Sigma-Aldrich®
Lab & Production Materials

Technical Note

Custom Oligos Modifications

These are some of the modifications that we offer for oligonucleotides. If you do not see the one that you require, please send a feasibility request to oligotechserv@merckgroup.com.

Table of Contents

Fluorescent

Reporter Dyes

Fluorescent	Positions	Excitation Maximum (nm)	Emission Maximum (nm)	Fluorescent Color
6-FAM™ (fluorescein)	5' End, 3' End	495	520	Green
ROX™	5' End, 3' End	586	610	Orange
Cyanine 3	5' End, 3' End	549	566	Green-Yellow
Cyanine 5	5' End, 3' End	646	669	Red
Cyanine 5.5	5' End	675	694	Red
6-FAM dT	5' End, Internal	495	520	Green
HEX™	5' End	535	556	Green
JOE™	5' End, 3' End	529	555	Green
6-Carboxy-rhodamine 6G™	5' End, 3' End	524	550	Green
TAMRA	3' End	557	583	Green-Yellow
TAMRA NHS Ester	5' End	557	583	Yellow
TET™	5' End	521	536	Green
TxRd (Sulforhodamine 101-X)	5' End, 3' End	597	616	Red-Orange
A488 (Sulfonated Fluorescein 488)	5' End, 3' End	495	519	Green

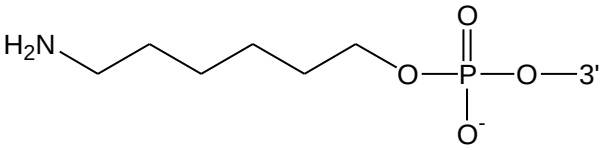
Attachment

Amino Modifiers

Amino modifiers are used for attaching ligands to oligonucleotides and linking oligonucleotides to solid surfaces. 5′-Amino-dT is used for attaching a peptide or PNA sequence to an oligonucleotide. Amino modifiers can sometimes be used interchangeably with thiols.

5′-DMS(O)MT-Amino-Modifier-C6 (DMS(O)MT protecting group on amine)

Structure

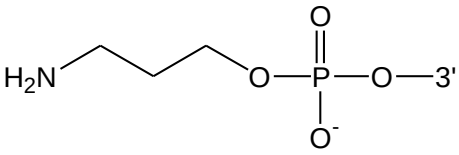


Availability

Positions	Scales (µmol)	Purifications
5′ End	0.05, 0.2, 1.0	Cartridge, HPLC

5′-Amino-Modifier-C3-TFA (trifluoroacetic acid protecting group on amine)

Structure

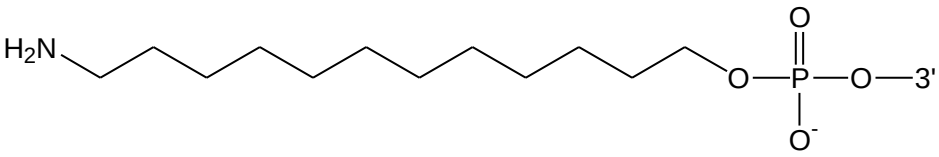


Availability

Positions	Scales (µmol)	Purifications
5′ End	0.05, 0.2, 1.0	Desalt, HPLC

5’-Amino-Modifier-C12

Structure

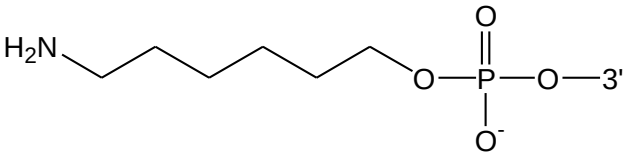


Availability

Positions	Scales (µmol)	Purifications
5’ End	0.05, 0.2, 1.0	Cartridge, HPLC

5’-Amino-Modifier-C6-TFA (trifluoroacetic acid protecting group on amine)

Structure

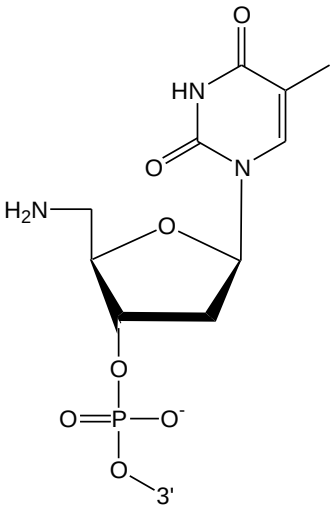


Availability

Positions	Scales (µmol)	Purifications
5’ End	0.05, 0.2, 1.0	Desalt, PAGE

5′-Amino-dT

Structure

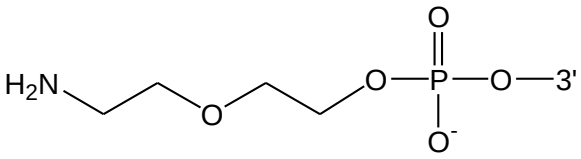


Availability

Positions	Scales (µmol)	Purifications
5′ End	0.05, 0.2, 1.0	Cartridge, HPLC

5′-Amino-Modifier-5

Structure

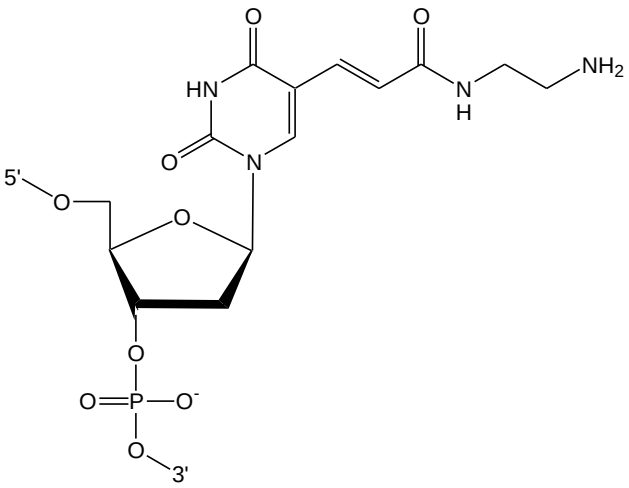


Availability

Positions	Scales (µmol)	Purifications
5′ End	0.05, 0.2, 1.0	Cartridge, HPLC

Amino-Modifier-C2-dT

Structure

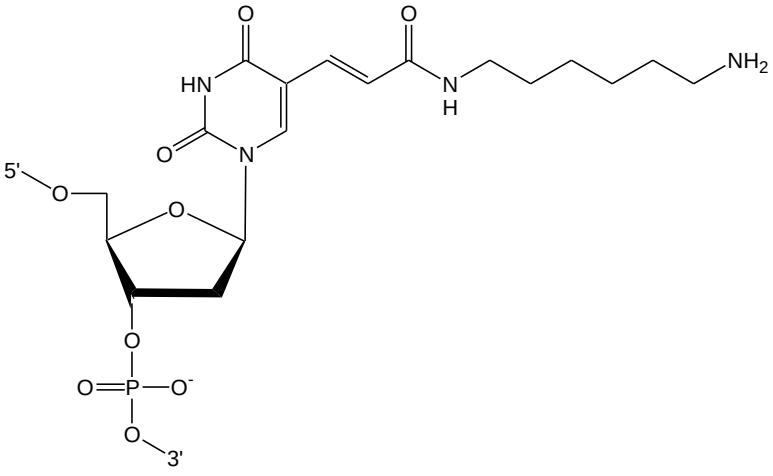


Availability

Positions	Scales (µmol)	Purifications
Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

Amino-Modifier-C6-dT

Structure

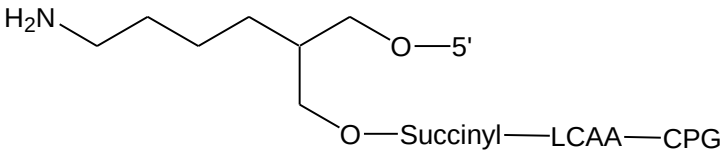


Availability

Positions	Scales (µmol)	Purifications
Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

3’-Amino-Modifier-C7-CPG

Structure



Availability

Positions	Scales (µmol)	Purifications
3’ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Nielsen PS, Ohlsson H, Alsbo C, Andersen MS, and Kauppinen S.
Expression profiling by oligonucleotide microarrays spotted on coated polymer slides.
J Biotechnol. 2005 Mar 16;116(2):125-34.

Walsh MK, Wang X, and Weimer BC.
Optimizing the immobilization of single-stranded DNA onto glass beads.
J Biochem Biophys Methods. 2001 Feb 26;47(3):221-31.

Minard-Basquin C, Chaix C, Pichot C, and Mandrand B.
Oligonucleotide-polymer conjugates: effect of the method of synthesis on their structure and performance in diagnostic assays.
Bioconjug Chem. 2000 Nov-Dec;11(6):795-804.

Penchovsky R, Birch-Hirschfeld E, and McCaskill JS.
End-specific covalent photo-dependent immobilisation of synthetic DNA to paramagnetic beads.
Nucleic Acids Res. 2000 Nov 15;28(22):E98.

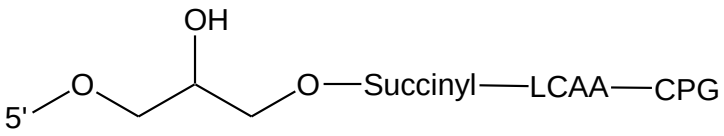
Hung SC, Mathies RA, and Glazer AN.
Comparison of fluorescence energy transfer primers with different donor-acceptor dye combinations.
Anal Biochem. 1998 Jan 1;255(1):32-8.

Nelson PS, Sherman-Gold R, and Leon R.
A new and versatile reagent for incorporating multiple primary aliphatic amines into synthetic oligonucleotides.
Nucleic Acids Res. 1989 Sep 25;17(18):7179-86.

3’-Glyceryl

3’-glyceryl produces a 3'-phosphoglyceryl terminus, which can then be oxidized to either the aldehyde or carboxylic acid. Either oxidation state can be conjugated to molecules with amino functional groups.

Structure



Availability

Positions	Scales (µmol)	Purifications
3’ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

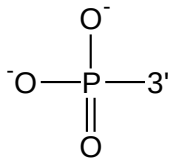
Urata H and Akagi M.
A convenient synthesis of oligonucleotides with a 3’-phosphoglycolate and 3’-phosphglyceraldehyde terminus.
Tetrahedron Lett. 1993;34(25):4015-4018.

Phosphate

5′-Phosphate and 5′-Phosphate II

5′-phosphate is used for ligations, as a linker and adaptor, and to facilitate cellular uptake of oligonucleotides. It can only be purified by desalt and PAGE, whereas 5′-phosphate II can undergo cartridge and RP-HPLC purifications.

Structure



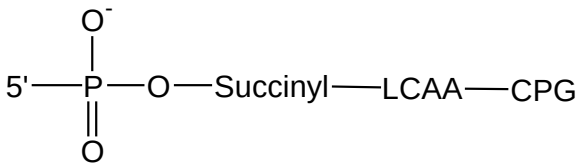
Availability

Positions	Scales (µmol)	Purifications
5′ End	0.05, 0.2, 1.0	Desalt, PAGE (Phosphate) & Cartridge, HPLC (Phosphate II)

3′-Phosphate

3′-phosphate is used to inhibit DNA polymerases and ligases as well as alter susceptibility to exonucleases. It is also sometimes required when certain 3′ quenchers are conjugated to probes.

Structure



Availability

Positions	Scales (µmol)	Purifications
3′ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Tang J, Li Y, Pan Z, Guo Y, Ma J, Ning S, Xiao P, and Lu Z.
Single nucleotide variation detection by ligation of universal probes on a 3D poyacrylamide gel DNA microarray.
Hum Mutat. 2009 Oct;30(10):1460-8.

Dobbs TA, Palmer P, Maniou Z, Lomax ME, and O'Neill P.
Interplay of two major repair pathways in the processing of complex double-strand DNA breaks.
DNA Repair(Amst). 2008 Aug 2;7(8):1372-83.

Harrigan JA, Fan J, Momand J, Perrino FW, Bohr VA, and Wilson DM 3rd.
WRN exonuclease activity is blocked by DNA termini harboring 3' obstructive groups.
Mech Ageing Dev. 2007 Mar;128(3):259-66.

Hadshiew IM, Eller MS, Gasparro FP, and Gilchrest BA.
Stimulation of melanogenesis by DNA oligonucleotides: effect of size, sequence and 5' phosphorylation.
J Dermatol Sci. 2001 Feb;25(2):127-38.

Pourquier P, Pilon AA, Kohlhagen G, Mazumder A, Sharma A, and Pommier Y.
Trapping of mammalian topoisomerase I and recombinations induced by damaged DNA containing nicks or gaps.
Importance of DNA end phosphorylation and camptothecin effects.
J Biol Chem. 1997 Oct 17;272(42):26441-7.

Horn T and Urdea M.
A chemical 5'-phosphorylation of oligodeoxyribonucleotides that can be monitored by trityl cation release.
Tetrahedron Lett. 1986;27(39):4705-4708.

Guzaev A, Salo H, Azhayev A, and Lonnberg H.
A new approach for chemical phosphorylation of oligonucleotides at the 5'-terminus.
Tetrahedron. 1995;51(34):9375-9384.

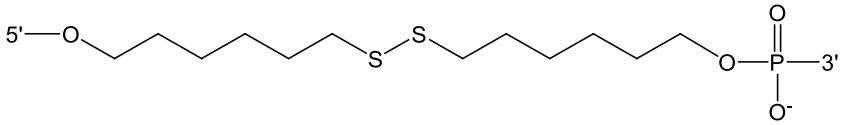
Thiol

5'-Thiol-Modifier C6 S-S

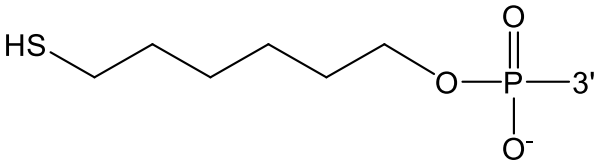
Thiol C6 S-S is used for attaching ligands to oligonucleotides and linking oligonucleotides to solid surfaces. Thiols are shipped in oxidized form and must be reduced with DTT before being used in coupling reactions. Thiols can sometimes be used interchangeably with amino modifiers.

Structures

Oxidized



Reduced



Availability

Positions	Scales (µmol)	Purifications
5’ End, Internal	0.05, 0.2, 1.0	Cartridge, HPLC

References

Mahajan S, Sethi D, Seth S, Kumar A, Kumar P, and Gupta KC.
Construction of oligonucleotide microarrays (biochips) via thioether linkage for the detection of bacterial meningitis.
Bioconjug Chem. 2009 Sep;20(9):1703-10.

Anne A and Demaille C.
Electron transport by molecular motion of redox-DNA strands: unexpectedly slow rotational dynamics of 20-mer ds-DNA chains end-grafted onto surfaces via C6 linkers.
J Am Chem Soc. 2008 Jul 30;130(30):9812-23.

Wang K, Goyer C, Anne A, and Demaille C.
Exploring the motional dynamics of end-grafted DNA oligonucleotides by in situ electrochemical atomic force microscopy.
J Phys Chem B. 2007 May 31;111(21):6051-8.

Oktem HA, Bayramoglu G, Ozalp VC, and Arica MY.
Single-step purification of recombinant Thermus aquaticus DNA polymerase using DNA-aptamer immobilized novel affinity magnetic beads.
Biotechnol Prog. 2007 Jan-Feb;23(1):146-54.

Schlapak R, Pammer P, Armitage D, Zhu R, Hinterdorfer P, Vaupel M, Frühwirth T, and Howorka S.
Glass surfaces grafted with high-density poly(ethylene glycol) as substrates for DNA oligonucleotide microarrays.
Langmuir. 2006 Jan 3;22(1):277-85.

Ferenc G, Kupihár Z, Kele Z, and Kovács L.
A convenient method for the synthesis of oligonucleotide-cationic peptide conjugates.
Nucleosides Nucleotides Nucleic Acids. 2005;24(5-7):1059-61.

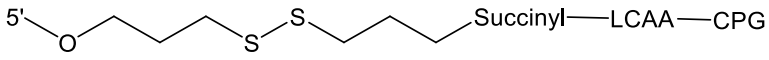
Adessi C, Matton G, Ayala G, Turcatti G, Mermod JJ, Mayer P, and Kawashima E.
Solid phase DNA amplification: characterisation of primer attachment and amplification mechanisms.
Nucleic Acids Res. 2000 Oct 15;28(20):E87.

3'-Thiol-Modifier-C3 S-S

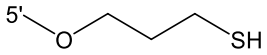
3′-thiol-modifier C3 is used for attaching ligands to oligonucleotides and linking oligonucleotides to solid surfaces. It is shipped in oxidized form and must be reduced with DTT before use in coupling reactions. Thiols can sometimes be used interchangeably with amino modifiers.

Structures

Oxidized



Reduced



Availability

Positions	Scales (µmol)	Purifications
3′ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Vaidya AA and Norton ML.
DNA attachment chemistry at the flexible silicone elastomer surface: toward disposable microarrays.
Langmuir. 2004 Dec 7;20(25):11100-7.

Zuckermann R, Corey D, and Schultz P.
Efficient methods for attachment of thiol specific probes to the 3'-ends of synthetic oligodeoxyribonucleotides.
Nucleic Acids Res. 1987 Jul 10;15(13):5305-21.

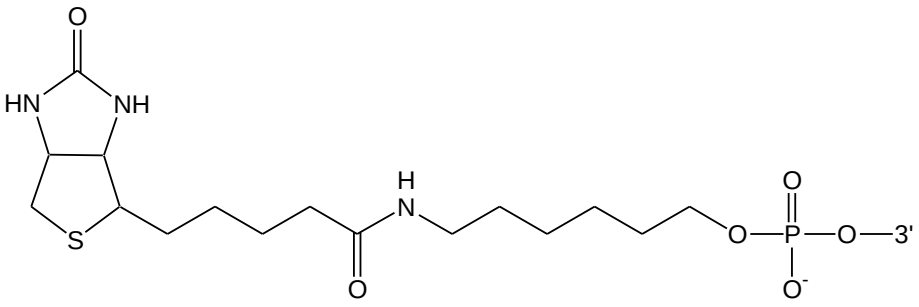
Binding

Biotin and its binding partner streptavidin are used in various hybridization assays (e.g. blots, arrays, and ELISA) and diagnostics. Streptavidin is often conjugated to alkaline phosphatase or horseradish peroxidase, which report a reaction via chemiluminescence.

Biotin

5′-Biotin

Structure

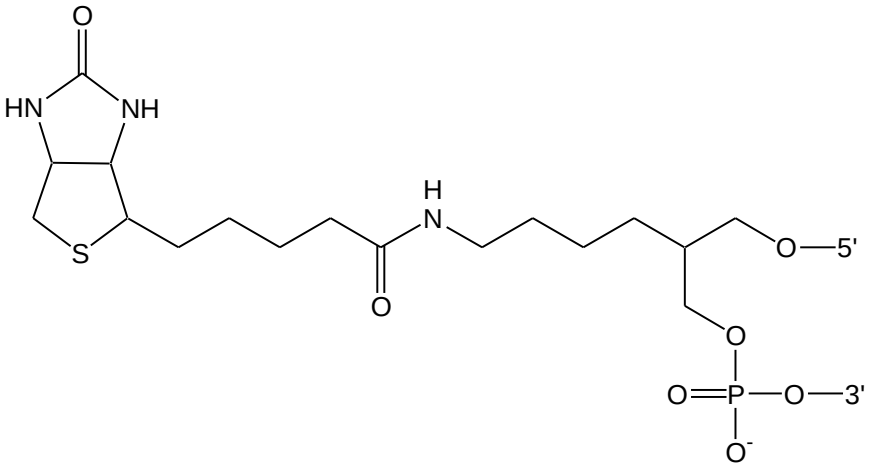


Availability

Positions	Scales (µmol)	Purifications
5′ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

Biotin

Structure

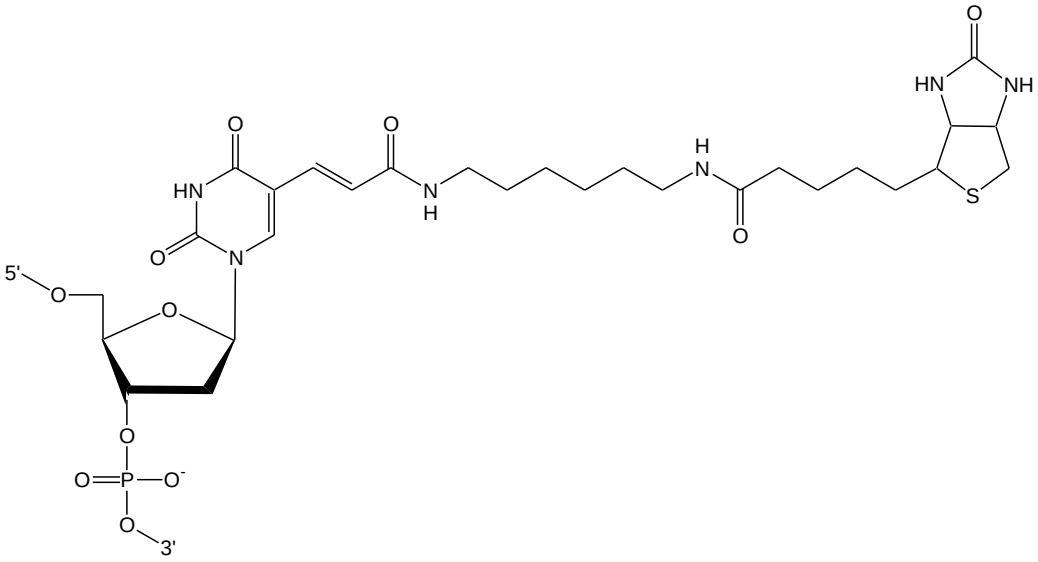


Availability

Positions	Scales (µmol)	Purifications
Internal	0.05, 0.2, 1.0	HPLC, PAGE

Biotin-dT

Structure

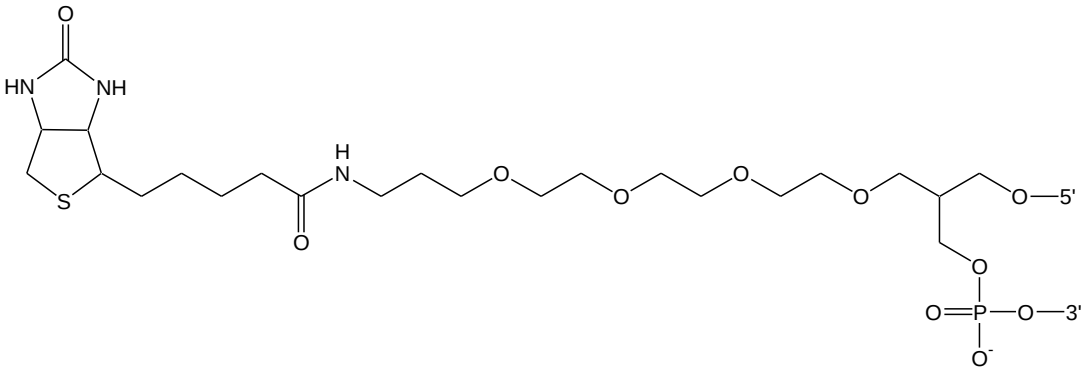


Availability

Positions	Scales (µmol)	Purifications
5’ End, Internal	0.05, 0.2, 1.0	HPLC, PAGE

Biotin-TEG

Structure

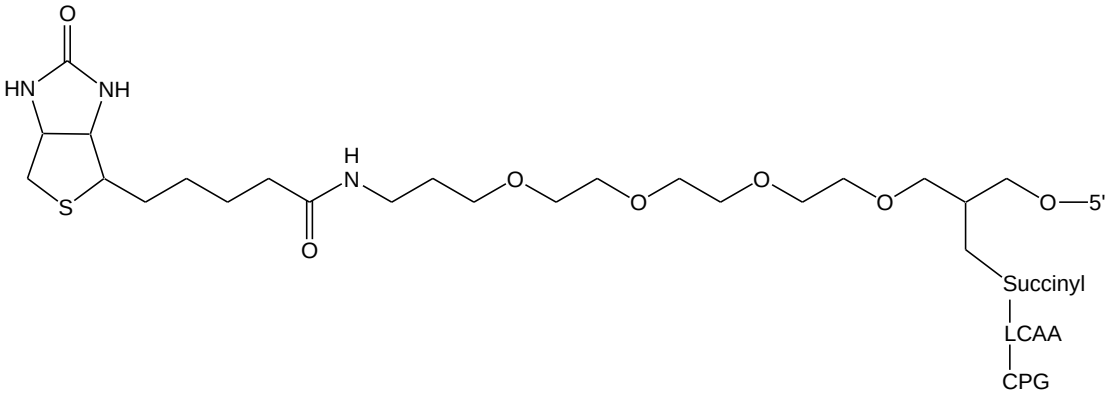


Availability

Positions	Scales (µmol)	Purifications
5’ End, Internal	0.05, 0.2, 1.0	Cartridge, HPLC

3’-Biotin-TEG-CPG

Structure



Availability

Positions	Scales (µmol)	Purifications
3’ End, Internal	0.05, 0.2, 1.0	HPLC, PAGE

References

Ki HA, Kim MJ, Pal S, and Song JM.
Oligonucleotide chip assay for quantification of gamma ray-induced single strand breaks.
J Pharm Biomed Anal. 2009 Feb 20;49(2):562-6.

Balamurugan S, Obubuafo A, Soper SA, and Spivak DA.
Surface immobilization methods for aptamer diagnostic applications.
Anal Bioanal Chem. 2008 Feb;390(4):1009-21.

Günther S, Groth I, Grabley S, and Munder T.
Design and evaluation of an oligonucleotide-microarray for the detection of different species of the genus Kitasatospora.
J Microbiol Methods. 2006 May;65(2):226-36.

Sabanayagam CR, Smith CL, and Cantor CR.
Oligonucleotide immobilization on micropatterned streptavidin surfaces.
Nucleic Acids Res. 2000 Apr 15;28(8):E33.

Wilson PA, Phipps J, Samuel D, and Saunders NA.
Development of a simplified polymerase chain reaction-enzyme immunoassay for the detection of Chlamydia pneumoniae.
J Appl Bacteriol. 1996 Apr;80(4):431-8.

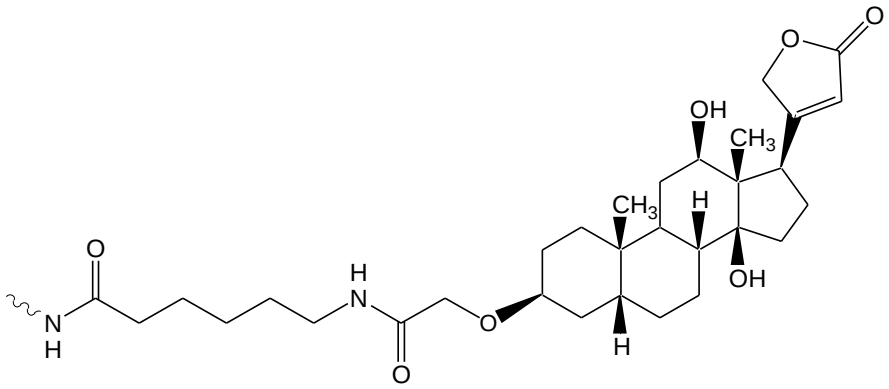
Pardridge WM and Boado RJ.
Enhanced cellular uptake of biotinylated antisense oligonucleotide or peptide mediated by avidin, a cationic protein.
FEBS Lett. 1991 Aug 19;288(1-2):30-2.

Guitteny AF, Fouque B, Mougin C, Teoule R, and Bloch B.
Histological detection of messenger RNAs with biotinylated synthetic oligonucleotide probes.
J Histochem Cytochem. 1988 Jun;36(6):563-71.

Digoxigenin

Digoxigenin and anti-digoxigenin antibodies substitute for biotin and streptavidin in various hybridization assays (e.g. blots, arrays, and ELISA) and diagnostics. Anti-digoxigenin or secondary antibodies are typically conjugated to reporters such as alkaline phosphatase, horseradish peroxidase, fluorescein, rhodamine, or colloidal gold.

Structure



Availability

Positions	Scales (µmol)	Purifications
5′ End, 3′ End	0.05, 0.2, 1.0	HPLC

References

Liu G, Wan Y, Gau V, Zhang J, Wang L, Song S, and Fan C.
An enzyme-based E-DNA sensor for sequence-specific detection of femtomolar DNA targets.
J Am Chem Soc. 2008 May 28;130(21):6820-5.

Qi X, Chai X, and Chai T.
An improved primer extension method for detection of mRNA start-points using non-radioactive digoxigenin-labeling primers.
Biotechnol Lett. 2007 Jul;29(7):1125-8.

Wei X, Dai G, Marcucci G, Liu Z, Hoyt D, Blum W, and Chan KK.
A specific picomolar hybridization-based ELISA assay for the determination of phosphorothioate oligonucleotides in plasma and cellular matrices.
Pharm Res. 2006 Jun;23(6):1251-64.

Alfieri AA, Leite JP, Alfieri AF, Jiang B, Glass RI, and Gentsch JR.
Detection of field isolates of human and animal group C rotavirus by reverse transcription-polymerase chain reaction and digoxigenin-labeled oligonucleotide probes.
J Virol Methods. 1999 Dec;83(1-2):35-43.

Tarrasón G, Bellido D, Eritja R, Vilaró S, and Piulats J.
Digoxigenin-labeled phosphorothioate oligonucleotides: a new tool for the study of cellular uptake.
Antisense Res Dev. 1995 Fall;5(3):193-201.

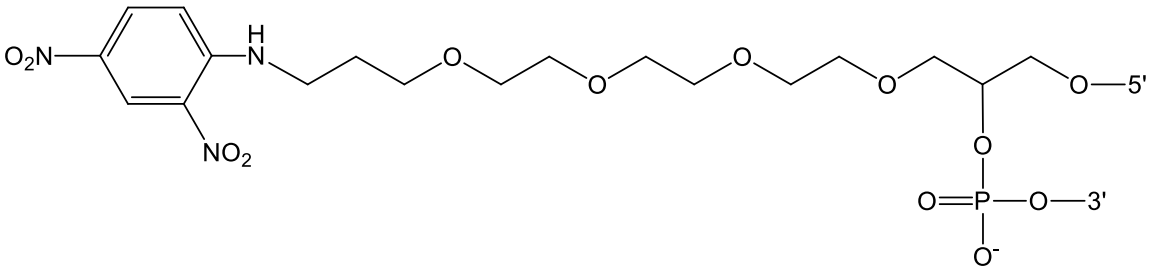
Artero RD, Akam M, and Pérez-Alonso M.
Oligonucleotide probes detect splicing variants in situ in Drosophila embryos.
Nucleic Acids Res. 1992 Nov 11;20(21):5687-90.

Zischler H, Nanda I, Schäfer R, Schmid M, and Epplen JT.
Digoxigenated oligonucleotide probes specific for simple repeats in DNA fingerprinting and hybridization in situ.
Hum Genet. 1989 Jun;82(3):227-33.

2,4-Dinitrophenol-TEG

DNP and anti-DNP antibodies substitute for biotin and streptavidin in various hybridization assays (e.g. blots, arrays, and ELISA) and diagnostics. Anti-DNP or secondary antibodies are typically conjugated to alkaline phosphatase or horseradish peroxidase, which report a reaction via chemiluminescence.

Structure



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal	0.05, 0.2, 1.0	HPLC

References

Harper SJ, Bailey E, McKeen CM, Stewart AS, Pringle JH, Feehally J, and Brown T.
A comparative study of digoxigenin, 2,4-dinitrophenyl, and alkaline phosphatase as deoxyoligonucleotide labels in non-radioisotopic in situ hybridisation.
J Clin Pathol. 1997 Aug;50(8):686-90.

McClean J, Davison A, Rao MV, and Brown T.
Antibody-mediated detection and physical properties of oligonucleotides labelled with multiple internal and terminal 2,4-dinitrophenyl groups.
Biomed Pept Proteins Nucleic Acids. 1996;2(1):7-12.

Stevenson K, Walker CA, Grzybowski J, Brown T, and Sharp JM.
Detection of PCR products from Mycobacterium avium subspecies Paratuberculosis using oligonucleotides containing multiple 2,4-dinitrophenyl reporter groups.
Biomed Pept Proteins Nucleic Acids. 1994-1995;1(1):17-20.

Grzybowski J, Will DW, Randall RE, Smith CA, and Brown T.
Synthesis and antibody-mediated detection of oligonucleotides containing multiple 2,4-dinitrophenyl reporter groups.
Nucleic Acids Res. 1993 Apr 25;21(8):1705-12.

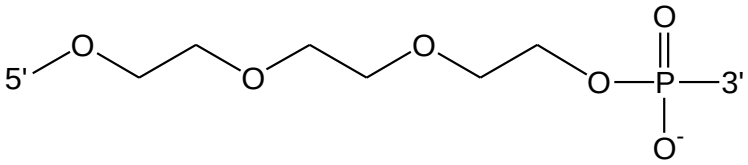
Will DW, Pritchard CE, and Brown T.
The synthesis of oligonucleotides that contain 2,4-dinitrophenyl reporter groups.
Carbohydr Res. 1991 Sep 2;216:315-22.

Spacers

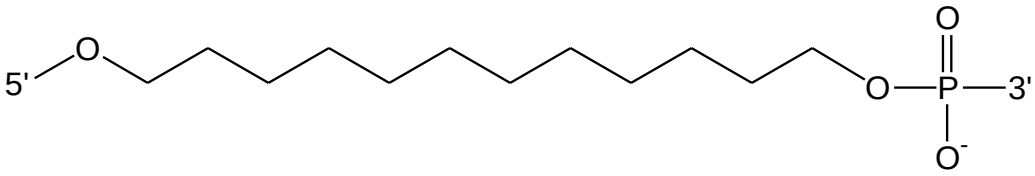
Spacers are used for investigating duplex formation, creating distance between an oligonucleotide and a conjugated modification, and inhibiting polymerases, topoisomerases, and exonucleases. Multiple additions may be made when longer spacers are necessary.

Structures

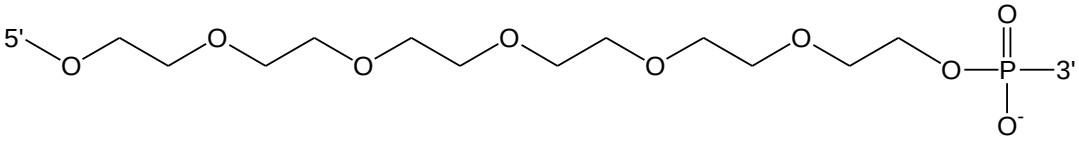
Spacer 9



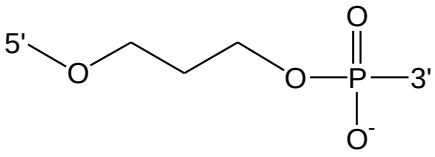
Spacer 12



Spacer 18



Spacer C3



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Pyshnaya IA, Vinogradova OA, Kabilov MR, Ivanova EM, and Pyshnyi DV.
Bridged oligonucleotides as molecular probes for investigation of enzyme-substrate interaction and allele-specific analysis of DNA.
Biochemistry (Mosc). 2009 Sep;74(9):1009-20.

Li M, Sato Y, Nishizawa S, Seino T, Nakamura K, and Teramae N.
2-Aminopurine-modified abasic-site-containing duplex DNA for highly selective detection of theophylline.
J Am Chem Soc. 2009 Feb 25;131(7):2448-9.

Lao YH, Peck K, and Chen LC.
Enhancement of Aptamer Microarray Sensitivity through Spacer Optimization and Avidity Effect.
Anal Chem. 2009 Feb 4.

Wang Y, Ng MT, Zhou T, Li X, Tan CH, and Li T.
C3-Spacer-containing circular oligonucleotides as inhibitors of human topoisomerase I.
Bioorg Med Chem Lett. 2008 Jun 15;18(12):3597-602.

Dai Q, Xu CY, Sato Y, Yoshimoto K, Nishizawa S, and Teramae N.
Enhancement of the binding ability of a ligand for nucleobase recognition by introducing a methyl group.
Anal Sci. 2006 Feb;22(2):201-3.

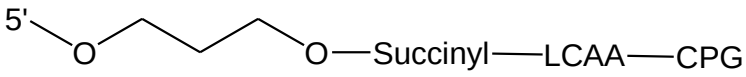
Carmon A, Vision TJ, Mitchell SE, Thannhauser TW, Müller U, and Kresovich S.
Solid-phase PCR in microwells: effects of linker length and composition on tethering, hybridization, and extension.
Biotechniques. 2002 Feb;32(2):410, 412, 414-8, 420.

Kozerski L, Mazurek AP, Kawecki R, Bocian W, Krajewski P, Bednarek E, Sitkowski J, Williamson MP, Moir AJ, and Hansen PE.
A nicked duplex decamer DNA with a PEG(6) tether.
Nucleic Acids Res. 2001 Mar 1;29(5):1132-43.

3’-Spacer-C3-CPG

3’-Spacer C3 is used to inhibit DNA polymerases and exonucleases.

Structure



Availability

Positions	Scales (µmol)	Purifications
3’ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Vestheim H and Jarman SN.
Blocking primers to enhance PCR amplification of rare sequences in mixed samples - a case study on prey DNA in Antarctic krill stomachs.
Front Zool. 2008 Jul 20;5:12.

Dames S, Margraf RL, Pattison DC, Wittwer CT, and Voelkerding KV.
Characterization of aberrant melting peaks in unlabeled probe assays.
J Mol Diagn. 2007 Jul;9(3):290-6.

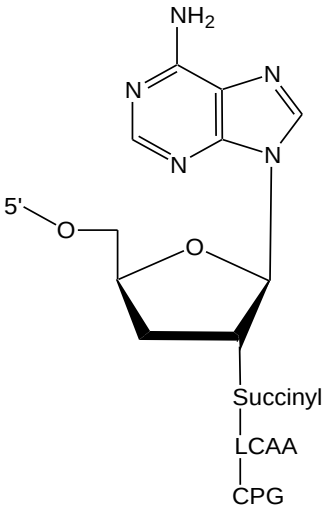
Analog

Chain Terminating

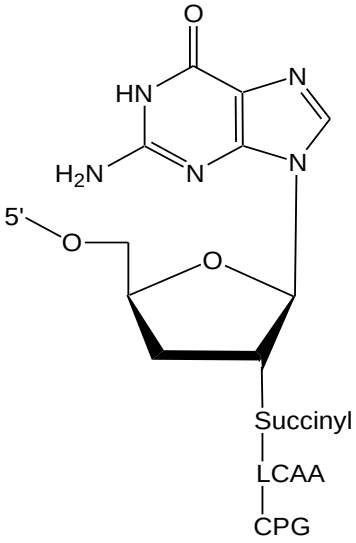
3′-dA, -dC, -dG, and -dT are used to inhibit DNA polymerases and topoisomerases.

Structures

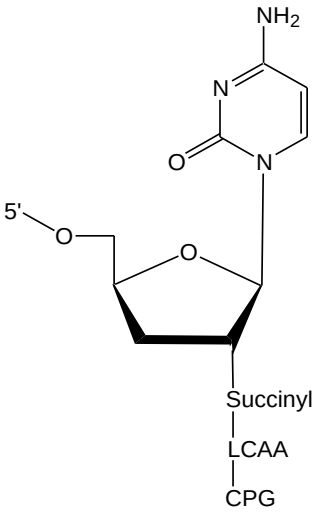
3′-dA-CPG (Cordycepin)



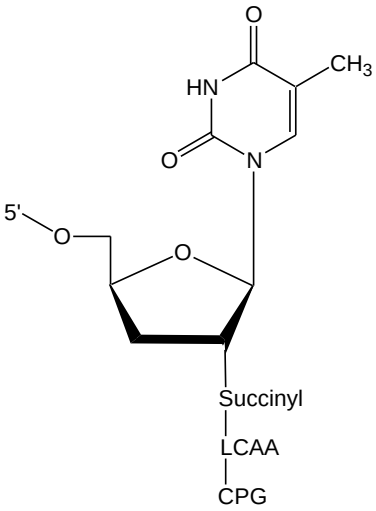
3′-dG-CPG



3′-dC-CPG



3′-dT-CPG



Availability

Positions	Scales (µmol)	Purifications
3′ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Arslan T, Abraham AT, and Hecht SM.
Structurally altered substrates for DNA topoisomerase I. Effects of inclusion of a single 3'-deoxynucleotide within the scissile strand.
Nucleosides Nucleotides. 1998 Jan-Mar;17(1-3):515-30.

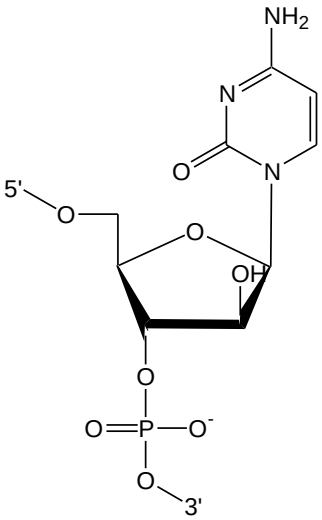
Austermann S, Kruhøffer M, and Grosse F.
Inhibition of human immunodeficiency virus type 1 reverse transcriptase by 3'-blocked oligonucleotide primers.
Biochem Pharmacol. 1992 Jun 23;43(12):2581-9.

Chemotherapeutic

Cytosine arabinoside (Ara-C, Cytarabine)

Ara-C is a chemotherapeutic agent that inhibits DNA replication, decreases binding of transcription factors, and induces cleavage by topoisomerases and endonucleases. Ara-C is also used in a PCR-based, restriction-enzyme-free splicing and mutagenesis protocol.

Structure



Availability

Positions	Scales (µmol)	Purifications
Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Ailenberg M, Goldenberg NM, and Silverman M.
Description of a PCR-based technique for DNA splicing and mutagenesis by producing 5' overhangs with run through stop DNA synthesis utilizing Ara-C.
BMC Biotechnol. 2005 Sep 1;5:23.

Zhang X and Kiechle FL.
Cytosine arabinoside substitution decreases transcription factor-DNA binding element complex formation.
Arch Pathol Lab Med. 2004 Dec;128(12):1364-71.

Chou KM, Kukhanova M, and Cheng YC.
A novel action of human apurinic/apyrimidinic endonuclease: excision of L-configuration deoxyribonucleoside analogs from the 3' termini of DNA.
J Biol Chem. 2000 Oct 6;275(40):31009-15.

Cline SD and Osheroff N.
Cytosine arabinoside lesions are position-specific topoisomerase II poisons and stimulate DNA cleavage mediated by the human type II enzymes.
J Biol Chem. 1999 Oct 15;274(42):29740-3.

Gmeiner WH, Skradis A, Pon RT, and Liu J.
Cytarabine-induced destabilization of a model Okazaki fragment.
Nucleic Acids Res. 1998 May 15;26(10):2359-65.

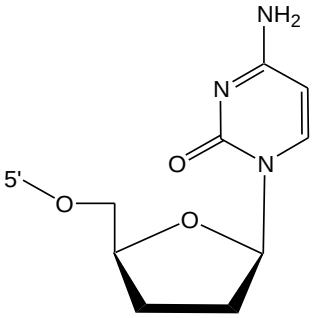
Zhang H, van der Marel GA, van Boom JH, and Wang AH.
Conformational perturbation of the anticancer nucleotide arabinosylcytosine on Z-DNA: molecular structure of (araC-dG)3 at 1.3 A resolution.
Biopolymers. 1992 Nov;32(11):1559-69.

Mikita T and Beardsley GP.
Functional consequences of the arabinosylcytosine structural lesion in DNA.
Biochemistry. 1988 Jun 28;27(13):4698-705.

2′,3′-Dideoxycytidine (ddC, Zalcitabine)

2′,3′-dideoxycytidine (ddC) is a reverse transcriptase inhibitor that blocks HIV replication.

Structure



Availability

Positions	Scales (µmol)	Purifications
3′ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Brachman EE and Kmiec EB.
Gene repair in mammalian cells is stimulated by the elongation of S phase and transient stalling of replication forks.
DNA Repair (Amst). 2005 Apr 4;4(4):445-57.

Han T, Fernandez M, Sarkar M, and Agarwal RP.
2', 3'-Dideoxycytidine represses thymidine kinases 1 and 2 expression in T-lymphoid cells.
Life Sci. 2004 Jan 2;74(7):835-42.

Lim SE, Ponamarev MV, Longley MJ, and Copeland WC.
Structural determinants in human DNA polymerase gamma account for mitochondrial toxicity from nucleoside analogs.
J Mol Biol. 2003 May 23;329(1):45-57.

Johnson AA, Ray AS, Hanes J, Suo Z, Colacino JM, Anderson KS, and Johnson KA.
Toxicity of antiviral nucleoside analogs and the human mitochondrial DNA polymerase.
J Biol Chem. 2001 Nov 2;276(44):40847-57.

Gröschel B, Himmel N, Cinatl J, Périgaud C, Gosselin G, Imbach JL, Doerr HW, and Cinatl J Jr.
ddC- and 3TC-bis(SATE) monophosphate prodrugs overcome cellular resistance mechanisms to HIV-1 associated with cytidine kinase deficiency.
Nucleosides Nucleotides. 1999 Apr-May;18(4-5):921-6.

Veal GJ, Agrawal S, and Byrn RA.
Synergistic inhibition of HIV-1 by an antisense oligonucleotide and nucleoside analog reverse transcriptase inhibitors.
Antiviral Res. 1998 Apr;38(1):63-73.

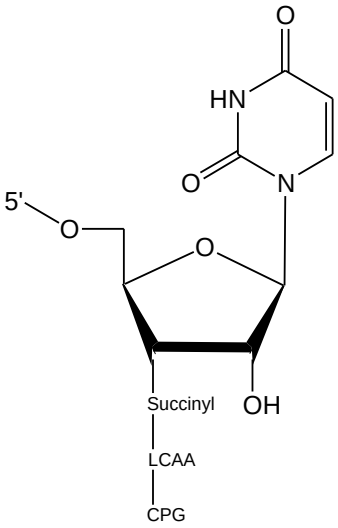
Fraternale A, Casabianca A, Rossi L, Chiarantini L, Brandi G, Aluigi G, Schiavano GF, and Magnani M.
Inhibition of murine AIDS by combination of AZT and dideoxycytidine 5'-triphosphate.
J Acquir Immune Defic Syndr Hum Retrovirol. 1996 Jun 1;12(2):164-73.

Contamination Prevention

Ribo U

Ribo U prevents cross contamination of PCR-amplified sequences.

Structure



Availability

Positions	Scales (µmol)	Purifications
3’ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Walder RY, Hayes JR, and Walder JA.
Use of PCR primers containing a 3'-terminal ribose residue to prevent cross-contamination of amplified sequences.
Nucleic Acids Res. 1993 Sep 11;21(18):4339-43.

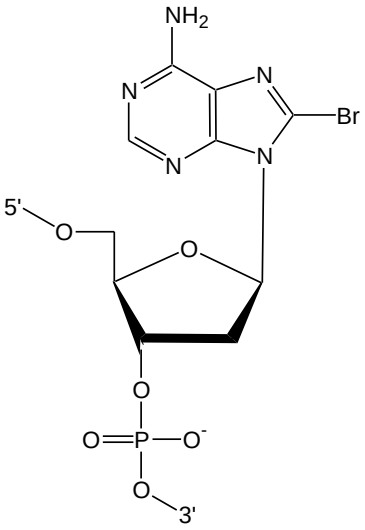
Crosslinking

Halogenated Bases

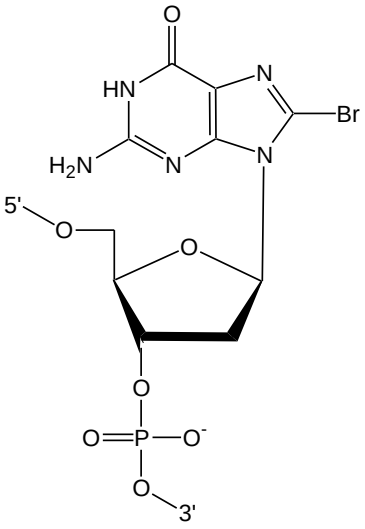
Halogenated nucleosides are used to crosslink oligonucleotides to DNA, RNA, and proteins. They are also used to investigate structures via x-ray diffraction and NMR.

Structures

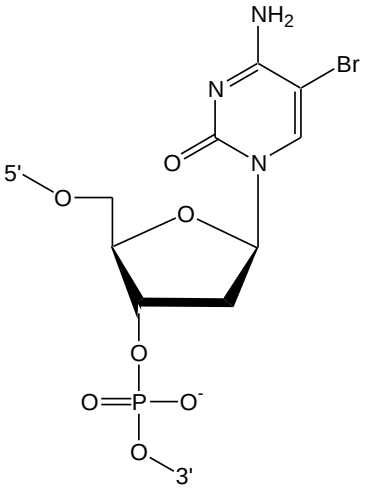
8-Br-dA



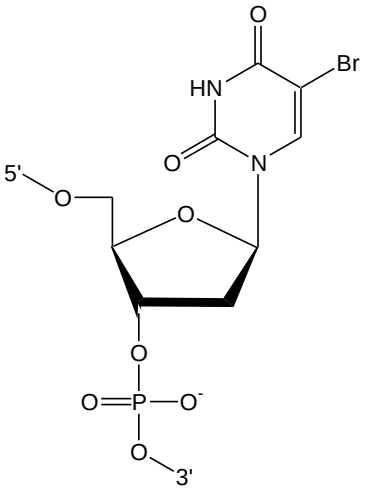
8-Br-dG



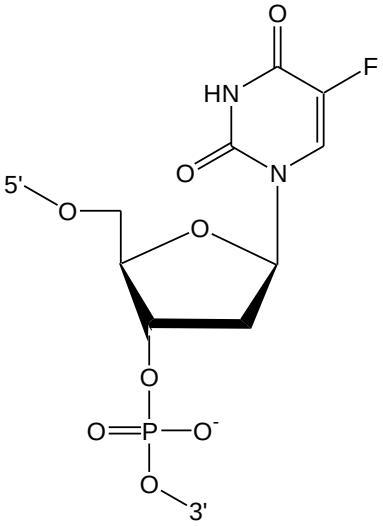
5-Br-dC



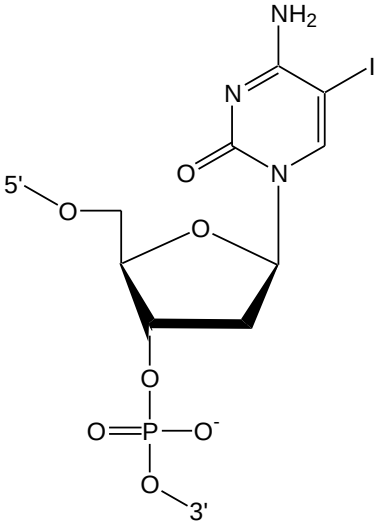
5-Br-dU



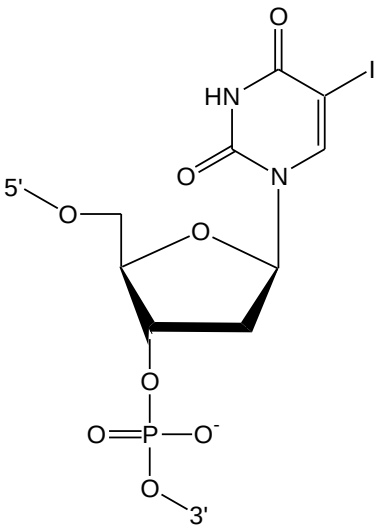
5-F-dU



5-I-dC



5-I-dU



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Petraccone L, Duro I, Randazzo A, Virno A, Mayol L, and Giancola C.
Biophysical properties of quadruplexes containing two or three 8-bromodeoxyguanosine residues.
Nucleosides Nucleotides Nucleic Acids. 2007;26(6-7):669-74.

Zeng Y and Wang Y.
Sequence-dependent formation of intrastrand crosslink products from the UVB irradiation of duplex DNA containing a 5-bromo-2'-deoxyuridine or 5-bromo-2'-deoxycytidine.
Nucleic Acids Res. 2006;34(22):6521-9.

Petraccone L, Erra E, Esposito V, Randazzo A, Galeone A, Barone G, and Giancola C.
Biophysical properties of quadruple helices of modified human telomeric DNA.
Biopolymers. 2005 Feb 5;77(2):75-85.

Fàbrega C, Macías MJ, and Eritja R.
Synthesis and properties of oligonucleotides containing 8-bromo-2'-deoxyguanosine.
Nucleosides Nucleotides Nucleic Acids. 2001Mar;20(3):251-60.

Holz B, Dank N, Eickhoff JE, Lipps G, Krauss G, and Weinhold E.
Identification of the binding site for the extrahelical target base in N6-adenine DNA methyltransferases by photo-cross-linking with duplex oligodeoxyribonucleotides containing 5-iodouracil at the target position.
J Biol Chem. 1999 May 21;274(21):15066-72.

Shepard W, Cruse WB, Fourme R, de la Fortelle E, and Prangé T.
A zipper-like duplex in DNA: the crystal structure of d(GCGAAAGCT) at 2.1 A resolution.
Structure. 1998 Jul 15;6(7):849-61.

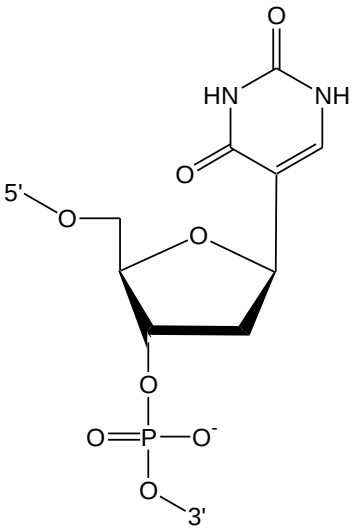
Wang Y and Adzuma K.
Differential proximity probing of two DNA binding sites in the Escherichia coli recA protein using photo-cross-linking methods.
Biochemistry. 1996 Mar 19;35(11):3563-71.

Damage and Repair

2′-Deoxypseudouridine

2′-deoxypseudouridine is used to investigate the function of uracil-DNA glycosylase and the mechanisms of DNA damage and repair. It is also used to study triple-helix motifs.

Structure



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Krusong K, Carpenter EP, Bellamy SR, Savva R, and Baldwin GS.
A comparative study of uracil-DNA glycosylases from human and herpes simplex virus type 1.
J Biol Chem. 2006 Feb 24;281(8):4983-92.

Chen CY, Mosbaugh DW, and Bennett SE.
Mutational analysis of arginine 276 in the leucine-loop of human uracil-DNA glycosylase.
J Biol Chem. 2004 Nov 12;279(46):48177-88.

Häberli A and Leumann CJ.
DNA binding properties of oligodeoxynucleotides containing pyrrolidino C-nucleosides.
Org Lett. 2002 Sep 19;4(19):3275-8.

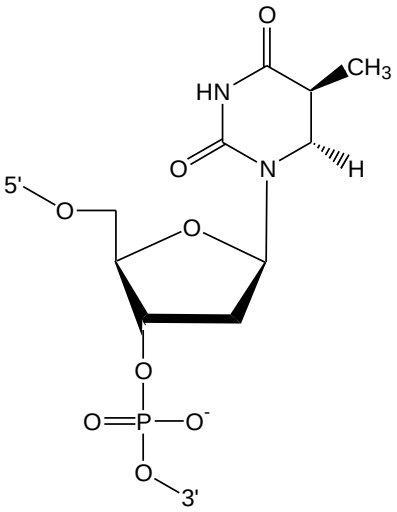
Ono A and Nishizima A.
Synthesis of oligodeoxyribonucleotides containing 2'deoxypseudouridine: inhibition of uracil-DNA glycosylase.
Nucleic Acids Symp Ser. 2000;(44):127-8.

Dihydro Bases

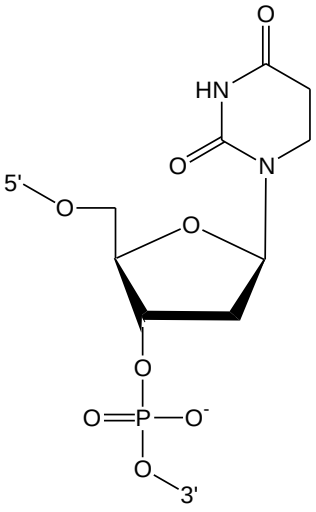
5,6-dihydro-dT and -dU are used to investigate DNA damage and repair. Both structures can form when thymine and uracil are chemically altered by oxidation, free radicals, ultraviolet light, or ionizing radiation.

Structures

5,6-Dihydro-dT



5,6-Dihydro-dU



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Byrne S, Cunniffe S, O'Neill P, and Lomax ME.
5,6-Dihydrothymine impairs the base excision repair pathway of a closely opposed AP site or single-strand break.
Radiat Res. 2009 Nov;172(5):537-49.

Matsumoto N, Hayashi R, Himoto M, Kuraoka I, Morita S, Hagiwara F, Katayanagi K, Ide H, and Iwai S.
Fluorescence detection of the endonuclease III reaction using modified oligonucleotides.
Nucleic Acids Symp Ser (Oxf). 2009;(53):213-4.

Blaisdell JO and Wallace SS.
Rapid determination of the active fraction of DNA repair glycosylases: a novel fluorescence assay for trapped intermediates.
Nucleic Acids Res. 2007;35(5):1601-11.

Elder RH and Dianov GL.
Repair of dihydrouracil supported by base excision repair in mNTH1 knock-out cell extracts.
J Biol Chem. 2002 Dec 27;277(52):50487-90.

D'Ham C, Romieu A, Jaquinod M, Gasparutto D, and Cadet J.
Excision of 5,6-dihydroxy-5,6-dihydrothymine, 5,6-dihydrothymine, and 5-hydroxycytosine from defined sequence oligonucleotides by *Escherichia coli* endonuclease III and Fpg proteins: kinetic and mechanistic aspects.
Biochemistry. 1999 Mar 16;38(11):3335-44.

Augeri L, Lee YM, Barton AB, and Doetsch PW.
Purification, characterization, gene cloning, and expression of *Saccharomyces cerevisiae* redoxyendonuclease, a homolog of *Escherichia coli* endonuclease III.
Biochemistry. 1997 Jan 28;36(4):721-9.

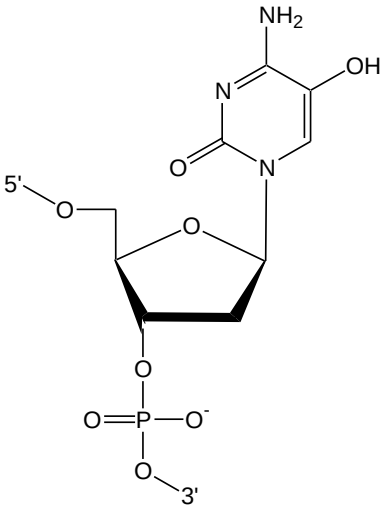
Paul CR, Budzinski EE, Maccubbin A, Wallace JC, and Box HC.
Characterization of radiation-induced damage in d(TpApCpG).
Int J Radiat Biol. 1990 Nov;58(5):759-68.

Hydroxylated Bases

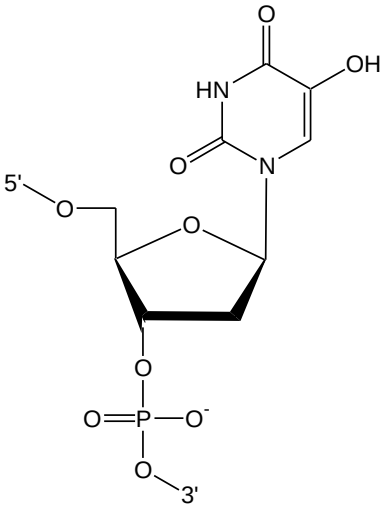
5-OH-dC and -dU are used to investigate DNA damage and repair. Both structures can form when cytosine and uracil are chemically altered by oxidation, free radicals, ultraviolet light, or ionizing radiation.

Structures

5-OH-dC



5-OH-dU



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Negishi K, Sekine D, Morimitsu T, Suzuki T, Okugawa Y, Kawakami A, Otsuka C, Oyama H, and Loakes D.
Oligonucleotide transformation for the study of mutagenic specificities of DNA lesions in yeast. Nucleic Acids Symp Ser (Oxf). 2007;(51):211-2.

Simon P, Gasparutto D, Gambarelli S, Saint-Pierre C, Favier A, and Cadet J.
Formation of isodialuric acid lesion within DNA oligomers via one-electron oxidation of 5-hydroxyuracil: characterization, stability and excision repair.
Nucleic Acids Res. 2006 Aug 2;34(13):3660-9.

Rivière J, Bergeron F, Tremblay S, Gasparutto D, Cadet J, and Wagner JR.
Oxidation of 5-hydroxy-2'-deoxyuridine into isodialuric acid, dialuric acid, and hydantoin products.
J Am Chem Soc. 2004 Jun 2;126(21):6548-9.

Gros L, Ishchenko AA, Ide H, Elder RH, and Saparbaev MK.
The major human AP endonuclease (Ape1) is involved in the nucleotide incision repair pathway.
Nucleic Acids Res. 2004 Jan 2;32(1):73-81. Print 2004.

Ishchenko AA, Sanz G, Privezentzev CV, Maksimenko AV, and Saparbaev M.
Characterisation of new substrate specificities of *Escherichia coli* and *Saccharomyces cerevisiae* AP endonucleases.
Nucleic Acids Res. 2003 Nov 1;31(21):6344-53.

Morningstar ML, Kreutzer DA, and Essigmann JM.
Synthesis of oligonucleotides containing two putatively mutagenic DNA lesions: 5-hydroxy-2'-deoxyuridine and 5-hydroxy-2'-deoxycytidine.
Chem Res Toxicol. 1997 Dec;10(12):1345-50.

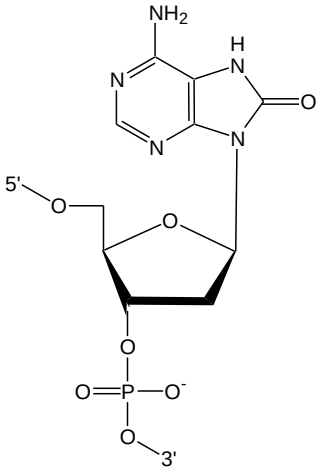
Wang D and Essigmann JM.
Kinetics of oxidized cytosine repair by endonuclease III of *Escherichia coli*.
Biochemistry. 1997 Jul 15;36(28):8628-33.

Oxo Bases

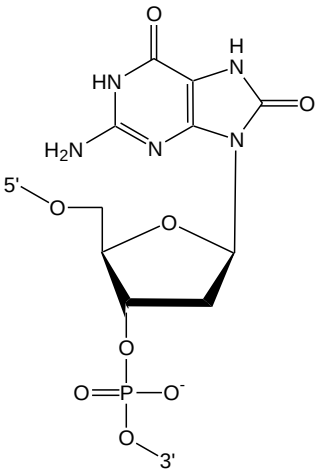
8-oxo-dA and -dG are used to investigate DNA damage and repair. Both structures can form when adenine and guanine are chemically altered by oxidation, free radicals, ultraviolet light, or ionizing radiation. 8-oxo-dA is also used to study triple-helix motifs.

Structures

8-oxo-dA



8-oxo-dG



Availability

Positions	Scales (µmol)	Purifications
5’ End, Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Dobbs TA, Palmer P, Maniou Z, Lomax ME, and O'Neill P.
Interplay of two major repair pathways in the processing of complex double-strand DNA breaks.
DNA Repair (Amst). 2008 Aug 2;7(8):1372-83.

Yung C, Suzuki T, Okugawa Y, Kawakami A, Loakes D, Negishi K, and Negishi T.
Nucleotide incorporation against 7,8-dihydro-8-oxoguanine is influenced by neighboring base sequences in TLS DNA polymerase reaction.
Nucleic Acids Symp Ser (Oxf). 2007;(51):49-50.

Tretyakova NY, Niles JC, Burney S, Wishnok JS, and Tannenbaum SR.
Peroxynitrite-induced reactions of synthetic oligonucleotides containing 8-oxoguanine.
Chem Res Toxicol. 1999 May;12(5):459-66.

Girard PM, D'Ham C, Cadet J, and Boiteux S.
Opposite base-dependent excision of 7,8-dihydro-8-oxoadenine by the Ogg1 protein of Saccharomyces cerevisiae.
Carcinogenesis. 1998 Jul;19(7):1299-305.

Ishibashi T, Yamakawa H, Wang Q, Tsukahara S, Takai K, Maruyama T, and Takaku H.
Properties of triple helix formation with oligodeoxyribonucleotides containing 8-oxo-2'-deoxyadenosine and 2'-modified nucleoside derivatives.
Bioorg Med Chem. 1996 Dec;4(12):2029-34.

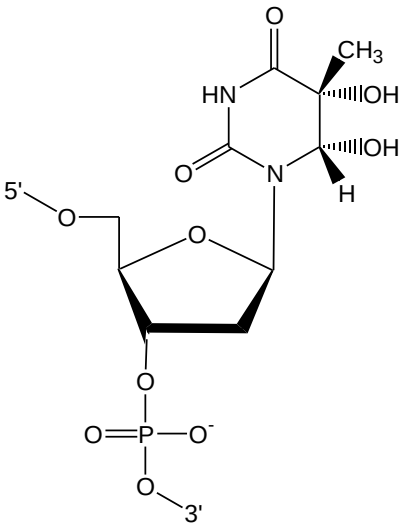
Wood ML, Esteve A, Morningstar ML, Kuziemko GM, and Essigmann JM.
Genetic effects of oxidative DNA damage: comparative mutagenesis of 7,8-dihydro-8-oxoguanine and 7,8-dihydro-8-oxoadenine in Escherichia coli.
Nucleic Acids Res. 1992 Nov 25;20(22):6023-32.

Tchou J, Kasai H, Shibutani S, Chung MH, Laval J, Grollman AP, and Nishimura S.
8-oxoguanine (8-hydroxyguanine) DNA glycosylase and its substrate specificity.
Proc Natl Acad Sci U S A. 1991 Jun 1;88(11):4690-4.

Thymidine Glycol

Thymidine glycol is used to investigate DNA damage and repair. It can form when thymine is chemically altered by oxidation, free radicals, ultraviolet light, or ionizing radiation.

Structure



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal	0.05, 0.2, 1.0	PAGE

References

Yang F, Romanova E, Kubareva E, Dolinnaya N, Gajdos V, Burenina O, Fedotova E, Ellis JS, Oretskaya T, Hianik T, and Thompson M.
Detection of DNA damage: effect of thymidine glycol residues on the thermodynamic, substrate and interfacial acoustic properties of oligonucleotide duplexes. Analyst. 2009 Jan;134(1):41-51.

Imoto S, Bransfield LA, Croteau DL, Van Houten B, and Greenberg MM.
DNA tandem lesion repair by strand displacement synthesis and nucleotide excision repair.
Biochemistry. 2008 Apr 8;47(14):4306-16. Epub 2008 Mar 15.

Ito T, Kondo A, Terada S, and Nishimoto S.
Photoinduced reductive repair of thymine glycol: implications for excess electron transfer through DNA containing modified bases.
J Am Chem Soc. 2006 Aug 23;128(33):10934-42.

Wang Y and Wang Y.
Synthesis and thermodynamic studies of oligodeoxyribonucleotides containing tandem lesions of thymidine glycol and 8-oxo-2'-deoxyguanosine.
Chem Res Toxicol. 2006 Jun;19(6):837-43.

Shimizu T, Manabe K, Yoshikawa S, Kawasaki Y, and Iwai S.
Preferential formation of (5S,6R)-thymine glycol for oligodeoxyribonucleotide synthesis and analysis of drug binding to thymine glycol-containing DNA.
Nucleic Acids Res. 2006 Jan 9;34(1):313-21. Print 2006.

Gasparutto D, Bourdat AG, D'Ham C, Duarte V, Romieu A, and Cadet J.
Repair and replication of oxidized DNA bases using modified oligodeoxyribonucleotides.
Biochimie. 2000 Jan;82(1):19-24.

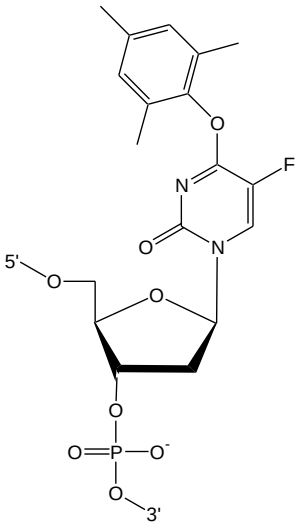
Lustig MJ, Cadet J, Boorstein RJ, and Teebor GW.
Synthesis of the diastereomers of thymidine glycol, determination of concentrations and rates of interconversion of their cis-trans epimers at equilibrium and demonstration of differential alkali lability within DNA.
Nucleic Acids Res. 1992 Sep 25;20(18):4839-45.

TMP-F-dU

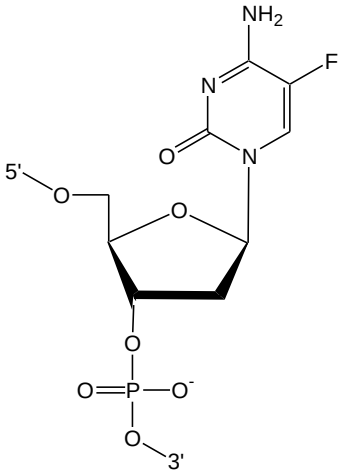
TMP-F-dU is used to introduce the difficult-to-synthesize F-dC into oligonucleotides. The conversion from F-dU to F-dC occurs during deprotection with ammonia. F-dC influences DNA structure and inhibits methyltransferases.

Structures

F-dU (Initial)



F-dC (Final)



Availability

Positions	Scales (µmol)	Purifications
Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Warncke S, Gégout A, and Carell T.
Phosphorothioation of oligonucleotides strongly influences the inhibition of bacterial (M.HhaI) and human (Dnmt1) DNA methyltransferases.
Chembiochem. 2009 Mar 2;10(4):728-34.

Ishibashi T, Yamakawa H, Wang Q, Tsukahara S, Takai K, Maruyama T, and Takaku H.
Properties of triple helix formation with oligodeoxyribonucleotides containing 8-oxo-2'-deoxyadenosine and 2'-modified nucleoside derivatives.
Bioorg Med Chem. 1996 Dec;4(12):2029-34.

Baker DJ, Laayoun A, and Smith SS.
Transition state analogs as affinity labels for human DNA methyltransferases.
Biochem Biophys Res Commun. 1993 Oct 29;196(2):864-71.

Hanck T, Schmidt S, and Fritz HJ.
Sequence-specific and mechanism-based crosslinking of Dcm DNA cytosine-C5 methyltransferase of E. coli K-12 to synthetic oligonucleotides containing 5-fluoro-2'-deoxycytidine.
Nucleic Acids Res. 1993 Jan 25;21(2):303-9.

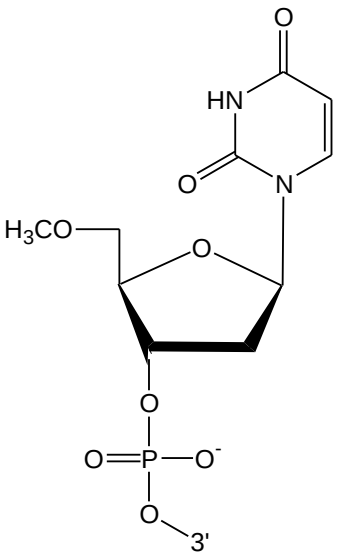
MacMillan AM, Chen L, and Verdine GL.
Synthesis of an oligonucleotide suicide substrate for DNA methyltransferases.
J Org Chem. 1992 May;57(11):2989-2991.

Schmidt S, Niemann A, Krynetskaya NF, Oretskaya TS, Metelev VG, Suchomlinov VV, Shabarova ZA, and Cech D.
The use of oligonucleotide probes containing 2'-deoxy-2'-fluoronucleosides for regiospecific cleavage of RNA by RNase H from Escherichia coli.
Biochim Biophys Acta. 1992 Feb 28;1130(1):41-6.

dUracil

dU substitutes for thymidine and is used to investigate DNA damage and repair. Cleavage of uracil-containing DNA also has a practical application in that it can be used to prevent cross contamination of PCR-amplified sequences.

Structure



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal, 3′ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Krusong K, Carpenter EP, Bellamy SR, Savva R, and Baldwin GS.
A comparative study of uracil-DNA glycosylases from human and herpes simplex virus type 1.
J Biol Chem. 2006 Feb 24;281(8):4983-92.

Chung JH, Im EK, Park HY, Kwon JH, Lee S, Oh J, Hwang KC, Lee JH, and Jang Y.
A novel uracil-DNA glycosylase family related to the helix-hairpin-helix DNA glycosylase superfamily.
Nucleic Acids Res. 2003 Apr 15;31(8):2045-55.

Kubareva EA, Volkov EM, Vinogradova NL, Kanevsky IA, Oretskaya TS, Kuznetsova SA, Brevnov MG, Gromova ES, Nevinsky GA, and Shabarova ZA.
Modified substrates as probes for studying uracil-DNA glycosylase.
Gene. 1995 May 19;157(1-2):167-71.

Varshney U and van de Sande JH.
Specificities and kinetics of uracil excision from uracil-containing DNA oligomers by Escherichia coli uracil DNA glycosylase.
Biochemistry. 1991 Apr 23;30(16):4055-61.

Stuart GR and Chambers RW.
Synthesis and properties of oligodeoxynucleotides with an AP site at a preselected position. Nucleic Acids Res. 1987 Sep 25;15(18):7451-62.

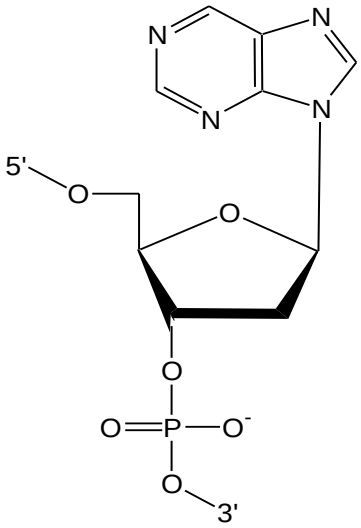
Delort AM, Duplaa AM, Molko D, Teoule R, Leblanc JP, and Laval J.
Excision of uracil residues in DNA: mechanism of action of Escherichia coli and Micrococcus luteus uracil-DNA glycosylases.
Nucleic Acids Res. 1985 Jan 25;13(2):319-35.

Degenerate

2’-Deoxynebularine

2’-deoxynebularine functions as a degenerate nucleoside in primers and probes. It is also used to investigate the function of DNA endonucleases and triple-helix motifs as well as develop electrochemical sensors.

Structure



Availability

Positions	Scales (µmol)	Purifications
5’ End, Internal	0.05, 0.2, 1.0	Cartridge, HPLC, PAGE

References

Boal AK and Barton JK.
Electrochemical detection of lesions in DNA.
Bioconjug Chem. 2005 Mar-Apr;16(2):312-21.

Ishikawa R, Ono A, and Kainosho M.
The NMR studies of substituent effects on the N-H...N hydrogen bond in duplex DNA using 2'-deoxynebularine and 15N labeled 5-substituted-2'-deoxyuridine base pairs.
Nucleic Acids Res Suppl. 2003;(3):57-8.

Fox KR, Allinson SL, Sahagun-Krause H, and Brown T.
Recognition of GT mismatches by Vsr mismatch endonuclease.
Nucleic Acids Res. 2000 Jul 1;28(13):2535-40.

Rahman MS and Humayun MZ.
Nebularine (9-2'-deoxy-beta-D-ribofuranosylpurine) has the template characteristics of adenine in vivo and in vitro.
Mutat Res. 1997 Jul 3;377(2):263-8.

Stilz HU and Dervan PB.
Specific recognition of CG base pairs by 2-deoxynebularine within the purine.purine.pyrimidine triple-helix motif.
Biochemistry. 1993 Mar 9;32(9):2177-85.

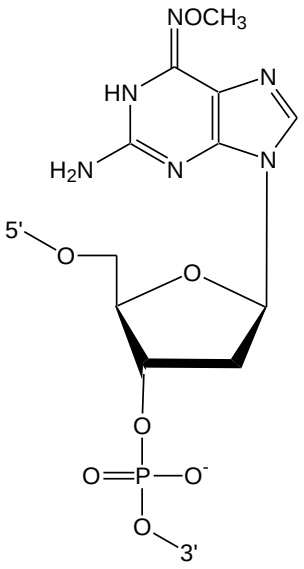
Jiricny J, Wood SG, Martin D, and Ubasawa A.
Oligonucleotide duplexes containing inosine, 7-deazainosine, tubercidin, nebularine and 7-deazanebularine as substrates for restriction endonucleases HindII, SalI and TaqI.
Nucleic Acids Res. 1986 Aug 26;14(16):6579-90.

Eritja R, Horowitz DM, Walker PA, Ziehler-Martin JP, Boosalis MS, Goodman MF, Itakura K, and Kaplan BE.
Synthesis and properties of oligonucleotides containing 2'-deoxynebularine and 2'-deoxyxanthosine.
Nucleic Acids Res. 1986 Oct 24;14(20):8135-53.

Derivative K (dK)

dK is used in mutagenesis studies and functions as a degenerate base in primers and probes. It is a purine derivative and base pairs with deoxycytidine and thymidine.

Structure



Availability

Positions	Scales (µmol)	Purifications
5’ End, Internal, 3’ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Boyd VL and Zon G.
Capillary electrophoretic analysis of methylation status in CpG-rich regions by single-base extension of primers modified with N6-methoxy-2,6-diaminopurine.
Anal Biochem. 2008 Sep 1;380(1):13-20.

Hill F, Loakes D, and Brown DM.
Polymerase recognition of synthetic oligodeoxyribonucleotides incorporating degenerate pyrimidine and purine bases.
Proc Natl Acad Sci U S A. 1998 Apr 14;95(8):4258-63.

Hill F, Williams DM, Loakes D, and Brown DM.
Comparative mutagenicities of N6-methoxy-2,6-diaminopurine and N6-methoxyaminopurine 2'-deoxyribonucleosides and their 5'-triphosphates.
Nucleic Acids Res. 1998 Mar 1;26(5):1144-9.

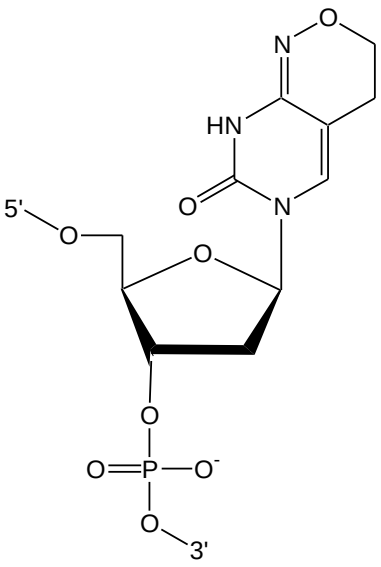
Lin PK and Brown DM.
Synthesis of oligodeoxyribonucleotides containing degenerate bases and their use as primers in the polymerase chain reaction.
Nucleic Acids Res. 1992 Oct 11;20(19):5149-52.

Brown DM and Lin PK.
Synthesis and duplex stability of oligonucleotides containing adenine-guanine analogues.
Carbohydr Res. 1991 Sep 2;216:129-39.

Derivative P (dP)

dP is used in mutagenesis studies and functions as a degenerate base in primers and probes. It is a pyrimidine derivative and base pairs with deoxyadenosine and deoxyguanosine.

Structure



Availability

Positions	Scales (µmol)	Purifications
5’ End, Internal, 3’ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Harris VH, Smith CL, Jonathan Cummins W, Hamilton AL, Adams H, Dickman M, Hornby DP, and Williams DM.
The effect of tautomeric constant on the specificity of nucleotide incorporation during DNA replication: support for the rare tautomer hypothesis of substitution mutagenesis.
J Mol Biol. 2003 Mar 7;326(5):1389-401.

Schuerman GS, Van Meervelt L, Loakes D, Brown DM, Kong Thoo Lin P, Moore MH, and Salisbury SA.
A thymine-like base analogue forms wobble pairs with adenine in a Z-DNA duplex.
J Mol Biol. 1998 Oct 9;282(5):1005-11.

Hill F, Loakes D, and Brown DM.
Polymerase recognition of synthetic oligodeoxyribonucleotides incorporating degenerate pyrimidine and purine bases.
Proc Natl Acad Sci U S A. 1998 Apr 14;95(8):4258-63.

Moore MH, Van Meervelt L, Salisbury SA, Lin PK, and Brown DM.
Direct observation of two base-pairing modes of a cytosine-thymine analogue with guanine in a DNA Z-form duplex: significance for base analogue mutagenesis.
J Mol Biol. 1995 Sep 1;251(5):665-73.

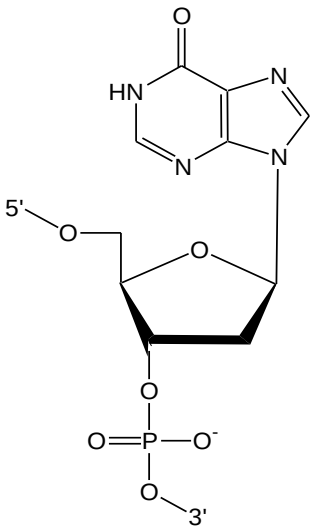
Lin PK and Brown DM.
Synthesis of oligodeoxyribonucleotides containing degenerate bases and their use as primers in the polymerase chain reaction.
Nucleic Acids Res. 1992 Oct 11;20(19):5149-52.

Lin PK and Brown DM.
Synthesis and duplex stability of oligonucleotides containing cytosine-thymine analogues.
Nucleic Acids Res. 1989 Dec 25;17(24):10373-83.

Inosine

Inosine is used to investigate DNA damage and repair and functions as a degenerate nucleoside in primers and probes. It base pairs in the following order of preference: deoxycytidine > deoxyadenosine > deoxyguanosine = thymidine. The base of inosine is hypoxanthine.

Structure



Availability

Positions	Scales (µmol)	Purifications
5’ End, Internal, 3’ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Weiss B.
Removal of deoxyinosine from the Escherichia coli chromosome as studied by oligonucleotide transformation.
DNA Repair (Amst). 2008 Feb 1;7(2):205-12.

Ben-Dov E, Shapiro OH, Siboni N, and Kushmaro A.
Advantage of using inosine at the 3' termini of 16S rRNA gene universal primers for the study of microbial diversity.
Appl Environ Microbiol. 2006 Nov;72(11):6902-6.

Schroeder SJ, Fountain MA, Kennedy SD, Lukavsky PJ, Puglisi JD, Krugh TR, and Turner DH. Thermodynamic stability and structural features of the J4/5 loop in a Pneumocystis carinii group I intron.
Biochemistry. 2003 Dec 9;42(48):14184-96.

Ehlers B, Borchers K, Grund C, Frölich K, Ludwig H, and Buhk HJ.
Detection of new DNA polymerase genes of known and potentially novel herpesviruses by PCR with degenerate and deoxyinosine-substituted primers.
Virus Genes. 1999;18(3):211-20.

Case-Green SC and Southern EM.
Studies on the base pairing properties of deoxyinosine by solid phase hybridisation to oligonucleotides.
Nucleic Acids Res. 1994 Jan 25;22(2):131-6.

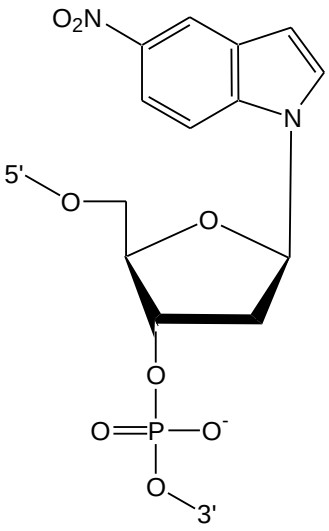
Fordham-Skelton AP, Yarwood A, and Croy RR.
Synthesis of saporin gene probes from partial protein sequence data: use of inosine-oligonucleotides, genomic DNA and the polymerase chain reaction.
Mol Gen Genet. 1990 Mar;221(1):134-8.

Martin FH, Castro MM, Aboul-ela F, and Tinoco I Jr.
Base pairing involving deoxyinosine: implications for probe design.
Nucleic Acids Res. 1985 Dec 20;13(24):8927-38.

5-Nitroindole

5-nitroindole functions as a degenerate base in primers and probes. It does not hydrogen bond to native bases but stabilizes the duplex through stacking interactions. Melting experiments have demonstrated that 5-nitroindole is superior to 3-nitropyrrole.

Structure



Availability

Positions	Scales (µmol)	Purifications
5’ End, Internal, 5’ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Gallego J and Loakes D.
Solution structure and dynamics of DNA duplexes containing the universal base analogues 5-nitroindole and 5-nitroindole 3-carboxamide.
Nucleic Acids Res. 2007;35(9):2904-12.

Vasiliskov VA, Prokopenko DV, and Mirzabekov AD.
Parallel multiplex thermodynamic analysis of coaxial base stacking in DNA duplexes by oligodeoxyribonucleotide microchips.
Nucleic Acids Res. 2001 Jun 1;29(11):2303-13.

Fotin AV, Drobyshev AL, Proudnikov DY, Perov AN, and Mirzabekov AD.
Parallel thermodynamic analysis of duplexes on oligodeoxyribonucleotide microchips.
Nucleic Acids Res. 1998 Mar 15;26(6):1515-21.

Loakes D, Hill F, Brown DM, and Salisbury SA.
Stability and structure of DNA oligonucleotides containing non-specific base analogues.
J Mol Biol. 1997 Jul 18;270(3):426-35.

Bergstrom DE, Zhang P, and Johnson WT.
Comparison of the base pairing properties of a series of nitroazole nucleobase analogs in the oligodeoxyribonucleotide sequence 5'-d(CGCXAATTYGCG)-3'.
Nucleic Acids Res. 1997 May 15;25(10):1935-42.

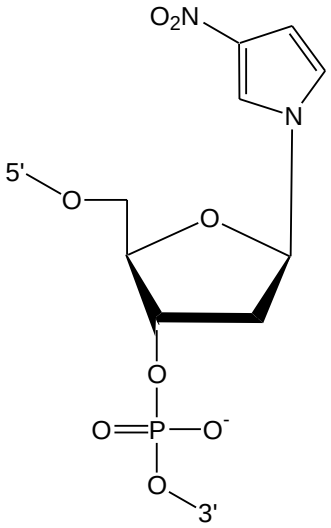
Loakes D, Brown DM, Linde S, and Hill F.
3-Nitropyrrole and 5-nitroindole as universal bases in primers for DNA sequencing and PCR.
Nucleic Acids Res. 1995 Jul 11;23(13):2361-6.

Loakes D and Brown DM.
5-Nitroindole as a universal base analogue.
Nucleic Acids Res. 1994 Oct 11;22(20):4039-43.

3-Nitropyrrole

3-nitropyrrole functions as a degenerate base in primers and probes. It does not hydrogen bond to native bases but stabilizes the duplex through stacking interactions. Melting experiments have demonstrated that 3-nitropyrrole is inferior to 5-nitroindole.

Structure



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal, 3′ End	0.05, 0.2, 1.0	Desalt (Internal only), Cartridge, HPLC, PAGE

References

Burgner D, D'Amato M, Kwiatkowski DP, and Loakes D.
Improved allelic differentiation using sequence-specific oligonucleotide hybridization incorporating an additional base-analogue mismatch.
Nucleosides Nucleotides Nucleic Acids. 2004 May;23(5):755-65.

Oliver JS, Parker KA, and Suggs JW.
Effect of the universal base 3-nitropyrrole on the selectivity of neighboring natural bases.
Org Lett. 2001 Jun 28;3(13):1977-80.

Kukreti S, Sun JS, Loakes D, Brown DM, Nguyen CH, Bisagni E, Garestier T, and Helene C.
Triple helices formed at oligopyrimidine*oligopurine sequences with base pair inversions: effect of a triplex-specific ligand on stability and selectivity.
Nucleic Acids Res. 1998 May 1;26(9):2179-83.

Bergstrom DE, Zhang P, and Johnson WT.
Comparison of the base pairing properties of a series of nitroazole nucleobase analogs in the oligodeoxyribonucleotide sequence 5'-d(CGCXAATTYGCG)-3'.
Nucleic Acids Res. 1997 May 15;25(10):1935-42.

Amosova O, George J, and Fresco JR.
Effect of the 1-(2'-deoxy-beta-D-ribofuranosyl)-3-nitropyrrole residue on the stability of DNA duplexes and triplexes.
Nucleic Acids Res. 1997 May 15;25(10):1930-4.

Loakes D, Brown DM, Linde S, and Hill F.
3-Nitropyrrole and 5-nitroindole as universal bases in primers for DNA sequencing and PCR.
Nucleic Acids Res. 1995 Jul 11;23(13):2361-6.

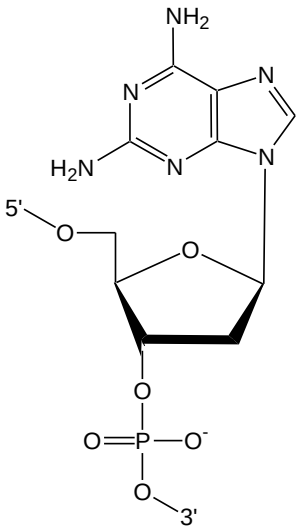
Nichols R, Andrews PC, Zhang P, and Bergstrom DE.
A universal nucleoside for use at ambiguous sites in DNA primers.
Nature. 1994 Jun 9;369(6480):492-3.

Duplex Stabilizing

2,6-Diaminopurine (2-Amino-dA)

2,6-diaminopurine (DAP) enhances duplex stability by forming three hydrogen bonds with thymidine. It increases DNA melting temperatures by up to 3ºC per addition and therefore creates tighter binding primers and probes. DAP is also used to investigate DNA curvature and the function of deoxyribozymes.

Structure



Availability

Positions	Scales (µmol)	Purifications
5’ End, Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Okumoto Y, Tanabe Y, and Sugimoto N.
Factors that contribute to efficient catalytic activity of a small Ca2+-dependent deoxyribozyme in relation to its RNA cleavage function.
Biochemistry. 2003 Feb 25;42(7):2158-65.

Kutyavin IV, Rhinehart RL, Lukhtanov EA, Gorn VV, Meyer RB Jr, and Gamper HB Jr.
Oligonucleotides containing 2-aminoadenine and 2-thiothymine act as selectively binding complementary agents.
Biochemistry. 1996 Aug 27;35(34):11170-6.

Lebedev Y, Akopyants N, Azhikina T, Shevchenko Y, Potapov V, Stecenko D, Berg D, and Sverdlov E.
Oligonucleotides containing 2-aminoadenine and 5-methylcytosine are more effective as primers for PCR amplification than their nonmodified counterparts.
Genet Anal. 1996 May;13(1):15-21.

Prosnyak MI, Veselovskaya SI, Myasnikov VA, Efremova EJ, Potapov VK, Limborska SA, and Sverdlov ED.
Substitution of 2-aminoadenine and 5-methylcytosine for adenine and cytosine in hybridization probes increases the sensitivity of DNA fingerprinting.
Genomics. 1994 Jun;21(3):490-4.

Cheong C, Tinoco I Jr, and Chollet A.
Thermodynamic studies of base pairing involving 2,6-diaminopurine.
Nucleic Acids Res. 1988 Jun 10;16(11):5115-22.

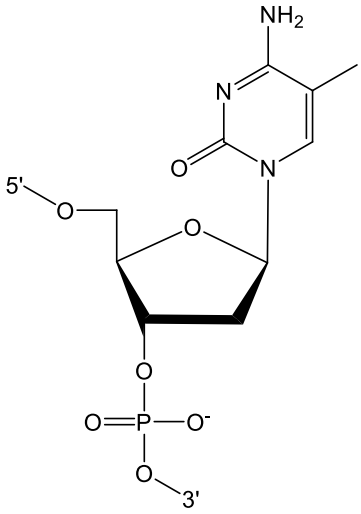
Chollet A and Kawashima E.
DNA containing the base analogue 2-aminoadenine: preparation, use as hybridization probes and cleavage by restriction endonucleases.
Nucleic Acids Res. 1988 Jan 11;16(1):305-17.

Diekmann S, von Kitzing E, McLaughlin L, Ott J, and Eckstein F.
The influence of exocyclic substituents of purine bases on DNA curvature.
Proc Natl Acad Sci U S A. 1987 Dec;84(23):8257-61.

5-Me-dC

5-Me-dC enhances duplex stability by elevating DNA melting temperatures 0.5–1.3ºC per addition. When substituted for deoxycytidine, it creates tighter binding primers and probes. 5-Me-dC is also used for investigating triple-helix motifs.

Structure



Availability

Positions	Scales (µmol)	Purifications
5’ End, Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Lebedev Y, Akopyants N, Azhikina T, Shevchenko Y, Potapov V, Stecenko D, Berg D, and Sverdlov E.
Oligonucleotides containing 2-aminoadenine and 5-methylcytosine are more effective as primers for PCR amplification than their nonmodified counterparts.
Genet Anal. 1996 May;13(1):15-21.

Xodo LE, Alunni-Fabbroni M, and Manzini G.
Effect of 5-methylcytosine on the structure and stability of DNA. Formation of triple-stranded concatenamers by overlapping oligonucleotides.
J Biomol Struct Dyn. 1994 Feb;11(4):703-20.

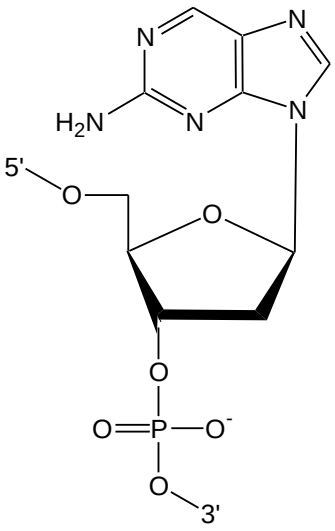
Xodo LE, Manzini G, Quadrifoglio F, van der Marel GA, and van Boom JH.
Effect of 5-methylcytosine on the stability of triple-stranded DNA—a thermodynamic study.
Nucleic Acids Res. 1991 Oct 25;19(20):5625-31.

Fluorescent

2-Aminopurine

2-aminopurine is a fluorescent base that substitutes for adenine and guanine. It is a useful probe for investigating DNA conformational changes, mutagenesis, and polymerase function.

Structure



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Reha-Krantz LJ.
The use of 2-aminopurine fluorescence to study DNA polymerase function.
Methods Mol Biol. 2009;521:381-96.

Lee BJ, Barch M, Castner EW Jr, Völker J, and Breslauer KJ.
Structure and dynamics in DNA looped domains: CAG triplet repeat sequence dynamics probed by 2-aminopurine fluorescence.
Biochemistry. 2007 Sep 25;46(38):10756-66.

Johnson NP, Baase WA, and Von Hippel PH.
Low-energy circular dichroism of 2-aminopurine dinucleotide as a probe of local conformation of DNA and RNA.
Proc Natl Acad Sci U S A. 2004 Mar 9;101(10):3426-31.

Kourentzi KD, Fox GE, and Willson RC.
Hybridization-responsive fluorescent DNA probes containing the adenine analog 2-aminopurine. Anal Biochem. 2003 Nov 1;322(1):124-6.

Law SM, Eritja R, Goodman MF, and Breslauer KJ.
Spectroscopic and calorimetric characterizations of DNA duplexes containing 2-aminopurine. Biochemistry. 1996 Sep 24;35(38):12329-37.

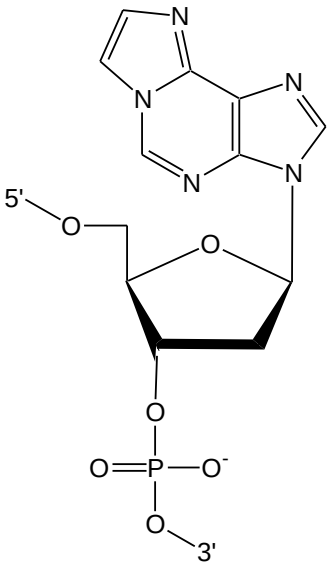
Nordlund TM, Xu D, and Evans KO.
Excitation energy transfer in DNA: duplex melting and transfer from normal bases to 2-aminopurine.
Biochemistry. 1993 Nov 16;32(45):12090-5.

Eritja R, Kaplan BE, Mhaskar D, Sowers LC, Petruska J, and Goodman MF.
Synthesis and properties of defined DNA oligomers containing base mispairs involving 2-aminopurine.
Nucleic Acids Res. 1986 Jul 25;14(14):5869-84.

Etheno-dA

Etheno-dA is a fluorescent nucleoside used for studying DNA damage and repair. It will not base pair with thymidine or uridine, therefore it must be located at the 5′ terminus of primers.

Structure



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Ringvoll J, Moen MN, Nordstrand LM, Meira LB, Pang B, Bekkelund A, Dedon PC, Bjelland S, Samson LD, Falnes PØ, and Klungland A.
AlkB homologue 2-mediated repair of ethenoadenine lesions in mammalian DNA.
Cancer Res. 2008 Jun 1;68(11):4142-9.

Sauvaigo S, Guerniou V, Rapin D, Gasparutto D, Caillat S, and Favier A.
An oligonucleotide microarray for the monitoring of repair enzyme activity toward different DNA base damage.
Anal Biochem. 2004 Oct 1;333(1):182-92.

Guliaev AB, Hang B, and Singer B.
Structural insights by molecular dynamics simulations into differential repair efficiency for ethano-A versus etheno-A adducts by the human alkylpurine-DNA N-glycosylase.
Nucleic Acids Res. 2002 Sep 1;30(17):3778-87.

Bielecki L, Skalski B, Zagórowska I, Verrall RE, and Adamiak RW.
Fluorescent alpha-anomeric 1,N(6)etheno-deoxyadenosine in DNA duplexes. The alpha-epsilondA / dG pair.
Nucleosides Nucleotides Nucleic Acids. 2000 Oct-Dec;19(10-12):1735-50.

Litinski V, Chenna A, Sagi J, and Singer B.
Sequence context is an important determinant in the mutagenic potential of 1,N6-ethenodeoxyadenosine (epsilonA): formation of epsilonA basepairs and elongation in defined templates.
Carcinogenesis. 1997 Aug;18(8):1609-15.

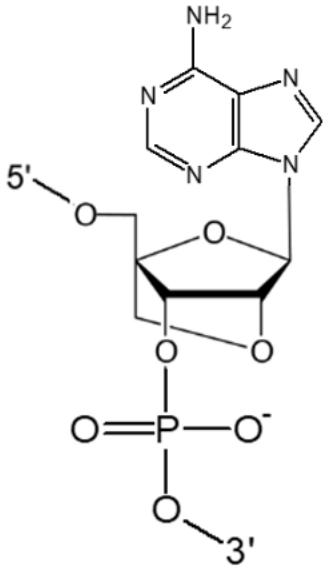
Srivastava SC, Raza SK, and Misra R.
1,N6-etheno deoxy and ribo adenosine and 3,N4-etheno deoxy and ribocytidine phosphoramidites. Strongly fluorescent structures for selective introduction in defined sequence DNA and RNA molecules.
Nucleic Acids Res. 1994 Apr 11;22(7):1296-304.

Locked Nucleic Acid

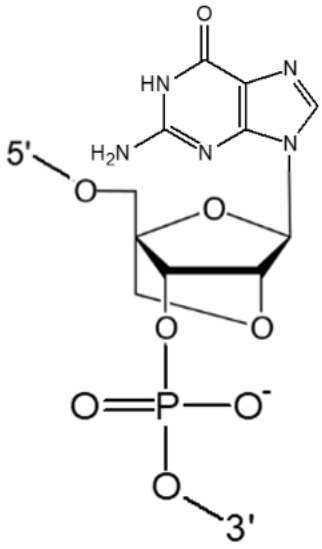
Locked Nucleic Acid is a novel type of nucleic acid analog that contains a 2'-O, 4'-C methylene bridge. This bridge–locked in the 3'-endo conformation–restricts the flexibility of the ribofuranose ring and locks the structure into a rigid bicyclic formation. This confers enhanced assay performance and an increased breadth of applications, such as increased thermal stability and hybridization specificity, more accurate gene quantification and allelic discrimination, and easier and more flexible designs for problematic target sequences.

Structures

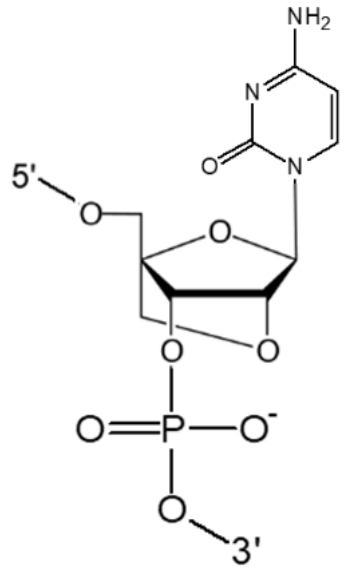
Locked A



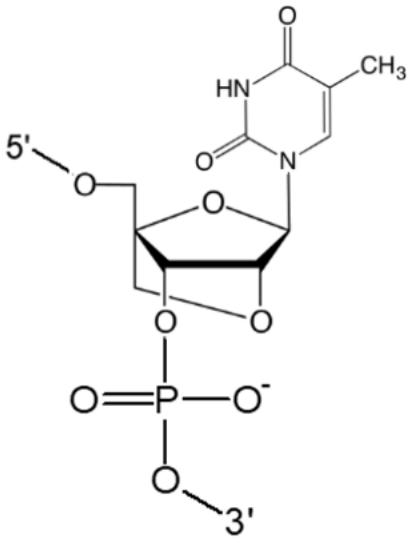
Locked G



Locked C



Locked T



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal, 3′ End	0.05, 0.2, 1.0, 10, 15	Cartridge, HPLC, PAGE

References

Egli M, Teplova M, Minasov G, Kumar R, and Wengel J.
X-ray crystal structure of a locked nucleic acid (LNA) duplex composed of a palindromic 10-mer DNA strand containing one LNA thymine monomer.
Chem. Commun. 2001 (7):651-652.

Braasch DA, Jensen S, Liu Y, Kaur K, Arar K, White MA, and Corey DR.
RNA Interference in Mammalian Cells by Chemically-Modified RNA
Biochemistry. 2003 42(26):7967-7975.

Latorra D, Arar K, and Michael Hurley J.
Design considerations and effects of LNA in PCR primers.
Molecular and Cellular Probes. 2003 17(5):253-259.

CHRISTENSEN U, JACOBSEN N, RAJWANSHI VK, WENGEL J, and KOCH T.
Stopped-flow kinetics of locked nucleic acid (LNA)—oligonucleotide duplex formation: studies of LNA—DNA and DNA—DNA interactions.
Biochemical Journal. 2001 354(3):481-484.

Latorra D, Hopkins D, Campbell K, and Hurley JM.
Multiplex Allele-Specific PCR with Optimized Locked Nucleic Acid Primers.
BioTechniques. 2003 34(6):1150-1158.

Latorra D, Campbell K, Wolter A, and Hurley JM.
Enhanced allele-specific PCR discrimination in SNP genotyping using 3′ locked nucleic acid (LNA) primers.
Hum. Mutat. 2003 22(1):79-85.

Mouritzen P, Nielsen AT, Pfundheller HM, Choleva Y, Kongsbak L, and Møller S.
Single nucleotide polymorphism genotyping using locked nucleic acid (LNA).
Expert Review of Molecular Diagnostics. 2014 3(1):27-38.

Simeonov A.
Single nucleotide polymorphism genotyping using short, fluorescently labeled locked nucleic acid (LNA) probes and fluorescence polarization detection.
Nucleic Acid Res. 2002 30(17):91e-91.

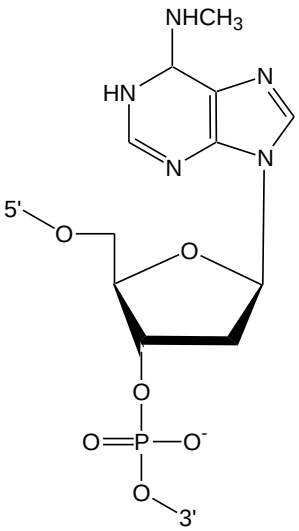
Ugozzoli LA, Latorra D, Pucket R, Arar K, and Hamby K.
Real-time genotyping with oligonucleotide probes containing locked nucleic acids.
Analytical Biochemistry. 2004 324(1):143-152.

Methylation Mutagenesis

N6-Me-dA

N6-Me-dA is used for investigating mutagenesis caused by methylation of exocyclic amines.

Structure



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

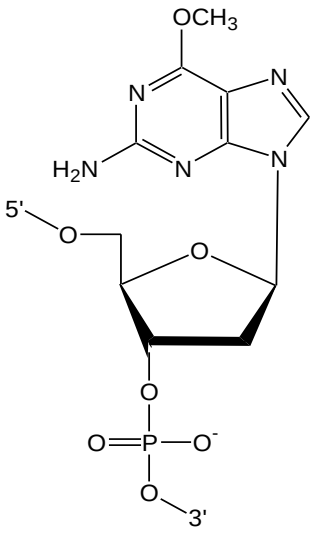
References

Dong ZG and Jeffrey AM.
Hydrolysis of carcinogen--DNA adducts by three classes of deoxyribonucleosidase to their corresponding bases.
Carcinogenesis. 1991 Jun;12(6):1125-8.

O6-Me-dG

O6-Me-dG is used for investigating mutagenesis caused by methylation of exocyclic oxygens.

Structure



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Shibutani S.
Quantitation of base substitutions and deletions induced by chemical mutagens during DNA synthesis in vitro.
Chem Res Toxicol. 1993 Sep-Oct;6(5):625-9.

Georgiadis P, Smith CA, and Swann PF.
Nitrosamine-induced cancer: selective repair and conformational differences between O6-methylguanine residues in different positions in and around codon 12 of rat H-ras.
Cancer Res. 1991 Nov 1;51(21):5843-50.

Souliotis VL, Giannopoulos A, Koufakis I, Kaila S, Dimopoulos C, and Kyrtopoulos SA.
Development and validation of a new assay for O6-alkylguanine-DNA-alkyltransferase based on the use of an oligonucleotide substrate, and its application to the measurement of DNA repair activity in extracts of biopsy samples of human urinary bladder mucosa.
Carcinogenesis. 1989 Jul;10(7):1203-8.

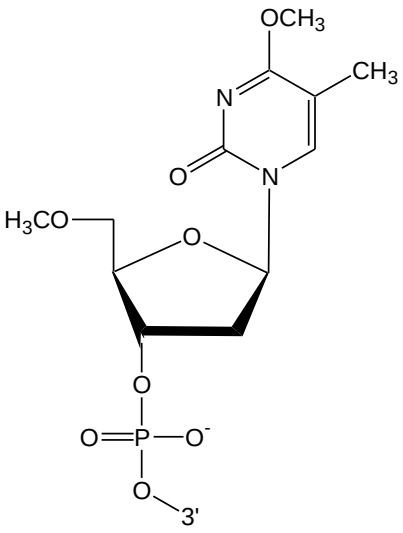
Richardson FC, Boucheron JA, Skopek TR, and Swenberg JA.
Formation of O6-methyldeoxyguanosine at specific sites in a synthetic oligonucleotide designed to resemble a known mutagenic hotspot.
J Biol Chem. 1989 Jan 15;264(2):838-41.

Patel DJ, Shapiro L, Kozlowski SA, Gaffney BL, and Jones RA.
Covalent carcinogenic O6-methylguanosine lesions in DNA. Structural studies of the O6 meG X A and O6meG X G interactions in dodecanucleotide duplexes.
J Mol Biol. 1986 Apr 20;188(4):677-92.

O4-Me-dT

O4-Me-dT is used for investigating mutagenesis caused by methylation of exocyclic oxygens.

Structure



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

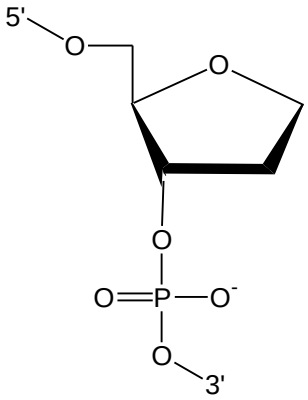
Richardson FC and Richardson KK.
Alterations in DNA-restriction enzyme interactions by O4-alkyldeoxythymidines.
Mol Carcinog. 1991;4(2):162-8.

No Base

dSpacer

dSpacer forms a stable abasic site. It is used to create FRET primers, study quadruplex structures, and investigate DNA damage and repair mechanisms.

Structure



Availability

Positions	Scales (µmol)	Purifications
Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Rachwal PA, Brown T, and Fox KR.
Sequence effects of single base loops in intramolecular quadruplex DNA.
FEBS Lett. 2007 Apr 17;581(8):1657-60.

Cevec M and Plavec J.
Role of loop residues and cations on the formation and stability of dimeric DNA G-quadruplexes. Biochemistry. 2005 Nov 22;44(46):15238-46.

Fox KR, Allinson SL, Sahagun-Krause H, and Brown T.
Recognition of GT mismatches by Vsr mismatch endonuclease.
Nucleic Acids Res. 2000 Jul 1;28(13):2535-40.

Shida T, Ogawa T, Ogasawara N, and Sekiguchi J.
Characterization of Bacillus subtilis ExoA protein: a multifunctional DNA-repair enzyme similar to the Escherichia coli exonuclease III.
Biosci Biotechnol Biochem. 1999 Sep;63(9):1528-34.

Ju J, Glazer AN, and Mathies RA.
Cassette labeling for facile construction of energy transfer fluorescent primers.
Nucleic Acids Res. 1996 Mar 15;24(6):1144-8.

Kalnik MW, Chang CN, Grollman AP, and Patel DJ.
NMR studies of abasic sites in DNA duplexes: deoxyadenosine stacks into the helix opposite the cyclic analogue of 2-deoxyribose.
Biochemistry. 1988 Feb 9;27(3):924-31.

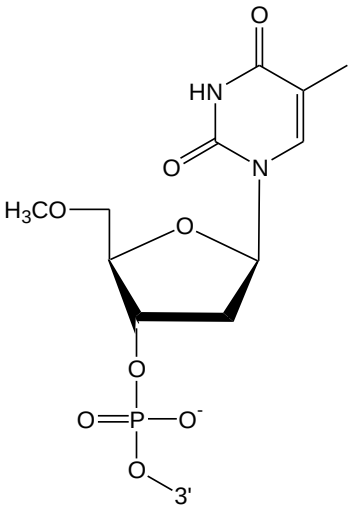
Takeshita M, Chang CN, Johnson F, Will S, and Grollman AP.
Oligodeoxynucleotides containing synthetic abasic sites. Model substrates for DNA polymerases and apurinic/apyrimidinic endonucleases.
J Biol Chem. 1987 Jul 25;262(21):10171-9.

siRNA Guide Strand Selection

5′-O-Me-dT

5′-O-Me-dT controls guide strand selection and targeting specificity of siRNA duplexes as they are loaded into RISC (RNA-induced silencing complex).

Structure



Availability

Positions	Scales (µmol)	Purifications
5′ End	0.05, 0.2, 1.0	Desalt, HPLC, PAGE

References

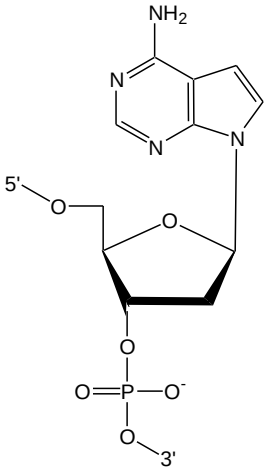
Chen PY, Weinmann L, Gaidatzis D, Pei Y, Zavolan M, Tuschl T, and Meister G.
Strand-specific 5'-O-methylation of siRNA duplexes controls guide strand selection and targeting specificity.
RNA. 2008 Feb;14(2):263-74.

Deaza Bases

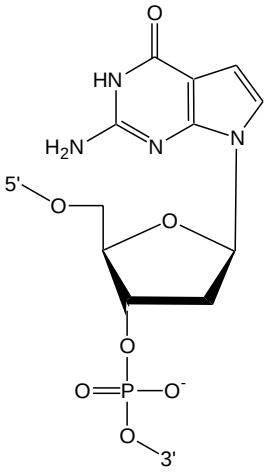
The deaza and aza nucleosides are used to study DNA structure and function. 7-deaza-dA and 7-deaza-dG lack nitrogens critical for hydrogen bond formation and thereby influence DNA bending. 7-deaza-dX has interesting effects on triple-helix motifs and forms a non-standard base pair with 2,4-diaminopyrimidine. 7-deaza-8-aza-dA is slightly stabilizing relative to dA.

Structures

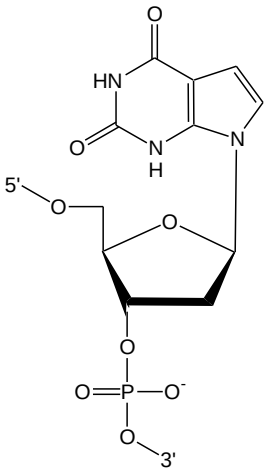
7-Deaza-dA



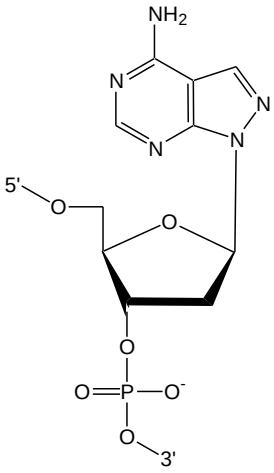
7-Deaza-dG



7-Deaza-dX



7-Deaza-8-Aza-dA



Availability

Positions	Scales (µmol)	Purifications
5’ End, Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Shaikh KI, Leonard P, and Seela F.
7-deaza-2'-deoxyxanthosine: nucleobase protection and base pairing of oligonucleotides.
Nucleosides Nucleotides Nucleic Acids. 2007;26(6-7):737-41.

Seela F, Wei C, Becher G, Zulauf M, and Leonard P.
The influence of modified purine bases on the stability of parallel DNA.
Bioorg Med Chem Lett. 2000 Feb 7;10(3):289-92.

Milligan JF, Krawczyk SH, Wadwani S, and Matteucci MD.
An anti-parallel triple helix motif with oligodeoxynucleotides containing 2'-deoxyguanosine and 7-deaza-2'-deoxyxanthosine.
Nucleic Acids Res. 1993 Jan 25;21(2):327-33.

Seela F and Grein T.
7-Deaza-2'-deoxyadenosine and 3-deaza-2'-deoxyadenosine replacing dA within d(A6)-tracts: differential bending at 3'- and 5'-junctions of d(A6).d(T6) and B-DNA.
Nucleic Acids Res. 1992 Jul 11;20(13):2297-306.

Seela F, Berg H, and Rosemeyer H.
Bending of oligonucleotides containing an isosteric nucleobase: 7-deaza-2'-deoxyadenosine replacing dA within d(A)6 tracts.
Biochemistry. 1989 Jul 25;28(15):6193-8.

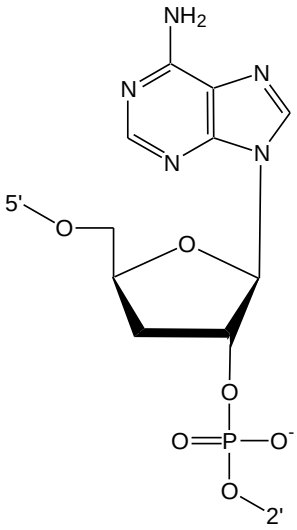
Seela F and Driller H.
Alternating d(G-C)3 and d(C-G)3 hexanucleotides containing 7-deaza-2'-deoxyguanosine or 8-aza-7-deaza-2'-deoxyguanosine in place of dG.
Nucleic Acids Res. 1989 Feb 11;17(3):901-10.

2′ → 5′ Synthesis

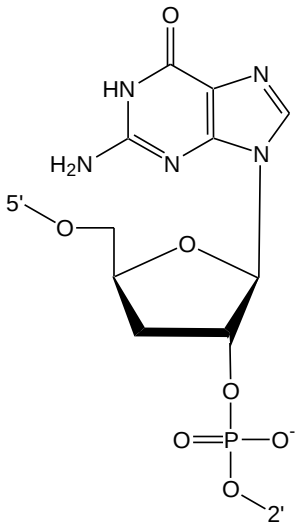
2′ → 5′ linked oligonucleotides selectively bind to RNA, making them useful as probes or antisense agents. They also drive formation of triple-helix motifs.

Structures

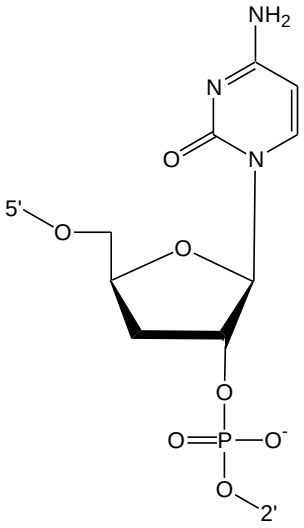
dA-5′



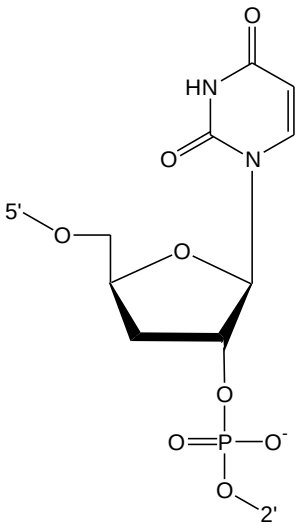
dG-5′



dC-5′



dT-5′



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal, 3′ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Obika S, Hiroto A, Nakagawa O, and Imanishi T.
Presence of 2',5'-linkages in a homopyrimidine DNA oligonucleotide promotes stable triplex formation under physiological conditions.
Nucleosides Nucleotides Nucleic Acids. 2005;24(5-7):1055-8.

Premraj BJ, Raja S, Bhavesh NS, Shi K, Hosur RV, Sundaralingam M, and Yathindra N.
Solution structure of 2',5' d(G4C4). Relevance to topological restrictions and nature's choice of phosphodiester links.
Eur J Biochem. 2004 Jul;271(14):2956-66.

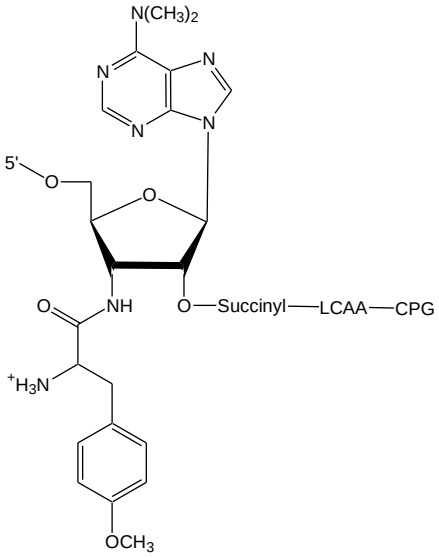
Kumar A, Dass D, Atreyi M, Rao MV, and Katti SB.
Conformational rigidity introduced by 2',5'-phosphodiester links in DNA.
Nucleosides Nucleotides Nucleic Acids. 2001 Oct-Nov;20(10-11):1783-96.

Bhan P, Bhan A, Hong M, Hartwell JG, Saunders JM, and Hoke GD.
2',5'-linked oligo-3'-deoxyribonucleoside phosphorothioate chimeras: thermal stability and antisense inhibition of gene expression.
Nucleic Acids Res. 1997 Aug 15;25(16):3310-7.

Puromycin

Puromycin is a potent prokaryotic and eukaryotic translation-termination antibiotic. It is best known for its ability to direct the evolution of polypeptides via mRNA display. Puromycin can also be used to initiate ribosome-free peptide synthesis and reveal ribosome structure and function.

Structure



Availability

Positions	Scales (µmol)	Purifications
3′ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Starck SR and Roberts RW.
Puromycin oligonucleotides reveal steric restrictions for ribosome entry and multiple modes of translation inhibition.
RNA. 2002 Jul;8(7):890-903.

Tamura K and Schimmel P.
Oligonucleotide-directed peptide synthesis in a ribosome- and ribozyme-free system.
Proc Natl Acad Sci U S A. 2001 Feb 13;98(4):1393-7.

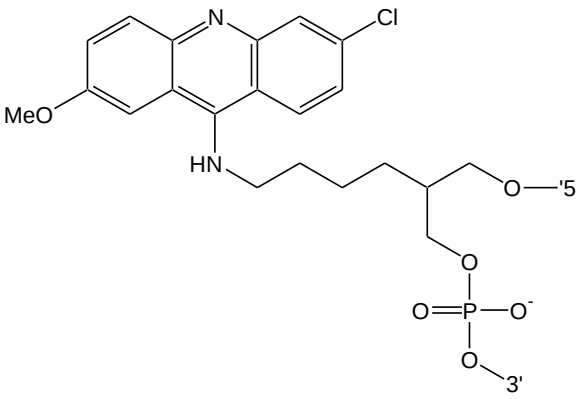
Roberts RW and Szostak JW.
RNA-peptide fusions for the in vitro selection of peptides and proteins.
Proc Natl Acad Sci U S A. 1997 Nov 11;94(23):12297-302.

Intercalation

Acridine

Acridine is a fluorescent intercalating agent used to investigate DNA cleavage, mutagenesis, and triple-helix-motif formation. It is also used to deliver antisense oligonucleotides and inhibit HIV integrase.

Structure



Availability

Positions	Scales (µmol)	Purifications
Internal	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

de Piédoue G, Andrieu-Soler C, Concordet JP, Maurisse R, Sun JS, Lopez B, Kuzniak I, Leboulch P, and Feugeas JP.
Targeted gene correction with 5' acridine-oligonucleotide conjugates.
Oligonucleotides. 2007 Summer;17(2):258-63.

Pinskaya M, Romanova E, Volkov E, Deprez E, Leh H, Brochon JC, Mouscadet JF, and Gottikh M.
HIV-1 integrase complexes with DNA dissociate in the presence of short oligonucleotides conjugated to acridine.
Biochemistry. 2004 Jul 13;43(27):8735-43.

Shchyolkina AK, Timofeev EN, Lysov YP, Florentiev VL, Jovin TM, and Arndt-Jovin DJ.
Protein-free parallel triple-stranded DNA complex formation.
Nucleic Acids Res. 2001 Feb 15;29(4):986-95.

Saison-Behmoaras TE, Duroux I, Nguyen TT, Asseline U, and Hélène C.
Antisense properties of end-modified oligonucleotides targeted to Ha-ras oncogene.
Antisense Nucleic Acid Drug Dev. 1997 Aug;7(4):361-8.

Boiziau C, Kurfurst R, Cazenave C, Roig V, Thuong NT, and Toulmé JJ.
Inhibition of translation initiation by antisense oligonucleotides via an RNase-H independent mechanism.
Nucleic Acids Res. 1991 Mar 11;19(5):1113-9.

Loke SL, Stein CA, Zhang XH, Mori K, Nakanishi M, Subasinghe C, Cohen JS, and Neckers LM.
Characterization of oligonucleotide transport into living cells.
Proc Natl Acad Sci U S A. 1989 May;86(10):3474-8.

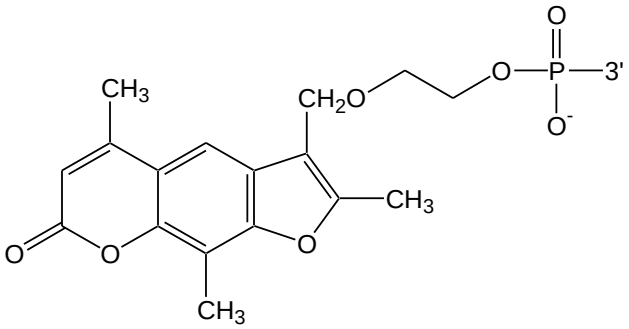
Boidot-Forget M, Chassignol M, Takasugi M, Thuong NT, and Hélène C.
Site-specific cleavage of single-stranded and double-stranded DNA sequences by oligodeoxyribonucleotides covalently linked to an intercalating agent and an EDTA-Fe chelate.
Gene. 1988 Dec 10;72(1-2):361-71.

Psoralen

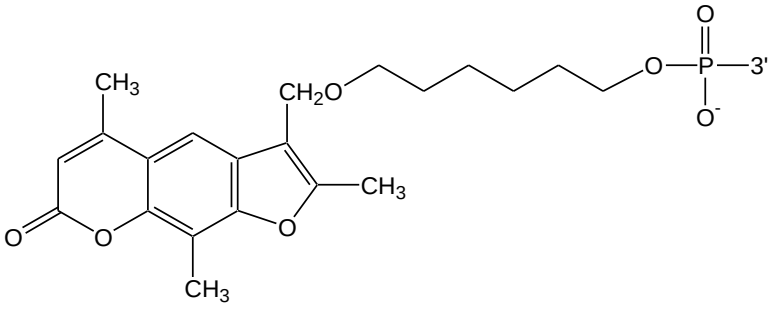
Psoralen is an intercalating agent used for investigating DNA structure and function and DNA-protein interactions. It forms either monoadducts or diadducts with DNA bases when exposed to 350 nm UV light. Exposure to 254 nm UV light reverses the diadducts. C2 is for crosslinking to double-stranded DNA, and C6 is for crosslinking to triple-stranded DNA.

Structure

C2



C6



Availability

Positions	Scales (µmol)	Purifications
5′ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Liu Y, Nairn RS, and Vasquez KM.
Targeted gene conversion induced by triplex-directed psoralen interstrand crosslinks in mammalian cells.
Nucleic Acids Res. 2009 Oct;37(19):6378-88.

Zhao J, Jain A, Iyer RR, Modrich PL, and Vasquez KM.
Mismatch repair and nucleotide excision repair proteins cooperate in the recognition of DNA interstrand crosslinks.
Nucleic Acids Res. 2009 Jul;37(13):4420-9.

Li H, Broughton-Head VJ, Peng G, Powers VE, Ovens MJ, Fox KR, and Brown T.
Triplex staples: DNA double-strand cross-linking at internal and terminal sites using psoralen-containing triplex-forming oligonucleotides.
Bioconjug Chem. 2006 Nov-Dec;17(6):1561-7.

Diviacco S, Rapozzi V, Xodo L, Helene C, Quadrifoglio F, and Giovannangeli C.
Site-directed inhibition of DNA replication by triple helix formation.
FASEB J. 2001 Dec;15(14):2660-8.

Oh DH and Hanawalt PC.
Triple helix-forming oligonucleotides target psoralen adducts to specific chromosomal sequences in human cells.
Nucleic Acids Res. 1999 Dec 15;27(24):4734-42.

Bornet O, Prévost C, Vovelle F, Chassignol M, Thuong NT, and Lancelot G.
Solution structure of oligonucleotides covalently linked to a psoralen derivative.
Nucleic Acids Res. 1995 Mar 11;23(5):788-95.

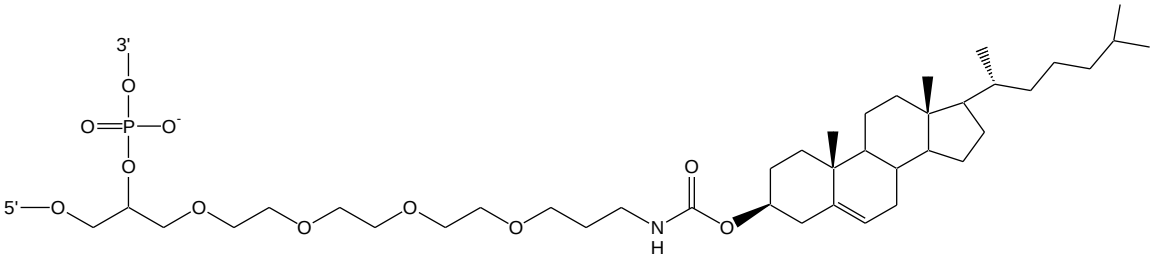
Pieles U and Englisch U.
Psoralen covalently linked to oligodeoxyribonucleotides: synthesis, sequence specific recognition of DNA and photo-cross-linking to pyrimidine residues of DNA.
Nucleic Acids Res. 1989 Jan 11;17(1):285-99.

Antisense

Cholesterol's lipophilic properties promote its uptake through the plasma membrane, thereby facilitating delivery of oligonucleotides. It also has potential for initiating construction of nanotechnological structures on the plasma membrane and developing in vivo biosensors.

Cholesteryl-TEG

Structure

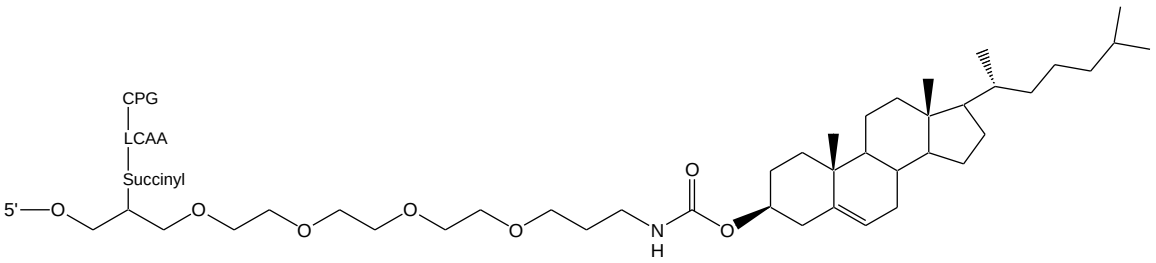


Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal	0.05, 0.2, 1.0	Cartridge, HPLC

3′-Cholesteryl-TEG-CPG

Structure



Availability

Positions	Scales (µmol)	Purifications
3′ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Bunge A, Loew M, Pescador P, Arbuzova A, Brodersen N, Kang J, Dahne L, Liebscher J, Herrmann A, Stengel G, and Huster D.
Lipid Membranes Carrying Lipophilic Cholesterol-Based Oligonucleotides-Characterization and Application on Layer-by-Layer Coated Particles.
J Phys Chem B. 2009 Dec 24;113(51):16425-16434.

Seo YJ, Jeong HS, Bang EK, Hwang GT, Jung JH, Jang SK, and Kim BH.
Cholesterol-linked fluorescent molecular beacons with enhanced cell permeability.
Bioconjug Chem. 2006 Sep-Oct;17(5):1151-5.

Maszewska M, Kobylańska A, Gendaszewska-Darmach E, and Koziołkiewicz M.
Bromodeoxyuridine-labeled oligonucleotides as tools for oligonucleotide uptake studies. Antisense Nucleic Acid Drug Dev. 2002 Dec;12(6):379-91.

Bijsterbosch MK, Manoharan M, Dorland R, Waarlo IH, Biessen EA, and van Berkel TJ.
Delivery of cholesteryl-conjugated phosphorothioate oligodeoxynucleotides to Kupffer cells by lactosylated low-density lipoprotein.
Biochem Pharmacol. 2001 Sep 1;62(5):627-33.

Hayashi M, Maeda A, Kihara M, Arai S, Hanaki K, and Nozaki T.
Inhibitory effects of modified oligonucleotides complementary to the leader RNA on the multiplication of mouse hepatitis virus.
Adv Exp Med Biol. 1998;440:701-5.

MacKellar C, Graham D, Will DW, Burgess S, and Brown T.
Synthesis and physical properties of anti-HIV antisense oligonucleotides bearing terminal lipophilic groups.
Nucleic Acids Res. 1992 Jul 11;20(13):3411-7.

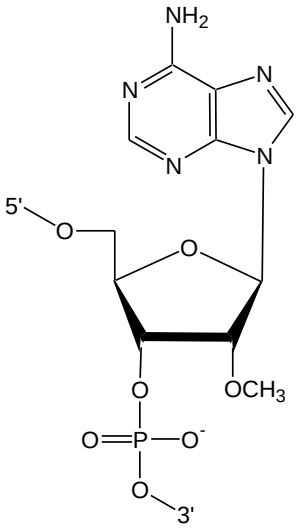
Letsinger RL, Zhang GR, Sun DK, Ikeuchi T, and Sarin PS.
Cholesteryl-conjugated oligonucleotides: synthesis, properties, and activity as inhibitors of replication of human immunodeficiency virus in cell culture.
Proc Natl Acad Sci U S A. 1989 Sep;86(17):6553-6.

Methyl RNA

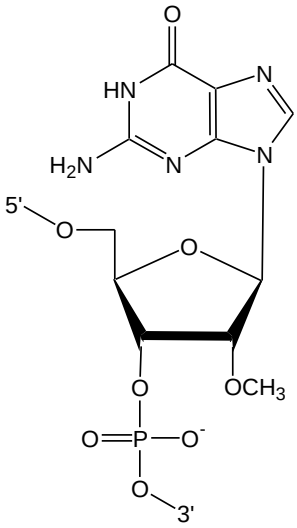
2′-OMe-nucleoside-containing oligonucleotides are resistant to a variety of nucleases and therefore are used in antisense applications.

Structures

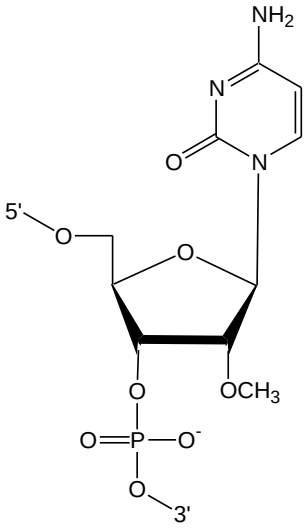
2′-OMe-RNA-A



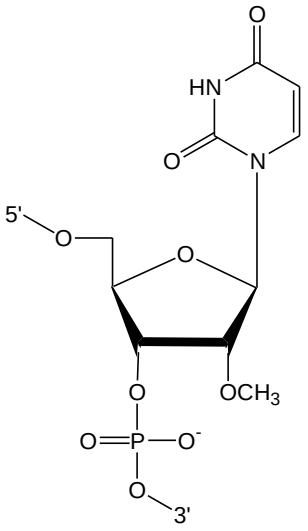
2′-OMe-RNA-G



2’-OMe-RNA-C



2’-OMe-RNA-U



Availability

Positions	Scales (µmol)	Purifications
5’ End, Internal, 3’ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Mäe M, El Andaloussi S, Lundin P, Oskolkov N, Johansson HJ, Guterstam P, and Langel U.
A stearylated CPP for delivery of splice correcting oligonucleotides using a non-covalent co-incubation strategy.
J Control Release. 2009 Mar 19;134(3):221-7.

Küpfer PA and Leumann CJ.
The chemical stability of abasic RNA compared to abasic DNA.
Nucleic Acids Res. 2007;35(1):58-68.

Gamper HB, Nulf CJ, Corey DR, and Kmiec EB.
The synaptic complex of RecA protein participates in hybridization and inverse strand exchange reactions.
Biochemistry. 2003 Mar 11;42(9):2643-55.

Liu Q, Swiderski P, and Sommer SS.
Truncated amplification: a method for high-fidelity template-driven nucleic acid amplification.
Biotechniques. 2002 Jul;33(1):129-32, 134-6, 138.

Beban M and Miller PS.
Pyrimidine motif triplexes containing polypurine RNA or DNA with oligo 2'-O-methyl or DNA triplex forming oligonucleotides.
Biochim Biophys Acta. 2000 Jun 21;1492(1):155-62.

Hacia JG, Novotny EA, Mayer RA, Woski SA, Ashlock MA, and Collins FS.
Design of modified oligodeoxyribonucleotide probes to detect telomere repeat sequences in FISH assays.
Nucleic Acids Res. 1999 Oct 15;27(20):4034-9.

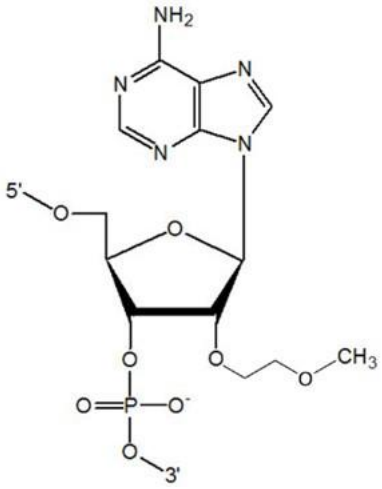
Lamond AI, Sproat B, Ryder U, and Hamm J.
Probing the structure and function of U2 snRNP with antisense oligonucleotides made of 2'-OMe RNA.
Cell. 1989 Jul 28;58(2):383-90.

Methoxyethyl RNA

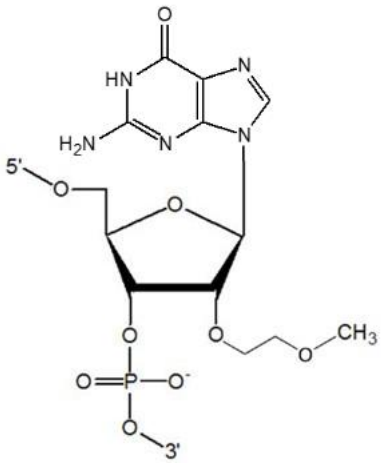
2′-OMe-nucleoside-containing oligonucleotides are resistant to a variety of nucleases and therefore are used in antisense applications.

Structures

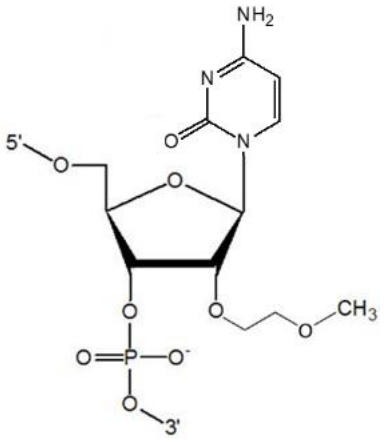
2′-MOE-RNA-A



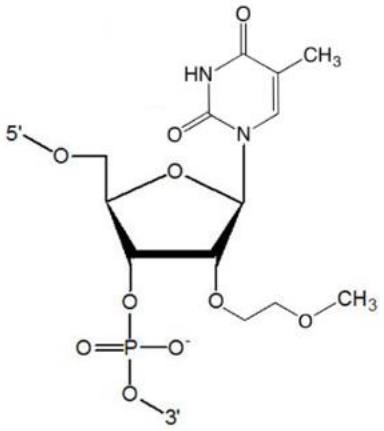
2′-MOE-RNA-G



2′-MOE-RNA-C



2′-MOE-RNA-meU



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal, 3′ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Shadid M, Badawi M., and Abulrob A.
Antisense oligonucleotides: absorption, distribution, metabolism, and excretion.
Exp Opin Drug Met. & Tox. 2021. Oct 22;17(11):1281-92.

Kole R, Krainer A, and Altman A.
RNA therapeutics: Beyond RNA interference and antisense oligonucleotides.
Nat Rev Drug Discov. 2012. Jan 20;11:125-40.

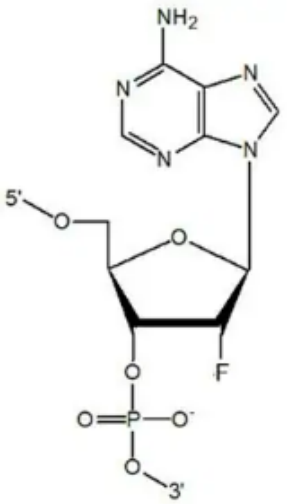
Nishina T, Numata J, Nishina K, Yoshida-Tanaka K, Nitta K, Piao W, Iwata R, Ito S, Kuwahara H, Wada T, Mizusawa H, and Yokota T.
Chimeric Antisense Oligonucleotide Conjugated to α-Tocopherol.
Mol Ther Nucleic Acids. 2015. Jan 13;4(1):e220.

Fluoro RNA

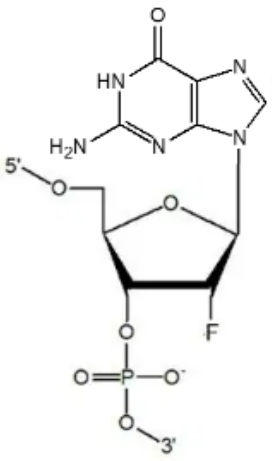
Replacing the 2′-hydroxyl group in RNA with fluorine substantially increases its melting temperature, chemical stability, and resistance to nucleases.

Structures

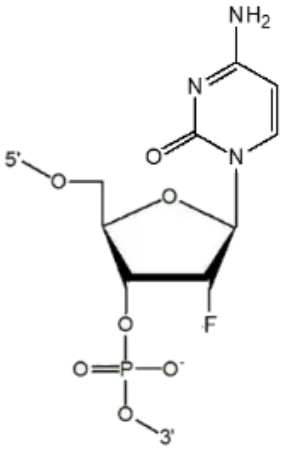
2′-F-RNA-A



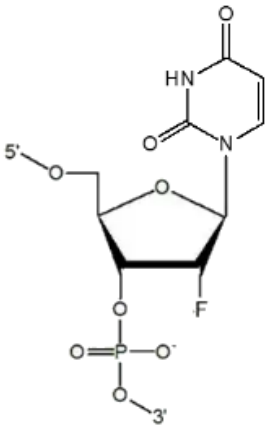
2′-F-RNA-G



2′-F-RNA-C



2′-F-RNA-U



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal, 3′ End	0.05, 0.2, 1.0	Desalt, Cartridge, HPLC, PAGE

References

Egli M and Manoharan M.
Chemistry, structure and function of approved oligonucleotide therapeutics.
Nucleic Acid Res. 2023. Apr 11;51(6):2529-73.

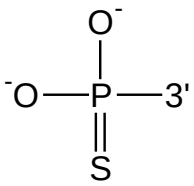
Holm A, Hansen S, Klitgaard H, and Kauppinen S.
Clinical advances of RNA therapeutics for treatment of neurological and neuromuscular diseases.
RNA Biol. 2022. Apr 28;19(1):594-608.

Manoharan M, Akinc A, Pandey RK, Qin J, Hadwiger P, John M, Mills K, Charisse K, Maier MA, Nechev L, Greene EM, Pallan PS, Rozners E, Rajeev KG, and Egli M.
Unique Gene-silencing and Structural Properties of 2’-F Modified siRNAs.
Angew Chem Int Ed Engl. 2011. Jan 31;50(10):2284-88.

Thiophosphate

Thiosphosphate is used to study how reverse transcriptases are affected by structural mutations in the nucleic acid template.

Structure



Availability

Positions	Scales (µmol)	Purifications
5′ End, Internal, 3′ End	0.05, 0.2, 1.0	Desalt, Cartridge (5′ End, Internal) & Desalt, Cartridge, HPLC, PAGE (3′ End)

References

Remaut K, Symens N, Lucas B, Demeester J, and De Smedt SC.
Efficient delivery of intact phosphodiester oligonucleotides by poly-beta-amino esters.
J Control Release. 2010 Jan 26.

Ozbaş-Turan S, Akbuğa J, and Enneli B.
Evaluation of antisense oligonucleotide loaded chitosan nanoparticles; characterization and antisense effect.
Pharmazie. 2009 Dec;64(12):807-11.

De Rosa G and La Rotonda MI.
Nano and microtechnologies for the delivery of oligonucleotides with gene silencing properties. Molecules. 2009 Jul 29;14(8):2801-23.

Aartsma-Rus A, van Vliet L, Hirschi M, Janson AA, Heemskerk H, de Winter CL,
de Kimpe S, van Deutekom JC, 't Hoen PA, and van Ommen GJ.
Guidelines for Antisense Oligonucleotide Design and Insight Into Splice-modulating Mechanisms.
Mol Ther. 2008 Sep 23.

Alam MR, Dixit V, Kang H, Li ZB, Chen X, Trejo J, Fisher M, and Juliano RL.
Intracellular delivery of an anionic antisense oligonucleotide via receptor-mediated endocytosis.
Nucleic Acids Res. 2008 May;36(8):2764-76.

Goebl N, Berridge B, Wroblewski VJ, and Brown-Augsburger PL.
Development of a sensitive and specific in situ hybridization technique for the cellular localization of antisense oligodeoxynucleotide drugs in tissue sections.
Toxicol Pathol. 2007;35(4):541-8.

Zhang C, Pei J, Kumar D, Sakabe I, Boudreau HE, Gokhale PC, and Kasid UN.
Antisense oligonucleotides: target validation and development of systemically delivered therapeutic nanoparticles.
Methods Mol Biol. 2007;361:163-85.

Chen R, Luo X, Di X, Li Y, Sun Y, and Hu Y.
Single-based resolution for oligodeoxynucleotides and their phosphorothioate modifications by replaceable capillary gel electrophoresis.
J Chromatogr B Analyt Technol Biomed Life Sci. 2006 Nov 7;843(2):334-8.

Shi J, Yan WW, Qi XR, Maitani Y, and Nagai T.
Characteristics and biodistribution of soybean sterylglucoside and polyethylene glycol-modified cationic liposomes and their complexes with antisense oligodeoxynucleotide.
Drug Deliv. 2005 Nov-Dec;12(6):349-56.

Goodchild J.
Oligonucleotide therapeutics: 25 years agrowing.
Curr Opin Mol Ther. 2004 Apr;6(2):120-8.

Matsuyama M, Yoshimura R, Akioka K, Okamoto M, Ushigome H, Kadotani Y, Nakatani T, and Yoshimura N.
Tissue factor antisense oligonucleotides prevent renal ischemia-reperfusion injury.
Transplantation. 2003 Sep 15;76(5):786-91.

Henry SP, Beattie G, Yeh G, Chappel A, Giclas P, Mortari A, Jagels MA, Kornbrust DJ, and Levin AA.
Complement activation is responsible for acute toxicities in rhesus monkeys treated with a phosphorothioate oligodeoxynucleotide.
Int Immunopharmacol. 2002 Nov;2(12):1657-66.

Yu RZ, Baker B, Chappell A, Geary RS, Cheung E, and Levin AA.
Development of an ultrasensitive noncompetitive hybridization-ligation enzyme-linked immunosorbent assay for the determination of phosphorothioate oligodeoxynucleotide in plasma.
Anal Biochem. 2002 May 1;304(1):19-25.

Braasch DA and Corey DR.
Novel antisense and peptide nucleic acid strategies for controlling gene expression.
Biochemistry. 2002 Apr 9;41(14):4503-10.

Graham MJ, Crooke ST, Lemonidis KM, Gaus HJ, Templin MV, and Crooke RM.
Hepatic distribution of a phosphorothioate oligodeoxynucleotide within rodents following intravenous administration.
Biochem Pharmacol. 2001 Aug 1;62(3):297-306.

Leeds JM, Henry SP, Geary R, Burckin T, and Levin AA.
Comparison of the pharmacokinetics of subcutaneous and intravenous administration of a phosphorothioate oligodeoxynucleotide in cynomolgus monkeys.
Antisense Nucleic Acid Drug Dev. 2000 Dec;10(6):435-41.

Aliño SF, Crespo J, Tarrasón G, Blaya C, Adán J, Escrig E, Benet M, Crespo A, Peris JE, and Piulats J.
Pharmacokinetics of oligodeoxynucleotides encapsulated in liposomes: effect of lipid composition and preparation method.
Xenobiotica. 1999 Dec;29(12):1283-91.

Zhao Q, Yu D, and Agrawal S.
Site of chemical modifications in CpG containing phosphorothioate oligodeoxynucleotide modulates its immunostimulatory activity.
Bioorg Med Chem Lett. 1999 Dec 20;9(24):3453-8.

Benimetskaya L, Takle GB, Vilenchik M, Lebedeva I, Miller P, and Stein CA.
Cationic porphyrins: novel delivery vehicles for antisense oligodeoxynucleotides.
Nucleic Acids Res. 1998 Dec 1;26(23):5310-7.

Broaddus WC, Prabhu SS, Gillies GT, Neal J, Conrad WS, Chen ZJ, Fillmore H, and Young HF.
Distribution and stability of antisense phosphorothioate oligonucleotides in rodent brain following direct intraparenchymal controlled-rate infusion.
Neurosurg Focus. 1997 Nov 15;3(5):Article4.

Monteith DK, Henry SP, Howard RB, Flournoy S, Levin AA, Bennett CF, and Crooke ST.
Immune stimulation--a class effect of phosphorothioate oligodeoxynucleotides in rodents.
Anticancer Drug Des. 1997 Jul;12(5):421-32.

Rockwell P, O'Connor WJ, King K, Goldstein NI, Zhang LM, and Stein CA.
Cell-surface perturbations of the epidermal growth factor and vascular endothelial growth factor receptors by phosphorothioate oligodeoxynucleotides.
Proc Natl Acad Sci U S A. 1997 Jun 10;94(12):6523-8.

Agrawal S, Jiang Z, Zhao Q, Shaw D, Cai Q, Roskey A, Channavajjala L, Saxinger C, and Zhang R.
Mixed-backbone oligonucleotides as second generation antisense oligonucleotides: in vitro and in vivo studies.
Proc Natl Acad Sci U S A. 1997 Mar 18;94(6):2620-5.

Cohen AS, Bourque AJ, Wang BH, Smisek DL, and Belenky A.
A nonradioisotope approach to study the in vivo metabolism of phosphorothioate oligonucleotides.
Antisense Nucleic Acid Drug Dev. 1997 Feb;7(1):13-22.

Kairemo KJ, Tenhunen M, and Jekunen AP.
Dosimetry of radionuclide therapy using radiophosphonated antisense oligodeoxynucleotide phosphorothioates based on animal pharmacokinetic and tissue distribution data.
Antisense Nucleic Acid Drug Dev. 1996 Fall;6(3):215-20.

Branda RF, Moore AL, Lafayette AR, Mathews L, Hong R, Zon G, Brown T, and McCormack JJ.
Amplification of antibody production by phosphorothioate oligodeoxynucleotides.
J Lab Clin Med. 1996 Sep;128(3):329-38.

Marquez VE, Siddiqui MA, Ezzitouni A, Russ P, Wang J, Wagner RW, and Matteucci MD.
Nucleosides with a twist. Can fixed forms of sugar ring pucker influence biological activity in nucleosides and oligonucleotides?
J Med Chem. 1996 Sep 13;39(19):3739-47.

Thorogood H, Grasby JA, and Connolly BA.
Influence of the phosphate backbone on the recognition and hydrolysis of DNA by the EcoRV restriction endonuclease. A study using oligodeoxynucleotide phosphorothioates.
J Biol Chem. 1996 Apr 12;271(15):8855-62.

Khaled Z, Benimetskaya L, Zeltser R, Khan T, Sharma HW, Narayanan R, and Stein CA.
Multiple mechanisms may contribute to the cellular anti-adhesive effects of phosphorothioate oligodeoxynucleotides.
Nucleic Acids Res. 1996 Feb 15;24(4):737-45.

Zhao Q, Temsamani J, and Agrawal S.
Use of cyclodextrin and its derivatives as carriers for oligonucleotide delivery.
Antisense Res Dev. 1995 Fall;5(3):185-92.

Zhang R, Lu Z, Zhang X, Zhao H, Diasio RB, Liu T, Jiang Z, and Agrawal S.
In vivo stability and disposition of a self-stabilized oligodeoxynucleotide phosphorothioate in rats.
Clin Chem. 1995 Jun;41(6 Pt 1):836-43.

Brown DA, Kang SH, Gryaznov SM, DeDionisio L, Heidenreich O, Sullivan S, Xu X, and Nerenberg MI.
Effect of phosphorothioate modification of oligodeoxynucleotides on specific protein binding.
J Biol Chem. 1994 Oct 28;269(43):26801-5.

Boiziau C, Moreau S, and Toulmé JJ.
A phosphorothioate oligonucleotide blocks reverse transcription via an antisense mechanism.
FEBS Lett. 1994 Mar 7;340(3):236-40.

Ghosh MK, Ghosh K, and Cohen JS.
Phosphorothioate-phosphodiester oligonucleotide co-polymers: assessment for antisense application.
Anticancer Drug Des. 1993 Feb;8(1):15-32.
awley P and Gibson I.
The detection of oligodeoxynucleotide molecules following uptake into mammalian cells.
Antisense Res Dev. 1992 Summer;2(2):119-27.

Jaroszewski JW, Syi JL, Maizel J, and Cohen JS.
Towards rational design of antisense DNA: molecular modelling of phosphorothioate DNA analogues.
Anticancer Drug Des. 1992 Jun;7(3):253-62.

Metelev V and Agrawal S.
Ion-exchange high-performance liquid chromatography analysis of oligodeoxyribonucleotide phosphorothioates.
Anal Biochem. 1992 Feb 1;200(2):342-6.

Akhtar S, Kole R, and Juliano RL.
Stability of antisense DNA oligodeoxynucleotide analogs in cellular extracts and sera.
Life Sci. 1991;49(24):1793-801.

Ghosh M, Ghosh K, and Cohen JS.
Oligodeoxynucleotide analogs as informational drugs to regulate translation.
Nucleic Acids Symp Ser. 1991;(24):139-42.

Agrawal S, Temsamani J, and Tang JY.
Pharmacokinetics, biodistribution, and stability of oligodeoxynucleotide phosphorothioates in mice.
Proc Natl Acad Sci U S A. 1991 Sep 1;88(17):7595-9.

Agrawal S, Mayrand SH, Zamecnik PC, and Pederson T.
Site-specific excision from RNA by RNase H and mixed-phosphate-backbone oligodeoxynucleotides.
Proc Natl Acad Sci U S A. 1990 Feb;87(4):1401-5.

Stein CA, Subasinghe C, Shinozuka K, and Cohen JS.
Physicochemical properties of phosphorothioate oligodeoxynucleotides.
Nucleic Acids Res. 1988 Apr 25;16(8):3209-21.

Marcus-Sekura CJ, Woerner AM, Shinozuka K, Zon G, Quinnan GV Jr.
Comparative inhibition of chloramphenicol acetyltransferase gene expression by antisense oligonucleotide analogues having alkyl phosphotriester, methylphosphonate and phosphorothioate linkages.
Nucleic Acids Res. 1987 Jul 24;15(14):5749-63.

Zamecnik PC, Goodchild J, Taguchi Y, and Sarin PS.
Inhibition of replication and expression of human T-cell lymphotropic virus type III in cultured cells by exogenous synthetic oligonucleotides complementary to viral RNA.
Proc Natl Acad Sci U S A. 1986 Jun;83(12):4143-6.

Stridh S, Oberg B, Chattopadhyaya J, and Josephson S.
Functional analysis of influenza RNA polymerase activity by the use of caps, oligonucleotides and polynucleotides.
Antiviral Res. 1981 Jun;1(2):97-105.

Stephenson ML and Zamecnik PC.
Inhibition of Rous sarcoma viral RNA translation by a specific oligodeoxyribonucleotide.
Proc Natl Acad Sci U S A. 1978 Jan;75(1):285-8.

Zamecnik PC and Stephenson ML.
Inhibition of Rous sarcoma virus replication and cell transformation by a specific oligodeoxynucleotide.
Proc Natl Acad Sci U S A. 1978 Jan;75(1):280-4.

To Place an Order or Receive Technical Assistance

In the U.S. and Canada, call toll-free
1(800)-645-5476

For other countries across Europe, call
+44 (0) 115 943 0840

For other countries across Europe
and the world, please visit
MerckMillipore.com/offices

For Technical Service, please visit
MerckMillipore.com/techservice

Merck KGaA
Frankfurter Strasse 250
64293 Darmstadt
Germany

Lit. No. 0000000000 Ver. 0.0
00-00-00000
00/2019