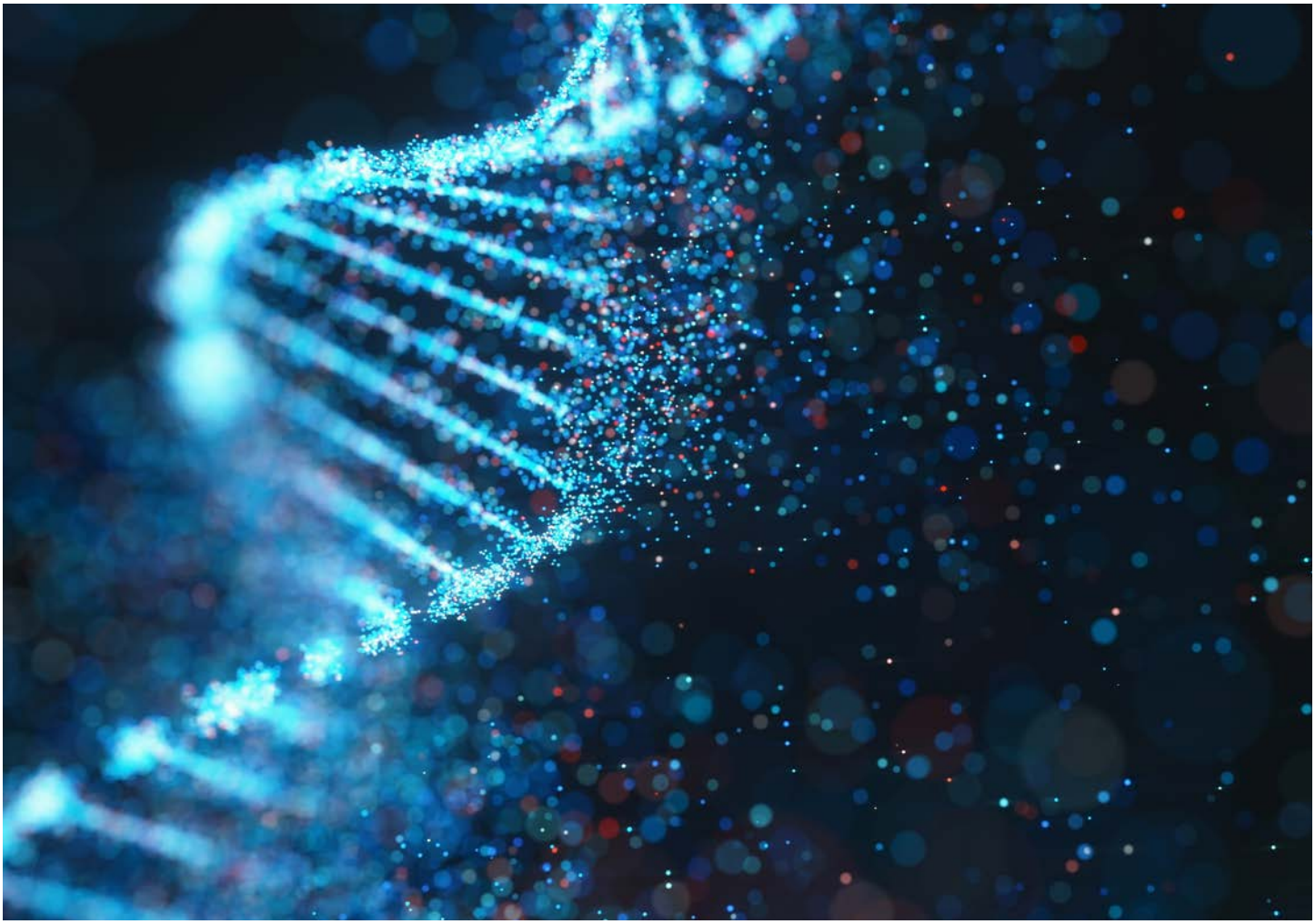
Cambridge Isotope Laboratories, Inc.
isotope.com

RESEARCH PRODUCTS

Stable Isotope-Labeled Nucleic Acids and Related Compounds



Cambridge Isotope Laboratories, Inc.
North America: 1.800.322.1174 cilsales@isotope.com | **International:** +1.978.749.8000 intlsales@isotope.com | f: 1.978.749.2768 | w: isotope.com

Table of Contents

Introduction

Nucleic acids (includes DNA and RNA) are necessary building blocks of living organisms, which are fundamentally important to a multitude of cellular processes. Compositionally, nucleic acids are comprised of nucleobases (e.g., adenine, cytosine), nucleosides (e.g., adenosine, guanosine), and nucleotides (e.g., ATP, CDP). These compounds may be used as starting materials in the enzymatic or chemical synthesis of RNA and DNA. Applications of stable isotope labeled nucleic acids are broad, ranging from the evaluation of protein structure and dynamics to the evaluation of nucleic acids as potential biotherapies, such as RNA therapeutics.

To assist with RNA/DNA-related NMR- and/or MS-based research, CIL offers a large selection of various stable isotope-labeled compounds. We also offer sets of deoxyribonucleoside monophosphates (dNMPs), deoxyribonucleoside triphosphates (dNTPs), and ribonucleoside triphosphate (rNTPs) in different unit configurations for ease of use. Please visit **isotope.com** for product details, pricing, availability, and to inquire about compounds of interest that may not be featured in this catalog.

Nuclear Magnetic Resonance (NMR) Spectroscopy

NMR spectroscopy is an extremely powerful and versatile tool for studying the dynamics and structure of RNA and DNA molecules in solution and in the solid state. Most often, nucleic acids containing roughly less than ~40 nucleotides will require simple ^{15}N or $^{13}C/^{15}N$ enrichment to provide the constraints necessary to determine full three-dimensional structures. For studying larger proteins, the use of selectively and uniformly deuterated nucleotides and segmental isotope labeling using deuterium has been critical. The types of information gained from NMR studies of RNA and DNA include:

- Base-pairing pattern
- Site-specific information regarding ligand binding
- Delineation of secondary structure motifs, such as hairpins and bulges
- Conformational equilibria
- Local structure and dynamics
- Global structure derived from RDCs

Example Reference

Furtig, B; Richter, C; Wohnert, J; Schwalbe, H. **2003**. NMR spectroscopy of RNA. *Chembiochem, 4(10),* 936-962.

“We are grateful for the continued support from CIL and Eurisotop. Since March 2020, we have been focusing our efforts on characterizing the proteome and the genome of SARS-CoV-2. Our research is conducted in a coordinated manner within the COVID19-NMR network. The work conducted by groups worldwide has led to the NMR characterization of all conserved viral RNA elements as well as the majority of all viral proteins. With NMR chemical shift assignments at hand, we are able to screen viral drug targets for their interactions with low molecular weight binders to contribute to the development of antiviral drugs. These massive efforts require reliable, high-quality isotope precursor compounds – a resource that CIL and Eurisotop are continuously providing to us.”

Harald Schwalbe, PhD
BMRZ, Goethe University Frankfurt (Germany)

Ribonucleic Acids (RNA)

Ribonucleoside Triphosphates (rNTPs)

The most popular approaches to produce labeled RNA molecules for NMR studies use enzymatic *in vitro* transcription methods that employ labeled rNTPs, T7-RNA polymerase, and either linearized plasmids or double-stranded DNA as templates. These techniques are used to construct labeled RNA molecules of which all of one type of nucleotide is labeled.

Uniformly Deuterated rNTPs

Perdeuterated NTPs can be used in combination with protonated NTPs to create RNA molecules in which specific types of nucleotides are protonated, thus allowing spectral editing without the significant signal broadening associated with ^{13}C incorporation.

Catalog No.	Description
DLM-7514-CA	Adenosine 5′-triphosphate, ammonium salt (D_8, 98%) (in solution) CP 95%
DLM-7515-CA	Cytidine 5′-triphosphate, ammonium salt (D_8, 98%) (in solution) CP 95%
DLM-7516-CA	Guanosine 5′-triphosphate, ammonium salt (D_7, 98%) (in solution) CP 95%
DLM-7517-CA	Uridine 5′-triphosphate, ammonium salt (D_8, 98%) (in solution) CP 95%

Example References

Song, Z.; Gremminger, T.; Singh, G.; et al. **2021**. The three-way junction structure of the HIV-1 PBS-segment binds host enzyme important for viral infectivity. *Nucleic Acids Res, 49(10),* 5925-5942.

Lu, K; Miyazaki, Y; Summers, M. **2010**. Isotope labeling strategies for NMR studies of RNA. *J Biomol NMR, 46(1),* 113-125.

Selectively Deuterated rNTPs

Because severe signal degeneracy has hampered NMR studies of larger RNAs, key researchers in this area have utilized selectively deuterated rNTPs, in conjunction with *in vitro* synthesis methods, to reduce spectral complexity, spectral line-widths, and for observing NOEs over larger distances.

Catalog No.	Description
DLM-8815-CA	Adenosine 5′-triphosphate, ammonium salt (2-D, 98%) (in solution) CP 95%
DLM-11405-CA	Adenosine 5′-triphosphate, ammonium salt (4′-D, 97%) (in solution) CP 95%
DLM-9268-CA	Adenosine 5′-triphosphate, ammonium salt (2,8-D_2, 98%) (in solution) CP 95%
DLM-11406-CA	Adenosine 5′-triphosphate, ammonium salt (5′,5″-D_2, 97%) (in solution) CP 95%
DLM-9619-CA	Adenosine 5′-triphosphate, ammonium salt (ribose-1′,2′,3′,4′,5′,5″-D_6, 98%) (in solution) CP 95%
DLM-9366-CA	Cytidine 5′-triphosphate, ammonium salt (cytosine-5-D, 98%) (in solution) CP 95%
DLM-9267-CA	Cytidine 5′-triphosphate, ammonium salt (5,6-D_2, 98%) (in solution) CP 95%
DLM-8594-CA	Cytidine 5′-triphosphate, ammonium salt (cytosine-5-D, 6-H; ribose-1,2,3,4,5,5-D_6, 98%) (in solution) CP 95%
DLM-11407-CA	Guanosine 5′-triphosphate, ammonium salt (3′-D, 97%) (in solution) CP 95%
DLM-9365-CA	Uridine 5′-triphosphate, ammonium salt (uracil-5-D, 97%) (in solution) CP 95%
DLM-9100-CA	Uridine 5′-triphosphate, ammonium salt (5,6-D_2, 98%) (in solution) CP 95%
DLM-8637-CA	Uridine 5′-triphosphate, ammonium salt (uracil-5-D, 6-H; ribose-1,2,3,4,5,5-D_6, 98%) (in solution) CP 95%

Example Reference

Pang, H.; Lilla, E.A.; Zhang, P.; et al. **2020**. Mechanism of rate acceleration of radical C-C bond formation reaction by a radical SAM GTP 3′,8-cyclase. *J Am Chem Soc, 142(20),* 9314-9326.

“We’ve been using CIL’s perdeuterated rNTPs for many years to facilitate NMR studies of larger RNAs. Their newer products, which include partially deuterated rNTPs, have been extraordinarily helpful, and have enabled high resolution NMR structural studies of RNAs that were previously intractable.”

Michael Summers, PhD, Howard Hughes Medical Institute, University of Maryland, Baltimore County (USA)

“Without these labeled rNTPs from CIL we would not have been able to prepare such high-quality samples which made the assignment and structure determination possible.”

Michael Durney, PhD, Department of Molecular and Cellular Biology, Harvard University (USA)

Chemical purity (CP) is 98% or greater, unless otherwise specified. For research use only. Not for use in diagnostic procedures.

Alternatively Labeled rNTPs

Catalog No.	Description
CLM-8932-CA	Adenosine 5′-triphosphate, ammonium salt (2-^{13}C, 99%) (in solution) CP 95%
CLM-11402-CA	Adenosine 5′-triphosphate, ammonium salt (4′-^{13}C, 99%) (in solution) CP 95%
CLM-11403-CA	Adenosine 5′-triphosphate, ammonium salt (5′-^{13}C, 99%) (in solution) CP 95%
CLM-11404-CA	Adenosine 5′-triphosphate, ammonium salt (1′,2′,3′,4′,5′-$^{13}C_5$, 99%) (in solution) CP 95%
CLM-8426-CA	Adenosine 5′-triphosphate, ammonium salt ($^{13}C_{10}$, 99%) (in solution) CP 95%
NLM-3987-CA	Adenosine 5′-triphosphate, ammonium salt ($^{15}N_5$, 98%) (in solution) CP 95%
CNLM-4265-CA	Adenosine 5′-triphosphate, ammonium salt ($^{13}C_{10}$, 99%; $^{15}N_5$, 98%) (in solution) CP 95%
DNLM-10985-CA	Adenosine 5′-triphosphate, ammonium salt (ribose-D_6, 98%; $^{15}N_5$, 98%) (in solution) CP 95%
CLM-10987-CA	Cytidine 5′-triphosphate, ammonium salt ($^{13}C_9$, 99%) (in solution) CP 95%
NLM-4266-CA	Cytidine 5′-triphosphate, ammonium salt ($^{15}N_3$, 98%) (in solution) CP 95%
CNLM-4267-CA	Cytidine 5′-triphosphate, ammonium salt ($^{13}C_9$, 99%; $^{15}N_3$, 98%) (in solution) CP 95%
CLM-10988-CA	Guanosine 5′-triphosphate, ammonium salt ($^{13}C_{10}$, 99%) (in solution) CP 95%
NLM-4268-CA	Guanosine 5′-triphosphate, ammonium salt ($^{15}N_5$, 98%) (in solution) CP 90%
CNLM-4269-CA	Guanosine 5′-triphosphate, ammonium salt ($^{13}C_{10}$, 99%; $^{15}N_5$, 98%) (in solution) CP 95%
DNLM-10913-CA	Guanosine 5′-triphosphate, ammonium salt (ribose-1′,2′,3′,4′,5′,5″-D_6, 98%; $^{15}N_5$, 98%) (in solution) CP 90%
CLM-10914-CA	Uridine 5′-triphosphate, ammonium salt ($^{13}C_9$, 99%) (in solution) CP 95%
NLM-4270-CA	Uridine 5′-triphosphate, ammonium salt ($^{15}N_2$, 98%) (in solution) CP 95%
CNLM-4271-CA	Uridine 5′-triphosphate, ammonium salt ($^{13}C_9$, 99%; $^{15}N_2$, 98%) (in solution) CP 95%
DNLM-10986-CA	Uridine 5′-triphosphate, ammonium salt (ribose-D_6,98%; uracil-$^{15}N_2$, 98%) (in solution) CP 95%

Please inquire for lithium salts.

Example References

Ning, S.; Sun, M.; Dong, X.; et al. **2023**. Dynamic geometry design of cyclic peptide architectures for RNA structure. *Phys Chem Chem Phys, 25(41),* 27967-27980.

Warden, M.S.; DeRose, E.F.; Tamayo, J.V.; et al. **2023**. The translational repressor Glorund uses interchangeable RNA recognition domains to recognize Drosophila nanos. *Nucleic Acids Res, 51(16),* 8836-8849.

Gato, A.; Catala, M.; Tisne, C.; et al. **2021**. A method to monitor the introduction of post-transcriptional modifications in tRNAs with NMR spectroscopy. *Methods Mol Biol, 2298,* 307-323.

Nam, H.; Becette, O.; LeBlanc, R.M.; et al. **2020**. Deleterious effects of carbon-carbon dipolar coupling on RNA NMR dynamics. *J Biomol NMR, 74(6-7),* 321-331.

Pang, H.; Lilla, E.A.; Zhang, P.; et al. **2020**. Mechanism of rate acceleration of radical C-C bond formation reaction by a radical SAM GTP 3′,8-cyclase. *J Am Chem Soc, 142(20),* 9314-9326.

Barraud, P.; Gato, A.; Heiss, M.; et al. **2019**. Time-resolved NMR monitoring of tRNA maturation. *Nat Commun, 10,* 3373-3387.

Warden, M.S.; Cai, K.; Cornilescu, G.; et al. **2018**. Conformational flexibility in the enterovirus RNA replication platform. *RNA, 25(3),* 376-387.

Song, Y.; Marmion, R.A.; Park, J.O.; et al. **2017**. Dynamic control of dNTP synthesis in early embryos. *Dev Cell, 42(3),* 301-308.

Le, M.T.; Brown, R.E.; Simon, A.E.; et al. **2015**. *In vivo*, large-scale preparation of uniformly ^{15}N- and site-specifically ^{13}C-labeled homogeneous, recombinant RNA for NMR studies. *Methods Enzymol, 565,* 495-535.

Alverado, L.J.; Longhini, A.P.; LeBlanc, R.M.; et al. **2014**. Chemo-enzymatic synthesis of selectively ^{13}C/^{15}N labeled RNA for NMR structural and dynamics studies. *Methods Enzymol, 549,* 133-162.

Lu, K.; Miyazaki, Y.; Summers, M.F. **2010**. Isotope labeling strategies for NMR studies of RNBA. *J Biomol NMR, 46(1),* 113-125.

Dayie, K.T. **2008**. Key labeling technologies to tackle sizeable problems in RNA structural biology. *Int J Mol Sci, 9(7),* 1214-1240.

Nikonowicz, E.P.; Sirr, A.; Legault, P.; et al. **1992**. Preparation of ^{13}C and ^{15}N labelled RNAs for heteronuclear multidimensional NMR studies. *Nucleic Acids Res, 20(17),* 4507-4513.

“When we prepare labeled RNAs, we want the yield of transcription to be as high as possible. In our hands, transcription efficiencies using CIL rNTPs ammonium salt solutions are indistinguishable from those performed with top-quality unlabeled rNTPs solutions. Our transcriptions are always perfectly reproducible using CIL rNTPs. We are very happy with the quality of the labeled RNA samples we get.”

Pierre Barraud, PhD
Institute of Physico-Chemical Biology, CNRS, Paris City University (France)

Chemical purity (CP) is 98% or greater, unless otherwise specified. For research use only. Not for use in diagnostic procedures.

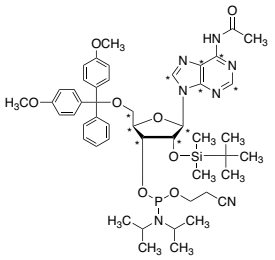
Ribonucleoside Monophosphates (rNMPs)

Catalog No.	Description
NLM-3792	Adenosine 5′-monophosphate, lithium salt ($^{15}N_5$, 98%) (in solution) CP 95%
CNLM-3802	Adenosine 5′-monophosphate, lithium salt ($^{13}C_{10}$, 98%; $^{15}N_5$, 98%) (in solution) CP 95%
CLM-11433	Cyclic adenosine-3′,5′-monophosphate (ribose-$^{13}C_5$, 95%) CP 96%
NLM-3793	Cytidine 5′-monophosphate (CMP), lithium salt ($^{15}N_3$, 98%) (in solution) CP 95%
CNLM-3803	Cytidine 5′-monophosphate (CMP), lithium salt ($^{13}C_9$, 98%; $^{15}N_3$, 98%) (in solution) CP 95%
NLM-3794	Guanosine 5′-monophosphate, lithium salt ($^{15}N_5$, 98%) (in solution) CP 95%
CNLM-3804	Guanosine 5′-monophosphate, lithium salt ($^{13}C_{10}$, 98%; $^{15}N_5$, 98%) (in solution) CP 95%
NLM-3795	Uridine 5′-monophosphate, lithium salt ($^{15}N_2$, 98%) (in solution) CP 95%
CNLM-3805	Uridine 5′-monophosphate, lithium salt ($^{13}C_9$, 98%; $^{15}N_2$, 98%) (in solution) CP 95%

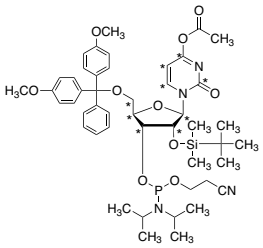
RNA Phosphoramidites

^{13}C-Labeled

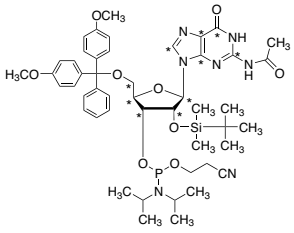
Catalog No.	Description
CLM-11604	Adenosine phosphoramidite (U-$^{13}C_{10}$, 98%) CP 95%
CLM-11606	Cytidine phosphoramidite (U-$^{13}C_9$, 98%) CP 95%
CLM-11607	Guanosine phosphoramidite (U-$^{13}C_{10}$, 98%) CP 95%
CLM-11608	Uridine phosphoramidite (U-$^{13}C_9$, 98%) CP 95%



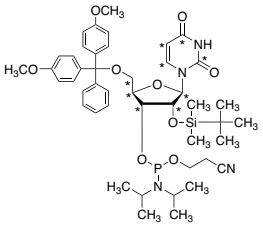
CLM-11604



CLM-11606



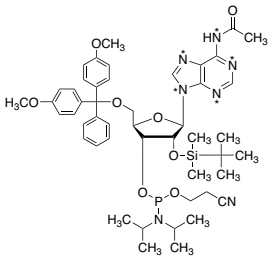
CLM-11607



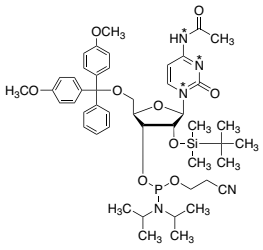
CLM-11608

^{15}N-Labeled

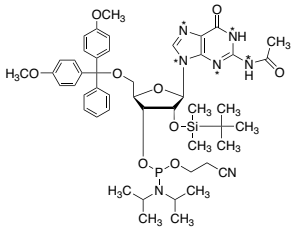
Catalog No.	Description
NLM-11609	Adenosine phosphoramidite (U-$^{15}N_5$, 98%) CP 95%
NLM-11610	Cytidine phosphoramidite (U-$^{15}N_3$, 98%) CP 95%
NLM-11611	Guanosine phosphoramidite (U-$^{15}N_5$, 98%) CP 95%
NLM-11612	Uridine phosphoramidite (U-$^{15}N_2$, 98%) CP 95%



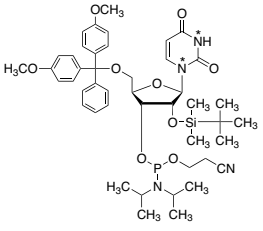
NLM-11609



NLM-11610



NLM-11611



NLM-11612

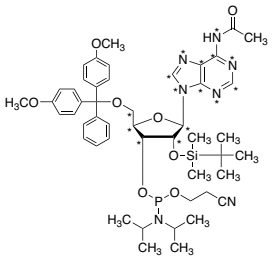
Continued ➤

Chemical purity (CP) is 98% or greater, unless otherwise specified. For research use only. Not for use in diagnostic procedures.

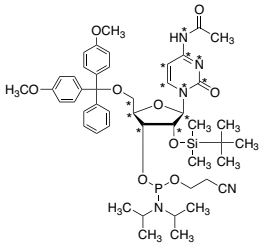
RNA Phosphoramidites *(continued)*

$^{13}C/^{15}N$-Labeled

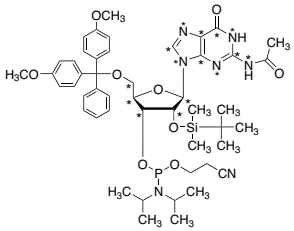
Catalog No.	Description
CNLM-11613	Adenosine phosphoramidite (U-$^{13}C_{10}$, 98%; U-$^{15}N_5$, 98%) CP 95%
CNLM-11614	Cytidine phosphoramidite (U-$^{13}C_9$, 98%; U-$^{15}N_3$, 98%) CP 95%
CNLM-11615	Guanosine phosphoramidite (U-$^{13}C_{10}$, 98%; U-$^{15}N_5$, 98%) CP 95%
CNLM-11616	Uridine phosphoramidite (U-$^{13}C_9$, 98%; U-$^{15}N_2$, 98%) CP 95%



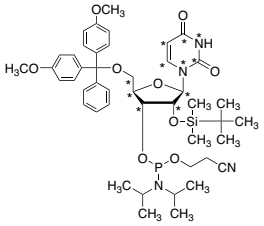
CNLM-11613



CNLM-11614



CNLM-11615



CNLM-11616

Deoxyribonucleic Acids (DNA)

Labeled DNA oligonucleotides are routinely synthesized using enzymatic *in vitro* methods that require labeled dNTPs, a DNA polymerase, and a cDNA template. One particular advantage of using enzymatic methods over synthetic chemistry methods is that large oligonucleotides (e.g., >50 nucleotides in length) can be easily prepared in milligram quantities.

Deoxyribonucleoside Triphosphates (dNTPs)

Catalog No.	Description
DLM-7507	2-Deoxyadenosine 5′-triphosphate, lithium salt (D, 98%) (in solution) CP 95%
NLM-6215	2′-Deoxyadenosine 5′-triphosphate, lithium salt ($^{15}N_5$, 98%) (in solution) CP 95%
CNLM-6219-CA*	2′-Deoxyadenosine 5′-triphosphate, ammonium salt ($^{13}C_{10}$, 99%; $^{15}N_5$, 98%) (in solution) CP 90%
DLM-7508	2-Deoxycytidine 5′-triphosphate, lithium salt (D, 98%) (in solution) CP 95%
NLM-6216	2′-Deoxycytidine 5′-triphosphate, lithium salt ($^{15}N_3$, 98%) (in solution) CP 95%
CNLM-6220	2′-Deoxycytidine 5′-triphosphate, lithium salt ($^{13}C_9$, 98%; $^{15}N_3$, 98%) (in solution) CP 95%
DLM-7509	2-Deoxyguanosine 5′-triphosphate, lithium salt (D, 98%) (in solution) CP 95%
NLM-6217-CA*	2′-Deoxyguanosine 5′-triphosphate, ammonium salt ($^{15}N_5$, 98%) (in solution) CP 95%
CNLM-6221-CA*	2′-Deoxyguanosine 5′-triphosphate, ammonium salt ($^{13}C_{10}$, 99%; $^{15}N_5$, 98%) (in solution) CP 95%
DLM-7510	Thymidine 5′-triphosphate, lithium salt (D, 98%) (in solution) CP 95%
NLM-6218	Thymidine 5′-triphosphate, lithium salt ($^{15}N_2$, 98%) (in solution) CP 95%
CNLM-6222	Thymidine 5′-triphosphate, lithium salt ($^{13}C_{10}$, 98%; $^{15}N_2$, 98%) (in solution) CP 95%

**Please inquire for lithium salts.*

Deoxyribonucleoside Monophosphates (dNMPs)

Catalog No.	Description
NLM-3919	2′-Deoxyadenosine 5′-monophosphate, lithium salt ($^{15}N_5$, 98%) (in solution) CP 95%
CNLM-3918	2′-Deoxyadenosine 5′-monophosphate, lithium salt ($^{13}C_{10}$, 98%; $^{15}N_5$, 98%) (in solution) CP 95%
NLM-3921	2′-Deoxycytidine 5′-monophosphate, lithium salt ($^{15}N_3$, 96%) (in solution)
CNLM-6834	2′-Deoxycytidine 5′-monophosphate, lithium salt (^{13}C, 98%; ^{15}N, 98%) (in solution) CP 95%
NLM-6835	2′-Deoxyguanosine 5′-monophosphate, lithium salt (^{15}N, 98%) (in solution) CP 95%
CNLM-6836	2′-Deoxyguanosine 5′-monophosphate, lithium salt (^{13}C, 98%; ^{15}N, 98%) (in solution) CP 95%
NLM-3925	Thymidine 5′-monophosphate, lithium salt ($^{15}N_2$, 98%) (in solution)
CNLM-3924	Thymidine 5′-monophosphate, lithium salt ($^{13}C_{10}$, 98%; $^{15}N_2$, 98%) (in solution) CP 95%

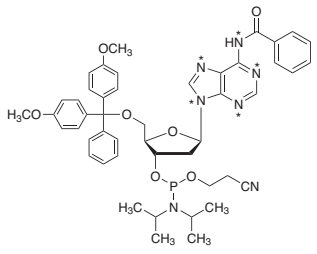
Chemical purity (CP) is 98% or greater, unless otherwise specified. For research use only. Not for use in diagnostic procedures.

DNA Phosphoramidites

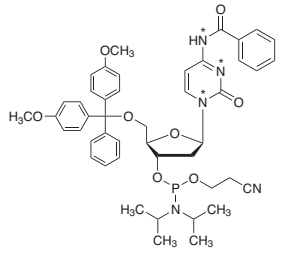
Position-specific labeled DNA molecules can be synthesized using standard phosphoramidite chemistry to overcome the limited chemical-shift dispersion of DNA, as well as to obtain residue-specific functional, structural, and dynamic information.

^{15}N-Labeled

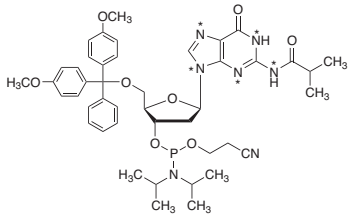
Catalog No.	Description
NLM-6829	2′-Deoxyadenosine phosphoramidite ($^{15}N_5$, 98%) CP 95%
NLM-6827	2′-Deoxycytidine phosphoramidite ($^{15}N_3$, 98%) CP 95%
NLM-6826	2′-Deoxyguanosine phosphoramidite ($^{15}N_5$, 98%) CP 95%
NLM-6823	Thymidine phosphoramidite ($^{15}N_2$, 98%) CP 95%



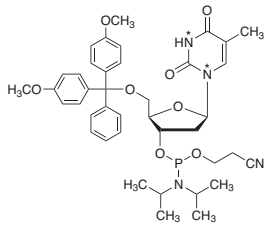
NLM-6829



NLM-6827



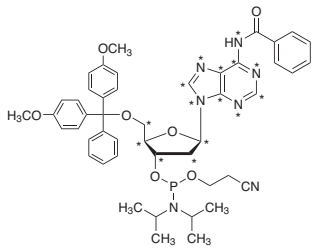
NLM-6826



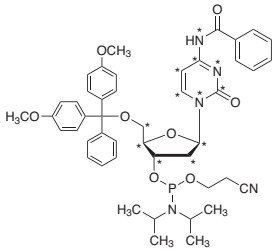
NLM-6823

^{13}C/^{15}N-Labeled

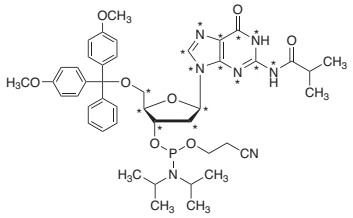
Catalog No.	Description
CNLM-6828	2′-Deoxyadenosine phosphoramidite ($^{13}C_{10}$, 98%; $^{15}N_5$, 98%) CP 95%
CNLM-6830	2′-Deoxycytidine phosphoramidite ($^{13}C_9$, 98%; $^{15}N_3$, 98%) CP 95%
CNLM-6825	2′-Deoxyguanosine phosphoramidite ($^{13}C_{10}$, 98%; $^{15}N_5$, 98%) CP 95%
CNLM-6824	Thymidine phosphoramidite ($^{13}C_{10}$, 98%; $^{15}N_2$, 98%) CP 95%



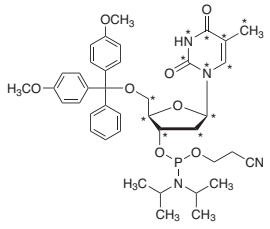
CNLM-6828



CNLM-6830



CNLM-6825



CNLM-6824

RNA and DNA Ribonucleoside Sets and Mixes

To simplify the purchasing process for those looking to label all residues in an oligomer, CIL offers the following sets for your convenience.

Catalog No.	Description
DLM-7518-CA	Set of 4 ribonucleoside 5′-triphosphates, ammonium salt (D, 98%) (in solution) CP 95%
NLM-7519-CA	Set of 4 ribonucleoside 5′-triphosphates, ammonium salt (^{15}N, 98%) (in solution) CP 90%
CNLM-7503-CA	Set of 4 ribonucleoside 5′-triphosphates, ammonium salt (^{13}C, 98%; ^{15}N; 98%) (in solution) CP 95%
CNLM-7871	Set of 4 2′-deoxyribonucleoside 5′-monophosphates, lithium salt (^{13}C, 98%; ^{15}N, 98%) (in solution) CP 95%
DLM-7511	Set of 4 2′-deoxyribonucleoside 5′-triphosphates, lithium salt (D, 98%) (in solution) CP 95%
NLM-7512	Set of 4 2′-deoxyribonucleoside 5′-triphosphates, lithium salt (^{15}N, 98%) (in solution) CP 95%
CNLM-7513	Set of 4 2′-deoxyribonucleoside 5′-triphosphates, lithium salt (^{13}C, 98%; ^{15}N, 98%) (in solution) CP 95%

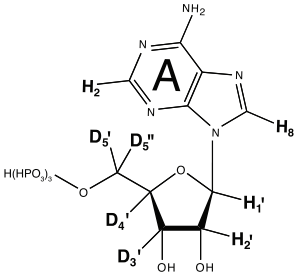
Continued ➤

Chemical purity (CP) is 98% or greater, unless otherwise specified. For research use only. Not for use in diagnostic procedures.

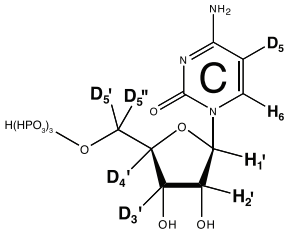
RNA and DNA Ribonucleoside Sets and Mixes *(continued)*

Equimolar Mix

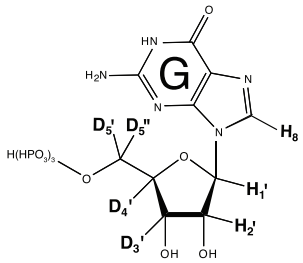
Catalog No.	Description
DLM-7862	Equimolar Mix: ATP, CTP, GTP, UTP, ammonium salt (ribose-3′,4′,5′,5″-D_4, 98%) (in solution) CP 95%



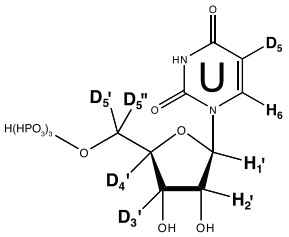
DLM-8922 (ATP)



DLM-8924 (CTP)



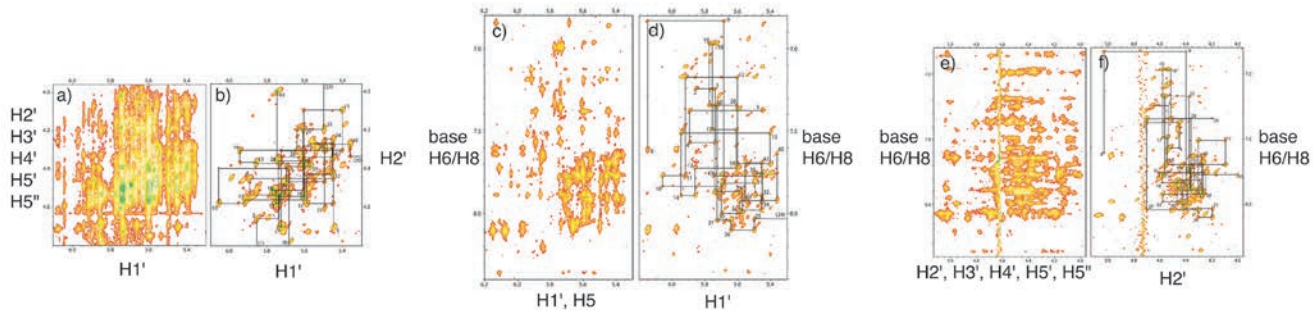
DLM-8923 (GTP)



DLM-8925 (UTP)

Mix Components

DLM-8922-CA	Adenosine-5′-triphosphate (ATP), ammonium salt (ribose-3′,4′,5′,5″-D_4, 98%) (in solution) CP 95%
DLM-8924-CA	Cytidine-5′-triphosphate (CTP), ammonium salt (5-D, ribose-3′,4′,5′,5″-D_4, 98%) (in solution) CP 95%
DLM-8923-CA	Guanosine-5′-triphosphate (GTP), ammonium salt (ribose-3′,4′,5′,5″-D_4, 98%) (in solution) CP 95%
DLM-8925-CA	Uridine-5′-triphosphate (UTP), ammonium salt (5-D, ribose-3′,4′,5′,5″-D_4, 98%) (in solution) CP 95%



^{1}H-^{1}H-NOESY Spectra of the Tetraloop-Receptor RNA (45 nt dimer; 30 kDa). Spectra above are from unlabeled RNA (a, c, e) and selectively deuterated RNA (b, d, f). The selectively deuterated RNA was prepared using the equimolar mix (CIL catalog no. DLM-7862). The left two panels (a, b) contain NOEs between the H1′ proton and all other ribose protons. The middle two panels (c, d) contain NOEs between the base protons and H1′ protons. The right two panels (e, f) contain NOEs between the base and other ribose protons. Spectra taken from Davis, J.H., et al. (see reference below) were provided courtesy of professor Sam Butcher at the University of Wisconsin. The sequential assignment pattern of inter- and intranucleotide NOEs is shown for the D_5-RNA. The advantages of the selectively deuterated pattern are evident in these key regions of the spectra.

Example Reference

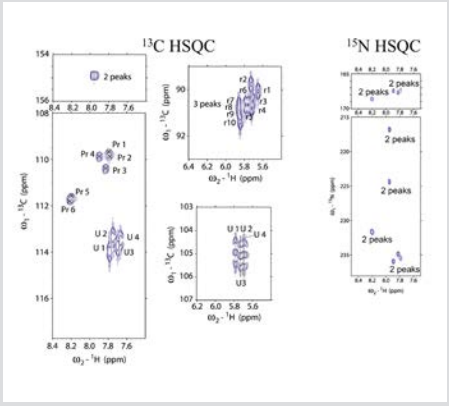
Davis, J.H.; Tonelli, M.; Scott, L.G.; et al. **2005**. Helical packing in solution: NMR structure of a 30 kDa GAAA tetraloop-receptor complex. *J Mol Biol, 351(2),* 371-382.

“The detailed analyses by means of stable isotope-labeled RNA are provided on the interaction between Musashi protein, which regulates the neural differentiation and its target RNA. It has been difficult to detect chemical shift changes for RNA bases upon complex formation, because base signals overlap each other and also with protein signals. This time, however, the introduction of stable isotope-labeled RNAs enables us to sensitively detect the RNA residues involved in the interaction with protein by utilizing either carbon or nitrogen frequency in addition to proton frequency.”

Masato Katahira, PhD
Institute of Advanced Energy, Kyoto University (Japan)

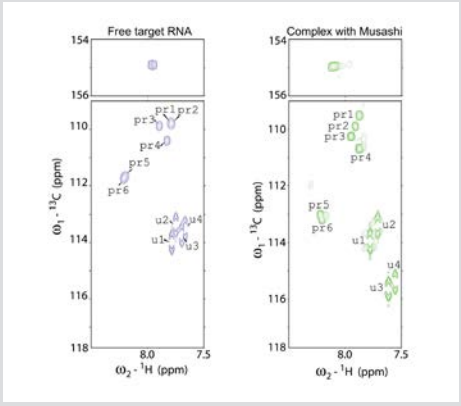
Chemical purity (CP) is 98% or greater, unless otherwise specified. For research use only. Not for use in diagnostic procedures.

NMR Spectra of ^{13}C-, ^{15}N-labeled target RNA: r(GGUAGUAGUU)



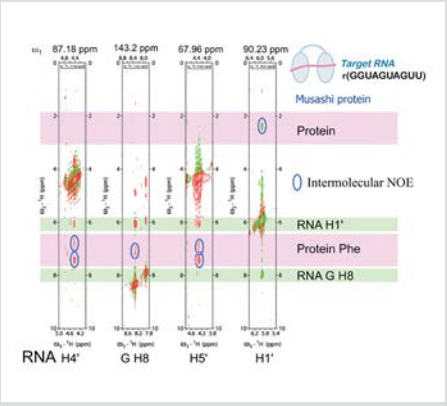
Overlapping of signals is basically resolved owing to the introduction of either ^{13}C- or ^{15}N-frequencies in addition to ^{1}H-frequency.

Identification of RNA residues interacting with Musashi protein



NMR spectra of free ^{13}C-, ^{15}N-labeled target RNA (left) and the complex with Musashi protein (right). The chemical shift changes for RNA residues interacting with Musashi protein are sensitively detected because of the resolution of overlapping of signals owing to the introduction of either ^{13}C- or ^{15}N-frequencies in addition of ^{1}H-frequency.

Observation of intermolecular NOEs between RNA and Musashi protein



Intermolecular NOEs are successfully observed from the ^{13}C-edited NOESY spectrum of the complex between ^{13}C-, ^{15}N-labeled target RNA and nonlabeled Musashi protein.

These data were provided by Dr. Takako Ohyama, Graduate School of Nanobioscience, Yokohama City University, Japan.

Fluorine-Labeled Compounds

The fluorine nucleus is extremely sensitive to the local chemical environment, which leads to a wide chemical shift range. This makes it an excellent probe for secondary structure, especially where the chemical shift dispersion is limited, such as in RNA. Although researchers have used ^{19}F-NMR to study nucleic acids for decades, only recently has a larger RNA been uniformly labeled with fluorine and investigated using ^{19}F-NMR. CIL offers fluorinated nucleoside triphosphates and other related compounds for use in studying structure and dynamics of RNA using ^{19}F-NMR.

Catalog No.	Description
ULM-10698-CA	2-Fluoroadenosine 5′-triphosphate (2F-ATP), ammonium salt (unlabeled) (in solution) CP 90%
CLM-11562	2-Fluoroadenosine 5′-triphosphate, lithium salt (2-^{13}C, 98%) (in solution) CP 95%
ULM-11411-CA	2-Fluoro-2′-deoxyadenosine 5′-triphosphate, ammonium salt (unlabeled) (in solution) CP 95%
ULM-11243-CA	2′-Fluoro-2′-deoxyadenosine 5′-triphosphate, ammonium salt (unlabeled) (in solution) CP 90%
ULM-11244-CA	2′-Fluoro-2′-deoxycytidine 5′-triphosphate, ammonium salt (unlabeled) (in solution) CP 90%
ULM-11245-CA	2′-Fluoro-2′-deoxyguanosine 5′-triphosphate, ammonium salt (unlabeled) (in solution) CP 90%
ULM-11246-CA	2′-Fluoro-2′-deoxythymidine 5′-triphosphate, ammonium salt (unlabeled) (in solution) CP 90%
CNLM-10422	2′-Fluoro-2′-deoxyuridine (uracil-$^{13}C_4$, 99%; $^{15}N_2$, 98%)
ULM-11247-CA	2′-Fluoro-2′-deoxyuridine 5′-triphosphate, ammonium salt (unlabeled) (in solution) CP 90%
ULM-11412-CA	5-Fluoro-2′-deoxycytidine 5′-triphosphate, ammonium salt (unlabeled) (in solution) CP 95%
ULM-11413-CA	5-Fluoro-2′-deoxyuridine 5′-triphosphate, ammonium salt (unlabeled) (in solution) CP 95%
ULM-10697-CA	5-Fluorocytidine 5′-triphosphate (5F-CTP), ammonium salt (unlabeled) (in solution) CP 90%
ULM-10696-CA	5-Fluorouridine 5′-triphosphate (5F-UTP), ammonium salt (unlabeled) (in solution) CP 90%
NLM-798	5-Fluorouracil (1,3-$^{15}N_2$, 99%)
CNLM-3916	5-Fluorouracil ($^{13}C_4$, 99%; $^{15}N_2$, 98%)

Example Reference

Sochor, F.; Silvers, R.; Muller, D.; et al. **2016**. ^{19}F-labeling of the adenine H2-site to study large RNAs by NMR spectroscopy. *J Biomol NMR, 64(1),* 63-74.

Chemical purity (CP) is 98% or greater, unless otherwise specified. For research use only. Not for use in diagnostic procedures.

Miscellaneous Compounds and Starting Materials

RNA Nucleosides

Catalog No.	Description
CLM-3698	Adenosine (ribose-2-^{13}C, 99%)
CLM-3678	Adenosine (ribose-$^{13}C_5$, 98%) CP 97%
DLM-7676	Adenosine (ribose-1-D, 98%)
DLM-7677	Adenosine (ribose-2-D, 97%)
DLM-7678	Adenosine (ribose-5,5-D_2, 98%)
NLM-9750	Adenosine (U-$^{15}N_5$, 98%)
CNLM-3806-CA	Adenosine ($^{13}C_{10}$, 99%; $^{15}N_5$, 98%) CP 95%
CLM-8518-CA	Adenosine, hydrate ($^{13}C_{10}$, 99%)
CLM-3605	Adenosine·H_2O (ribose-1-^{13}C, 99%) CP 95%
CLM-7674	Adenosine·H_2O (3′-^{13}C, 98%)
CLM-3611	Cytidine (ribose-1-^{13}C, 99%)
CLM-3699	Cytidine (ribose-2-^{13}C, 99%)
CLM-3679	Cytidine (ribose-$^{13}C_5$, 98%)
DLM-7681	Cytidine (ribose-5,5-D_2, 98%)
NLM-3797	Cytidine ($^{15}N_3$, 98%)
CNLM-3807	Cytidine ($^{13}C_9$, 99%; $^{15}N_3$, 99%)
DLM-9101-CA	Cytidine·H_2O (5,6-D_2, 98%) CP 95%
DLM-1846	Guanidine·DCl (D_6, 98%)
CLM-7688	Guanosine·H_2O (ribose-1-^{13}C, 98%)
DLM-7689	Guanosine·H_2O (ribose-5,5-D_2, 98%)
CNLM-3808-CA	Guanosine·H_2O ($^{13}C_{10}$, 99%; $^{15}N_5$, 98%)
NLM-3798	Guanosine·$2H_2O$ ($^{15}N_5$, 99%)
CLM-3630	Uridine (ribose-1-^{13}C, 99%)
CLM-3680	Uridine (ribose-$^{13}C_5$, 98%)
DLM-11408-CA	Uridine (5-D, 97%) (in solution) CP 95%
DLM-7693	Uridine (ribose-5,5-D_2, 98%)
NLM-812	Uridine ($^{15}N_2$, 98%)
CDLM-11409-CA	Uridine (5-D, 97%; 1′,2′,3′,4′,5′-$^{13}C_5$, 99%) (in solution) CP 95%
CDNLM-11410-CA	Uridine (2,4,5,6-$^{13}C_4$, 99%; 5-D, 97%; 1,3-$^{15}N_2$, 98%) (in solution) CP 95%
CNLM-3809-CA	Uridine·H_2O ($^{13}C_9$, 99%; $^{15}N_2$, 98%) CP 95%

DNA Nucleosides

CLM-3700	2'-Deoxyadenosine·H_2O (deoxyribose-1-^{13}C, 99%)
CLM-3701	2'-Deoxyadenosine·H_2O (deoxyribose-2-^{13}C, 99%)
CLM-7682	2'-Deoxyadenosine·H_2O (ribose-5-^{13}C, 98%)
CLM-4579	2'-Deoxyadenosine·H_2O (ribose-$^{13}C_5$, 99%)
DLM-7683	2'-Deoxyadenosine·H_2O (ribose-5,5-D_2, 98%)
NLM-3895	2'-Deoxyadenosine·H_2O ($^{15}N_5$, 99%)
CNLM-3896-CA	2′-Deoxyadenosine·H_2O ($^{13}C_{10}$, 99%; $^{15}N_5$, 98%)
NLM-3897	2'-Deoxycytidine ($^{15}N_3$, 99%)
CNLM-3898	2′-Deoxycytidine ($^{13}C_9$, 98%; $^{15}N_3$, 98%)
CLM-7684	2'-Deoxycytidine·H_2O (ribose-1-^{13}C, 98%)
CLM-3702	2'-Deoxycytidine·H_2O (deoxyribose-2-^{13}C, 99%)
DLM-7685	2'-Deoxycytidine·H_2O (ribose-5,5-D_2, 98%)
CLM-7686	2′-Deoxyguanosine·H_2O (ribose-1-^{13}C, 98%)
CLM-11401-CA	2′-Deoxyguanosine·H_2O ($^{13}C_{10}$, 99%) CP 95%
DLM-7687	2′-Deoxyguanosine·H_2O (ribose-5,5-D_2, 98%)
NLM-3899-CA	2′-Deoxyguanosine·H_2O ($^{15}N_5$, 98%) CP 95%
CNLM-3900-CA	2′-Deoxyguanosine·H_2O ($^{13}C_{10}$, 98%; $^{15}N_5$, 96%)
NLM-10691	α-Thymidine ($^{15}N_2$, 98%)

Chemical purity (CP) is 98% or greater, unless otherwise specified. For research use only. Not for use in diagnostic procedures.

Miscellaneous Compounds and Starting Materals *(continued)*

Catalog No.	Description
CLM-3647	Thymidine (methyl-^{13}C, 98%) CP 97%
CLM-4289	Thymidine (deoxyribose-1-^{13}C, 99%)
CLM-3703	Thymidine (deoxyribose-2-^{13}C, 99%)
CLM-7692	Thymidine (deoxyribose-3-^{13}C, 99%)
DLM-7691	Thymidine (deoxyribose-5,5-D_2, 98%)
DLM-3327	Thymidine (methyl-D_3, ring-6-D, 97%) CP 95%
NLM-3901	Thymidine ($^{15}N_2$, 98%)
CNLM-4263	Thymidine (deoxyribose-$^{13}C_5$, 98%; $^{15}N_2$, 98%) CP 95%
CNLM-3902	Thymidine ($^{13}C_{10}$, 98%; $^{15}N_2$, 96%)

Nitrogenous Bases

CLM-1654	Adenine (8-^{13}C, 95%) (may contain up to 7% 2-^{13}C)
NLM-6924	Adenine·HCl ($^1/_2$ H_2O) ($^{15}N_5$, 98%)
CLM-1001	Cytosine (2-^{13}C, 99%)
CNLM-4424	Cytosine (2-^{13}C, 99%; 1,3-$^{15}N_2$, 98%)
CLM-1019	Guanine (8-^{13}C, 99%)
NLM-6925	Guanine ($^{15}N_5$, 98%)
CNLM-3990	Guanine (8-^{13}C, 99%; 7,9-$^{15}N_2$, 98%)
CLM-3764	Thymine (6-^{13}C, 99%)
DLM-1089	Thymine (α,α,α,6-D_4, 98%)
NLM-3995	Thymine (1,3-$^{15}N_2$, 98%)
CNLM-6945	Thymine ($^{13}C_5$, 98%; $^{15}N_2$, 98%)
CLM-3276	Uracil (2-^{13}C, 99%)
CLM-692	Uracil (4,5-$^{13}C_2$, 99%)
CLM-10507	Uracil ($^{13}C_4$, 99%)
DLM-8633	Uracil (5-D, 98%)
DLM-8502	Uracil (5,6-D_2, 98%)
NLM-637	Uracil (1,3-$^{15}N_2$, 98%)
CNLM-3917	Uracil ($^{13}C_4$, 99%; $^{15}N_2$, 98%)

Example References

Lowenthal, M.S.; Antonishek, A.S.; Phinney, K.W. **2024**. Quantification of mRNA in lipid nanoparticles using mass spectrometry. *Anal Chem, 96(3),* 1214-1222.

Marchante-Gayón, J.M.; Carcelén, J.N.; Rodríguez, H.P.; et al. **2023**. Quantification of modified nucleotides and nucleosides by isotope dilution mass spectrometry. *Mass Spectrom Rev, 1-21, in press.*

Chemical purity (CP) is 98% or greater, unless otherwise specified. For research use only. Not for use in diagnostic procedures.

Continued ➤

Miscellaneous Compounds and Starting Materals *(continued)*

Other

Catalog No.	Description
CLM-11441-CA	Adenylosuccinate (AdS), ammonium salt (ribose-$^{13}C_5$, 99%) (in solution) CP 95%
NLM-12312	DL-Allantoin ($^{15}N_4$, 98%) CP 97%
CLM-11740-CA	2-Amino-2′-deoxyadenosine 5′-triphosphate, ammonium salt (ribose-1′,2′,3′,4′,5′-$^{13}C_5$, 99%) (in solution) CP 95%
CLM-11638-CA	2-Aminoadenosine 5′-triphosphate, ammonium salt (ribose-1′,2′,3′,4′,5′-$^{13}C_5$, 99%) (in solution) CP 95%
DLM-11273-CA	2′,3′-cGAMP, ammonium salt (adenosine-1′,2′,3′,4′,5′,5″-D_6, 98%) (in solution) CP 90%
CNLM-8771-CA	2′-Deoxyuridine, ammonium salt ($^{13}C_9$, 99%; $^{15}N_2$, 98%) (in solution) CP 90%
DLM-4391	5,6-Dihydrothymine (5,6,6-D_3, methyl-D_3, 99%)
CNLM-4510	5,6-Dihydrouracil ($^{13}C_4$, 99%; $^{15}N_2$, 98%)
NLM-6715	8-Hydroxy-2′-deoxyguanosine ($^{15}N_5$, 98%) CP 95%
CNLM-3832	8-Hydroxyadenine (8-^{13}C, 98%; 6,9-diamino-$^{15}N_2$, 98%)
CNLM-4392	5-Hydroxycytosine (2-^{13}C, 99%; 1,3-$^{15}N_2$, 98%)
NLM-8712-CA	Inosine 5′-monophosphate, ammonium salt ($^{15}N_4$, 98%) (in solution) CP 95%
DLM-6142	5-Methyl-2′-deoxycytidine·HCl (methyl-D_3, ring-6-D, 96%) CP 95%
DLM-7471	3-Methyladenine (methyl-D_3, 98%)
CNLM-11120	2′-*O*-Methyladenosine ($^{13}C_{10}$, 98%; $^{15}N_5$, 96%)
DLM-7473	6-*O*-Methylguanine (methyl-D_3, 98%)
DLM-7472	7-Methylguanine (methyl-D_3, 98%)
CLM-11738-CA	5-Methyluridine 5′-triphosphate, ammonium salt (ribose-1′,2′,3′,4′,5′-$^{13}C_5$, 99%) (in solution) CP 95%
CLM-11510-CA	Orotidine 5′-monophosphate, ammonium salt (ribose-$^{13}C_5$, 99%) (in solution)
CLM-11442-CA	1-(5′-Phosphoribosyl)-4-(*N*-succinocarboxamide)-5-aminoimidazole, ammonium salt (ribose-$^{13}C_5$, 99%) (in solution) CP 95%
CLM-9427-CA	1-(5′-Phosphoribosyl)-5-amino-4-imidazole-carboxamide salt ($^2NH_4$+) (ribose-$^{13}C_5$, 99%) CP 90%
CLM-11345-CA	Pseudouridine ($^{13}C_9$, 99%; $^{15}N_2$, 98%) (in solution)
CLM-11344-CA	Pseudouridine 5′-monophosphate, ammonium salt ($^{13}C_9$, 99%; $^{15}N_2$, 98%) (in solution)
CNLM-11739-CA	Pseudouridine 5'-triphosphate, ammonium salt ($^{13}C_9$, 99%; $^{15}N_2$, 98%) (in solution) CP 95%
CNLM-10505	2-Pyrimidinone (2-^{13}C, 99%; $^{15}N_2$, 98%)
CLM-11443-CA	1-Ribosyl-4-(*N*-succinocarboxamide)-5-aminoimidazole, ammonium salt (ribose-$^{13}C_5$, 99%) (in solution) CP 95%
CLM-11348-CA	1-Ribosyl-5-aminoimidazole-4-carboxamide (acadesine) (ribose-$^{13}C_5$, 99%)
CLM-3629	Ribothymidine (ribose-1-^{13}C, 99%)
CLM-11454-CA	N6-Succinyladenosine, ammonium salt (ribose-$^{13}C_5$, 99%) (in solution) CP 95%
CLM-10513-CA	Uridine diphosphate-α-D-glucose, ammonium salt (glucose-1″,2′′,3″,4″,5″,6″-$^{13}C_6$, 99%) (in solution) CP 95%
CLM-8700-CA	Xanthosine-5′-monophosphate, ammonium salt ($^{13}C_{10}$, 99%) (in solution) CP 95%

Tips and Tricks

Unit Size Conversions

mg to µmol Conversion

Shorthand Formula:

$$\text{amt in µmol} = \frac{\text{amt in mg}}{\text{MW of compound}} \times 1000$$

I would like to order 50 mg of CNLM-4269-CA. How many µmol is that?

Shorthand example:

50/(606.2)×1000 = 82.48 µmol

Longhand example:

$$50\ \text{mg} \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{1\ \text{mol}}{606.2\ \text{g}} \times \frac{1000\ \text{mmol}}{1\ \text{mol}} \times \frac{1000\ \text{µmol}}{1\ \text{mmol}} = 82.48\ \text{µmol}$$

µmol to mg Conversion

Shorthand Formula:

$$\text{amt in mg} = \frac{(\text{amt in µmol} \times \text{MW of compound})}{1000}$$

How many mg of material are in the 20 µmol size of CNLM-4269-CA?

Shorthand example:

(20×606.2)/1000 = 12.12 mg

Longhand example:

$$20\ \text{µmol} \times \frac{1\ \text{mmol}}{1000\ \text{µmol}} \times \frac{1\ \text{mol}}{1000\ \text{mmol}} \times \frac{606.2\ \text{g}}{1\ \text{mol}} \times \frac{1000\ \text{mg}}{1\ \text{g}} = 12.12\ \text{mg}$$

“CIL has been a strong supporter of NMR methods of development over the years, providing critical isotope-enriched reagents for research and development, without which many of the recent advances in biomolecular NMR would simply not have been possible. In particular, the broad biological impact and tremendous success of the multi-dimensional triple-resonance biomolecular NMR would not have been achieved without the high quality and broadly accessible reagents that CIL has provided to the scientific community over the last 40 years.”

Gaetano Montelione, PhD
Nexomics Biosciences (USA)

“We have enjoyed a close working relationship with CIL for over 15 years, both as a customer and a collaborator. We’ve had great interactions with sales, management, and the chemists from top to bottom. CIL is a great company that you can really work with in this specialized area. We’ve been able to do science that we couldn’t have done without working with CIL.”

James R. Williamson, PhD
The Skaggs Institute for Chemical Biology – The Scripps Research Institute (USA)

Top 10 Reasons to Use Ammonium Salts

1. Self-buffering (pH ~7.6).
2. "Soft cation."
3. Nucleotides of ammonium salts are active with polymerases, synthetases, and phosphatases.
4. Volatile counter-ion.
5. The ammonium cation can be easily exchanged using DOWEX cation exchange resin.
6. The pH does not change during drying of the nucleotide (i.e. "speed-vac," lyophilize).
7. Stoichiometry between the counter-ion and the nucleotide is preserved.
8. Routinely compatible in down-stream syntheses.
9. Compatible in a variety of down-stream chromatography applications.
10. Tested to be comparable in side-by-side, *in vitro* transcription reactions!

A Special Thanks to Our Partner

Cassia LLC was founded in 2005 by noted NMR spectroscopists Drs. Jamie Williamson and Lincoln Scott. CIL gives special thanks to Cassia for the special relationship that combines CIL's isotopic material production and marketing with Cassia's unique expertise in RNA and DNA biosynthesis. Since 2005, CIL and Cassia have developed the most extensive product line of stable isotope-labeled RNA and DNA triphosphates, DNA phosphoramidites and other related compounds. All of these products are routinely available from CIL.

Please visit isotope.com for a complete list of isotope-labeled compounds.

Cambridge Isotope Laboratories (CIL) is the world leader in the separation and manufacture of stable isotopes and stable isotope-labeled compounds. For over 40 years, CIL has remained the premier supplier of stable isotopes for NMR- and MS-based research applications. These products include a diverse line of RNA/DNA products, minimal media reagents (carbohydrates, ammonium salts), cell-free expression reagents and kits, free and protected amino acids, as well as cell-growth media for eukaryotic and prokaryotic cell lines. Additionally, CIL offers a comprehensive line of deuterated solvents, detergents, and buffers. Our products have been specifically designed and tested with the most discerning NMR and MS spectroscopists in mind. CIL actively supports the world's NMR and MS communities through meeting sponsorships and customer collaborations.

Research products are distributed and sold worldwide via our extensive network.
CIL's distributor listing is available at isotope.com.

To request a quotation or place an order:
North America: 1.978.749.8000 | 1.800.322.1174 | cilsales@isotope.com
International: +1.978.749.8000 | intlsales@isotope.com
Fax: 1.978.749.2768 | isotope.com

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

Scan the QR code for an electronic version of the catalog.