

Practical Handbook of
**Biochemistry and
Molecular Biology**

Edited by

Gerald D. Fasman, Ph.D.

58.17073

p895

Practical Handbook of **Biochemistry and Molecular Biology**

Edited by

Gerald D. Fasman, Ph.D.

Graduate Department of Biochemistry

Brandeis University

Waltham, Massachusetts



CRC Press, Inc.
Boca Raton, Florida

Library of Congress Cataloging-in-Publication Data

Practical handbook of biochemistry and molecular biology/editor,

Gerald D. Fasman.

p. cm

Includes selections from Handbook of biochemistry and molecular biology. Cleveland CRC Press, c1975-1977

Bibliography p

Includes index

ISBN 0-8493-3705-4

1. Biochemistry--Handbooks, manuals, etc. 2. Molecular biology--Handbooks, manuals, etc. I. Fasman, Gerald D.

QP514.2.P73 1989

574.1'92--dc19

88-38230

CIP

This book represents information obtained from authentic and highly regarded sources. Reprinted material is quoted with permission, and sources are indicated. A wide variety of references are listed. Every reasonable effort has been made to give reliable data and information, but the author and the publisher cannot assume responsibility for the validity of all materials or for the consequences of their use.

All rights reserved. This book, or any parts thereof, may not be reproduced in any form without written consent from the publisher.

Direct all inquiries to CRC Press, Inc., 2000 Corporate Blvd., N.W., Boca Raton, Florida, 33431.

© 1989 by CRC Press, Inc

International Standard Book Number 0-8493-3705-4

Library of Congress Card Number
Printed in the United States

PREFACE

New methodologies and databases for biochemistry and molecular biology are constantly being added to current sources. This *Handbook* updates previous handbooks in a format which is easy to use in the laboratory.

New information, in areas such as restriction enzymes, is always being published, so it is impossible to be completely up-to-date. However, the tables in this *Handbook* contain the most relevant data available at the time of publication.

Gerald D. Fasman
Editor

THE EDITOR

Gerald D. Fasman, Ph.D., is the Rosenfield Professor of Biochemistry, Graduate Department of Chemistry, Brandeis University, Waltham, Massachusetts.

Dr. Fasman graduated from the University of Alberta in 1948 with a B.S. Honors Degree in Chemistry, and he received his Ph.D. in Organic Chemistry in 1952 from the California Institute of Technology, Pasadena, California. Dr. Fasman did postdoctoral studies at Cambridge University, England, Eidg. Technische Hochschule, Zurich, Switzerland, and the Weizmann Institute of Science, Rehovoth, Israel. Prior to moving to Brandeis University, he spent several years at the Children's Cancer Research Foundation at the Harvard Medical School. He has been an Established Investigator of the American Heart Association, a National Science Foundation Senior Postdoctoral Fellow in Japan, and has been awarded two John Simon Guggenheim Fellowships.

Dr. Fasman is a member of the American Chemical Society, a Fellow of the American Association for the Advancement of Science, member of Sigma Xi, the Biophysical Society, the American Society of Biological Chemists, the Chemical Society (London), the New York Academy of Science, the Protein Society, and a Fellow of the American Institute of Chemists. He has published 250 research papers.

ACKNOWLEDGMENT

With exceptions as noted, materials in this volume were derived from the multi-volume *CRC Handbook of Biochemistry and Molecular Biology*, edited by Gerald D. Fasman:

Section 1. Proteins: derived from *Proteins*, Volumes I and II (pages 3 to 102 from Volume I and pages 103 to 366 from Volume II) as well as new material, beginning on page 367.

Section 2. Nucleic Acids: derived from *Nucleic Acids*, Volumes I and II (pages 385 to 402 and 403 to 448, respectively), with added new material on pages 449 to 511.

Section 3. Lipids: contains selected tables from *Lipids, Carbohydrates and Steroids*.

Section 4. Physical-Chemical Data: drawn from Volumes I and II (pages 531 to 565 and 566 to 576, respectively) of *Physical and Chemical Data*.

TABLE OF CONTENTS

SECTION 1. AMINO ACIDS AND PROTEINS

Amino Acids	3
Data on the Naturally Occurring Amino Acids	3
α,β -Unsaturated Amino Acids	69
Amino Acid Antagonists	71
Properties of the α -Keto Acid Analogs of Amino Acids	75
Far Ultraviolet Absorption Spectra of Amino Acids	77
UV Absorption Characteristics of <i>N</i> -Acetyl Methyl Esters of the Aromatic Amino Acids, Cystine, and of <i>N</i> -Acetylcysteine	80
Numerical Values of the Absorbances of the Aromatic Amino Acids in Acid, Neutral, and Alkaline Solutions	81
Table 1 Molecular Absorbances of Tyrosine	81
Table 2 Molecular Absorbances of Tryptophan	82
Table 3 Molecular Absorbances of Phenylalanine	83
Table 4 Alkaline vs. Neutral Difference Spectra of Tyrosine, Tryptophan, and Phenylalanine	84
Table 5 Acid vs. Neutral Difference Spectra of Tyrosine, Tryptophan, and Phenylalanine	85
Luminescence	86
Table 1 Luminescence of the Aromatic Amino Acids	86
Table 2 Luminescence of Derivatives of the Aromatic Amino Acids	87
Table 3 Luminescence of Proteins Lacking Tryptophan	90
Table 4 Luminescence of Proteins Containing Tryptophan	91
Table 5 Covalent Protein Conjugates	94
Specific Rotatory Dispersion Constants for 0.1 <i>M</i> Amino Solutions	95
Amino Acid Suffixes and Prefixes	
Poly(α -Amino) Acids	96
Poly(α -Amino) Acids, Their Solubility and Susceptibility to Enzymatic Activities	97
Proteins	103
Specificity of Reagents Commonly Used to Chemically Modify Proteins	103
Acid Hydrolysis of Proteins	106
Table 1 Destruction of Serine and Threonine	106
Table 2 Destruction of Serine, Threonine, Cystine, and Tyrosine	106
Table 3 Recovery of Tryptophan from Various Proteins after Acid Hydrolysis in the Presence of 4% Thioglycollic Acid	107
Hydrolysis of Proteins	108
Table 1 Hydrolysis of Peptides in Acid Solution	108
Table 2 Enzymatic Hydrolysis of Proteins and Polypeptides	109
Table 3 Enzymatic Hydrolysis of Several Conjugated Proteins	111
Table 4 Specificity of Trypsin toward Synthetic Substrates	111
Table 5 Specificity of Chymotrypsin for Hydrolysis of Peptide Bonds in Proteins and Polypeptides	112
Table 6 Products formed on Chymotryptic Hydrolysis of α -Chains of Human Globin under Two Different Conditions of Hydrolysis	114
Table 7 Conditions for Chymotryptic Hydrolysis of Certain Proteins	115
Table 8 Specificity of Pepsin for Hydrolysis of Peptide Bonds in Proteins and Polypeptides	116
Table 9 Specificity of Papain for Hydrolysis of Peptide Bonds in Proteins and Polypeptides	117

Table 10	Specificity of Subtilisin for Hydrolysis of Peptide Bonds in Proteins and Polypeptides.....	118
	Index to Physical-Chemical Data of Proteins	119
Table 1	Globular Proteins	119
Table 2	Fibrous Proteins	126
	The Proteins of Blood Coagulation	127
	Glycoproteins	130
Table 1	Glycoproteins, Human Plasma	131
Table 2	Plasma Glycoproteins (Other Than Human)	132
Table 3	Glycoproteins, Blood Group Substances, and Mucins	135
Table 4	Glycoproteins, Tissues	137
Table 4A	Glycoproteins, Cell Membranes	139
Table 4B	Glycoproteins, Enveloped Viruses	140
Table 5	Glycoproteins, Body Fluids	140
Table 6	Glycoproteins, Eggs, Milk	141
Table 7	Glycoproteins, Plants	143
Table 8	Glycoproteins, Hormones	144
Table 9	Glycoproteins, Enzymes	146
	Characterization of Histones	149
Table 1	Characterization of Histones	150
Table 2	Histone Sequences	151
	Molecular Parameters of the Contractile Proteins	157
	Subunit Constitution of Proteins	158
	Molar Absorptivity $A_{1\%}^{1\text{cm}}$ and Values for Proteins at Selected Wavelengths of the Ultraviolet and Visible Region.....	196
	Protein pK Values	359
	Gel Electrophoresis of Proteins	367
	SDS-Electrophoresis	367
	Proteins Studied by Electrophoresis	367
	Comparison of Mobilities of Proteins of Different Molecular Weights	369
	A Nonurea Electrophoretic Gel System for Resolution of Polypeptides of M, 2,000 to M, 200,000	370
	Molecular Weights of Phage Proteins Determined by Comparing Their Mobility in SDS Gels with Those of Marker Proteins with Known Molecular Weights	371
	Molecular Weight Analysis of Oligopeptides by Electrophoresis in Polyacrylamide Gel with Sodium Dodecyl Sulfate	372
	Molecular Weights of Polypeptides Employed in Electrophoresis	372
	Use of Dimethyl Suberimide, a Cross-Linking Reagent, in Studying the Subunit Structure of Oligomeric Proteins.....	373
	Prestained Electrophoresis Standards	374
	Polyacrylamide Gels	376
	Relationship of Polyacrylamide Gel Concentration and Mobility of a Number of Different Proteins	376
	Buffers for Acrylamide Gels (Single-Gel Systems)	377
	Buffers for Acrylamide Gels with More Than One Layer	378
	References	379
	Detection Methods for Enzymes after Separation in Starch or Acrylamide Gel	380
	Starch Gels	381
Table 1	Starch Gels: Buffer Solutions	381
Table 2	Starch Gels Containing Urea Buffer Solutions	382

SECTION 2. NUCLEOSIDES, NUCLEOTIDES, AND NUCLEIC ACIDS

Alkyl Bases, Nucleosides, and Nucleotides	385
UV Spectra Characteristics and Acid Dissociation Constants of 280 Alkyl Bases, Nucleosides, and Nucleotides.....	385
UV Absorbance of Oligonucleotides containing 2'-O-Methylpentose Residues	395
Optical Rotatory Dispersion Parameters of Oligonucleotides of RNA	396
Circular Dichroism Parameters of Oligonucleotides of RNA	399
Circular Dichroism Parameters of Oligonucleotides of DNA	401
Functional Characterizations of Nucleophosphodiesterases	403
Table 1 Deoxyribonucleases	404
Table 2 Ribonuclease	417
Table 3 Nucleases Nonspecific for the Sugar Moiety	427
Deoxynucleotide Polymerizing Enzymes	441
Ribonucleotide Polymerizing Enzymes	443
Gel Electrophoresis of Nucleic Acids	449
Table 1 Two-Dimensional Gel Systems for RNA Separation	449
Table 2 Conditions for the Electrophoresis of Oligonucleotides: Comparison of the Original Procedure and Some Modifications	450
Table 3 Conditions for the Electrophoresis of RNA Fragments	451
Table 4 Conditions for the Electrophoresis of Small RNA Molecules	452
Table 5 Conditions for the Electrophoresis of mRNA	453
Table 6 Conditions for the Electrophoresis of DNA Restriction Fragments on Conventional Gels	454
Table 7 Conditions for the Electrophoresis of DNA Restriction Fragments on Denaturing Gradient Gels	455
References	456
Electrophoresis of Nucleoproteins	457
Recipes of Gel Mixtures Used for Separating Polysomes and Ribosomes	457
Nucleic Acid Molecular Weight Markers	459
DNA Size Markers	459
pBR322	459
Table 1 Sizes of the Restriction Fragments of pBR322	459
SV40	460
Table 2 Sizes of Restriction Fragments from SV40	460
Bacteriophage Lambda (λ)	460
Table 3 Sizes of Restriction Fragments of Phage λ el ts 857	461
Table 4 Sizes of Restriction Fragments of Phage λ C 72	462
ϕ X174	462
Table 5 Sizes of Restriction Fragments of ϕ X174	462
fd DNA	463
Table 6 Sizes of Restriction Fragments for fd DNA	463
RNA Size Markers	464
Table 7 Molecular Weight Markers for Gel Electrophoresis of RNA	464
References	465
Nucleases	466
Endonucleases Specific for Single-stranded Polynucleotides	466
Properties of Single-Stranded Polynucleotide-Specific Endonucleases	466
Exodeoxyribonucleases of <i>Escherichia coli</i>	468
Exonucleases of <i>E. coli</i>	468

RecBC-Like Enzymes.....	469
Exonuclease V: Deoxynucleases.....	469
Purification and Properties of ExoV Enzymes	469
Restriction and Modification Enzymes and Their Recognition Sequences.....	470
SECTION 3. LIPIDS	
Fatty Acids: Physical and Chemical Characteristics	514
Dielectric Constants of Some Fats, Fatty Acids, and Esters	522
Solubilities of Fatty Acids in Water	523
Approximate Solubilities of Water in Saturated Fatty Acids at Various Temperatures.....	523
Solubility of Simple Saturated Triglycerides.....	524
Solubilities of Mixed Triacid Triglycerides at 25°C.	525
Properties and Fatty Acid Composition of Fats and Oils	526
SECTION 4. PHYSICAL-CHEMICAL DATA	
Thermodynamic Terms Recommended	531
Deci-Normal Solutions of Oxidation and Reduction Reagents.....	534
Measurement of pH	535
Buffer Solutions	544
Amine Buffers Useful for Biological Research.....	550
Preparation of Buffers for Use in Enzyme Studies	553
Indicators for Volumetric Work and pH Determinations	561
Mixed Indicators.....	563
Concentration of Acids and Bases	565
Transmission Limits of Common Ions.....	566
Spectrophotometric Determination of Protein Concentration in the Short-Wavelength Ultraviolet.....	567
Weights of Cells and Cell Constituents.....	568
Particle Diameter.....	569
Chemical and Physical Properties of Various Commercial Plastics	570
Chemical Resistance and Other Properties of Centerpiece Materials Used in the Beckman® Model-E Analytical Ultracentrifuge.....	572
Chemical Compatibility of Millipore® Filters, O-Rings, and Filter Holders	575
INDEX.....	579

Section 1

Amino Acids and Proteins

AMINO ACIDS

DATA ON THE NATURALLY OCCURRING AMINO ACIDS

Elizabeth Dodd Mooz

The amino acids included in these tables are those for which reliable evidence exists for their occurrence in nature. These tables are intended as a guide to the primary literature in which the isolation and characterization of the amino acids are reported. Originally, it was planned to include more factual data on the chemical and physical properties of these compounds; however, the many different conditions employed by various authors in measuring these properties (i.e., chromatography and spectral data) made them difficult to arrange into useful tables. The rotation values are as given in the references cited; unfortunately, in some cases there is no information given on temperature, solvent, or concentration.

The investigator employing the data in these tables is urged to refer to the original articles in order to evaluate for himself the reliability of the information reported. These references are intended to be informative to the reader rather than to give credit to individual scientists who published the original reports. Thus not all published material is cited.

The compounds listed in Sections A to N are known to be of the *L* configuration. Section O contains some of the *D* amino acids which occur naturally. This last section is not intended to be complete since most properties of the *D* amino acids correspond to those of their *L* enantiomorphs. Therefore, emphasis was placed on including those *D* amino acids whose *L* isomers have not been found in nature. The reader will find additional information on the *D* amino acids in the review by Corrigan^{2,6,3} and in the book by Meister.¹

Compilation of data for these tables was completed in December 1974. Appreciation is expressed to Doctors L. Fowden, John F. Thompson, Peter Müller, and M. Bodanszky who were helpful in supplying recent references and to Dr. David Pruess who made review material available to me prior to its publication. A special word of thanks to Dr. Alton Meister who made available reprints of journal articles which I was not able to obtain.

DATA ON THE NATURALLY OCCURRING AMINO ACIDS (continued)

No.	Amino acid (synonym)	Source	Structure	Formula (mol wt)	Melting point °C ^a	[α] _D ^b	pK _a	References		
								Isolation and puri- fication	Chroma- tography	Spectral data
A. L-Monoamino, Monocarboxylic Acids										
1	Alanine (α-aminopropionic acid)	Silk fibroin	CH ₃ CH(NH ₂)COOH	C ₃ H ₇ NO ₂ (89.09)	297°	+1.8 ²⁵ (c 2, H ₂ O) (1) +14.6 ²⁵ (c 2, 5 N HCl) (1)	2.34 9.69	2	3	4
2	β-Alanine (β-aminopropionic acid)	<i>Iris tingitana</i>	NH ₂ CH ₂ CH ₂ COOH	C ₃ H ₇ NO ₂ (89.09)	196° (dec)	-	3.55 10.24	5	5	5
3	α-Aminobutyric acid	Yeast protein	CH ₃ CH ₂ CH(NH ₂)COOH	C ₄ H ₉ NO ₂ (103.12)	292° (dec)	+20.5 ²⁵ (c 1-2, 5 N HCl) (290) +9.3 ²⁵ (c 1-2, (H ₂ O) (290) -42 ²⁵ (c 1-2, gl acetic) (290)	2.29 9.83	6	7	6
4	γ-Aminobutyric acid (piperidinic acid)	Bacteria	NH ₂ CH ₂ CH ₂ CH ₂ COOH	C ₄ H ₉ NO ₂ (103.12)	203° (dec)	-	4.03 10.56 (290)	8-10	9, 10	11
5	1-Aminocyclopropane- 1-carboxylic acid	Peas and apples	$\begin{array}{c} \text{CH}_2 \\ \diagup \quad \diagdown \\ \text{H}_2\text{C} \quad \text{C} - \text{COOH} \\ \quad \quad \quad \\ \quad \quad \quad \text{NH}_2 \end{array}$	C ₄ H ₇ NO ₂ (101.11)	-	-	-	11	11	12
6	2-Amino-3-formyl-3- pentenoic acid	<i>Banquera fulginea</i> (a mushroom)	$\begin{array}{c} \text{CHO} \\ \\ \text{CH}_2\text{CH} = \text{CCH}(\text{NH}_2)\text{COOH} \end{array}$	C ₆ H ₉ NO ₂ (143.15)	-	-	-	13	13	13
7	α-Aminoheptanoic acid	<i>Claviceps purpurea</i>	CH ₃ (CH ₂) ₄ CH(NH ₂)COOH	C ₇ H ₁₃ NO ₂ (145.21)	-	-	-	14	14	-

DATA ON THE NATURALLY OCCURRING AMINO ACIDS (continued)

No.	Amino acid (synonym)	Source	Structure	Formula (mol wt)	Melting point °C ^a	[α] _D ^b	pK _a	References		
								Isolation and purification	Chromatography	Spectral data
7a	2-Amino-4,5-hexadienoic acid	<i>Amarilia solitaria</i>	$H_2C=CHCH_2-CH(NH_2)COOH$	$C_6H_9NO_2$ (127.16)	200° (dec) (14a)	-	-	14a	-	14a
8	2-Amino-4-hexenoic acid	Ilamycin	$CH_3CH=CHCH_2CH(NH_2)COOH$	$C_7H_{11}NO_2$ (129.17)	-	-	-	15	15	-
8a	2-Amino-4-hydroxy- hept-6-ynoic acid	<i>Euphorbia longan</i>	$HC\equiv C-CH_2CH(OH)CH_2CH(NH_2)COOH$	$C_8H_{11}NO_3$ (157.19)	-	-27° ^a (c 2, H ₂ O) -8° ^a (c 1, 5 N HCl) (15a)	-	15a	15a	15a
8b	2-Amino-6-hydroxy-4-methyl-4-hexenoic acid	<i>Aesculus Californica</i> seeds	$HOH_2C-CH=CH-C(CH_3)=CH-CH_2CH(NH_2)COOH$	$C_9H_{15}NO_3$ (159.21)	-	-31° ^a (c 2, H ₂ O) +2° ^a (c 1, 1, 5 N HCl) (23b)	-	23b	-	15b
8c	2-Amino-4-hydroxy-5-methyl hexenoic acid	<i>Euphorbia longan</i>	$HC\equiv C-CH_2CH_2CH(NH_2)COOH$	$C_8H_{11}NO_2$ (157.19)	-	-27° ^a (c 2, H ₂ O) -13° ^a (c 1, 5 N HCl) (15a)	-	15a	15a	15a
8d	2-Amino-3-hydroxy-methyl-3-pentenoic acid	<i>Bankea fuliginosa</i>	$HOH_2C-CH_2CH_2CH(OH)CH_2COOH$	$C_8H_{11}NO_3$ (145.18)	160-161° (dec) (13)	+182° ^a (c 0.8, H ₂ O) +201° ^a (c 0.8, 0.3 N HCl) (13)	-	13	13	13
9	α-Aminoisobutyric acid	<i>Iris tingiana</i> , muscle protein	$(CH_3)_2C(NH_2)COOH$	$C_4H_9NO_2$ (103.12)	200° (dec)	-	2.36 10.21 (23b)	16	16	-
10	β-Aminoisobutyric acid	<i>Iris tingiana</i>	$NH_2CH_2CH(COOH)CH_3$	$C_4H_9NO_2$ (103.12)	179° (BT)	-21° ^a (c 0.43, H ₂ O) (17)	-	17	17	17

DATA ON THE NATURALLY OCCURRING AMINO ACIDS (continued)

No.	Amino acid (synonym)	Source	Structure	Formula (mol wt)	Melting point °C ^a	[α] _D ^b	pK _a	References		
								Isolation and puri- fication	Chromatography	Spectral data
10a	2-Amino-4-methoxy- trans-3-butenic acid	<i>Pseudomonas</i> <i>aeruginosa</i>		C ₅ H ₉ NO ₃ (131.15)	-	-	-	17a	17b	17a, 17b
11	γ-Amino-α-methylene butyric acid	<i>Arcuth hypogaea</i> (groundnut plants)		C ₅ H ₉ NO ₃ (115.13)	152° (18)	-	-	18	18	18
12	2-Amino-4-methyl- hexanoic acid (homoleucine)	<i>Axcelus</i> <i>Californica</i> seeds		C ₇ H ₁₃ NO ₃ (145.21)	-	-2 ²⁰ (c 1, H ₂ O) (19) +24 ²⁰ (c 0.87, 5 N HCl) (19)	-	19	19	19
13	2-Amino-4-methyl- 4-hexenoic acid	<i>Axcelus</i> <i>Californica</i> seeds		C ₇ H ₁₃ NO ₃ (145.19)	-	-61 ¹⁰ (c 2.4, H ₂ O) (19) -36 (c 1.2, 6 N HCl) (19)	-	19	19	19
13a	2-Amino-4-methyl- 5-hexenoic acid	<i>Streptomyces</i> species		C ₇ H ₁₃ NO ₃ (143.21)	260° (dec) (19a)	-9.6° (c 1.78, H ₂ O) +5.7° (c 0.7, 1 N HCl) (99a)	-	19a	19a	19a
14	2-Amino-5-methyl- 4-hexenoic acid	<i>Leuconotarius</i> <i>bulbiger</i>		C ₇ H ₁₃ NO ₃ (143.19)	260-270° (dec) (22a)	-45.9 ¹³ (c 0.47, H ₂ O) -7 ¹³ (c 0.4, 1 N HCl) (22a)	-	22, 22a	22a	22a

DATA ON THE NATURALLY OCCURRING AMINO ACIDS (continued)

No.	Amino acid (synonym)	Source	Structure	Formula (mol wt)	Melting point °C ^a	[α] _D ^b	pK _a	References		
								Isolation and puri- fication	Chroma- tography	Spectral data
14a	2-Amino-4-methyl-5-hexenoic acid	<i>Euphorbia longin</i>	$\begin{array}{c} \text{HC} \equiv \text{C} \\ \\ \text{CHCH}_2\text{CH}(\text{NH}_2)\text{COOH} \\ \\ \text{H}_3\text{C} \end{array}$	C ₈ H ₁₁ NO ₂ (141.19)	-	-33° ^c (c 2, H ₂ O) -27° ^c (c 1, 5 N HCl) (15a)	-	15a	-	15a
15	α-Amino-octanoic acid	<i>Aspergillus niger</i>	CH ₃ (CH ₂) ₆ CH(NH ₂)COOH	C ₈ H ₁₅ NO ₂ (159.23)	-	-	-	23	23	23
15a	2-Amino-4-pentynoic acid	<i>Streptomyces</i> sp. #8-4	$\begin{array}{c} \text{HC} \equiv \text{CCH}_2\text{CH}(\text{NH}_2)\text{COOH} \end{array}$	C ₈ H ₁₁ NO ₂ (113.13)	241-242° (dec) (23a)	-31.1° ^c (c 1, H ₂ O) -5.5° ^c (c 1, 5 N HCl) (23a)	-	23a	23a	23a
15a'	de-α-(Carboxy-cyclopropyl)glycine	<i>Alexandrium perfringens</i>	$\begin{array}{c} \text{HOOCCH} \begin{array}{c} \diagup \text{CH}_2 \\ \diagdown \text{CH} \end{array} \text{CH}(\text{NH}_2)\text{COOH} \end{array}$	C ₈ H ₁₁ NO ₂ (159.16)	-	+25° ^c (c 1, H ₂ O) +58° (c 0.5, 5 N HCl) (23a')	-	23a'	23a'	23a'
15b	trans-α-(Carboxy-cyclopropyl)glycine	<i>Blighia sapida</i>	$\begin{array}{c} \text{HOOCCH} \begin{array}{c} \diagup \text{CH}_2 \\ \diagdown \text{CH} \end{array} \text{CH}(\text{NH}_2)\text{COOH} \end{array}$	C ₈ H ₁₁ NO ₂ (159.16)	-	+107° ^c (c 2, H ₂ O) +146° ^c (c 1, 5 N HCl) (23a')	-	23a'	23a'	23a'
15b'	trans-α-(2-Carboxy-methylcyclopropyl)glycine	<i>Blighia unguis</i>	$\begin{array}{c} \text{HC} \begin{array}{c} \diagup \text{CH}_2 \\ \diagdown \text{CH} \end{array} \text{CH}(\text{NH}_2)\text{COOH} \\ \\ \text{CH}_2\text{COOH} \end{array}$	C ₈ H ₁₁ NO ₂ (173.19)	-	+12° ^c (c 1, H ₂ O) +45° ^c (c 0.5, 5 N HCl) (99a)	-	99a	99a	99a