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Terminology for Biorelated Polymers and Applications (IUPAC Recommendations 20XX)*

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Abstract: Like most of the materials used by humans, polymeric materials are proposed in literature, and occasionally exploited clinically, as such, as devices or as part of devices, by surgeons, dentists and pharmacists to treat trauma 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, biotechnologies and renewable resources are regarded as attractive sources of polymers. In all cases, water, ions, biopolymers, cells and tissues are involved. Polymerists, therapists, biologists of the animal and environment kingdoms 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 specific of 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: IUPAC Polymer Division; Polymer; Degradable; Biodegradable; Bioresorbable; Biomaterial; Biomedical; Pharmacological; Dental; Environmental.

CONTENTS

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 molecular weight polyethylene (UHMWPE), polytetrafluroethylene (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-hydroxy ethyl 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 ~ 1,000 mol. Accordingly, high molar mass molecules introduced in the gastro-intestinal (GI or enteral compartment) track cannot be absorbed by the intestinal mucosa whereas those introduced in parenteral (between skin and mucosa) compartments of animal or human bodies are entrapped. Exits are kidneys via complex filtration of small water soluble molecules, and lungs after metabolization and conversion 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 molecular mass compounds to be excretable, unless degradation by-products 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), dentistry (bone augmentation, periodontal membranes). The most recent research is oriented towards 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.

It is more recently that humans started to pay attention to the fact that, in outdoor applications, non-natural polymers are also in contact with living systems. Initially selected for their resistance to the attack by micro-organisms, 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, (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 compounds 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, biotechnologies; 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) non-specialists like journalists, politicians and partners of complementary disciplines are more and more implicated and need a common language.

TERMS COMMON TO ALL DOMAINS

1 abiotic
abiological
Not associated with living systems. [1].

2 absorption (chemistry)
Process of penetration of a substance into another substance as a result of the action of attractive forces.
Note 1: In pharmacology, absorption means transfer of a drug from the enteral to the parenteral compartments.
Note 2: In spectrometry, diminution of the intensity of an electromagnetic radiation as it passes through a substance.
Note 3: Modified from [1]. The given definition did not reflect the dynamic of absorption and creates confusion with adsorption (surface phenomenon).

3 adhesion
Attachment of a substance to the surface of another substance as a result of attractive forces.
Note 1: Adhesion requires energy that can come from chemical 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 dissolved substance at the interface of a condensed and a liquid phase due to the operation of surface forces. Adsorption can also occur at the interface of a condensed and a gaseous phase [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, that is largely predominant, is generally adsorbed first, and then rearrangements occur in favor of other minority proteins according to surface affinity (Vroman effect).
Note 2: Adsorbed molecules are those that resist to washing with the solvent medium in case of adsorption from solutions. The washing conditions can thus modify the measurements, particularly when the interaction energy is low.

5 aggregate
Assembly of otherwise isolated single molecules or particles.
Note: Adapted from definition 2.2 in [2] and 1.42 in [3].

6 artificial
Qualifier for something that is made by man, rather than occurring naturally [4].

7 artificial (polymer)
Man-made polymer that is not a *biopolymer.*
Note 1: term used as opposed to a polymer found in living systems, also named *biopolymer*.
Note 2: Artificial should also be used in the case of chemically modified biopolymers.
Note 3: Biochemists are now capable of synthesizing copy of biopolymers that should be named synthetic biopolymers to make a distinction with true biopolymers.
Note 4: *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. In such a reaction the observed rate of reaction is often found to increase with time from its initial value [1].

9 bioactive (material)
Material that exhibits beneficial or adverse effects on living systems.
Note 1: Modified from [5]. 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
Beneficial or adverse effects of a substance, such as a drug or a vaccine, on living matter.
Note 1: Modified from [4]. 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 2: *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
Adhesion of cells or tissues to the surface of a material [5].

12. bioalteration (polymer)
Cell-mediated chemical modification without main chain scissions
Note: See *biodegradation*

13 bioassay
Measurement used to determine the concentration or biological activity 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 [1].

14 bioassimilation
Conversion of a substance into biomass by biochemical processes.

15 bioattachment
Fastening of cells to a surface of a material.
Note 1: Cell attachment is generally followed by proliferation as a biofilm or as a tissue.
Note 2: Assessing of attachment is made after washing to eliminate unattached cells.

16 bioavailability
Property of being physically and chemically accessible to the action of cells and enzymes released by them.
Note 1: In pharmacology, extent of absorption of a substance by a living organism compared to a standard system [6].
Note 1: The use of biological availability and physiological availability suggested in 6 as synonymous is not recommended.
Note 2: In pharmacology, fraction of an administered dose of unchanged drug that reaches the systemic circulation, one of the principal pharmacokinetic properties of drugs [7].
Note 3: Ratio of the systemic exposure from extravascular (ev) exposure to that following intravenous (iv) exposure as described by the equation:

$$F = \frac{A_{ev}\, D_{iv}}{B_{iv}\, D_{ev}}$$

where F is the bioavailability, A and B are areas under the (plasma) concentration-time curve following extravascular and intravenous administration, respectively, and D_{ev} and D_{iv} are the administered extravascular and intravenous doses.

17 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 petrobased (oilbased) polymer.

18 biocatalyst
Enzyme or enzyme 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 [1].

19 biocompatibility
Ability of a material to be in contact with a biological system without producing an adverse effect.
Note: This general definition can be used in any domain relevant to the *biorelated* concept (biomedical, biological and environmental).

20 biocompatibility (medicinal therapy)
Ability of a material to perform with an appropriate host response in a specific application [5].
Note: The previous definition is more general and could be adopted by the biomedical field.

21 biodegradability
Ability of being degraded by biological activity.
Note: in vitro activity of enzymes cannot be considered as biological activity, unless it is in the presence of living cells or tissues or micro-organisms.

22 biodegradable
Qualifier for a substance or device that undergo *biodegradation.*

23 biodegradable (polymer)
Polymer susceptible to degradation by biological activity, with the degradation accompanied by a lowering of its molar mass [8].
Note 1: In the case of a polymer, *biodegradation* proceeds not only by catalytic activity of enzymes, but also by contribution of a wide variety of biological activities like the production of acidic compounds released by cells.
Note 2: Biodegradation can produce metabolites or cause other chemical modifications beside chain scission.
Note 3: 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. Correct use of the terminology is essential.
Note 4: *In vivo* or environmental degradation of a polymer resulting from the sole water without any contribution from living elements is not *biodegradation*. The use of *hydrolysis* is recommended. See also *degradation*.

24 biodegradation (polymer)
Degradation of a polymeric item due to cell-mediated phenomena [9].
Note 1: The definition given in [1] 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 enzymic degradation)
This definition 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, basically.
Note 1: see *theoretical degree of biodegradation.*

Note 2: *In vivo*, degradation resulting from the sole hydrolysis by the water present in tissues and organs is not biodegradation; it must be referred to as hydrolytic degradation.
Note 3: This definition is applicable to any of the *biorelated* domains
Note 4: *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. (See *ultimate biodegradation*).
Note 5: When *biodegradation* is combined with another degrading phenomenon, a term combining two prefix can be used, like oxobiodegradation, provided that both contribution are demonstrated.
Note 6: *Biodegradation* should only be used when the mechanism is proved, otherwise degradation is pertinent.
Note 7: *Enzymatic degradation* or *decomposition* processed abiotically *in vitro* is not biodegradation (See *enzymatic degradation*).
Note 8: Cell-mediated chemical modification without main chain scissions is not biodegradation. See *bioalteration*.

25 biodisintegration
Disintegration resulting from the action of cells.
Note: see *disintegration.*

26 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 cleavage is greater than the rate of biological degradation.
Note 3: Erosion with constancy of the bulk molar mass is also observed in the case of *in vitro* abiotic enzymic degradation (see *enzymatic degradation*).
Note 4: In some cases, bioerosion results from a combination of cell-mediated and chemical degradation, actually.

27 biofilm
Aggregate of microorganisms in which cells adhere to each other and/or to a surface. These adherent cells are frequently embedded within a self-produced matrix of extracellular polymeric substance (EPS).
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 extracellular polymeric substance (EPS) which is also referred to as *slime*, is a polymeric conglomeration generally composed of extracellular DNA, proteins, and polysaccharides in various configurations.

28 biofragmentation
Fragmentation resulting from the action of cells (see *fragmentation*)

29 biomacromolecule,
Macromolecule (including proteins, nucleic acids, and polysaccharides) formed by living organisms.
Note 1: Not to be confused with "biopolymer" although this term is often used as a synonymous (see *biopolymer*).
Note 2: See *macromolecule (polymer molecule).*

30 biomass
Ensemble of organic substances that constitute living systems and post-mortem residues.
Note 1: Modified from [1] where the definition does not include substances of natural origin embedded in geological formation or transformed to fossil.
Note 2: Living systems also produce minerals that are not integrated in *biomass*.

31 biomaterial

Material exploited in contact of living tissues, organisms or micro-organisms.

Note 1: see *material.*

Note 2: This is one of the controversial words sources of debate between people of the biomedical and the environmental fields.

Note 3: The definition “Non-viable material used in a medical device, intended to interact with biological systems” recommended in [5] cannot be extended to the environmental field where people means “material of natural origin”.

Note 4: This general term should not be confused with terms *biopolymer* or *biomacromolecule*. The use of “polymeric biomaterial” is recommended when one deals with polymer or polymer device of therapeutic interest.

32 biomineralization

Mineralization caused by cell-mediated phenomena [9].

Note 1: see *mineralization.*

Note 2: Biomineralization process is generally concomitant to biodegradation.

33 biopolymers

Substances, macromolecular in nature, (including proteins, nucleic acids and polysaccharides) formed by living organisms.

Note 1: Modified from the definition given in [1] in order to avoid confusion between polymer and macromolecule.

Note 2: Biopolymer reflects the substance composed of biomacromolecules whereas biomacromolecule is to be referred to as molecule forming that substance.

34 biopolymer.

Substance composed of one type of *biomacromolecules.*

Note 1: The use of *biomacromolecule* is recommended when molecular characteristics are considered.

35 bioreactor

Apparatus used to grow and/or take advantage of micro-organisms or of biochemically active compounds derived from these micro-organisms to produce or modify substances by biochemical processes.

Note: Modified from the definition given in [1]. The proposed definition is more general.

36 biorelated

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

37 biostability

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

Note: The term has to be related to a lifetime, because almost any material ages in contact with living system and biochemical processes regardless of the domain.

38 biotechnology

Integration of natural sciences and engineering in order to achieve the application of organisms, cells, part of thereof and their molecular analogues for products and services [1].

39 bulk degradation

Homogeneous degradation affecting the volume of a sample.

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

Note 2: The molar mass of the whole sample decreases progressively in opposition to the constancy observed in the case of erosion (see *erosion* and *bioerosion*).

Note 2: This expression that is often used in the case of surface degradation more slowly than inside degradation is not appropriate. However, it should be adopted specifically in opposition to erosion. In this case the molar mass distribution becomes rapidly bimodal.
Note 3: Bulk degradation generally occurs because of autocatalysis by entrapped degradation by-products or by the presence of a chain-cleaving reagent entrapped within the matrix.
Note 4: The molar mass of the whole sample decrease progressively.

40 chain scission
chain cleavage
Chemical reaction resulting in the breaking of skeletal bonds [1].
Note 1: see *degradation.*
Note 2: In the field of biorelated polymers, chain scission and degradation are interchangeable although the latter is more commonly used.

41 chiral
Qualifier for an object that cannot be superimposed on its mirror image
Note 1: In chemistry, a molecule is said chiral when it has no plan of symmetry
Note 2: The object can be an atom holding a set of ligands in a spatial arrangement which is not superposable on its mirror image. A chirality centre is thus a generalized extension of the concept of the asymmetric carbon atom to central atoms of any element [10]

42 chirality
Geometric property of a rigid 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}). If the object is superposable on its mirror image the object is described as being achiral [10].
Note 1: In chemistry, objects can be molecules or macromolecules with blocked non-planar conformation or self-assembled plurimolecular systems like liquid crystals, although the use of the term is not recommended in this case [10]

43 conjugate
Desired substance obtained by covalent coupling of, at least, two chemical entities for a specific reason.
Note 1: In the absence of a specific reason, the coupling of chemical entities is a chemical reaction.
Note 2: One of the chemical entities can be a macromolecule or a polymer. See *prodrug*, *drug carrier* and *macromolecular prodrug*

44 controlled delivery
Release of a substance from a delivery system according to a desired profile that includes desired release rate and released amounts over time.
Note 1: If only a delayed or prolonged release is obtained without matching a desired release profile, the term sustained delivery is to be used (see *sustained delivery*).

45 degradability
Ability of being degraded.
Note: In the field of biorelated polymers, desired property to eliminate or bioassimilate the compound.

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

47 degradable (macromolecule)
Macromolecule that is able to undergo chain scissions under specific conditions resulting in a decrease of molar mass.

48 degradable (polymer)
Polymer in which the macromolecules it is composed of are able to undergo chain scissions resulting in a decrease of molar mass.
Note: see *degradation (polymer).*

49 degradation
Loss of the performance or of the characteristics of a substance or a device, regardless of the mechanism.
Note 1: See *degradable*.
Note 2: Causes of degradation may be specified by prefixes or by adjectives preceding the term *degradation*. For example, degradation caused by the action of water is termed hydrodegradation or *hydrolysis*, visible or ultraviolet light is termed photodegradation; degradation induced by the action of oxygen or by the combined action of light and oxygen is termed oxidative degradation or photo-oxidative degradation, respectively; degradation induced by the action of heat or by the combined effect of chemical agents and heat is termed thermal degradation or thermochemical degradation, respectively; degradation induced by the combined action of heat and oxygen is termed thermo-oxidative degradation.

50 degradation (biorelated polymer)
Degradation that results in desired changes in the values of in-use properties of the material because of macromolecules cleavages and molar mass decrease.
Note 1: Adapted from [6] where the definition is general.
Note 2: Degradation must be used when the mechanism of chain cleavage is not known.

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

52 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: expression like degree of biodegradability, extent of biodegradability, etc… are improper, indeed, the suffix "ity" reflects a property and not a phenomena.

53 degree of biodisintegration
Mass fraction of a biodisintegrated substance [9].

54 degree of biofragmentation
Mass fraction of the original material that is biofragmented [9].

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

56 degree of degradation (polymer)
Mass fraction of a polymer that is degraded under specified conditions as measured through a specified phenomenon sensitive to molecular dimensions [9].
Note: see *degradation (polymer).*

57 degree of disintegration
Mass fraction of the particles of defined size issued from a fragmented substance [9];
Note 1: the size is generally defined by sieving. It is a practical characteristic in composting.
Note 2: See *composting.*

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

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

60 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 [1]. This presented definition is more precise.
Note 2: Denaturation can occur when proteins and nucleic acids are subjected to elevated temperature or to extremes of pH, or to non-physiological concentrations of salt, organic solvents, urea or other chemical agents.
Note 2: An *enzyme* looses its catalytic activity when it is denaturized.

61 depolymerase
Enzyme that is able to catalyze the depolymerization of a biomacromolecule and turn it to low molar mass compounds.
Note 1: The depolymerization does not lead necessarily to monomer molecules.
Note 2: this term is generally used in the case of polymers produced by bacteria, because bacteria have the potential to degrade the biopolymers they synthesized.

62 depolymerization
Process of converting a macromolecule into low molar mass degradation by-products, not necessarily monomer molecules or a mixture of monomers.
Note 1: Modified from [1]. The presented definition is more general and includes non-enzymatic depolymerization, regardless of the mechanism.
Note 2: The use of this term is recommended in the case of monomer molecules and polymer formation depending on equilibrium.

63 deterioration
Deleterious alteration of a material in quality, serviceability, or vigor.
Note: Deterioration is connected to a loss of performances and thus to the function, whereas degradation is connected with a loss of properties.

64 deterioration (polymer)
Gradual decline of useful properties resulting from physical and/or chemical phenomena.
Note: Polymer deterioration is more general than polymer degradation that reflects loss of properties resulting from chemical cleavage of macromolecules only.

65 disintegration
Fragmentation to particles of a defined size [9].
Note: The limiting size is generally defined according to sieving conditions.

66 dissolution (polymer)
Dispersion of the molecules that constitute a polymer in a liquid medium.
Note 1: This definition is not appropriate in the case of simultaneous degradation. In this case "degradation" should be used. See *degradation.*
Note 2: Modified from the definition in [9]. This definition avoids the frequent confusion with the dispersion of nanosized micelles and aggregates in a liquid medium.

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

68 enzymatic degradation
enzymic degradation
enzymatic decomposition

Degradation caused by the catalytic action of *enzymes* [9].
Note 1: Modified from [1]. The presented definition is more general.
Note 2: *Enzymatic degradation* can be observed under *biotic* or *abiotic* conditions but only *enzymatic degradation* due to cell *bioactivity* can be called *biodegradation*.
Note 3: The use of e*nzymatic degradation* or *decomposition* under *in vitro abiotic* conditions is not biodegradation.
Note 3: See *biodegradation*).

69 enzyme(s)
Macromolecules, mostly proteins in nature, that function as (bio)catalysts [1].
Note 1: In general, 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 (regiospecificity) and only one or preferentially one of the enantiomers of chiral substrates or of racemic mixtures is attacked (stereospecificity).
Note 2: Some enzymes like lipases or cutinases are able to function as biocatalysts on a range of substances that are not specific substrates.
Note 3: In the case of polymer enzymatic degradation, the enzyme can cleave links between repeating units within the chain more or less at random (endoenzyme) or from chain extremity (exoenzyme).
Note 4: Some biomacromolecules that are not protein in nature are now known to behave as catalysts (RNA in the case of ribozymes, for instance).
Note 5: Enzymatic systems can react unusually in organic solvent, like 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: See *enzymic 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 2: Erosion can also result from chemical degradation when the degrading reagent reacts faster than it diffuses inside. There is here a risk of confusion that can be eliminated after careful and detailed investigation of the degradation mechanisms.
Note 3: Bulk erosion is nonsense and its used is discouraged.

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

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

73 fragmentation
Breakdown of a material to tiny particles regardless of the mechanism and the size of fragments.
Note: Modified from [9]. The given definition is not general.

74 genetic engineering
Process of inserting new genetic information into existing cells in order to modify a specific organism for the purpose of changing one of its characteristics [11].

75 hydrolases
Enzymes that catalyze the cleavage of C-O, C-N, and other bonds by reactions involving the addition or removal of water.
Note: Modified from [1] to consider the fact that C-C bonds are not directly hydrolyzed by hydrolases.

76 hydrolysis
Bond cleavage by the action of water.

Note 1: Modified from the definition given in [1]. The proposed definition is more precise since hydrolysis can occur in a water-containing solid or solvent.
Note 2: Hydrolysis can be catalyzed and autocatalyzed. See *autocatalytic reaction*.
Note 3: see *solvolysis*.

77 inhibitor
Substance that diminishes the rate of a chemical reaction; the process is called inhibition [1].
Note 1: 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 2: In enzyme-catalyzed reactions, an inhibitor frequently acts by binding to the enzyme, in which case it may be called an enzyme inhibitor.
Note 3: Inhibitors may decrease enzyme (or other) activity simply by competing for the active (recognition) site.

78 macromolecule
polymer molecule
Molecule of high relative molecular mass, the structure of which essentially comprises the multiple repetitions of units derived, actually or conceptually, from molecules of low relative molecular mass [1].
Note 1: In many cases, especially for synthetic polymers, a molecule can be regarded as having a high relative molecular 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.
Note 2: If a part or the whole of the molecule has a high relative molecular mass and essentially comprises the multiple repetition of units derived, actually or conceptually, from molecules of low relative molecular mass, it may be described as either macromolecular or polymeric, or by polymer used adjectivally.

79 material
Substance that is used in practical applications.
Note 1: Sand on the beach is a substance, in concrete it is a material.

80 maximum degree of biodegradation
Maximum value of the degree of biodegradation that can be reached under selected experimental conditions [9].
Note: “Maximum degree of biodegradation” reflects the fact that some of the biodegradable components of a material may not be accessible to biodegradation.

81 micelle (polymeric)
Micellar structure formed in a liquid and composed of amphiphilic macromolecules, generally amphiphilic di-block 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 unimers and thus 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 size in the $1 \times 10^{-7} – 1 \times 10^{-4}$ m range [12].

Note: The 10^{-7} m limit between micro- and nano-sizing is still a matter of debate. Some scientists consider that the prefix “micro” should be reserved to sizes above 10^{-6} m.

84 microsphere

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

Note 1: 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.

Note 2: see *microcapsule*.

85 mineralization

Process through which an organic substance becomes impregnated by or turn to 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 CO2 and H_2O and other minerals. 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 surrounding a core forming space available to entrap substances.

87 nanoparticle

Particle with size in the $1 \times 10^{-9} – 1 \times 10^{-7}$ m [12].

Note: The 100 nm limit between micro- and nano-sizing is still a matter of debate. Some scientists consider that the prefix “nano” should be reserved to sizes below 10^{-6} m.

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 polymer 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 that can be processed by flow.

90 polymer

Substance composed of macromolecules [1].

91 polymerase

Enzyme that is able to catalyze the polymerization of *macromolecule* precursors.

92 polymerization

Process in which a monomer, or a mixture of monomers is converted into a polymer

Note 1: Modified from [1]. The definition therein is awkward.

Note 2: The 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 [1].

Note 3: It is important to note that a polymer made by ring opening polymerization using an initiator and by polycondensation of the bifunctional open cycle do not necessarily lead to the same 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 activity*).

93 resorption

Disappearance of a substance from its initial place thanks to physical or chemical phenomena.

Note: Resorption of a polymer, like its dissolution in a solvent medium, does not mean that macromolecules are degraded.

94 stimulus-responsive polymer

smart polymer

Polymer that reacts or that is designed to react to a stimulus like pH, light, heat, etc. change, and provide 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.

95 solid solution

Solid mixture 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 [1] and [13] is not general and, thus, is not recommended.

96 solid solution (polymer)

Homogeneous mixture with at least one polymer component.

Note 1: The other components 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 2: In pharmaceutical preparations, the concept of solid solution is often applied to the case of mixtures of drug and polymer.

Note 3: The number of drug molecules that do behave as plasticizer of polymers is small.

97 solid dispersion (polymer)

Solid multiphasic mixture with at least one polymer component dominating.

Note 1: The non-polymeric components can act as fillers [3].

Note 1: The dispersed compounds can be in clusters of particles.

Note 2: Solid dispersion is commonly prepared by three different methods, namely solvent-based, fusion-melt and hybrid fusion-solvent methods.

Note 3: In pharmaceutical preparations, incompatible polymer-drug mixtures are generally solid dispersions.

98 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 [1].

Note: See lyonium ion and lyate ion in [1].

99 sustained delivery

prolonged delivery

Release 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 of various forms like solid *implant*, film, *microparticle, micelle*, or *prodrug*

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

Note 3: The term is to be used for drugs, pesticides, dyes, etc.

100 swelling

Increase in volume of a gel or solid associated with the uptake of a liquid or gas [1].

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].
Note 1: This expression is used as reference to assess biodegradable components that are not accessible to biodegradation from those that are bioavailable.
Note 2: See *bioavailability.*

102 ultimate biodegradation
Complete breakdown of a compound to either fully oxidized or reduced simple molecules (such as carbon dioxide/methane, nitrate/ammonium and water) [1].
Note 1: This term reflects the end products of biodegradation. As such it differs from the *theoretical degree of biodegradation* that depends on the presence of non biodegradable components.
Note 2: The use of this expression is not recommended.

POLYMERS OF BIOLOGICAL AND BIOMEDICAL INTEREST

103 artificial organ
Medical device that replaces, in part or in whole, the function of one of the organs of the body [5].

104 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...

105 bioprosthesis
Implantable prosthesis that consists totally or substantially of non-viable, treated donor tissue [5].

106 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.

107 bioresorbable
Qualifier use 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.

108 bioresorption
Process of elimination of a foreign substance from an animal or human body through natural pathways.
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: 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.

109 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 like 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 radiations in contrast to bone cements.

110 carcinogenicity
ability or tendency to produce cancer.
Note 1: In general, polymer are not known as carcinogen or mutagen, however residual monomers or additives can cause genetic mutations.

111 complement
System of multiple proteins part of the non-specific immune defenses that are activated by foreign micro-organisms or material surfaces with the aim of lysing essential constituting molecules.

112 drug
medicine
Any substance which when absorbed into a living organism may modify one or more of its functions. The term is generally accepted for a substance taken for a therapeutic purpose, but is also commonly used for abused substances [1].

113 drug carrier (polymer)
Macromolecule or polymer used to transport a pharmacologically active compound to be release later on due to an abiotic or biotic process.
Note 1: A complementary property of a polymeric drug carrier is targeting that can be obtained by specific interactions with a receptor or by selective passive interaction.
Note 2: See *conjugate* and *sustained release*.

114 drug delivery
Process of administration of a pharmaceutically active substance.
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 fulfill therapeutic and pharmacokinetics requirements, one talks of controlled drug delivery. If only a slow release is observed without relation to a desired pharmacokinetics profile, the term sustained drug delivery must be used
Note 3: See *sustained delivery* and *controlled delivery.*

115 excipient
Any more or less inert substance added to a drug to give suitable consistency or form to the drug formulation.
Note: Modified from [1]. The presented definition addresses the concept of formulation.

116 foreign body reaction
Variation of normal tissue behavior by the presence of a foreign material.
Note: The foreign body reaction result in more or less intense events like fibrous tissue formation, macrophage activation, giant cells formation etc…

117 graft
Piece of non-viable 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 [1].

118 host response

Reaction of a living system to the presence of a substance or a material
Note: Complemented from [5].

119 hybrid artificial organ
Artificial organ that is a combination of viable cells and one or more biomaterials [5].

120 immunogenicity
Property of a material or substance that elicits a cellular immune response and/or antibody production [1].

121 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 [5].
Note: There are also other devices implanted that are not medical devices, e.g. for cosmetic, cultural or esthetic purposes.

122 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 [5].

123 opsonin
Any molecule that acts as a binding enhancer for the process of phagocytosis, for example, by coating the negatively-charged molecules on the membrane [7].
Note 1: Opsonin molecules include antibodies: IgG and IgA, components of the complement system: C3b, C4b, and iC3b, mannose-binding lectin (initiates the formation of C3b), etc.
Note 2: See *complement*.

124 pharmaceutical
Qualifier for substances or systems, including polymers, exploited by the pharmaceutical industry.
Note: A pharmaceutical substance can be exploited for its bioactivity or as an excipient.

125 pharmacodynamics
Study of pharmacological actions on living systems, including the reactions with and binding to cell constituents, and the biochemical and physiological consequences of these actions [1].

126 pharmacokinetics
Process of 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 [1].
Note: 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.

127 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 pharmacology active substance.

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

129 pharmacologically active
Qualifier for a substance that exhibits bioactivity of pharmacological interest.

130 polymeric drug
Macromolecular drug
Bioactive macromolecule of pharmacological interest.

131 prodrug
Covalent combination of a drug molecule and another chemical entity that is aimed at modifying the properties of the drug (increase of solubility, protection against body defenses, etc.) until it is cleaved to release the free bioactive drug molecule.
Note: Modified from [14]. The presented definition is more precise.

132 prodrug (macromolecule)
Prodrug in which the temporary chemical entity is a macromolecule.

133 prosthesis
Device that replaces a limb, organ or tissue of the body [5].

134 scaffold
Matrix, generally porous with communicating pores, aimed at culturing cells and form neotissues to be implanted and integrated in a living organism.
Note: Such a matrix should be degradable or biodegradable and, ideally bioresorbable.

135 stealth (biomedical polymer)
Qualifier for surfaces of devices introduced in parenteral compartments that are not detected by defense proteins of the complement and the monuclear phagocyte system, especially macrophages.
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

136 therapeutic polymer
biomedical polymer
Polymer aimed at helping therapists in treating diseases or trauma.

137 targeting
Exploitation of specific or non specific interactions to target a particular part of a living systems or a particular type of cells.

138 thrombogenicity
Property of a material (or substance), which induces and/or promotes the formation of a thrombus [5].

139 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 1: 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.).

140 toxicity
Adverse effect of a substance on a living system defined with reference to the quantity of substances administered or absorbed [1].

Note: This definition is general and can be applied to any form of life. In the biomedical field, the quantity is usually expressed according to survival tests as lethal dose LD in percentage of dead animals in the test population (LD50 for 50%) or as lethal concentration (LC50 for instance).

141 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. [5].

ENVIRONMENTAL POLYMERS AND POLYMERIC SYSTEMS

142 aerobic biodegradation
Biodegradation in the presence of molecular oxygen.
Note 1: Modified from [1]. The presented definition is more general.
Note 2: Oxygen is generally supplied by the atmosphere.

143 anaerobic biodegradation
Biodegradation in the absence of oxygen.
Note: see mineralization.

144 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 by opposition to polymers issued 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 *biobased polymer*.
Note 4: A *biobased polymer* similar to a petrobased one does not imply any superiority with respect to the environment.
Note 5: The potential of a *biobased polymer* is to be evaluated after the balance of a *Life Cycle Assessment.*

145 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.

146 composting
Purposeful biodegradation of organic matter performed by micro-organisms, mostly bacteria, but also yeasts and fungi [7].
Note: Composting can be performed industrially under aerobic or anaerobic conditions.

147 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 micro-organisms or cells.
Note 2: A conditioning film frequently consists of proteins.
Note 3: 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* that implies the presence of cells or micro-organisms.

148 environmentally degradable polymer

Polymer that can be degraded by the action of the environment, through, for example, air, light, heat, or micro-organisms [8].
Note 1: The degradation of an environmentally degradable polymer after use is sometimes desirable.
Note 2: A controlled degradable polymer is a polymer designed to degrade into products at a predictable rate. Such products are usually of lower molar mass than the original polymer

149 environmentally friendly polymer
Polymer the properties of which are not environmentally harmful.
Note: The assignment of this qualifier to a *polymer* must be based on a precise evaluation of the *Life Cycle Assessment*.

150 green polymer
Polymer that respects 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 literature.

151 life cycle assessment
Investigation and valuation of the environmental impacts of a given product or service caused or necessitated by its existence [1].
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.

152 litter
Waste that people unlawfully dispose of out of doors [7].

153 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.

154 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.

155 sustainable chemistry
green chemistry
Chemical philosophy encouraging the design of products and processes that reduce or eliminate the use and generation of hazardous substances [7].
Note: Green Chemistry discusses the engineering concept of pollution prevention and zero waste both at laboratory and industrial scale. It encourages the use of economical and eco-friendly benign techniques which not only improves the yield but also brings down the cost of disposal of wastes at the end of a chemical process.

156 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.

157 waste management
Control of the collection, treatment and disposal of wastes.

158 weathering
Exposure of a polymeric material to a natural or simulated environment. [1];
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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REFERENCES

1. Compendium of Chemical Terminology, 2nd ed. (the "Gold Book"). Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997). XML on-line corrected version: http://goldbook.iupac.org (2006-) created by M. Nic, J. Jirat, B. Kosata; updates compiled by A. Jenkins. ISBN 0-9678550-9-8. doi:10.1351/goldbook.
2. Definitions of Terms Relating to the Structure and Processing of Sols, Gels, Networks and Inorganic-Organic Hybrid Materials (IUPAC Recommendations 2007), Prepared for publication by J. Alemán, A. V. Chadwick, J. He, M. Hess, K. Horie, R. G. Jones, P. Kratochvil, I. Meisel, I. Mita, G. Moad, S. Penczek and R. F. T. Stepto, Pure Appl. Chem. **79**, 1801-1829 (2007).
3. Definitions of Terms Related to Polymer Blends, Composites and Multiphase Polymeric Materials (IUPAC Recommendations 2004), Prepared for publication by W. J. Work, K. Horie, M. Hess and R. F. T Stepto, Pure Appl. Chem. **76**, 1985-2007 (2004).
4. The American Heritage® Dictionary of the English Language, Fourth Edition copyright ©2000 by Houghton Mifflin Company. Updated in 2009. Published by Houghton Mifflin Company. All rights reserved].

5. Definitions in Biomaterials, Proceedings of a Consensus Conference of the European Society for Biomterials.
6. Pure *Appl. Chem.*, **2004**, 76, 1033 (Glossary of terms used in toxicokinetics (IUPAC Recommendations 2003)) on page 1041.
7. Wikipedia (http://en.wikipedia.org/wiki/ (specific entry).
8.. IUPAC. Compendium of Polymer Terminology and Nomenclature, (The Purple Book) IUPAC recommendations 2008 RSC Publishing, 2009 [ISBN 978-0-85404-491-7].
9. CEN/TR 15351:**2006** report (http://esearch.cen.eu/(biodegradable polymers)
10. IUPAC. Compendium of Chemical Terminology, 2nd ed. (the "Gold Book"). Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997). XML on-line corrected version: http://goldbook.iupac.org (2006-) created by M. Nic, J. Jirat, B. Kosata; updates compiled by A. Jenkins. ISBN 0-9678550-9-8. doi:10.1351/goldbook
11. US EPA on line (http://www.epa.gov/OCEPAterms/gterms.html (entry).
12. Pure Appl. Chem., **2007,** 79, 1801-29, Definitions of terms relating to the structure and processing of sols, gels, networks, and inorganic-organic hybrid materials (IUPAC Recommendations 2007).
13. IUPAC *Compendium of Analytical Nomenclature,* edited by H M N H Irving, H Freiser and T S West, Pergamon, Oxford, 1978. The Orange Book, 3rd edition, edited by J Inczedy, Blackwell Scientific Publications, 1998. [ISBN 0-86542-615-5], p85.
14. Glossary of Terms Used in Medicinal Chemistry" [PAC **70**(5), 1129 – 1143 (1998)].
15. The dictionary of sustainable development (http://www.sustainabilitydictionary.com/ + entry).
16. Waste Framework Directive (European Directive 75/442/EC as amended).

APPENDIX : Index in alphabetical order