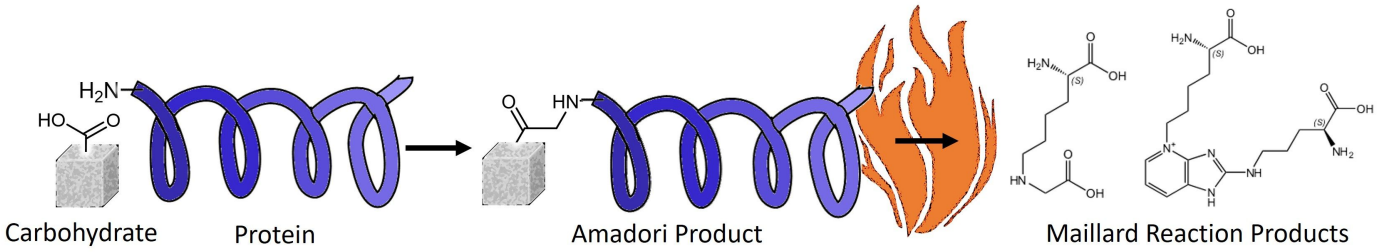
Iris Biotech

Empowering Peptide Innovation

New: Maillard Reaction Products

Markers and Indicators in Food, Pharma and Cosmetic Industry



Proteins contained in meat and other comestible goods are usually rich in the amino acids arginine and lysine. The side chain functional groups of Arg and Lys 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. Moreover, MRPs are widely used as markers for the nutritional quality of food and have furthermore gained broad attention in cosmetics, biochemistry and pharma industry. 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. From a pharmacological point of view they may cause kidney damage and show carcinogenic, but also antiallergenic, antibiotic, anti-mutagenic, and antioxidant properties.

Food Industry	Biochemisty and Pharma
✔ indicators for heat treatment of food	✔ biomarker for diabetes and other diseases
✔ determination of thermal history of food	✔ marker in ageing and pathology
✔ marker for the nutritional quality of food	
✔ used in quality control of food	

The analysis of Furosine content is an innovative method to assess the effects of milk or dairy product thermal treatments or the addition of UHT or milk powder to crude or pasteurized milk. It is the first stable product of Maillard's reaction in milk and can then be analyzed by HPLC. This test is widely used in milk and nutrition industry.

References:

- Forty years of furosine – Forty years of using Maillard reaction products as indicators of the nutritional quality of foods; Helmut F. Erbersdobler and Veronika Somoza; *Mol. Nutr. Food Res.* 2007; **51**: 423-430. DOI 10.1002/mnfr.200600154 423.
- Food Browning and Its Prevention: An Overview; Mendel Friedman; *J. Agric. Food Chem.* 1996; 44(3): 631-653.
- www.imars.org





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Maillard Reaction Products derived from Arginine

Article No.	Quantity	Price

HAA3050 Argpyrimidine

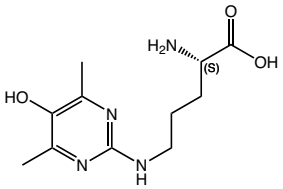
(S)-2-amino-5-(5-hydroxy-4,6-dimethylpyrimidin-2-ylamino)pentanoic acid trifluoroacetic acid salt

CAS-NO: **195143-52-3 net**

FORMULA: $C_{11}H_{18}N_4O_3$

MOLECULAR WEIGHT: **254,29 g/mol**

Argpyrimidine is a fluorescent adduct derived from methylglyoxal and arginine.



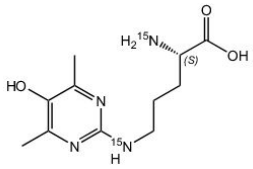
HAA3050.0005	5 mg	€ 300,00
HAA3050.0010	10 mg	€ 495,00

HAA3055 Argpyrimidine-15N2 TFA salt

(S)-2-(amino-15N)-5-((5-hydroxy-4,6-dimethylpyrimidin-2-yl-15N)amino)pentanoic acid

FORMULA: $C_{11}H_{18}N_2[_{15}N]_2O_3$ (net)

MOLECULAR WEIGHT: **256,28 (net) g/mol**



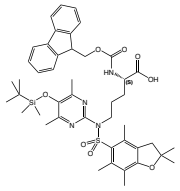
HAA3055.0005	5 mg	€ 600,00
HAA3055.0025	25 mg	€ 2400,00

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

FORMULA: $C_{45}H_{58}N_4O_8SSi$

MOLECULAR WEIGHT: **843,11 g/mol**



FAA5530.0100	100 mg	€ 250,00
FAA5530.0250	250 mg	€ 500,00
FAA5530.1000	1 g	€ 1750,00

References:

- Antioxidant properties of argpyrimidine; N. Sreejayan, X. Yang, K. Palanichamy, K. Dolence and J. Ren; Eur J Pharmacol 2008; **593**: 30-5. https://doi.org/10.1016/j.ejphar.2008.07.030
- Argpyrimidine, a methylglyoxal-derived advanced glycation end-product in familial amyloidotic polyneuropathy; R. Gomes, M. Sousa Silva, A. Quintas, C. Cordeiro, A. Freire, P. Pereira, A. Martins, E. Monteiro, E. Barroso and A. Ponces Freire; *The Biochemical journal 2005*; **385**: 339-45. https://doi.org/10.1042/BJ20040833
- Therapeutic potential of breakers of advanced glycation end product-protein crosslinks; S. Vasan, P. Foiles and H. Founds; *Archives of biochemistry and biophysics* 2003; **419**: 89-96. https://doi.org/10.1016/j.abb.2003.08.016
- N(delta)-(5-hydroxy-4,6-dimethylpyrimidine-2-yl)-l-ornithine, a novel methylglyoxal-arginine modification in beer; M. A. Glomb, D. Rosch and R. H. Nagaraj; *J Agric Food Chem* 2001; **49**: 366-72. https://doi.org/10.1021/jf000493r
- Argpyrimidine, a blue fluorophore in human lens proteins: high levels in brunescent cataractous lenses; P. S. Padayatti, A. S. Ng, K. Uchida, M. A. Glomb and R. H. Nagaraj; *Invest Ophthalmol Vis Sci* 2001; **42**: 1299-304.
- Methylglyoxal modification of protein. Chemical and immunochemical characterization of methylglyoxal-arginine adducts; T. Oya, N. Hattori, Y. Mizuno, S. Miyata, S. Maeda, T. Osawa and K. Uchida; *J Biol Chem* 1999; **274**: 18492-502. https://doi.org/10.1074/jbc.274.26.18492
- Protein modification by methylglyoxal: chemical nature and synthetic mechanism of a major fluorescent adduct; I. N. Shipanova, M. A. Glomb and R. H. Nagaraj; Archives of biochemistry and biophysics 1997; **344**: 29-36. https://doi.org/10.1006/abbi.1997.0195
- Novel modifications of Nα-boc-arginine and Nα-CBZ-lysine by methylglyoxal; Y. Al-Abed, T. Mitsuhashi, P. Ulrich and R. Bucala; *Bioorganic & Medicinal Chemistry Letters* 1996; **6**: 1577-1578. https://doi.org/10.1016/s0960-894x(96)00276-4

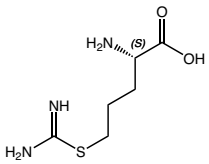
HAA9165 L-Thioarginine

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

CAS-NO: **190374-70-0**

FORMULA: $C_6H_{13}N_3O_2S$

MOLECULAR WEIGHT: **191,25 g/mol**



HAA9165.0010	10 mg	€ 200,00
HAA9165.0050	50 mg	€ 800,00

References:

- Amino acid discrimination by arginyl-tRNA synthetases as revealed by an examination of natural specificity variants; G. L. Igloi and E. Schiefermayr; *FEBS J* 2009; **276**: 1307-18. https://doi.org/10.1111/j.1742-4658.2009.06866.x
- Synthesis and evaluation of alternative substrates for arginase; S. Han, R. A. Moore and R. E. Viola; *Bioorg Chem* 2002; **30**: 81-94. https://doi.org/10.1006/bioo.2001.1228
- A spectrophotometric assay of arginase; S. Han and R. E. Viola; *Anal Biochem* 2001; **295**: 117-9. https://doi.org/10.1006/abio.2001.5189

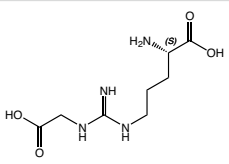
HAA9155 CMA

N-omega-Carboxymethyl-L-arginine

CAS-NO: **278610-96-1**

FORMULA: $C_8H_{16}N_4O_4$

MOLECULAR WEIGHT: **232,24 g/mol**



HAA9155.0005	5 mg	€ 200,00
HAA9155.0010	10 mg	€ 360,00

References:

- Identification of N(omega)-carboxymethylarginine, a new advanced glycation endproduct in serum proteins of diabetic patients: possibility of a new marker of aging and diabetes; H. Odani, K. Iijima, M. Nakata, S. Miyata, H. Kusunoki, Y. Yasuda, Y. Hiki, S. Irie, K. Maeda and D. Fujimoto; *Biochemical and biophysical research communications* 2001; **285**: 1232-6. https://doi.org/10.1006/bbrc.2001.5322
- Isolation and characterization of glyoxal-arginine modifications; M. A. Glomb and G. Lang; *J Agric Food Chem* 2001; **49**: 1493-501. https://doi.org/10.1021/jf001082d
- Identification of Nω-carboxymethylarginine as a novel acid-labile advanced glycation end product in collagen; K. Iijima, M. Murata, H. Takahara, S. Irie and D. Fujimoto; *Biochemical Journal* 2000; **347**: 23-27. https://doi.org/10.1042/bj3470023

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	Article No.	Quantity	Price

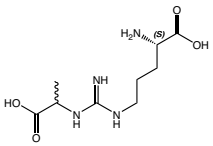
HAA9160 CEA

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

CAS-NO: **864902-72-9**

FORMULA: $C_9H_{18}N_4O_4$

MOLECULAR WEIGHT: **246,27 g/mol**



HAA9160.0005	5 mg	€	200,00
HAA9160.0010	10 mg	€	360,00

References:

- Arginine-derived advanced glycation end products generated in peptide-glucose mixtures during boiling; A. Frolov, R. Schmidt, S. Spiller, U. Greifenhagen and R. Hoffmann; *J Agric Food Chem* 2014; **62**: 3626-35. https://doi.org/10.1021/jf4050183
- Formation of arginine modifications in a model system of Nalpha-tert-butoxycarbonyl (Boc)-arginine with methylglyoxal; A. Klopfer, R. Spanneberg and M. A. Glomb; *J Agric Food Chem* 2011; **59**: 394-401. https://doi.org/10.1021/jf103116c
- Model studies on the influence of high hydrostatic pressure on the formation of glycated arginine modifications at elevated temperatures; N. Alt and P. Schieberle; *J Agric Food Chem* 2005; **53**: 5789-97. https://doi.org/10.1021/jf050615l

HAA2970 G-H1

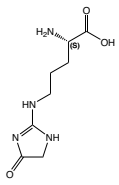
Glyoxal-hydroimidazolone isomer

CAS-NO: **207856-23-3**

FORMULA: $C_8H_{14}N_4O_3$

MOLECULAR WEIGHT: **214,22 g/mol**

G-H1 is one of hydroimidazolone isomers derived from glyoxal and arginine residues.



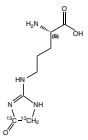
HAA2970.0010	10 mg	€	185,00
HAA2970.0050	50 mg	€	750,00

HAA2971 G-H1-$^{13}C_2$

Glyoxal-hydroimidazolone isomer-$^{13}C_2$

FORMULA: $C_6[^{13}C]_2H_{14}N_4O_3$

MOLECULAR WEIGHT: **216,21 g/mol**



HAA2971.0005	5 mg	€	435,00
HAA2971.0010	10 mg	€	695,00

References:

- Degradation products of proteins damaged by glycation, oxidation and nitration in clinical type 1 diabetes; N. Ahmed, R. Babaei-Jadidi, S. K. Howell, P. J. Beisswenger and P. J. Thornalley; *Diabetologia* 2005; **48**: 1590-603. https://doi.org/10.1007/s00125-005-1810-7
- Proteomic analysis of arginine adducts on glyoxal-modified ribonuclease; W. E. Cotham, T. O. Metz, P. L. Ferguson, J. W. Brock, D. J. Hinton, S. R. Thorpe, J. W. Baynes and J. M. Ames; *Mol Cell Proteomics* 2004; **3**: 1145-53. https://doi.org/10.1074/mcp.M400002-MCP200
- Quantitative screening of advanced glycation endproducts in cellular and extracellular proteins by tandem mass spectrometry; P. J. Thornalley, S. Battah, N. Ahmed, N. Karachalias, S. Agalou, R. Babaei-Jadidi and A. Dawnay; *The Biochemical journal* 2003; **375**: 581-92. https://doi.org/10.1042/BJ20030763
- Assay of advanced glycation endproducts (AGEs): surveying AGEs by chromatographic assay with derivatization by 6-aminoquinolyl-N-hydroxysuccinimidyl-carbamate and application to Nepsilon-carboxymethyl-lysine- and Nepsilon-(1-carboxyethyl)lysine-modified albumin; N. Ahmed, O. K. Argirov, H. S. Minhas, C. A. Cordeiro and P. J. Thornalley; *The Biochemical journal* 2002; **364**: 1-14. https://doi.org/10.1042/bj3640001
- Chromatographic assay of glycation adducts in human serum albumin glycated in vitro by derivatization with 6-aminoquinolyl-N-hydroxysuccinimidyl-carbamate and intrinsic fluorescence; N. Ahmed and P. J. Thornalley; *The Biochemical journal* 2002; **364**: 15-24. https://doi.org/10.1042/bj3640015
- Isolation and characterization of advanced glycation end products derived from the in vitro reaction of ribose and collagen; R. G. Paul, N. C. Avery, D. A. Slatter, T. J. Sims and A. J. Bailey; *The Biochemical journal* 1998; **330** (Pt 3): 1241-8. https://doi.org/10.1042/bj3301241

HAA3270 G-H2

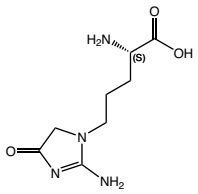
(S)-2-amino-5-(2-amino-4-oxo-4,5-dihydro-1H-imidazol-1-yl)pentanoic acid

CAS-NO: **846021-23-6**

FORMULA: $C_8H_{14}N_4O_3$

MOLECULAR WEIGHT: **214,22 g/mol**

G-H2 is one of hydroimidazolone isomers derived from glyoxal and arginine residues.



HAA3270.0010	10 mg	€	275,00
HAA3270.0050	50 mg	€	1100,00

HAA3280 G-H3

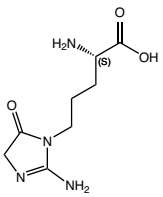
(S)-2-amino-5-(2-amino-5-oxo-4,5-dihydro-1H-imidazol-1-yl)pentanoic acid trifluoroacetic acid salt

CAS-NO: **194494-49-0 net**

FORMULA: $C_8H_{14}N_4O_3$

MOLECULAR WEIGHT: **214,22 g/mol**

G-H3 is one of hydroimidazolone isomers derived from glyoxal and arginine residues.



HAA3280.0010	10 mg	€	220,00
HAA3280.0050	50 mg	€	880,00

References:

- Proteomic analysis of arginine adducts on glyoxal-modified ribonuclease; W. E. Cotham, T. O. Metz, P. L. Ferguson, J. W. Brock, D. J. Hinton, S. R. Thorpe, J. W. Baynes and J. M. Ames; *Mol Cell Proteomics* 2004; **3**: 1145-53. https://doi.org/10.1074/mcp.M400002-MCP200
- Quantitative screening of advanced glycation endproducts in cellular and extracellular proteins by tandem mass spectrometry; P. J. Thornalley, S. Battah, N. Ahmed, N. Karachalias, S. Agalou, R. Babaei-Jadidi and A. Dawnay; *The Biochemical journal* 2003; **375**: 581-92. https://doi.org/10.1042/BJ20030763
- Isolation and characterization of glyoxal-arginine modifications; M. A. Glomb and G. Lang; *J Agric Food Chem* 2001; **49**: 1493-501. https://doi.org/10.1021/jf001082d
- On the reaction of glyoxal with proteins; U. Schwarzenbolz, T. Henle, R. Haeßner and H. Klostermeyer; *Zeitschrift fr Lebensmitteluntersuchung und -Forschung A* 1997; **205**: 121-124. https://doi.org/10.1007/s002170050137

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	Article No.	Quantity	Price

HAA3003 MG-H1

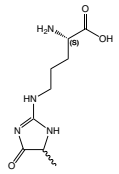
Methylglyoxal-hydroimidazolone isomer (mixture of two diastereoisomers)

CAS-NO: **149204-50-2 net**

FORMULA: $C_9H_{16}N_4O_3$

MOLECULAR WEIGHT: **228,25 g/mol**

MG-H1 is one of hydroimidazolone isomers derived from methylglyoxal and arginine residues.



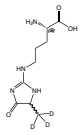
HAA3003.0010	10 mg	€ 145,00
HAA3003.0050	50 mg	€ 580,00

HAA3002 MG-H1-d_3

Trideuteromethylglyoxal-hydroimidazolone isomer (mixture of two diastereoisomers)

FORMULA: $C_9H_{13}D_3N_4O_3$

MOLECULAR WEIGHT: **231,27 g/mol**



HAA3002.0005	5 mg	€ 300,00
HAA3002.0010	10 mg	€ 495,00

References:

- Isolation and identification of 5-methyl-imidazolin-4-one derivative as glyceraldehyde-derived advanced glycation end product; T. Usui, H. Watanabe and F. Hayase; *Biosci Biotechnol Biochem* 2006; **70**: 1496-8. https://doi.org/10.1271/bbb.50584
- Quantitative screening of advanced glycation endproducts in cellular and extracellular proteins by tandem mass spectrometry; P. J. Thornalley, S. Battah, N. Ahmed, N. Karachalias, S. Agalou, R. Babaei-Jadidi and A. Dawnay; *The Biochemical journal* 2003; **375**: 581-92. https://doi.org/10.1042/BJ20030763
- Assay of advanced glycation endproducts (AGEs): surveying AGEs by chromatographic assay with derivatization by 6-aminoquinolyl-N-hydroxysuccinimidyl-carbamate and application to Nepsilon-carboxymethyl-lysine- and Nepsilon-(1-carboxyethyl)lysine-modified albumin; N. Ahmed, O. K. Argirov, H. S. Minhas, C. A. Cordeiro and P. J. Thornalley; *The Biochemical journal* 2002; **364**: 1-14. https://doi.org/10.1042/bj3640001
- Isolation and characterization of advanced glycation end products derived from the in vitro reaction of ribose and collagen; R. G. Paul, N. C. Avery, D. A. Slatter, T. J. Sims and A. J. Bailey; *The Biochemical journal* 1998; **330 (Pt 3)**: 1241-8. https://doi.org/10.1042/bj3301241
- Detection and identification of a protein-bound imidazolone resulting from the reaction of arginine residues and methylglyoxal; T. Henle, A. W. Walter, R. Haener and H. Klostermeyer; *Zeitschrift fr Lebensmittel-Untersuchung und -Forschung* 1994; **199**: 55-58. https://doi.org/10.1007/bf01192954

HAA3320 MG-H2

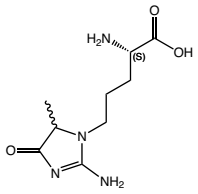
(S)-2-amino-5-(2-amino-5-methyl-4-oxo-4,5-dihydro-1H-imidazol-1-yl)pentanoic acid (mixture of two diastereoisomers)

CAS-NO: **1232154-60-7**

FORMULA: $C_9H_{16}N_4O_3$

MOLECULAR WEIGHT: **228,25 g/mol**

MG-H2 is one of hydroimidazolone isomers derived from methylglyoxal and arginine residues.



HAA3320.0010	10 mg	€ 175,00
HAA3320.0050	50 mg	€ 700,00

HAA3330 MG-H3

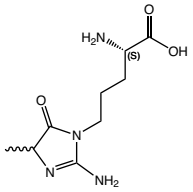
(S)-2-amino-5-(2-amino-4-methyl-5-oxo-4,5-dihydro-1H-imidazol-1-yl)pentanoic acid trifluoroacetic acid salt (mixture of two diastereoisomers)

CAS-NO: **1596174-76-3 net**

FORMULA: $C_9H_{16}N_4O_3$

MOLECULAR WEIGHT: **228,25 g/mol**

MG-H3 is one of hydroimidazolone isomers derived from methylglyoxal and arginine residues.



HAA3330.0010	10 mg	€ 220,00
HAA3330.0050	50 mg	€ 880,00

References:

- Quantitative screening of advanced glycation endproducts in cellular and extracellular proteins by tandem mass spectrometry; P. J. Thornalley, S. Battah, N. Ahmed, N. Karachalias, S. Agalou, R. Babaei-Jadidi and A. Dawnay; *The Biochemical journal* 2003; **375**: 581-92. https://doi.org/10.1042/BJ20030763
- Chromatographic assay of glycation adducts in human serum albumin glycated in vitro by derivatization with 6-aminoquinolyl-N-hydroxysuccinimidyl-carbamate and intrinsic fluorescence; N. Ahmed and P. J. Thornalley; *The Biochemical journal* 2002; **364**: 15-24. https://doi.org/10.1042/bj3640015
- Detection and identification of a protein-bound imidazolone resulting from the reaction of arginine residues and methylglyoxal; T. Henle, A. W. Walter, R. Haener and H. Klostermeyer; *Zeitschrift fr Lebensmittel-Untersuchung und -Forschung* 1994; **199**: 55-58. https://doi.org/10.1007/bf01192954

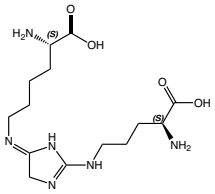
HAA9125 GODIC

(2S)-N_6-(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: $C_{14}H_{26}N_6O_4$

MOLECULAR WEIGHT: **342,4 g/mol**



HAA9125.0005	5mg	€ 530,00
HAA9125.0010	10 mg	€ 950,00

References:

- Identification and quantification of major maillard cross-links in human serum albumin and lens protein. Evidence for glucosepane as the dominant compound; K. M. Biemel, D. A. Friedl and M. O. Lederer; *J Biol Chem* 2002; **277**: 24907-15. https://doi.org/10.1074/jbc.M202681200
- Involvement of Maillard reactions in Alzheimer disease; V. P. Reddy, M. E. Obrenovich, C. S. Atwood, G. Perry and M. A. Smith; *Neurotox Res* 2002; **4**: 191-209. https://doi.org/10.1080/1029840290007321
- Identification and quantitative evaluation of the lysine-arginine crosslinks GODIC, MODIC, DODIC, and glucosepan in foods; K. M. Biemel, H. P. Buhler, O. Reihl and M. O. Lederer; *Nahrung* 2001; **45**: 210-4. https://doi.org/10.1002/1521-3803(20010601)45:3<210::AID-FOOD210>3.0.CO;2-L
- Cross-linking of proteins by Maillard processes: characterization and detection of lysine-arginine cross-links derived from glyoxal and methylglyoxal; M. O. Lederer and R. G. Klaiber; *Bioorg Med Chem* 1999; **7**: 2499-507. https://doi.org/10.1016/s0968-0896(99)00212-6

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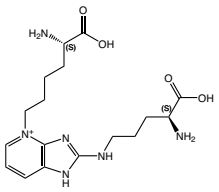
D-95615 Marktredwitz, Germany

Article No.	Quantity	Price

HAA3030 Pentosidine



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

CAS-NO: **124505-87-9 net**

FORMULA: $C_{17}H_{27}N_6O_4$

MOLECULAR WEIGHT: **379,43 g/mol**

In pentosidine arginine and lysine have been crosslinked by a pentose. It is used as marker in ageing and diseases. The fluorescence properties of the crosslink makes it easily detectable *via* UV in HPLC.

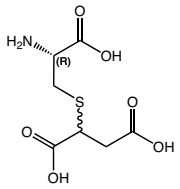
HAA3030.0002	2 mg	€ 395,00
HAA3030.0005	5 mg	€ 750,00
HAA3030.0010	10mg	€ 1350,00

References:

- A sensitive and specific HPLC method for the determination of total pentosidine concentration in plasma; D. Slowik-Zylka, K. Safranow, V. Dziedziejko, H. Bukowska, K. Ciechanowski and D. Chlubek; *J Biochem Biophys Methods* 2004; **61**: 313-29. https://doi.org/10.1016/j.jbbm.2004.06.002
- Early glycation products produce pentosidine cross-links on native proteins. novel mechanism of pentosidine formation and propagation of glycation; P. Chellan and R. H. Nagaraj; *J Biol Chem* 2001; **276**: 3895-903. https://doi.org/10.1074/jbc.M008626200
- Cell-associated pentosidine as a marker of aging in human diploid cells in vitro and in vivo; D. R. Sell, M. Primc, I. A. Schafer, M. Kovach, M. A. Weiss and V. M. Monnier; *Mechanisms of Ageing and Development* 1998; **105**: 221-240. https://doi.org/10.1016/s0047-6374(98)00090-6
- Detection and quantification of pentosidine in foods; T. Henle, U. Schwarzenbolz and H. Klostermeyer; *Zeitschrift fr Lebensmitteluntersuchung und -Forschung A* 1997; **204**: 95-98. https://doi.org/10.1007/s002170050043
- Identification of pentosidine as a native structure for advanced glycation end products in beta-2-microglobulin-containing amyloid fibrils in patients with dialysis-related amyloidosis; T. Miyata, S. Taneda, R. Kawai, Y. Ueda, S. Horiuchi, M. Hara, K. Maeda and V. M. Monnier; *Proc Natl Acad Sci U S A* 1996; **93**: 2353-8. https://doi.org/10.1073/pnas.93.6.2353
- Formation of pentosidine during nonenzymatic browning of proteins by glucose. Identification of glucose and other carbohydrates as possible precursors of pentosidine in vivo; D. G. Dyer, J. A. Blackledge, S. R. Thorpe and J. W. Baynes; *Journal of Biological Chemistry* 1991; **266**: 11654-11660.
- Mechanism of formation of the Maillard protein cross-link pentosidine. Glucose, fructose, and ascorbate as pentosidine precursors; S. K. Grandhee and V. M. Monnier; *Journal of Biological Chemistry* 1991; **266**: 11649-11653.
- End-stage renal disease and diabetes catalyze the formation of a pentose-derived crosslink from aging human collagen; D. R. Sell and V. M. Monnier; *J Clin Invest* 1990; **85**: 380-4. https://doi.org/10.1172/JCI114449
- Structure elucidation of a senescence cross-link from human extracellular matrix. Implication of pentoses in the aging process; D. R. Sell and V. M. Monnier; *J Biol Chem* 1989; **264**: 21597-602.

Maillard Reaction Products derived from Cysteine

HAA3060 2-SC



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

CAS-NO: **547764-73-8**

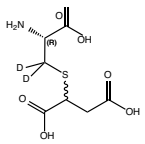
FORMULA: $C_7H_{11}NO_6S$

MOLECULAR WEIGHT: **237,23 g/mol**

2-SC has been identified as a chemical modification in tissue proteins and is formed by a Michael addition of cysteine to fumarate at physiological pH.

HAA3060.0010	10 mg	€ 185,00
HAA3060.0050	50 mg	€ 750,00

HAA3061 2-SC-d_2



S-(2-Succinyl)-L-cysteine-d_2 (mixture of two diastereoisomers)

FORMULA: $C_7H_9D_2NO_6S$

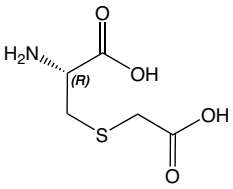
MOLECULAR WEIGHT: **239,24 g/mol**

HAA3061.0002	2mg	€ 220,00
HAA3061.0010	10mg	€ 880,00

References:

- Aspartyl and Glutamyl Peptides and the Acidic Cysteine Derivatives in Asparagus (Asparagus officinalis) Shoots; T. Kasai, Y. Hirakuri and S. Sakamura; *Agricultural and Biological Chemistry* 2014; **45**: 433-437. https://doi.org/10.1080/00021369.1981.10864519
- S-(2-Succinyl)cysteine: a novel chemical modification of tissue proteins by a Krebs cycle intermediate; N. L. Alderson, Y. Wang, M. Blatnik, N. Frizzell, M. D. Walla, T. J. Lyons, N. Alt, J. A. Carson, R. Nagai, S. R. Thorpe and J. W. Baynes; *Archives of biochemistry and biophysics* 2006; **450**: 1-8. https://doi.org/10.1016/j.abb.2006.03.005
- Optical Resolution of (RS)-Mercaptosuccinic Acid and Syntheses of Four Stereoisomers of 2-Amino-3-1(1,2-dicarboxyethyl)sulfanyl)propanoic Acid; T. Shiraiwa, M. Ohkubo, M. Kubo, H. Miyazaki, M. Takehata, H. Izawa, K. Nakagawa and H. Kurokawa; *Chemical & Pharmaceutical Bulletin* 1998; **46**: 1364-1369. https://doi.org/10.1248/cpb.46.1364
- (2R), (1'R) and (2R), (1'S)-2-amino-3-(1,2-dicarboxyethylthio)propanoic acids from Amanita pantherina. Antagonists of N-methyl-D-aspartic acid (NMDA) receptors; S. Fushiya, Q. Q. Gu, K. Ishikawa, S. Funayama and S. Nozoe; *Chem Pharm Bull (Tokyo)* 1993; **41**: 484-6. https://doi.org/10.1248/cpb.41.484

HAA1077 CMC



S-Carboxymethyl-L-cysteine

CAS-NO: **638-23-3**

FORMULA: $C_5H_9NO_4S$

MOLECULAR WEIGHT: **179,19 g/mol**

S-carboxymetyl-L-cysteine (CMC) is a stable advanced glycation end product and can be used as a potential marker of glycation.

HAA1077.0025	25 mg	€ 95,00
HAA1077.0100	100 mg	€ 175,00

References:

- Evidence for inactivation of cysteine proteases by reactive carbonyls via glycation of active site thiols; J. Zeng, R. A. Dunlop, K. J. Rodgers and M. J. Davies; *The Biochemical journal* 2006; **398**: 197-206. https://doi.org/10.1042/BJ20060019
- Evidence for the formation of adducts and S-(carboxymethyl)cysteine on reaction of alpha-dicarbonyl compounds with thiol groups on amino acids, peptides, and proteins; J. Zeng and M. J. Davies; *Chemical research in toxicology* 2005; **18**: 1232-41. https://doi.org/10.1021/tx050074u
- Chemical modification of muscle protein in diabetes; N. Alt, J. A. Carson, N. L. Alderson, Y. Wang, R. Nagai, T. Henle, S. R. Thorpe and J. W. Baynes; *Archives of biochemistry and biophysics* 2004; **425**: 200-6. https://doi.org/10.1016/j.abb.2004.03.012

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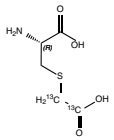
	Article No.	Quantity	Price

HAA3230 CMC-$^{13}C_2$

S-[$^{13}C_2$]-carboxymethyl-L-cysteine

FORMULA: $C_3[^{13}C]_2H_9NO_4S$

MOLECULAR WEIGHT: **181,18 g/mol**



HAA3230.0005	5 mg	€ 310,00
HAA3230.0010	10 mg	€ 495,00

References:

- Evidence for inactivation of cysteine proteases by reactive carbonyls via glycation of active site thiols; J. Zeng, R. A. Dunlop, K. J. Rodgers and M. J. Davies; *The Biochemical journal* 2006; **398**: 197-206. https://doi.org/10.1042/BJ20060019
- Evidence for the formation of adducts and S-(carboxymethyl)cysteine on reaction of alpha-dicarbonyl compounds with thiol groups on amino acids, peptides, and proteins; J. Zeng and M. J. Davies; *Chemical research in toxicology* 2005; **18**: 1232-41. https://doi.org/10.1021/tx050074u
- Chemical modification of muscle protein in diabetes; N. Alt, J. A. Carson, N. L. Alderson, Y. Wang, R. Nagai, T. Henle, S. R. Thorpe and J. W. Baynes; *Archives of biochemistry and biophysics* 2004; **425**: 200-6. https://doi.org/10.1016/j.abb.2004.03.012

Maillard Reaction Products derived from Lysine

HAA2950 CML

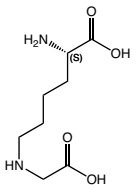
N-epsilon-carboxymethyl-L-Lysine

CAS-NO: **5746-04-3**

FORMULA: $C_8H_{16}N_2O_4$

MOLECULAR WEIGHT: **204,22 g/mol**

CML can be used as marker for diabetes, pathology in aging or heat damage of food.



HAA2950.0050	50mg	€ 145,00
HAA2950.0250	250mg	€ 400,00
HAA2950.1000	1g	€ 1200,00

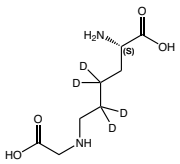
HAA2952 CML-d_4

N-ε-carboxymethyl-[4,4,5,5-D_4]-L-Lysine

CAS-NO: **936233-18-0**

FORMULA: $C_8H_{12}D_4N_2O_4$

MOLECULAR WEIGHT: **208,25 g/mol**



HAA2952.0005	5 mg	€ 310,00
HAA2952.0010	10 mg	€ 495,00

References:

- Determination of N εcarboxymethyllysine in heated milk products by immunochemical methods; A. Tauer, K. Hasenkopf, T. Kislinger, I. Frey and M. Pischetsrieder; *European Food Research and Technology* 1999; **209**: 72-76. https://doi.org/10.1007/s002170050460
- N epsilon-(carboxymethyl)lysine is a dominant advanced glycation end product (AGE) antigen in tissue proteins; S. Reddy, J. Bichler, K. J. Wells-Knecht, S. R. Thorpe and J. W. Baynes; *Biochemistry* 1995; **34**: 10872-8. https://doi.org/10.1021/bi00034a021
- Mechanism of protein modification by glyoxal and glycolaldehyde, reactive intermediates of the Maillard reaction; M. A. Glomb and V. M. Monnier; *J Biol Chem* 1995; **270**: 10017-26. https://doi.org/10.1074/jbc.270.17.10017
- Mechanism of the degradation of non-enzymatically glycated proteins under physiological conditions. Studies with the model fructosamine, N epsilon-(1-deoxy-D-fructos-1-yl)hippuryl-lysine; P. R. Smith and P. J. Thornalley; *Eur J Biochem* 1992; **210**: 729-39. https://doi.org/10.1111/j.1432-1033.1992.tb17474.x
- Oxidative degradation of glucose adducts to protein. Formation of 3-(N epsilon-lysino)-lactic acid from model compounds and glycated proteins; M. U. Ahmed, J. A. Dunn, M. D. Walla, S. R. Thorpe and J. W. Baynes; *J Biol Chem* 1988; **263**: 8816-21.

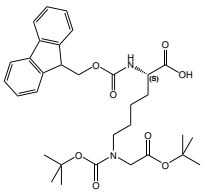
FAA3620 Fmoc-L-CML(OtBu)(Boc)-OH

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

CAS-NO: **866602-35-9**

FORMULA: $C_{32}H_{42}N_2O_8$

MOLECULAR WEIGHT: **582,68 g/mol**



FAA3620.1000	1 g	€ 625,00
FAA3620.5000	5 g	€ 2500,00

References:

- Chemoselective synthesis of peptides containing major advanced glycation end-products of lysine and arginine; P. Gruber and T. Hofmann; *J Pept Res* 2005; **66**: 111-24. https://doi.org/10.1111/j.1399-3011.2005.00279.x

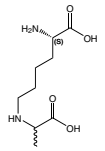
HAA2940 CEL

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

CAS-NO: **5746-03-2**

FORMULA: $C_9H_{18}N_2O_4$

MOLECULAR WEIGHT: **218,25 g/mol**



HAA2940.0050	50 mg	€ 200,00
HAA2940.0100	100 mg	€ 350,00

References:

- N-epsilon-(carboxyethyl)lysine, a product of the chemical modification of proteins by methylglyoxal, increases with age in human lens proteins; M. U. Ahmed, E. Brinkmann Frye, T. P. Degenhardt, S. R. Thorpe and J. W. Baynes; *The Biochemical journal* 1997; **324 (Pt 2):** 565-70. https://doi.org/10.1042/bj3240565
- Carboxyethyllysine in a protein: native carbonyl reductase/NADP(+)-dependent prostaglandin dehydrogenase; M. Krook, D. Ghosh, R. Stromberg, M. Carlquist and H. Jornvall; *Proc Natl Acad Sci U S A* 1993; **90**: 502-6. https://doi.org/10.1073/pnas.90.2.502

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D-95615 Marktredwitz, Germany

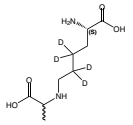
	Article No.	Quantity	Price

HAA2941 CEL-d_4

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

FORMULA: $C_9H_{14}D_4N_2O_4$

MOLECULAR WEIGHT: **222,27 g/mol**



HAA2941.0005	5 mg	€	310,00
HAA2941.0010	10 mg	€	495,00

References:

- N-epsilon-(carboxyethyl)lysine, a product of the chemical modification of proteins by methylglyoxal, increases with age in human lens proteins; M. U. Ahmed, E. Brinkmann Frye, T. P. Degenhardt, S. R. Thorpe and J. W. Baynes; *The Biochemical journal* 1997; **324 (Pt 2):** 565-70. https://doi.org/10.1042/bj3240565
- Carboxyethyllysine in a protein: native carbonyl reductase/NADP(+)-dependent prostaglandin dehydrogenase; M. Krook, D. Ghosh, R. Stromberg, M. Carlquist and H. Jornvall; *Proc Natl Acad Sci U S A* 1993; **90**: 502-6. https://doi.org/10.1073/pnas.90.2.502

FAA3630 Fmoc-L-CEL(OtBu)(Boc)-OH

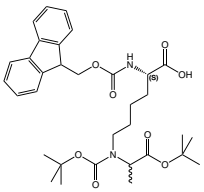
N-alpha-(9-Fluorenylmethyloxycarbonyl)-N-epsilon-t-butyloxycarbonyl-N-epsilon-(t-butoxycarbonyleth-1-yl)-L-lysine

CAS-NO: **866602-36-0**

FORMULA: $C_{33}H_{44}N_2O_8$

MOLECULAR WEIGHT: **596,71 g/mol**

Building block for solid phase synthesis to implement CEL in any peptide sequence. CEL can be used as marker for diabetes, pathology, in aging or heat damage of food.



FAA3630.0250	250 mg	€	250,00
FAA3630.1000	1 g	€	690,00
FAA3630.5000	5 g	€	2750,00

References:

- Chemoselective synthesis of peptides containing major advanced glycation end-products of lysine and arginine; P. Gruber and T. Hofmann; *J Pept Res* 2005; **66**: 111-24. https://doi.org/10.1111/j.1399-3011.2005.00279.x

HAA3240 Dpd

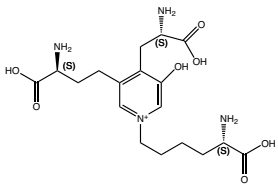
(+)-Deoxypyridinoline trifluoroacetic acid salt

CAS-NO: **83462-55-9 net**

FORMULA: $C_{18}H_{29}N_4O_7$

MOLECULAR WEIGHT: **413,44 g/mol**

(+)-Deoxypyridinoline (Dpd) is a cross-link of bone collagen detected in human urine and used as a biochemical marker of various bone diseases such as osteoporosis, arthropathies and bone cancer. Dhp can be measured by HPLC and is essential for the use as reference standard in diagnostics of diseases.



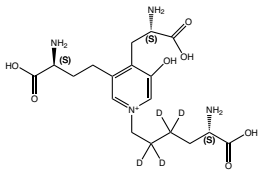
HAA3240.0002	2mg	€	330,00
HAA3240.0005	5mg	€	660,00
HAA3240.0010	10mg	€	1190,00

HAA4010 Dpd-d_4

(+)-Deoxypyridinoline-d_4 trifluoroacetic acid salt

FORMULA: $C_{18}H_{25}D_4N_4O_7$

MOLECULAR WEIGHT: **417,47 g/mol**



HAA4010.0005	5mg	€	900,00
HAA4010.0010	10mg	€	1620,00

References:

- Practical syntheses of pyridinolines, important amino acidic biomarkers of collagen health; P. Allevi, R. Cribiu, E. Giannini and M. Anastasia; *J Org Chem* 2007; **72**: 3478-83. https://doi.org/10.1021/jo070136g
- Bone collagen cross-links: an efficient one-pot synthesis of (+)-pyridinoline and (+)-dexoypyridinoline; M. Adamczyk, D. D. Johnson and R. E. Reddy; *Tetrahedron: Asymmetry* 2000; **11**: 2289-2298. https://doi.org/10.1016/s0957-4166(00)00195-6
- First total synthesis of the bone resorption markers deoxypyridinoline and hydroxypyridinoline; R. Waelchli, C. Beerli, H. Meigel and L. Révész; *Bioorganic & Medicinal Chemistry Letters* 1997; **7**: 2831-2836. https://doi.org/10.1016/s0960-894x(97)10084-1

HAA3250 FFI

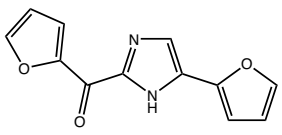
2-(2-Furoyl)-4(5)-(2-furanyl)-1H-imidazole

CAS-NO: **91037-91-1**

FORMULA: $C_{12}H_8N_2O_3$

MOLECULAR WEIGHT: **228,20 g/mol**

FFI is a fluorescent molecule derived from protein amino groups and glucose.



HAA3250.0050	50 mg	€	120,00
HAA3250.0100	100 mg	€	190,00

References:

- Mechanism of formation of the putative advanced glycosylation end product and protein cross-link 2-(2-furoyl)-4(5)-(2-furanyl)-1H-imidazole; F. G. Njoroge, A. A. Fernandes and V. M. Monnier; *J Biol Chem* 1988; **263**: 10646-52.
- Evidence against in vivo presence of 2-(2-furoyl)-4(5)-(2-furanyl)-1H-imidazole, a major fluorescent advanced end product generated by nonenzymatic glycosylation; S. Horiuchi, M. Shiga, N. Araki, K. Takata, M. Saitoh and Y. Morino; *J Biol Chem* 1988; **263**: 18821-6.
- Detection of an advanced glycosylation product bound to protein in situ; J. C. Chang, P. C. Ulrich, R. Bucala and A. Cerami; *J Biol Chem* 1985; **260**: 7970-4.
- Aging of proteins: isolation and identification of a fluorescent chromophore from the reaction of polypeptides with glucose; S. Pongor, P. C. Ulrich, F. A. Bencsath and A. Cerami; *Proc Natl Acad Sci U S A* 1984; **81**: 2684-8. https://doi.org/10.1073/pnas.81.9.2684

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D-95615 Marktredwitz, Germany

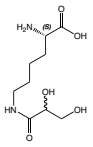
	Article No.	Quantity	Price

HAA9150 H-L-Lys(Glycerinyl)-OH

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

FORMULA: $C_9H_{18}N_2O_5$

MOLECULAR WEIGHT: **234,25 g/mol**



HAA9150.0010	10 mg	€	165,00
HAA9150.0050	50 mg	€	660,00

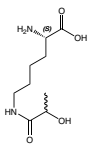
HAA9145 H-L-Lys(Lactoyl)-OH

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

CAS-NO: **928122-01-4**

FORMULA: $C_9H_{18}N_2O_4$

MOLECULAR WEIGHT: **218,25 g/mol**



HAA9145.0010	10 mg	€	165,00
HAA9145.0050	50 mg	€	660,00

References:

- Analysis of Advanced Glycation Endproducts in Rat Tail Collagen and Correlation to Tendon Stiffening; T. Jost, A. Zipprich and M. A. Glomb; *J Agric Food Chem* 2018; **66**: 3957-3965. https://doi.org/10.1021/acs.jafc.8b00937
- Detection of Free Advanced Glycation End Products in Vivo during Hemodialysis; C. Hohmann, K. Liehr, C. Henning, R. Fiedler, M. Girndt, M. Gebert, M. Hulko, M. Storr and M. A. Glomb; *J Agric Food Chem* 2017; **65**: 930-937. https://doi.org/10.1021/acs.jafc.6b05013
- Comprehensive analysis of maillard protein modifications in human lenses: effect of age and cataract; M. Smuda, C. Henning, C. T. Raghavan, K. Johar, A. R. Vasavada, R. H. Nagaraj and M. A. Glomb; *Biochemistry* 2015; **54**: 2500-7. https://doi.org/10.1021/bi5013194
- Molecular basis of maillard amide-advanced glycation end product (AGE) formation in vivo; C. Henning, M. Smuda, M. Girndt, C. Ulrich and M. A. Glomb; *J Biol Chem* 2011; **286**: 44350-6. https://doi.org/10.1074/jbc.M111.282442
- Degradation of 1-deoxy-D-erythro-hexo-2,3-diulose in the presence of lysine leads to formation of carboxylic acid amides; M. Smuda, M. Voigt and M. A. Glomb; *J Agric Food Chem* 2010; **58**: 6458-64. https://doi.org/10.1021/jf100334r

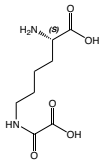
HAA9140 H-L-Lys(Oxalyl)-OH

N-epsilon-Carboxycarbonyl-L-lysine

CAS-NO: **5238-83-5**

FORMULA: $C_8H_{14}N_2O_5$

MOLECULAR WEIGHT: **218,21 g/mol**



HAA9140.0010	10 mg	€	165,00
HAA9140.0050	50 mg	€	660,00

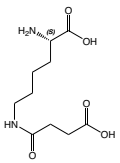
HAA3990 H-L-Lys(Suc)-OH

N-epsilon-succinimidyl-L-lysine hydrochloride salt

CAS-NO: **52685-16-2 net**

FORMULA: $C_{10}H_{18}N_2O_5$

MOLECULAR WEIGHT: **246,26 g/mol**



HAA3990.0050	50 mg	€	100,00
HAA3990.0100	100 mg	€	180,00
HAA3990.0250	250 mg	€	400,00
HAA3990.1000	1 g	€	1200,00

References:

- Adipocyte protein modification by Krebs cycle intermediates and fumarate ester-derived succination; A. M. Manuel and N. Frizzell; *Amino Acids* 2013; **45**: 1243-7. https://doi.org/10.1007/s00726-013-1568-z
- Formation of Nepsilon-(succinyl)lysine in vivo: a novel marker for docosahexaenoic acid-derived protein modification; Y. Kawai, H. Fujii, M. Okada, Y. Tsuchie, K. Uchida and T. Osawa; *J Lipid Res* 2006; **47**: 1386-98. https://doi.org/10.1194/jlr.M600091-JLR200
- New Aspects of the Maillard Reaction in Foods and in the Human Body; F. Ledl and E. Schleicher; *Angewandte Chemie International Edition in English* 1990; **29**: 565-594. https://doi.org/10.1002/anie.199005653

HAA3070 GOLD

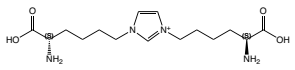
Glyoxyl-derived lysine dimer acetic acid salt

CAS-NO: **209267-39-0 net**

FORMULA: $C_{15}H_{27}N_4O_4$

MOLECULAR WEIGHT: **327,40 g/mol**

In GOLD two lysines are crosslinked by imidazolium, which is derived from glyoxal.



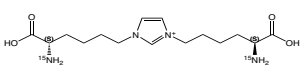
HAA3070.0010	10 mg	€	165,00
HAA3070.0050	50 mg	€	660,00

HAA3071 GOLD-$^{15}N_2$

Glyoxyl-derived lysine dimer-$^{15}N_2$ acetic acid salt

FORMULA: $C_{15}H_{27}N_2[^{15}N]_2O_4$

MOLECULAR WEIGHT: **329,39 g/mol**



HAA3071.0005	5 mg	€	360,00
HAA3071.0010	10 mg	€	575,00

Reference:

- Intact glycation end products containing carboxymethyl-lysine and glyoxal lysine dimer obtained from synthetic collagen model peptide; H. Yamada, T. Sasaki, S. Niwa, T. Oishi, M. Murata, T. Kawakami and S. Aimoto; *Bioorg Med Chem Lett* 2004; **14**: 5677-80. https://doi.org/10.1016/j.bmcl.2004.08.044
- Protein crosslinking by the Maillard reaction: dicarbonyl-derived imidazolium crosslinks in aging and diabetes; P. Chellan and R. H. Nagaraj; *Archives of biochemistry and biophysics* 1999; **368**: 98-104. https://doi.org/10.1006/abbi.1999.1291
- Role of the Maillard reaction in aging of tissue proteins. Advanced glycation end product-dependent increase in imidazolium cross-links in human lens proteins; E. B. Frye, T. P. Degenhardt, S. R. Thorpe and J. W. Baynes; *J Biol Chem* 1998; **273**: 18714-9. https://doi.org/10.1074/jbc.273.30.18714
- Imidazolium crosslinks derived from reaction of lysine with glyoxal and methylglyoxal are increased in serum proteins of uremic patients: evidence for increased oxidative stress in uremia; H. Odani, T. Shinzato, J. Usami, Y. Matsumoto, E. Brinkmann Frye, J. W. Baynes and K. Maeda; *FEBS Lett* 1998; **427**: 381-5. https://doi.org/10.1016/s0014-5793(98)00416-5
- Characterization of an Imidazolium Salt Formed from Glyoxal and N.alpha.-Hippuryllysine: A Model for Maillard Reaction Crosslinks in Proteins; K. J. Wells-Knecht, E. Brinkmann and J. W. Baynes; *The Journal of Organic Chemistry* 1995; **60**: 6246-6247. https://doi.org/10.1021/jo00125a001

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	Article No.	Quantity	Price

HAA2960 Furosine

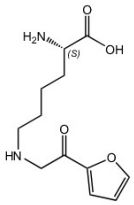
(S)-2-amino-6-(2-(furan-2-yl)-2-oxoethylamino)hexanoic acid hydrochloride salt

CAS-NO: **19746-33-9 net**

FORMULA: $C_{12}H_{18}N_2O_4$

MOLECULAR WEIGHT: **254.28 g/mol**

The thermal history of food can be determined by HPLC analytics of furosine. Hence it is used in a number of different applications including quality control of comestible goods.



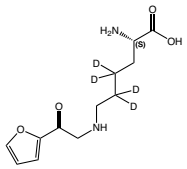
HAA2960.0010	10 mg	€ 155,00
HAA2960.0050	50 mg	€ 620,00

HAA2961 Furosine-d_4

N-epsilon-(2-furoyl-methyl)-L-[4,4,5,5-D_4]-Lysine hydrochloride salt

FORMULA: $C_{12}H_{14}D_4N_2O_4$

MOLECULAR WEIGHT: **258,31 g/mol**



HAA2961.0005	5 mg	€ 310,00
HAA2961.0010	10 mg	€ 495,00

References:

- The fluorescence of advanced Maillard products is a good indicator of lysine damage during the Maillard reaction; J. Leclere and I. Birlouez-Aragon; *J Agric Food Chem* 2001; **49**: 4682-7. https://doi.org/10.1021/jf001433o
- Furosine in consumption milk and milk powders; R. Van Renterghem and J. De Block; *International Dairy Journal* 1996; **6**: 371-382. https://doi.org/10.1016/0958-6946(95)00060-7
- Fast and sensitive determination of furosine; T. Henle, G. Zehetner and H. Klostermeyer; *Z Lebensm Unters Forsch* 1995; **200**: 235-7. https://doi.org/10.1007/BF01190503
- Detection and identification of pyridosine, a second lysine derivative obtained upon acid hydrolysis of heated milk; P. A. Finot, R. Viani, J. Bricout and J. Mauron; *Experientia* 1969; **25**: 134-5. https://doi.org/10.1007/BF01899081
- Der Abbau von Fructose-aminosäuren zu N-(2-Furoylmethyl)aminosäuren. Zwischenprodukte von Bräunungsreaktionen; K. Heyns, J. Heukeshoven and K. H. Brose; *Angewandte Chemie* 1968; **80**: 627-627. https://doi.org/10.1002/ange.19680801522
- Identification of a new lysine derivative obtained upon acid hydrolysis of heated milk; P. A. Finot, J. Bricout, R. Viani and J. Mauron; *Experientia* 1968; **24**: 1097-9. https://doi.org/10.1007/BF02147778

HAA3260 GALA

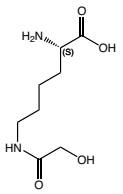
Glycolic acid-lysine-amide

CAS-NO: **171262-64-9**

FORMULA: $C_8H_{16}N_2O_4$

MOLECULAR WEIGHT: **204,22 g/mol**

GALA is an advanced glycation end product derived from the Amadori product of glucose and lysine residue.



HAA3260.0010	10 mg	€ 165,00
HAA3260.0050	50 mg	€ 660,00

Reference:

- Amides are novel protein modifications formed by physiological sugars; M. A. Glomb and C. Pfahler; *J Biol Chem* 2001; **276**: 41638-47. https://doi.org/10.1074/jbc.M103557200

HAA3290 GOLA

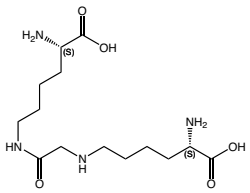
(2S)-amino-6-(2-((5S)-amino-5-carboxypentylamino)acetamido)hexanoic acid hydrochloride salt

CAS-NO: **1704455-01-5 net**

FORMULA: $C_{14}H_{28}N_4O_5$

MOLECULAR WEIGHT: **332,40 g/mol**

GOLA is an advanced glycation end product derived from the Amadori product of glucose and lysine residue.



HAA3290.0010	10 mg	€ 165,00
HAA3290.0050	50 mg	€ 660,00

Reference:

- Amides are novel protein modifications formed by physiological sugars; M. A. Glomb and C. Pfahler; *J Biol Chem* 2001; **276**: 41638-47. https://doi.org/10.1074/jbc.M103557200

HAA3980 GA-pyridine

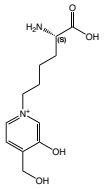
(S)-1-(5-amino-5-carboxypentyl)-3-hydroxy-4-(hydroxymethyl)pyridinium trifluoroacetic acid

CAS-NO: **526211-14-3 net**

FORMULA: $C_{12}H_{19}N_2O_4$

MOLECULAR WEIGHT: **255,29**

Hydroxypropyl-lysine is a reduced form of Schiff-base adduct derived from malondialdehyde and lysine residues.



HAA3980.0005	5 mg	€ 180,00
HAA3980.0010	10 mg	€ 300,00

References:

- Assay of advanced glycation endproducts (AGEs): surveying AGEs by chromatographic assay with derivatization by 6-aminoquinolyl-N-hydroxysuccinimidyl-carbamate and application to Nepsilon-carboxymethyl-lysine- and Nepsilon-(1-carboxyethyl)lysine-modified albumin; N. Ahmed, O. K. Argirov, H. S. Minhas, C. A. Cordeiro and P. J. Thornalley; *The Biochemical journal* 2002; **364**: 1-14. https://doi.org/10.1042/bj3640001

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Article No.	Quantity	Price

HAA3300 LM

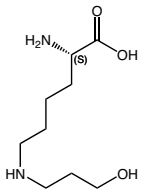
epsilon-N-3-hydroxypropyl-L-lysine

CAS-NO: **188896-12-0**

FORMULA: $C_9H_{20}N_2O_3$

MOLECULAR WEIGHT: **204,27 g/mol**

Hydroxypropyl-lysine is a reduced form of Schiff-base adduct derived from malondialdehyde and lysine residues.



HAA3300.0005	5 mg	€ 310,00
HAA3300.0010	10 mg	€ 495,00

References:

- Bound malondialdehyde in foods: bioavailability of the N-2-propenals of lysine; J. Giron-Calle, M. Alaiz, F. Millan, V. Ruiz-Gutierrez and E. Vioque; *J Agric Food Chem* 2002; **50**: 6194-8. https://doi.org/10.1021/jf025681r
- Quantification of malondialdehyde and 4-hydroxynonenal adducts to lysine residues in native and oxidized human low-density lipoprotein; J. R. Requena, M. X. Fu, M. U. Ahmed, A. J. Jenkins, T. J. Lyons, J. W. Baynes and S. R. Thorpe; *The Biochemical journal* 1997; **322 (Pt 1)**: 317-25. https://doi.org/10.1042/bj3220317
- Lipoxidation products as biomarkers of oxidative damage to proteins during lipid peroxidation reactions; J. R. Requena, M. X. Fu, M. U. Ahmed, A. J. Jenkins, T. J. Lyons and S. R. Thorpe; *Nephrol Dial Transplant* 1996; 11 Suppl **5**: 48-53. https://doi.org/10.1093/ndt/11.supp5.48
- High-performance liquid chromatographicdetermination of n-ε-(2-propenal)lysine in biological samples after derivatization with diethylethoxymethylenemalonate; J. Girón, M. Alaiz and E. Vioque; *Analytical Biochemistry* 1992; **206**: 155-160. https://doi.org/10.1016/s0003-2697(05)80026-0

HAA3310 LAL

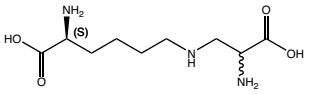
Lysinoalanine hydrochloride salt (mixture of two diastereoisomers)

CAS-NO: **4418-81-9**

FORMULA: $C_9H_{19}N_3O_4$

MOLECULAR WEIGHT: **233,26 g/mol**

Lysinoalanine (LAL) is a cross-linked amino acid which can be found in food proteins after alkali and/or thermal treatments. LAL implicates for food safety as metal chelator and can be used as a marker of thermal damage in foods.



HAA3310.0010	10 mg	€ 145,00
HAA3310.0050	50 mg	€ 580,00

References:

- Optimization of the synthesis of the cross-linked amino acid ornithinoalanine and nuclear magnetic resonance characterization of lysinoalanine and ornithinoalanine; G. Boschin, L. Scaglioni and A. Arnoldi; *J Agric Food Chem* 1999; **47**: 939-44. https://doi.org/10.1021/jf980869p
- Copper(II) and cobalt(II) affinities of LL- and LD-lysinoalanine diastereomers: implications for food safety and nutrition; M. Friedman and K. N. Pearce; *Journal of Agricultural and Food Chemistry* 1989; **37**: 123-127. https://doi.org/10.1021/jf00085a029
- Lysinoalanine in foods; J. A. Maga; *Journal of Agricultural and Food Chemistry* 1984; 32: 955-964. https://doi.org/10.1021/jf00125a001
- Lysinoalanine as a metal chelator. An implication for toxicity; R. Hayashi; *Journal of Biological Chemistry* 1982; **257**: 13896-8.
- Synthesis and properties of Nepsilon-(DL-2-amino-2-carboxyethyl)-L-lysine, lysinoalanine; J. C. Woodard, D. D. Short, C. E. Strattan and J. H. Duncan; *Food Cosmet Toxicol* 1977; **15**: 109-15. https://doi.org/10.1016/s0015-6264(77)80315-5

HAA3080 MOLD

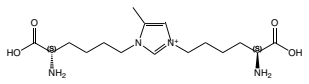
Methylglyoxyl-derived lysine dimer acetic acid salt

CAS-NO: **209267-80-2 net**

FORMULA: $C_{16}H_{29}N_4O_4$

MOLECULAR WEIGHT: **341,4 g/mol**

In MOLD two lysines are crosslinked by imidazolium, which is derived from methylglyoxal.



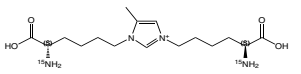
HAA3080.0010	10 mg	€ 165,00
HAA3080.0050	50 mg	€ 660,00

HAA3081 MOLD-$^{15}N_2$

Methylglyoxyl-derived lysine dimer-$^{15}N_2$ acetic acid salt

FORMULA: $C_{16}H_{29}N_2[^{15}N]_2O_4$

MOLECULAR WEIGHT: **343,41 g/mol**



HAA3081.0005	5 mg	€ 360,00
HAA3081.0010	10 mg	€ 575,00

References:

- Role of the Maillard reaction in aging of tissue proteins. Advanced glycation end product-dependent increase in imidazolium cross-links in human lens proteins; E. B. Frye, T. P. Degenhardt, S. R. Thorpe and J. W. Baynes; *J Biol Chem* 1998; **273**: 18714-9. https://doi.org/10.1074/jbc.273.30.18714
- Imidazolium crosslinks derived from reaction of lysine with glyoxal and methylglyoxal are increased in serum proteins of uremic patients: evidence for increased oxidative stress in uremia; H. Odani, T. Shinzato, J. Usami, Y. Matsumoto, E. Brinkmann Frye, J. W. Baynes and K. Maeda; *FEBS Lett* 1998; **427**: 381-5. https://doi.org/10.1016/s0014-5793(98)00416-5
- Protein crosslinking by the Maillard reaction: dicarbonyl-derived imidazolium crosslinks in aging and diabetes; P. Chellan and R. H. Nagaraj; *Archives of biochemistry and biophysics* 1999; **368**: 98-104. https://doi.org/10.1006/abbi.1999.1291
- Protein cross-linking by the Maillard reaction. Isolation, characterization, and in vivo detection of a lysine-lysine cross-link derived from methylglyoxal; R. H. Nagaraj, I. N. Shipanova and F. M. Faust; *J Biol Chem* 1996; **271**: 19338-45. https://doi.org/10.1074/jbc.271.32.19338

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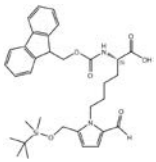
	Article No.	Quantity	Price

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: $C_{33}H_{42}N_2O_6Si$

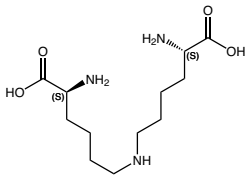
MOLECULAR WEIGHT: **590,78 g/mol**

Article No.	Quantity	Price
FAA7520.1000	1 g	€1200,00

References:

- Chemical Synthesis of Peptides Containing Site-Specific Advanced Glycation Endproducts; H. Kaur, M. Kamalov and M. A. Brimble; *Acc Chem Res* 2016; **49**: 2199-2208. https://doi.org/10.1021/acs.accounts.6b00366

HAA4000 LNL



Lysinonorleucine

CAS-NO: **25612-46-8**

FORMULA: $C_{12}H_{25}N_3O_4$

MOLECULAR WEIGHT: **275,34 g/mol**

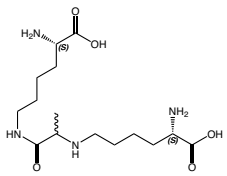
LNL is an advanced glycation end product derived from the Amadori product of glucose and lysine residue.

Article No.	Quantity	Price
HAA4000.0005	5 mg	€ 150,00
HAA4000.0010	10 mg	€ 250,00

References:

- Structural studies on cross-lined peptides containing lysinonorleucine from elastin of porcine aorta; M. Davril and K. K. Han; *Can J Biochem* 1977; **55**: 244-8. https://doi.org/10.1139/o77-034
- Lysinonorleucine. A new amino acid from hydrolysates of elastin; C. Franzblau, B. Faris and R. Papaioannou; *Biochemistry* 1969; **8**: 2833-7. https://doi.org/10.1021/bi00835a021

HAA9135 MOLA



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

FORMULA: $C_{15}H_{30}N_4O_5$

MOLECULAR WEIGHT: **346,43 g/mol**

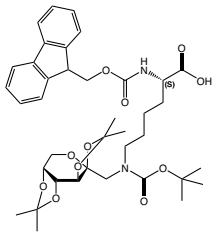
MOLA is an advanced glycation end product derived from the Amadori product of glucose and lysine residue.

Article No.	Quantity	Price
HAA9135.0050	50 mg	€ 660,00

References:

- Analysis of Advanced Glycation Endproducts in Rat Tail Collagen and Correlation to Tendon Stiffening; T. Jost, A. Zipprich and M. A. Glomb; *J Agric Food Chem* 2018; **66**: 3957-3965. https://doi.org/10.1021/acs.jafc.8b00937
- Binding and modification of proteins by methylglyoxal under physiological conditions. A kinetic and mechanistic study with N alpha-acetylarginine, N alpha-acetylcysteine, and N alpha-acetyllysine, and bovine serum albumin; T. W. Lo, M. E. Westwood, A. C. McLellan, T. Selwood and P. J. *Thornalley; J Biol Chem* 1994; **269**: 32299-305.

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



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

CAS-NO: **1133875-59-8**

FORMULA: $C_{38}H_{50}N_2O_{11}$

MOLECULAR WEIGHT: **710,82 g/mol**

Fructose conjugated lysine building block for solid phase peptide synthesis of Amadori-modified peptides.

Article No.	Quantity	Price
FAA5540.0250	250 mg	€ 250,00
FAA5540.0001	1 g	€ 750,00

References:

- Building blocks for the synthesis of post-translationally modified glycated peptides and proteins; S. Carganico, P. Rovero, J. A. Halperin, A. M. Papini and M. Chorev; *J Pept Sci* 2009; **15**: 67-71. https://doi.org/10.1002/psc.1105
- A new procedure for the synthesis of peptide-derived Amadori products on a solid support; P. Stefanowicz, K. Kapczyńska, A. Kluczyk and Z. Szewczuk; *Tetrahedron Letters* 2007; **48**: 967-969. https://doi.org/10.1016/j.tetlet.2006.12.022
- Site-specific synthesis of Amadori-modified peptides on solid phase; A. Frolov, D. Singer and R. Hoffmann; *J Pept Sci* 2006; **12**: 389-95. https://doi.org/10.1002/psc.739

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	Article No.	Quantity	Price
HAA3040 Pyrraline	HAA3040.0005	5 mg	€ 215,00
	HAA3040.0010	10 mg	€ 340,00

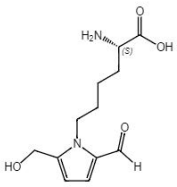
(2S)-2-amino-6-(formyl-5-hydroxymethyl-pyrrol-1-yl)-hexanoic acid

CAS-NO: **74509-14-1**

FORMULA: $C_{12}H_{18}N_2O_4$

MOLECULAR WEIGHT: **254,28 g/mol**

Pyrraline is an advanced Maillard reaction product, derived from the reaction of glucose with lysine.



	Article No.	Quantity	Price
HAA3045 Pyrraline-d_4	HAA3045.0005	5 mg	€ 530,00
	HAA3045.0010	10 mg	€ 950,00

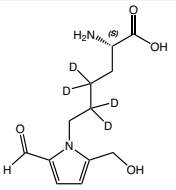
(2S)-2-amino-6-(formyl-5-hydroxymethyl-pyrrol-1-yl)-(4,4,5,5-tetradeutero) hexanoic acid

CAS-NO: **2446534-02-5**

FORMULA: $C_{12}H_{14}D_4N_2O_4$

MOLECULAR WEIGHT: **258,31 g/mol**

Pyrraline is an advanced Maillard reaction product, derived from the reaction of glucose with lysine.



References:

- Formation of ε(2-Formyl-5-hydroxy-methyl-pyrrol-1-yl)-l-norleucine in the Maillard Reaction betweend-Glucose andl-Lysine; T. Nakayama, F. Hayase and H. Kato; *Agricultural and Biological Chemistry* 2014; **44**: 1201-1202. https://doi.org/10.1080/00021369.1980.10864104
- Transport of free and peptide-bound pyrraline at intestinal and renal epithelial cells; M. Hellwig, S. Geissler, A. Peto, I. Knutter, M. Brandsch and T. Henle; *J Agric Food Chem* 2009; **57**: 6474-80. https://doi.org/10.1021/jf901224p
- Synthesis of pyrraline reference material; T. Henle and A. Bachmann; *Z Lebensm Unters Forsch* 1996; **202**: 72-4. https://doi.org/10.1007/BF01229689
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