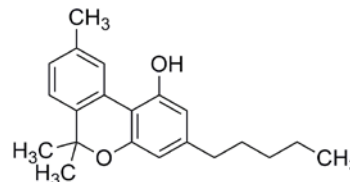


Certified Reference Material - Certificate of Analysis

Cannabinol, Primary Measurement Standard

6,6,9-Trimethyl-3-pentyl-6H-dibenzo[b,d]pyran-1-ol

Catalog Number: C-046-1ML
Lot: FE06131701
Expiration: June 2021
Description: Cannabinol in Methanol.
Packaging: Solution in 2 mL amber USP Type I glass ampoule containing not less than 1 mL of certified solution.



Storage: Store unopened in freezer (-10 °C to -25 °C).
Shipping: Ambient. See Stability Section.
Intended Use: This Certified Reference Material is suitable for the *in vitro* identification, calibration, and quantification of the analyte(s) in analytical and R&D applications. Not suitable for human or animal consumption.

Instructions for Use: Users should quantitatively transfer desired volume using established good laboratory practices to spike into matrix or to dilute to the desired concentration. Each ampoule is intended for one-time use.

Regulatory: USDEA Exempt | Canadian TK # 61-1089

Safety: Danger. See Safety Data Sheet

- Expiration date has been established through real time stability studies.
- Ampoules are overfilled to ensure a minimum 1 mL volume can be transferred when using a 1 mL Class A volumetric pipette.
- For quantitative applications, the minimum sample size for intended use is 1 µL.

Analyte	Certified Concentration Value
Cannabinol	1.000 ± 0.005 mg/mL
<ul style="list-style-type: none"> Uncertainty of the concentration is expressed as an expanded uncertainty in accordance with ISO 17025 and Guide 34 at the approximate 95% confidence interval using a coverage factor of k = 2 and has been calculated by statistical analysis of our production system and incorporates uncertainty of the mass balance purity factor, material density, balance, and weighing technique. This standard is prepared gravimetrically and mass results are reported on the conventional basis for weighing in air. Nominal concentration is calculated based on: the actual measured mass; Mass Balance Purity Factor of the analyte(s); measured mass of the solution; and the density of the pure diluent at 20 °C. Concentration is corrected for chromatographic purity, residual water, residual solvents and residual inorganics. No adjustment required before use. Additional certification information available upon request. 	

Metrological Traceability

- This standard has been prepared and certified under the ISO Guide 34, ISO/IEC 17025, ISO 9001 and ISO 13485 standards. This standard meets the requirements of a Certified Reference Material and a Primary Measurement Standard as defined by ISO and is traceable to the SI and higher order standards through an unbroken chain of comparisons.
- This standard has been gravimetrically prepared using balances that have been fully qualified and calibrated to ISO 17025 requirements. All calibrations utilize NIST traceable weights which are calibrated externally by a qualified ISO 17025 accredited calibration laboratory to NIST standards. Qualification of each balance includes the assignment of a minimum weighing by a qualified and ISO 17025 accredited calibration vendor taking into consideration the balance and installed environmental conditions to ensure compliance with USP tolerances of NMT 0.10% relative error. Balance calibration adjustments are performed weekly utilizing the balance's internal adjustment mechanism. Calibration verifications are performed pre-use. Weigh tapes from the calibration verification are included in the production batch record for this standard. Production data package available upon request.
- Fill volume is gravimetrically verified throughout the dispensing process using qualified and calibrated balances.
- Concentration is verified against an independently prepared calibration solution gravimetrically prepared.
- Each raw material utilized has been identified and thoroughly characterized through the use of multiple analytical techniques. Spectral data is provided on subsequent pages of this COA. The density and material Mass Balance Purity Factor is traceable to the SI and higher order reference standards through mass measurement and instrument qualification and calibrations.

Cerilliant certifies that this standard meets the specifications stated in this certificate and warrants this product to meet the stated acceptance criteria through the expiration/retest date when stored unopened as recommended. Product should be used shortly after opening to avoid concentration changes due to evaporation. Warranty does not apply to ampoules stored after opening.




Darron Ellsworth, Quality Assurance Manager

July 12, 2017

Date

Solution Standard Verification

Concentration accuracy and within- and between-bottle homogeneity are analytically verified against an independently prepared calibration solution and to the prior lot.

Solution standard verification demonstrates confirmation that the specified requirements for the Primary Measurement Standard have been fulfilled and validated under ISO 13485.

Standard Solution Assay Parameters				Calibration Curve	
Analysis Method:	HPLC/UV			Calibration Curve:	Linear Regression
Column:	Ascentis Express C18, 2.7 µm, 3.0 x 50 mm			Number of Points:	4
Mobile Phase:	Acetonitrile:[Methanol:Water:Tetrahydrofuran (62:33:5)] (25:75)			Linearity (r) :	1.000
Flow Rate:	1.5 mL/min				
Wavelength:	228 nm				

Standard Solution	Lot Number	Verified Concentration (mg/mL)		%RSD - Homogeneity	
		Actual Results	Acceptance Criteria	Actual Results	Acceptance Criteria
New Lot	FE06131701	0.976	± 3%	0.5	≤ 3%
Previous Lot	FE06081502	0.989	± 3%	0.2	≤ 3%

- Concentration is verified through multiple analyses and is calculated as the average of multiple analyses compared to an independently prepared calibration solution.
- Within-sample and between-sample homogeneity of the New Lot is ensured through rigorous production process controls statistically analyzed to evaluate risk and verified by analysis. Multiple samples pulled from across the lot using a random stratified sampling plan were analyzed to verify homogeneity. % RSD results shown above for the New Lot demonstrate ampoule-to-ampoule homogeneity.

Analyte Certification - Mass Balance Purity Factor

Each analyte is thoroughly identified and characterized using an orthogonal approach. A mass balance purity factor is assigned incorporating chromatographic purity and residual impurities. The mass balance purity factor is utilized to calculate the weighing adjustment necessary to ensure accuracy of the solution standard concentration.

Material Name:	Cannabinol	Chemical Formula:	C ₂₁ H ₂₆ O ₂
Material Lot:	FC06051701	CAS Number:	521-35-7
		Molecular Weight:	310.43

Material Characterization Summary		
Analytical Test	Method	Results
Primary Chromatographic Purity by HPLC/UV Analysis	SP10-0102	99.4% ¹
Secondary Chromatographic Purity by GC/FID Analysis	SP10-0101	98.7%
Identity by GC/MS Analysis	SP10-0105	Consistent with Structure
Identity by ¹ H-NMR Analysis	USP <761>, SP10-0116	Consistent with Structure
Residual Solvent Analysis by GC/FID Headspace	AM1087 ²	0.99%
Residual Water Analysis by Karl Fischer Coulometry	AM1346 ²	Below Quantitation Limit
Mass Balance Purity Factor		98.39%

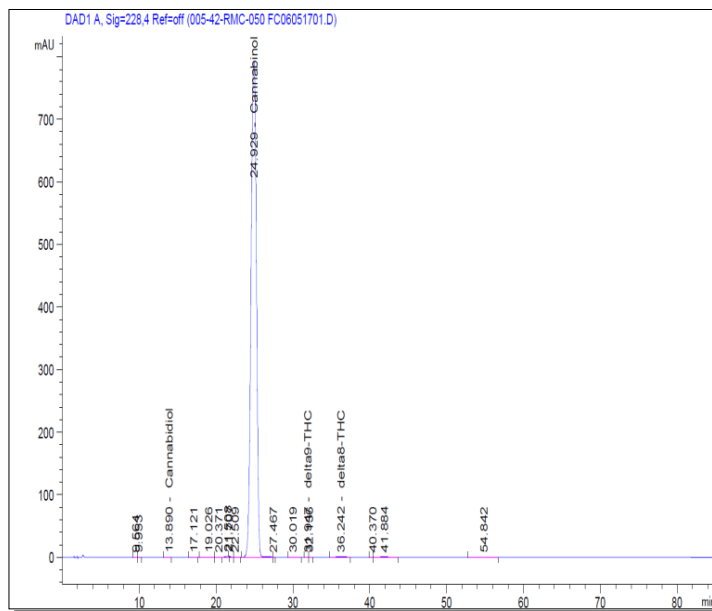
- The primary chromatographic purity is calculated as the average of two independently performed analyses utilizing two different methods. Acceptance criteria requires the purity values to be within 0.5% of each other.
- The primary chromatographic purity value is used to calculate the Mass Balance Purity Factor.
- A secondary chromatographic purity method is utilized as a control.
- Mass Balance Purity Factor = [(100 - wt% residual solvent - wt% residual water - wt% residual inorganics) x Chromatographic Purity/100].
- Mass Balance Purity Factor does not include adjustment for chiral and/or isotopic purity.

¹ 0.15% (-)-Δ⁸-THC, 0.01% Cannabidiol and < 0.01% (-)-Δ⁹-THC detected by HPLC/UV analysis.

² Validated analytical method

Spectral and Physical Data

HPLC/UV



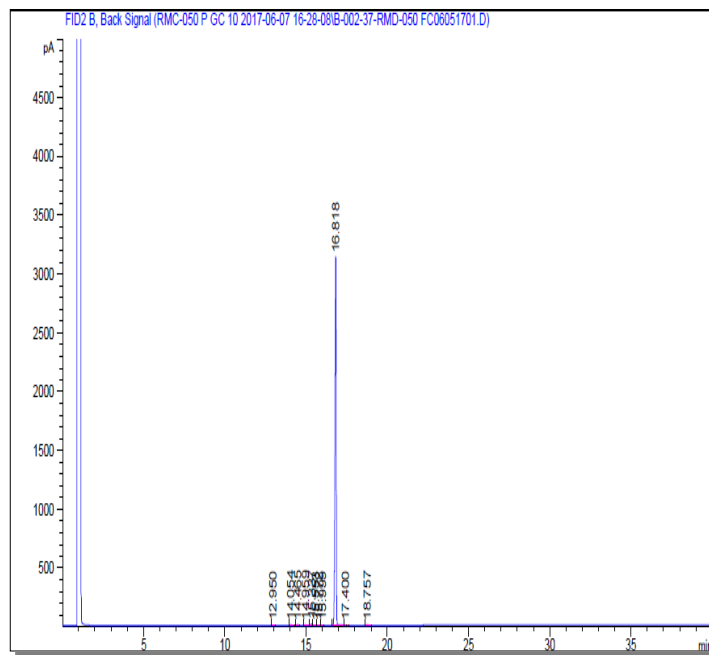
Column: Luna C18 (2), 3 μ m, 4.6 x 150 mm
Mobile Phase: Methanol:Water:Tetrahydrofuran (71:24:5)
Flow Rate: 1.0 mL/min
Wavelength: 228 nm

Data File Name: RMC-050 P2 LC 4 2017-06-13 16-57-23\005-42.D
Instrument: LC#4
Sample Name: FC06051701
Acquired: June 13, 2017

Peak #	Ret Time	Area	Area %	
1	9.56	8.20	0.02	
2	9.95	2.41	0.01	
3	13.89	2.03	0.01	Cannabidiol
4	17.12	7.22	0.02	
5	19.03	10.17	0.03	
6	20.37	2.18	0.01	
7	21.51	72.53	0.19	
8	21.71	0.18	0.00	
9	22.51	3.44	0.01	
10	24.93	38596.50	99.37	Cannabinol
11	27.47	0.30	0.00	
12	30.02	9.95	0.03	
13	31.95	1.48	0.00	(-)- Δ^9 -THC
14	32.14	0.77	0.00	
15	36.24	58.57	0.15	(-)- Δ^8 -THC
16	40.37	0.49	0.00	
17	41.88	37.57	0.10	
18	54.84	25.29	0.07	

Spectral and Physical Data (cont.)

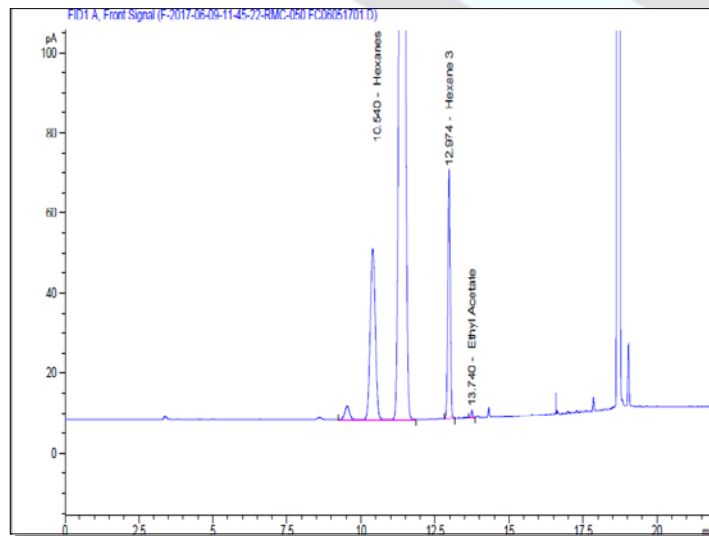
GC/FID



Column: DB-35ms, 30 m x 0.53 mm ID, 1.0 μ m film thickness
Temp Program: 40°C to 200°C at 40°C/min
 200°C to 300°C at 5°C/min hold 16 min
Injector Temp: Cool-on-Column
Detector Temp: 325°C
Data File Name: RMC-050 P GC 10 2017-06-07 16-28-08\B-002-37.D
Instrument: GC#10
Sample Name: FC06051701
Acquired: June 07, 2017

Peak #	Ret Time	Area	Height	Area %
1	12.95	5.73	0.99	0.03
2	14.05	29.72	5.73	0.18
3	14.47	38.15	7.11	0.23
4	14.96	30.71	5.48	0.18
5	15.34	76.05	14.94	0.45
6	15.55	6.93	1.04	0.04
7	15.77	6.36	1.13	0.04
8	16.00	2.69	0.50	0.02
9	16.82	16548.60	3128.49	98.67
10	17.40	1.71	0.39	0.01
11	18.76	25.67	3.80	0.15

Residual Solvent Analysis by GC/FID Headspace



Column: DB-ALC1 30 m x 0.53 mm, 3 μ m film thickness
Temp Program: 40°C (12 min) to 220°C at 40°C/min (5.5 min)
Carrier Gas: Helium
Flow Rate: 2.0 mL/min
Detector Heater Temp: 250°C
Injector: Headspace Sampler
HS Oven Temp: 60°C
Vial Equilibration: 10 minutes

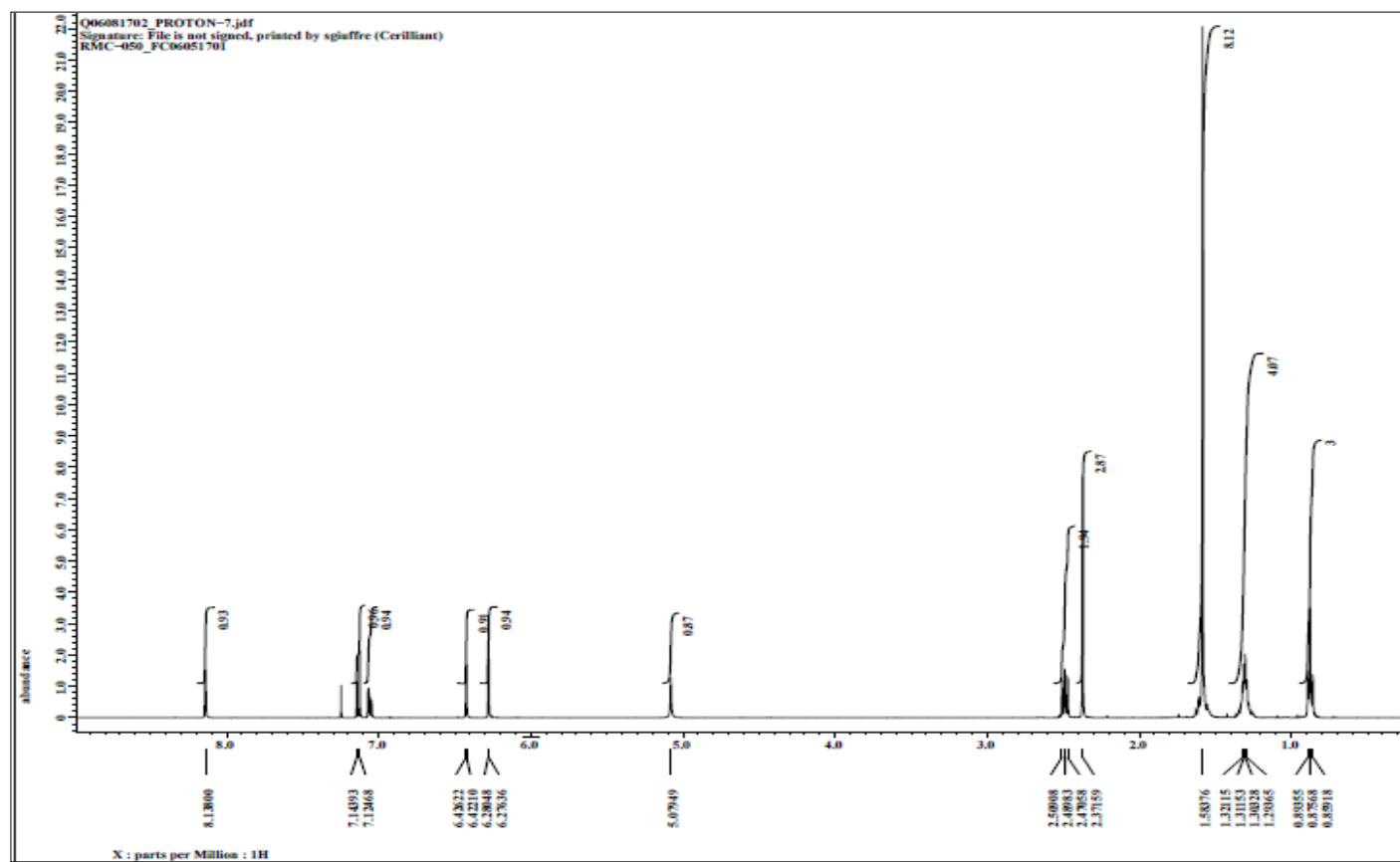
Data File Name: 2017-06-09 11-11-40\F-2017-06-09-11-45-22.D
Instrument: GC#11
Sample Name: FC06051701
Acquired: June 09, 2017

Peak	Compound	Area	Weight %
1	Hexanes	4573.39	0.97
2	Ethyl acetate	7.60	0.02
3	NMP	NA	NA
Total			0.99

Spectral and Physical Data (cont.)

¹H NMR

Instrument: JEOL ECS 400
Solvent: Chloroform-D

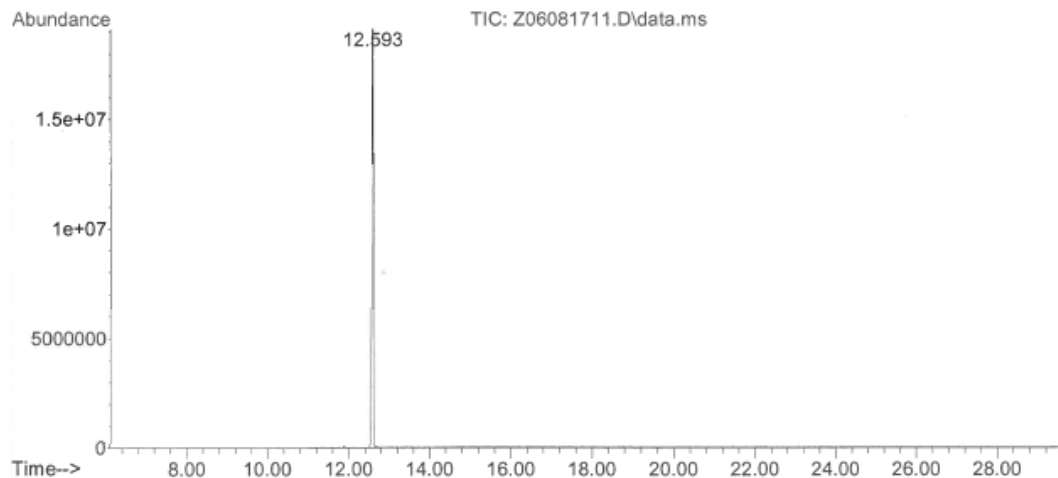


Spectral and Physical Data (cont.)

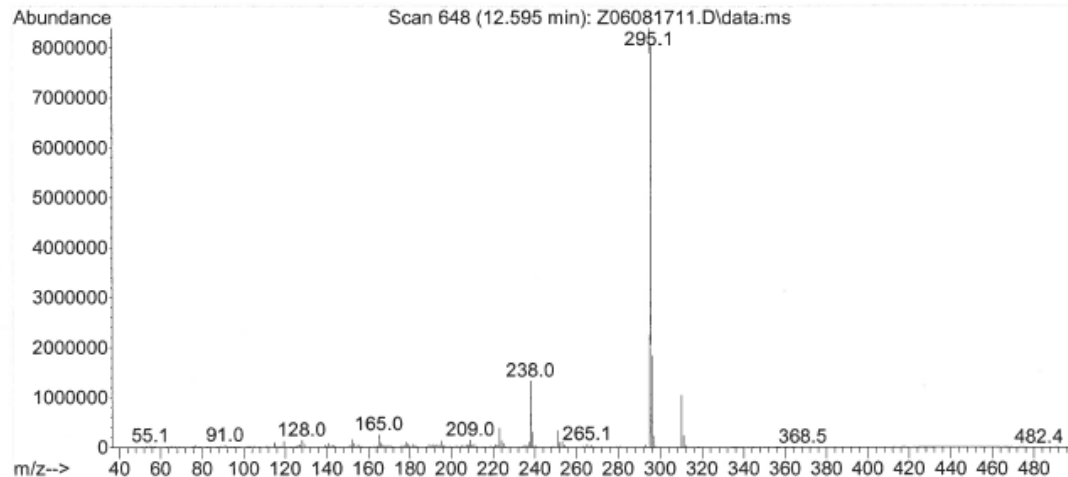
GC/MS

Compound Name : Cannabinol
Lot Number : FC06051701
Instrument : Agilent GCMS
Operator : ECM(SGIUFFRE)
Date Reported : Thu Jun 08 18:22:30 2017
Column Type : DB-5ms, 30m x 0.25mm ID, 0.25um film thickness
Temp. Program : 50°C to 200°C@40°C/min, 200°C to 300°C@10°C/min, 16min hold
Injector Temp. : Cool on-column
Carrier Gas : Helium
Flow Rate (mL/min) : 0.80 mL/min
Transfer Line Temp. : 280°C
Scan Range : 50-500

Total Ion Chromatogram



Mass Spectrum



Stability

Short term stability studies have been performed under accelerated conditions for a period of up to four weeks. Short term data is utilized to predict long term stability and to support transport conditions and normal laboratory use. Real-time stability studies are performed at the recommended storage conditions over the life of the product.

Short Term Stability: A summary of accelerated stability findings for this product is listed below.

Storage Condition	Mean Kinetic Temperature (MKT)	Time Period/Result
Freezer	-15°C	No decrease in purity was noted after four weeks.
Refrigerator	4°C	
Room Temperature	21°C	
40°C	40°C	

Transport/Shipping: Stability studies support the transport of this product at ambient conditions.

Long Term Stability: Long term stability has been assessed for Freezer storage (-10 °C to -25 °C) conditions. Stability of a minimum of 56 months has been established through real-time stability studies.

COA Revision History

Revision No.	Date	Reason for Revision
00	July 12, 2017	Initial version