35. Nucleotides

Part XXXVIII1)

Syntheses and Characterization of Phosphorothioate Analogues of (2'-5')Adenylate Dimer and Trimer and Their 5'-O-Monophosphates

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Dedicated to Prof. Dr. Wilhelm Fleischhacker on the occasion of his 60th birthday

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The chemical syntheses of the phosphorothioate of (2'-5') adenylate dimer (see **6a**, **6b**) and trimer (see **11a**, **11b**, **12a**, **12b**) as well as of their 5'-monophosphates (see **15a**, **15b**, **16a**, **16b**) using the phosphoramidite method are described. The resulting diastereoisomer mixtures were separated into the pure components by chromatographical means. All synthetic intermediates were characterized by TLC, elemental analysis, and UV and ¹H-NMR spectra.

1. Introduction. – Establishment of an antiviral state in cells results from a multitude of biochemical changes induced by interferons and involving several proteins in a cascade of reactions [2–4]. One of the proteins is the enzyme 2'-5'A synthetase, which is activated upon binding to double-stranded RNA [5] and converts then ATP into a series of (2'-5')-linked adenylate oligonucleotides containing a 5'-terminal triphosphate function [6]. Such oligomers carrying a 5'-di- or 5'-triphosphate and consisting of three or more monomer units bind to, and subsequently reversibly activate, an endogenous or sometimes interferon-induced endoribonuclease [7] [8]. The activated endoribonuclease, RNase L, cleaves then messenger and ribosomal RNA's [9], resulting in inhibition of translation. This effect, however, is only transitory, since the 2'-5'A molecules are rapidly cleaved by cellular phosphodiesterases [10] leading to loss of antiviral activity. In order to suppress the digestion of the 2'-5'A oligomers, several synthetic modifications of the native structure were accomplished at the aglycone [11-20], the sugar [21-37], and the phosphate moiety [38-45]. It is well established, mainly due to the pioneering work of Eckstein [46], that phosphorothioate analogues of oligonucleotides are valuable models to study certain stereochemical aspects of enzyme-catalyzed phosphoryl and nucleotidyl transfer reactions.

The first synthesis of phosphorothioate analogues of (2'-5')oligoadenylates were performed by *Nelson*, *Bach*, and *Verheyden* [42] applying the phosphite triester approach in conjunction with sulfur oxidation. Formation of chiral phosphorothioate functions led to diastereoisomeric mixtures of which the dimer cores could be separated chromato-

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graphically, whereas the trimer cores were studied in form of the corresponding diastereoisomeric pairs. It was found [47] that the configuration at the P-atoms markedly affects the biochemical and biological properties of the phosphorothioate analogues of the 2'-5'A core, revealing also a significantly higher enzymatic stability in the (*PS*)- over the (*PR*)-configuration. Furthermore, the synthesis of the two individual diastereoisomeric 2'-5'A trimer cores containing only one phosphorothioate linkage between the middle and the 2'-terminal unit was reported [48].

Finally, we successfully achieved the syntheses and separation of the two 2'-5'A (*PR*)and (*PS*)-dimer cores **6a** and **6b**, respectively, as well as the four diastereoisomeric 2'-5'A (*PR,PR*)-, (*PR,PS*)-, (*PS,PR*)-, and (*PS,PS*)-trimer cores **11a**, **12a**, **11b**, and **12b**, respectively, and accomplished the configurational assignment of the new chiral centers by HPLC, charge separation, ³¹P-NMR spectra and enzymatic hydrolyses [49] [50]. It was also demonstrated that the configuration of the internucleotidic phosphorothioate linkages does not affect the binding to RNase L but markedly controls the activation process [51]. Activation decreases in the order (*PR,PR*) > (*PS,PR*) > (*PR,PS*), whereas the (*PS,PS*)-2'-5'A trimer core and its 5'-monophosphate can be considered as effective inhibitors, which bind strongly to RNase L, but are unable to activate the enzyme up to concentrations as high as 10^{-3} and 10^{-5} M, respectively. We now describe the detailed synthesis of the dimers **6a, b** and the trimers **11a, b** and **12a, b** as well as of the corresponding 5'-monophosphates **15a, b** and **16a, b** on a preparative scale.

2. Syntheses. – The chemical syntheses of the pure diastereoisomeric 2'-5'A dimer and trimer cores on a preparative scale in solution were achieved by the phosphoramidite



Scheme (cont.)



approach, sulfur oxidation, and subsequent separation of the isomers by silica-gel chromatography. In the first step, N^6 -benzoyl-3'-O-[(*tert*-butyl)dimethylsilyl]-5'-O-(monomethoxytrityl)adenosine (1) [52] was converted by chloro[2-(4-nitrophenyl)ethoxy](octahydro-1*H*-azonin-1-yl)phosphane [53] into the corresponding phosphoramidite **2** in 97% yield. This building block was then condensed with N^6 -benzoyl-2',3'-bis-O-[(*tert*-butyl)- dimethylsilyl]adenosine (3) in MeCN in presence of 3-nitro-1*H*-1,2,4-triazole and subsequent oxidation by sulfur in pyridine to give the corresponding fully protected 2'-5'A phosphorothioate dimers **4a** and **4b** as a diastereoisomer mixture. These isomers could be separated by silica-gel chromatography on prep. TLC plates using CH₂Cl₂/hexane/AcOEt 1:1:1. The faster running component **4a** was obtained in 42% yield and turned out to possess the (*PR*)-configuration, whereas the slower moving diastereoisomer **4b** with (*PS*)-configuration was isolated in 28% yield. Detritylation of these compounds using 2% 4-toluenesulfonic acid in CH₂Cl₂/MeOH 4:1 afforded in yields of *ca*. 90% the 5'-OH components **5a** and **5b**, respectively, which were then separately condensed again with the phosphoramidite **2** in an analogous manner. Subsequent sulfur oxidation yielded the two new diastereoisomeric pairs **7a**(*PR*,*PR*)/**7b**(*PS*,*PR*) from **5a** and **9a**(*PR*,*PS*)/**9b**(*PS*,*PS*) from **5b**, respectively. Separation into the pure components was achieved again by prep. TLC on silica gel to give, always in higher yields, the faster moving isomer which has in all cases the (*PR*)-configuration.

The four diastereoisomeric 2'-5'A trimer cores 7a, 7b, 9a, and 9b were then detritylated in the usual manner to the corresponding 5'-OH derivatives 8a, 8b, 10a, and 10b, respectively, which were furthermore converted by reaction with (2,5-dichlorophenyl)phosphoditriazolide and subsequent treatment with 2-(4-nitrophenyl)ethanol into their fully protected 5'-O-phosphotriesters 13a, 13b, 14a, and 14b in yields of 70–80%.

The final deblocking of the various protecting groups from the dimers **5a** and **5b** and from the trimers **9a**, **9b**, **10a**, and **10b** was achieved by subsequent treatment 1) with DBU (1,8-diazabicyclo[5.4.0]undec-7-ene) in abs. pyridine to eliminate the 2-(4-nitrophenyl)ethyl group, 2) with Bu_4NF in THF for removal of the (*tert*-butyl)dimethylsilyl groups, and 3) with conc. ammonia to cleave the benzoyl groups. The resulting dimers **6a** and **6b** and the corresponding trimers **11a**, **11b**, **12a**, and **12b**, respectively, were isolated and purified by *DEAE-Sephadex* column chromatography using a linear gradient of (Et₃NH)HCO₃ and subsequent purification by paper chromatography in i-PrOH/conc. NH₃/H₂O 7:1:2.

The deprotection of the fully protected 5'-O-phosphoryl trimers 13a, 13b, 14a, and 14b afforded one additional step: removal of the 2,5-dichlorophenoxy group by use of triethylammonium 4-nitrobenzaldehyde oximate was followed by the described treatment with DBU, Bu_4NF , and NH_3 to give, after the purification procedures, the corresponding 5'-O-monophosphate phosphorothioate analogues 15a, 15b, 16a, and 16b of (2'-5') adenylate trimer in 68–74% isolated yields.

3. Physical Data. – The characterization of the protected nucleotides was performed by C,H,N analyses, UV spectra, ¹H- and ³¹P-NMR spectra, and their chromatographic behaviour (see *Table*). The ¹H-NMR spectra were difficult to analyse due to many overlapping signals; therefore, only some distinct signals like those of the aglycones, the anomeric protons, and the MeO group are reported to help finding the anticipated reaction product during the isolation procedures. The ³¹P-NMR data and the HPLC retention times of the blocked oligonucleotides were already reported elsewhere [50].

$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	$ \begin{array}{c c c c c c c c c c c c c c c c c c c $			UV Spects	ra (MeOH)	¹ H-NMR Spectra (CDCl ₃ , δ	[ppm])		³¹ P-NMR Spectra	TLC
2 20 447 612 (d) 4 (PR) 21 4.66 6.11 (d), 5.87 (d) 8.66 (s), 8.00 (s) 8.19 (s), 8.17 (s) 155.27 (s) 4 (PS) 231 4.66 6.31 (d), 5.84 (d) 8.66 (s), 8.00 (s) 8.19 (s), 8.17 (s) 90.32 0.460 (s) 5 (PS) 231 4.70 6.51 (d), 5.54 (d) 8.72 (s, 8.60 (s) 8.36 (s, 8.10 (s) 9.32 (s, 110 (s) 9.32 (s, 120 (s) 9.32	2 20 447 612 (d) 4 (PR) 231 4.60 6.31 (d), 5.87 (d) 8.66 (s), 8.06 (s) 8.19 (s), 8.17 (s) 155.21 4 (PS) 231 4.60 6.31 (d), 5.87 (d) 8.66 (s), 8.06 (s) 8.19 (s), 8.17 (s) 0.921 0.54% 5 (PS) 231 4.00 6.30 (d), 5.94 (d) 8.72 (s), 8.62 (s) 8.26 (s), 8.16 (s) 0.923 (s) 0.946 (s) 5 (PS) 233 4.00 6.50 (d), 5.94 (d) 8.72 (s), 8.62 (s) 8.26 (s), 8.16 (s) 0.923 (s) 0.37 (s) 6 (PS) 233 4.00 6.51 (d), 5.94 (d) 8.73 (s), 8.62 (s), 8.53 (s) 8.26 (s), 8.16 (s) 0.923 (s) 0.37 (s) 7.3 (PR) 230 4.70 6.01 (d), 5.94 (d) 8.73 (s), 8.83 (s), 8.23 (s) 8.23 (s), 8.11 (s) 0.34 (s) 0.37 (s) 7.3 (PR) 230 4.73 6.11 (d), 5.29 (d) 8.71 (s), 8.63 (s), 8.53 (s) 8.24 (s) 7.81 (s) 9.24 (s) 9.24 (s) 9.24 (s) 9.24 (s) 9.24 (s) 9.24 (s)			λ _{max} [nm]	lge	H-C(1')	H-C(8)	H-C(2)	(CDCl ₃)	$R_{ m f}$
4(P.R) 231 406 $6.31(d), 5.87(d)$ $8.66(), 8.60(c)$ $8.19(6), 8.17(c)$ 6.931 0.591 0.547 b(PS) 231 4.00 $6.97(d), 5.94(d)$ $8.72(), 8.67(c)$ $8.26(s), 8.16(s)$ 6.921 0.467 53(PS) 237 4.70 $6.97(d), 5.94(d)$ $8.22(s), 8.75(s)$ $8.25(s), 8.01(s)$ 0.922 0.467 b(PS) 238 4.70 $6.17(d), 5.24(d)$ $8.22(s), 8.75(s)$ $8.20(s, 8.16(s))$ $8.24(s), 7.86(s)$ 0.920 0.277 b(PS) 238 4.70 $6.17(d), 5.24(d)$ $8.72(s), 8.65(s), 8.57(s)$ $8.20(s, 8.11(s), 8.01(s)$ 0.920 0.277 b(PS) PR) 239 4.78 $6.22(d), 6.17(d), 5.24(d)$ $8.72(s), 8.65(s), 8.57(s)$ $8.20(s, 8.11(s), 8.01(s)$ 0.920 0.920 b(PS) PR) $231(s)$ 4.73 $6.21(d), 6.03(d), 5.84(d)$ $8.77(s), 8.65(s), 8.57(s)$ $8.20(s, 8.11(s), 8.01(s)$ 0.920 0.920 b(PS) PR) $231(s)$ 4.73 $6.11(d), 6.03(d), 5.84(d)$ $8.77(s), 8.65(s), 8.57(s)$ $8.20(s, 3.11(s), 8.01(s)$ $0.75(s)$ b(PS) PR) $231(s)$ 4.73 $6.11(d), 6.03(d), 5.84(d)$ $8.71(s), 8.65(s), 8.24(s)$ $8.20(s, 3.11(s), 9.01(s)$ 0.47^3 b(PS) PR) $231(s)$ 4.73 $6.11(d), 6.03(d), 5.84(d)$ $8.71(s), 8.65(s), 8.24(s)$ $8.20(s, 8.11(s), 9.01(s)$ 0.47^3 b(PS) PR) $231(s)$ 4.73 $6.11(d), 6.01(d), 5.84(s), 8.64(s), 8.65(s), 8.24(s)$	4 (P3) 231 4.60 6.31 (d) 5.87 (d) 8.66 (b) 8.00 (c) 8.19 (b), 8.17 (c) 6631 0.547 b (P3) 237 4.00 6.39 (d), 5.94 (d) 8.72 (a), 8.65 (a) 8.26 (b), 8.16 (b) 6022 0.467 5 (P3) 238 4.70 607 (d), 5.94 (d) 8.72 (a), 8.75 (a) 8.26 (b), 8.13 (b) 607 (a), 5.94 (d) 8.72 (a), 8.75 (a) 8.26 (a), 8.13 (b) 6.92 (a), 0.11 b (P3) 238 4.70 607 (d), 5.24 (d) 8.72 (a), 8.85 (a), 8.53 (a) 8.26 (a), 8.11 (a), 5.80 (a) 9.76 (a)	14		230 277	4.47	6.12 (<i>d</i>)		-	155.27 154.01	
	$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	4a	(PR)	231	4.66	6.31(d), 5.87(d)	8.68 (s), 8.60 (s)	8.19 (s), 8.17 (s)	18.69	0.54 ^a)
5 (P) 27 4.0 6.04 (A): 5.84 (A) 8.25 (A): 8.75 (A) 8.25 (A): 8.24 (A) 0.27 (A)	5 (R_3) 273 4.70 $607(d)$, $594(d)$ $8.20(s, 387(s))$ $202(s)$ 20300 2030 2030 <th>-</th> <th>(Sd)</th> <th>211</th> <th>4.70 4.69</th> <th>(P) 20 (P) 2 07 (P)</th> <th>8 72 (s) 8 62 (s)</th> <th>8 26 (s) 8 18 (s)</th> <th>69 22</th> <th>0.46^a)</th>	-	(Sd)	211	4.70 4.69	(P) 20 (P) 2 07 (P)	8 72 (s) 8 62 (s)	8 26 (s) 8 18 (s)	69 22	0.46 ^a)
5a (PR) 278 4.70 6.07 (d), 5.94 (d) 8.82 (s), 8.75 (s) 8.23 (s), 8.23 (s) 9.27 (s) 0.27 (s) 0.32 (s) b (PS) 258 4.70 6.13 (d), 5.90 (d) 8.74 (s), 8.73 (s) 8.23 (s), 8.24 (s) 9.33 (s), 9.18 (s) 0.30 (s)	5a (PR) 278 4.70 607(d), 534(d) 8.72(s, 187(s)) 8.25(s, 18.03(s)) 0.277(s) 0.275(s)	2		277	4.70					(21.22
	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	5a	(PR)	278	4.70	6.07(d), 5.94(d)	8.82 (s), 8.75 (s)	8.25(s), 8.03(s)		$0.27^{\rm a}$), $0.15^{\rm b}$)
6a (PR) 238() $614(d)$ $8.24(a)$ $8.24(a)$ $736(a)$ $736(a)$ $736(a)$ $9300, 69.47$ 0.29^{0} 7a (PR,PR) 239 4.78 $6.21(d), 5.92(d)$ $8.23(a, 2.14)^{4}$ $8.24(a)$ $8.61(a), 8.86(a), 8.55(a)$ $8.20(a, 811(b), 801(c)$ $6930, 69.47$ 0.38^{0} b (PS,PR) 230 4.78 $6.21(d), 6.17(d), 5.84(d)$ $8.67(a), 8.65(a), 8.55(a)$ $8.20(a, 31H)$ $6.17(a), 0.30^{1}$ 0.42^{1} 0.38^{0} b (PS,PR) 231(sh) 4.64 $6.11(d), 5.34(d)$ $8.70(a), 8.55(a), 8.55(a)$ $8.20(m, 3H)$ 0.42^{1} 0.42^{1} b (PS,PR) 231(sh) 4.64 $6.11(d), 6.34(d), 5.36(d)$ $8.71(a), 8.65(a), 8.55(a)$ $8.20(m, 3H)$ 0.42^{1} 0.29^{1} b (PS,PR) 231(sh) 4.64 $6.11(d), 6.34(d), 5.39(d)$ $8.71(a), 8.65(a), 8.55(a)$ $8.20(m, 3H)$ 0.42^{1} b (PS,PR) 231(sh) 4.73 $6.12(d), 6.13(d), 5.39(d)$ $8.71(a), 8.65(a), 8.25(a)$ $8.20(m, 3H)$ <td< th=""><th>6a (PR) 238 $6.14(4), 5.34(4)$ $8.23(s, 3HY)$ $7.39(s')$ 7.657 2.637 2.613° 0.30° 7a (PR) 238 $6.17(4), 5.34(4)$ $8.32(s, 2HY)$ $8.23(s, 1), 8.01(s)$ $9.80(s, 9.47)$ 0.30° 7a (PR, PR) 239 4.78 $6.23(4), 6.08(4), 5.84(4)$ $8.67(s), 8.65(s), 8.55(s)$ $8.23(s, 1), 8.01(s)$ $9.60(s, 9.47)$ 0.30° 8a (PR, PR) 231(sh) 4.64 $6.11(d), 6.03(d), 5.84(d)$ $8.77(s), 8.65(s), 8.55(s)$ $8.20(m, 3H)$ 0.42° 9a (PR, PR) 231(sh) 4.64 $6.11(d), 6.03(d), 5.84(d)$ $8.77(s), 8.65(s), 8.55(s)$ $8.20(m, 3H)$ 0.42° 9a (PR, PS) 231(sh) 4.72 $6.19(d), 6.13(d), 5.84(d), 8.60(s), 8.55(s)$ $8.21(s), 8.13(m, 2H)$ 0.42° 9a (PR, PS) 231(sh) 4.77 $6.13(d), 6.30(d)$ $8.71(s), 8.60(s), 8.55(s)$ $8.21(s), 8.13(m, 2H)$ 0.42° 9a (PR, PS) 231(sh) 4.77 $6.13(d), 6.13(d), 5.80(d)$ $8.71(s), 8.6$</th><th>Ą</th><th>(PS)</th><th>278</th><th>4.70</th><th>6.13(d), 5.90(d)</th><th>8.74 (s), 8.73 (s)</th><th>8.26 (s), 8.24 (s)</th><th></th><th>0.30^{a}), 0.18^{b})</th></td<>	6a (PR) 238 $6.14(4), 5.34(4)$ $8.23(s, 3HY)$ $7.39(s')$ 7.657 2.637 2.613° 0.30° 7a (PR) 238 $6.17(4), 5.34(4)$ $8.32(s, 2HY)$ $8.23(s, 1), 8.01(s)$ $9.80(s, 9.47)$ 0.30° 7a (PR, PR) 239 4.78 $6.23(4), 6.08(4), 5.84(4)$ $8.67(s), 8.65(s), 8.55(s)$ $8.23(s, 1), 8.01(s)$ $9.60(s, 9.47)$ 0.30° 8a (PR, PR) 231(sh) 4.64 $6.11(d), 6.03(d), 5.84(d)$ $8.77(s), 8.65(s), 8.55(s)$ $8.20(m, 3H)$ 0.42° 9a (PR, PR) 231(sh) 4.64 $6.11(d), 6.03(d), 5.84(d)$ $8.77(s), 8.65(s), 8.55(s)$ $8.20(m, 3H)$ 0.42° 9a (PR, PS) 231(sh) 4.72 $6.19(d), 6.13(d), 5.84(d), 8.60(s), 8.55(s)$ $8.21(s), 8.13(m, 2H)$ 0.42° 9a (PR, PS) 231(sh) 4.77 $6.13(d), 6.30(d)$ $8.71(s), 8.60(s), 8.55(s)$ $8.21(s), 8.13(m, 2H)$ 0.42° 9a (PR, PS) 231(sh) 4.77 $6.13(d), 6.13(d), 5.80(d)$ $8.71(s), 8.6$	Ą	(PS)	278	4.70	6.13(d), 5.90(d)	8.74 (s), 8.73 (s)	8.26 (s), 8.24 (s)		0.30^{a}), 0.18^{b})
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	b (PR, PR) 238 $6.17(d_1, 5.92(d^2))$ $8.33(s, 2Hb)$ $8.34(s_1, 788(s))$ 56.13° 0.38° b (PR, PR) 230 4.78 $6.23(d_1, 6.08(d_1, 5.84(d))$ $8.67(s), 8.65(s), 8.55(s)$ $8.23(s), 8.11(s)$ 56.13° 0.38° b (PS, PR) 230 4.78 $6.23(d_1, 6.03(d_1, 5.84(d))$ $8.67(s), 8.65(s), 8.55(s)$ $8.20(s), 8.11(s)$ 0.24° 0.16° 0.24° b (PS, PR) 231(sh) 4.66 $611(d_1, 6.03(d_1, 5.84(d))$ $8.67(s), 8.55(s)$ $8.20(m, 3H)$ 0.24° 0.24° b (PS, PR) 231(sh) 4.66 $611(d_1, 6.10(d_1, 5.84(d))$ $8.71(s), 8.61(s)$ $8.20(m, 3H)$ 0.24° 0.16° 0.24° b (PS, PR) 231 $8.71(s), 8.61(s), 8.61(s), 8.61(s)$ $8.21(s), 8.13(m, 2H)$ 0.24° 0.16° 0.24° b (PS, PS) 230 4.73 $6.23(d_1, 5.90(d)$ $8.71(s), 8.61(s), 8.61(s), 8.61(s)$ $8.21(s), 8.21(s), 8.13(s)$ 0.24° 0.24°	6a	(PR)	258°)		$6.14(d), 5.81(d)^{d}$	$8.22(s, 3H)^{d}$	$7.79(s)^{d}$	57.63°)	0.29 ^b)
Ta (PR,PR) 230 478 6.23 (d), 6.08 (d), 5.84 (d) 8.60 (s), 8.53 (s) 8.20 (s), 8.11 (s), 8.01 (s) 69.80, 69.47 0.38 ^b b (PS,PR) 238 430 6.11 (d), 6.03 (d), 5.84 (d) 8.67 (s), 8.65 (s), 8.53 (s) 8.20 (s), 8.11 (s), 8.01 (s) 69.80, 69.47 0.38 ^b b (PS,PR) 231 (sh) 4.64 6.11 (d), 6.03 (d), 5.84 (d) 8.67 (s), 8.65 (s), 8.53 (s) 8.20 (m, 3H) 0.42 ^b 0.24 ^b b (PS,PR) 231 (sh) 4.72 6.19 (d), 6.10 (d), 5.84 (d) 8.67 (s), 8.65 (s), 8.53 (s) 8.20 (m, 3H) 0.24 ^b 0.24 ^b b (PS,PR) 231 (sh) 4.72 6.19 (d), 6.10 (d), 5.83 (d) 8.71 (s), 8.66 (s), 8.55 (s) 8.20 (m, 3H) 0.24 ^b 0.24 ^b b (PS,PS) 230 4.73 6.19 (d), 5.93 (d) 8.71 (s), 8.66 (s), 8.65 (s), 8.25 (s) 8.20 (m, 3H) 0.24 ^b 0.24 ^b b (PS,PS) 230 4.73 6.11 (d), 6.10 (d), 5.93 (d) 8.71 (s), 8.61 (s), 8.61 (s) 8.20 (m, 3H) 0.24 ^c 0.24 ^b b (PS,PS) <th>Ta (<i>Rs, PR</i>) 230 478 6.23 (d), 6.08 (d), 5.84 (d) 8.66 (s), 8.55 (s) 8.20 (s), 8.11 (s), 8.01 (s) 69.80, 69.47 0.389 b (<i>PS, PR</i>) 238 4.90 6.23 (d), 6.17 (d), 5.84 (d) 8.67 (s), 8.65 (s), 8.55 (s) 8.23 (m, 3H) 0.42⁹ 8a (<i>PS, PR</i>) 231 (sh) 4.72 6.11 (d), 6.03 (d), 5.84 (d) 8.67 (s), 8.65 (s), 8.55 (s) 8.20 (m, 3H) 0.126⁹ 9a (<i>PR, PR</i>) 231 (sh) 4.72 6.19 (d), 6.13 (d), 5.93 (d) 8.71 (s), 8.66 (s), 8.65 (s), 8.23 (s) 8.23 (m, 3H) 0.16⁹ 0.24⁹ 9a (<i>PR, PS</i>) 230 4.78 6.27 (d), 6.13 (d), 5.93 (d) 8.71 (s), 8.60 (s) 8.21 (s), 8.13 (m, 2H) 0.16⁹ 0.24⁹ 9a (<i>PR, PS</i>) 230 4.78 6.27 (d), 6.13 (d), 5.91 (d) 8.71 (s), 8.60 (s), 8.51 (s) 8.21 (s), 8.13 (m, 2H) 0.16⁹ 0.24⁹ 10a (<i>PR, PS</i>) 231 (s) 8.71 (s), 8.67 (s), 8.65 (s), 8.25 (s), 8.21 (s), 8.13 (m, 2H) 0.12⁹ 0.12⁹ 10a (<i>PR, PS</i>) 231 (s) 8.71 (s), 8.67 (s), 8.65 (s), 8.2</th> <th>م</th> <th>(PS)</th> <th>258°)</th> <th></th> <th>$(6.17 (d), 5.92 (d)^{d})$</th> <th>8.32 (s, 2H)^d)</th> <th>$8.24(s), 7.98(s)^{d}$</th> <th>56.13°)</th> <th>0.30^{b})</th>	Ta (<i>Rs, PR</i>) 230 478 6.23 (d), 6.08 (d), 5.84 (d) 8.66 (s), 8.55 (s) 8.20 (s), 8.11 (s), 8.01 (s) 69.80, 69.47 0.389 b (<i>PS, PR</i>) 238 4.90 6.23 (d), 6.17 (d), 5.84 (d) 8.67 (s), 8.65 (s), 8.55 (s) 8.23 (m, 3H) 0.42 ⁹ 8a (<i>PS, PR</i>) 231 (sh) 4.72 6.11 (d), 6.03 (d), 5.84 (d) 8.67 (s), 8.65 (s), 8.55 (s) 8.20 (m, 3H) 0.126 ⁹ 9a (<i>PR, PR</i>) 231 (sh) 4.72 6.19 (d), 6.13 (d), 5.93 (d) 8.71 (s), 8.66 (s), 8.65 (s), 8.23 (s) 8.23 (m, 3H) 0.16 ⁹ 0.24 ⁹ 9a (<i>PR, PS</i>) 230 4.78 6.27 (d), 6.13 (d), 5.93 (d) 8.71 (s), 8.60 (s) 8.21 (s), 8.13 (m, 2H) 0.16 ⁹ 0.24 ⁹ 9a (<i>PR, PS</i>) 230 4.78 6.27 (d), 6.13 (d), 5.91 (d) 8.71 (s), 8.60 (s), 8.51 (s) 8.21 (s), 8.13 (m, 2H) 0.16 ⁹ 0.24 ⁹ 10a (<i>PR, PS</i>) 231 (s) 8.71 (s), 8.67 (s), 8.65 (s), 8.25 (s), 8.21 (s), 8.13 (m, 2H) 0.12 ⁹ 0.12 ⁹ 10a (<i>PR, PS</i>) 231 (s) 8.71 (s), 8.67 (s), 8.65 (s), 8.2	م	(PS)	258°)		$(6.17 (d), 5.92 (d)^{d})$	8.32 (s, 2H) ^d)	$8.24(s), 7.98(s)^{d}$	56.13°)	0.30^{b})
	$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	7а	(PR, PR)	230	4.78	6.23(d), 6.08(d), 5.84(d)	8.69 (s), 8.58 (s), 8.55 (s)	8.20 (s), 8.11 (s), 8.01 (s)	69.80, 69.47	0.58 ^b)
	$ \begin{array}{llllllllllllllllllllllllllllllllllll$			278	4.90					
8a(<i>PR, PR</i>) 238 4.89 4.87 4.89 4.87 $6.11(d), 6.03(d), 5.84(d)$ $8.67(s), 8.55(s), 8.55(s)$ $8.09(m, 3H)$ $0.24^b)$ 9a(<i>PS, PR</i>) $231(sh)$ 4.72 4.87 $6.19(d), 6.10(d), 5.86(d)$ $8.70(s), 8.65(s), 8.54(s)$ $8.20(m, 3H)$ $0.16^{a}, 0.30^{b}$ 9a(<i>PR, PS</i>) $231(sh)$ 4.72 4.87 $6.13(d), 5.33(d)$ $8.71(s), 8.61(s), 8.60(s)$ $8.21(s), 8.13(m, 2H)$ $0.16^{a}, 0.34^{b}$ 9a(<i>PR, PS</i>) 230 278 4.78 4.90 $6.27(d), 6.13(d), 5.90(d)$ $8.71(s), 8.61(s)$ $8.21(s), 8.13(m, 2H)$ $0.14^{3}b$ 10a(<i>PR, PS</i>) 230 278 4.78 4.90 $6.27(d), 6.20(d)$ $8.71(s), 8.61(s)$ $8.22(m, 3H)$ 0.12^{b} 11a(<i>PR, PS</i>) $231(sh)$ 4.70 	8 (<i>PR,PR</i>) $\frac{278}{231}$ 4.89 6.11 (<i>d</i>), 6.03 (<i>d</i>), 5.84 (<i>d</i>) 8.67 (6), 8.65 (s), 8.55 (s) 8.09 (<i>m</i> , 3H) 0.24 ^h 0.37 $\frac{278}{231}$ 4.87 6.19 (<i>d</i>), 6.03 (<i>d</i>), 5.86 (<i>d</i>) 8.70 (s), 8.65 (s), 8.54 (s) 8.20 (<i>m</i> , 3H) 0.16 ^h , 0.36 $\frac{27}{231}$ 5.10 4.72 6.19 (<i>d</i>), 6.13 (<i>d</i>), 5.98 (<i>d</i>) 8.71 (s), 8.61 (s) 8.60 (s) 8.21 (s), 8.13 (<i>m</i> , 2H) 0.54 ^h 0.54 $\frac{278}{238}$ 4.78 6.27 (<i>d</i>), 6.13 (<i>d</i>), 5.93 (<i>d</i>) 8.71 (s), 8.61 (s) 8.20 (s) 8.21 (s), 8.19 (s) 0.43 ^h 0.54 ^h 1.78 $\frac{273}{230}$ 4.78 6.27 (<i>d</i>), 6.13 (<i>d</i>), 5.90 (<i>d</i>) 8.71 (s), 8.65 (s) 8.22 (<i>m</i> , 3H) 0.12 ^h 0.43 ^h 1.77 (s) 2.23 (s) 4.78 6.27 (d), 6.10 (d), 5.90 (d) 8.71 (s), 8.65 (s) 8.22 (<i>m</i> , 3H) 0.12 ^h 1.77 (s) 2.27 (s) 8.19 (s) 2.27 (s) 8.23 (s) 8.23 (s) 8.10 (s) 7.90 (s) 7.70 (s) 7.95 (s) 7.73 (s) 7.95 (s) 7.54 (s) 7.95 (s) 7.54 (s) 7.55 (s) 7.55 (s) 0.12 ^h 1.71 (<i>PR,PS</i>) 2.28 (<i>d</i>) 4.66 (<i>d</i>), 5.93 (<i>d</i>) 8.23 (s) 8.16 (s), 8.13 (s) 7.90 (s) 7.70 (s) 7.95 (s) 7.73 (s) 7.55 (s)	q	(PS, PR)	230	4.78	6.22(d), 6.17(d), 5.84(d)	8.67 (s), 8.60 (s), 8.57 (s)	8.23 (<i>m</i> , 3H)		0.42 ^b)
8a (<i>PR, PR</i>)231(si) 4.64 $6.11(d)$, $6.03(d)$, $5.84(d)$ $8.67(s)$, $8.55(s)$ $8.09(m, 3H)$ 0.24° b (<i>P5, PR</i>)231 4.87 4.87 $6.19(d)$, $6.10(d)$, $5.86(d)$ $8.70(s)$, $8.65(s)$, $8.54(s)$ $8.20(m, 3H)$ 0.16° , 0.30° 9a (<i>P5, PS</i>)230 4.78 $6.27(d)$, $6.13(d)$, $5.90(d)$ $8.71(s)$, $8.61(s)$ $8.21(s)$, $8.13(m, 2H)$ 0.43° 9a (<i>P5, PS</i>)230 4.78 $6.27(d)$, $6.22(d)$, $5.90(d)$ $8.71(s)$, $8.61(s)$ $8.27(s)$, $8.19(s)$ 0.43° 10a (<i>P5, PS</i>)230 4.78 $6.27(d)$, $6.20(d)$ $8.71(s)$, $8.67(s)$, $8.65(s)$ $8.27(s)$, $8.19(s)$ 0.43° 10a (<i>P5, PS</i>)231(sh) 4.70 $6.17(d)$, $6.06(d)$, $5.90(d)$ $8.71(s)$, $8.65(s)$ $8.22(m, 3H)$ 0.12° 10a (<i>P5, PS</i>)231(sh) 4.70 $6.17(d)$, $6.06(d)$, $5.90(d)$ $8.71(s)$, $8.65(s)$ $8.22(s)$, $8.22(s)$, $8.20(s)$ 0.12° 11a (<i>PR, PS</i>)231(sh) 4.70 $6.17(d)$, $5.90(d)$ $8.71(s)$, $8.65(s)$ $8.22(s)$, $7.90(s)$ 0.17° 11a (<i>PR, PS</i>)258' $6.04(d)$, $5.91(d)$ $8.33(s)$, $8.16(s)$ $8.23(s)$, $8.16(s)$ $8.22(s)$, $7.36(s)$ 0.17° 11a (<i>PR, PS</i>)258' $6.04(d)$, $5.91(d)$ $8.216(s)$, $8.16(s)$ $8.22(s)$, $7.20(s)$ 0.17° 11a (<i>PR, PS</i>)258' $6.04(d)$, $5.91(d)$ $8.216(s)$, $8.16(s)$ $8.22(s)$, $7.20(s)$ $0.726(s)$ <th>8a (PK,PK) 211 (sh) 4.64 6.11 (d), 6.03 (d), 5.84 (d) 8.67 (s), 8.65 (s), 8.54 (s) 8.09 (m, 3H) 0.24³) b (PS,PK) 211 (sh) 4.72 6.19 (d), 6.10 (d), 5.86 (d) 8.70 (s), 8.65 (s), 8.54 (s) 8.20 (m, 3H) 0.16⁶), 0.37 277 4.87 6.27 (d), 6.13 (d), 5.93 (d) 8.71 (s), 8.66 (s) 8.21 (s), 8.13 (m, 2H) 0.54⁵) b (PS,PS) 230 4.78 6.27 (d), 6.12 (d), 5.90 (d) 8.71 (s), 8.66 (s), 8.61 (s) 8.21 (s), 8.13 (m, 2H) 0.54⁵) c (PR,PS) 230 4.78 6.27 (d), 6.12 (d), 5.90 (d) 8.71 (s), 8.66 (s), 8.62 (s), 8.22 (s), 8.22 (s), 8.19 (s) 0.43⁵) d (PR,PS) 231 (sh) 4.70 6.17 (d), 6.06 (d), 5.90 (d) 8.71 (s), 8.66 (s), 8.65 (s) 8.22 (s), 8.22 (s), 8.19 (s) 0.12⁵) d (PR,PS) 231 (sh) 4.70 6.17 (d), 6.10 (d), 5.91 (d) 8.73 (s), 8.69 (s), 8.65 (s) 8.22 (s), 8.20 (s) 7.90 (s), 7.70 (s)⁴) b (PS,PS) 231 (sh) 4.66 6.18 (d), 6.10 (d), 5.81 (s), 8.16 (s), 8.13 (s)⁴ 8.09 (s), 7.90 (s), 7.70 (s)⁴) c (PR,PS) 238 6.04 (d), 5.92 (d), 5.81 (d)⁶ 8.23 (s), 8.16 (s), 8.03 (s), 7.90 (s), 7.70 (s)⁴) b (PS,PS) 238 6.04 (d), 5.92 (d), 5.81 (d)⁶ 8.23 (s), 8.13 (s)⁴ 8.09 (s), 7.90 (s), 7.70 (s)⁴) c (PR,PS) 238 6.04 (d), 5.92 (d), 5.81 (d)⁶ 8.23 (s), 8.13 (s)⁶ 8.03 (s), 7.90 (s), 7.70 (s)⁴) c (PR,PS) 238 6.04 (d), 5.92 (d), 5.81 (d)⁶ 8.23 (s), 8.16 (s), 8.13 (s)⁶ 8.03 (s), 7.90 (s), 7.70 (s)⁶) c (PR,PS) 238 6.04 (d), 5.92 (d), 5.81 (d)⁶ 8.23 (s), 8.16 (s), 8.10 (s), 8.03 (s), 7.90 (s), 7.70 (s)⁴) c (PR,PS) 238 6.04 (d), 5.92 (d), 5.81 (d)⁶ 8.23 (s), 8.16 (s), 8.12 (s)⁶ (s), 7.90 (s), 7.70 (s)⁶) c (PR,PS) 238 6.04 (d), 5.92 (d), 5.81 (d)⁶ 8.23 (s), 8.16 (s), 8.12 (s), 8.10 (s), 7.20 (s), 7.70 (s)⁶) b (PS,PS) 238 6.04 (d), 5.92 (d), 5.81 (d)⁶ 8.21 (s), 8.12 (s), 8.12 (s), 7.20 (s), 7.70 (s)⁶) c (PR,PS) 238 6.04 (d), 5.92 (d), 5.92 (d), 5.92 (d), 5.92 (d), 5.92 (s), 8.12 (s), 8.10 (s), 7.20 (s), 7.70 (s)⁶) c (PR,PS) 238 6.02 (d), 5.92 (d), 5.92 (d), 5.92 (d), 5.92 (s), 8.12 (s), 8.10 (s), 7.20 (s), 7.70 (s), 7.16 (s), 7.55 (</th> <th></th> <th></th> <th>278</th> <th>4.89</th> <th></th> <th></th> <th></th> <th></th> <th></th>	8a (PK,PK) 211 (sh) 4.64 6.11 (d), 6.03 (d), 5.84 (d) 8.67 (s), 8.65 (s), 8.54 (s) 8.09 (m, 3H) 0.24 ³) b (PS,PK) 211 (sh) 4.72 6.19 (d), 6.10 (d), 5.86 (d) 8.70 (s), 8.65 (s), 8.54 (s) 8.20 (m, 3H) 0.16 ⁶), 0.37 277 4.87 6.27 (d), 6.13 (d), 5.93 (d) 8.71 (s), 8.66 (s) 8.21 (s), 8.13 (m, 2H) 0.54 ⁵) b (PS,PS) 230 4.78 6.27 (d), 6.12 (d), 5.90 (d) 8.71 (s), 8.66 (s), 8.61 (s) 8.21 (s), 8.13 (m, 2H) 0.54 ⁵) c (PR,PS) 230 4.78 6.27 (d), 6.12 (d), 5.90 (d) 8.71 (s), 8.66 (s), 8.62 (s), 8.22 (s), 8.22 (s), 8.19 (s) 0.43 ⁵) d (PR,PS) 231 (sh) 4.70 6.17 (d), 6.06 (d), 5.90 (d) 8.71 (s), 8.66 (s), 8.65 (s) 8.22 (s), 8.22 (s), 8.19 (s) 0.12 ⁵) d (PR,PS) 231 (sh) 4.70 6.17 (d), 6.10 (d), 5.91 (d) 8.73 (s), 8.69 (s), 8.65 (s) 8.22 (s), 8.20 (s) 7.90 (s), 7.70 (s) ⁴) b (PS,PS) 231 (sh) 4.66 6.18 (d), 6.10 (d), 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$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{llllllllllllllllllllllllllllllllllll$	8a	(PR, PR)	231 (sh)	4.64	6.11(d), 6.03(d), 5.84(d)	8.67 (s), 8.65 (s), 8.55 (s)	8.09 (m, 3H)		$0.24^{\rm b}$)
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9a (<i>PR,PS</i>) 237 4.87 $6.27(d), 6.13(d), 5.93(d)$ $8.71(s), 8.60(s)$ $8.21(s), 8.13(m, 2H)$ 0.54^{b} b (<i>PS,PS</i>) 230 4.78 $6.27(d), 6.22(d), 5.90(d)$ $8.71(s), 8.64(s), 8.61(s)$ $8.27(s), 8.22(s), 8.19(s)$ 0.43^{b} 10a (<i>PR,PS</i>) 230 4.78 $6.27(d), 6.22(d), 5.90(d)$ $8.71(s), 8.67(s), 8.65(s)$ $8.27(s), 8.22(s), 8.19(s)$ 0.43^{b} 10a (<i>PR,PS</i>) $231(sh)$ 4.70 $6.17(d), 6.06(d), 5.90(d)$ $8.71(s), 8.65(s)$ $8.27(s), 8.22(s), 8.19(s)$ 0.17^{b} b (<i>PS,PS</i>) $231(sh)$ 4.70 $6.17(d), 6.10(d), 5.91(d)$ $8.71(s), 8.65(s)$ $8.25(s), 8.22(s), 8.20(s)$ 0.17^{b} b (<i>PS,PS</i>) $231(sh)$ 4.66 $6.18(d), 6.10(d), 5.91(d)$ $8.73(s), 8.65(s)$ $8.25(s), 8.22(s), 8.20(s)$ 0.17^{b} b (<i>PS,PR</i>) 238^{s} $6.04(d), 5.92(d), 5.78(d)^{4}$ $8.23(s), 8.16(s), 7.90(s), 7.70(s)^{4}$ $57.45, 57.71^{c}$ 0.52^{b} b (<i>PS,PR</i>) 258^{s} $6.04(d), 5.92(d), 5.80(d)^{4}$ $8.21(s), 8.10(s), 7.70(s)^{4}$ $57.45, 57.71^{c}$ 0.52^{b} b (<i>PS,PR</i>) 258^{s} $6.04(d), 5.92(d), 5.81(d)^{4}$ $8.21(s), 8.10(s), 7.70(s)^{4}$ $57.45, 57.71^{c}$ 0.52^{b} b (<i>PS,PR</i>) 258^{s} $6.04(d), 5.92(d), 5.80(d)^{4}$ $8.21(s), 8.10(s), 7.70(s)^{4}$ $57.45, 57.71^{c}$ 0.52^{b} b (<i>PS,PR</i>) 258^{s} $6.04(d), 5.92(d), 5.80(d)^{4}$ $8.21(s), 8.10(s), 7.70(s)^{4}$ $7.68(s)^{4}$ <	9a (<i>PR,PS</i>) 277 4.87 6.27 (<i>d</i>), 6.13 (<i>d</i>), 5.93 (<i>d</i>) 8.71 (5), 8.60 (5) 8.21 (<i>s</i>), 8.13 (<i>m</i> , 2H) 0.54 ^b) b (<i>PS,PS</i>) 230 4.78 6.27 (<i>d</i>), 6.22 (<i>d</i>), 5.90 (<i>d</i>) 8.71 (5), 8.64 (s), 8.61 (<i>s</i>) 8.21 (<i>s</i>), 8.19 (<i>s</i>) 0.43 ^b) 278 4.90 6.17 (<i>d</i>), 6.06 (<i>d</i>), 5.90 (<i>d</i>) 8.71 (<i>s</i>), 8.67 (<i>s</i>), 8.65 (<i>s</i>) 8.22 (<i>m</i> , 3H) 0.12 ^b) b (<i>PS,PS</i>) 231 (<i>sh</i>) 4.70 6.17 (<i>d</i>), 6.06 (<i>d</i>), 5.91 (<i>d</i>) 8.73 (<i>s</i>), 8.67 (<i>s</i>), 8.65 (<i>s</i>) 8.22 (<i>m</i> , 3H) 0.12 ^b) b (<i>PS,PS</i>) 231 (<i>sh</i>) 4.70 6.17 (<i>d</i>), 6.06 (<i>d</i>), 5.91 (<i>d</i>) 8.73 (<i>s</i>), 8.69 (<i>s</i>), 8.65 (<i>s</i>) 8.22 (<i>s</i>), 8.22 (<i>s</i>), 8.20 (<i>s</i>) 0.17 ^b) b (<i>PS,PS</i>) 231 (<i>sh</i>) 4.66 6.18 (<i>d</i>), 6.10 (<i>d</i>), 5.91 (<i>d</i>) 8.73 (<i>s</i>), 8.69 (<i>s</i>), 8.65 (<i>s</i>) 8.25 (<i>s</i>), 8.22 (<i>s</i>), 8.20 (<i>s</i>) 0.17 ^b) b (<i>PS,PS</i>) 231 (<i>sh</i>) 4.66 6.18 (<i>d</i>), 6.10 (<i>d</i>), 5.91 (<i>d</i>) 8.13 (<i>s</i>), 8.16 (<i>s</i>), 8.13 (<i>s</i>) ^d 8.09 (<i>s</i>), 7.70 (<i>s</i>) ^d 57.45, 57.71 ^b 0.17 ^b) b (<i>PS,PR</i>) 238 4.66 6.04 (<i>d</i>), 5.92 (<i>d</i>), 5.80 (<i>d</i>) ^d 8.15 (<i>s</i>), 8.16 (<i>s</i>), 8.16 (<i>s</i>), 7.36 (<i>s</i>), 7.36 (<i>s</i>) 0.52 ^d) 0.52 ^d) 11a (<i>PR,PS</i>) 2389 6.04 (<i>d</i>), 5.92 (<i>d</i>), 5.81 (<i>d</i>) ^b 8.12 (<i>s</i>), 8.16 (<i>s</i>), 7.36 (<i>s</i>), 7.36 (<i>s</i>) ^d 9.56.45, 57.55 ^d 0.52 ^d , 5.50, 56.26 ^d 9.57.54 (5.37) 1.54 (5.37) 1.54 (5.37) 1.54 (5.37) 1.54 (5.37) 1.54 (5.37) 1.54 (5.37) 1.54 (5.37) 1.54 (5.37) 1.55 (<i>PS,PR</i>) 2589 6.012 (<i>d</i>), 5.82 (<i>d</i>), 8.11 (<i>d</i>), 8.12 (<i>s</i>), 8.11 (<i>s</i>), 7.36 (<i>s</i>), 7.36 (<i>s</i>), 7.66 (<i>s</i>), 7.64 (<i>s</i>), 7.54 (<i>s</i> , 7.54 (<i>s</i> , 7.55 (<i>s</i>	A	(PS, PR)	231 (sh)	4.72	6.19(d), 6.10(d), 5.86(d)	8.70(s), 8.65(s), 8.54(s)	8.20 (m, 3H)		0.16^{a}), 0.30^{b})
9a (PR.PS)230 4.78 $6.27(d), 6.13(d), 5.93(d)$ $8.71(s), 8.60(s)$ $8.21(s), 8.13(m, 2H)$ 0.54°) b (PS.PS)238 4.90 $6.27(d), 6.22(d), 5.90(d)$ $8.71(s), 8.64(s), 8.61(s)$ $8.27(s), 8.22(s), 8.19(s)$ 0.43°) 10a (PS.PS)231(sh) 4.70 $6.17(d), 6.06(d), 5.90(d)$ $8.71(s), 8.65(s)$ $8.22(m, 3H)$ 0.12°) 10a (PS.PS)231(sh) 4.70 $6.17(d), 6.06(d), 5.90(d)$ $8.71(s), 8.65(s)$ $8.22(m, 3H)$ 0.12°) b (PS.PS)231(sh) 4.66 $6.18(d), 6.10(d), 5.90(d)$ $8.71(s), 8.65(s)$ $8.22(s), 8.22(s), 8.20(s)$ 0.12°) b (PS.PS)231(sh) 4.66 $6.18(d), 6.10(d), 5.80(d)$ $8.73(s), 8.65(s)$ $8.22(s), 8.20(s)$ 0.25°) b (PS.PS)231(sh) 4.66 $6.18(d), 5.80(d)^{\circ}$ $8.33(s), 8.16(s), 8.13(s)^{\circ}$ $8.09(s), 7.70(s)^{d}$ $57.45, 57.71^{\circ}$ 0.25°) b (PS.PR)2588) $6.09(d), 5.80(d)^{\circ}$ $8.21(s), 8.16(s), 8.13(s)^{\circ}$ $8.09(s), 7.70(s)^{d}$ $57.45, 57.71^{\circ}$ 0.25°) b (PS.PR)2588) $6.09(d), 5.92(d), 5.81(d)^{\circ}$ $8.21(s), 8.16(s), 8.10(s), 7.70(s)^{d}$ $57.45, 57.71^{\circ}$ 0.25° b (PS.PR)2588) $6.09(d), 5.92(d), 5.81(d)^{\circ}$ $8.21(s), 8.10(s), 7.70(s)^{\circ}$ $57.45, 57.49^{\circ}$ 0.25° b (PS.PR)2588) $6.09(d), 5.92(d), 5.81(d)^{\circ}$ $8.21(s), 8.10(s), 7.70(s)^{\circ}$ $7.66(s), 7.76(s)^{\circ}$ 0.25°	9a (<i>PR.PS</i>) 230 4.78 6.27 (<i>d</i>), 6.13 (<i>d</i>), 5.93 (<i>d</i>) 8.71 (5), 8.60 (<i>s</i>) 8.21 (<i>s</i>), 8.13 (<i>m</i> , 2H) 0.54 ⁵) 10a (<i>PS.PS</i>) 230 4.78 6.27 (<i>d</i>), 6.22 (<i>d</i>), 5.90 (<i>d</i>) 8.71 (<i>s</i>), 8.64 (<i>s</i>), 8.61 (<i>s</i>) 8.27 (<i>s</i>), 8.22 (<i>s</i>), 8.19 (<i>s</i>) 0.43 ⁵) 10a (<i>PR.PS</i>) 231 (<i>s</i> h) 4.70 6.17 (<i>d</i>), 6.06 (<i>d</i>), 5.90 (<i>d</i>) 8.71 (<i>s</i>), 8.65 (<i>s</i>) 8.22 (<i>m</i> , 3H) 0.12 ⁶) 10a (<i>PR.PS</i>) 231 (<i>s</i> h) 4.70 6.17 (<i>d</i>), 6.06 (<i>d</i>), 5.90 (<i>d</i>) 8.71 (<i>s</i>), 8.65 (<i>s</i>) 8.22 (<i>m</i> , 3H) 0.12 ⁶) 11a (<i>PR.PS</i>) 231 (<i>s</i> h) 4.66 6.18 (<i>d</i>), 6.10 (<i>d</i>), 5.91 (<i>d</i>) 8.73 (<i>s</i>), 8.65 (<i>s</i>) 8.25 (<i>s</i>), 8.22 (<i>s</i>), 8.20 (<i>s</i>) 7.70 (<i>s</i>) 7.76 (<i>s</i>) 0.12 ⁶) 11a (<i>PR.PS</i>) 231 (<i>s</i> h) 4.66 6.18 (<i>d</i>), 5.92 (<i>d</i>) 5.81 (<i>s</i>) 8.15 (<i>s</i> , 2H) ³ (<i>s</i>) 8.09 (<i>s</i>), 7.90 (<i>s</i>), 7.70 (<i>s</i>) 7.75 (<i>s</i>) 0.22 ⁷) 11a (<i>PR.PS</i>) 238 ⁵ 6.04 (<i>d</i>), 5.92 (<i>d</i>), 5.81 (<i>s</i>), 8.15 (<i>s</i> , 2H) ³ (<i>s</i>) 8.05 (<i>s</i>), 7.90 (<i>s</i>), 7.70 (<i>s</i>) 6.62 (<i>s</i> , 57.55° 0.52 ⁶) 12a (<i>PR.PS</i>) 238 ⁵ 6.04 (<i>d</i>), 5.92 (<i>d</i>), 5.82 (<i>d</i>) ⁹ 8.23 (<i>s</i>), 8.16 (<i>s</i>), 8.11 (<i>s</i>) 7.92 (<i>s</i>), 7.76 (<i>s</i>) ⁴ 5.62, 57.55° 0.52 ⁷) 12a (<i>PR.PR</i>) 258 ⁵ 6.04 (<i>d</i>), 5.92 (<i>d</i>), 5.82 (<i>d</i>) ⁹ 8.15 (<i>s</i> , 2H) ⁹ 8.05 (<i>s</i> , 7.79 (<i>s</i>), 7.76 (<i>s</i>) ⁴ 5.63, 5.62, 57.55° 0.52 ⁷) 12a (<i>PR.PR</i>) 258 ⁵ 6.04 (<i>d</i>), 5.92 (<i>d</i>), 5.82 (<i>d</i>) ⁹ 8.15 (<i>s</i> , 8.11 (<i>s</i>), 8.16 (<i>s</i> , 7.19) (<i>s</i>), 7.76 (<i>s</i>) ⁴ 5.63, 5.62, 57.55° 0.52 ⁷) 15a (<i>PR.PR</i>) 258 ⁵ 6.04 (<i>d</i>), 5.92 (<i>d</i>), 5.82 (<i>d</i>) ⁹ 8.21 (<i>s</i>), 8.11 (<i>s</i>) 7.92 (<i>s</i>), 7.78 (<i>s</i>) ⁴ 0.550, 56.26 ⁵ 0.52 ⁷ 0.52 ⁷ 0.52 ⁷ 0.52 ⁷ 0.72 ⁸ 0.728 (<i>s</i>) 7.78 (<i>s</i>) ⁴ 0.550, 56.26 ⁵ 0.52 ⁶ 0.52			277	4.87					
	b (<i>PS,PS</i>) $2.00 + 7.80 + 7.90 + 7.70 + 7.590 (d) 8.71 (s), 8.64 (s), 8.61 (s) 8.27 (s), 8.22 (s), 8.19 (s) 0.43b) 0.43b$ 10a (<i>PR,PS</i>) $2.31 (sh) + 4.70 + 7.71 (d), 6.06 (d), 5.90 (d) 8.71 (s), 8.67 (s), 8.62 (s) 8.22 (m, 3H) 0.12b) 0.12b (PS,PS) 2.2131 (sh) 4.66 + 6.18 (d), 6.10 (d), 5.91 (d) 8.73 (s), 8.65 (s) 8.22 (s), 8.20 (s) 0.12^{b} (s) 1.71 (s), 8.65 (s) 1.71 (s), 8.65 (s) 1.71 (s), 8.65 (s) 1.71 (s) 0.12^{b} (s) 1.11 (PR,PS) 2.2131 (sh) 4.66 + 6.18 (d), 5.91 (d) 8.33 (s), 8.16 (s), 8.13 (s)^{d} 8.09 (s), 7.70 (s)^{d} 5.745 (s) 7.70 (s)^{d} 5.62 (s) 7.71 (s) 0.52^{d} (s) 1.12 (PR,PS) 2.288 + 6.04 (d), 5.92 (d) 5.80 (d) 8.23 (s), 8.16 (s), 8.13 (s)^{d} 8.05 (s), 7.70 (s)^{d} 5.65 (s) 7.73 (s)^{d} 0.22^{d} (s) 1.24 (PR,PS) 2.288 + 6.04 (d), 5.92 (d) 5.81 (d) 9.81.5 (s, 2H)^{d} 8.05 (s), 7.70 (s)^{d} 5.65 (s) 7.76 (s)^{d} 0.22^{d} (s) 1.26 (s) 1.26 (s) 1.79 (s) 7.71 (s) 1.72 (s) 1.71 (s) 1.25 (s) 1.72 (s) 1.71 (s) 1.25 (s) 1.21 (s) 1.$	9a	(PR,PS)	230	4.78	6.27(d), 6.13(d), 5.93(d)	8.71(s), 8.61(s), 8.60(s)	8.21 (s), 8.13 (m, 2H)		0.54 ^b)
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	b (PS,PS) 230 4.78 6.27 (d), 6.22 (d), 5.90 (d) 8.71 (s), 8.64 (s), 8.61 (s) 8.27 (s), 8.19 (s) 0.13 ^b) 0.12 ^b) 10a (PR,PS) 231 (sh) 4.70 6.17 (d), 6.06 (d), 5.90 (d) 8.71 (s), 8.67 (s), 8.62 (s) 8.22 (n, 3H) 0.17 ^b) b (PS,PS) 231 (sh) 4.66 6.18 (d), 6.10 (d), 5.91 (d) 8.73 (s), 8.69 (s), 8.65 (s) 8.22 (n, 3H) 0.17 ^b) 11a (PR,PS) 231 (sh) 4.66 6.18 (d), 6.10 (d), 5.91 (d) 8.73 (s), 8.66 (s) 8.13 (s), 8.25 (s), 8.22 (s), 8.20 (s) 0.17 ^b) 0.17 ^b) 11a (PR,PS) 238° 6.04 (d), 5.92 (d), 5.78 (d) ^d 8.33 (s), 8.16 (s), 8.13 (s) ^d 8.09 (s), 7.70 (s) ^d 5.745, 57.71° 0.52 ^f) 12a (PR,PS) 258° 6.04 (d), 5.91 (d) 5.80 (d) ^d 8.23 (s), 8.16 (s), 8.13 (s) ^d 8.09 (s), 7.70 (s) ^d 5.662, 57.55° 0.52 ^f) 12a (PR,PS) 258° 6.04 (d), 5.91 (d) 5.81 (d) ^d 8.21 (s), 8.10 (s, 2H) ^d 8.05 (s), 7.96 (s), 7.66 (s), 7.66 (s), 6.25 ^f) 0.52 ^f) 12a (PR,PS) 258° 6.04 (d), 5.91 (d) 5.81 (d) ^d 8.21 (s), 8.11 (s) ^d 7.98 (s), 7.96 (s), 7.66 (s) ^d 5.50, 56.26 ^f) 0.52 ^f) 12a (PR,PS) 258° 6.04 (d), 5.95 (d), 5.82 (d) 8.15 (s), 8.11 (s) ^d 7.99 (s), 7.78 (s) ^d 7.68 (s) ^d 0.52 ^f) 0.52 ^f) 12a (PR,PS) 258° 6.04 (d), 5.95 (d), 5.82 (d), 8.11 (s) ^d 7.99 (s), 7.96 (s), 7.68 (s) ^d 0.562, 57.55 ^f 0.52 ^f) 0.52 ^f] 12a (PR,PS) 258° 6.05 (d), 5.95 (d), 5.82 (d), 8.11 (s) ^d 7.98 (s), 7.96 (s), 7.68 (s) ^d 0.562, 57.55 ^f 0.52 ^f] 0.52 ^f] 12a (PR,PS) 258° 6.03 (d), 5.95 (d), 5.82 (d), 8.11 (s) ^d 7.98 (s), 7.98 (s), 7.88 (s), 7.88 (s) 7.96 (s), 7.96 (s			017	4.90					-
10a(<i>PR,PS</i>)231 (sh)4.706.17 (d), 6.06 (d), 5.90 (d)8.71 (s), 8.67 (s), 8.62 (s)8.22 (m, 3H)0.12 ^b)b(<i>PS,PS</i>)231 (sh)4.876.18 (d), 6.10 (d), 5.91 (d)8.73 (s), 8.65 (s)8.25 (s), 8.20 (s)0.17 ^b)0.17 ^b)11a(<i>PS,PS</i>)231 (sh)4.666.18 (d), 5.92 (d), 5.78 (d) ^d 8.33 (s), 8.16 (s), 8.13 (s) ^d 8.09 (s), 7.70 (s) ^d 5.645, 57.71'0.52 ^f)12a(<i>PS,PS</i>)258'6.04 (d), 5.92 (d), 5.78 (d) ^d 8.23 (s), 8.15 (s, 2H) ^d)8.09 (s), 7.70 (s) ^d 5.645, 57.71'0.52 ^f)12a(<i>PS,PS</i>)258'6.04 (d), 5.92 (d), 5.81 (d) ^d 8.23 (s), 8.15 (s, 2H) ^d)8.06 (s), 7.70 (s) ^d 5.65.45, 57.71'0.52 ^f)12a(<i>PS,PS</i>)258'6.04 (d), 5.92 (d), 5.81 (d)^d8.23 (s), 8.11 (s)^d8.06 (s), 7.70 (s) ^d 56.50, 56.26')0.52 ^f)12a(<i>PS,PS</i>)258'6.04 (d), 5.92 (d), 5.92 (d), 5.81 (d)^d8.21 (s), 8.11 (s)^d7.99 (s), 7.70 (s) ^d 56.50, 56.26')0.52 ^f)15a(<i>PS,PS</i>)258'6.04 (d), 5.92 (d), 5.81 (d)^d8.21 (s), 8.11 (s)^d7.99 (s), 7.70 (s) ^d 56.50, 56.26')0.28 ^f)15a(<i>PS,PS</i>)258'6.04 (d), 5.92 (d), 5.92 (d), 5.14 (d)^d8.21 (s), 8.11 (s)^d7.99 (s), 7.78 (s)^d0.52 ^f)0.18 ^g)15a(<i>PS,PS</i>)258'6.03 (d), 5.95 (d), 5.92 (d), 5.14 (s), 8.21 (s), 8.11 (s)^d8.04 (s), 7.29 (s), 7.78 (s)^d0.18 ^g)0.18 ^g)16a(<i>PS,PS</i>)258'6.09 (d), 5.94 (d), 5.94 (d	10a (<i>PR,PS</i>) 231 (sh) 4.70 6.17 (<i>d</i>), 6.06 (<i>d</i>), 5.90 (<i>d</i>) 8.71 (s), 8.67 (s), 8.62 (s) 8.22 (<i>m</i> , 3H) 0.12 ^b) b (<i>PS,PS</i>) 231 (sh) 4.66 6.18 (<i>d</i>), 6.10 (<i>d</i>), 5.91 (<i>d</i>) 8.73 (s), 8.65 (s) 8.25 (s), 8.20 (s) 7.00 (s), 7.70 (s) ^d 57.45, 57.71 ^b) 0.17 ^b) b (<i>PS,PS</i>) 231 (sh) 4.66 6.18 (<i>d</i>), 6.90 (<i>d</i>), 6.81 (<i>s</i>), 8.15 (s, 2H) ^d 8.09 (s), 7.90 (s), 7.70 (s) ^d 57.45, 57.71 ^b) 0.52 ^f) b (<i>PS,PR</i>) 258° 6.04 (<i>d</i>), 5.91 (<i>d</i>) 8.23 (s), 8.15 (s, 2H) ^d 8.05 (s), 7.90 (s), 7.70 (s) ^d 56.62, 57.55 ^g) 0.52 ^f) b (<i>PS,PR</i>) 258° 6.04 (<i>d</i>), 5.91 (<i>d</i>) 8.23 (s), 8.16 (s), 8.09 (s), 7.90 (s), 7.70 (s) ^d 56.62, 57.55 ^g) 0.52 ^f) b (<i>PS,PR</i>) 258° 6.04 (<i>d</i>), 5.92 (<i>d</i>), 5.81 (<i>d</i>) ^d 8.13 (s), 8.10 (s, 2H) ^d) 8.05 (s), 7.96 (s), 7.76 (s) ^d 56.62, 57.55 ^g) 0.52 ^f) b (<i>PS,PR</i>) 258° 6.04 (<i>d</i>), 5.92 (<i>d</i>), 5.81 (<i>d</i>) ^d 8.11 (s), 8.10 (s, 2H) ^d) 8.00 (s), 7.70 (s) ^d 56.62, 57.55 ^g) 0.52 ^f) b (<i>PS,PR</i>) 258° 6.04 (<i>d</i>), 5.92 (<i>d</i>), 5.81 (<i>d</i>) ^d 8.11 (s), 8.10 (s, 2H) ^d) 8.00 (s), 7.70 (s) ^d 56.50, 56.26 ^g) 0.52 ^f) b (<i>PS,PR</i>) 258° 6.04 (<i>d</i>), 5.92 (<i>d</i>), 5.14 (<i>d</i>) 8.21 (s), 8.11 (s), 8.12 (s), 8.10 (s), 7.70 (s) ^d) 56.50, 56.26 ^g) 0.52 ^f } 0.52 ^f) b (<i>PS,PR</i>) 258° 6.04 (<i>d</i>), 5.92 (<i>d</i>), 5.14 (<i>d</i>) 8.21 (s), 8.12 (s), 8.12 (s) ^d) 7.99 (s), 7.74 (s), 7.28 (s) ^d) 0.52 ^f 0.52 ^f } 0.52 ^f) b (<i>PS,PR</i>) 258° 6.04 (<i>d</i>), 5.94 (<i>d</i>), 5.94 (<i>d</i>), 8.25 (s), 8.11 (s) ^d 8.04 (s), 7.39 (s), 7.81 (s) ^d] 0.18 ^g b (<i>PS,PS</i>) 258° 6.09 (<i>d</i>), 5.94 (<i>d</i>), 5.82 (<i>d</i>), 8.25 (<i>s</i>), 8.14 (<i>s</i>), 8.26 (<i>s</i>), 7.80 (<i>s</i>), 7.80 (<i>s</i>), 7.80 (<i>s</i>) ^d 0.018 ^g) b (<i>PS,PS</i>) 258° 6.09 (<i>d</i>), 5.94 (<i>d</i>), 5.82 (<i>d</i>), 8.25 (<i>s</i>), 8.14 (<i>s</i>), 8.20 (<i>s</i>), 7.94 (<i>s</i>), 7.78 (<i>s</i>) 7.80 (<i>s</i>) ^d 0.018 ^g) b (<i>PS,PS</i>) 258° 6.09 (<i>d</i>), 5.94 (<i>d</i>), 5.82 (<i>d</i>), 8.25 (<i>s</i>), 8.14 (<i>s</i>), 8.20 (<i>s</i>), 7.93 (<i>s</i>), 7.80 (<i>s</i>), 7.80 (<i>s</i>), 9.018 ^g) b (<i>PS,PS</i>) 258° 6.09 (<i>d</i>), 5.94 (<i>d</i>), 5.82 (<i>d</i>), 8.216 (<i>s</i>), 8.14 (<i>s</i>), 8.20 (<i>s</i>), 7.39 (<i>s</i>), 7.80 (<i>s</i>), 7.80 (<i>s</i>), 9.018 ^g) 0.18 ^g	۰ ۹	(PS,PS)	230 278	4.78 4.90	6.27(d), 6.22(d), 5.90(d)	8.71 (s), 8.64 (s), 8.61 (s)	8.27 (s), 8.22 (s), 8.19 (s)		0.43 ^b)
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{llllllllllllllllllllllllllllllllllll$	10a	(PR, PS)	231 (sh)	4.70	(6.17 (d), 6.06 (d), 5.90 (d)	8.71 (s), 8.67 (s), 8.62 (s)	8.22 (<i>m</i> , 3H)		0.12 ^b)
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{llllllllllllllllllllllllllllllllllll$			277	4.87			~ ~ ~		
2784.864.866.04 (d), 5.92 (d), 5.78 (d)^d)8.33 (s), 8.16 (s), 8.13 (s)^d)8.09 (s), 7.90 (s), 7.70 (s)^d) $57.45, 57.71^\circ$ 0.52° b (PS,PR)258°6.09 (d), 6.00 (d), 5.80 (d)^d)8.23 (s), 8.15 (s, 2H)^d)8.05 (s), 7.70 (s)^d) $56.42, 57.57^\circ$ 0.52° 12a (PS,PR)258°6.09 (d), 6.00 (d), 5.80 (d)^d)8.27 (s), 8.15 (s, 2H)^d)8.05 (s), 7.70 (s)^d) $56.42, 57.57^\circ$ 0.52° 12a (PS,PR)258°6.09 (d), 5.95 (d), 5.81 (d)^d)8.15 (s, 2H)^d)8.05 (s), 7.70 (s)^d) $56.52, 56.34^\circ$ 0.52° b (PS,PS)258°6.04 (d), 5.95 (d), 5.81 (d)^d)8.15 (s), 8.10 (s), 7.79 (s), 7.78 (s)^d) $56.50, 56.26^\circ$ 0.52° b (PS,PR)258°6.04 (d), 5.95 (d), 5.95 (d), 5.92 (d), 5.14 (s)^G)8.12 (s)^d, 7.98 (s), 7.78 (s)^d) $56.50, 56.26^\circ$ 0.52° b (PS,PR)258° $6.04 (d), 5.92 (d), 5.92 (d), 5.14 (d)^G)$ 8.24 (s), 8.11 (s)^d $7.99 (s), 7.78 (s)^d$ $56.50, 56.26^\circ$ 0.28° b (PS,PR)258° $6.04 (d), 5.92 (d), 5.76 (d)^5, 8.21 (s), 8.11 (s)^d$ $7.99 (s), 7.78 (s)^d$ 0.18° b (PS,PS)258° $6.03 (d), 5.92 (d), 5.92 (d), 5.92 (d), 5.82 (s), 8.12 (s)^d$ $8.04 (s), 7.73 (s)^d$ 0.18° b (PS,PS)258° $6.09 (d), 5.94 (d), 5.94 (d), 5.82 (s), 8.14 (s)^d$ $8.04 (s), 7.79 (s), 7.78 (s)^d$ 0.18° b (PS,PS)258° $6.09 (d), 5.94 (d), 5.94 (d), 5.82 (s), 8.14 (s)^d$ $8.04 (s), 7.79 (s), 7.78 (s)^d$ 0.18° </th <th>11a (<i>PR,PS</i>) 258' 4.86 11a (<i>PR,PS</i>) 258' 6.04 (<i>d</i>), 5.92 (<i>d</i>), 5.78 (<i>d</i>)^d 8.33 (s), 8.16 (s), 8.13 (s)^d 8.09 (s), 7.70 (s)^d 57.45, 57.71' 0.52' 0.52' 1, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10</th> <th>q</th> <th>(PS,PS)</th> <th>231 (sh)</th> <th>4.66</th> <th>6.18(d), 6.10(d), 5.91(d)</th> <th>8.73 (s), 8.69 (s), 8.65 (s)</th> <th>8.25 (s), 8.22 (s), 8.20 (s)</th> <th></th> <th>0.17^b)</th>	11a (<i>PR,PS</i>) 258' 4.86 11a (<i>PR,PS</i>) 258' 6.04 (<i>d</i>), 5.92 (<i>d</i>), 5.78 (<i>d</i>) ^d 8.33 (s), 8.16 (s), 8.13 (s) ^d 8.09 (s), 7.70 (s) ^d 57.45, 57.71' 0.52' 0.52' 1 , 10, 10, 10, 10, 10, 10, 10, 10, 10, 10	q	(PS,PS)	231 (sh)	4.66	6.18(d), 6.10(d), 5.91(d)	8.73 (s), 8.69 (s), 8.65 (s)	8.25 (s), 8.22 (s), 8.20 (s)		0.17 ^b)
11a (<i>PR,PS</i>)258°) $6.04(d)$, $5.92(d)$, $5.78(d)^d$ $8.33(s)$, $8.16(s)$, $8.13(s)^d$ $8.09(s)$, $7.70(s)^d$ 57.45 , 57.71^c 0.52^f b (<i>PS,PR</i>)258°) $6.09(d)$, $6.00(d)$, $5.80(d)^d$ $8.23(s)$, $8.15(s)$, 211^d $8.05(s)$, $7.90(s)$, $7.70(s)^d$ $56.62, 57.55^s$ 0.52^f b (<i>PS,PR</i>)258°) $6.04(d)$, $5.91(d)$, $5.81(d)^d$ $8.23(s)$, $8.15(s)$, $8.10(s)$ $8.05(s)$, $7.96(s)$, $7.68(s)^d$ $56.62, 57.55^s$ 0.52^f b (<i>PS,PS</i>)258°) $6.04(d)$, $5.92(d)$, $5.81(d)^d$ $8.12(s)$, $8.10(s, 211)^d$ $8.06(s)$, $7.78(s)^d$ $56.50, 56.26^s$ 0.52^f b (<i>PS,PR</i>)258°) $6.04(d)$, $5.92(d)$, $5.82(d)^d$ $8.116(s)$, $8.10(s, 211)^d$ $8.04(s)$, $7.28(s)^d$ $56.50, 56.26^s$ 0.52^f b (<i>PS,PR</i>)258°) $6.04(d)$, $5.92(d)$, $5.74(d)^d$ $8.21(s)$, $8.118(s)$ $8.12(s)^d$ $7.98(s)$, $7.78(s)^d$ $56.50, 56.26^s$ 0.18^s b (<i>PS,PR</i>)258°) $6.03(d)$, $5.92(d)$, $5.74(d)^d$ $8.26(s)$, $8.11(s)^d$ $7.99(s)$, $7.78(s)^d$ $56.50, 56.26^s$ 0.18^s b (<i>PS,PR</i>)258°) $6.03(d)$, $5.92(d)$, $5.74(d)^d$ $8.26(s)$, $8.11(s)^d$ $8.04(s)$, $7.78(s)^d$ $56.50, 56.26^s$ 0.18^s b (<i>PS,PS</i>)258°) $6.03(d)^2$, $5.92(d)^2$, $5.92(d)^2$, $8.21(s)$, $8.11(s)^d$ $8.04(s)$, $7.94(s)$, $7.78(s)^d$ 0.18^s b (<i>PS,PS</i>)258° $6.03(d)^2$, $5.92(d)^2$, $5.92(d)^2$, $5.92(d)^2$, $5.92(s)^2$, $7.80(s)^2$ $0.18(s)$ 0.18^s	11a (<i>PR.PS</i>) 258°) 604 (<i>d</i>), 5.92 (<i>d</i>), 5.78 (<i>d</i>) ^d 8.33 (s), 8.16 (s), 8.13 (s) ^d 8.09 (s), 7.70 (s) ^d 57.45, 57.71°) 0.52 ^f b (<i>PS.PR</i>) 258°) 609 (<i>d</i>), 600 (<i>d</i>), 5.80 (<i>d</i>) ^d 8.23 (s), 8.15 (s, 2H) ^d 8.05 (s), 7.90 (s), 7.70 (s) ^d 56.62, 57.55° 0.52 ^f 12a (<i>PR.PS</i>) 258°) 609 (<i>d</i>), 600 (<i>d</i>), 5.81 (<i>d</i>) ^d 8.13 (s), 8.10 (s), 7.90 (s), 7.70 (s) ^d 56.62, 57.55° 0.52 ^f 15a (<i>PR.PS</i>) 258°) 600 (<i>d</i>), 5.91 (<i>d</i>), 8.15 (s), 8.10 (s, 2H) ^d 8.05 (s), 7.96 (s), 7.76 (s) ^d 56.62, 57.55° 0.52 ^f 0.52 ^f 15a (<i>PS.PS</i>) 258°) 600 (<i>d</i>), 5.92 (<i>d</i>), 8.11 (s)			278	4.86					
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{llllllllllllllllllllllllllllllllllll$	11a	(PR,PS)	258°)		$6.04 (d), 5.92 (d), 5.78 (d)^{d}$	$8.33(s), 8.16(s), 8.13(s)^{d}$	$8.09(s), 7.90(s), 7.70(s)^{d}$	57.45, <i>57.7</i> 1°)	0.52 ^f)
12a(<i>PR.PS</i>)258°) $6.04(d)$, $5.91(d)$, $5.81(d)^4$ $8.27(s)$, $8.16(s)$, $8.09(s)$ $8.05(s)$, $7.68(s)^4$ 57.54 , 56.34° 0.52° b(<i>PS.PS</i>)258°) $6.05(d)$, $5.95(d)$, $5.82(d)^4$ $8.15(s)$, $8.10(s, 2H)^4$ $8.04(s)$, $7.28(s)^4$ $56.50, 56.26^\circ$ 0.52° 15a(<i>PR.PR</i>)258°) $6.04(d)$, $5.92(d)$, $5.74(d)^4$ $8.115(s)$, $8.118(s)$, $8.12(s)^4$ $7.98(s)$, $7.38(s)^4$ $56.50, 56.26^\circ$ 0.52° b(<i>PS.PR</i>)258°) $6.04(d)$, $5.92(d)$, $5.74(d)^4$ $8.21(s)$, $8.11(s)^4$ $7.98(s)$, $7.38(s)^4$ $56.50, 56.26^\circ$ 0.18° b(<i>PS.PR</i>)258°) $6.04(d)$, $5.92(d)$, $5.76(d)^4$ $8.26(s)$, $8.21(s)$, $8.11(s)^4$ $7.99(s)$, $7.38(s)^7$ $56.50, 56.26^\circ$ 0.18° b(<i>PS.PR</i>)258°) $6.03(d)$, $5.92(d)$, $5.76(d)^4$ $8.26(s)$, $8.21(s)$, $8.11(s)^4$ $7.99(s)$, $7.38(s)^7$ 0.18° b(<i>PS.PR</i>)258°) $6.03(d)$, $5.92(d)$, $5.92(d)$, $5.82(d)^5$ $8.26(s)$, $8.14(s)^4$ $8.04(s)$, $7.99(s)$, $7.38(s)^4$ 0.18° b(<i>PS.PS</i>)258° $6.09(d)$, $5.94(d)$, $8.41(s)$, $8.26(s)$, $8.14(s)^4$ $8.07(s)$, $7.29(s)$ $7.99(s)^7$ $9(s)^2$ b(<i>PS.PS</i>) $258°$ $6.09(d)$, $5.94(d)$, $5.81(d)^3$ $8.26(s)$, $8.14(s)^4$ $8.07(s)$, $8.02(s)$, $7.78(s)^4$ 0.18° b(<i>PS.PS</i>) $258°$ $6.09(d)$, $5.94(d)$, $5.94(d)$, $5.81(d)^3$ $8.14(s)$ $8.14(s)$ $8.07(s)$, $7.78(s)^2$ 9° 0.18°	12a (<i>PR,PS</i>) 258') $6.04 (d)$, 5.91 (d), 5.81 (d) ^d 8.27 (s), 8.16 (s), 8.09 (s) 8.05 (s), 7.68 (s) ^d 57.54, 56.34 ^e 0.52') 15 b (<i>PS,PS</i>) 258') $6.05 (d)$, 5.95 (d), 5.82 (d) ^d 8.15 (s), 8.10 (s, 2H) ^d 8.04 (s), 7.28 (s) ^d 56.50, 56.26' 0.52') 15 b (<i>PS,PR</i>) 258' $6.04 (d)$, 5.92 (d), 5.82 (d) ^d 8.31 (s), 8.12 (s) ^d 7.98 (s), 7.88 (s) ^d 56.50, 56.26' 0.52') 15 b (<i>PS,PR</i>) 258' $6.04 (d)$, 5.92 (d), 5.92 (d), 5.14 (d) ^d 8.31 (s), 8.12 (s) ^d 7.98 (s), 7.86 (s) ^d 56.50, 56.26' 0.51') 0.18 ') 16a (<i>PS,PR</i>) 258' $6.04 (d)$, 5.95 (d), 5.96 (d) ^d 8.21 (s), 8.11 (s) ^d 7.99 (s), 7.38 (s) ^d 7.94 (s), 7.86 (s) ^d 0.188') 0.18 ') 16a (<i>PR,PS</i>) 258' $6.09 (d)$, 5.94 (d), 5.94 (d), 8.21 (s), 8.14 (s) ^d 8.01 (s), 7.93 (s), 7.78 (s) ^d 0.16') (0.188') 16 (<i>PS,PS</i>) 258' $6.09 (d)$, 5.94 (d), 5.84 (d), 8.26 (s), 8.14 (s), 8.02 (s), 7.94 (s), 7.78 (s) ^d 0.188') 0.18 ') 16 (<i>PS,PS</i>) 258' $6.09 (d)$, 5.94 (d), 5.84 (s), 8.26 (s), 8.14 (s), 8.02 (s), 7.94 (s), 7.93 (s), 7.84 (s), 7.89 (s) 0.18^{g})	q	(PS, PR)	258°)		$(6.09 (d), 6.00 (d), 5.80 (d)^{d})$	$8.23(s), 8.15(s, 2H)^{d}$	$8.05(s), 7.90(s), 7.70(s)^{d}$	56.62, 57.55 ^e)	0.52^{1}
b (<i>PS,PS</i>) 258°) $(6.05 (d), 5.95 (d), 5.82 (d)^3) 8.15 (s), 8.10 (s, 2H)^d) 8.04 (s), 7.29 (s), 7.78 (s)^d) 56.50, 56.26°) 0.52^f)$ 15a (<i>PR,PR</i>) 258°) $(6.04 (d), 5.92 (d), 5.74 (d)^d) 8.31 (s), 8.18 (s), 8.12 (s)^d) 7.98 (s), 7.86 (s), 7.80 (s)^d) 0.18e)$ b (<i>PS,PR</i>) 258°) $(6.12 (d), 5.95 (d), 5.76 (d)^d) 8.26 (s), 8.21 (s), 8.11 (s)^d) 7.99 (s), 7.78 (s)^d) 7.94 (s), 7.86 (s)^d) 0.18e)$ 16a (<i>PR,PS</i>) 258°) $(6.03 (d), 5.92 (d), 5.80 (d)^d) 8.27 (s), 8.21 (s), 8.14 (s)^d) 8.04 (s), 7.78 (s)^d) 7.91 (s)^d) 0.18e)$ 16a (<i>PR,PS</i>) 258°) $(6.03 (d), 5.92 (d), 5.80 (d)^d) 8.27 (s), 8.24 (s), 8.14 (s)^d) 8.04 (s), 7.78 (s)^d) 9.07 (s), 7.81 (s)^d) 0.18e)$ 16a (<i>PR,PS</i>) 258°) $(6.09 (d), 5.94 (d), 5.81 (d)^d) 8.41 (s), 8.26 (s), 8.14 (s)^d) 8.07 (s), 20 (s), 7.78 (s)^d) 0.18^e)$ $(0.18e)$	$ \begin{array}{llllllllllllllllllllllllllllllllllll$	12a	(PR, PS)	258°)		$6.04(d), 5.91(d), 5.81(d)^{d}$	8.27(s), 8.16(s), 8.09(s)	$8.05(s), 7.96(s), 7.68(s)^{d}$	57.54, 56.34 ^e)	0.52 ^f)
15a (<i>PR.PR</i>) 258°) $6.04(d)$, $5.92(d)$, $5.74(d)^d$) $8.31(s)$, $8.12(s)^d$, $7.98(s)$, $7.88(s)$, $7.20(s)^d$) 0.18°) b (<i>PS.PR</i>) 258°) $6.12(d)$, $5.95(d)$, $5.76(d)^d$) $8.26(s)$, $8.21(s)$, $8.11(s)^d$) $7.99(s)$, $7.34(s)$, $7.80(s)^d$) 0.18°) 16a (<i>PR.PS</i>) 258°) $6.03(d)$, $5.92(d)$, $5.80(d)^d$) $8.27(s)$, $8.22(s)$, $8.14(s)^d$) $8.04(s)$, $7.34(s)$, $7.31(s)^d$) 0.18°) b (<i>PS.PS</i>) 258°) $6.03(d)$, $5.92(d)$, $5.81(d)^d$) $8.41(s)$, $8.26(s)$, $8.14(s)^d$) $8.04(s)$, $7.39(s)^d$, $7.31(s)^d$) 0.18°) b (<i>PS.PS</i>) 258°) $6.09(d)$, $5.94(d)$, $5.81(d)^d$) $8.41(s)$, $8.26(s)$, $8.14(s)^d$) $8.07(s)$, $8.02(s)$, $7.78(s)^d$) 0.18°)	15a (PR, PR) 258° $6.04(al)$, $5.92(al)$, $5.74(a)^d$ $8.11(s)$, $8.12(s)^d$ $7.98(s)$, $7.38(s)$, $7.30(s)^d$ 0.18^s b (PS, PR) 258° $6.012(al)$, $5.95(al)$, $5.76(a)^d$ $8.21(s)$, $8.11(s)^d$ $7.99(s)$, $7.38(s)^d$ 0.18^s 0.18^s 16a (PR, PS) 258° $6.03(al)$, $5.92(al)$, $5.80(a)^d$ $8.27(s)$, $8.21(s)^a$ $8.04(s)$, $7.38(s)^d$ 0.18^s 0.18^s 16a (PR, PS) 258° $6.03(al)$, $5.92(al)$, $5.80(a)^d$ $8.21(s)$, $8.15(s)^d$ $8.04(s)$, $7.38(s)^d$ 0.18^s 0.18^s b (PS, PS) 258° $6.09(al)$, $5.91(a)^d$ $8.21(s)$, $8.26(s)$, $8.14(s)^d$ $8.07(s)$, $7.29(s)^d$ 0.18^s 0.18^s b (PS, PS) 258° $6.09(al)$, $5.94(a)$, $5.81(a)^d$ $8.41(s)$, $8.26(s)$, $8.14(s)^d$ $8.07(s)$, $8.02(s)$, $7.39(s)^d$ 0.18^s $a^3)$ SiO ₂ , CH ₂ Cl ₂ /AcOEt/hexane 1:1:1. b) $5iO2$, $CH2Cl2/AcOEt/hexane 1:1:0. c) 0.50^s, 0^s In H2.O. ^s In D2O. ^s In D2O. t) Culloks, i-PrOH/conc. NH3 soln./H2O 6:1 $	q	(PS, PS)	258°)		$6.05(d), 5.95(d), 5.82(d)^{d}$	8.15 (s), 8.10 (s, 2 H) ^d)	$8.04(s), 7.92(s), 7.78(s)^{d}$	56.50, 56.26°)	0.52 ^f)
b (<i>PS</i> , <i>PR</i>) 258°) 6.12 (<i>d</i>), 5.95 (<i>d</i>), 5.76 (<i>d</i>) ^d) 8.26 (<i>s</i>), 8.21 (<i>s</i>), 8.11 (<i>s</i>) ^d) 7.99 (<i>s</i>), 7.36 (<i>s</i>) ^d) 0.186 ^h 0.18 ^b (<i>PR</i> , <i>PS</i>) 258°) 6.03 (<i>d</i>), 5.92 (<i>d</i>), 5.80 (<i>d</i>) ^d) 8.27 (<i>s</i>), 8.22 (<i>s</i>), 8.15 (<i>s</i>) ^d 8.04 (<i>s</i>), 7.73 (<i>s</i>), 7.81 (<i>s</i>) ^d) 0.18 ^b 0.18 ^b (<i>PS</i> , <i>PS</i>) 258°) 6.09 (<i>d</i>), 5.94 (<i>d</i>), 5.81 (<i>s</i>) ^d 8.41 (<i>s</i>), 8.26 (<i>s</i>), 8.14 (<i>s</i>) ^d 8.07 (<i>s</i>), 8.02 (<i>s</i>), 7.89 (<i>s</i>) ^d) 0.18 ^b 0.18 ^b 0.18 ^b	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	15a	(PR, PR)	258°)		$6.04(d), 5.92(d), 5.74(d)^{d}$	$8.31(s), 8.18(s), 8.12(s)^{d}$	$7.98(s), 7.85(s), 7.80(s)^{d}$		0.18^{g}
16a (<i>PR,PS</i>) 258°) 6.03 (<i>d</i>), 5.92 (<i>d</i>), 5.80 (<i>d</i>) ^d) 8.27 (<i>s</i>), 8.15 (<i>s</i>) ^d 8.04 (<i>s</i>), 7.93 (<i>s</i>), 7.81 (<i>s</i>) ^d) 0.18 [§]) b (<i>PS,PS</i>) 258°) 6.09 (<i>d</i>), 5.94 (<i>d</i>), 5.81 (<i>d</i>) ^d) 8.41 (<i>s</i>), 8.14 (<i>s</i>) ^d 8.07 (<i>s</i>), 8.02 (<i>s</i>), 7.89 (<i>s</i>) ^d) 0.18 [§]) 0.18 [§])	16a (PR,PS) 258°) 6.03 (d), 5.92 (d), 5.80 (d) ^d 8.27 (s), 8.15 (s) ^d 8.04 (s), 7.79 (s), 7.73 (s), 7.73 (s) 0.18°) b (PS,PS) 258°) 6.09 (d), 5.94 (d), 5.81 (d) ^d 8.41 (s), 8.26 (s), 8.14 (s) ^d 8.07 (s), 8.02 (s), 7.79 (s) ^d 0.18°) 0.18°) ^a) SiO ₂ , CH ₂ Cl ₂ /AcOEt/hexane 1:1:1. b) SiO ₂ , CH ₂ Cl ₂ /AcOEt/hexane 1:1:0.5. 0.1 In H ₂ O. d) In D ₂ O. 0.1 In D ₂ O. f) Cellulose, i-PrOH/conc. NH ₃ soln./H ₂ O 6:1	q	(PS, PR)	258°)		$6.12(d), 5.95(d), 5.76(d)^{d}$	$8.26(s), 8.21(s), 8.11(s)^{d}$	$7.99(s), 7.94(s), 7.86(s)^{d}$		0.18^{g}
b (<i>PS,PS</i>) 258 ^c) 6.09(<i>d</i>), 5.94(<i>d</i>), 5.81(<i>d</i>) ^d 8.41(<i>s</i>), 8.26(<i>s</i>), 8.14(<i>s</i>) ^d 8.07(<i>s</i>), 8.02(<i>s</i>), 7.89(<i>s</i>) ^d) 0.18 ^s)	b (PS,PS) 258°) $6.09(d)$, $5.94(d)$, $5.81(d)^3$ $8.41(s)$, $8.26(s)$, $8.14(s)^4$ $8.07(s)$, $8.02(s)$, $7.89(s)^4$ 0.18^9 *) SiO ₂ , CH ₂ Cl ₂ /AcOEt/hexane 1:1:1. b) SiO ₂ , CH ₂ Cl ₂ /AcOEt/hexane 1:1:0.5. c) In H ₂ O. d) In D ₂ O. f) Cellulose, i-PrOH/conc. NH ₃ soln./H ₂ O 6:1	16a	(PR, PS)	258°)		$6.03(d), 5.92(d), 5.80(d)^{d}$	$8.27(s), 8.22(s), 8.15(s)^{d}$	$8.04(s), 7.93(s), 7.81(s)^{d}$		0.18^{g}
	^a) SiO ₂ , CH ₂ Cl ₂ /AcOEt/hexane 1:1:1. ^b) SiO ₂ , CH ₂ Cl ₂ /AcOEt/hexane 1:1:0.5. ^c) In H ₂ O. ^d) In D ₂ O. ^c) In D ₂ O. ^f) Cellulose, i-PrOH/conc. NH ₃ soln/H ₂ O 6:1:	q	(PS, PS)	258°)		$6.09(d), 5.94(d), 5.81(d)^d$	8.41 (s), 8.26 (s), 8.14 (s) ^d)	8.07 (s), 8.02 (s), 7.89 (s) ^d)		0.18^{g}

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Experimental Part

General. TLC: precoated silica-gel thin-layer sheets F 1500 LS 254 and cellulose thin-layer sheets F 1440 from Schleicher & Schüll. Prep. TLC: silica gel 60 PF_{254} (Merck). Prep. column chromatography (CC): silica gel (Merck 60, 0.063–0.2 mesh). Paper chromatography: PC sheets (58 × 60 cm) from Schleicher & Schüll. Ion-exchange chromatography: DEAE Sephadex A-25 (Pharmacia). UV/VIS: Uvikon 820 (Kontron); λ_{max} in nm (lg ε). ¹H-NMR: Bruker WM 250; δ in ppm rel. to CHCl₃, dcblocked compounds in D₂O.

1. N⁶-Benzoyl-3'-O-[(tert-butyl)dimethylsilyl]-5'-O-(monomethoxytrityl)adenosine 2'-[2-(4-Nitrophenyl)ethyl N,N-Octamethylenephosphoramidite] (2). To a soln. of 0.758 g (1 mmol) of 1 [52] and 0.52 g (4 mmol) of Et(i-Pr₂)N in CH₂Cl₂ (5 ml), 0.8 g (2.22 mmol) of chloro[2-(4-nitrophenyl)ethoxy](octahydro-1*H*-azonin-1yl)phosphane [53] was added dropwise under N₂. After stirring at r.t. for 2 h, the mixture was treated with sat. aq. NaHCO₃ soln. (50 ml) and then the product isolated by extraction with AcOEt (2 × 50 ml). The org. layer was washed with sat. NaCl soln., dried (Na₂SO₄), and evaporated. The residue was dissolved in AcOEt/Et₃N 95:5 and submitted to CC (silica gel, 10×2 cm, equilibration with AcOEt/Et₃N 9:1 and 95:5, elution with AcOEt/Et₃N 95:5). The product fractions were evaporated, coevaporated with CH₂Cl₂ (5 × 10 ml), and dried at 40°/h.v.: 1.05 g (97%) of **2**. ³¹P-NMR (CDCl₃): 155.27, 154.01. Anal. calc. for C₅₉H₇₀N₇O₉PSi · 1 H₂O (1098.3): C 64.52, H 6.60, N 8.92; found: C 63.93, H 6.85, N 8.62.

2. (PR)- and (PS)-N⁶-Benzoyl-3'-O-[(tert-butyl)dimethylsilyl]-5'-O-(monomethoxytrityl)-P-thioadenylyl-{2'-{O^P-[2-(4-nitrophenyl)ethyl]}-5'}-N⁶-benzoyl-2',3'-bis-O-[(tert-butyl)dimethylsilyl]adenosine (**4a** and **4b**, resp.). Phosphoramidite **2** (1.09 g, 1 mmol) and N⁶-benzoyl-2',3'-bis-O-[(tert-butyl)dimethylsilyl]adenosine (**3**; 0.478 g, 0.7 mmol) were dried overnight at 40°/h.v. The mixture was then dissolved in dry MeCN (6 ml), 3-nitro-1H-1,2,4-triazole (0.285 g, 2.5 mmol) [54] was added and the mixture stirred at r.t. for 3 h (TLC: complete conversion). Pyridine (6 ml) and sulfur (0.5 g, 15.6 mmol) were added, and after stirring at r.t. for 20 h, the mixture was extracted with CHCl₃ (300 ml), the org. layer washed with sat. NaCl soln. (2 × 200 ml), dried (Na₂SO₄), and evaporated, and the residue coevaporated with toluene (2 × 20 ml). The residue was dissolved in CHCl₃ and submitted to CC (silica gel, 15 × 2.5 cm, CHCl₃ (1 l)). The product fractions containing both (PR)- and (PS)-isomers were evaporated, and their separation was achieved by prep. TLC (silica gel, CH₂Cl₂/AcOEt/hexane 1:1:1): 0.47 g (42%; TLC (same system): R_f 0.54) of **4a** and 0.31 g (28%; TLC: R_f 0.46) of **4b**, both as colourless amorphous powders after drying at 40°.

4a (*PR*): ³¹P-NMR (CDCl₃): 69.84. Anal. calc. for $C_{80}H_{98}N_{10}O_{14}PSSi_3 \cdot H_2O$ (1589.0): C 59.89, H 6.28, N 9.61; found: C 59.89, H 6.32, N 9.21.

4b (*PS*): 31 P-NMR (CDCl₃): 69.22. Anal. calc. for $C_{80}H_{98}N_{10}O_{14}PSSi_3 \cdot H_2O$ (1589.0): C 59.89, H 6.28, N 9.61; found: C 59.91, H 6.41, N 9.28.

3. (PR)- and (PS)-N⁶-Benzoyl-3'-O-[(tert-butyl) dimethylsilyl]-P-thioadenylyl-{2'-{O^P-[2-(4-nitrophenyl)ethyl]}-5'}-N⁶-benzoyl-2',3'-bis-O-[(tert-butyl) dimethylsilyl] adenosine (**5a** and **5b**, resp.). Dimers **4a** or **4b** (0.258 g, 0.164 mmol) was treated with 2% TsOH in CH₂Cl₂/MeOH 4:1 (3.2 ml) at r.t. for 40 min. The mixture was taken up in CHCl₃ (50 ml), washed with phosphate buffer pH 7.5 (2 × 20 ml), and evaporated to a foam. The residue was purified by CC (silica gel, 10 × 2.5 cm, first CHCl₃, then CHCl₃/MeOH 100:0.5 and 100:1, resp.). The product fractions were evaporated and dried at 40°/h.v.: 0.198 g (92%) of **5a** and 0.192 g (89%) of **5b**, resp.

5a (*PR*): TLC (CH₂Cl₂/AcOEt/hexane 1:1:1): R_f 0.27. Anal. calc. for $C_{60}H_{82}N_{11}O_{13}PSSi_3 \cdot H_2O$ (1330.7): C 54.15, H 6.36, N 11.57; found: C 53.78, H 6.44, N 10.72.

5b (*PS*): TLC (CH₂Cl₂/AcOEt/hexane 1:1:1): R_{f} 0.30. Anal. calc. for $C_{66}H_{82}N_{11}O_{13}PSSi_{3}$ (1312.7): C 54.90, H 6.29, N 11.73; found: C 54.90, H 6.20, N 11.45.

4. (PR)- and (PS)-P-Thioadenylyl-(2'-5')-adenosine (diammonium salts; **6a** and **6b**, resp.). In a soln. of 0.5 M DBU in dry pyridine (9 ml) was treated 0.039 g (0.03 mmol) of **5a** or **5b** by stirring at r.t. for 2 h. The mixture was neutralized with 1M AcOH in dry pyridine (4.5 ml) and then evaporated. The residue was taken up in 1M Bu₄NF in THF (5 ml), and after stirring at r.t. for 24 h, the mixture was again evaporated. The resulting residue was treated in conc. NH₃ soln. (20 ml) by stirring at r.t. for 48 h. After another evaporated. The residue was taken up in 1_A O (50 ml) and washed with CHCl₃ (2 × 20 ml) and the H₂O phase applied onto a *DEAE-Sephadex* column *A*-25 (60 × 1 cm). Elution was performed with a linear gradient (0.001-0.25M) of (Et₃NH)HCO₃ buffer (pH 7.5). The product fractions were evaporated several times with H₂O. The Et₃NH⁺ salt was converted into its NH₄ salt by paper chromatography using i-PrOH/NH₃/H₂O 7:1:2 by H₂O and lyophilization to yield 630 *OD* units (A₂₆₀) of **6b** (90%) as colourless powders, resp. TLC (cellulose, i-PrOH/conc. NH₃ soln./H₂O 7:1:2): $R_{\rm f}$ (**6b**) 0.30.

5. (PR)- and (PS)-N⁶-Benzoyl-3'-O-[(tert-butyl)dimethylsilyl]-5'-O-(monomethoxytrityl)-P-thioadenylyl- $\{2'-\{O^P-[2-(4-nitrophenyl)ethyl]\} \rightarrow 5'\}$ -(PR)-N⁶-benzoyl-3'-O-[(tert-butyl)dimethylsilyl]-P-thioadenylyl- $\{2'-\{O^P-[2-(4-nitrophenyl)ethyl]\} \rightarrow 5'\}$ -N⁶-benzoyl-2', 3'-bis-O-[(tert-butyl)dimethylsilyl]adenosine (7a and 7b, resp.) and Their (PR,PS)- and (PS,PS)-Isomers 9a and 9b, resp. A soln. of 2 (0.449 g, 0.41 mmol), 0.262 g (0.2 mmol) of 5a or 5b, and 3-nitro-1H-1,2,4-triazole (0.114 g, 1 mmol) in MeCN (3.2 ml) was stirred at r.t. for 3 h. Then, sulfur (0.2 g, 6.25 mmol) and pyridine (0.4 ml) were added, and the mixture was stirred at r.t. for another 20 h. The product was extracted with CH₂Cl₂ (50 ml), the org. phase washed with sat. NaCl soln. (2 × 20 ml), dried (Na₂SO₄), and evaporated. Final co-evaporation was done with toluene to remove pyridine. The crude product was purified by CC (silica gel; 15 × 2 cm, CHCl₃/MeOH 50:1) and the two diastereoisomers were then separated by prep. TLC (silica gel; 20 × 20 × 0.2 cm, CH₂Cl₂/AcOEt/hexane 1:1:0.5, 3 times). The product bands were eluted with CHCl₃/MeOH 4:1: less polar 7a (0.218 g, 48 %) and more polar 7b (0.154 g, 34%) as colourless amorphous powders.

7a (PR,PR): Anal. calc. for C₁₁₁H₁₃₅N₁₇O₂₂P₂S₂Si₄· H₂O (2315.8): C 57.56, H 5.96, N 10.28; found: C 57.38, H 5.99, N 10.11.

7b (*PS*,*PR*): Anal. calc. for $C_{111}H_{135}N_{17}O_{22}P_2S_2Si_4 \cdot H_2O$ (2315.8): C 57.56, H 5.96, N 10.28; found: C 57.40, H 5.97, N 10.19.

Condensation of **2** and **5b** according to the same procedure gave the less polar **9a** (0.186 g, 41%) and the more polar **9b** (0.159 g, 35%) in form of colourless solid foams.

9a (*PR,PS*): Anal. calc. for C₁₁₁H₁₃₅N₁₇O₂₂P₂S₂Si₄ (2297.8): C 58.02, H 5.92, N 10.36; found: C 58.00, N 5.84, N 10.66.

9b (*PS,PS*): Anal. calc. for $C_{111}H_{135}N_{17}O_{22}P_2S_2Si_4$ · H_2O (2315.8): C 57.56, H 5.96, N 10.28; found: C 57.30, H 5.78, N 10.03.

6. (PR)- and (PS)-N⁶-Benzoyl-3'-O-[(tert-butyl)dimethylsilyl]-P-thioadenylyl-{2'-{O^P-[2-(4-nitrophenyl)ethyl]}-5'}-(PR)-N⁶-benzoyl-3'-O-[(tert-butyl)dimethylsilyl]-P-thioadenylyl-{2'-{O^P-[2-(4-nitrophenyl)ethyl]}-5'}-N⁶-benzoyl-2',3'-bis-O-[(tert-butyl)dimethylsilyl]denosine (8a and 8b, resp.) and Their (PR,PS)and (PS,PS)-Isomers 10a and 10b, resp. At r.t., 7a, 7b, 9a, or 9b (0.149 g, 0.065 mmol) was stirred with 2% TsOH in CH₂Cl₂/MeOH 4:1 (1.5 ml) for 3 h. The soln. was taken up in CHCl₃ (50 ml) and washed with H₂O (2 × 25 ml), the CHCl₃ phase dried (Na₂SO₄) and evaporated, and the crude product purified by prep. TLC (silica gel; 20 × 20 × 0.2 cm, CH₂Cl₂/AcOEt/hexane 1:1:0.5). The pure product was eluted from the plates with CHCl₃/ MeOH 1:1 giving in all cases 80% yields.

8a (*PR*,*PR*): Anal. calc. for C₉₁H₁₁₉N₁₇O₂₁P₂S₂Si₄· H₂O (2043.7): C 53.48, H 5.96, N 11.65; found: C 53.22, H 5.95, N 11.51.

8b (*PS*,*PR*): Anal. calc. for C₉₁H₁₁₉N₁₇O₂₁P₂S₂Si₄ (2025.7): C 53.95, H 5.87, N 11.75; found: C 53.61, H 6.00, N 11.49.

10a(PR,PS): Anal. calc. for $C_{91}H_{119}N_{17}O_{21}P_2S_2Si_4$ (2025.7): C 53.95, H 5.87, N 11.75; found: C 53.65, H 5.87, N 11.38.

10b (*PS*,*PS*): Anal. calc. for $C_{91}H_{119}N_{17}O_{21}P_2S_2Si_4(2025.7)$: C 53.48, H 5.96, N 11.65; found: C 53.18, H 5.88, N 11.50.

7. (PR)- and (PS)-P-Thioadenylyl-($2' \rightarrow 5'$)-(PR)-P-thioadenylyl-($2' \rightarrow 5'$)-adenosine (diammonium salts; **11a** and **11b**, resp.) and Their (PR,PS)- and (PS,PS)-Isomers **12a** and **12b**, resp. A soln. of 38.5 mg (0.0189 mmol) of **8a**, **8b**, **10a**, or **10b** in 0.5m DBU in dry pyridine (7.5 ml) was stirred at r.t. for 20 h. The mixture was neutralized with 1M AcOH in dry pyridine (3.75 ml) and then evaporated. The residue was taken up in 1M Bu₄NF in THF, and after stirring for 48 h, the solvent was evaporated and the residue treated with conc. NH₃ soln. (25 ml) for another 48 h. The solvent was evaporated and the residue dissolved in H₂O (20 ml) and washed with CHCl₃ (2 × 10 ml). The aq. phase was put onto a *DEAE Sephadex A-25* column (60 × 1 cm) and the product eluted with a linear gradient (0.001–0.5m) of (Et₃NH)HCO₃ buffer (pH 7.5). The product fractions were evaporated and co-evaporated several times with H₂O. The products were further purified by paper chromatography (i-PrOH/conc. NH₃ soln./H₂O 6:1:3) to give, after lyophilisation, the fully deblocked trimers in 75–80% yields as colourless powders.

8. N⁶-Benzoyl-3'-O-[(tert-butyl)dimethylsilyl]-5'-O-{(2,5-dichlorophenoxy)[2-(4-nitrophenyl)ethoxy]phosphoryl}-P-thioadenylyl-{2'-{O^P-[2-(4-nitrophenyl)ethyl]}-5'}-N⁶-benzoyl-3'-O-[(tert-butyl)dimethylsilyl]-Pthioadenylyl-{2'-{O^P-[2-(4-nitrophenyl)ethyl]}-5'}-N⁶-benzoyl-2',3'-di-O-[(tert-butyl)dimethylsilyl]adenosine (13a (PR,PR), 13b (PS,PR), 14b (PR,PS), and 14b (PS,PS)). To a soln. of 1H-1,2,4-triazole (0.011 g, 0.16 mmol) and 2,5-dichlorophenyl phosphorodichloridate (0.022 g, 0.078 mmol) in dry pyridine (0.5 ml) was added 8a, 8b, 10a, or 10b (80.1 mg, 0.049 mmol) in dry pyridine (0.5 ml). After stirring for 30 min, 2-(4-nitrophenyl)ethanol (0.02 g, 0.119 mmol) was added and stirring continued at r.t. for 20 h. The product was extracted with CHCl₃ (50 ml), the org. phase washed with H₂O (2 × 20 ml), evaporated, and finally co-evaporated with toluene. The residue was purified by prep. TLC (silica gel; $20 \times 20 \times 0.2$ cm, CH₂Cl₂/AcOEt/hexane 1:1:1). The product band was eluted with CHCl₃/MeOH 7:3 and gave, on evaporation, the trimer 5'-monophosphates in 70–80% yield as colourless amorphous powders.

9. 5'-O-Phosphoryl-P-thioadenylyl-($2' \rightarrow 5'$)-P-thioadenylyl-($2' \rightarrow 5'$)-adenosine (tetraammonium salts; **15a** (*PR*,*PR*), **15b** (*PS*,*PR*), **16a** (*PR*,*PS*), and **16b** (*PS*,*PS*)). A soln. of 4-nitrobenzaldehydeoxime (0.036 g, 0.216 mmol) in dioxane/Et₃N/H₂O (each 0.5 ml) was stirred for 30 min. Then **13a**, **13b**, **14a**, or **14b** (0.05 g, 0.02 mmol) was added and stirred at r.t. for 4 h. After evaporation and co-evaporation with toluene (2×5 ml), the product was purified by prep. TLC (silica gel; $20 \times 20 \times 0.2$ cm, CH₂Cl₂/MeOH 95:5). The product band was eluted with CHCl₃/MeOH/Et₃N 5:1:1 and, after evaporation and drying (0.022 g, 0.01 mmol), treated with 0.5m DBU in pyridine (8 ml). After stirring for 24 h, the mixture was neutralized with 1m AcOH in pyridine (4 ml) and again evaporated. The residue was taken up in 1M Bu₄NF in THF (6 ml), and, after stirring at r.t. for 4 h and evaporated, the residue taken up in 1_{2O} (25 ml) and washed with CHCl₃ (2 × 10 ml), and the aq. phase applied onto a *DEAE-Sephadex A-25* column (60 × 1 cm) for elution with a linear gradient (0.001-1M) of (Et₃NH)HCO₃ buffer (pH 7.5). The product fractions were evaporated and co-evaporated several times with H₂O. Further purification by paper chromatography (i-PrOH/conc. NH₃ soln./H₂O 55:10:35) gave, after lyophilisation, colourless powders of the trimer 5'-monophosphates in 68-74% yield.

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