THE 2016 EMERALD CONFERENCE

Cerilliant® Analytical Reference Standards

Potency Claims - only as Accurate as your Reference Material

Challenges with unstable THC and related Cannabinoids

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Cerilliant Corporation

Why is accuracy of potency assignment is important?

Various biomarkers are naturally at low levels, even with enhanced strains

- Safety & efficacy
- Legal & regulatory requirements

Safety & patient care

- Reduce risks associated with variable dosage - recent studies have highlighted potential dangers associated with *Cannabis* dosage
  - In studies treating depression, *Cannabis* has shown therapeutic efficacy at low doses, but in high doses THC can worsen symptoms of depression and other psychiatric conditions like psychosis.[1]
  - Epidemiologic research suggests that *Cannabis* may have a dose-dependent influence on seizure threshold, provoking and prolonging seizures at certain doses in adults and children with epilepsy.[2,3]
  - Marijuana use can increase convulsant effects in animal epilepsy models and in a case study, marijuana use was implicated as the cause of new-onset seizures.[4]
- Accuracy of Cannabis profiling and potency testing using accurate Certified Reference Materials (CRMs) is therefore critical to ensuring safe and successful patient outcomes when using Cannabis-based medicines.[5]

1. http://www.sciencedaily.com/releases/2007/10/071023183937.htm
2. http://dx.doi.org/10.1016/j.yebeh.2014.08.135
3. www.ncbi.nlm.nih.gov/pubmed/11737161
4. http://onlinelibrary.wiley.com/doi/10.1046/j.1528-1157.2001.19301.x/full
5. www.canorml.org/RingTestOShaughnessys_Aut11.pdf

Legal & regulatory requirements

- Legal requirements for classifying a strain are tight; inconsistencies in raw material and reference material lots could be critical
  - The state of Colorado requires *Cannabis* retailers to provide a cannabinoid potency profile for *Cannabis*-derived products.[1]
  - District of Columbia requires listing the cannabinoid profile of the marijuana contained within, including the THC level. [2]
  - European pharmaceutical companies that manufacture *Cannabis*-based medicines must conform to botanical raw material specifications that include tests for identification, impurities, and extraneous matter as well as assays for acidic and neutral cannabinoids.[3,4]
  - Cannabinoid profile; amount per package; amount per patient

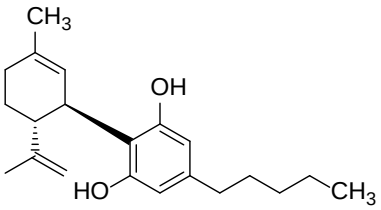
1. http://www.sos.state.co.us/CCR/GenerateRulePdf.do?ruleVersionId=5890&fileName=1%20CCR%20212-2
2. Comparison of Marijuana Laws- medicinal use-FINAL
3. *Cannabis*-med.org/data/pdf/2003-02-4_0.pdf
4. Mechoulam, R.: Cannabinoids as Therapeutics, Birkhäuser 2005

Results are only as accurate as the reference!

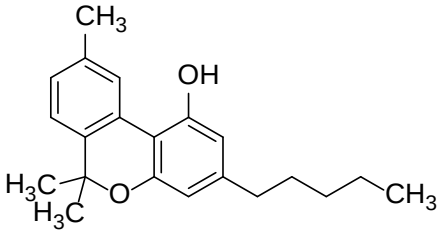
- Reference materials play a critical role in assuring quality of medicines and supplements
- Accuracy and reliability of analytical results is dependent on accuracy and reliability of the method of analysis, accuracy in the preparation of samples, and accuracy of the calibrators used
- Highly pure, well-characterized, reference materials are critical to the accuracy of the analysis
- Design, preparation, packaging, and storage of reference materials affect traceability, accuracy of concentration, stability, and uncertainty

What makes a good Reference Material? One suitable for quantitative applications?

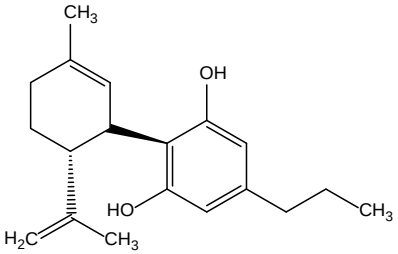
- ✓ High purity thoroughly & accurately characterized components – neat material characterization
- ✓ Solution standard design – whether pre-prepared or prepared at the bench
  - ✓ Prepared using accurate, calibrated, and qualified balances (pipettes & glassware when needed)
  - ✓ Accurate weighing operation and solvent addition
  - ✓ Traceability of all components
  - ✓ High purity diluents and/or stabilizers, compatible with the compound(s) and method
  - ✓ Analyzed to verify accuracy & consistency
  - ✓ Appropriate packaging and storage
  - ✓ Assessment of shelf life



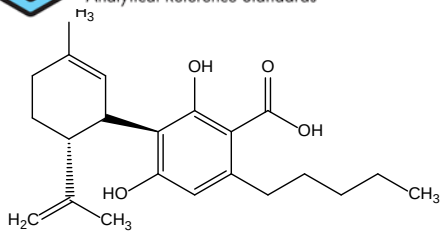
Cannabidiol



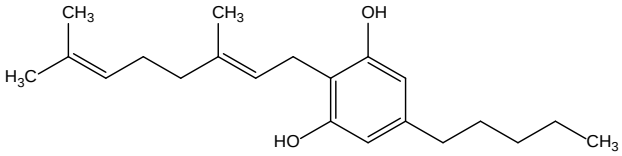
Cannabinol



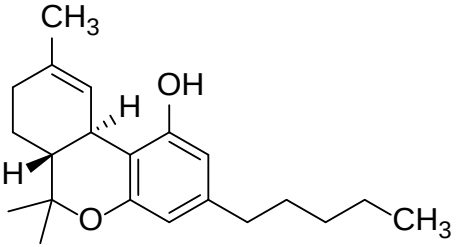
Cannabidivarin (CBDV)



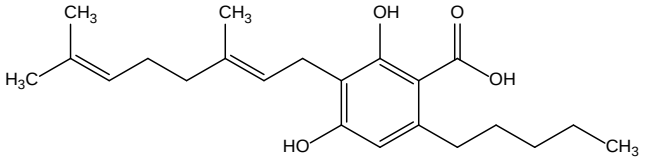
Cannabidiolic acid (CBDA)



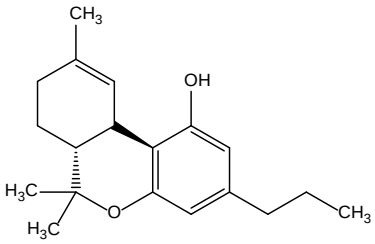
Cannabigerol (CBG)



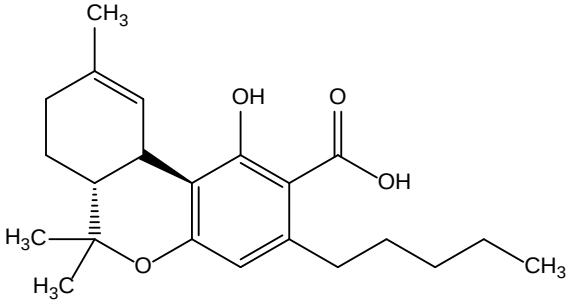
(-)-Δ^9-THC

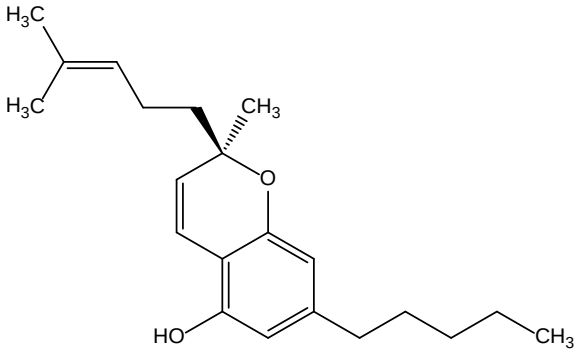


Cannabigerolic acid (CBGA)



Tetrahydrocannabivarin (THCV)





Cannabichromene (CBC)

Δ^9-Tetrahydrocannabinolic acid A (THCA-A)

Most commonly monitored *Cannabis* cannabinoid biomarkers

Reference materials – two options:

Reference Solution Prepared from Neat Starting Material – Typical Approach

- Volumetric solutions are prepared by weighing neat materials, diluting and assessing stabilit
volumetric flask
- Accurate prepa
certification of t
- Requires perso
equipment, QC
- Requires specia
toxic, potent, or
- Hygroscopic, el
difficult to handl
repeatability ch
- Weighing small
accurately is tim
and costly (Lilly
45 minutes per v
- Solutions may not be stable over time due to changes in concentration and degradation

Some *Cannabis* biomarkers require dilution immediately upon isolation including:

- **Δ^9-THC**
- **THCV**
- **CBC**
- **CBDA**
- **THCAA**



Ampouled Certified Solution Standards

- Spiked directly into diluent for calibrators or controls
Quantitatively transferred without dilution for analysis
Pre-prepared dilute solution provides safety in handling of toxic, potent, or hazardous materials in the analytical lab
Provides labor savings by eliminating weighing operations and providing consistency of analysis by eliminating variability of the reference – particularly for difficult to handle materials
Format (inert atmosphere) promotes long term stability
Fully certified with uncertainty & traceability established
DEA & Health Canada exemptions eliminate regulatory burden for laboratory
- Widely used in clinical/forensic toxicology & environmental industries



Proper design & preparation necessary to ensure stability & accuracy

Neat Material & Characterization

- Sourcing – Internal or external
- Material properties
- Full certification

Solution development

- End use implications
- Material handling
- Diluent selection
- Method development
- Stability assessment

Manufacture

- Planning
- Gravimetric prep
- Dispensing controls

Certification

- Purity
- Concentration
- Stability

Maintenance

- Inventory management
- Ongoing stability
- Technical improvements

One manufacturer's approach

Neat materials - certification

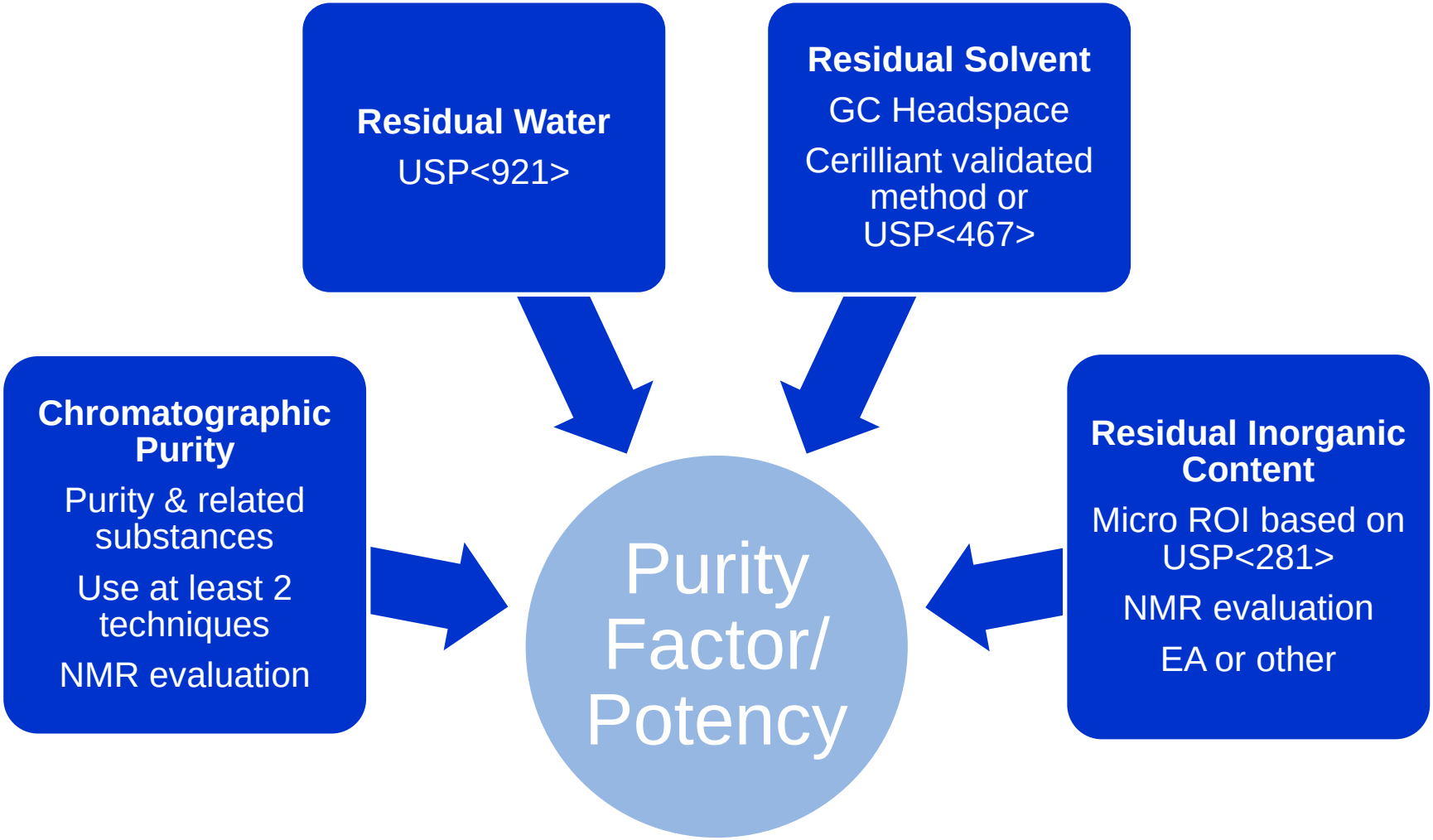
Identity

- Multiple techniques
  - 1D and 2D NMR
    - Proton
    - Carbon-13
    - Other nuclei
  - FTIR
  - GCMS, LCMS, LCMSMS
  - Other techniques as needed: EA, Optical Rotation, DSC, Melting Point, TGA
- Comparison to literature references

Purity / Potency

- Mass Balance – orthogonal approach
  - Multiple techniques for chrom purity and residuals
  - Based on ISO Guide 34
  - Used by NIST
  - Appropriate mass balance equation critical
- Assays – when appropriate
  - Availability of established methods with high precision
  - Availability of primary reference materials

Mass Balance – orthogonal approach



$$PurityFactor = \left[[100 - (wt\%Solvents) - (wt\%H_2O) - (wt\%Inorganics)] * \frac{ChromPurity}{100} \right]$$

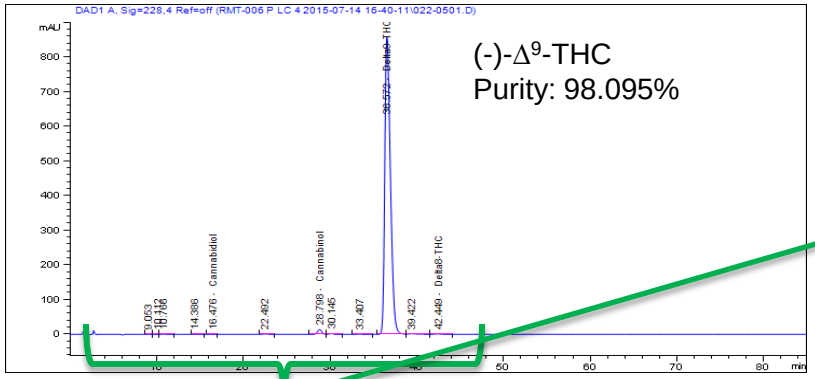
Analytical challenges with testing *Cannabis* cannabinoid biomarkers

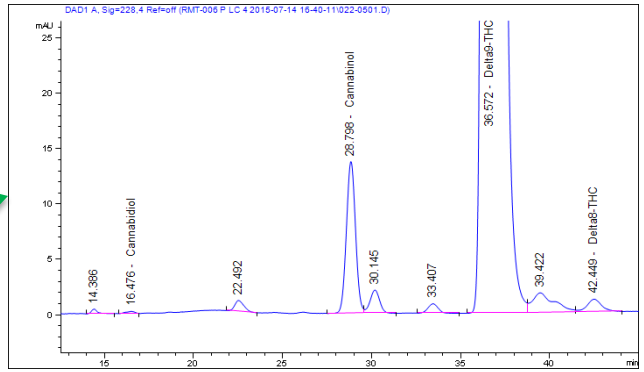
Impurity profiles and presence of one analyte in another

- Purity profile will contain related cannabinoids as impurities
- Relative response factors (RRFs) for impurities may be unknown complicating purity value determination by HPLC/UV
- RRFs for some THC-related impurities are highly variable
- Cannabinoid impurities have different UV absorption characteristics based on their structure
  - HPLC/UV may not reflect the actual level of certain impurities
  - Cannabinoids with higher aromaticity /conjugation have higher UV response : HPLC area % ≠ Impurity content
- Orthogonal purity techniques such as GC/FID and LC/MS should be employed, however
  - Cannabinoid instability may cause compound breakdown on GC/FID systems
  - MS response of analytes may not be equivalent

Measuring impurities/cannabinoid profile by HPLC/UV

- Cannabinol and Cannabidiol
  - By HPLC at a wavelength of 228 nm, Cannabinol has a 2.7 fold higher response than Cannabidiol
  - Cannabidiol raw material showed a 1% Cannabinol impurity, this value must be divided by the relative response factor of 2.7 to provide the accurate result of a-~0.37%Cannabinol impurity





Analyte	RRT	RRF	Unadjusted Purity %	Adjusted Purity %
Cannabidiol	0.45	1.14	0.02	0.02
Cannabinol	0.78	2.77	1.24	0.45
Δ^8-THC	1.14	0.94	0.17	0.17
Δ^9-THC	1.00	1.00	97.32	98.09

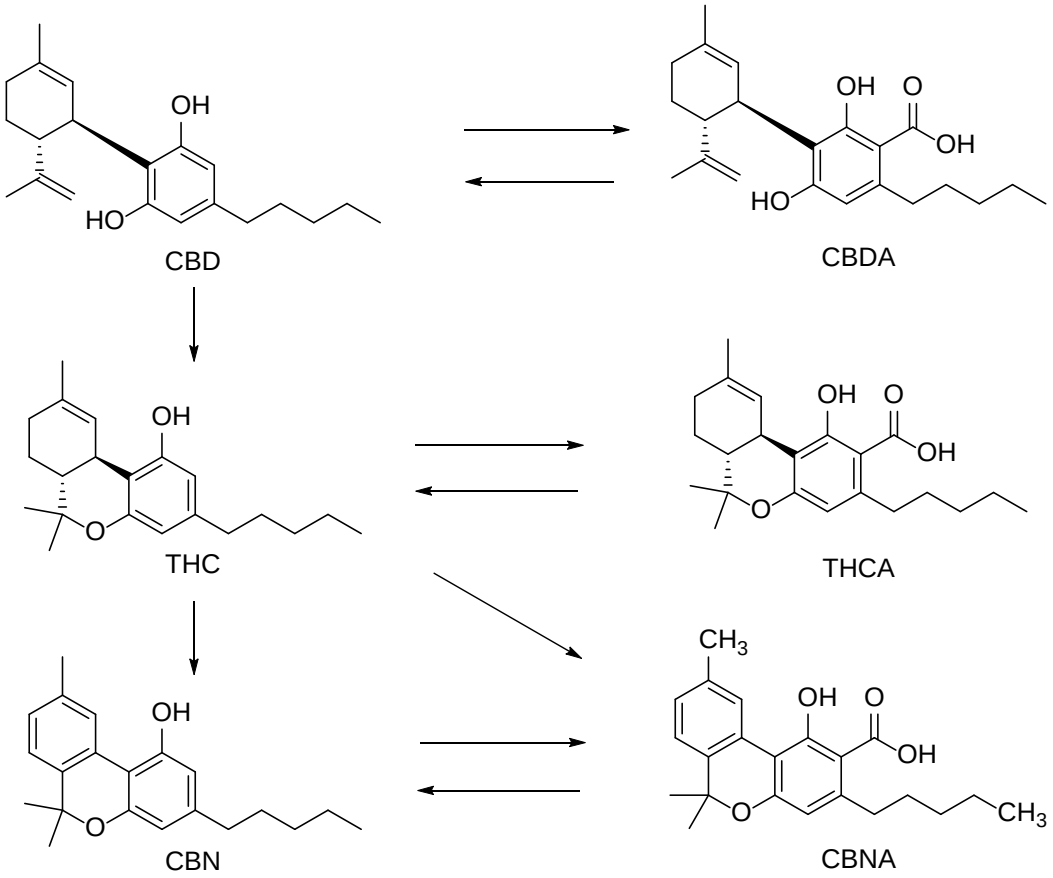
*Area% calculation, RRF between 0.9 and 1.1 will be considered as 1, this includes Cannabidiol and Δ^8-THC

USP Tolerances

Name	Relative Retention Time	Relative Response Factor	Limit (%)
Cannabinol	0.78	2.7	1.5
Δ⁹-Tetrahydrocannabinol	1.00	1.0	—
Exo-tetrahydrocannabinol[1]	1.07	0.92	0.5
Δ⁸-Tetrahydrocannabinol	1.18	0.90	2.0
Any other individual impurity	—	1.0	1.0

[1](6a*R*, 10a*R*)-6,6-Dimethyl-9-methylene-3-pentyl-6a,7,8,9,10,10a-hexahydro-6*H*-benzo[*c*]chromen-1-ol.

Impurity profiles – potential impurities

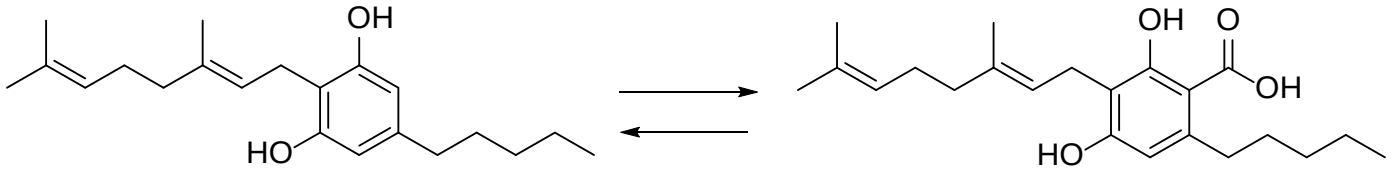


THCV analogs: Propyl side chain

- Related cannabinoids naturally occurring or due to oxidative degradation
- Derived from similar chemistries and can interconvert

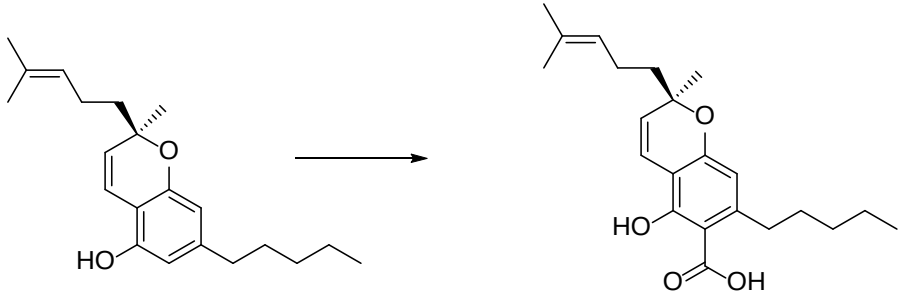
Impurity profiles – potential impurities

CBC & CBG Related Substances



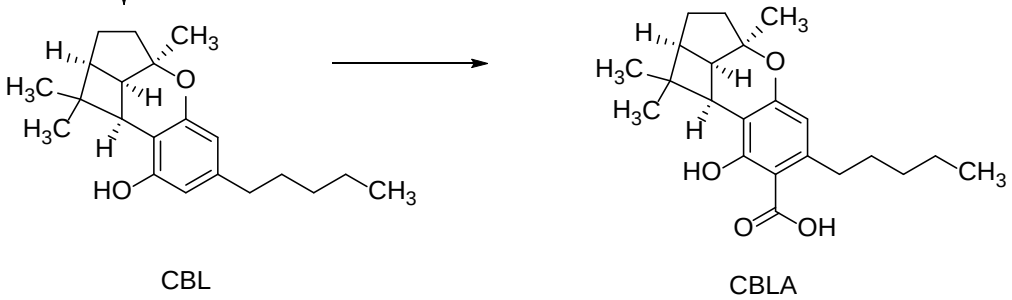
CBG

Cannabigerolic acid CBGA



CBC

CBCA



CBL

CBLA

Complete characterization critical

Use of chromatographic purity alone can introduce error into the concentration of the reference solution; impurities in one CRM can contribute to an analyte of interest if not accounted for in mixes

	Chrom. Purity (%)	Residual Solvent Content (%)	Residual Water Content (%)	Trace Inorganic Content (%)	Purity Factor for Quantitative Use (%)	PF Difference from Chrom Purity (%)	Catalog Number
Cannabidiol	99.3	0.85	Not detected	BQL	98.43	0.90	C-045
Cannabinol	99.5	3.39	0.11	NA	95.99	3.50	C-046
(-)-Δ^9-THC	98.6	1.47	NA	NA	98.70*	-0.10	T-005
Cannabigerol (CBG)	99.0	ND	BQL	BQL	99.00	0.00	C-141
Cannabichromene (CBC)	99.0	ND	BQL	NA	99.02	0.00	C-143
Cannabidiolic acid (CBDA)	99.0	1.40	BQL	BQL	97.57	1.40	C-144
Cannabigerolic acid (CBGA)	99.3	0.16	ND	BQL	99.11	0.20	C-142
Δ^9-Tetrahydrocannabinolic acid A (THCA-A)	98.4	0.41	ND	BQL	97.95	0.50	T-093
Tetrahydrocannabivarin (THCV)	98.8	1.68	BQL	NA	97.18	1.60	T-094
Cannabidivarin (CBDV)	98.8	0.91	BQL	BQL	97.90	0.90	C-140

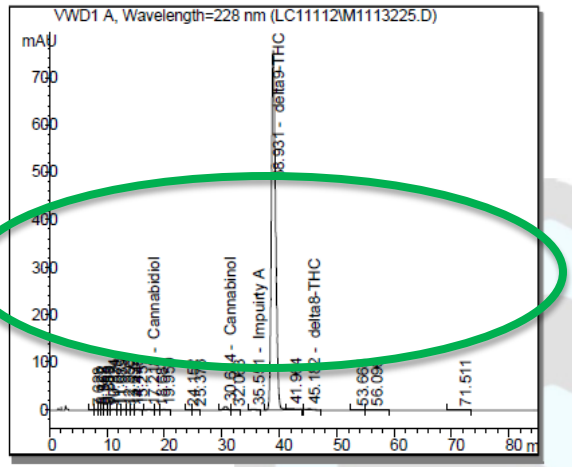
ND = None Detected; BQL = beyond quantitation limit (<0.2%)
*Chrom purity is adjusted and an average of two. Purity factor based on assay value

Impact is low due to documented specifications and robust manufacturing, testing and purification procedures.

Example of impurity notation on COA

Spectral and Physical Data

HPLC/UV



Column:	Luna C18(2), 3.0 µm, 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:	S:\HPLC\HPLC1\2012\LC11112\M1113225.D
Instrument:	LC#1
Sample Name:	FC110112-02
Acquired:	November 14, 2012

Peak #	Ret Time	Area	Area %
1	7.63	3.65	0.01
2	8.12	5.35	0.01
3	8.56	4.12	0.01
4	9.25	12.96	0.03
5	9.59	5.71	0.01
6	10.32	2.15	0.01
7	11.07	15.46	0.04
8	11.69	5.68	0.01
9	12.99	10.25	0.03
10	13.70	5.42	0.01
11	14.45	7.30	0.02
12	15.26	14.92	0.04
13	17.22	20.40	0.05
14	18.68	6.60	0.02
15	19.95	10.86	0.03
16	24.15	2.31	0.01
17	25.38	4.58	0.01
18	30.64	311.69	0.80
19	32.06	7.59	0.02
20	35.55	37.10	0.09
21	38.93	38449.20	98.25
22	41.96	72.52	0.19
23	45.18	87.42	0.22
24	53.67	12.35	0.03
25	56.10	11.08	0.03
26	71.51	7.84	0.02

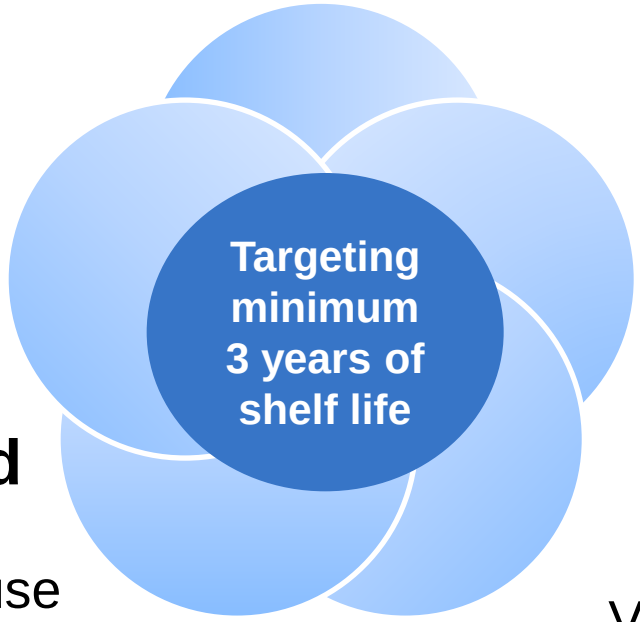
Solution standard development

Goal is long term shelf life and suitability for intended use

Understanding the Intended Use

Stability Studies
Accelerated at various conditions
Precipitation
Degradation

Material Properties
Handling & Preparation Considerations
Hygroscopicity
Air & light sensitive
Potency / Toxicity

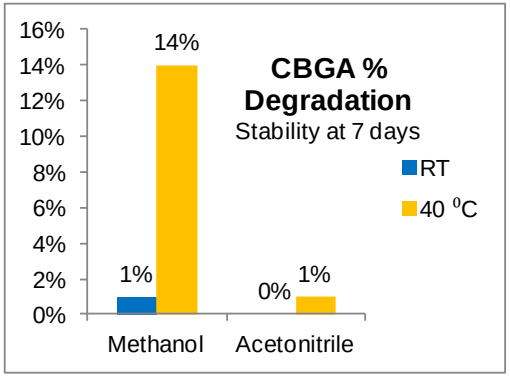


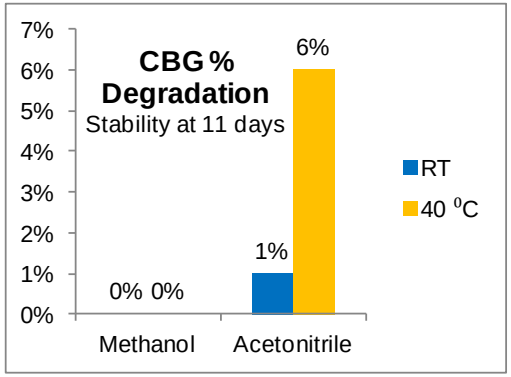
Analytical Method Development
Interferences with end use method
Resolution of known impurities

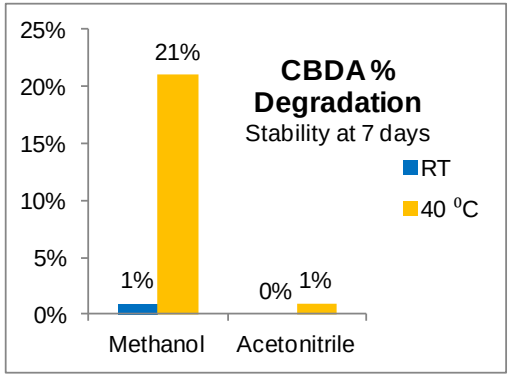
Diluent & Concentration
Solubility & Stability
Various solvents
Various concentrations
Suitability for end use

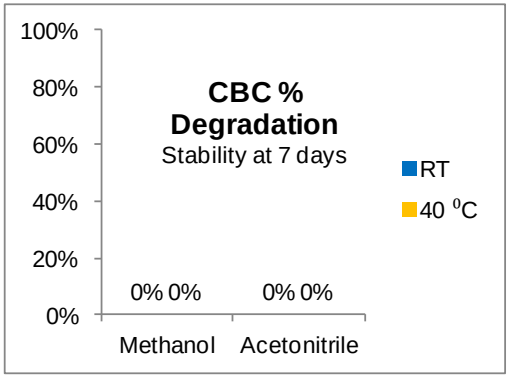
Solution development – challenges in selecting appropriate diluent

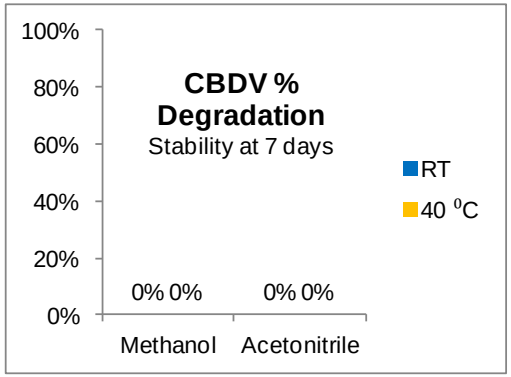
Methanol vs. Acetonitrile in accelerated studies











- Stability impacted by diluent and handling
- Stability controlled by validated processes, storage container, diluent quality, and inert gas overlay

Manufacturing

Robust manufacturing practices critical to accuracy & consistency

Material / Equipment Needs

- Hygroscopicity
- Sensitivity to air or light
- Static potential
- Viscosity / volatility
- Toxicity/potency
- Room selection
- Environmental controls – glove box

Gravimetric Preparation

- Weight/Weight
- Higher precision vs. volumetric
- Balance selection
- Batch size flexibility vs. volumetric
- Traceability with weigh tapes
- Repeatability

Dispensing

- Equipment checks
- Line purge
- Tubing & syringes
- Sampling plans
- Segregation
- Evaporation control

Handling challenges with *Cannabis* cannabinoid biomarkers

	Physical form	O2 Sensitive	Heat Sensitive	Light
Cannabidiol	Solid	✓	✓	
Cannabinol	Viscous liquid	✓		
Cannabidivarin (CBDV)	Solid	✓	✓	
Cannabidiolic acid (CBDA)	Solid	✓	✓	
Cannabigerol (CBG)	Solid	✓	✓	
(-)-Δ^9-THC	Glassy solid	✓	✓	✓
Cannabigerolic acid (CBGA)	Solid		✓	
Tetrahydrocannabivarin (THCV)	Glassy solid	✓	✓	✓
Δ^9-Tetrahydrocannabinolic acid A (THCA-A)	Foam		✓	
Cannabichromene (CBC)	Viscous liquid	✓	✓	✓

- Difficult to handle materials; some viscous liquids or “glassy” solids
- Glassy solids / liquids are hard to handle: sticky or so hard they cannot be weighed without melting
- Sensitive to air, light and heat – requiring glove box weighing in low actinic lighting
  - THC, THCV & CBC: Rapid darkening upon exposure to oxygen
  - Oxidative degradation produces a large number of polar impurities (eluting early under reverse-phase chromatography conditions)
  - THCV is not stable for more than an hour or two unless immediately put into a diluent

Certification of the solution standard

Certified gravimetric preparation supported by analytical verification of purity, concentration & homogeneity

Consistency

Lot-to-lot consistency verified by comparing to the previous lot

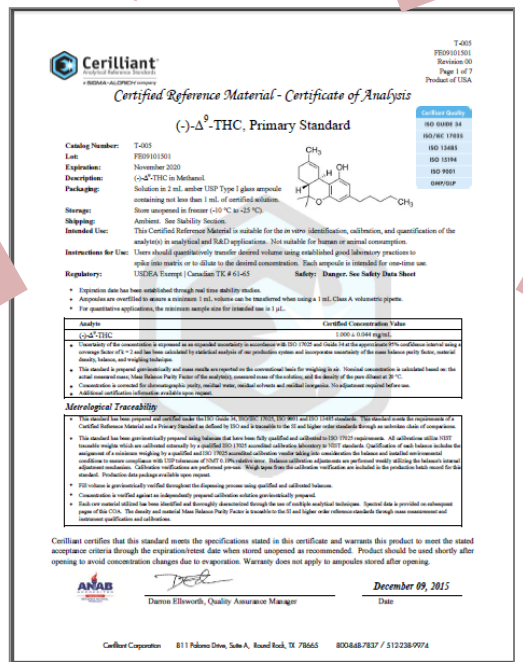
Homogeneity

Across the batch of ampoules/vials

Accuracy

Comparison to a primary source or certified second source – curve/calibration standard

Comparison of multiple independent preparations



Cerilliant

T-005
FE09101501
Revision: 00
Page 1 of 7
Product of USA

Certified Reference Material - Certificate of Analysis

(-)-Δ^9-THC, Primary Standard

Catalog Number: T-005
Lot: FE09101501
Expiration: November 2020
Description: (-)-Δ^9-THC 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 TC # 61-65 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
(-)-Δ^9-THC	1.000 ± 0.044 mg/mL

- 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 this 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 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 mechanisms. 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 calibration.

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.

ANAB

Darron Ellsworth, Quality Assurance Manager

December 09, 2015
Date

Cerilliant Corporation 811 Paloma Drive, Suite A, Round Rock, TX 78665 800.848.7837 / 512.238.9974

Purity

Consistent with neat material

No contamination or degradation

Assessment of solution stability

Ampouled format promotes stability by preventing evaporation & degradation due to presence of oxygen

- Accelerated stability– determination of requirements for transport and short term use at the bench
  - Qualified shippers and packing protocols
  - Shipping studies determine extremes encountered during transit
  - Accelerated data determines need for shipment under controlled conditions
  - Data supports short-term excursions and normal lab use
- Real-time stability collected upon release of new lots
- Concentration verification of solution standards compared to a calibration standard
- Initial assignment of retest date and tested per a protocol until shelf life is established

Stability – purity & concentration

Properly designed & prepared ampouled solutions can be stable for many years

Compound	Solvent	Stability	Purity		Analyzed Concentration	
			Original	Stability Interval	Original	Stability Interval
Cannabinol	Methanol	42 months **Refrigerate**	99.7% at 228 nm	99.3% at 228 nm	0.991 mg/mL	0.979 mg/mL
Cannabidiol	Methanol	47 months **Refrigerate**	99.7% at 228 nm	99.6% at 228 nm	1.002 mg/mL	0.974 mg/mL
Cannabigerol (CBG)	Methanol	12 months **Freeze**	99.1% at 225 nm	99.2% at 225 nm	1.001 mg/mL	0.997 mg/mL

Concentration acceptance criteria for each of the examples = ± 3% and incorporates variability of the analysis.

LONG TERM STABILITY			
Compound	**Solvent**	**Storage**	**Stability**
Cannabidinol	Methanol	Freezer	60 months
Cannabinol	Methanol	Freezer	56 months
Cannabidivarin (CBDV)	Methanol	Sub-Freezer	12 months
Cannabidiolic acid (CBDA)	Acetonitrile	Sub-Freezer	8 months
Cannabigerol (CBG)	Methanol	Freezer	12 months
(-)-Δ^9-THC	Methanol	Freezer	60 months
Cannabigerolic acid (CBGA)	Acetonitrile	Sub-Freezer	11 months
Tetrahydrocannabivarin (THCV)	Methanol	Sub-Freezer	3 months
Δ^9-Tetrahydrocannabinolic acid A (THCA)	Acetonitrile	Sub-Freezer	6 months
Cannabichromene (CBC)	Methanol	Freezer	15 months

Example stability section of a COA

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.

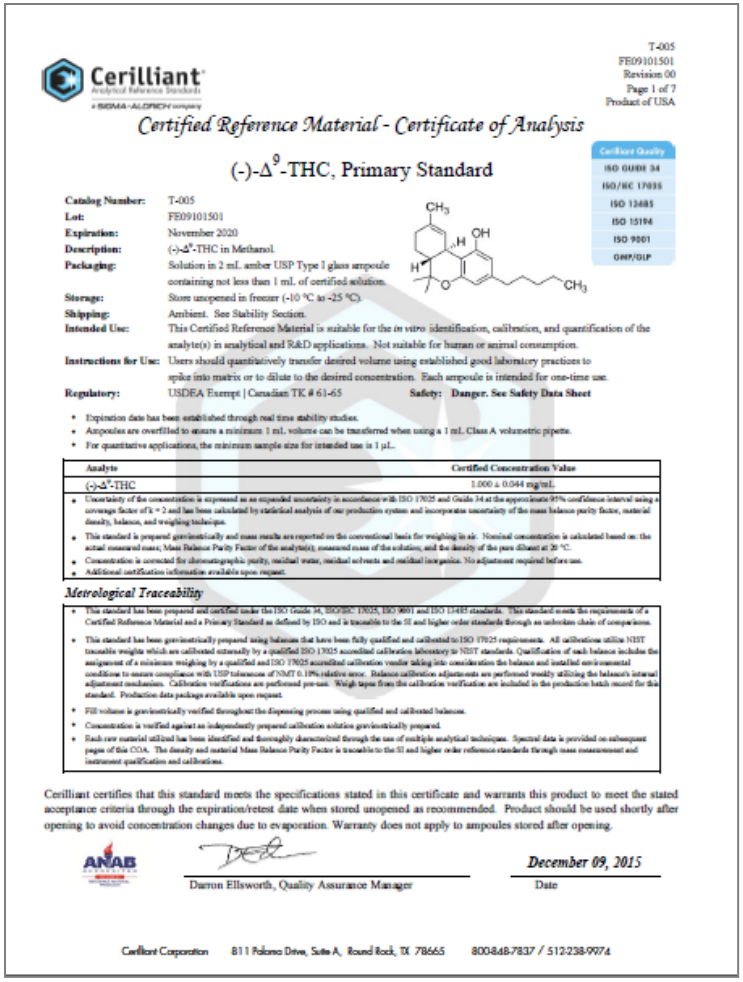
Short Term Stability: *A summary of accelerated stability findings for this product is listed below.*		
Storage Condition	**Mean Kinetic Temperature (MKT)**	**Time Period/Result**
Freezer	-15°C	No decrease in purity was noted after four weeks.
Refrigerator	4°C	
Room Temperature	21°C	
40°C	40°C	
Transport/Shipping: *Stability studies support the transport of this product at ambient conditions.*		
Short Term Storage: *Stability data supports short term storage for up to 12 months at Refrigerate conditions.*		
Long Term Stability: *Long term stability has been assessed for Freezer storage (-10 °C to -25 °C) conditions. Stability of a minimum of 60 months has been established through real-time stability studies.*		

*Sub-freezer= -70 ºC

Comprehensive COA

Includes full details of all analyses, including method, run conditions, chromatograms, and spectral data

- Expiration/retest date
- Isotopic purity
- Concentration & uncertainty
- Uncertainty statement
- Analytical verification of concentration
- Ampoule to ampoule consistency
- Traceability statement
- Solution standard assay
- Neat material characterization summary & purity factor assignment
  - Chromatographic purity
  - Residuals & method details
  - Purity factor
  - Identity
- Storage
- Stability data



Cerilliant

T-005
FE09101501
Revision 00
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Product of USA

Certified Reference Material - Certificate of Analysis

(-)-Δ^9-THC, Primary Standard

Cerilliant Quality
ISO GUIDE 34
ISO/IEC 17025
ISO 13485
ISO 15194
ISO 9001
GMP/GLP

Catalog Number: T-005
Lot: FE09101501
Expiration: November 2020
Description: (-)-Δ^9-THC 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 # 61-65 **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
(-)-Δ^9-THC	1.000 ± 0.044 mg/mL

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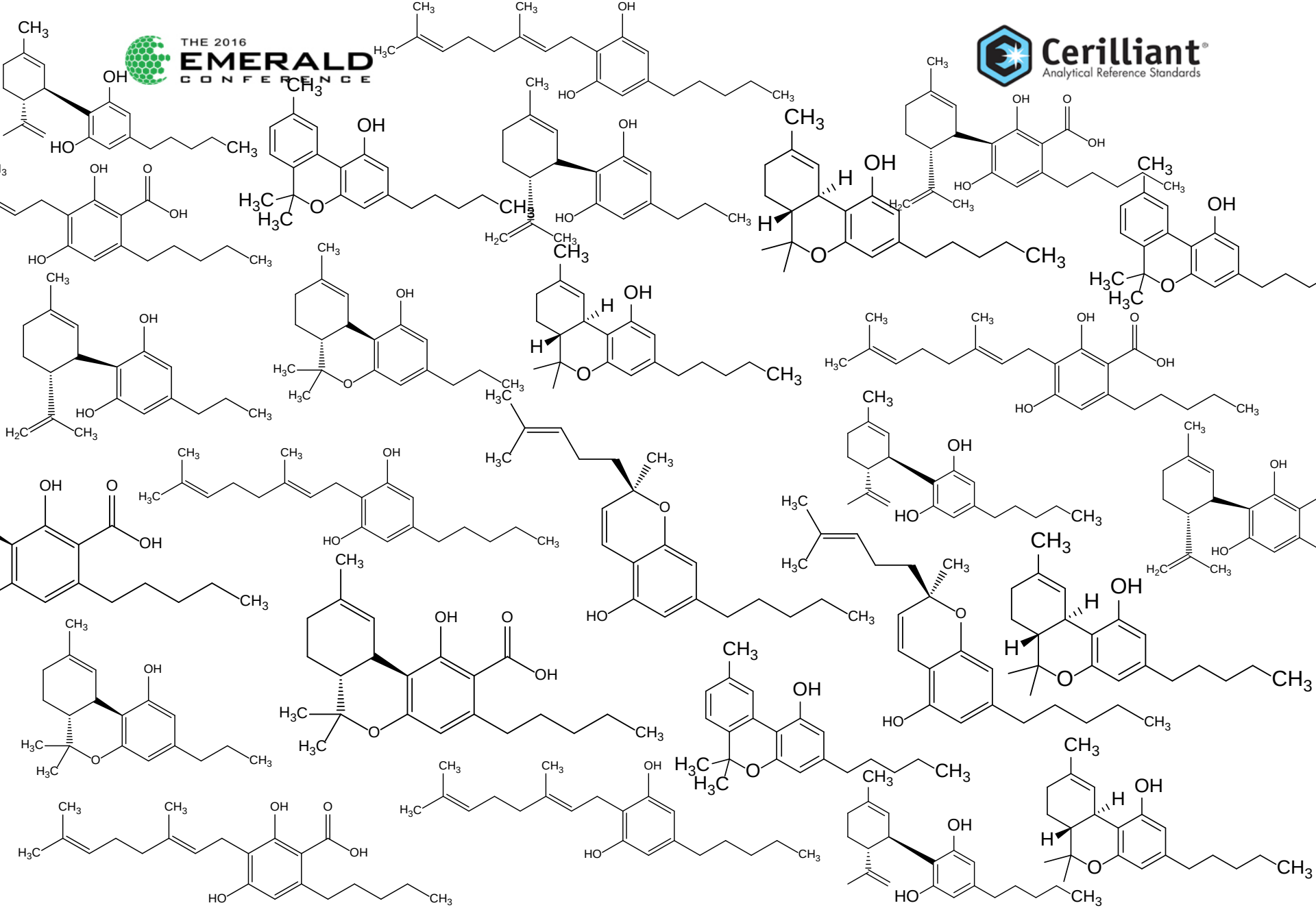
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What makes a good reference material?

- Fully characterized high purity neat materials and high purity diluents
  - Careful assignment of chromatographic purity by multiple methods
  - Analysis of residual impurities including water, inorganics and solvent
- Sound understanding of material characteristics through design & development
- Validated preparation process ensuring consistency and accuracy of solution concentration, purity & stability
- Qualified balances in their installed state with minimum weighings set for <0.1% relative error
- Gravimetric approach in solvent addition
- Traceability to SI units
- Uncertainty statement encompassing all aspects of standard preparation from neat material characterization to solution preparation.
- Prepared in a stable ampouled format
- Preparation and certification by an ISO Guide 34 and ISO 17025 accredited laboratory whose quality systems are also compliant to GMP and GLP

Pre-made ampouled certified solution standards
A significant advantage over neat reference materials…


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EMERALD
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Analytical Reference Standards