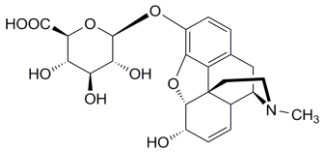
Certified Reference Material - Certificate of Analysis

Morphine-3-β-D-glucuronide, Primary Measurement Standard

(5α, 6α)-7,8-didehydro-4,5-epoxy-6-hydroxy-17-methylmorphinan-3-yl-β-D-glucopyranosiduronic acid

Product No.: M-031-1ML
Lot No.: FE02142003
Description of CRM: Morphine-3-β-D-glucuronide in Methanol with 0.05% NaOH (w/v) (Solution)
Expiration Date: February 2025 See Section "Stability Assessment".
Storage: Store unopened and upright in refrigerator (2 °C to 8 °C). Do not freeze.
Shipping: Ambient. See Section "Stability Assessment".
Chemical formula: $C_{23}H_{27}NO_9$
CAS No.: 20290-09-9
Regulatory: USDEA Exempt | Canadian TK # 61-1297

Cerilliant Quality
ISO 17034
ISO/IEC 17025
ISO 13485
ISO 14001
ISO 9001



Analyte	Certified Concentration ± associated uncertainty U, u=k*u (k=2)
Morphine-3-β-D-glucuronide	1.000 ± 0.006 mg/mL

Metrological traceability: Traceable to the SI and higher order standards from NIST through an unbroken chain of comparisons. See "Details on metrological traceability" on page 2.

Measurement method: The certified value is calculated from high precision weighing of thoroughly characterized starting material. See "Details about certification process" on page 2.

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.

Minimum sample size: 1 µL for quantitative applications

Instructions for handling and correct use: Concentration is corrected for chromatographic purity, residual water, residual solvents, and residual inorganics. No adjustment required before 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.
15-30 minute sonication required before use to ensure accurate concentration.

Health and safety information: Danger. Please refer to the Safety Data Sheet for detailed information about the nature of any hazard and appropriate precautions to be taken.

Accreditation: Cerilliant Corp. is accredited by the US accreditation authority ANAB as registered reference material producer AR-1353 in accordance with ISO 17034 and registered testing laboratory AT-1352 according to ISO/IEC 17025.

Darron Ellsworth, Quality Assurance Manager

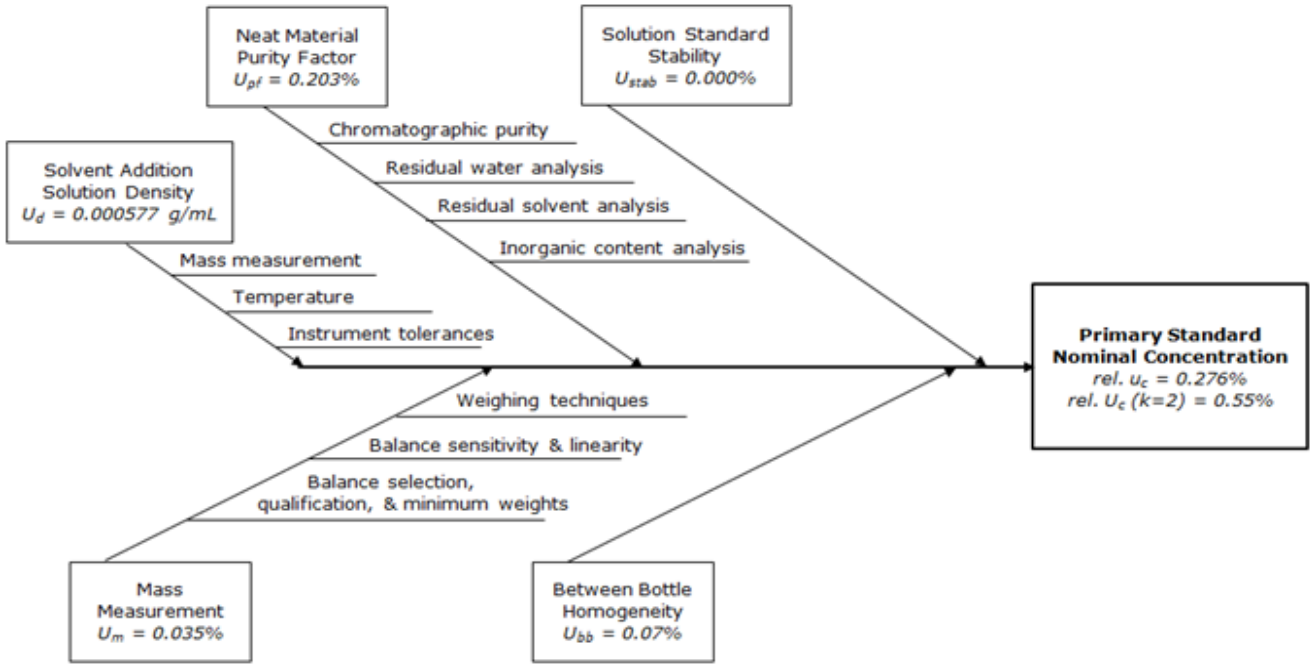
April 09, 2020
Issue Date

Cerilliant Corporation, 811 Paloma Drive, Suite A Round Rock, TX 78665, USA, Tel: 800-848-7837 / 512-238-9974

Packaging:	2 mL amber USP Type 1 glass ampoule containing not less than 1 mL of certified solution. Ampoules are overfilled to ensure a minimum of 1 mL volume can be transferred when using a 1mL Class A volumetric pipette.
Details on starting materials:	Each raw material utilized has been identified and thoroughly characterized through the use of multiple analytical techniques and is assigned a Mass Balance Purity Factor. Spectral data is provided on subsequent pages of this CoA.
Certificate of Origin:	Cerilliant Corporation certifies no material of animal origin (BSE/TSE) was used in the preparation of this product. This material was manufactured in the USA.

Associated uncertainty:

The uncertainty has been calculated by statistical analysis of all aspects of our production system and incorporated uncertainty of the mass balance purity factor, material density, balance, weighing technique, and homogeneity. Uncertainty components of the gravimetrically prepared Primary Standard concentration are shown in the figure below. Uncertainty is expressed as an expanded uncertainty in accordance with ISO 17034 at the approximate 95% confidence interval using a coverage factor of k=2. Uncertainty contribution from neat material homogeneity was established to be negligible through establishment of process controls and verification of the control process. Stability uncertainty was determined to be negligible by regression analysis.



Details on metrological traceability:

- 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.
- Fill volume to predetermined specifications is gravimetrically verified throughout the dispensing process using qualified and calibrated balances.
- The density and material Mass Balance Purity Factor of each raw material is traceable to the SI and higher order reference materials through mass measurement and instrument qualification and calibrations.

Details about certification process:

This standard has been prepared and certified under the ISO 17034, 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.

- Nominal concentration is calculated based on: the actual mass; Mass balance purity factor of the analyte(s); measured mass of the solution; and the density of the pure diluent at 20°C.
- 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.
- Additional certification information available upon request.

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 Phenyl-Hexyl, 2.7 µm, 3.0 x 100 mm	**Number of Points:**	4
Mobile Phase:	Methanol:0.1% Phosphoric acid in Water (10:90)	**Linearity (r) :**	1.000
Flow Rate:	1.2 mL/min		
Wavelength:	218 nm		

		Verified Concentration (mg/mL)	**%RSD - Homogeneity**
Standard Solution	**Lot Number**	**Actual Results**	**Actual Results**
New Lot	FE02142003	1.004	0.6
Previous Lot	FE11301701	1.006	0.2

- 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:	Morphine-3-β-D-glucuronide	**Chemical Formula:**	$C_{23}H_{27}NO_9$
Material Lot:	FC05261602	**CAS Number:**	20290-09-9
		Molecular Weight:	461.46

Material Characterization Summary

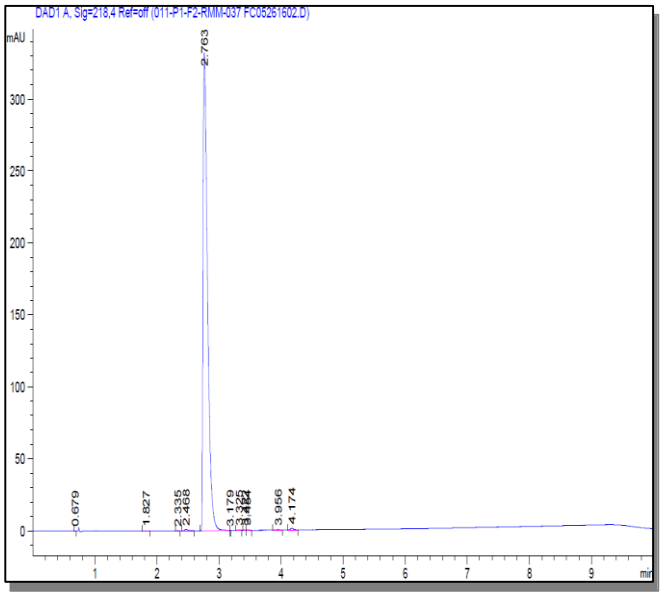
Analytical Test	Method	Results
Primary Chromatographic Purity by HPLC/UV Analysis	20384348	99.3% [1]
Secondary Chromatographic Purity by LC/MS Analysis	20384217	> 99.9%
Identity by LC/MS Analysis	20384217	Consistent with Structure
Identity by ^{1}H-NMR Analysis	20384224	Consistent with Structure
Residual Solvent Analysis by GC/FID Headspace	20397799 [2]	None Detected
Residual Water Analysis by Karl Fischer Coulometry	20398075 [2]	Below Quantitation Limit
Inorganic Content by Microash Analysis	20384350	< 0.2%
Mass Balance Purity Factor		99.31%

[1] 0.06% Morphine detected by HPLC/UV analysis.
[2] Validated analytical method

- 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 purity method was selected to optimize resolution of impurities while minimizing degradation of the analyte. Secondary purity methods with orthogonal detector capabilities from the primary purity method are used as controls to confirm an accurate purity value.
- 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.

Spectral and Physical Data

HPLC/UV



Column: Ascentis Express Phenyl-Hexyl, 2.7 µm, 3.0 x 100 mm

Mobile Phase: A: Methanol
B: 0.1% Phosphoric acid in Water

Gradient:

Time (min)	% A	% B
0.0	3	97
4.0	15	85
8.0	40	60
8.1	3	97

Flow Rate: 0.6 mL/min

Wavelength: 218 nm

Sample Name: FC05261602

Acquired: October 29, 2019

Peak #	Ret Time	Area %
1	0.68	0.01
2	1.83	0.02
3	2.34	0.02
4	2.47	0.21
5	2.76	99.31
6	3.18	0.00
7	3.33	0.06
8	3.42	0.03
9	3.45	0.03
10	3.96	0.06
11	4.17	0.25

Peak 10 has been identified as Morphine.

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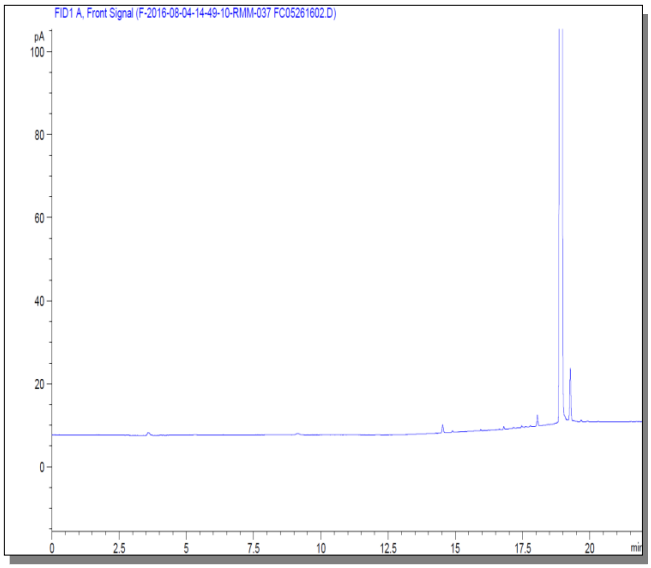
Spectral and Physical Data (cont.)

Residual Solvent Analysis by GC/FID Headspace



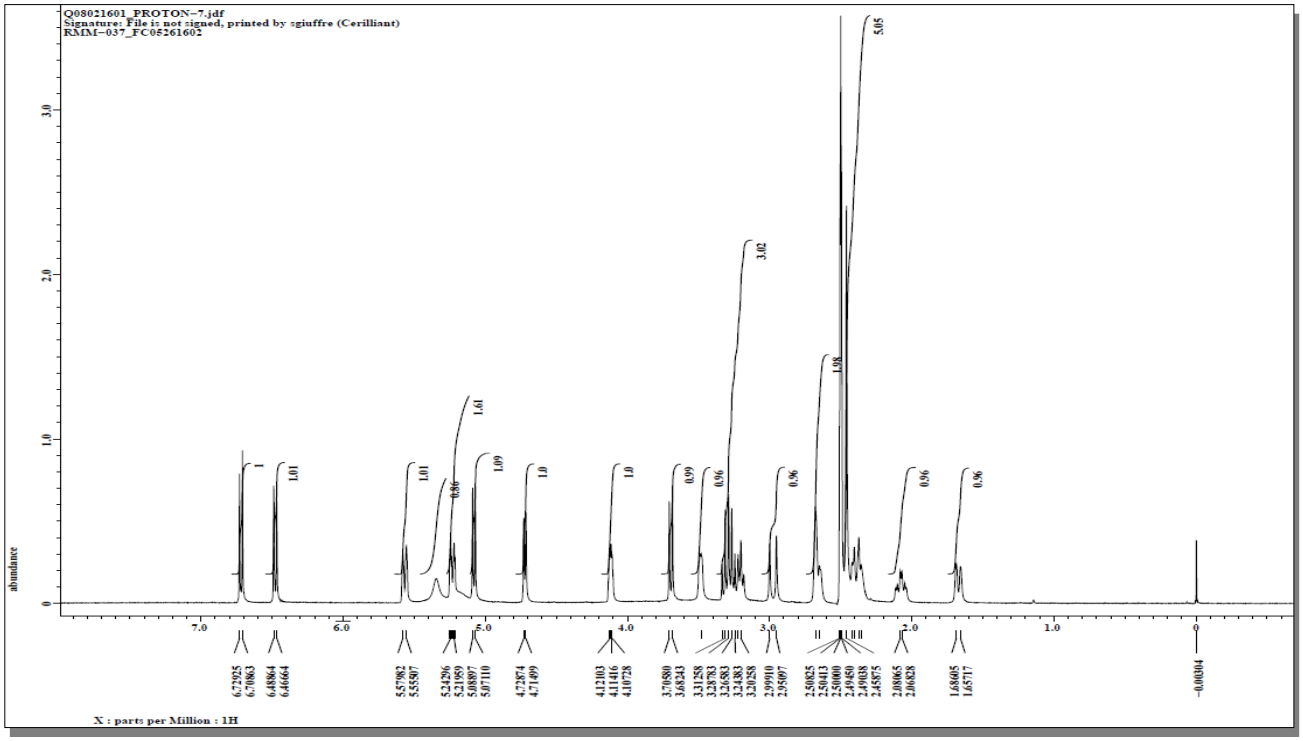
Column:	DB-ALC1 30 m x 0.53 mm, 3 µm film thickness
Temp Program:	40°C hold 12 min to 220°C at 40°C/min hold 5.5 min
Carrier Gas:	Helium
Flow Rate:	2.0 mL/min
Detector Heater Temp:	250°C
Injector:	Headspace Sampler
HS Oven Temp:	60°C
Vial Equilibration:	10 minutes
Sample Name:	FC05261602
Acquired:	August 04, 2016

Peak	Compound	Area	Weight %
1	NMP	NA	NA
Total			**ND**

ND - None Detected

^{1}H NMR

Instrument: JEOL ECS 400
Solvent: DMSO-D_6



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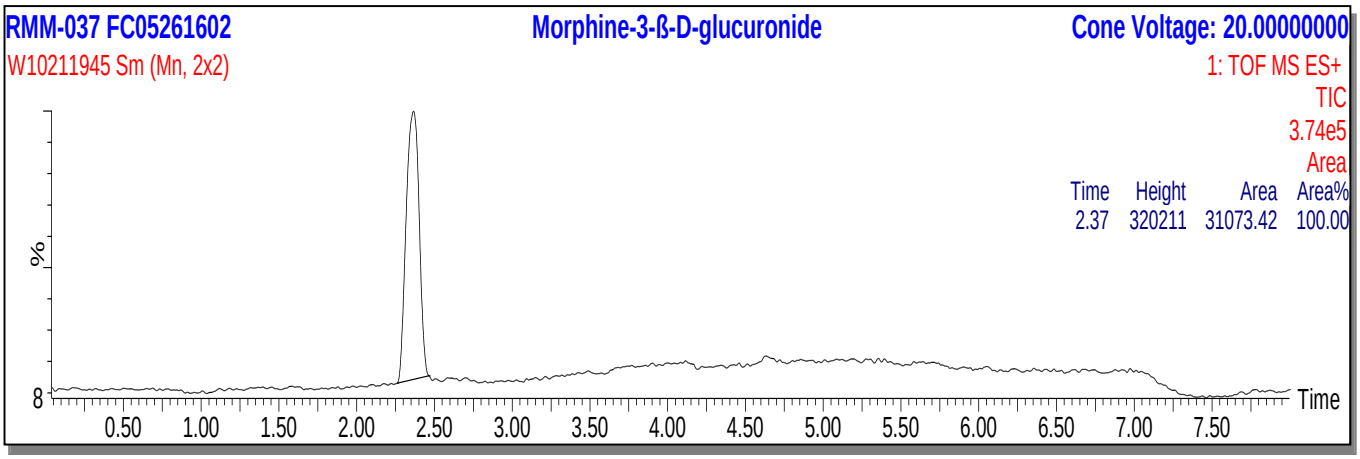
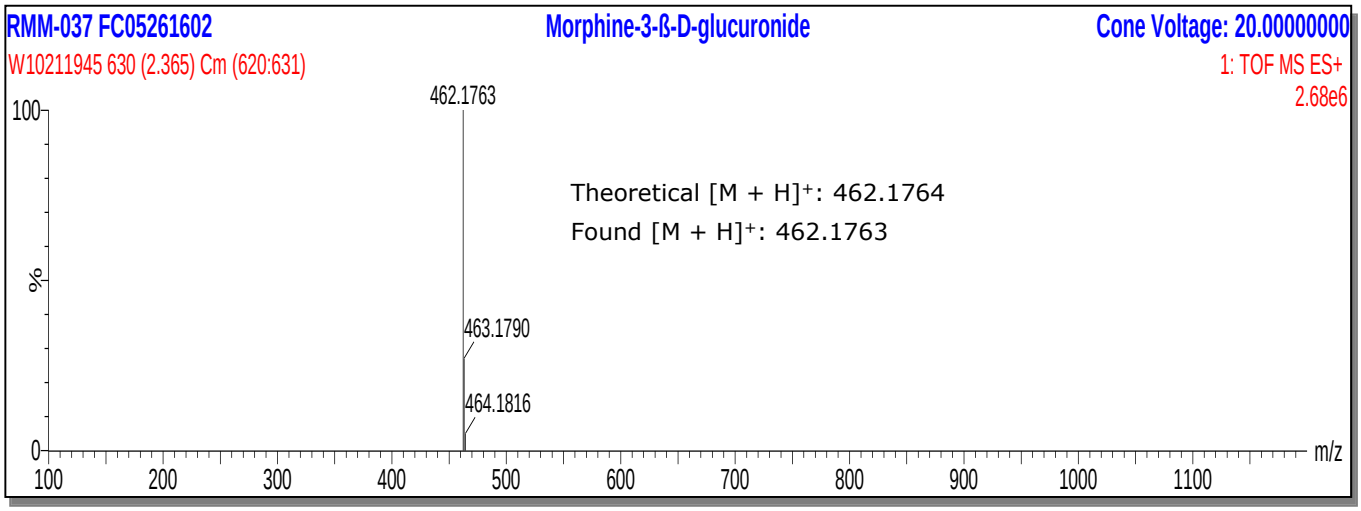
Spectral and Physical Data (cont.)

LC/MS

Column:	Ascentis Express Phenyl-Hexyl, 2.7 µm, 3.0 x 100 mm	**Flow Rate:**	0.4 mL/min
Mobile Phase:	A: 0.1% Ammonium acetate in Water B: Acetonitrile	**Scan Range:**	100-1200 amu
		Ionization:	Electrospray, Positive Ion
		Instrument:	Waters XEVO G2 QTOF
Gradient:		**Acquired:**	October 21, 2019

Time (min)	% A	% B
0.0	80	20
0.5	80	20
4.0	20	80
5.8	20	80
6.0	80	20
8.0	80	20





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Stability

Short term stability studies have been performed in multiple storage conditions for a period of up to four weeks. Short term data is utilized 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 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 Refrigerator storage (2 °C to 8 °C) conditions. Stability of a minimum of 60 months has been established through real-time stability studies.*

Commutability

This standard is a solution of a pure substance in an organic solvent and is a Primary Standard. This Primary Standard is suitable for use in the preparation of calibrators and/or controls in any biological matrix. This standard is not in a biological matrix and therefore commutability to methods or standards in biological matrices does not apply.

COA Revision History

Revision No.	Date	Reason for Revision
00	April 09, 2020	Initial version.

Cerilliant Corporation, 811 Paloma Drive, Suite A Round Rock, TX 78665, USA, Tel: 800-848-7837 / 512-238-9974

Certified Reference Material - Certificate of Analysis

Morphine-3β-D-glucuronide-D_3, Primary Measurement Standard

7,8-Didehydro-4,5-epoxy-17-trideuteromethylmorphinan-6-ol-3beta-glucuronic acid

Cerilliant Quality
ISO 17034
ISO/IEC 17025
ISO 13485
ISO 14001
ISO 9001

Product No.: M-032-1ML

Lot No.: FE06102005

Description of CRM: Morphine-3β-D-glucuronide-D_3 in 0.05% NaOH in Methanol (w/v) (Solution)

Retest Date: August 2021 See Section "Stability Assessment".

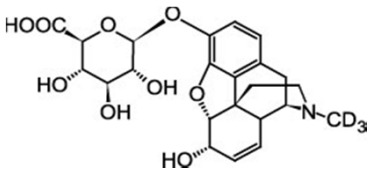
Storage: Store unopened and upright in refrigerator (2 °C to 8 °C). Do Not Freeze.

Shipping: Ambient. See Section "Stability Assessment".

Chemical formula: $C_{23}H_{24}D_3NO_9$

CAS No.: 136765-44-1

Regulatory: USDEA Exempt



Analyte	Certified Concentration ± associated uncertainty U, u=k*u (k=2)
Morphine-3β-D-glucuronide-D_3	**1.000 ± 0.006 mg/mL**

Metrological traceability: Traceable to the SI and higher order standards from NIST through an unbroken chain of comparisons. See "Details on metrological traceability" on page 2.

Measurement method: The certified value is calculated from high precision weighing of thoroughly characterized starting material. See "Details about certification process" on page 2.

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.

Minimum sample size: 1 µL for quantitative applications

Instructions for handling and correct use: Concentration is corrected for chromatographic purity, residual water, residual solvents, and residual inorganics. No adjustment required before 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.

For MS Applications, we advise laboratories not to mix lots during a single sequence.

Health and safety information: Danger. Please refer to the Safety Data Sheet for detailed information about the nature of any hazard and appropriate precautions to be taken.

Accreditation: Cerilliant Corp. is accredited by the US accreditation authority ANAB as registered reference material producer AR-1353 in accordance with ISO 17034 and registered testing laboratory AT-1352 according to ISO/IEC 17025.

Darren Ellsworth, Quality Assurance Manager

June 30, 2020

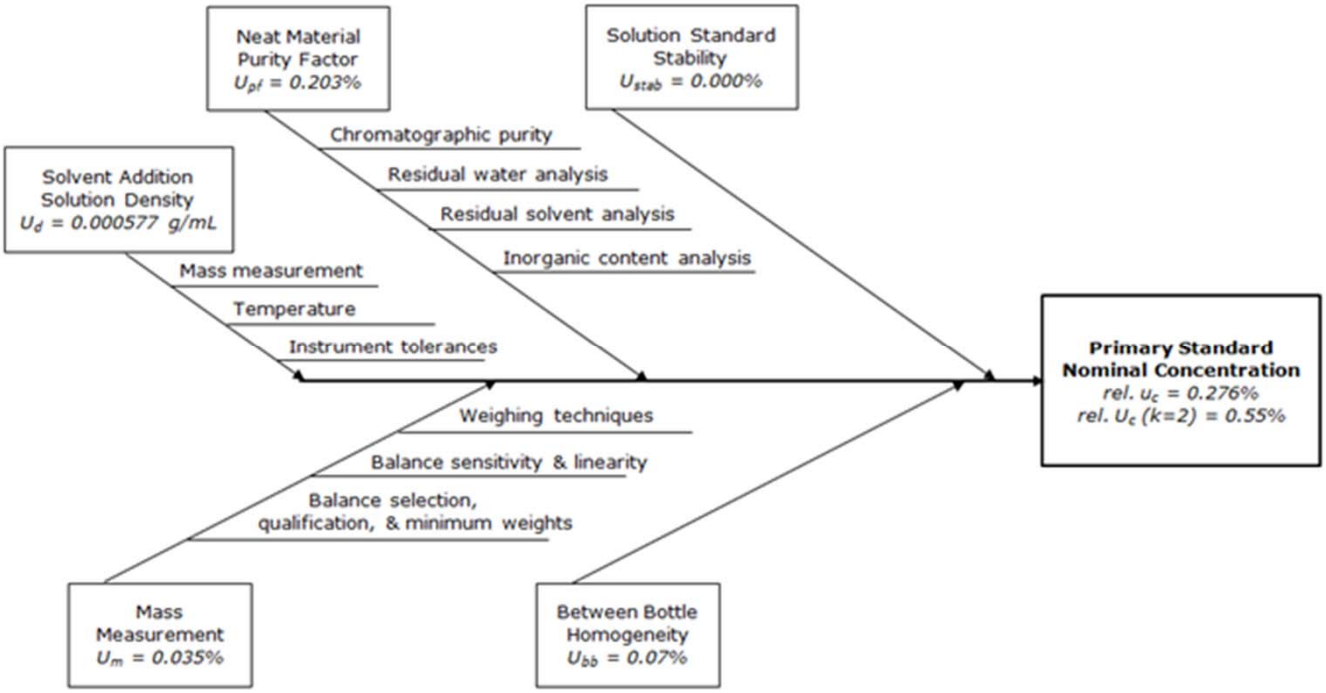
Issue Date

Cerilliant Corporation, 811 Paloma Drive, Suite A Round Rock, TX 78665, USA, Tel: 800-848-7837 / 512-238-9974

Packaging:	2 mL amber USP Type 1 glass ampoule containing not less than 1 mL of certified solution. Ampoules are overfilled to ensure a minimum of 1 mL volume can be transferred when using a 1mL Class A volumetric pipette.
Details on starting materials:	Each raw material utilized has been identified and thoroughly characterized through the use of multiple analytical techniques and is assigned a Mass Balance Purity Factor. Spectral data is provided on subsequent pages of this CoA.
Certificate of Origin:	Cerilliant Corporation certifies no material of animal origin (BSE/TSE) was used in the preparation of this product. This material was manufactured in the USA.

Associated uncertainty:

The uncertainty has been calculated by statistical analysis of all aspects of our production system and incorporated uncertainty of the mass balance purity factor, material density, balance, weighing technique, and homogeneity. Uncertainty components of the gravimetrically prepared Primary Standard concentration are shown in the figure below. Uncertainty is expressed as an expanded uncertainty in accordance with ISO 17034 at the approximate 95% confidence interval using a coverage factor of k=2. Uncertainty contribution from neat material homogeneity was established to be negligible through establishment of process controls and verification of the control process. Stability uncertainty was determined to be negligible by regression analysis.



Details on metrological traceability:

- 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.

- Fill volume to predetermined specifications is gravimetrically verified throughout the dispensing process using qualified and calibrated balances.

- The density and material Mass Balance Purity Factor of each raw material is traceable to the SI and higher order reference materials through mass measurement and instrument qualification and calibrations.

Details about certification process:

This standard has been prepared and certified under the ISO 17034, 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.

- Nominal concentration is calculated based on: the actual mass; Mass balance purity factor of the analyte(s); measured mass of the solution; and the density of the pure diluent at 20°C.

- 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.

- Additional certification information available upon request.

Solution Standard Verification

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

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 F5, 2.7 µm, 3.0 x 100 mm	**Number of Points:**	4
Mobile Phase:	Methanol:0.1% Phosphoric acid in Water (10:90)	**Linearity (r) :**	1.000
Flow Rate:	1.2 mL/min		
Wavelength:	218 nm		

		Verified Concentration (mg/mL)	**%RSD - Homogeneity**
Standard Solution	**Lot Number**	**Actual Results**	**Actual Results**
New Lot	FE06102005	1.006	1.0

- 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:	Morphine-3β-D-glucuronide-D_3	**Chemical Formula:**	$C_{23}H_{24}D_3NO_9$
Material Lot:	FC10041905	**CAS Number:**	136765-44-1
		Molecular Weight:	464.48

Material Characterization Summary

Analytical Test	**Method**	**Results**	
Primary Chromatographic Purity by HPLC/UV Analysis	20384348	99.9% [1]	
Secondary Chromatographic Purity by LC/MS Analysis	20384217	> 99.9%	
Identity by LC/MS Analysis	20384217	Consistent with Structure	
Isotopic Purity and Distribution by LC/MS SIM Analysis	20384217	0.02% D_0 vs D_3	
		0.02% D_0	2.33% D_3
		0.11% D_1	97.54% D_4
Identity by ^{1}H-NMR Analysis	20384224	Consistent with Structure	
Residual Solvent Analysis by GC/FID Headspace	20397799 [2]	None Detected	
Residual Water Analysis by Karl Fischer Coulometry	20398075 [2]	0.70%	
Inorganic Content by Microash Analysis	20384350	0.35%	
Mass Balance Purity Factor		98.86%	

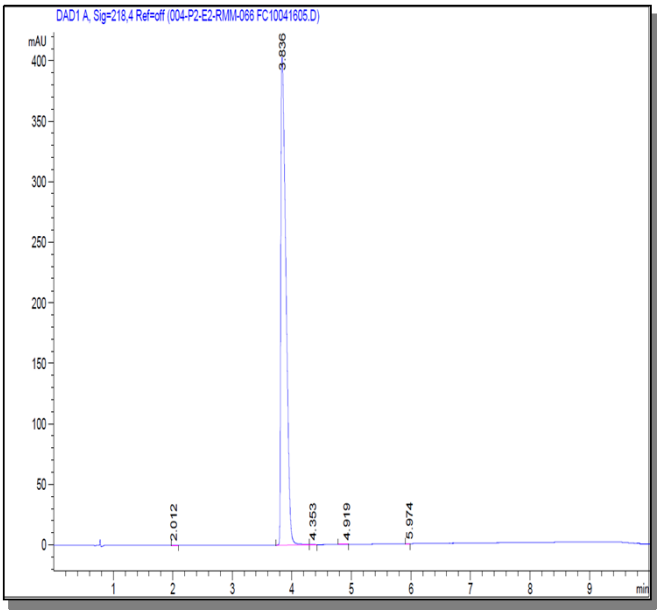
[1] No Morphine-D_3 detected by HPLC/UV analysis.

[2] Validated analytical method

- 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 purity method was selected to optimize resolution of impurities while minimizing degradation of the analyte. Secondary purity methods with orthogonal detector capabilities from the primary purity method are used as controls to confirm an accurate purity value.
- 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.

Spectral and Physical Data

HPLC/UV



Column: Ascentis Express F5, 2.7 µm, 3.0 x 100 mm

Mobile Phase: A: Methanol
B: 0.1% Phosphoric acid in Water

Gradient:

Time (min)	% A	% B
0.0	3	97
1.0	3	97
4.0	20	80
8.0	40	60
8.1	3	97

Flow Rate: 0.6 mL/min

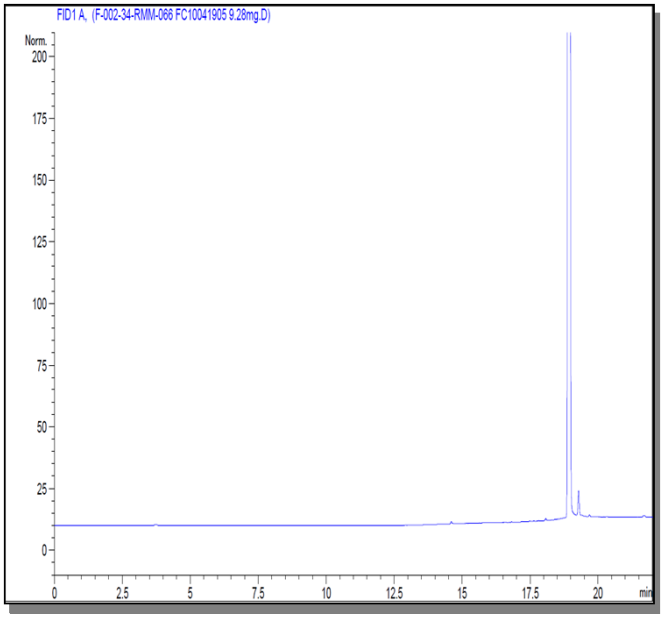
Wavelength: 218 nm

Sample Name: FC10041905

Acquired: April 01, 2020

Peak #	Ret Time	Area %
1	2.01	0.02
2	3.84	99.92
3	4.35	0.04
4	4.92	0.01
5	5.97	0.01

Residual Solvent Analysis by GC/FID Headspace



Column: DB-ALC1 30 m x 0.53 mm, 3 µm film thickness

Temp Program: 40°C hold 12 min to 220°C at 40°C/min hold 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

Sample Name: FC10041905

Acquired: March 30, 2020

Peak	Compound	Area	Weight %
1	NMP	NA	NA
Total			**ND**

ND- None Detected

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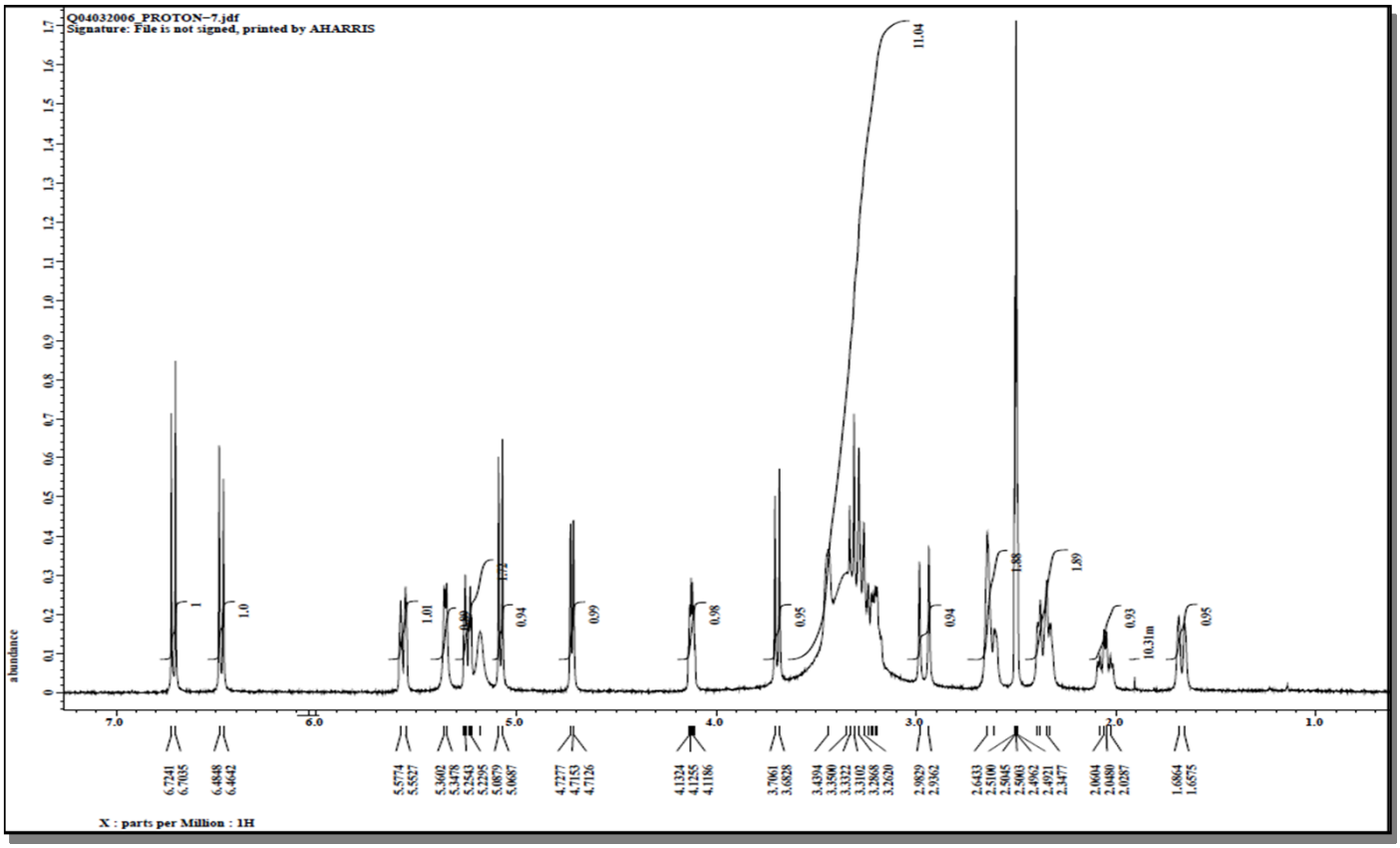
Spectral and Physical Data (cont.)

^{1}H NMR

Instrument: JEOL ECS 400
Solvent: DMSO-D_6



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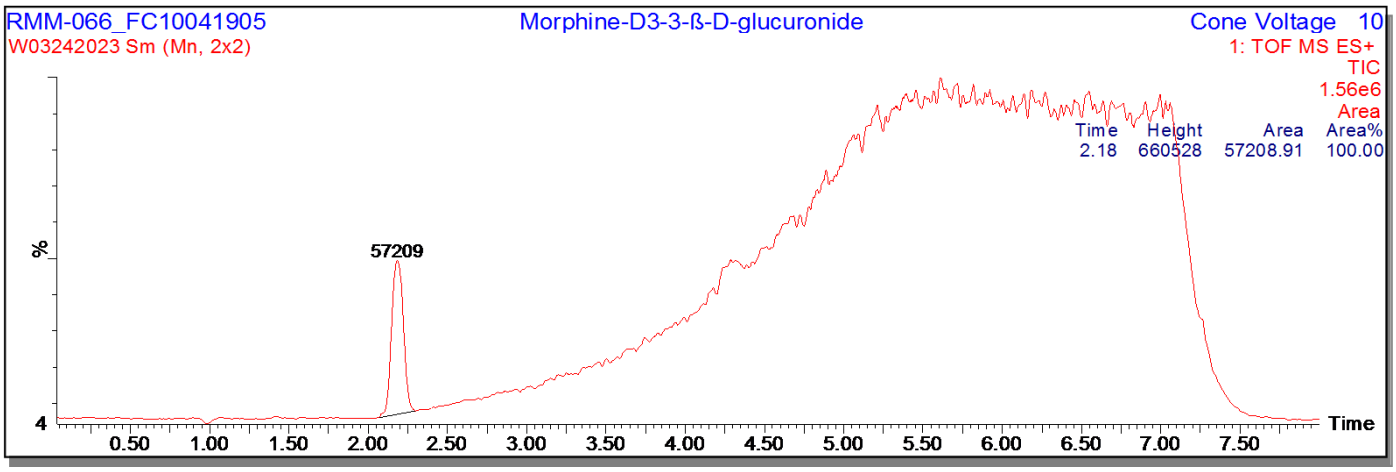
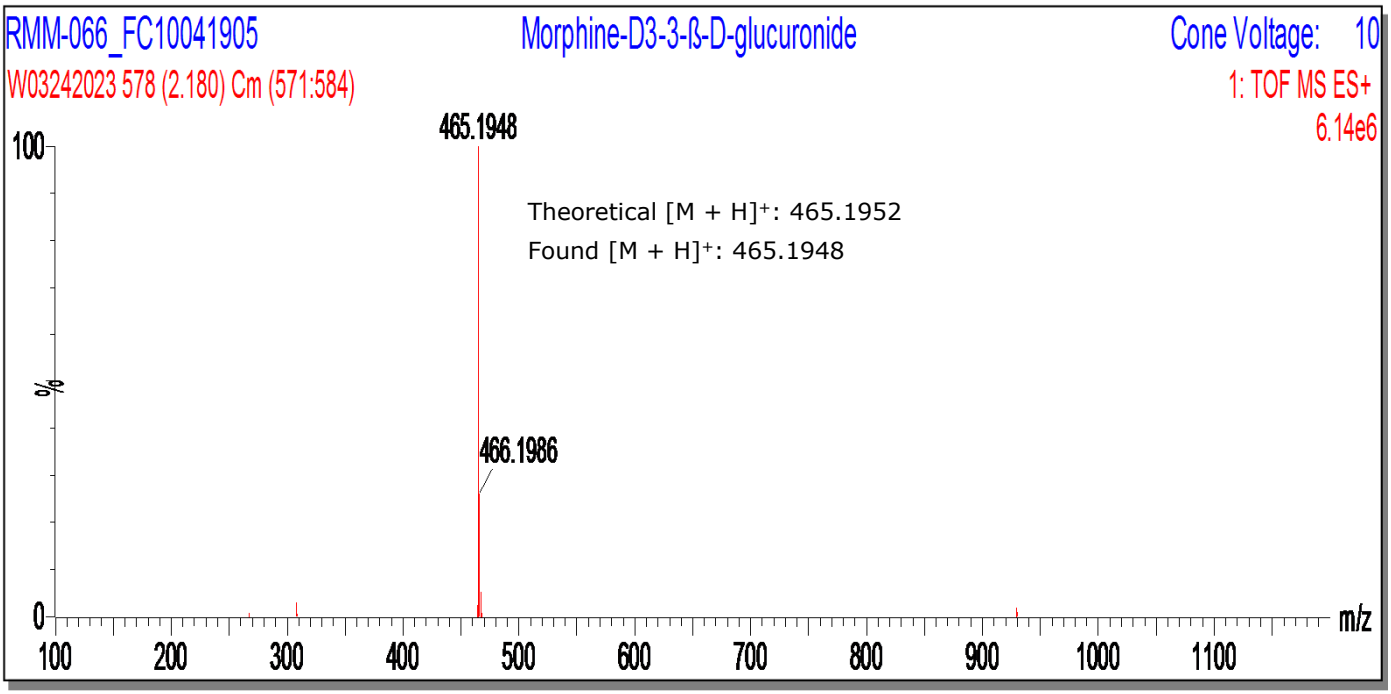
Spectral and Physical Data (cont.)

LC/MS

Column:	Ascentis Express F5, 2.7 µm, 3.0 x 100 mm	**Flow Rate:**	0.4 mL/min
Mobile Phase:	A: 0.1% Formic acid in Water B: Acetonitrile	**Scan Range:**	100-1200 amu
		Ionization:	Electrospray, Positive Ion
		Instrument:	Waters XEVO G2 QTOF
Gradient:		**Acquired:**	March 24, 2020

Time (min)	% A	% B
0.0	98	2
0.5	98	2
4.0	70	30
5.8	70	30
6.0	98	2
8.0	98	2





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Spectral and Physical Data (cont.)

Isotopic Purity by LC/MS SIM

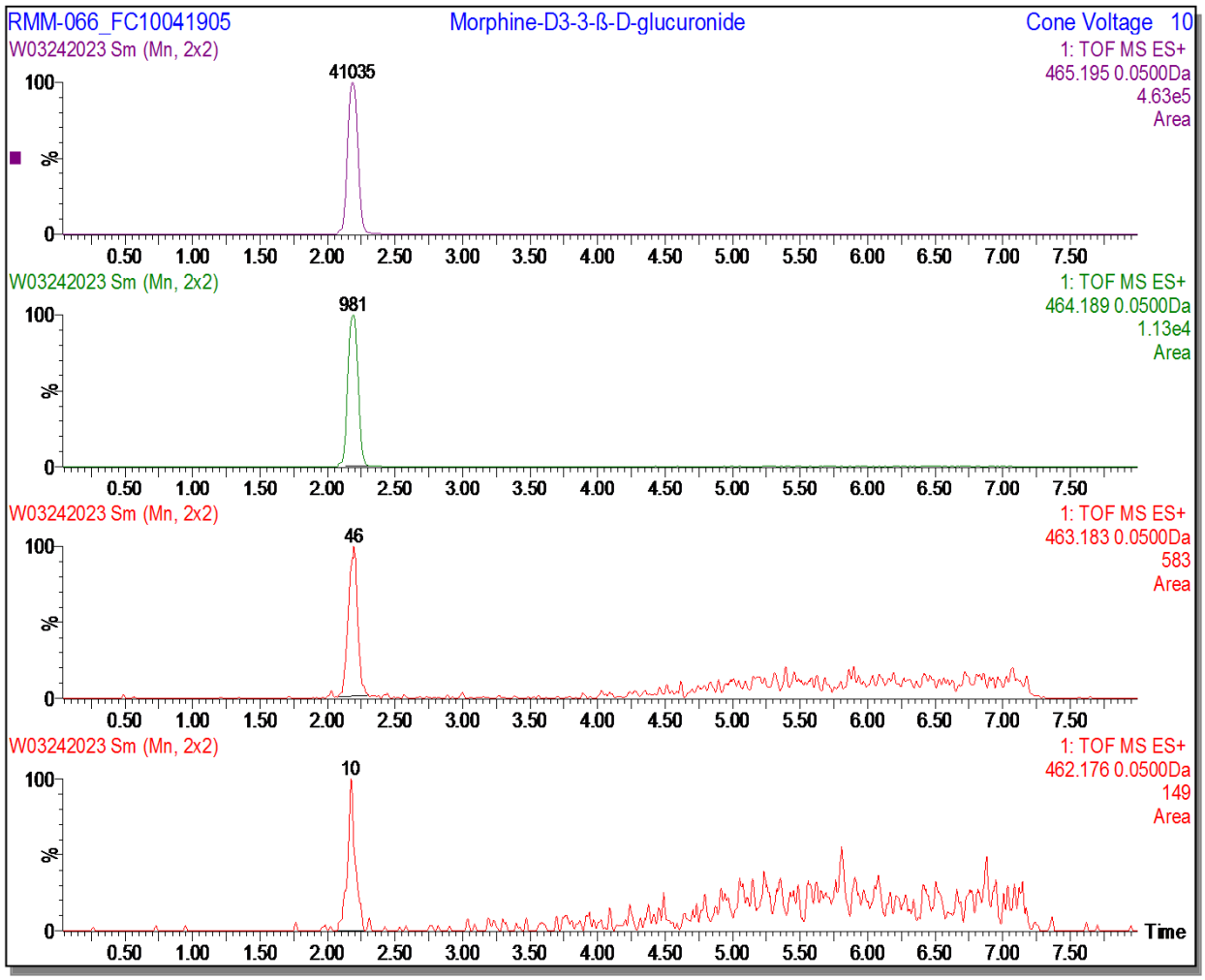
Column: Ascentis Express F5, 2.7 µm, 3.0 x 100 mm

Mobile Phase: A: 0.1% Formic acid in Water
B: Acetonitrile

Gradient:

Time (min)	% A	% B
0.0	98	2
0.5	98	2
4.0	70	30
5.8	70	30
6.0	98	2
8.0	98	2

Flow Rate: 0.4 mL/min
Scan Range: 462-465 amu
Ionization: Electrospray, Positive Ion
Instrument: Waters XEVO G2 QTOF
Acquired: March 24, 2020



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Stability

Short term stability studies have been performed in multiple storage conditions for a period of up to four weeks. Short term data is utilized 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 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.*

Commutability

This standard is a solution of a pure substance in an organic solvent and is a Primary Standard. This Primary Standard is suitable for use in the preparation of calibrators and/or controls in any biological matrix. This standard is not in a biological matrix and therefore commutability to methods or standards in biological matrices does not apply.

COA Revision History

Revision No.	Date	Reason for Revision
00	June 30, 2020	Initial version.

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