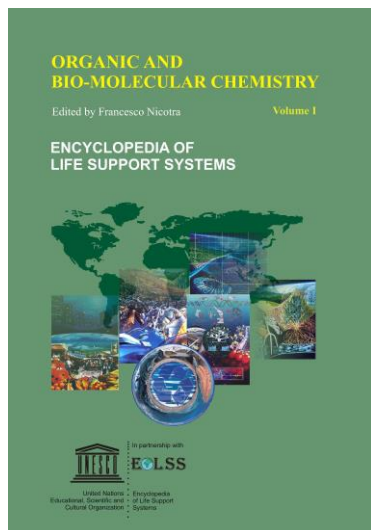


# CONTENTS

## ORGANIC AND BIO-MOLECULAR CHEMISTRY



### **Organic and Bio-molecular Chemistry Volume 1**

e-ISBN: 978-1-905839-98-8

ISBN : 978-1-84826-998-9

No. of Pages: 384

### **Organic and Bio-molecular Chemistry Volume 2**

e-ISBN: 978-1-905839-99-5

ISBN : 978-1-84826-999-6

No. of Pages: 434

For more information of e-book and Print Volume(s) order, [please click here](#)

Or contact : [eolssunesco@gmail.com](mailto:eolssunesco@gmail.com)

## CONTENTS

## VOLUME I

<b>Organic and Bio-molecular Chemistry</b>	<b>1</b>
Francesco Nicotra, <i>Department of Biotechnology and Biosciences, University of Milano-Bicocca, Milano, Italy</i>	

1. Introduction
2. The Carbon Atom
  - 2.1. The Carbon Atom Building Blocks: Hybridizations
  - 2.2. Single and Multiple Bonds
3. Structure of organic compounds
  - 3.1. Graphical Representation of the Structures of Organic Compounds
  - 3.2. Different Shapes that a Molecule can assume: Conformations
  - 3.3. Asymmetry of some Organic Molecules: Chirality and Stereoisomers
4. Classification of organic compounds, the functional groups
  - 4.1. Alkanes
  - 4.2. Alkenes
  - 4.3. Alkynes
  - 4.4. Aromatic Hydrocarbons
  - 4.5. Haloalkanes
  - 4.6. Alcohols
  - 4.7. Thiols
  - 4.8. Ethers
  - 4.9. Thioethers, Disulfides and Trisulfides
  - 4.10. Amines
  - 4.11. Aldehydes and Ketones
  - 4.12. Carboxylic Acids, Esters and Amides
5. Attractive interactions and molecular recognition
6. Reactivity of organic compounds
7. Molecules of life
  - 7.1. Carbohydrates
  - 7.2. Amino Acids, Peptides and Proteins
  - 7.3. Nucleic Acids
  - 7.4. Lipids
    - 7.4.1. Fats, Oils and Waxes
    - 7.4.2. Phospholipids and Glycolipids
    - 7.4.3. Terpenoids
    - 7.4.4. Fat-soluble Vitamins
    - 7.4.5. Steroids
8. Organic compounds in the market
  - 8.1. Dyes
  - 8.2. Compounds for Health Care
  - 8.3. Compounds for Food Industry
  - 8.4. Polymers
9. Isolation, purification and analysis of organic compounds
10. Conclusions

<b>Organic Substances and Structures, Nomenclature of Organic Compounds</b>	<b>56</b>
Luigi A. Agrofoglio, <i>ICOA UMR CNRS 6005, University of Orleans – France</i>	
Patrick Rollin, <i>ICOA UMR CNRS 6005, University of Orleans – France</i>	

1. Type(s) of Nomenclature Operations
  - 1.1. Substitutive Operation
  - 1.2. Replacement Operation

- 1.3. Additive Operation
- 1.4. Conjunctive Operation
- 1.5. Subtractive Operation
- 1.6. Ring Formation or Cleavage
2. General Rules
  - 2.1. Capitalized and Italic
  - 2.2. *Numbers of Position*
  - 2.3. Punctuation
3. Parent Name
  - 3.1. Alkanes
  - 3.2. Unsaturated Alkanes
  - 3.3. Substituent Prefix Names Derived from Parent Hydrides
4. Functional Groups
5. Specific Classes of Compounds
  - 5.1. Organometallic Compounds
  - 5.2. Halogen Compounds
  - 5.3. Nitrogen Compounds
    - 5.3.1. Amines and Imines
    - 5.3.2. Amides and Imides
    - 5.3.3. Nitrile, Isocyanide and their Derivatives
    - 5.3.4. Nitro and Nitroso Compounds
    - 5.3.5. Azo, azoxy, diazo, and related compounds
    - 5.3.6. Azides
  - 5.4. Hydroxy Compounds and Analogues
    - 5.4.1. Alcohols and Phenols
    - 5.4.2. Substituent Prefixes Derived from Alcohols, Phenols, and their Analogues
    - 5.4.3. Salts
    - 5.4.4. Ethers
    - 5.4.5. Cyclic Ethers
    - 5.4.6. Aldehydes
    - 5.4.7. Ketones
    - 5.4.8. Ketenes
    - 5.4.9. Acetals, Hemiacetals, Acylals, and their Analogues
  - 5.5. Nitrogenous Derivatives of Carbonyl Compounds
  - 5.6. Acids and Derivatives
6. Numbering of Some Heterocyclic Rings
7. Numbering of Multiple Ring Systems
8. Name Construction
  - 8.1. Rules
  - 8.2. Examples

**Stereochemistry**

85

Franco Cozzi, *Dipartimento di Chimica Organica e Industriale, Universita' degli Studi di Milano, Italy*

1. Introduction
2. Symmetry
  - 2.1. Molecular Models and Symmetry Evaluation
  - 2.2. Symmetry Elements and Symmetry Operations
  - 2.3. Point Groups
3. Chirality
  - 3.1. Pairwise Relationships between Isomeric Molecules
  - 3.2. Topicity Relationships among Atoms and Groups of Atoms in Molecules
  - 3.3. Chirotopicity
4. Stereogenicity
  - 4.1. On the Distinction between Chirality and Stereogenicity
5. Conformation and configuration

- 5.1. Conformation
- 5.2. Configuration
- 5.3. Some Considerations on the Use of the Terms Conformation and Configuration
- 6. Configuration descriptors
- 7. Dependence of the properties of chiral molecules on the enantiomeric composition
  - 7.1. Racemic Forms and Enantiomerically Pure Compounds
  - 7.2. Optical Activity
  - 7.3. Racemization
- 8. How to obtain stereoisomerically pure compounds
  - 8.1. Separations
  - 8.2. Stereoselective Transformations
    - 8.2.1. Reactions Involving Chiral Non-racemic Substrates and Achiral Reagents
    - 8.2.2. Reactions Involving Achiral Substrates and Chiral Non-racemic Reagents
    - 8.2.3. Reactions Involving Chiral Substrates and Chiral Reagents
      - 8.2.3.1. Kinetic Resolution
      - 8.2.3.2. Multiple Stereoselection

**Synthetic Organic Chemistry****129**

Francesco Nicotra, *Department of Biotechnology and Biosciences, University of Milano Bicocca, Milano, Italy*

- 1. Introduction
  - 1.1. Definition and Story of Synthetic Organic Chemistry
  - 1.2. Target Oriented Synthesis
  - 1.3. Method Oriented Synthesis
- 2. Synthetic Strategy
  - 2.1. Retrosynthetic Analysis
  - 2.2. Disconnections
    - 2.2.1. One Functional Group Disconnections
    - 2.2.2. Two Functional Group Disconnections
      - 2.2.2.1. Disconnections of 1,2 Dioxygenated Structures
      - 2.2.2.2. Disconnections of 1,3 Dioxygenated Structures
      - 2.2.2.3. Disconnections of 1,4 Dioxygenated Structures
      - 2.2.2.4. Disconnections of 1,5 Dioxygenated Structures
      - 2.2.2.5. Disconnections of 1,6 Dioxygenated Structures
- 3. Protection and Deprotection
  - 3.1. Temporary and Permanent Protective Groups
  - 3.2. Protection of Alcohols
    - 3.2.1. Esters
    - 3.2.2. Ethers
    - 3.2.3. Silyl Ethers
    - 3.2.4. Acetals
    - 3.2.5. Protection of Diols
  - 3.3. Protection of Amines
    - 3.3.1. Carbamates
    - 3.3.2. Amides
    - 3.3.3. Azides
  - 3.4. Protection of Aldehydes and Ketones
  - 3.5. Protection of Carboxylic acids
- 4. Control of Stereochemistry
  - 4.1. The Chiral Pool Approach
  - 4.2. Stereoselective Transformation
    - 4.2.1. Chiral Auxiliary
    - 4.2.2. Chiral Catalyst
    - 4.2.3. Enzymes as Chiral Catalysts
- 5. The Convergent Strategy
- 6. Solid Phase Synthesis

- 6.1. Solid Supports
- 6.2. Linkers and Spaces
  - 6.2.1. Acid-labile Linkers
  - 6.2.2. Base-labile Linkers
  - 6.2.3. Linkers Cleaved by Oxidation
  - 6.2.4. Photo Cleavable Linkers
  - 6.2.5. Silicon Linkers
  - 6.2.6. Metal-Assisted Cleavages
- 7. Combinatorial Synthesis
- 8. Environmental Friendly Synthetic Procedures
  - 8.1. Reaction Media
  - 8.2. Excess of Reagents
  - 8.3. Atomic Economy
- 9. Conclusions

**Organic Chemical Reactions****168**Alessandro Abbotto, *Department of Materials Science, University of Milano-Bicocca, Italy*

- 1. Introduction
- 2. The Organic Reaction
  - 2.1. Chemical Reaction Notation: Equilibrium Arrows, Reactants and Products
  - 2.2. Mechanisms of Organic Reactions: The Arrow Notation
  - 2.3. Thermodynamics and Kinetics: Reaction Equilibrium and Reaction Rate
  - 2.4. Ionic Reactions
    - 2.4.1. Nucleophiles and Electrophiles
  - 2.5. Acids and Bases
    - 2.5.1. Brønsted Theory
    - 2.5.2. Lewis Theory
    - 2.5.3. Hard and Soft Acids and Bases
  - 2.6. Reactive Intermediates
  - 2.7. Product Selectivity
- 3. Classification of Organic Reactions
  - 3.1. Addition
    - 3.1.1. Electrophilic Addition
    - 3.1.2. Nucleophilic Addition
  - 3.2. Elimination
  - 3.3. Substitution
    - 3.3.1. Aliphatic Nucleophilic Substitution
    - 3.3.2. Aromatic Electrophilic Substitution
    - 3.3.3. Aromatic Nucleophilic Substitution
  - 3.4. Oxidation and Reduction
  - 3.5. Rearrangements
  - 3.6. Pericyclic Reactions

**Organic Chemistry and Biological Systems -Biochemistry****223**Marina Lotti, *Department of Biotechnology and Biosciences, University of Milano-Bicocca, Italy*

- 1. From Molecules to Living Systems: Complexity is Obtained from Simple Building Blocks
- 2. Amino Acids and Proteins
  - 2.1. Proteogenic Amino Acids
  - 2.2. Non Proteinogenic Amino Acids
  - 2.3. Amino Acid Polymers: Proteins. Their Structure and Function
    - 2.3.1. Proteins Folding and Structure
    - 2.3.2. Proteins Function and Regulation
- 3. Nucleotides and nucleic acids: information, energy transport, catalysis
  - 3.1. Chemical Structures of Nucleotides

- 3.2. Nucleotide Polymers: RNA and DNA
  - 3.2.1. The Flow of Genetic Information
  - 3.2.2. DNA: Storage and Transmission of Information
  - 3.2.3. RNA: Expression of Information and Catalysis
- 3.3. Nucleotides Derivatives and Coenzymes
- 4. Sugars : Energy, Structures, Modulation of Proteins Properties
  - 4.1. Monosaccharides and Polysaccharides
  - 4.2. Structural Support and Intracellular Storage of Fuel for Cell Metabolism
  - 4.3. Effects of Glycans on Glycoproteins Properties
  - 4.4. Sugars as Sources of Energy and Metabolic Intermediates
- 5. Lipids: Energy, Membranes, Protein Targeting and Signal Transduction
  - 5.1. Structures of Lipids Common in Biochemistry
  - 5.2. Lipids in Cell Metabolism
  - 5.3. Lipids as the Constituents of Cell Membranes
  - 5.4. Lipid Tails Target Proteins to Membranes

## Chemistry of Natural Compounds

255

Laura Cipolla, *Department of Biotechnology and Biosciences, University of Milano-Bicocca, Italy*

- 1. Introduction
- 2. Chemistry of natural products: a general perspective
  - 2.1. Alkylation Reactions
    - 2.1.1. Nucleophilic Substitution
    - 2.1.2. Electrophilic Addition
  - 2.2. Wagner-Meerwein Rearrangements
  - 2.3. Aldol and Claisen Reactions
  - 2.4. Imine Formation and the Mannich Reaction
  - 2.5. Transamination Reactions
  - 2.6. Decarboxylation reactions
    - 2.6.1. Decarboxylation of  $\alpha$ -amino Acids
    - 2.6.2. Decarboxylation of  $\beta$ -keto Acids
    - 2.6.3. Decarboxylation of  $\alpha$ -keto Acids
  - 2.7. Oxidations and Reductions
    - 2.7.1. Dehydrogenases
    - 2.7.2. Oxidases
    - 2.7.3. Oxygenases
    - 2.7.4. Amine Oxidases
  - 2.8. Carbohydrate Processing Enzymes: Glycosidases and Glycosyl Transferases
- 3. Lipids
  - 3.1. Hydrolyzable lipids
    - 3.1.1. Waxes
    - 3.1.2. Triglycerides
    - 3.1.3. Phospholipids
  - 3.2. Non-hydrolyzable lipids
    - 3.2.1. Fat-soluble Vitamins
    - 3.2.2. Eicosanoids
    - 3.2.3. Terpenoids
    - 3.2.4. Steroids
- 4. Amino Acids, Peptides and Proteins
  - 4.1. Amino Acids: Structural Features and Acid-base Behavior
  - 4.2. Amino Acid Biosynthesis
  - 4.3. Peptides and Proteins
    - 4.3.1. Ribosomal Biosynthesis of Peptides and Proteins
    - 4.3.2. Nonribosomal Biosynthesis of Peptides and Proteins
  - 4.4. Relevant Peptides and Proteins
    - 4.4.1. Hormones
    - 4.4.2. Interferons

- 4.4.3. Opioid Peptides
- 4.4.4. Enzymes
- 5. Nucleosides, nucleotides and nucleic acids
  - 5.1. Purine Nucleotides Biosynthesis
  - 5.2. Pyrimidine Nucleotides Biosynthesis
- 6. Carbohydrates
  - 6.1. Monosaccharides
  - 6.2. Disaccharides, Oligosaccharides, Polysaccharides and Carbohydrate Processing Enzymes
  - 6.3. Glycoconjugates
    - 6.3.1. Glycoproteins
    - 6.3.2. Glycolipids

**Index** **321**

**About EOLSS** **327**

## VOLUME II

<b>Medicinal Chemistry</b>	<b>1</b>
<i>Fulvio Gualtieri, Department of Pharmaceutical Sciences, University of Florence, Italy</i>	

1. Introduction
  - 1.1. Definition of a Drug
  - 1.2. Classification of Drugs
  - 1.3. Definition of Medicinal Chemistry
2. From Bioactive Molecules to Drugs
  - 2.1. Pharmacokinetics: Absorption, Distribution, Metabolism, Excretion (ADME)
  - 2.2. Toxicity (T)
  - 2.3. Impact of Absorption, Distribution, Metabolism, Excretion, Toxicity (ADMET) on Drug Design and Development
3. The Basis for Drug Action
  - 3.1. Mechanism of Action of Drugs
  - 3.2. Drug Targets
  - 3.3. Preclinical Evaluation of Drug Activity
4. Drug Discovery and Development
  - 4.1. Drug Design and Development: in Silico Studies
  - 4.2. Drug Design: Lead Identification
    - 4.2.1. Existing Drugs
    - 4.2.2. Natural Compounds
    - 4.2.3. Serendipity
    - 4.2.4. Systematic Screening
    - 4.2.5. Combinatorial Chemistry
    - 4.2.6. Rational Design
  - 4.3. Drug Development: Lead Optimization
    - 4.3.1. Isosteric Replacement
    - 4.3.2. Molecular Simplification
    - 4.3.3. Molecular Complication
    - 4.3.4. Electronic Modulation
    - 4.3.5. Steric Modulation
    - 4.3.6. Derivatization (Prodrugs)
5. Clinical Evaluation
6. Industrial Drug Development
7. Conclusions

**Chemistry of Nutraceuticals, Flavors, Dyes and Additives**

42

Barbara La Ferla, *University of Milano Bicocca, Milan, Italy*

1. Introduction
2. Flavors
  - 2.1. Natural Flavors
    - 2.1.1. Flavors derived from Lipid Catabolism
    - 2.1.2. Flavors of the Terpene Family
    - 2.1.3. Flavors derived from Amino Acids Catabolism
  - 2.2. Artificial Flavors
3. Dyes
  - 3.1. Natural Colorings
    - 3.1.1. Carotenoids
    - 3.1.2. Anthocyanins
    - 3.1.3. Chlorophyll
    - 3.1.4. Betalaines
    - 3.1.5. Carminic Acid and Curcumin
  - 3.2. Synthetic Dyes
4. Additives
  - 4.1. Sweeteners or Edulcorants
    - 4.1.1. Nutritive Sweeteners
    - 4.1.2. Non-nutritive Sweeteners
  - 4.2. Preservatives
    - 4.2.1. Main Food Spoilage
    - 4.2.2. Antioxidants
    - 4.2.3. Antimicrobials
  - 4.3. Emulsifiers and Stabilizers
5. Nutraceuticals
  - 5.1. Flavonoids
  - 5.2. Polyunsaturated Fatty Acids (PUFAs)
  - 5.3. Amino Acids
  - 5.4. Vitamins

**Computational Organic Chemistry**

86

Giuseppe Zampella, *Department of Biotechnology and Biosciences, University of Milano-Bicocca, Italy*  
 Luca De Gioia, *Department of Biotechnology and Biosciences, University of Milano-Bicocca, Italy*

1. Introduction
2. Computational Approaches based on Classical Physics: Molecular Mechanics and Molecular Dynamics
  - 2.1. Molecular Mechanics
  - 2.2. Molecular Dynamics
3. Molecular Orbitals Theory and its Hartree-Fock Implementation
  - 3.1. Post Hartree-Fock Methods
    - 3.1.1. Configuration Interaction Theory (CI)
    - 3.1.2. Perturbation Methods
4. Density functional theory (DFT)
  - 4.1. Kohn-Sham (KS) Implementation
5. Semiempirical Methods

**Organic Photochemistry**

116

Antonio Papagni, *Department of Materials Science, University of Milano-Bicocca, Milano, Italy.*

1. Introduction
2. Photo-physics: Interaction of Light with Matter and Photostimulated Processes
  - 2.1. Interaction with Atoms



- 2.2. Interaction with Molecules
- 2.3. Photo-physical Processes
3. Photo-chemistry
  - 3.1. Photo-chemical Processes
  - 3.2. Organic Photostimulated Reactions
    - 3.2.1. Dissociation into Radicals
    - 3.2.2. Dissociation into Ions or “Internal” Electron Transfer
    - 3.2.3. Intramolecular rearrangement
    - 3.2.4. Photo-isomerization
    - 3.2.5. Hydrogen Atom Abstraction
    - 3.2.6. Photo-dimerization or Photo-addition
    - 3.2.7. Photo-sensitized Reactions
    - 3.2.8. Photo-ionization Reactions
  - 3.3. Miscellaneous
    - 3.3.1. Photo-reactivity of Aromatic Compounds
    - 3.3.2. Photo-chemistry of Diazo- and Azido Compounds
    - 3.3.3. Photo-cleavable Protecting Groups
    - 3.3.4. Photo-polymerization
    - 3.3.5. Chemo-luminescence
4. Technical and Experimental Aspects
5. Concluding Remarks

### Organometallic Chemistry

203

Sandro Cacchi, *Dipartimento di Studi di Chimica e Tecnologia delle Sostanze Biologicamente Attive, Università degli Studi “La Sapienza”, P. le A. Moro 5, 00185 Rome, Italy*

1. Introduction
2. Organometallic Compounds of the Group IA and IIA
  - 2.1. Organolithium Compounds
    - 2.1.1. Preparation of Organolithium Compounds
    - 2.1.2. Reactions of Organolithium Compounds
      - 2.1.2.1. Reactions with Carbon Acids
      - 2.1.2.2. Reactions with Alkylating Agents
      - 2.1.2.3. Reactions with Carbonyl Compounds
  - 2.2. Organomagnesium Compounds
    - 2.2.1. Preparation of Organomagnesium Compounds
    - 2.2.2. Reactions of Organomagnesium Compounds
      - 2.2.2.1. Formation of Carbon-Carbon Bonds
      - 2.2.2.2. Formation of Carbon-Hydrogen Bonds
      - 2.2.2.3. Formation of Carbon-Heteroatom Bonds
        - 2.2.2.3.1. Formation of Carbon-Nitrogen Bonds
        - 2.2.2.3.2. Formation of Carbon-Phosphorus Bonds
        - 2.2.2.3.3. Formation of Carbon-Oxygen Bonds
        - 2.2.2.3.4. Formation of Carbon-Sulfur Bonds
        - 2.2.2.3.5. Formation of carbon-halogen bonds
  - 2.3. Organozinc Compounds
    - 2.3.1. Preparation of Organozinc Compounds
    - 2.3.2. Reactions of Organozinc Compounds
      - 2.3.2.1. Reactions with Carbonyl Compounds
      - 2.3.2.2. Reactions with Alkenes
3. Transition Metal-based Organometallic Compounds
  - 3.1. Organocopper Compounds
    - 3.1.1. Preparation of Organocuprate Reagents
    - 3.1.2. Reactions of Organocuprate Reagents
      - 3.1.2.1. Reactions with Alkylating Agents
      - 3.1.2.2. Reactions with Carbonyl Compounds
      - 3.1.2.3. Reactions with  $\alpha,\beta$ -unsaturated Carbonyl Compounds

- 3.1.3. Copper-Catalyzed Reactions
- 3.2. Palladium-catalyzed Reactions
  - 3.2.1. Pd(II) and Pd(0)
  - 3.2.2. Pd(II)-catalyzed Reactions
    - 3.2.2.1. Pd(II)-catalyzed Reaction of Alkenes
    - 3.2.2.2. Pd(II)-catalyzed Reaction of Alkynes
    - 3.2.2.3. Pd(II)-catalyzed Reaction of Arenes
  - 3.2.3. Pd(0)-catalyzed Reactions
    - 3.2.3.1. The Heck Reaction
    - 3.2.3.2. The Tsuji-Trost Reaction
    - 3.2.3.3. Carbonylation Reactions
    - 3.2.3.4. The Cross-coupling Reactions
      - 3.2.3.4.1. The Negishi Cross-coupling
      - 3.2.3.4.2. The Stille Cross-coupling
      - 3.2.3.4.3. The Suzuki Cross-coupling
      - 3.2.3.4.4. The Sonogashira Cross-coupling
    - 3.2.3.5. The Reaction of Aryl Halides (or Pseudo Halides) with Non-organometallic Nucleophiles
- 4. Organoboranes
  - 4.1. Substitution of the C-B Bond with a C-O Bond
  - 4.2. Substitution of the C-B Bond with a C-N Bond
  - 4.3. Substitution of the C-B Bond with a C-halogen Bond
  - 4.4. Substitution of the C-B Bond with a C-C Bond
  - 4.5. Substitution of the C-B Bond with a C-H Bond

**Polymer Chemistry and Environmentally Degradable Polymers****260**Elisabetta Ranucci, *Department of Organic and Industrial Chemistry, University of Milan, Italy*

- 1. Introduction
- 2. General Structure of Polymers
  - 2.1. Basic Definitions
  - 2.2. Molecular Weights and Molecular Weight Distributions
  - 2.3. Regioisomery and Stereoregularity
  - 2.4. Primary, Secondary, and Tertiary Structure
  - 2.5. Crystalline and Amorphous Polymers
- 3. Synthesis of Polymers
  - 3.1. Step-wise Polymerization
    - 3.1.1. Crosslinking by Step-wise Polymerization
  - 3.2. Chain Polymerization
    - 3.2.1. Radical Polymerization
    - 3.2.2. Ionic Polymerization
      - 3.2.2.1. Cationic Polymerization
      - 3.2.2.2. Anionic Polymerization
    - 3.2.3. Co-ordination Polymerization
  - 3.3. Ring Opening Polymerization
- 4. Environmentally Degradable Polymers
  - 4.1. Environmental Problems Related to the use of Plastics
  - 4.2. Definition of Biodegradability and Compostability
  - 4.3. Environmentally Degradable Polymers
  - 4.4. Production of Plastics from Renewable Sources
  - 4.5. Biodegradable Oxidizable Polymers

**Organic Spectroscopy****330**Mauro Andrea Cremonini, *Department of Food Science, University of Bologna, Italy*  
Giorgio Bonaga, *Department of Food Science, University of Bologna, Italy*

1. Introduction
2. Nuclear Magnetic Resonance
  - 2.1. The Resonance Phenomenon
  - 2.2. Chemical Shift
  - 2.3. Chemical Equivalence and Signal Intensity
  - 2.4. A Simple  $^1\text{H}$ -NMR Spectrum
  - 2.5. Coupling Constant
  - 2.6. Dependence of the Proton Coupling Constant on the Molecular Structure
  - 2.7. More Complex Spectra
  - 2.8. A Real Life  $^1\text{H}$ -NMR Spectrum
  - 2.9. 2D Homonuclear Spectra
  - 2.10.  $^{13}\text{C}$  Spectra
  - 2.11. 2D Heteronuclear Spectra
3. Mass Spectrometry
  - 3.1. Brief Outline of the Technique
    - 3.1.1. Common Ionization Techniques
    - 3.1.2. Sensitivity and Resolution
    - 3.1.3. Ion analysis
  - 3.2. Mass Spectrum
  - 3.3. Isotope Content
  - 3.4. Fragmentation Pattern

**Index** **371**

**About EOLSS** **377**