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Terminology for biorelated polymers and applications (IUPAC Recommendations 2012)*

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Abstract: Like most of the materials used by humans, polymeric materials are proposed in the literature and occasionally exploited clinically, as such, as devices or as part of devices, by surgeons, dentists, and pharmacists to treat traumata and diseases. Applications have in common the fact that polymers function in contact with animal and human cells, tissues, and/or organs. More recently, people have realized that polymers that are used as plastics in packaging, as colloidal suspension in paints, and under many other forms in the environment, are also in contact with living systems and raise problems related to sustainability, delivery of chemicals or pollutants, and elimination of wastes. These problems are basically comparable to those found in therapy. Last but not least, biotechnology and renewable resources are regarded as attractive sources of polymers. In all cases, water, ions, biopolymers, cells, and tissues are involved. Polymer scientists, therapists, biologists, and ecologists should thus use the same terminology to reflect similar properties, phenomena, and mechanisms. Of particular interest is the domain of the so-called "degradable or biodegradable polymers" that are aimed at providing materials with specific time-limited applications in medicine and in the environment where the respect of living systems, the elimination, and/or the bio-recycling are mandatory, at least ideally.

Keywords: biodegradability; biomaterials; biomedicine; bioresorbability; degradability; dentistry; environment; IUPAC Polymer Division; polymers; pharmacology.

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INTRODUCTION

For thousands of years, humans have been using available substances for applications as materials, i.e., as substances of practical interest to achieve specific functions. As soon as they became industrially available, man-made polymers (as opposed to natural polymers) have been tested to serve in therapy, several having found clinical and commercial applications, thanks to the development of medical grades. Examples of such compounds are ultra-high-molar-mass polyethylene (UHMWPE), polytetrafluoroethylene (PTFE), poly(methyl methacrylate) (PMMA), and other acrylics and methacrylics, silicones, polyurethanes, etc., that are successfully used for applications such as total hip prosthesis (UHMWPE), vascular grafts (PTFE, silicones), intraocular lenses [PMMA and poly(2-hydroxyethyl methacrylate) (PHEMA) and silicones], dentistry (PMMA and other methacrylics), etc. Among these applications, some require a therapeutic aid for a limited period of time, namely, the healing period. Ideally, the temporary therapeutic aid must disappear from the body after healing in order to avoid storage of unnecessary foreign material. Indeed, skin, mucosa, and various endothelia are semi-permeable barriers that are closed to macromolecular compounds with molar mass higher than ca. 10^3 g·mol^{-1}. Accordingly, high-molar-mass molecules introduced in the gastrointestinal (GI or enteral compartment) tract cannot be absorbed by the intestinal mucosa, whereas those introduced in parenteral (between skin and mucosa) compartments of animal or human bodies are entrapped. There are only two exits available. The first is the kidneys via complex filtration, but molecules have to be soluble in blood. The second is the lungs, but molecules have to be metabolized and converted to water and carbon dioxide. Exceptionally, cyst formation can lead to expulsion through the skin. Therefore, any high-molar-mass macromolecule or polymer that is to be used parenterally for a limited period of time has to be first degraded, in terms of molar mass decrease, and turned into soluble low-molar-mass compounds to be excretable, unless degradation byproducts can be biochemically processed and transformed into carbon dioxide, water, and biomass. The demand of surgical life-respecting polymers was progressively extended to domains like pharmacology (drug delivery systems, bioactive macromolecules) and dentistry (bone augmentation, periodontal membranes). The most recent research is oriented toward tissue engineering and medicated temporary prostheses, i.e., temporary prostheses that are associated with drugs or other bioactive substances, including macromolecules (DNA, genes, proteins, and peptides). Therefore, biology is also implicated.

More recently, humans have started to pay attention to the fact that, in outdoor applications, nonnatural polymers are also in contact with living systems. Initially selected for their resistance to the attack by microorganisms, industrial polymers are now sources of problems related to their biostability in connection with the concept of time-limited applications after which a material becomes waste. In the environment, there are two different problems related to the use of bioresistant polymers and derived objects: (i) littering with its hidden form of water-soluble and water-dispersed macromolecular compounds that are found in detergents, cosmetics, paints, and washings products and (ii) industrial treatment of corresponding collected wastes in water-treatment and in composting plants. Basically, the elimination of environmental wastes and that of biomedical residues left after healing are comparable.

Science and applications of biorelated polymers require people of different disciplines and scientific domains. From the terminology viewpoint, polymer-based substances and devices aimed at working in contact with living systems are firstly relevant to terms and definitions recommended to polymer scientists, producers, and users by IUPAC through its various publications. However, scientists and users of other fields of application have often developed incoherent terminologies.

The aim of the following recommendations is to provide a terminology usable without any confusion in the various domains dealing with biorelated polymers, namely, medicine, surgery, pharmacology, agriculture, packaging, biotechnology, polymer waste management, etc. This is necessary because (i) human health and environmental sustainability are more and more interdependent, (ii) research, applications, norms, and regulations are still developed independently in each sector, and (iii)

nonspecialists like journalists, politicians, and partners of complementary disciplines are more and more implicated and need a common language.

Within each definition, terms defined elsewhere in the glossary are indicated by italics upon their first use.

TERMS COMMON TO ALL DOMAINS

1. abiotic
abiological

Not associated with living systems [1].

2. absorption (chemistry)

Process of penetration and diffusion of a substance (absorbate) into another substance (absorbent) as a result of the action of attractive phenomena.

Note 1: Modified from [2]. The definition given in [2] does not reflect the dynamic of absorption and creates confusion with *adsorption* (surface phenomenon).

Note 2: The attractive phenomena can be a gradient of concentration, affinity for the absorbent, etc.

Note 3: In pharmacology, absorption means transfer of a *drug* from the enteral to the parenteral compartments.

3. adhesion

Process of attachment of a substance to the surface of another substance.

Note 1: Adhesion requires energy that can come from chemical and/or physical linkages, the latter being reversible when enough energy is applied.

Note 2: In biology, adhesion reflects the behavior of cells shortly after contact to a surface.

Note 3: In surgery, adhesion is used when two tissues fuse unexpectedly.

4. adsorption

Increase in the concentration of a substance at the interface of a condensed and a liquid or gaseous layer owing to the operation of surface forces [1].

Note 1: Adsorption of proteins is of great importance when a *material* is in contact with blood or body fluids. In the case of blood, albumin, which is largely predominant, is generally adsorbed first, and then rearrangements occur in favor of other minor proteins according to surface affinity against mass law selection (Vroman effect).

Note 2: Adsorbed molecules are those that are resistant to washing with the same solvent medium in the case of adsorption from solutions. The washing conditions can thus modify the measurement results, particularly when the interaction energy is low.

5. aggregate
agglomerate

Scrambled auto-assembly of otherwise isolated single molecules or particles.

Note 1: Adapted from definitions in [2–4] to reflect the absence of order.

Note 2: Comb-like amphiphilic *macromolecules* form aggregates and not *micelles*, in contrast to diblock amphiphilic copolymers.

6. artificial

Qualifier for something that is made by human activity, rather than occurring naturally [5].

7. artificial polymer

Man-made *polymer* that is not a *biopolymer.*

Note 1: Artificial polymer should also be used in the case of chemically modified biopolymers.

Note 2: Biochemists are now capable of synthesizing copies of biopolymers that should be named synthetic biopolymers to make a distinction with true biopolymers.

Note 3: *Genetic engineering* is now capable of generating non-natural analogues of biopolymers that should be referred to as artificial biopolymers, e.g., artificial protein, artificial polynucleotide, etc.

8. autocatalytic reaction

Chemical reaction in which a product (or a reaction intermediate) also functions as a *catalyst* [2].

Note: In such a reaction, the observed rate of reaction is often found to increase with time from its initial value.

9. bioactive

Qualifier for a substance that provokes any response from a living system.

Note: Modified from [6]. The given definition "*material* which has been designed to induce specific biological activity" is limited to material made bioactive on purpose. However, the concept of *bioactivity* does not imply beneficial action only, although the term is often used positively, i.e., to reflect a beneficial action.

10. bioactivity
biological activity

Capability of a substance, such as a *drug* or a vaccine, to provoke a response from a living matter.

Note 1: Modified from [5]. The definition is more general.

Note 2: There is no *polymer* (solid or in solution) that is inert in contact with a living system, because of *adsorption* and/or physical-chemical interactions with life elements (*biopolymers*, cells, and tissues).

Note 3: *Stealth* is often used to reflect the absence of recognition by defense proteins of the complement, and more generally opsonins that serve as binding enhancers for the process of phagocytosis.

11. bioadhesion
bioattachment

Adhesion of cells or tissues to the surface of a *material* [6].

Note 1: Cell adhesion is generally followed by proliferation as a *biofilm* or as a tissue.

Note 2: Assessing of adhesion is made after washing to eliminate unattached cells.

Note 3: The use of the term "bioattachment" is discouraged.

12. bioalteration (polymer)

Cell-mediated chemical modification without main *chain scission.* (See *biodegradation.*)

13. bioassay

Measurement used to determine the concentration or *bioactivity* of a substance (e.g., vitamin, hormone, plant growth factor, and antibiotic) by measuring its effect on an organism or tissue compared to a standard preparation [2].

14. bioassimilation

Conversion of a substance into *biomass* by biochemical processes.

15. bioavailability

Property of being accessible to a living system to achieve or undergo a specific biological action.

Note 1: Modified from [1,2] to be general and correspond to a property and not to a quantity.

Note 2: The use of biological availability and physiological availability suggested in [1] as synonymous is not recommended.

Note 3: In general, how much a substance or part of a substance is bioavailable is reflected by the quantification of the achieved or undergone action. (See *biodegradation*, *degree of biodegradation*, *degree of biofragmentation*, for instances.)

Note 4: In *pharmacology*, fraction of an administered dose of unchanged drug that reaches the systemic circulation, one of the principal *pharmacokinetic* parameters of drugs [7].

16. biobased

Composed or derived in whole or in part of biological products issued from the *biomass* (including plant, animal, and marine or forestry *materials*).

Note: A biobased *polymer* or polymeric device is not necessarily *environmentally friendly* nor *biocompatible* nor *biodegradable,* especially if it is similar to a petro-based (oil-based) polymer.

17. biocatalyst

Molecule or molecular complex consisting of, or derived from, an organism or cell culture (in cell-free or whole-cell forms) that catalyses metabolic reactions in living organisms and/or substrate conversions in various chemical reactions.

Note: Modified from [2] to be consistent with the definition of *enzyme*.

18. biocompatibility

Ability to be in contact with a living system without producing an adverse effect.

19. biodegradability

Capability of being degraded by biological activity.

Note: In vitro activity of isolated *enzymes* cannot be considered as *biological activity.* (See *biodegradation* and *enzymatic degradation*.)

20. biodegradable

Qualifier for a substance or device that undergoes *biodegradation.*

21. biodegradable (biorelated polymer)

Qualifier for *macromolecules* or polymeric substances susceptible to *degradation* by *biological activity* by lowering of the molar masses of *macromolecules* that form the substances.

Note 1: Adapted from [8] to include the notion of decrease of molar mass in the definition.

Note 2: It is important to note that in the field of *biorelated polymers*, a biodegradable compound is *degradable* whereas a *degradable polymer* is not necessarily biodegradable.

Note 3: Degradation of a polymer in vivo or in the environment resulting from the sole water without any contribution from living elements is not *biodegradation*. The use of *hydrolysis* is recommended. (See also *degradation.*)

22. biodegradation

Degradation caused by enzymatic process resulting from the action of cells.

Note: Modified from [8] to exclude *abiotic enzymatic* processes.

23. biodegradation (biorelated polymer)

Degradation of a polymeric item due to cell-mediated phenomena [9].

Note 1: The definition given in [2] is misleading because a substance can be degraded by *enzymes* in vitro and never be degraded in vivo or in the environment because of a lack of proper enzyme(s) in situ (or simply a lack of water). This is the reason why *biodegradation* is referred to as limited to degradation resulting from cell activity. (See *enzymatic degradation*.) The definition in [2] is also confusing because a compounded *polymer* or a copolymer can include bioresistant additives or moieties, respectively. *Theoretical*

biodegradation should be used to reflect the sole organic parts that are *biodegradable*. (See *theoretical degree of biodegradation* and *maximum degree of biodegradation*.)

Note 2: In vivo, degradation resulting solely from hydrolysis by the water present in tissues and organs is not biodegradation; it must be referred to as *hydrolysis* or *hydrolytic degradation*.

Note 3: *Ultimate biodegradation* is often used to indicate complete transformation of organic compounds to either fully oxidized or reduced simple molecules (such as carbon dioxide/methane, nitrate/ammonium, and water. It should be noted that, in case of partial biodegradation, residual products can be more harmful than the initial substance.

Note 4: When biodegradation is combined with another degrading phenomenon, a term combining prefixes can be used, such as oxo-biodegradation, provided that both contributions are demonstrated.

Note 5: Biodegradation should only be used when the mechanism is proved, otherwise degradation is pertinent.

Note 6: *Enzymatic degradation* processed abiotically in vitro is not biodegradation.

Note 7: Cell-mediated chemical modification without main *chain scission* is not biodegradation. (See *bioalteration*.)

24. biodisintegration

Disintegration resulting from the action of cells.

25. bioerosion

Surface *degradation* resulting from the action of cells.

Note 1: *Erosion* is a general characteristic of *biodegradation* by cells that adhere to a surface and the molar mass of the bulk does not change, basically. (See *heterogeneous degradation*.)

Note 2: Chemical degradation can present the characteristics of cell-mediated *erosion* when the rate of chemical *chain scission* is greater than the rate of penetration of the cleaving chemical reagent, like diffusion of water in the case of hydrolytically *degradable polymer*, for instance.

Note 3: Erosion with constancy of the bulk molar mass is also observed in the case of in vitro *abiotic enzymatic degradation*.

Note 4: In some cases, bioerosion results from a combination of cell-mediated and chemical degradation, actually.

26. biofilm

Aggregate of microorganisms in which cells that are frequently embedded within a self-produced matrix of extracellular polymeric substance (EPS) adhere to each other and/or to a surface.

Note 1: A biofilm is a fixed system that can be adapted internally to environmental conditions by its inhabitants.

Note 2: The self-produced matrix of EPS, which is also referred to as slime, is a polymeric conglomeration generally composed of extracellular *biopolymers* in various structural forms.

27. biofragmentation

Fragmentation resulting from the action of cells.

28. biomacromolecule

Macromolecule (including proteins, nucleic acids, and polysaccharides) formed by living organisms.

Note: Not to be confused with *biopolymer*, although this term is often used as a synonym. In [2] the same definition is assigned to biopolymer. This is not recommended. (See *macromolecule* and *polymer*.)

29. biomass

Living systems and collection of organic substances produced by living systems that are exploitable as *materials*, including recent postmortem residues. (See *material*.)

Note 1: Modified from [2] to be more general.

Note 2: In energy, fossil substances like oil and coal that are issued from the long-term transformation of substances of the biomass are sometime considered as parts of the biomass.

Note 3: Living systems also produce minerals that are not integrated in biomass.

30. biomaterial

Material exploited in contact with living tissues, organisms, or microorganisms.

Note 1: The notion of exploitation includes utility for applications and for fundamental research to understand reciprocal perturbations as well.

Note 2: The definition "non-viable material used in a medical device, intended to interact with biological systems" recommended in [6] cannot be extended to the environmental field where people mean "material of natural origin".

Note 3: This general term should not be confused with the terms *biopolymer* or *biomacromolecule*. The use of "polymeric biomaterial" is recommended when one deals with *polymer* or polymer device of therapeutic or biological interest.

31. biomineralization

Mineralization caused by cell-mediated phenomena [9].

Note: Biomineralization is a process generally concomitant to *biodegradation*.

32. biopolymer

Substance composed of one type of *biomacromolecules*.

Note 1: Modified from the definition given in [2] in order to avoid confusion between *polymer* and *macromolecule* in the fields of proteins, polysaccharides, polynucleotides, and bacterial aliphatic polyesters.

Note 2: The use of the term "biomacromolecule" is recommended when molecular characteristics are considered.

33. bioreactor

Apparatus used to grow and/or take advantage of cells or microorganisms or of biochemically active compounds derived from these living systems to produce or modify substances by biochemical processes.

Note: Modified from the definition given in [2]. The definition proposed here is more general.

34. biorelated

Qualifier for actions or substances that are connected to living systems.

35. biostability

Resistance to the deleterious action of living systems that allows preservation of the initial characteristics of a substance.

Note: If the substance is involved in an application, the term has to be related to a desired duration of performance, because almost any *material* ages in contact with living systems and biochemical processes regardless of the domain.

36. biotechnology

Integration of natural sciences and engineering in order to achieve the application of organisms, cells, parts thereof, and their molecular analogues for products and services [2].

37. biotic

Pertaining to, or produced by, living cells or organisms.

38. bulk degradation

Homogeneous *degradation* affecting the volume of a sample.

Note 1: Modified from [9]. The definition given therein is not general.

Note 2: The molar mass of the whole sample decreases progressively as opposed to the constancy observed in the case of *erosion* and *bioerosion*.

Note 3: This expression is often used when degradation is faster inside than at the surface. This is not appropriate. Nevertheless, it should be adopted specifically in opposition to erosion. In this case, the molar mass distribution becomes rapidly bimodal.

Note 4: Generally, degradation is faster inside because of autocatalysis by entrapped degradation byproducts or by the presence of a chain-cleaving reagent entrapped within the matrix.

39. catalyst

Substance that increases the rate of a reaction without modifying the overall standard Gibbs energy change in the reaction.

40. chain scission
chain cleavage

Chemical reaction resulting in the breaking of skeletal bonds [2]. (See *degradation.*)

Note: In the field of *biorelated polymers*, chain scission and degradation are interchangeable although the latter is more commonly used.

41. chiral

Having the property of *chirality* [2].

Note: As applied to a molecule, the term has been used differently by different workers. Some apply it exclusively to the whole molecule, whereas others apply it to parts of a molecule. For example, according to the latter view, a meso compound is considered to be composed of two chiral parts of opposite chirality sense; this usage is to be discouraged.

42. chirality

Property of an object (or spatial arrangement of points or atoms) of being non-superposable on its mirror image; such an object has no symmetry elements of the second kind (a mirror plane, $\sigma = S_1$, a centre of inversion, $i = S_2$, a rotation-reflection axis, S_{2n}).

Note 1: Modified from [2] to avoid reference to geometry.

Note 2: If the object is superposable on its mirror image, the object is described as being achiral [2].

Note 3: In chemistry, the object can be an atom holding a set of ligands, a molecule, or a *macromolecule* with blocked nonplanar conformation, or a self-assembled plurimolecular system like liquid crystals, although the use of the term is not recommended in this case [2].

43. conjugate

Molecule obtained by covalent coupling of at least two chemical entities, one of them having a special function.

Note 1: Modified from [1] to emphasize the notion of function.

Note 2: The specific function may, for example, be exerted by a drug, a dye, or a chemical reagent.

Note 3: One of the chemical entities can be a *macromolecule* or a *polymer*. (See *prodrug*, *drug carrier*, and *macromolecular prodrug.*)

44. controlled delivery

Supply of a substance according to desired rate and amount over time.

Note: If only a delayed or prolonged release is obtained without matching a desired release profile, the expression *sustained delivery* is to be used.

45. controlled release

Progressive appearance of a substance outgoing from an including system according to desired characteristics.

Note 1: The control is generally obtained by designing the system adequately.

Note 2: If the progressive appearance is spontaneous, the expression *sustained release* is to be used.

46. degradability

Capability of undergoing *degradation.*

47. degradable

Qualifier to a substance that can undergo physical and/or chemical deleterious changes of some properties especially of integrity under stress conditions.

48. degradable macromolecule

Macromolecule that is able to undergo *chain scissions* under specific conditions, resulting in a decrease of molar mass.

49. degradable polymer

Polymer in which *macromolecules* are able to undergo *chain scissions*, resulting in a decrease of molar mass. (See *degradation* (biorelated polymer).)

50. degradation

Progressive loss of the performance or of the characteristics of a substance or a device. (See *degradable*.)

Note: The process of degradation may be specified by a prefix or an adjective preceding the term "degradation". For example, degradation caused by the action of water is termed "hydrodegradation" or *hydrolysis*; by visible or ultraviolet light is termed "photodegradation"; by the action of oxygen or by the combined action of light and oxygen is termed "oxidative degradation" or "photooxidative degradation", respectively; by the action of heat or by the combined effect of chemical agents and heat is termed "thermal degradation" or "thermochemical degradation", respectively; by the combined action of heat and oxygen is termed "thermooxidative degradation".

51. degradation (biorelated polymer)

Degradation that results in desired changes in the values of in-use properties of the *material* because of *macromolecule* cleavage and molar mass decrease.

Note 1: Adapted from [8] where the definition is general. For *biorelated polymers*, the definition is purposely and specifically limited to the chemical degradation of macromolecules in order to make a clear distinction with the physical degradation of the material. (See *fragmentation* and *disintegration.*)

Note 2: In any condition, degradation must be used instead of *biodegradation* when the mechanism of *chain scission* is not known or demonstrated as cell-mediated.

Note 3: Degradation can result from the action of *enzymes* (see *enzymatic degradation*), or from the action of cells, organisms, and/or microorganisms. (See *biodegradation.*)

52. degree of bioassimilation

Mass fraction of a substance that is bioassimilated [9].

53. degree of biodegradation

Mass fraction of a substance that is biodegraded under specified conditions as measured through specified phenomena or techniques sensitive to mineral and *biomass* formations [9].

Note: Expressions like degree of *biodegradability*, extent of biodegradability, etc., are improper because a property reflected by the suffix "ity" cannot be quantified contrary to a deed reflected by "tion".

54. degree of biodisintegration

Mass fraction of a biodisintegrated substance [9].

55. degree of biofragmentation

Mass fraction of the original *material* that is biofragmented [9].

56. degree of biomineralization

Mass fraction of a substance that is biomineralized [9].

57. degree of degradation (biorelated polymer)

Mass fraction of a *polymer* that is degraded under specified conditions as measured through a specified phenomenon sensitive to molecular dimensions [9]. (See *degradation* (biorelated polymer).)

58. degree of disintegration

Mass fraction of the particles of defined size issued from a fragmented substance [9].

Note: The size is generally defined by sieving. It is a practical characteristic in composting.

59. degree of fragmentation

Mass fraction of a substance that is fragmented [9].

60. degree of mineralization

Mass fraction of a substance that is mineralized [9].

61. denaturation

Process of partial or total alteration of the native secondary, and/or tertiary, and/or quaternary structures of proteins or nucleic acids resulting in a loss of *bioactivity*.

Note 1: Modified from the definition given in [2].

Note 2: Denaturation can occur when proteins and nucleic acids are subjected to elevated temperature or to extremes of pH, or to nonphysiological concentrations of salt, organic solvents, urea, or other chemical agents.

Note 3: An *enzyme* loses its catalytic activity when it is denaturized.

62. depolymerase

Enzyme that is able to catalyse the depolymerization of a *biomacromolecule*.

Note 1: A depolymerase does not necessarily convert all the *macromolecules* to monomer molecules, occasionally, a specific oligomer is the end-product, depending on the mechanism.

Note 2: This term is generally used in the case of macromolecules produced by bacteria, because bacteria have the potential to degrade the *biopolymers* they synthesized.

63. depolymerization

Process of converting a *macromolecule* into monomer or a mixture of monomers [2].

Note 1: This term is recommended when the formation of a macromolecule depends on an equilibrium with the monomer.

Note 2: Depolymerization can be caused by an *enzyme.* (See *depolymerase*.)

Note 3: In the absence of recovery of monomers, using *degradation* is recommended.

64. deterioration

Deleterious alteration of a *material* in quality, serviceability, or vigor.

Note 1: Deterioration can result from physical and/or chemical phenomena.

Note 2: Deterioration is connected to a loss of performances and thus to the function, whereas *degradation* is connected with a loss of properties.

Note 3: *Polymer* deterioration is more general than *polymer degradation*, which reflects loss of properties resulting from chemical cleavage of *macromolecules* only. (See *degradation*.)

65. disintegration

Fragmentation to particles of a defined size [9].

Note: The limiting size is generally defined according to sieving conditions.

66. dissolution (polymer)

Process of dispersion of *macromolecules* in a liquid medium where they are solvated.

Note 1: Modified from the definitions in [2,9] to take into account the particular thermodynamic behavior of macromolecules.

Note 2: Nanosized *micelles* and *aggregates* in a visually transparent liquid medium are not solubilized, the use of dispersion is recommended.

Note 3: This definition is not appropriate in the case of simultaneous *degradation*. In this case, the use of degradation is recommended.

67. durability

Ability of a *material* to retain the values of its properties under specified conditions [8].

68. enzymatic degradation
enzymatic decomposition

Degradation caused by the catalytic action of *enzymes* [9].

Note 1: Modified from [2]. The presented definition is more general.

Note 2: Sometimes called enzymic degradation.

Note 3: Degradation caused by *enzymes* can be observed under *biotic* or *abiotic* conditions but only degradation due to cell *bioactivity* can be called *biodegradation*, otherwise enzymatic degradation is to be used, especially in the case of in vitro abiotic conditions.

69. enzyme

Macromolecule, mainly protein in nature, which functions as *biocatalyst*.

Note 1: Modified from [2].

Note 2: Often, an enzyme catalyses only one reaction type (reaction specificity) and operates on only one type of substrate (substrate specificity). Substrate molecules are attacked at the same site (regioselectivity) and only one or preferentially one of the enantiomers of chiral substrates or in racemates is attacked (enantioselectivity).

Note 3: Some enzymes like lipases or cutinases are able to function as *biocatalysts* on a range of substances that are not specific substrates.

Note 4: In the case of *polymer enzymatic degradation*, the enzyme can cleave links between constitutional repeating units within the chain more or less at random (endoenzyme) or from chain extremity (exoenzyme).

Note 5: Some *biomacromolecules* that are not protein in nature are now known to behave as catalysts (e.g., RNA in the case of ribozymes).

Note 6: Enzymes or immobilized enzymes can react unusually in an organic solvent, such as in the case of lactone and hydroxy acid *polymerization* in the presence of some immobilized lipases.

70. erosion

Degradation that occurs at the surface and progresses from it into the bulk.

Note 1: Modified from [9] to be more precise.

Note 2: See *enzymatic degradation*. In the case of *polymers*, water-soluble *enzymes* can hardly diffuse into the macromolecular network, except, maybe, in some hydrogels. They adhere to surfaces to cause erosion.

Note 3: Erosion can also result from chemical degradation when the degrading reagent reacts faster than it diffuses inside. There is a risk of confusion that can be eliminated after careful and detailed investigation of the degradation mechanism. (See *bioerosion*.)

Note 4: The wording *bulk erosion* is incorrect and its use therefore discouraged.

71. fragmentation

Breakdown of a *material* to particles regardless of the mechanism and the size of fragments.

Note: Modified from [9] in order to remove size limitation. (See *disintegration*.)

72. genetic engineering

Process of inserting new genetic information into existing cells in order to modify a specific organism for the purpose of changing its characteristics.

Note: Adapted from [10].

73. heterogeneous degradation

Degradation or *biodegradation* occurring at different rates depending on the location within a matrix [9].

74. homogeneous degradation

Degradation that occurs at the same rate regardless of the location within a polymeric item [9].

75. hydrolases

Enzymes that catalyse the cleavage of C–O, C–N, and other bonds by reactions involving the addition or removal of water.

Note: Modified from [2] to consider the fact that C–C bonds are not directly hydrolysed by hydrolases.

76. hydrolysis

Bond cleavage by the action of water. (See also *solvolysis.*)

Note 1: Modified from the definition given in [2]. Hydrolysis can occur in a water-containing solid or solvent.

Note 2: Hydrolysis can be catalysed and autocatalysed. (See *autocatalytic reaction*.)

77. inhibitor

Substance that diminishes the rate of a chemical reaction [2].

Note 1: The process is called inhibition [2].

Note 2: Inhibitors are sometimes called negative *catalysts*, but since the action of an inhibitor is fundamentally different from that of a catalyst, this terminology is discouraged. In contrast to a catalyst, an inhibitor may be consumed during the course of a reaction.

Note 3: In *enzyme*-catalysed reactions, an inhibitor frequently acts by binding to the enzyme, in which case it may be called an enzyme inhibitor.

Note 4: Inhibitors may decrease enzyme (or other) activity simply by competing for the active (recognition) site.

78. macromolecule
polymer molecule

Molecule of high relative molar mass, the structure of which essentially comprises the multiple repetitions of units derived, actually or conceptually, from molecules of low relative molar mass [2].

Note 1: In many cases, especially for synthetic *polymers*, a macromolecule can be regarded as having a high relative molar mass if the addition or removal of one or a few of the units has a negligible effect on the molecular properties. This statement fails in the case of certain macromolecules for which the properties may be critically dependent on fine details of the molecular structure (e.g., a protein).

Note 2: If a part or the whole of the molecule has a high relative molar mass and essentially comprises the multiple repetition of units derived, actually or conceptually, from molecules of low relative molar mass, it may be described as either macromolecular or polymeric, or by *polymer* used adjectivally.

79. material

Substance that is exploited by humans in their practical activities.

Note: Sand on the beach is a substance, sand in concrete is a *material*.

80. maximum degree of biodegradation

Greater value of the degree of *biodegradation* that can be reached under selected experimental conditions [9].

Note 1: This expression reflects the fact that some *biodegradable* parts of a *biodegradable material* may not be accessible to biodegradation.

Note 2: Not to be confused with *ultimate degradation*.

81. micelle (polymers)

Organized auto-assembly formed in a liquid and composed of amphiphilic *macromolecules*, generally amphiphilic di- or tri-block copolymers made of solvophilic and solvophobic blocks.

Note 1: An amphiphilic behavior can be observed for water and an organic solvent or between two organic solvents.

Note 2: Polymeric micelles have a much lower critical micellar concentration (CMC) than soap or surfactant micelles, but are nevertheless at equilibrium with isolated macromolecules called unimers. Therefore, micelle formation and stability are concentration-dependent.

82. microcapsule

Hollow *microparticle* composed of a solid shell surrounding a core-forming space available to permanently or temporarily entrapped substances.

Note: The substances can be drugs, pesticides, dyes, etc.

83. microparticle

Particle with dimensions between 1×10^{-7} and 1×10^{-4} m.

Note 1: The lower limit between micro- and nano-sizing is still a matter of debate. (See *nanoparticle*.)

Note 2: To be consistent with the prefix "micro" and the range imposed by the definition, dimensions of microparticles should be expressed in μm.

84. microsphere

Microparticle of spherical shape without membrane or any distinct outer layer. (See *microcapsule*.)

Note: The absence of outer layer forming a distinct phase is important to distinguish microspheres from microcapsules because it leads to first-order diffusion phenomena, whereas diffusion is zero order in the case of microcapsules.

85. mineralization

Process through which an organic substance becomes impregnated by or turned into inorganic substances.

Note 1: A particular case is the process by which living organisms produce and structure minerals often to harden or stiffen existing tissues. (See *biomineralization*.)

Note 2: In the case of *polymer biodegradation*, this term is used to reflect conversion to CO_2 and H_2O and other inorganics. CH_4 can be considered as part of the mineralization process because it comes up in parallel to the minerals in *anaerobic composting*, also called methanization [9].

86. nanocapsule

Hollow *nanoparticle* composed of a solid shell that surrounds a core-forming space available to entrap substances.

87. nanoparticle

Particle of any shape with dimensions in the 1×10^{-9} and 1×10^{-7} m range.

Note 1: Modified from definitions of nanoparticle and nanogel in [2,3].

Note 2: The basis of the 100-nm limit is the fact that novel properties that differentiate particles from the bulk *material* typically develop at a critical length scale of under 100 nm.

Note 3: Because other phenomena (transparency or turbidity, ultrafiltration, stable dispersion, etc.) are occasionally considered that extend the upper limit, the use of the prefix "nano" is accepted for dimensions smaller than 500 nm, provided reference to the definition is indicated.

Note 4: Tubes and fibers with only two dimensions below 100 nm are also nanoparticles.

88. nanosphere

Nanoparticle of spherical shape without membrane or any distinct outer layer.

Note: A nanosphere is composed of a matrix where substances can be permanently or temporarily embedded, dissolved, or covalently bound. (See *microsphere*.)

89. plastic

Generic term used in the case of polymeric *material* that may contain other substances to improve performance and/or reduce costs.

Note 1: The use of this term instead of *polymer* is a source of confusion and thus is not recommended.

Note 2: This term is used in polymer engineering for materials often compounded that can be processed by flow.

90. polymer

Substance composed of *macromolecules* [2].

Note: Applicable to substance macromolecular in nature like cross-linked systems that can be considered as one macromolecule.

91. polymerase

Enzyme that is able to catalyse the addition of units in the process of *macromolecule* formation.

92. polymerisation

Process in which a monomer, or a mixture of monomers, is converted into *macromolecules.*

Note 1: Modified from [2] to be more precise.

Note 2: Two major types of polymerization are chain growth and step growth. The chain growth mechanism of unsaturated or cyclic monomers must not be confused with the step growth mechanism as in polycondensation and polyaddition reactions [2].

Note 3: It is important to note that a *polymer* made by ring-opening polymerization of a cyclic monomer using an initiator and that made by polycondensation of the corresponding bifunctional open cycle are not necessarily similar compounds. The resulting macromolecules may differ at chain ends because of the presence of initiator residues in the

case of the initiated *polymerization*, a difference that can have significant consequences in case chain ends play an important role in a subsequent chemical process. (See *autocatalytic reaction*.)

93. resorption

Total elimination of a substance from its initial place caused by physical and/or chemical phenomena.

Note: The resorption of a *polymer*, like its dissolution in a solvent medium, does not mean that *macromolecules* are degraded. (See *bioresorption*.)

94. solid dispersion (polymer)

Solid multiphasic mixture with at least one *polymer* component dominating.

Note 1: The nonpolymeric components can act as fillers [4].

Note 2: The dispersed compounds can be in clusters of particles.

Note 3: Solid dispersion is commonly prepared by three different methods, namely, solvent-based, fusion-melt, and hybrid fusion-solvent methods.

Note 4: In pharmaceutical preparations, incompatible polymer-drug mixtures are generally solid dispersions.

95. solid solution

Solid in which components are compatible and form a unique phase.

Note 1: The definition "crystal containing a second constituent which fits into and is distributed in the lattice of the host crystal" given in [2,11] is not general and, thus, is not recommended.

Note 2: The expression is to be used to describe a solid phase containing more than one substance when, for convenience, one (or more) of the substances, called the solvent, is treated differently from the other substances, called solutes.

Note 3: One or several of the components can be *macromolecules.* Some of the other components can then act as plasticizers, i.e., as molecularly dispersed substances that decrease the glass-transition temperature at which the amorphous phase of a *polymer* is converted between glassy and rubbery states.

Note 4: In pharmaceutical preparations, the concept of solid solution is often applied to the case of mixtures of *drug* and *polymer*.

Note 5: The number of drug molecules that do behave as solvent (plasticizer) of polymers is small.

96. solvolysis

Generally reaction with a solvent, or with a lyonium ion or lyate ion, involving the rupture of one or more bonds in the reaction solute [2]. (See lyonium ion and lyate ion in [2].)

97. stimulus-responsive polymer
smart polymer

Polymer that responds or that is designed to respond to a stimulus like pH, light, heat, etc. change, and provides a predetermined action.

Note 1: The generated action can be unique or cyclic. It generally results from cooperative phenomena.

Note 2: The stimulus can affect *macromolecules* or macromolecule assemblies forming the polymer.

98. sustained delivery
prolonged delivery

Supply of a substance from a container where it is temporarily entrapped for the sake of achieving a prolonged action.

Note 1: In some cases, the container is a *polymer* processed as *implant*, film, *microparticle*, or *nanoparticle*, auto-assembly of molecules, or a *macromolecule*.

Note 2: The substance can be temporarily embedded, dissolved, or covalently bound.

Note 3: The term is relevant to the release of substances like pesticides, dyes, *drugs*, etc.

Note 4: In the case of sustained delivery according to required specifications, the use of *controlled delivery* is recommended.

99. swelling

Increase in volume of a gel or solid associated with the uptake of a liquid or gas [2].

100. synthetic biopolymer

Copy of a *biopolymer* man-made using *abiotic* chemical routes. (See *artificial* and *biopolymer.*)

101. theoretical degree of biodegradation

Degree of biodegradation that corresponds to conversion of all the organic matter present in an original *polymer*-based item to minerals and *biomass* [9]. (See *bioavailability.*)

Note: This expression is used as reference to assess *biodegradable* components that are not accessible to biodegradation from those that are bioavailable.

102. toxicity

Consequence of adverse effects caused by a substance on a living system.

Note 1: Modified from [1,2] to be general.

Note 2: The adverse effects depend on the quantity of substances, the way in which the substance contacts the living system (single or repeated administrations), the type and severity of the reaction, the time needed to produce the reaction, the nature of the organism(s) affected, and other relevant conditions.

Note 3: The adverse effects are usually quantified according to the physiological response of the living system, and/or to local tissue and cell responses and/or to survival tests.

Note 4: A prefix can be used to specify the living system: "hemo" for blood, "cardio" for heart, "phyto" for plant, "bacterio" for bacteria, etc.

103. ultimate biodegradation

Complete breakdown of a compound to either fully oxidized or reduced simple molecules (such as carbon dioxide/methane, nitrate/ammonium, and water) [2].

Note 1: This term reflects the end-products of *biodegradation*. As such, it differs from the *theoretical degree of biodegradation*, which depends on the presence of non-*biodegradable* components.

Note 2: The use of this expression is not recommended.

POLYMERS OF BIOLOGICAL AND BIOMEDICAL INTEREST

104. acute toxicity

Toxicity occurring within a short time of dosing or exposure.

Note 1: Modified from [1].

Note 2: Usually, adverse effects are monitored up to 14 days after administration of a single exposure to a test substance (amount, dose, or concentration) or after multiple exposures, usually within 24 h of a starting point (which may be exposure to the toxicant, or loss of reserve capacity, or developmental change, etc.).

Note 3: The adverse effect is usually quantified according to the physiological behavior of the living system, to local tissue and cell responses, and/or to survival tests as lethal dose in percentage of dead animals in the test population (LD_{50} for 50 %) or as lethal concentration (e.g., LC_{50}).

105. artificial organ

Medical device that replaces, in part or in whole, the function of one of the organs of the body [6].

106. biocompatibility (biomedical therapy)

Ability of a *material* to perform with an appropriate host response in a specific application [6].

Note: The more general definition (**18**) could be adopted by the biomedical field.

107. biomedical

Qualifier for a domain grouping scientific and practical activities related to therapy.

Note: The term is relevant to therapy in surgery, medicine, pharmacology, dentistry, etc.

108. bioprosthesis

Implantable prosthesis that consists totally or substantially of nonviable, treated donor tissue [6].

109. bioresorbability

Ability to be eliminated from an animal or human body through natural pathways.

Note 1: Natural pathways are kidneys through glomerular filtration and lungs after metabolization.

Note 2: *Bioassimilation* with formation of novel *biomass* is a particular means of elimination often combined with the other pathways.

110. bioresorbable

Qualifier used to indicate that a compound or a device is bioresorbed, i.e., totally eliminated or bioassimilated by an animal or a human body.

Note: To be qualified as bioresorbable, demonstration must be made of the elimination or *bioassimilation*, the best tool being radioactivity labeling.

111. bioresorption

Disappearance of a substance from an organism by processes of metabolism, secretion, or excretion.

Note 1: Bioresorption is now considered as pertinent and should be used specifically only when foreign *material* and residues have been shown assimilated or eliminated from the living host, regardless of the followed route, namely, lungs or kidneys or insertion in biochemical processes.

Note 2: In the case of *polymers* or high-molar-mass *macromolecules* that are retained in parenteral compartments, *degradation* or *biodegradation* is necessary prior to bioresorption.

Note 3: This concept does not apply to the environment as everything, including degradation by-products issued from outdoor degradation or biodegradation can only be stored or chemically transformed on Earth, so far.

112. bone cement

Synthetic, self-curing organic or inorganic *material* used to fill up a cavity or to create a mechanical fixation.

Note 1: In situ self-curing can be the source of released reagents that can cause local and/or systemic *toxicity* as in the case of the monomer released from methacrylics-based bone cement used in orthopedic surgery.

Note 2: In dentistry, *polymer*-based cements are also used as fillers of cavities. They are generally cured photochemically using UV radiation in contrast to bone cements.

113. carcinogenicity

Ability or tendency to produce cancer.

Note: In general, *polymers* are not known as carcinogens or mutagens, however, residual monomers or additives can cause genetic mutations.

114. chronic toxicity

Toxicity that persists over a long period of time whether or not adverse effects occur immediately upon exposure or are delayed.

Note: Modified from [1].

115. complement

System of multiple proteins part of the nonspecific immune defenses that are activated by foreign microorganisms or *material* surfaces with the aim of lysing essential constituting molecules.

116. drug
medicine

Any substance that, when absorbed into a living organism, may modify one or more of its functions beneficially.

Note 1: Modified from [2] to emphasize that the benefit/risk ratio must be positive. (See *bioactive*.)

Note 2: The term is generally accepted for a substance taken for a therapeutic purpose, but is also commonly used for abused substances.

Note 3: The two terms are also used when the *bioactive* substance is formulated to become a *pharmaceutical* specialty.

Note 4: The use of medicine that is also a discipline is discouraged.

117. drug carrier (biorelated polymers)

Macromolecule or *polymer* used to transport a *pharmacologically active* compound to be released later on due to an *abiotic* or *biotic* process. (See *conjugate*, *sustained release*, and *controlled delivery*.)

Note: A complementary property of a polymeric drug carrier is *targeting*, which can be obtained by specific interactions with a receptor if bearing a specific ligand or by selection depending on other factors such as permeation through membranes or capillaries.

118. drug delivery

Process of administration of a *bioactive* substance of *pharmacological* interest. (See *sustained delivery* and *controlled delivery.*)

Note 1: A drug delivery system can be a stationary implant but also an active or passive transport system with or without *targeting* properties.

Note 2: If a drug delivery system fulfills therapeutic and *pharmacokinetic* requirements, one talks of controlled drug delivery. If only a slow release is observed without relation to desired *pharmacokinetic* characteristics, the expression "sustained drug delivery" must be used.

119. excipient

Any more or less inert substance added to a drug to give suitable consistency or form to the drug formulation.

Note: Modified from [2]. The presented definition addresses the concept of formulation.

120. foreign body reaction

Cellular response of the inflammatory and wound healing processes following introduction of a foreign object in a human or animal body.

Note 1: The foreign object can be a medical device, a *prosthesis*, a particle or any compound introduced accidentally.

Note 2: The foreign body reaction results in more or less intense events such as fibrous tissue formation, macrophage activation, giant cells formation, etc.

121. graft

Piece of nonviable *material*, viable tissue, or collection of viable cells transferred from a site in a donor to a site in a recipient for the purpose of the reconstruction of the recipient site.

Note: In *polymer* science, *graft* is used to indicate the presence of one or more species of block connected to *macromolecule* main chain as side chains, these side chains having constitutional or configurational features that differ from those in the main chain [2].

122. host response

Reaction of a living system to the presence of a substance or a *material.*

Note: Complemented from [6].

123. hybrid artificial organ

Artificial organ that is a combination of viable cells and one or more *biomaterials* [6].

124. immunogenicity

Ability of a *material* or substance to elicit a cellular immune response and/or antibody production [2].

125. implant

Medical device made from one or more *biomaterials* that is intentionally placed within the body, either totally or partially buried beneath an epithelial surface [6].

Note: There are also other devices implanted that are not medical devices, e.g., for cosmetic, cultural, or aesthetic purposes.

126. macromolecular prodrug

Prodrug in which the temporary chemical entity is a *macromolecule.*

Note: In this particular case of prodrug, the macromolecule carries several drug molecules generally. These molecules are linked to the carrier through cleavable bonds. (See *conjugate*.)

127. medical device

Instrument, apparatus, implement, machine, contrivance, in vitro reagent, or other similar or related article, including any component, part of accessory, which is intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation, treatment, or prevention of disease in man [6].

128. opsonin

Antibody in blood serum that attaches to invading microorganisms and other antigens to make them more susceptible to the action of phagocytes [12].

Note: Opsonin molecules include antibodies: IgG and IgA, proteins of the *complement* system: C3b, C4b, and iC3b, mannose-binding lectin (initiates the formation of C3b), etc.

129. pharmaceutical

Qualifier for substances or systems, including *polymers*, exploited by the pharmaceutical industry.

Note 1: A pharmaceutical substance can be exploited for its *bioactivity* or as an excipient.

Note 2: The term "pharmaceutical" is also used as short form for a pharmaceutical substance.

130. pharmacodynamics

Branch of *pharmacology* concerned with *pharmacological* actions on living systems, including the reactions with and binding to cell constituents, and the biochemical and physiological consequences of these actions.

Note: Modified from [2].

131. pharmacokinetics

Branch of *pharmacology* concerned with the uptake of *drugs* by the body, the biotransformation of the drugs and their metabolites in the tissues, and the elimination of the drugs and their metabolites from the body over a period of time.

Note 1: Modified from [2].

Note 2: Pharmacokinetics also includes the distribution of *bioactive* substances within the various compartments present in an animal or human body, especially high-molar-mass *polymers* that cannot cross endothelial or epithelial physiological barriers.

132. pharmacological
pharmacologic

Qualifiers for substances, including *macromolecules* or *polymers*, and actions involved in pharmacology.

Note: A pharmacological polymer can be *bioactive* by itself or because it is used as a temporary carrier of a bioactive substance of interest in *pharmacology*. (See *macromolecular prodrug*.)

133. pharmacologically active

Qualifier for a substance that exhibits *bioactivity* of *pharmacological* interest.

134. pharmacology

Science of *drugs* including their origin, composition, *pharmacokinetics*, *pharmacodynamics*, therapeutic use, and toxicology.

135. polymeric drug
macromolecular drug

Bioactive macromolecule of *pharmacological* interest.

136. prodrug

Compound that undergoes biotransformation before exhibiting *pharmacological* effects.

Note 1: Modified from [13].

Note 2: Prodrugs can thus be viewed as *drugs* containing specialized nontoxic protective groups used in a transient manner to alter or to eliminate undesirable properties in the parent molecule.

137. prosthesis

Device that replaces a limb, organ, or tissue of the body [6].

138. scaffold

Matrix, generally porous with communicating pores, aimed at culturing cells and forming neotissues to be implanted and integrated in a living organism.

Note: Such a matrix should be *degradable* or *biodegradable* and, ideally, *bioresorbable.*

139. stealth (biomedical polymer)

Qualifier for a *macromolecule*, a surface, or a device that is not detected by defense proteins of the *complement* and the Mononuclear Phagocyte System, especially macrophages, after introduction in parental compartments.

Note 1: Detection by natural defenses generally leads to the destruction of the device or of the surrounding tissues.

Note 2: Surfaces are often decorated by chemical entities aimed at suppressing the activation of the natural defense processes.

140. targeting

Exploitation of specific or nonspecific interactions to target a particular part of a living system, or a particular type of cells.

141. therapeutic polymer

Polymer aimed at helping therapists in treating diseases or trauma.

142. thrombogenicity

Property of a *material* (or substance) that induces and/or promotes the formation of a thrombus [6].

143. tissue engineering

Use of a combination of cells, engineering and *materials* methods, and suitable biochemical and physico-chemical factors to improve or replace biological functions [7].

Note: While most definitions of tissue engineering cover a broad range of applications, in practice the term is closely associated with applications that repair or replace portions of or whole tissues (i.e., bone, cartilage, blood vessels, bladder, skin, etc.).

144. transplant

Complete structure, such as an organ that is transferred from a site in a donor to a site in a recipient for the purpose of the reconstruction of the recipient site [6].

ENVIRONMENTAL POLYMERS AND POLYMERIC SYSTEMS

145. aerobic biodegradation

Biodegradation in the presence of molecular oxygen.

Note 1: Modified from [2]. The present definition is more general.

Note 2: Oxygen is generally supplied by the atmosphere.

146. anaerobic biodegradation

Biodegradation in the absence of oxygen. (See *mineralization*.)

147. bioplastic

Biobased polymer derived from the *biomass* or issued from monomers derived from the biomass and which, at some stage in its processing into finished products, can be shaped by flow.

Note 1: Bioplastic is generally used as the opposite of polymer derived from fossil resources.

Note 2: Bioplastic is misleading because it suggests that any polymer derived from the biomass is *environmentally friendly*.

Note 3: The use of the term "bioplastic" is discouraged. Use the expression "biobased polymer".

Note 4: A biobased polymer similar to a petrobased one does not imply any superiority with respect to the environment unless the comparison of respective *life cycle assessments* is favourable.

148. compost

Solid product resulting from the decomposition of organic wastes by fermentation.

Note: A compost is generally processed in personal composters or industrially to be used as fertilizer. In the latter case, specifications in structure and quality are to be provided.

149. composting

Process of biological decomposition of organic matter performed by microorganisms, mostly bacteria and fungi. (See *biodegradation.*)

Note 1: Modified from [10] to be more general.

Note 2: Composting can be performed industrially under aerobic or anaerobic conditions or individually (home-composting).

Note 3: If present, earthworms also contribute to composting. They are sometimes cultured purposely in industrial composting facilities. One often talks of lombri-composting.

150. conditioning film

Film that is rapidly formed on the surface of a solid in contact with a biological system (in the widest sense) that conditions the surface for subsequent interaction with constituents of the biological system.

Note 1: Frequently, the conditioning film consists of proteins that prepare almost any surface for subsequent colonization by microorganisms or cells.

Note 2: Not to be confused with conditioning film in packaging.

Note 3: The term can be applied to the surface of any *material* that is in contact with blood or body fluids because the very first event is coverage by more or less denaturized adhering proteins.

Note 4: Not to be confused with *biofilm*, which implies the presence of cells or microorganisms.

151. ecotoxicity

Consequence of adverse effects caused by a substance on the environment and on organisms living in it.

Note 1: Using the term is recommended when adverse effects concern water, air, sediments, etc.

Note 2: If only living organisms (animals, plants, microorganisms) are concerned, the use of *toxicity* is recommended.

152. environmentally degradable polymer

Polymer that can be degraded by the action of the environment, through, for example, air, light, heat, or microorganisms [8].

Note: When it is to be a source of *material*, such a polymer must be designed to degrade into products at a predictable rate compatible with the application. Such products are usually of lower molar mass than the original polymer.

153. environmentally friendly
ecocompatible

Qualifiers for a substance, device, or process that has minimal deleterious impact on the environment, which is air, water, minerals, living systems, etc.

Note 1: The assignment of these qualifiers to a *polymer* must be based on a consistent *life cycle assessment*.

Note 2: Ecocompatible is introduced to complement *biocompatible*, whose meaning is limited to living systems.

154. green chemistry
sustainable chemistry

Design of chemical products and processes that reduce or eliminate the use or generation of substances hazardous to humans, animals, plants, and the environment.

Note 1: Modified from [14] to be more general.

Note 2: Green chemistry discusses the engineering concept of pollution prevention and zero waste both at laboratory and industrial scales. It encourages the use of economical and *ecocompatible* techniques that not only improve the yield but also bring down the cost of disposal of wastes at the end of a chemical process.

155. green polymer

Polymer that conforms to the concept of *green chemistry*.

Note: Green polymer does not necessarily mean *environmentally friendly* polymer or *biobased polymer* although the confusion is often made in the literature.

156. life cycle assessment

Investigation and valuation of the environmental impacts of a given product or service caused or necessitated by its existence [2].

Note 1: Also known as life cycle analysis, LCA, ecobalance, and cradle-to-grave analysis.

Note 2: Assessing the life cycle of a *polymer* or a *plastic* must take into account all the factors that can be identified from the up-stage raw *material* to the *waste management*.

157. litter

Solid *waste* carelessly discarded outside the regular garbage and trash collection [10].

158. mulching film

Polymer film aimed at covering seeded area in order to protect the growing plants from weeds and cold and preserve humidity.

Note: Such film acts as a mobile green house.

159. sustainability

Developments that meet the needs of the present without compromising the ability of future generations to meet their needs [15].

Note: Other definitions are not recommended in the context of *biorelated polymers*.

160. waste

Residue left when a compound or a product reaches the end of its initial usefulness.

Note 1: Modified from [16]. The given definition is not general.

Note 2: Also referred to as rubbish, trash, garbage, or junk depending upon the type of *material* and the regional terminology.

Note 3: In living organisms, waste relates to unwanted substances or toxins that are expelled from them.

161. waste management

Control of the collection, treatment and disposal of *wastes*.

162. weathering

Exposure of a polymeric *material* to a natural or simulated environment [2].

Note 1: Weathering results in changes in appearance or mechanical properties.

Note 2: Weathering in which the rate of change has been artificially increased is termed "accelerated weathering".

Note 3: Weathering in a simulated environment is termed "artificial weathering".

Note 4: The ability of a *polymer* to resist weathering is termed "weatherability".

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Membership of the Subcommittee on Polymer Terminology (until 2005, the Subcommittee on Macromolecular Terminology) during the preparation of this report (2006–2011) was as follows:

***Chair*:** R. G. Jones (UK); ***Secretary*:** M. Hess (Germany), 2006–2007; T. Kitayama (Japan) 2008–2009; R. Hiorns (France), from 2010; ***Members*:** G. Allegra (Italy); M. Barón (Argentina); T. Chang (Korea); C. dos Santos (Brazil); A. Fradet (France); K. Hatada (Japan); J. He (China); K.-H. Hellwich (Germany); R. C. Hiorns (France); P. Hodge (UK); K. Horie (Japan); A. D. Jenkins (UK); J.-I. Jin (Korea); J. Kahovec (Czech Republic); P. Kratochvíl (Czech Republic); P. Kubisa (Poland); I. Meisel (Germany); W. V. Metanomski (USA); V. Meille (Italy); I. Mita (Japan); G. Moad (Australia); W. Mormann (Germany); C. Ober (USA); S. Penczek (Poland); L. P. Rebelo (Portugal); M. Rinaudo (France); I. Schopov (Bulgaria); M. Schubert (USA); F. Schué (France); V. P. Shibaev (Russia); S. Słomkowski (Poland); R. F. T. Stepto (UK); D. Tabak (Brazil); J.-P. Vairon (France); M. Vert (France); J. Vohlídal (Czech Republic); E. S. Wilks (USA); W. J. Work (USA).

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APPENDIX: INDEX IN ALPHABETICAL ORDER

