

## Development of a Clinical Research Method for the Measurement of Testosterone and Dihydrotestosterone

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*For research use only. Not for use in diagnostic procedures.*

This is an Application Brief and does not contain a detailed Experimental section.

### Abstract

This application brief demonstrates to develop a method to measure Testosterone and Dihydrotestosterone (DHT) from plasma samples.

### Benefits

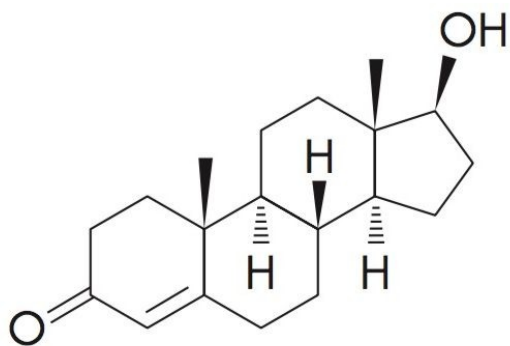
Direct measurement of androgens is made possible without derivatization using LC-MS with online SPE.

### Introduction

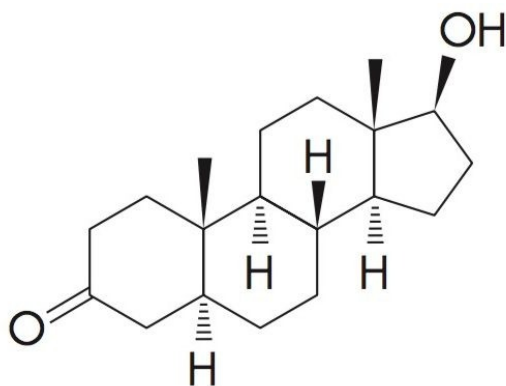
Testosterone is a steroid hormone from the androgen group and is the principal male sex hormone and an anabolic steroid (Figure 1).

In men, approximately 5% of testosterone undergoes 5 $\alpha$ -reduction to form the more potent androgen, dihydrotestosterone (DHT) (Figure 1).

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**Testosterone**



**Dihydrotestosterone**

Figure 1: Structure of Androgen Hormones. Dihydrotestosterone (DHT) is the product of the reduction of the double bond in the a ring of testosterone by the enzyme 5-alpha reductase.

Measuring the male steroid hormones and related metabolites, particularly at the low levels found in pediatrics and females, has proven to be a major challenge. Immunoassays for steroids often suffer from poor sensitivity and specificity. While traditional LC-MS assays require derivatization procedures and/or long and complicated sample preparation protocols.

In the current study, a research method for the measurement of testosterone and DHT in plasma was developed. This method allows for the direct measurement of these two androgens at physiological levels in male and female samples by LC-MS without the need for derivitization. Moreover the method makes use of automated sample prep, minimizing sample pretreatment.

## Experimental

### Method details:

LC-MS System Configuration:

LC System: ACQUITY UPLC

Mass Spectrometer: Xevo TQ-S

Column:

ACQUITY UPLC BEH C<sub>18</sub>, 1.7 μm, 2.1 x 50 mm

Sample Preparation:

ACQUITY UPLC Online SPE Manager (OSM)

|                       |  |
|-----------------------|--|
| SPE:                  | MassTrak C <sub>8</sub> OSM Cartridge  |
| Sample Pre-Treatment: | <p>200 µL Plasma</p> <p>20 µL Internal Standard (d3 Testosterone; 13C3 DHT) 300 µL Zinc Sulfate:MeOH Solution;<br/>Centrifuge to pellet protein; remove supernatant</p> <p>After addition of zinc sulfate:MeOH we filled up to 1.0mL prior to centrifugation. 25 uL was then injected (no transfer of supernatant → needle adjusted so stays above pellet).</p> <p>Dilute to 1 ml with Water</p> <p>Inject 25 µL of final sample</p> |

## Chromatographic conditions

|            |                            |
|------------|----------------------------|
| Solvent A: | 10% MeOH+0.05% Formic Acid |
| Solvent B: | MeOH+0.05% Formic Acid     |
| Flow rate: | 0.4 ml/min                 |

## Gradient

| Time | %A | %B  |
|------|----|-----|
| 0    | 60 | 40  |
| 3.0  | 0  | 100 |
| 4.0  | 0  | 100 |
| 4.1  | 60 | 40  |

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## Online SPE conditions

|                 |   |
|-----------------|---|
| Conditioning:   | Step 1: 0.5 ml MeOH @ 4 ml/min<br>Step 2: 2.0 ml Magic Mix* @ 3 ml/min  |
| Equilibration:  | 1.0 ml Water @ 4 ml/min   |
| Sample loading: | 1.0 ml Water @ 2 ml/min   |
| Cartridge wash: | Step 1: 0.5 ml 80% 0.2% NH <sub>4</sub> OH/20% MeOH @ 2 ml/min<br>Step 2: 0.5 ml 70% 0.2% Formic Acid/30% MeOH @ 2 ml/min |
| Elution:        | Elution Time: 0.8 minutes<br>Run Time: 0.8 minutes  |
| Clamp flush:    | Step 1: 2.0 ml Magic Mix* @ 3 ml/min<br>Step 2: 1.0 ml Water @ 3 ml/min   |

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\* *Magic Mix*= MeOH/ACN/IPA/Water+0.2% Formic Acid

## Results and Discussion

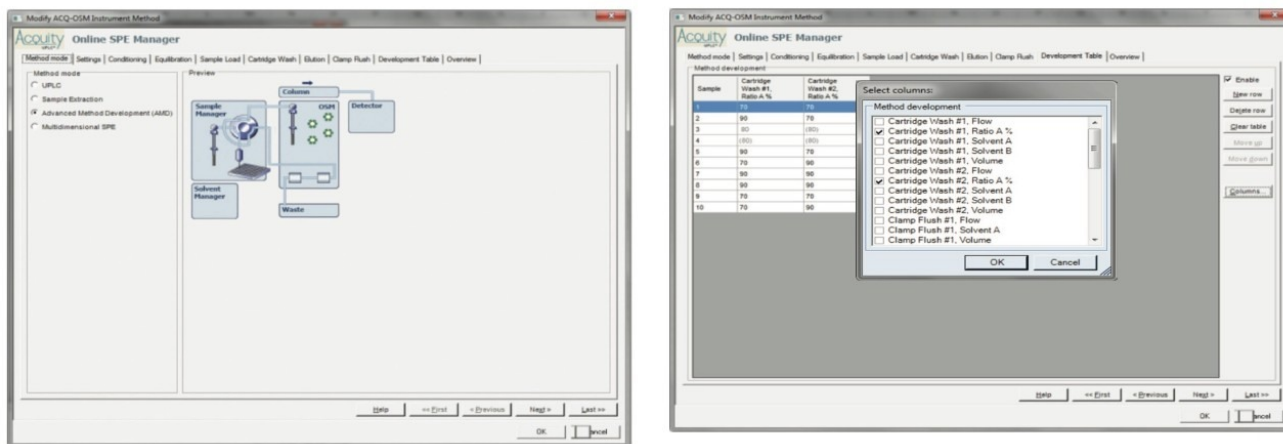


Figure 2: SPE Method Development. SPE sample preparation was facilitated by using an online SPE system and Design of Experiments (DoE) principles to manipulate multiple SPE variables simultaneously. This approach allowed for identification and optimization of significant sample preparation method development variables very quickly.

| Compound 1: Testosteron-Quan |             |                   |      |         |
|------------------------------|-------------|-------------------|------|---------|
| Name                         | Sample Text | ID                | RT   | Area    |
| 130529_033                   | 70/70       | 0.4mL/min - steep | 1.74 | 272098  |
| 130529_034                   | 90/30       | 0.4mL/min - steep | 1.75 | 1163025 |
| 130529_035                   | 80/80       | 0.4mL/min - steep | 1.75 | 1123519 |
| 130529_036                   | 80/80       | 0.4mL/min - steep | 1.75 | 1151666 |
| 130529_037                   | 90/70       | 0.4mL/min - steep | 1.75 | 1111988 |
| 130529_038                   | 70/90       | 0.4mL/min - steep | 1.75 | 1193007 |
| 130529_039                   | 90/90       | 0.4mL/min - steep | 1.76 | 1146458 |
| 130529_040                   | 90/90       | 0.4mL/min - steep | 1.76 | 1155421 |
| 130529_041                   | 70/70       | 0.4mL/min - steep | 1.74 | 103377  |
| 130529_042                   | 70/90       | 0.4mL/min - steep | 1.75 | 1114320 |

| Compound 3: DHT-Quan |             |                   |      |        |
|----------------------|-------------|-------------------|------|--------|
| Name                 | Sample Text | ID                | RT   | Area   |
| 130529_033           | 70/70       | 0.4mL/min - steep | 2.01 | 235415 |
| 130529_034           | 90/30       | 0.4mL/min - steep | 2.02 | 229790 |
| 130529_035           | 80/80       | 0.4mL/min - steep | 2.02 | 226338 |
| 130529_036           | 80/80       | 0.4mL/min - steep | 2.02 | 229653 |
| 130529_037           | 90/70       | 0.4mL/min - steep | 2.02 | 231851 |
| 130529_038           | 70/90       | 0.4mL/min - steep | 2.02 | 235417 |
| 130529_039           | 90/90       | 0.4mL/min - steep | 2.02 | 232147 |
| 130529_040           | 90/90       | 0.4mL/min - steep | 2.02 | 231634 |
| 130529_041           | 70/70       | 0.4mL/min - steep | 2.02 | 227648 |
| 130529_042           | 70/90       | 0.4mL/min - steep | 2.02 | 229368 |

Figure 3: SPE Method Development Results. Use of the Advanced Method Development (AMD) operation mode of the online SPE system to optimize sample preparation. AMD allowed a number of SPE conditions to be tested rapidly to identify the optimal SPE conditions for these two analytes. Also, the SPE method is also helping with separation of testosterone and DHT. Testosterone is breaking through, while DHT is retained under the conditions examined.

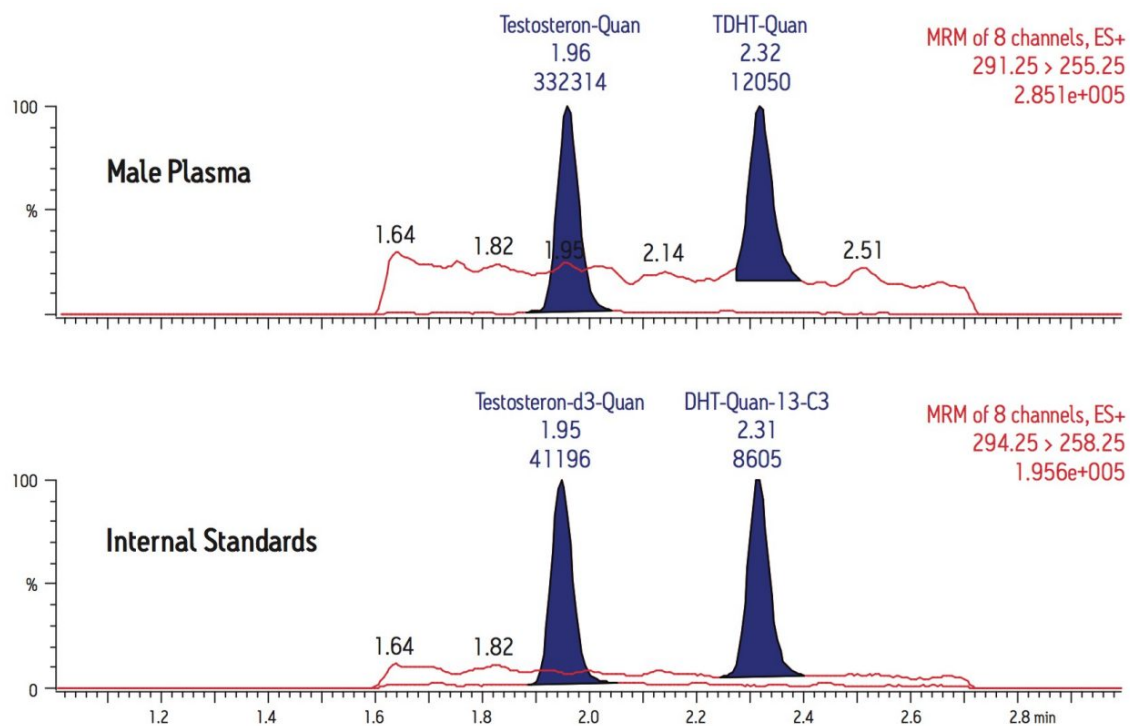


Figure 4: Separation and measurement of testosterone and DHT in male plasma samples (Sample from Male between 20 and 65 years of age). Testosterone and DHT are readily separated and quantitated.

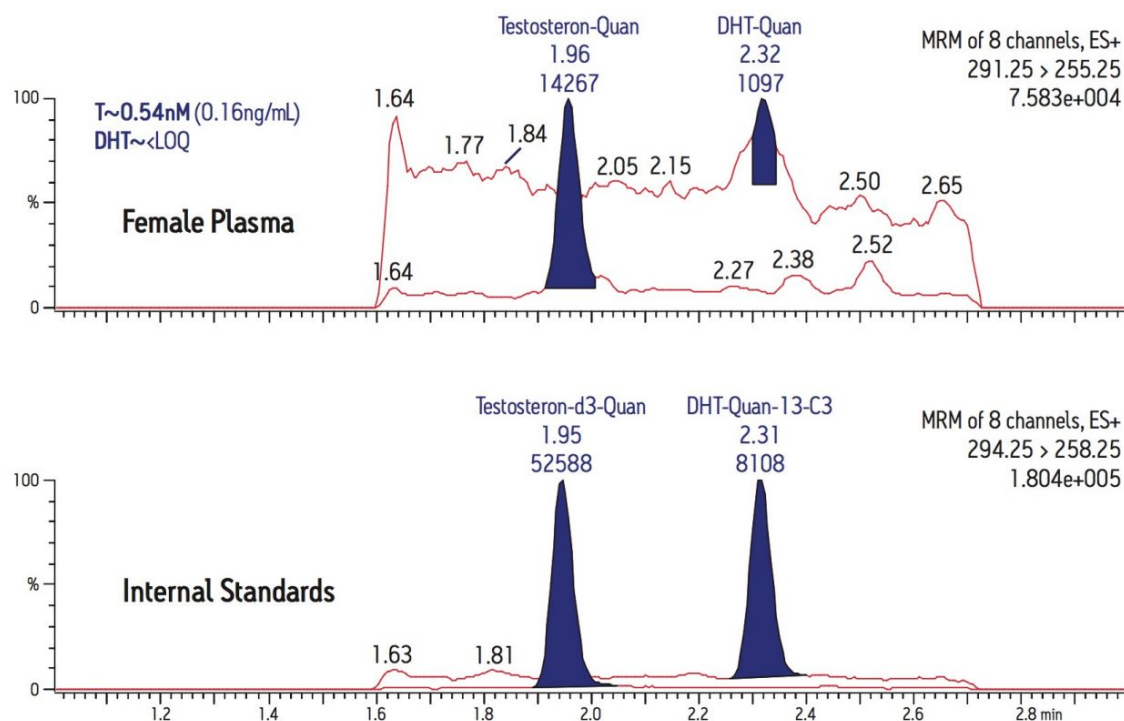


Figure 5: Separation and measurement of testosterone and DHT from Female plasma sample from pre-menopausal females. Testosterone can be measured at pM range in these samples, but DHT is below the LOQ in female samples.

## Conclusion

The wide variation in testosterone and DHT concentrations as well as the inherent difficulties in measuring these molecules, has made it difficult to develop test methods for them.

To measure these molecules successfully by LC-MS requires an effective sample preparation method. Using an online SPE system greatly accelerated the development of an LC-MS method by quickly identifying and utilizing optimized SPE conditions for isolating these androgens from plasma samples.

The focus of the clinical research method described herein was on quickly and efficiently developing an integrated SPE sample preparation method with high sensitivity mass spectrometry to simultaneously measure testosterone and DHT. The method developed uses online SPE to provide a high quality sample that is relatively free from sample matrix effects. By using LC-MS augmented with online SPE, the direct measurement of androgens, even at low levels, is possible.

The clinical research method developed here provides:



- Simultaneous analysis of testosterone and DHT in a single assay
- Simple sample preparation and androgen detection without derivatization
- Fast analysis time of < 5 min/sample
- Measurement of testosterone and DHT in male and female samples; where applicable
- Highly efficient SPE sample preparation integrated with LC-MS

## Featured Products

- [ACQUITY UPLC System <https://www.waters.com/514207>](https://www.waters.com/514207)
- [Xevo TQ-S <https://www.waters.com/10160596>](https://www.waters.com/10160596)

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