Iris Biotech

MAILLARD

and Amadori Reaction Products

It's Getting Hot in Here

Maillard and Amadori reaction products are particularly formed at elevated temperatures.

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Side chains of arginine and lysine react with carbohydrates.

page 1

MRPs are responsible for flavors of many food products.

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Markers and indicators in food, pharma and cosmetic industry.

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Version: IF14_3

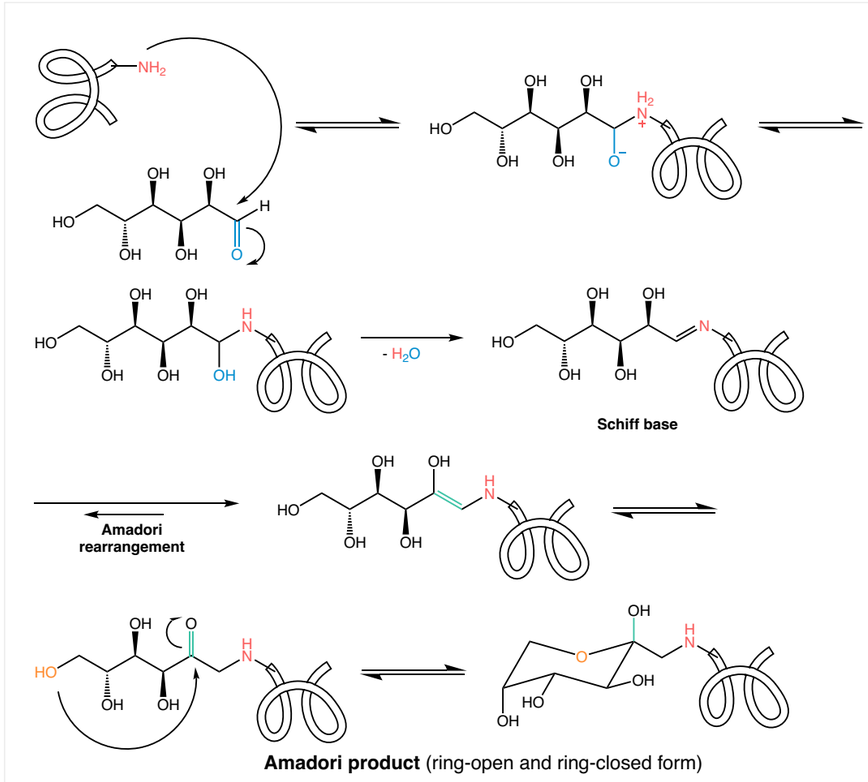
Maillard and Amadori Reaction Products

Markers and Indicators in Food, Pharma and Cosmetic Industry

General Introduction

Proteins contained in meat and other comestible goods are usually rich in the amino acids arginine and lysine. The side-chain functional groups of arginine and lysine react with reducing carbohydrates such as glucose or lactose to form Amadori reaction products. These characteristic intermediates decompose particularly at elevated temperatures to various Maillard reaction products (MRPs) which are responsible for the distinctive flavors of many food products.

In more detail, the Maillard Reaction is a nonenzymatic glycation reaction that proceeds *via* three stages. In a first step, the reducing end of a carbohydrate undergoes a condensation reaction with an amino group from an amino acid, peptide or protein to afford a Schiff base that rearranges to the Amadori product.



Formation of Amadori products.

The second stage involves the formation of a variety of reactive dicarbonyl compounds such as glyoxal, MGO, and deoxyglucosone by degradation of the Amadori product. In the third and final stage of the Maillard reaction, Advanced Glycation End Products (AGEs) are formed, as well as the typical brown polymers termed melanoidins resulting from the condensation and polymerization of proteins. AGEs also appear naturally in the human body. As such, they are indicators for body health and disease processes, including inflammation, diabetes, cancer, and ageing.

MRPs reduce the availability of essential amino acids, like lysine, in food and therefore influence their nutritional quality. They are responsible for deterioration of food during storage and processing. Thus, MRPs represent a valuable marker for the nutritional quality of food. From a pharmacological point of view they may cause kidney damage and show carcinogenic, but also antiallergenic, antibiotic, anti-mutagenic, and antioxidant properties.

As an example, Poojary *et al*. have developed a validated UHPLC-MS/MS method for the simultaneous identification and quantification of 15 different Advanced Glycation End Products, as well as furosine and various other related compounds (protein-derived crosslinks and certain amino acids). This novel method is highly sensitive (LOD and LOQ values in the ng/mL range), and is applicable for milk samples, for different varieties of meat, as well as for bovine plasma and perfusion liquid. All 25 AGE standards and internal standards used in this publication were purchased from Iris Biotech.

Food Industry

- indicators for heat treatment of food
- determination of thermal history of food
- markers for the nutritional quality of food
- used in quality control of food

Biochemistry and Pharma

- biomarkers for diabetes and other diseases
- markers in ageing and pathology

Product Handling

As Maillard reaction products are often used for analytics, the correct product handling is of crucial importance for reliable and reproducible results.

Maillard Reaction Products can be sticky oils or foamy powders. In order to improve the handling of these products, we provide them, depending on the respective characteristics, as free base, HCl, TFA or acetate salt. These salts are mainly powders, which can e.g., be weighed out more readily. Please be aware, that for this reason, the net content of the compound is crucial for your considerations/calculations/quantifications. It is determined for most of the products by elemental analysis and stated on the certificate of analysis.

Lyophilized Maillard Reaction Products should be stored desiccated at -20 °C. Before opening a vial, ensure that it has equilibrated to room temperature. When the product is not a weighable powder or foam, it is best reconstituted directly from the bottle. First try to dissolve in a small volume of pure

water. If it does not dissolve easily, sonication may help. Once in solution, the buffer for the experiment can be added. In the case of some very hydrophobic or neutral compounds, polar organic solvents such as DMSO or DMF can be used. These should be added in a stepwise fashion until the compound has dissolved, after which water or buffer may be added until the desired concentration is reached.

Reconstituted products should be used up as soon as possible to avoid degradation in solution. If this is not possible, we recommend dividing the solution in aliquots corresponding to the amount needed for one experiment. These aliquots should then be re-lyophilized and stored as before. Unused solutions should be stored frozen at -20 °C or lower for limited periods of time. We advise against repeated freeze-thaw cycles.

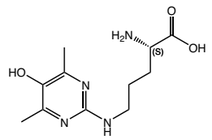
Derived from Arginine

Product details

HAA3050 Argpyrimidine

(S)-2-amino-5-(5-hydroxy-4,6-dimethylpyrimidin-2-ylamino)pentanoic acid trifluoroacetic acid salt

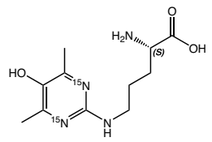
CAS-No. 195143-52-3
Formula $C_{11}H_{18}N_4O_3$
Mol. weight 254,29 g/mol



HAA3055 Argpyrimidine-^{15}N2

(S)-2-amino-5-((5-hydroxy-4,6-dimethylpyrimidin-2-yl-1,3-15N2)amino)pentanoic acid trifluoroacetic acid salt

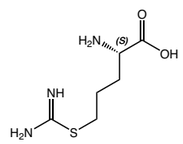
Formula $C_{11}H_{18}N_2[15N]2O_3$ (net)
Mol. weight 256,28 (net) g/mol



HAA9165 L-Thioarginine

(2S)-2-amino-5-(carbamimidoylsulfanyl)pentanoic acid hydrochloride salt

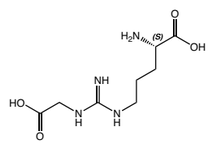
CAS-No. 190374-70-0
Formula $C_6H_{13}N_3O_2S$
Mol. weight 191,25 g/mol



HAA9155 CMA

N-omega-Carboxymethyl-L-arginine

CAS-No. 278610-96-1
Formula $C_8H_{16}N_4O_4$
Mol. weight 232,24 g/mol

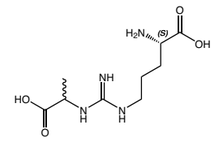


Product details

HAA9160 CEA

N-omega-Carboxyethyl-L-arginine (mixture of two diastereoisomers)

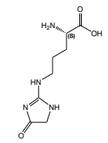
CAS-No. 861902-72-9
Formula $C_9H_{18}N_4O_4$
Mol. weight 246,27 g/mol



HAA2970 G-H1

Glyoxal-hydroimidazolone isomer

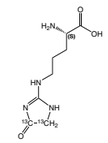
CAS-No. 207856-23-3
Formula $C_8H_{14}N_4O_3$
Mol. weight 214,22 g/mol



HAA2971 G-H1-^{13}C2

Glyoxal-hydroimidazolone isomer-13C2

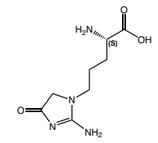
Formula $C_6[13C]2H_{14}N_4O_3$
Mol. weight 216,21 g/mol



HAA3270 G-H2

(S)-2-amino-5-(2-amino-4-oxo-4,5-dihydro-1H-imidazol-1-yl)pentanoic acid

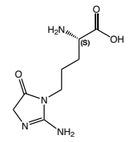
CAS-No. 846021-23-6
Formula $C_8H_{14}N_4O_3$
Mol. weight 214,22 g/mol



HAA3280 G-H3

(S)-2-amino-5-(2-amino-5-oxo-4,5-dihydro-1H-imidazol-1-yl)pentanoic acid trifluoroacetic acid salt

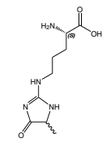
CAS-No. 194494-49-0
Formula $C_8H_{14}N_4O_3$
Mol. weight 214,22 g/mol



HAA3003 MG-H1

(S)-2-amino-5-(5-methyl-4-oxo-4,5-dihydro-1H-imidazol-2-ylamino)pentanoic acid

CAS-No. 149204-50-2
Formula $C_9H_{16}N_4O_3$
Mol. weight 228,25 g/mol

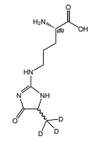


Product details

HAA3002 MG-H1-d3

Trideuteromethylglyoxal-hydroimidazolone isomer (mixture of two diastereoisomers)

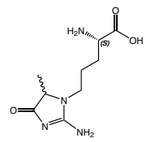
Formula $C_9H_{13}D_3N_4O_3$
Mol. weight 231,27 g/mol



HAA3320 MG-H2

(S)-2-amino-5-(2-amino-5-methyl-4-oxo-4,5-dihydro-1H-imidazol-1-yl)pentanoic acid (mixture of two diastereoisomers)

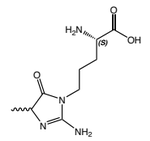
CAS-No. 1232154-60-7
Formula $C_9H_{16}N_4O_3$
Mol. weight 228,25 g/mol



HAA3330 MG-H3

(S)-2-amino-5-(2-amino-4-methyl-5-oxo-4,5-dihydro-1H-imidazol-1-yl)pentanoic acid trifluoroacetic acid salt (mixture of two diastereoisomers)

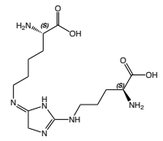
CAS-No. 1596174-76-3
Formula $C_9H_{16}N_4O_3$
Mol. weight 228,25 g/mol



HAA9125 GODIC

(2S)-N6-(2-(((S)-4-amino-4-carboxybutyl) amino)-3,5-dihydro-4H-imidazol-4-ylidene)-2,6-diaminohexanoic acid trifluoroacetic acid salt

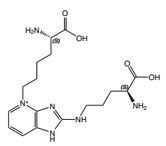
CAS-No. 252663-58-4 net
Formula $C_{14}H_{26}N_6O_4$
Mol. weight 342,39 g/mol



HAA3030 Pentosidine

2-(((S)-4-amino-4-carboxybutyl)amino)-4-((S)-5-amino-5-carboxypentyl)-1H-imidazo[4,5-b]pyridin-4-ium trifuoroacetic acid salt

CAS-No. 124505-87-9
Formula $C_{17}H_{27}N_6O_4$
Mol. weight 379,43 g/mol



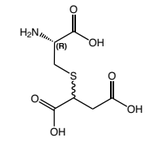
Derived from Cysteine

Product details

HAA3060 2-SC

S-(2-Succinyl)-L-cysteine (mixture of two diastereoisomers)

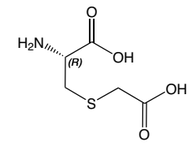
CAS-No. 547764-73-8
Formula $C_7H_{11}NO_6S$
Mol. weight 237,23 g/mol



HAA1077 CMC

S-Carboxymethyl-L-cysteine

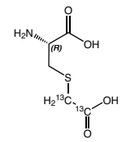
CAS-No. 638-23-3
Formula $C_5H_9NO_4S$
Mol. weight 179,19 g/mol



HAA3230 CMC-13C2

S-[13C2]-carboxymethyl-L-cysteine

CAS-No. 2389078-62-8
Formula $C_3[13C]2H_9NO_4S$
Mol. weight 181,18 g/mol



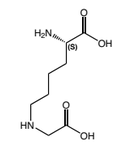
Derived from Lysine

Product details

HAA2950 CML

N-epsilon-carboxymethyl-L-Lysine

CAS-No. 5746-04-3
Formula $C_8H_{16}N_2O_4$
Mol. weight 204,22 g/mol

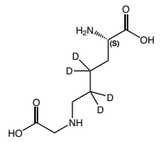


Product details

HAA2952 CML-d4

N-epsilon-carboxymethyl-[D4]-L-Lysine(S)-2-amino-6-(carboxymethylamino)-4,4,5,5-tetradeuterohexanoic acid

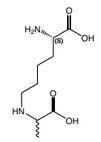
CAS-No. 936233-18-0
Formula $C_8H_{12}D_4N_2O_4$
Mol. weight 208,25 g/mol



HAA2940 CEL

(S)-2-amino-6-(1-carboxyethylamino)hexanoic acid (mixture of two diastereoisomers)

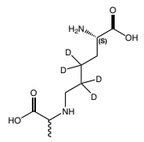
CAS-No. 5746-03-2
Formula $C_9H_{18}N_2O_4$
Mol. weight 218,25 g/mol



HAA2941 CEL-d4

(S)-2-amino-6-(1-carboxyethylamino)-4,4,5,5-tetradeuterohexanoic acid (mixture of two diastereoisomers)

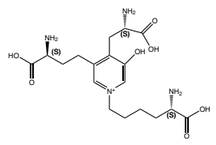
Formula $C_9H_{14}D_4N_2O_4$
Mol. weight 222,27 g/mol



HAA3240 Dpd

(+)-Deoxypyridinoline trifluoroacetic acid salt

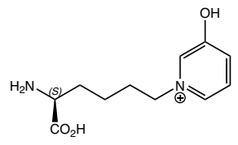
CAS-No. 83462-55-9
Formula $C_{18}H_{29}N_4O_7$
Mol. weight 413,44 g/mol



HAA3985 OP-Lysine

(S)-1-(5-amino-5-carboxypentyl)-3-hydroxy-pyridinium trifluoroacetic acid

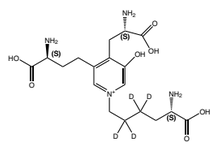
CAS-No. 672333-91-4
Formula $C_{11}H_{17}N_2O_3+$
Mol. weight 225,27 g/mol



HAA4010 Dpd-d4

(+)-Deoxypyridinoline-d4 trifluoroacetic acid salt

Formula $C_{18}H_{25}D_4N_4O_7$
Mol. weight 417,47 g/mol

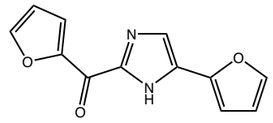


Product details

HAA3250 FFI

2-(2-Furoyl)-4(5)-(2-furanyl)-1H-imidazole

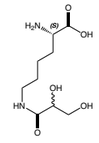
CAS-No. 91037-91-1
Formula $C_{12}H_8N_2O_3$
Mol. weight 228,20 g/mol



HAA9150 H-L-Lys(Glycerinyl)-OH

N-epsilon-(2,3-Dihydroxypropionyl)-L-lysine (mixture of two diastereoisomers)

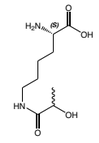
Formula $C_9H_{18}N_2O_5$
Mol. weight 234,25 g/mol



HAA9145 H-L-Lys(Lactoyl)-OH

N-epsilon-(2-Hydroxypropionyl)-L-lysine (mixture of two diastereoisomers)

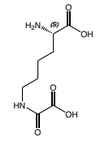
CAS-No. 928122-01-4
Formula $C_9H_{18}N_2O_4$
Mol. weight 218,25 g/mol



HAA9140 H-L-Lys(Oxalyl)-OH

N-epsilon-Carboxycarbonyl-L-lysine hydrochloride acid salt

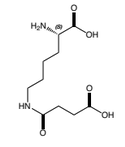
CAS-No. 5238-83-5 (net)
Formula $C_8H_{14}N_2O_5$ (net)
Mol. weight 218,21 (net) g/mol



HAA3990 H-L-Lys(Suc)-OH*HCl

N-epsilon-succinimidyl-L-lysine hydrochloride salt

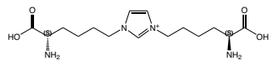
CAS-No. 52685-16-2 net
Formula $C_{10}H_{18}N_2O_5$*HCl
Mol. weight 246,26*36,45 g/mol



HAA3070 GOLD

Glyoxyl-derived lysine dimer acetic acid salt

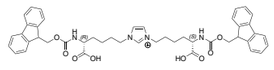
CAS-No. 209267-39-0
Formula $C_{15}H_{27}N_4O_4$
Mol. weight 327,40 g/mol



Product details

FAA9405 Fmoc2-GOLD

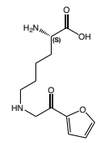
1-((R)-5-((((9H-fluoren-9-yl)methoxy)carbonyl)amino)-5-carboxypentyl)-3-((S)-5-((((9H-fluoren-9-yl)methoxy)carbonyl)amino)-5-carboxypentyl)-1H-imidazol-3-ium trifluoroacetic acidsalt



CAS-No. 1606122-24-0
Formula $C_{45}H_{47}N_4O_8$
Mol. weight 771,89 g/mol

HAA2960 Furosine

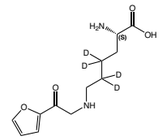
(S)-2-amino-6-(2-(furan-2-yl)-2-oxoethylamino)hexanoic acid hydrochloride salt



CAS-No. 19746-33-9
Formula $C_{12}H_{18}N_2O_4$
Mol. weight 254,28 g/mol

HAA2961 Furosine-d4

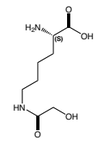
N-epsilon-(2-furoyl-methyl)-L-[4,4,5,5-D4]-Lysine hydrochloride salt



CAS-No. 2749985-82-6
Formula $C_{12}H_{14}D_4N_2O_4$
Mol. weight 258,31 g/mol

HAA3260 GALA

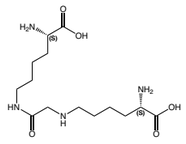
Glycolic acid-lysine-amide



CAS-No. 171262-64-9
Formula $C_8H_{16}N_2O_4$
Mol. weight 204,22 g/mol

HAA3290 GOLA

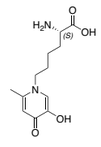
(2S)-amino-6-(2-((5S)-amino-5-carboxypentylamino) acetamido)hexanoic acid hydrochloride salt



CAS-No. 1704455-01-5
Formula $C_{14}H_{28}N_4O_5$
Mol. weight 332,40 g/mol

HAA9590 Pyridosine

(S)-2-amino-6-(5-hydroxy-2-methyl-4-oxopyridin-1(4H)-yl)hexanoic acid

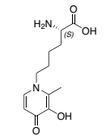


CAS-No. 31489-08-4
Formula $C_{12}H_{18}N_2O_4$
Mol. weight 254,29 g/mol

Product details

HAA9595 Maltosine

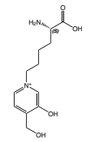
(S)-2-amino-6-(3-hydroxy-2-methyl-4-oxopyridin-1(4H)-yl)hexanoic acid



CAS-No. 121502-04-3
Formula $C_{12}H_{18}N_2O_4$
Mol. weight 254,29 g/mol

HAA3980 GA-pyridine

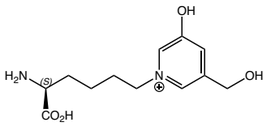
(S)-1-(5-amino-5-carboxypentyl)-3-hydroxy-4-(hydroxymethyl)pyridinium trifluoroacetic acid



CAS-No. 526211-14-3
Formula $C_{12}H_{19}N_2O_4$
Mol. weight 255,29 g/mol

HAA3975 GLAP

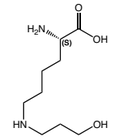
(S)-1-(5-amino-5-carboxypentyl)-3-hydroxy-5-(hydroxymethyl) pyridinium trifluoroacetic acid



CAS-No. 889659-45-4
Formula $C_{12}H_{19}N_2O_4^+$
Mol. weight 255,29 g/mol

HAA3300 LM

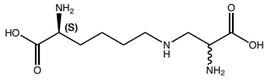
epsilon-N-3-hydroxypropyl-L-lysine acetic acid salt



CAS-No. 188896-12-0
Formula $C_9H_{20}N_2O_3$
Mol. weight 204,27 g/mol

HAA3310 LAL

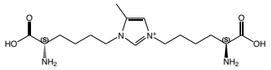
Lysinoalanine hydrochloride salt (mixture of two diastereoisomers)



CAS-No. 4418-81-9
Formula $C_9H_{19}N_3O_4$
Mol. weight 233,26 g/mol

HAA3080 MOLD

Methylglyoxyl-derived lysine dimer acetic acid salt

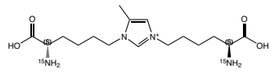


CAS-No. 209276-80-2
Formula $C_{16}H_{29}N_4O_4$
Mol. weight 341,4 g/mol

Product details

HAA3081 MOLD-^{15}N2

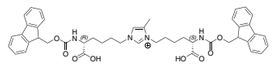
Methylglyoxyl-derived lysine dimer-15N2 acetic acid salt



Formula $C_{16}H_{29}N_2[15N]2O_4$
Mol. weight 343,41 g/mol

FAA9410 Fmoc2-MOLD

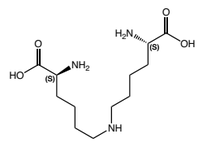
1-((R)-5-((((9H-fluoren-9-yl)methoxy)carbonyl)amino)-5-carboxypentyl)-3-((S)-5-((((9H-fluoren-9-yl)methoxy)carbonyl)amino)-5-carboxypentyl)-4-methyl-1H-imidazol-3-iumtrifluoroacetic acid salt



Formula $C_{46}H_{49}N_4O_8+$
Mol. weight 785,92 g/mol

HAA4000 LNL

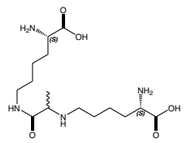
Lysinonorleucine



CAS-No. 25612-46-8
Formula $C_{12}H_{25}N_3O_4$
Mol. weight 275,34 g/mol

HAA9135 MOLA

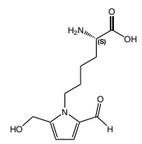
2,15-diamino-8-methyl-9-oxo-7,10-diaza-1,16-hexadecanedioic acid



CAS-No. 2760788-86-9
Formula $C_{15}H_{30}N_4O_5$
Mol. weight 346,43 g/mol

HAA3040 Pyrraline

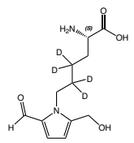
(2S)-2-amino-6-(formyl-5-hydroxymethyl-pyrrol-1-yl)-hexanoic acid



CAS-No. 74509-14-1
Formula $C_{12}H_{18}N_2O_4$
Mol. weight 254,28 g/mol

HAA3045 Pyrraline-d4

(2S)-2-amino-6-(formyl-5-hydroxymethyl-pyrrol-1-yl)-(4,4,5,5-tetradeutero)hexanoic acid

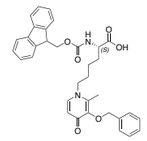


CAS-No. 2446534-02-5
Formula $C_{12}H_{14}D_4N_2O_4$
Mol. weight 258,31 g/mol

Product details

FAA9415 Fmoc-L-Maltosine(Bzl)-OH

(S)-2-((((9H-fluoren-9-yl)methoxy)carbonyl)amino)-6-(3-(benzyloxy)-2-methyl-4-oxopyridin-1(4H)-yl) hexanoic acid



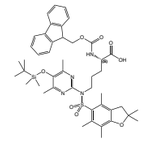
Formula $C_{34}H_{34}N_2O_6$
Mol. weight 566,65 g/mol

Related Building Blocks

Product details

FAA5530 Fmoc-L-Argpyrimidine(Pbf,TBMS)-OH

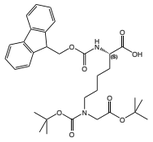
(S)-2-(9-Fluorenylmethyloxycarbonylamino)-5-(N-(4,6-dimethyl-5-(*t*-butyldimethylsilyloxy) pyrimidin-2-yl)-2,2,4,6,7-pentamethyl-2,3-dihydrobenzofuran-5-sulfonamido)pentanoic acid



CAS-No. 2389078-23-1
Formula $C_{45}H_{58}N_4O_8SSi$
Mol. weight 843,11 g/mol

FAA3620 Fmoc-L-CML(O*t*Bu)(Boc)-OH

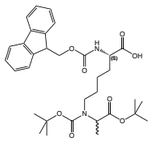
N-alpha-(9-Fluorenylmethyloxycarbonyl)-N-epsilon-*t*-butyloxycarbonyl-N-epsilon-(*t*-butoxycarbonylmethyl)-L-lysine



CAS-No. 866602-35-9
Formula $C_{32}H_{42}N_2O_8$
Mol. weight 582,68 g/mol

FAA3630 Fmoc-L-CEL(O*t*Bu)(Boc)-OH

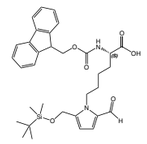
N-alpha-(9-Fluorenylmethyloxycarbonyl)-N-epsilon-*t*-butyloxycarbonyl-N-epsilon-(*t*-butoxycarbonyleth-1-yl)-L-lysine



CAS-No. 866602-36-0
Formula $C_{33}H_{44}N_2O_8$
Mol. weight 596,71 g/mol

FAA7520 Fmoc-L-Pyrraline(TBS)-OH

N-alpha-(9-Fluorenylmethoxycarbonyl)-6-(2-((*t*-butyldimethylsilyloxy)methyl)-5-formyl-1H-pyrrol-1-yl)-L-norleucine

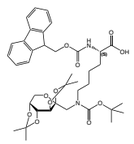


CAS-No. 1404451-31-5
Formula $C_{33}H_{42}N_2O_6Si$
Mol. weight 590,78 g/mol

Product details

FAA5540 Fmoc-L-Lys(Boc,Fructose)-OH

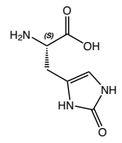
N-alpha-(9-Fluorenylmethyloxycarbonyl)-N-epsi-lon-[6-(t-butyloxycarbonyl)aminohexanoyl]-N-epsi-lon-(2,3:4,5-di-O-isopropylidene-1-deoxyfructopyrano-syl)-L-lysine



CAS-No.	1133875-59-8
Formula	$C_{38}H_{50}N_2O_{11}$
Mol. weight	710,82 g/mol

HAA4060 H-L-His(2-Oxo)-OH*HCL

(S)-2-amino-3-(2-oxo-2,3-dihydro-1H-imidazol-4-yl) propanoic acid



CAS-No.	2580100-34-9
Formula	$C_6H_9N_3O_3$
Mol. weight	171,15 g/mol

References:

- *Liquid chromatography quadrupole-Orbitrap mass spectrometry for the simultaneous analysis of advanced glycation end products and protein-derived cross-links in food and biological matrices; M. M. Poojary, W. Zhang, I. Greco, C. De Gobba, K. Olsen, M. N. Lund;* ***J Chromatogr A*** *2020;* ***1615****: 460767. https://doi.org/10.1016/j.chroma.2019.460767*
- *Effect of heating on Maillard reactions in milk; M. A. J. S. Van Boekel;* ***Food Chemistry*** *1998;* ***62****: 403-414. https://doi.org/10.1016/s0308-8146(98)00075-2*
- *Mechanism of protein modification by glyoxal and glycolaldehyde, reactive intermediates of the Maillard reaction; M. A. Glomb, V. M. Monnier;* ***J Biol Chem*** *1995;* ***270****: 10017-26 https://doi.org/10.1074/jbc.270.17.10017*
- *New Aspects of the Maillard Reaction in Foods and in the Human Body; F. Ledl, E. Schleicher;* ***Angew. Chem. Int. Ed. Engl.*** *1990;* ***29****: 565-594. https://doi.org/10.1002/anie.199005653*
- *Forty years of furosine – Forty years of using Maillard reaction products as indicators of the nutritional quality of foods; Helmut F. Erbersdobler, Veronika Somoza;* ***Mol. Nutr. Food Res.*** *2007;* ***51****: 423-430. https://doi.org/10.1002/mnfr.200600154*
- *Food Browning and Its Prevention: An Overview; M. Friedman;* ***J. Agric. Food Chem.*** *1996;* ***44(3)****: 631-653. www.imars.org*
- *Synthetic Approach to Argpyrimidine as a Tool for Investigating Nonenzymatic Posttranslational Modification of Proteins; M. Matveenko, C. F. W. Becker;* ***Synlett*** *2017;* ***28****: 1950-1955. https://doi.org/10.1055/s-0036-1588225*
- *Impaired Chaperone Activity of Human Heat Shock Protein Hsp27 Site-Specifically Modified with Argpyrimidine; M. Matveenko, E. Cichero, P. Fossa, C. F. W. Becker;* ***Ang. Chem. Int. Ed.*** *2016;* ***55****: 11397-11402. https://doi.org/10.1002/anie.201605366*
- *Random coil shifts of posttranslationally modified amino acids; A. C. Conibear, K. J. Rosengren, C. F. W. Becker, H. Kaehlig;* ***Journal of Biomolecular NMR*** *2019;* ***73****: 587-599. https://doi.org/10.1007/s10858-019-00270-4*

Notes

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