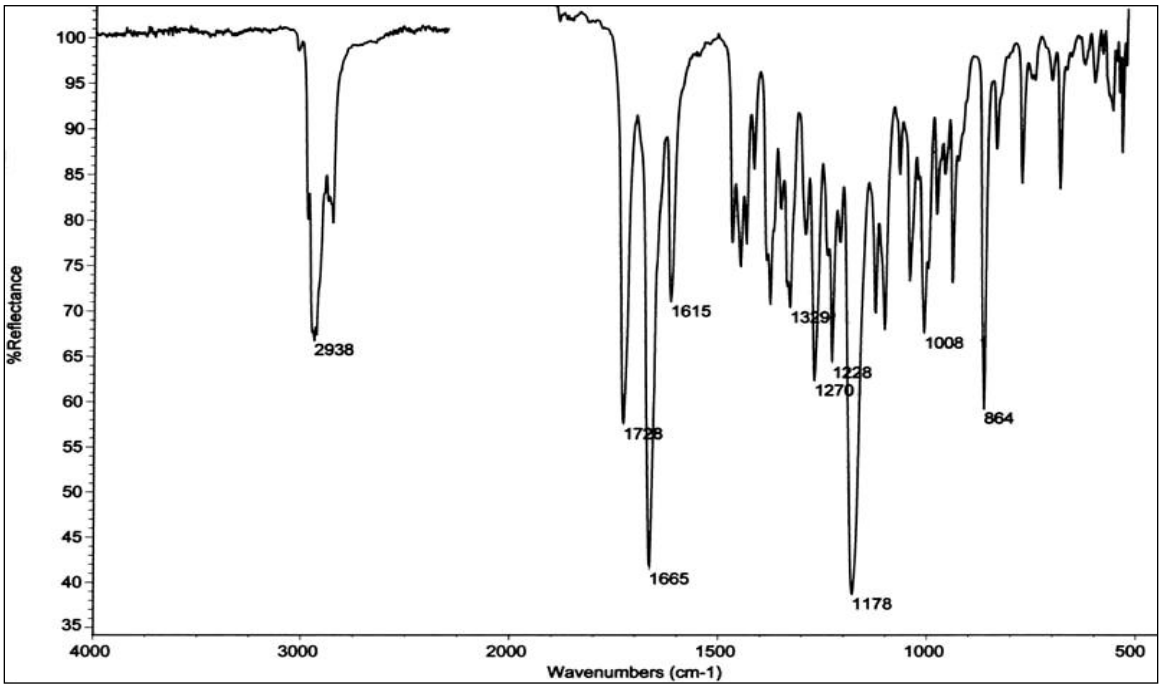

NMR (CARBON): Testosterone enanthate
50 mg/mL in $CDCl_3$ with TMS, 100 MHz



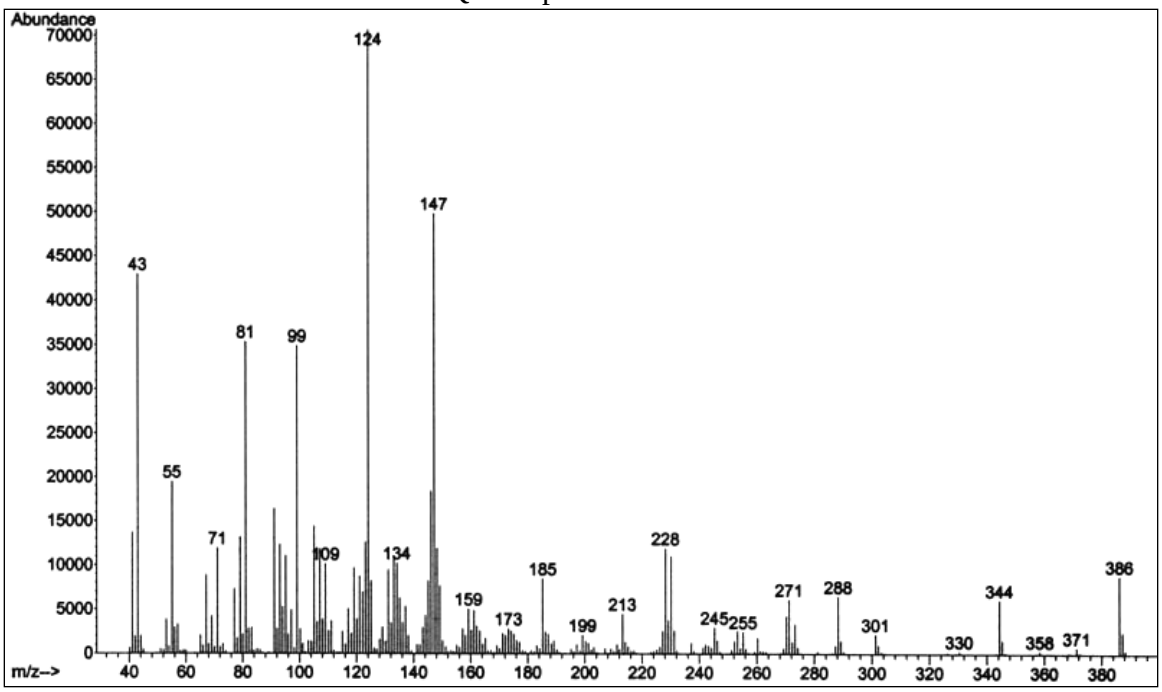
Transmission IR: Testosterone isocaproate
16 scans, 4.0 $cm^{-1}$ resolution, sample in potassium bromide matrix



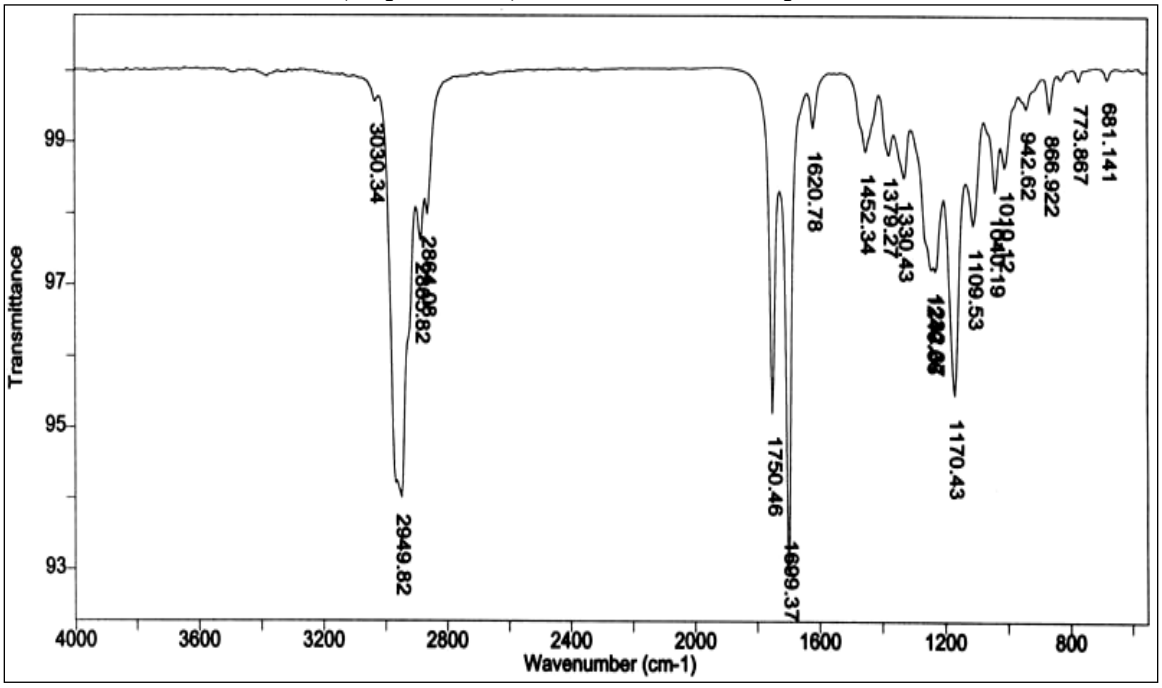

IR (ATR. 3-bounce diamond device): Testosterone isocaproate
16 scans, 4.0 $cm^{-1}$ resolution



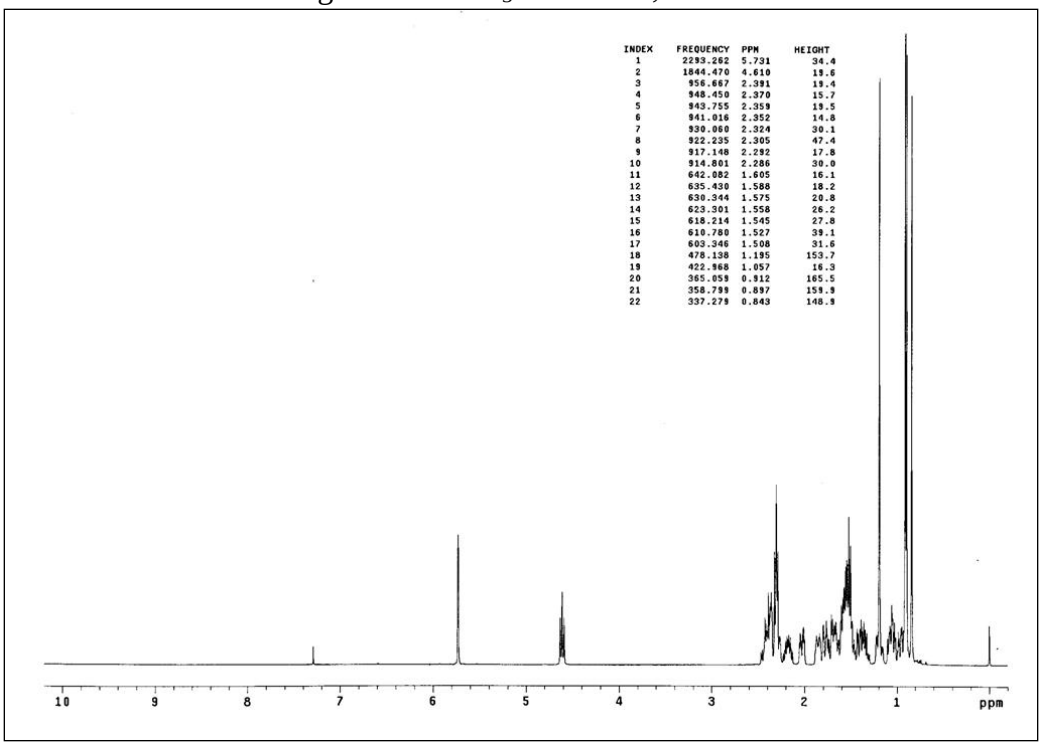
MS (EI): Testosterone isocaproate
Quadrupole Detector



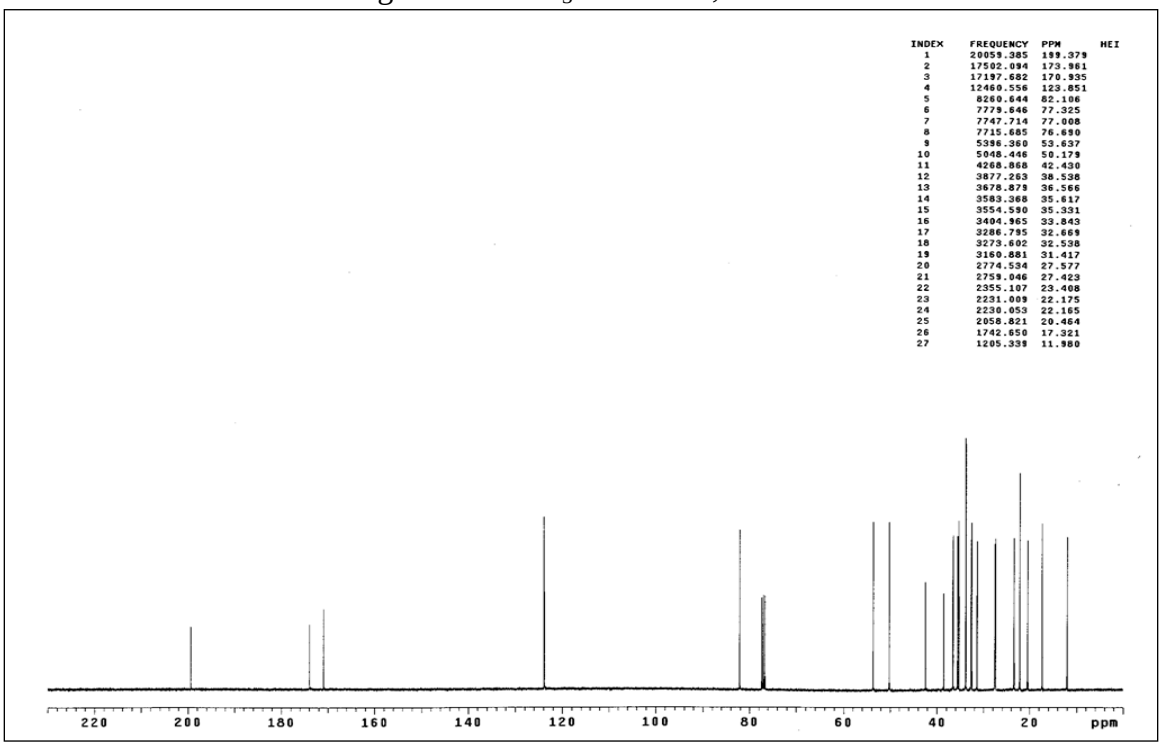

IR (Vapor Phase): Testosterone isocaproate



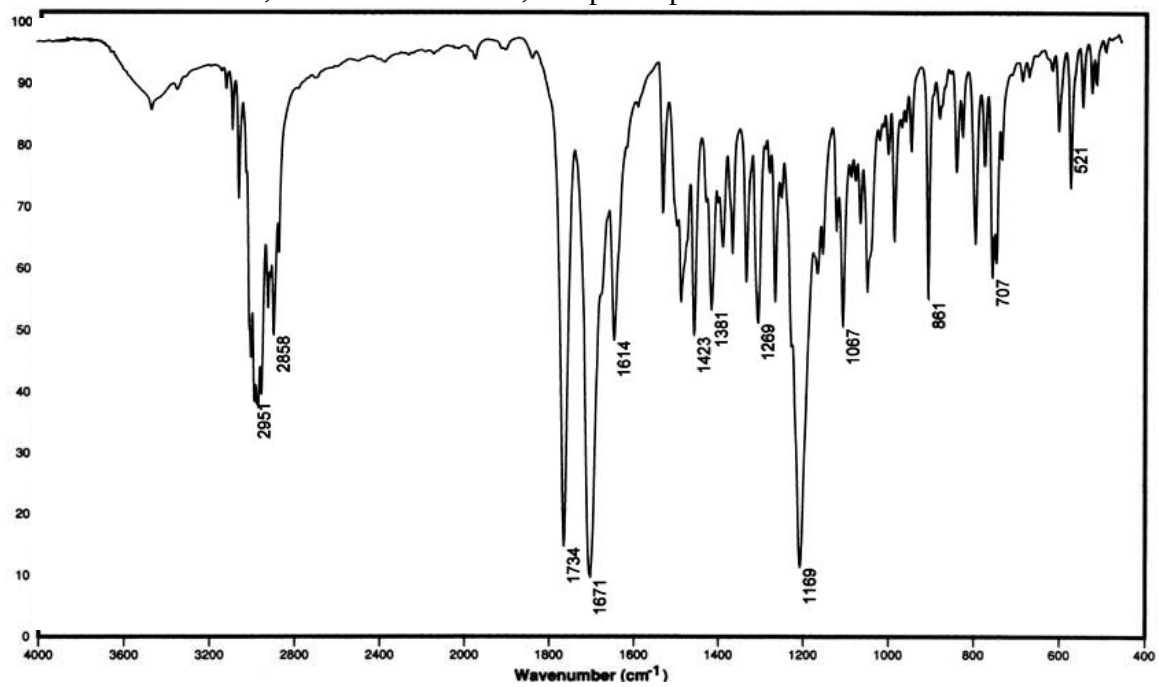
NMR (PROTON): Testosterone isocaproate
10 mg/mL in $CDCl_3$ with TMS, 400 MHz



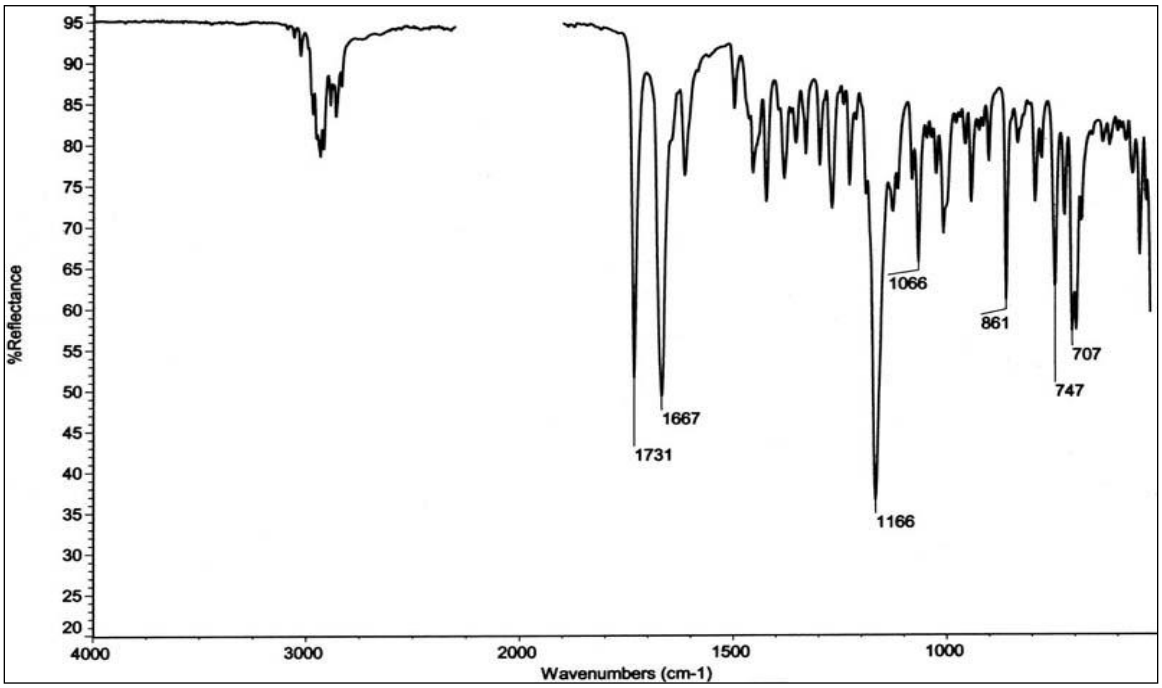

NMR (CARBON): Testosterone isocaproate
50 mg/mL in $CDCl_3$ with TMS, 100 MHz



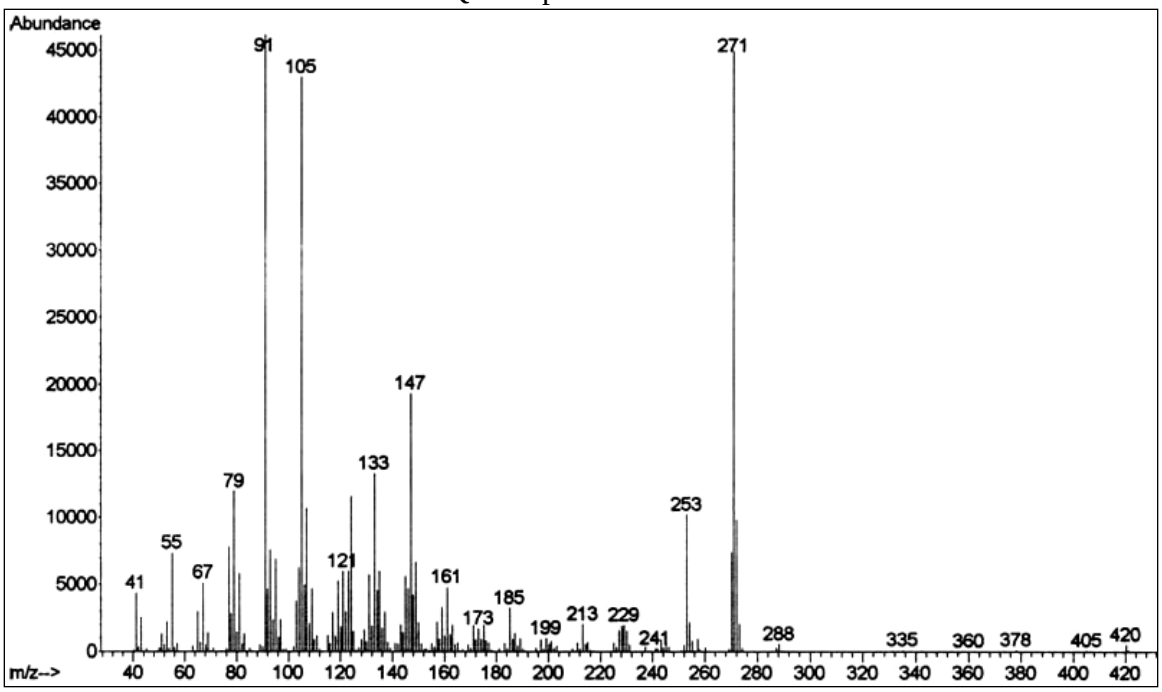
Transmission IR: Testosterone phenylpropionate
16 scans, 4.0 $cm^{-1}$ resolution, sample in potassium bromide matrix



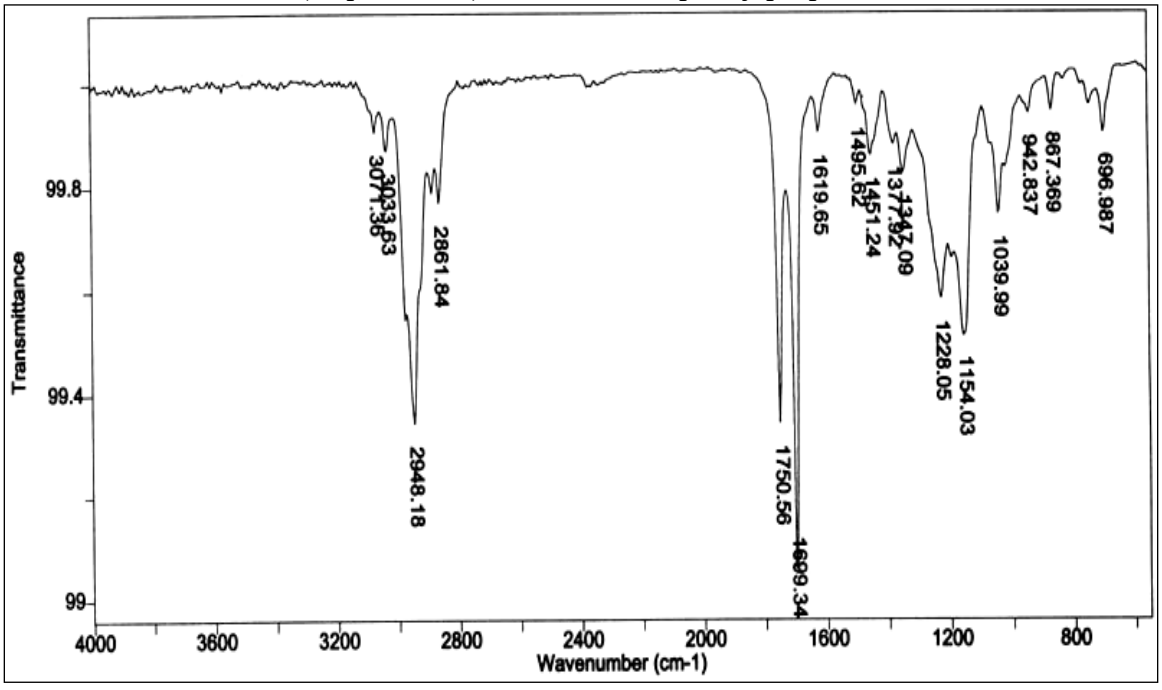

IR (ATR, 3-bounce diamond device): Testosterone phenylpropionate
16 scans, 4.0 $cm^{-1}$ resolution



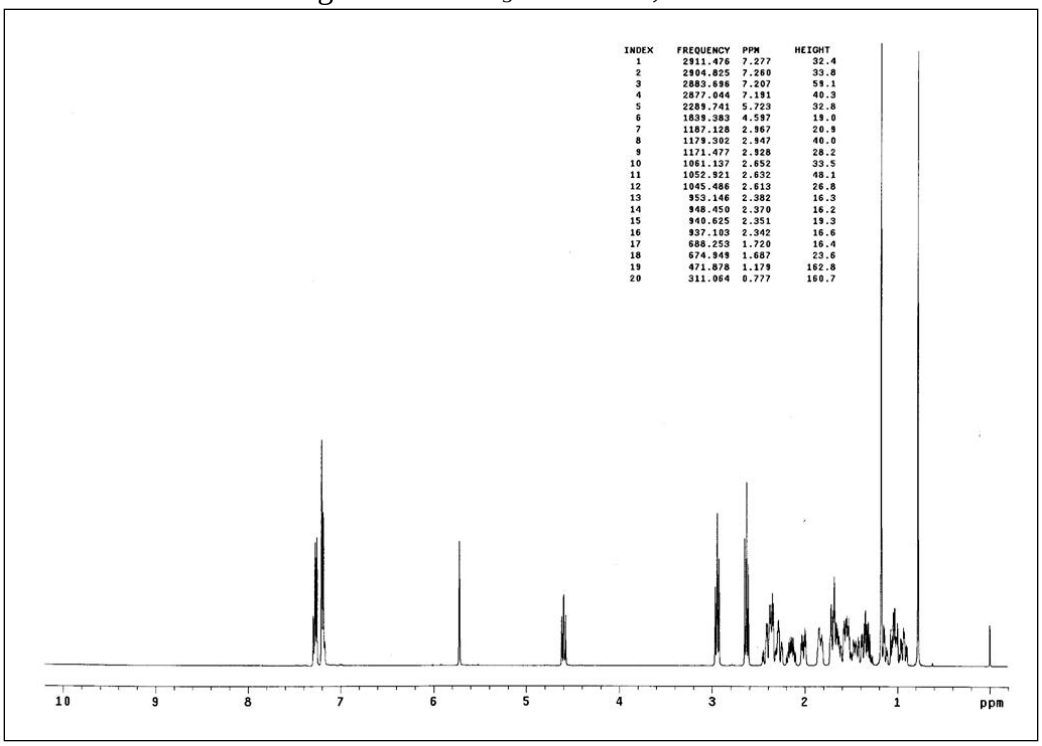
MS (EI): Testosterone phenylpropionate
Quadrupole Detector



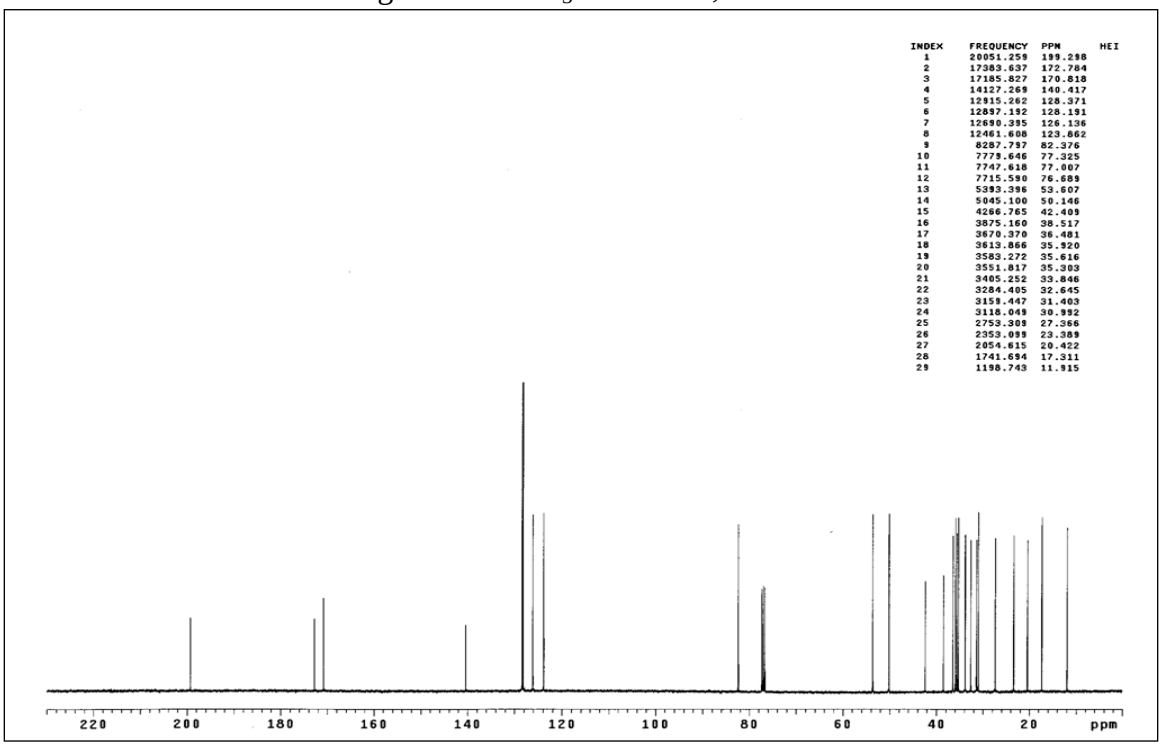

IR (Vapor Phase): Testosterone phenylpropionate



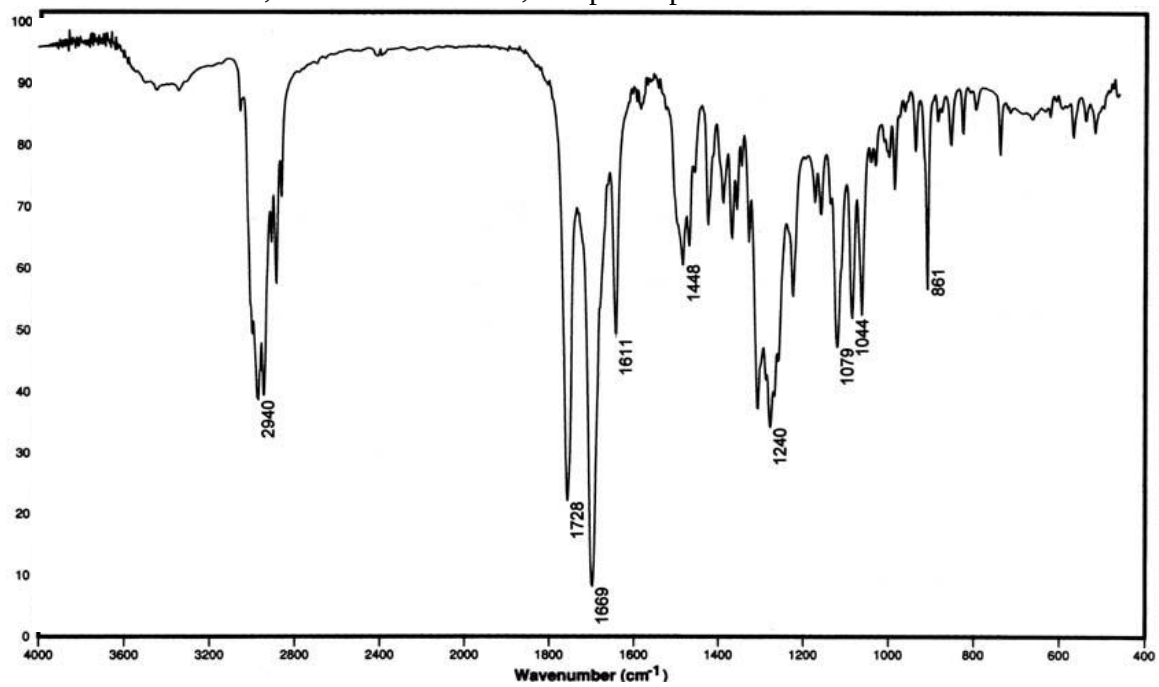
NMR (PROTON): Testosterone phenylpropionate
10 mg/mL in $CDCl_3$ with TMS, 400 MHz



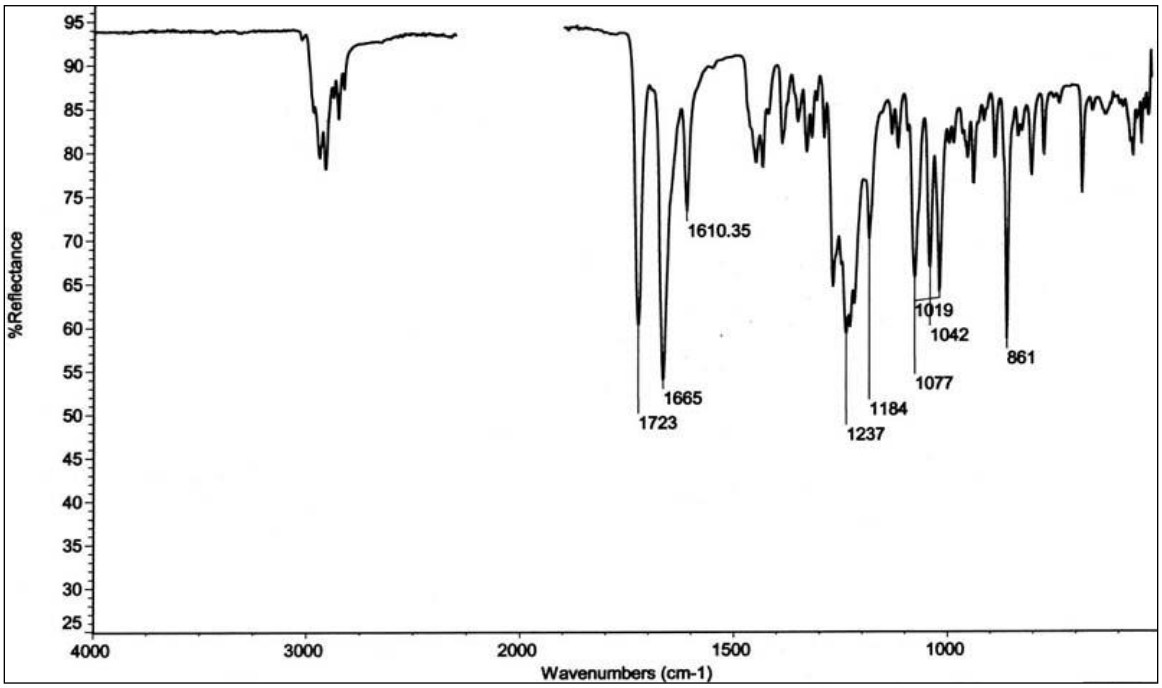

NMR (CARBON): Testosterone phenylpropionate
50 mg/mL in $CDCl_3$ with TMS, 100 MHz



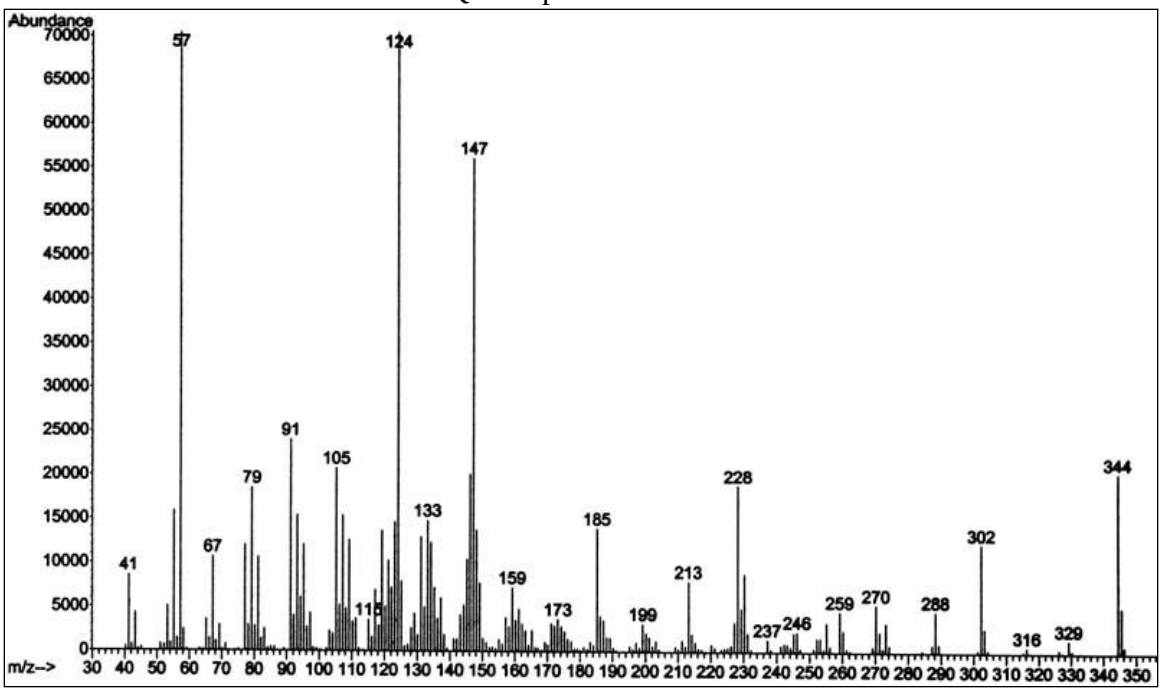
Transmission IR: Testosterone propionate
16 scans, 4.0 $cm^{-1}$ resolution, sample in potassium bromide matrix



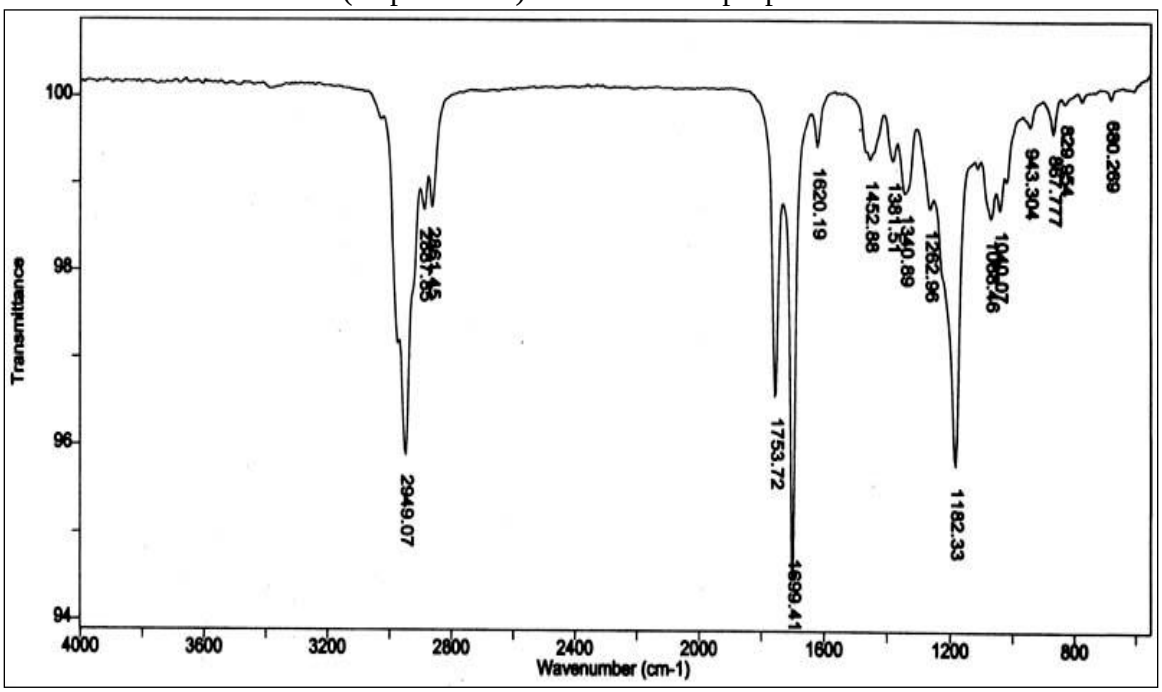

IR (ATR 3-bounce diamond device): Testosterone propionate
16 scans, 4.0 $cm^{-1}$ resolution



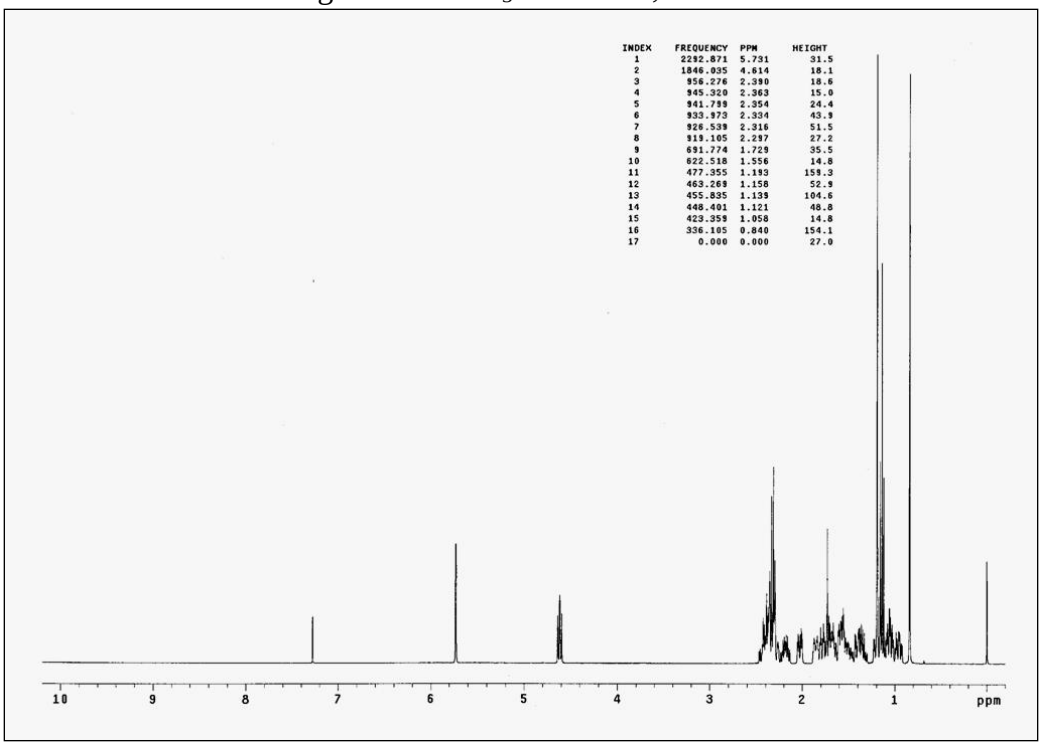
MS (EI): Testosterone propionate
Quadrupole Detector




IR (Vapor Phase): Testosterone propionate



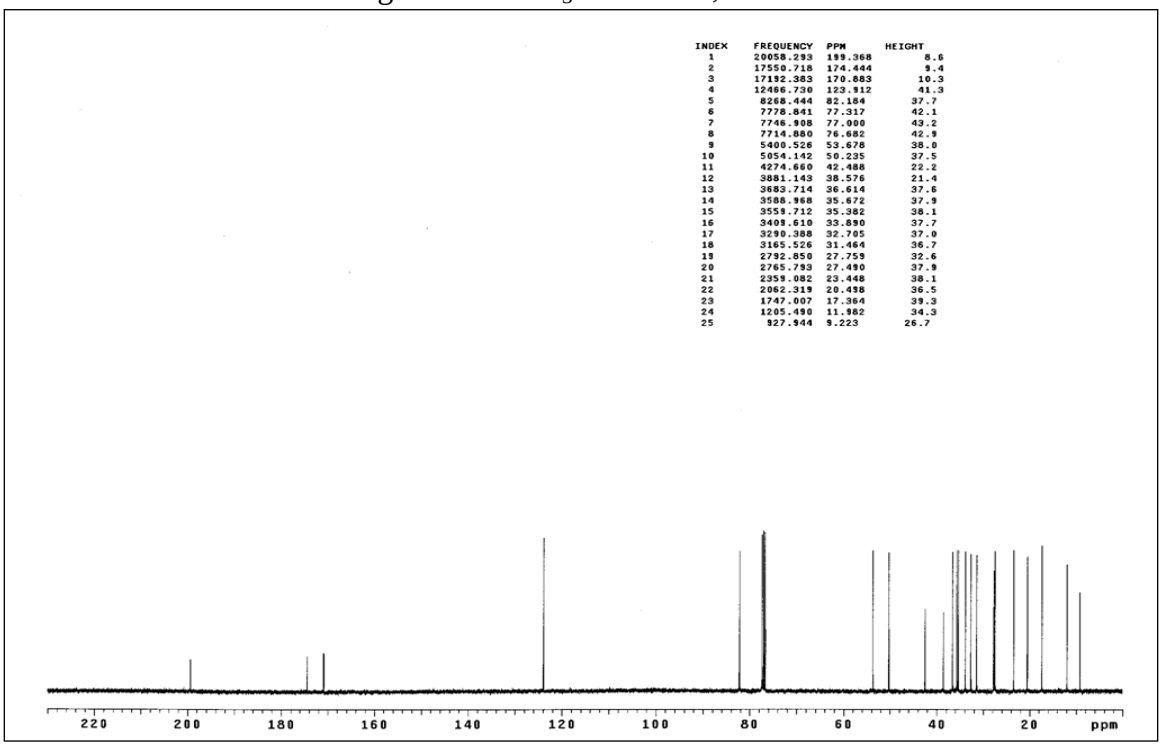
NMR (PROTON): Testosterone propionate
10 mg/mL in $CDCl_3$ with TMS, 400 MHz



| INDEX | FREQUENCY | PPM | HEIGHT |
|---|---|---|---|
| 1 | 2292.871 | 5.731 | 31.5 |
| 2 | 1846.035 | 4.614 | 18.1 |
| 3 | 956.276 | 2.390 | 18.6 |
| 4 | 945.320 | 2.363 | 15.0 |
| 5 | 941.791 | 2.354 | 24.4 |
| 6 | 933.973 | 2.334 | 43.9 |
| 7 | 926.539 | 2.316 | 51.5 |
| 8 | 919.105 | 2.297 | 27.2 |
| 9 | 691.774 | 1.729 | 35.5 |
| 10 | 622.518 | 1.556 | 14.8 |
| 11 | 477.355 | 1.193 | 158.3 |
| 12 | 463.269 | 1.158 | 52.9 |
| 13 | 455.835 | 1.139 | 104.6 |
| 14 | 448.401 | 1.121 | 48.8 |
| 15 | 423.359 | 1.058 | 14.8 |
| 16 | 336.105 | 0.840 | 154.1 |
| 17 | 0.000 | 0.000 | 27.0 |

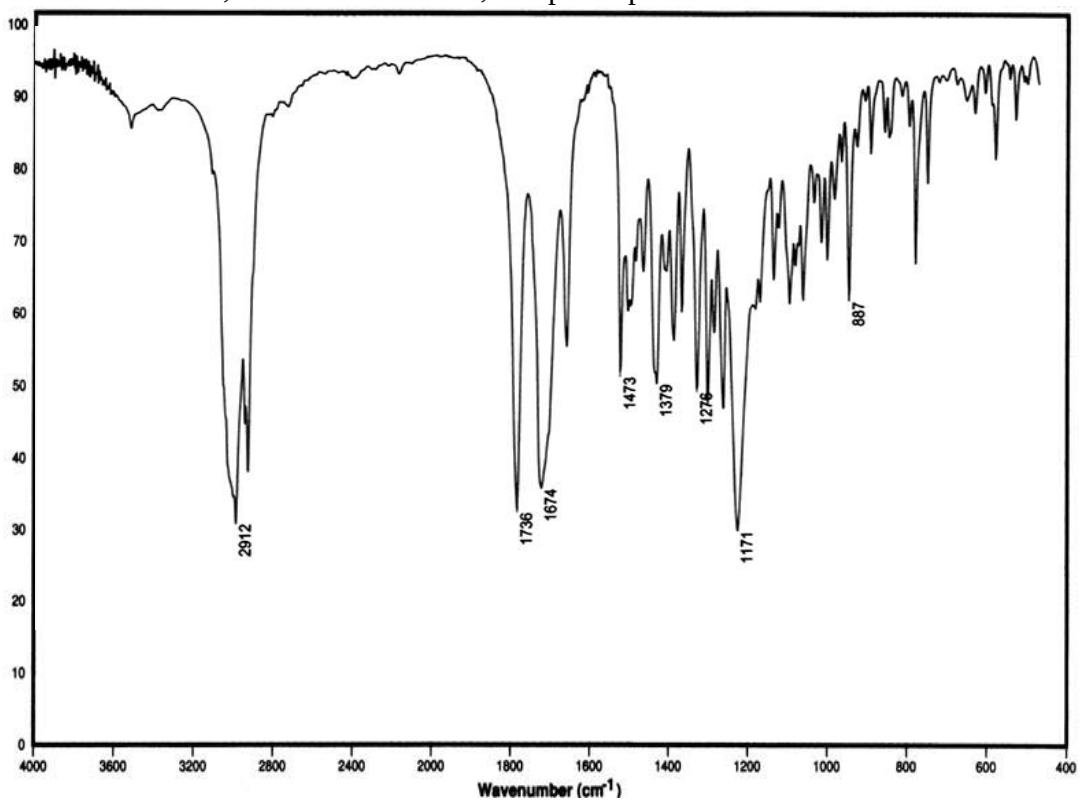


NMR (CARBON): Testosterone propionate
50 mg/mL in $CDCl_3$ with TMS, 100 MHz

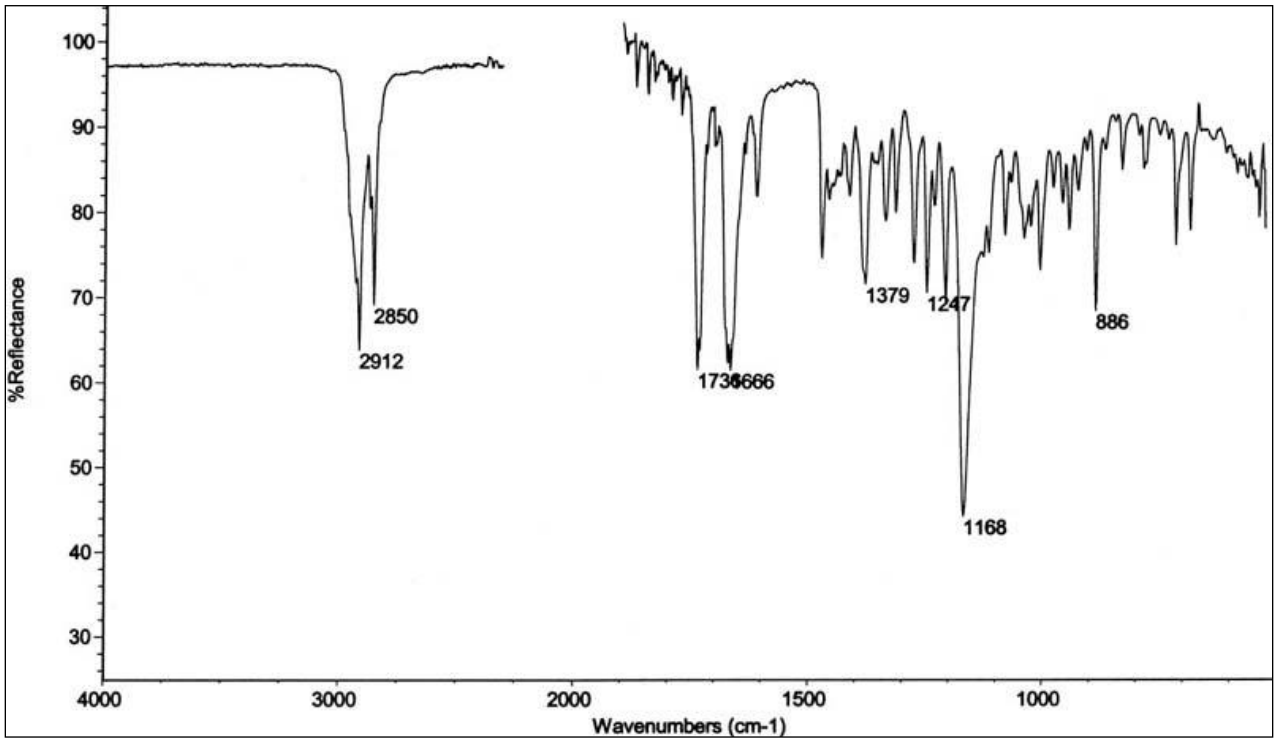


| INDEX | FREQUENCY | PPM | HEIGHT |
|---|---|---|---|
| 1 | 20058.293 | 199.368 | 8.6 |
| 2 | 17550.718 | 174.444 | 9.4 |
| 3 | 17192.383 | 170.883 | 10.3 |
| 4 | 12466.730 | 123.912 | 41.3 |
| 5 | 8268.444 | 82.184 | 37.7 |
| 6 | 7778.841 | 77.317 | 42.1 |
| 7 | 7746.908 | 77.000 | 43.2 |
| 8 | 7714.880 | 76.682 | 42.9 |
| 9 | 5400.526 | 53.678 | 38.0 |
| 10 | 5054.142 | 50.235 | 37.5 |
| 11 | 4274.660 | 42.488 | 22.2 |
| 12 | 3881.143 | 38.576 | 21.4 |
| 13 | 3683.714 | 36.614 | 37.6 |
| 14 | 3588.968 | 35.672 | 37.9 |
| 15 | 3559.712 | 35.382 | 38.1 |
| 16 | 3409.610 | 33.890 | 37.7 |
| 17 | 3290.388 | 32.705 | 37.0 |
| 18 | 3165.526 | 31.464 | 36.7 |
| 19 | 2792.850 | 27.759 | 32.6 |
| 20 | 2765.793 | 27.490 | 37.9 |
| 21 | 2359.082 | 23.448 | 38.1 |
| 22 | 2062.319 | 20.498 | 36.5 |
| 23 | 1747.007 | 17.364 | 39.3 |
| 24 | 1205.490 | 11.982 | 34.3 |
| 25 | 927.944 | 9.223 | 26.7 |

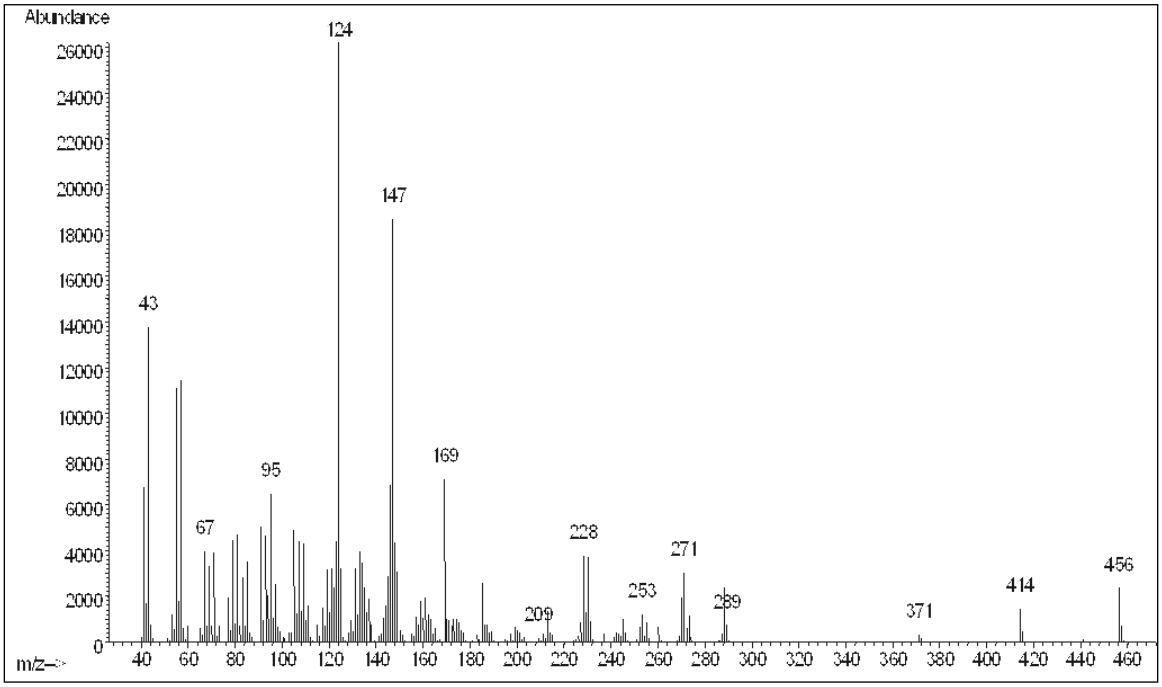
Transmission IR: Testosterone undecanoate
16 scans, 4.0 $cm^{-1}$ resolution, sample in potassium bromide matrix



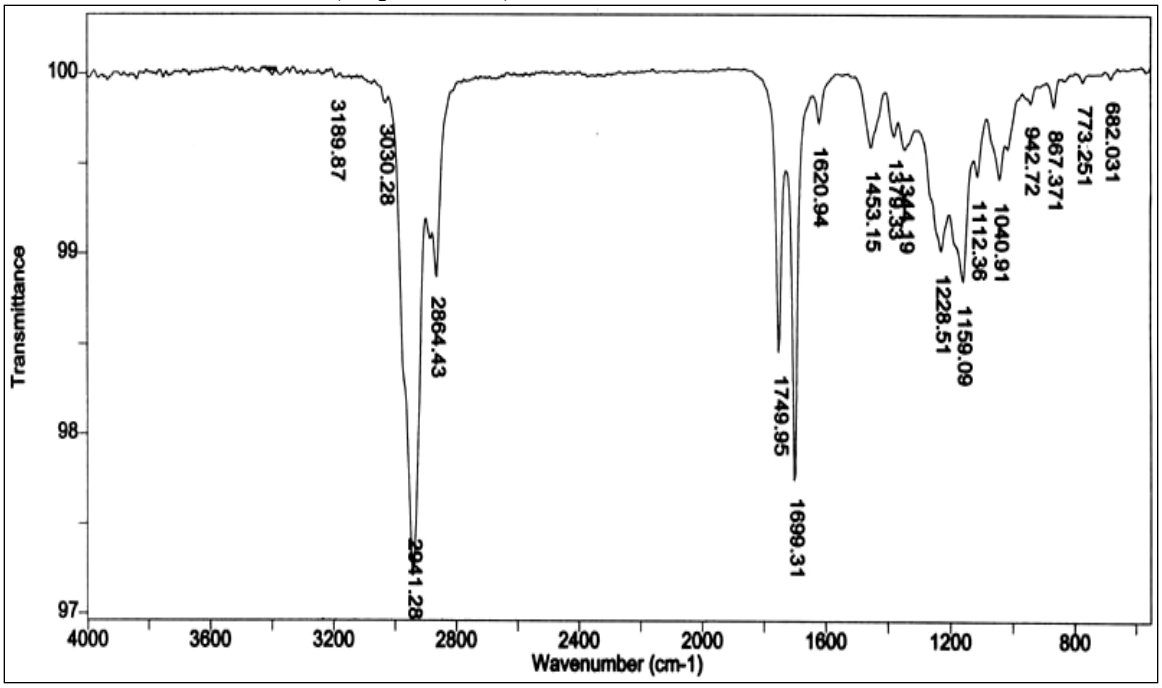

IR (ATR 3-bounce diamond device): Testosterone undecanoate
16 scans, 4.0 $cm^{-1}$ resolution



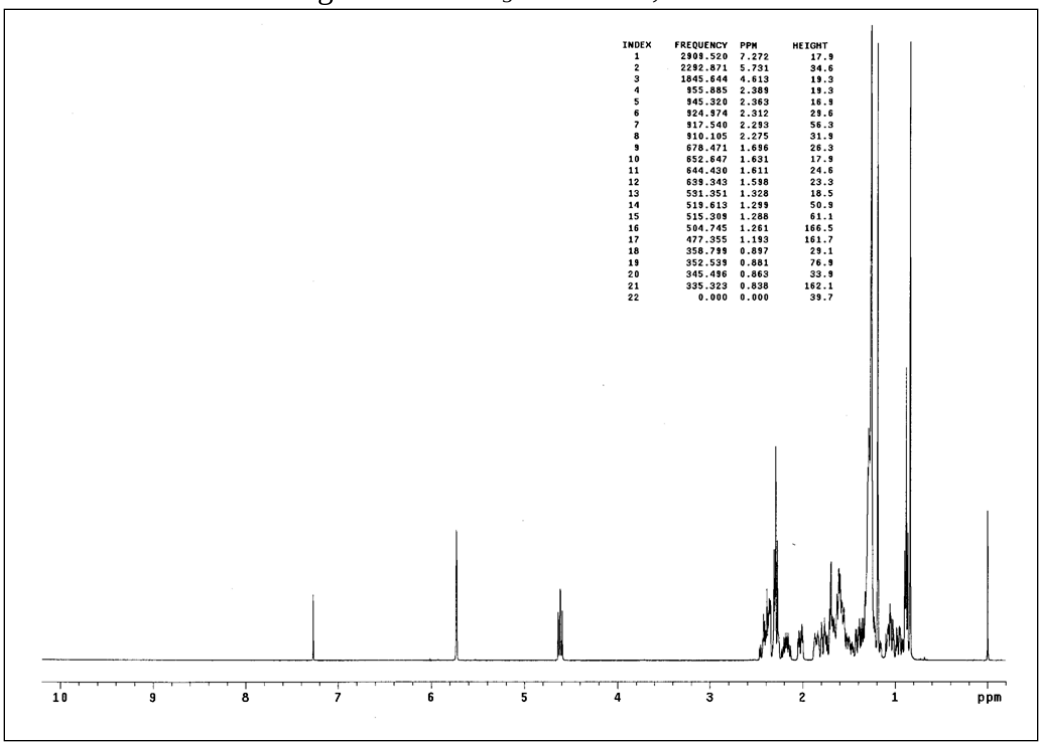

MS (EI): Testosterone undecanoate
Quadrupole Detector




IR (Vapor Phase): Testosterone undecanoate



NMR (PROTON): Testosterone undecanoate
10 mg/mL in $CDCl_3$ with TMS, 400 MHz




NMR (CARBON): Testosterone undecanoate
50 mg/mL in $CDCl_3$ with TMS, 100 MHz