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# DEFINITIONS OF TERMS RELATING TO REACTIONS OF POLYMERS AND TO FUNCTIONAL POLYMERIC MATERIALS

(IUPAC Recommendations)

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**ABSTRACT:** The document defines the terms most commonly encountered in the field of polymer reactions and functional polymers. The scope has been limited to terms that are specific to polymer systems. The document is organized into three Sections. The first defines the terms relating to reactions involving and specific to polymers. Names of individual chemical reactions are omitted from the document, even in cases where the reactions are important in the field of polymer reactions. The second Section defines the terms relating to polymer reactants and reactive polymeric materials. The third Section defines terms describing functional polymeric materials.

## INTRODUCTION

Chemical reactions of polymers have received great attention during the last two decades. Many fundamentally and industrially important reactive polymers and functional polymers are prepared by the reactions of linear or crosslinked polymers and by the introduction of reactive, catalytically active or other groups onto polymer chains. Characteristics of polymer reactions are appreciably different from both reactions of low-molar-mass compounds and polymerization reactions. Basic definitions of polymerization reactions have been included in the original [1] and revised [2] documents on basic terms in polymer science published by the IUPAC Commission on Macromolecular Nomenclature. Furthermore, the basic classification and definitions of polymerization reactions [3], and the terminology of kinetics and thermodynamics of polymerization [4] have been discussed. As to polymer reactions, terms relating to degradation, aging, and related chemical transformations of polymers have been defined [5]. However, a clear and uniform terminology covering the whole field of reactions and the functionalization of polymers has not been defined, in spite of the growing importance of the field. For example, combinatorial chemistry using reactive polymer beads has become a new field in recent years. The development of a uniform terminology for these multidisciplinary areas can greatly aid communication and avoid confusion.

This document has been prepared to present clear concepts and definitions of general and specific terms with regard to reactions of polymers and functional polymers. The document is divided into three sections. In Section 1, terms relating to reactions involving and specific to polymers are defined. Names of individual chemical reactions, e.g., chloromethylation, are omitted from this document, even in cases where the reactions are important in the field of polymer reactions, because they usually duplicate those already in widespread use and well defined in organic chemistry and other areas of chemistry [6]. Sections 2 and 3 deal with the terminology of reactive and functional polymers. The term "functional polymer" has two meanings: (a) a polymer bearing functional groups (such as hydroxy, carboxy, or amino groups)

that make the polymer reactive, (b) a polymer performing a specific function for which it is produced and used. The function in the latter case may be either a chemical function such as a specific reactivity or a physical function like electric conductivity. Polymers bearing reactive functional groups are usually regarded as polymers capable of undergoing chemical reactions. Thus, Section 2 deals with polymers and polymeric materials that undergo various kinds of chemical reactions, i.e., show chemical functions. Section 3 deals with terms relating to polymers and polymeric materials exhibiting some specific physical functions. For definitions of some physical functions, see also *Compendium of Chemical Terminology* (“Gold Book”) [7].

A functional polymer according to Definition **3.6** of the present document is a polymer that exhibits specified chemical reactivity or has specified physical, biological, pharmacological, or other uses. Thus, several terms concerned with properties or structure of polymers are included in Section 3, whenever they are closely related to some specific functions.

A document on structure-based and source-based polymer class names [8] is in preparation by IUPAC Subcommittee on Macromolecular Terminology. A significant part of Sections 2 and 3 of this recommendation can also be regarded as a glossary of polymer class names based on chemical and physical functions.

Terms that are defined implicitly in the notes related to the main terms are given in bold type.

## **1. REACTIONS INVOLVING POLYMERS**

### **1.1 chemical amplification**

A process consisting of a chemical reaction that generates a species that catalyses another reaction and the reaction so catalysed.

#### *Notes*

1. Chemical amplification can lead to a change in structure and by consequence to a change in physical properties of a polymeric material.

2. The term "chemical amplification" is commonly used in a chemical amplification process in lithography of photo-resists with a **photo-acid generator** or **photo-base generator**.
3. An example of a chemical-amplification process is the transformation of [(*tert*-butoxycarbonyl)oxy]phenyl groups in polymer chains to hydroxyphenyl groups catalyzed by a photo-generated acid.

## 1.2 chemical modification

A process by which at least one feature of the chemical constitution of a polymer is changed by chemical reaction(s).

### *Note*

A configurational change, e.g. cis-trans isomerization, is not usually referred to as a chemical modification.

## 1.3 crosslinking

A reaction involving pairs of polymer chains that results in the formation of small regions in a polymer from which at least four chains emanate (see Definition 1.59 in [2]).

### *Notes*

1. The small region may be an atom, a group of atoms, or a number of branch points connected by bonds, groups of atoms, or oligomeric chains.
2. A reaction of a reactive chain end of a linear polymer with an internal reactive site of another linear polymer results in the formation of a branch point, but is not regarded as a crosslinking reaction.

## 1.4 curing

A chemical process of converting a prepolymer or a polymer into a product with higher molar mass and functionality and finally into a network.

### *Notes*

1. Curing is typically accomplished by chemical reactions induced by heating (**thermal curing**), photo-irradiation (**photo-curing**), or electron-beam irradiation (**EB curing**), or by mixing with a chemical curing agent.
2. Physical aging, crystallization, physical crosslinking and postpolymerization reactions are sometimes referred to as "curing". Use of the term "curing" in these cases is discouraged.

## 1.5 **depolymerization**

The process of converting a polymer into its monomer or a mixture of monomers.

*Note*

See Definition 3.25 in [2].

## 1.6 **grafting**

A reaction in which blocks (see Definition 1.62 in [2]) of one or more types are attached as side chains to a polymer molecule having a constitutional or configurational feature different from that of the attached blocks.

## 1.7 **interchange reaction**

A reaction that results in an exchange of reactive atoms or groups between a polymer and low-molar-mass molecules, between two polymer molecules, or between two sites within the same macromolecule.

*Note*

A typical interchange reaction that occurs with polyesters is called **transesterification**.

## 1.8 **main-chain scission**

A chemical reaction that results in the breaking of main-chain bonds of a polymer molecule (see Definitions 1.34, 3.24 in [2]).

*Note*

Some main-chain scissions are classified according to the mechanism of scission process: **hydrolytic**, **mechanochemical**, **thermal**, **photochemical**, or **oxidative scission**. Others are classified according to their location in the backbone relative to a specific structural feature: **a-scission** (a scission of the C-C bond alpha to the carbon atom of a photo-excited carbonyl group), **b-scission** (a scission of the C-C bond beta to the carbon atom bearing a radical), etc.

## 1.9 **mechanochemical reaction**

A chemical reaction that is induced by direct absorption of mechanical energy.

*Note*

Shearing, stretching, and grinding are typical methods of mechanochemical generation of reactive sites, usually macroradicals, in polymer chains.

### **1.10 photochemical reaction**

A chemical reaction that is induced by visible or ultra-violet light irradiation and which proceeds through a photo-excited state.

*Notes*

1. Chemical reactions that are induced by a reactive intermediate (e.g., radical, carbene, nitrene, or ionic species) generated from a photo-excited state are sometimes dealt with as a part of photochemistry.
2. A typical example of a photochemical reaction concerned with polymers is **photopolymerization**.
3. See also Definitions **1.1, 3.15, 3.25**.

### **1.11 polymer complexation polymer complex formation**

A process that results in the formation of a polymer - polymer complex (see Definition 1.6 in [9]) or a complex composed of a polymer and a low-molar-mass substance.

### **1.12 polymer cyclization**

A chemical reaction that leads to the formation of ring structures in or from polymer chains.

*Notes*

1. Examples of cyclization along polymer chains are: (a) cyclization of poly(acrylonitrile), (b) acetalization of poly(vinyl alcohol) with an aldehyde, (c) cyclization of polymers of conjugated dienes such as polyisoprene or polybutadiene leading to macrocycles.
2. Examples of cyclization of polymer molecules are: (a) cyclization of poly(dimethylsiloxane), (b) back-biting during ionic polymerizations of heterocyclic monomers.

### 1.13 polymer degradation

Chemical changes in a polymeric material that usually result in undesirable changes in useful properties of the material.

#### *Notes*

1. In most cases (e.g. in vinyl polymers, polyamides) degradation is accompanied by a decrease in molar mass. In some cases (e.g. in polymers with aromatic rings in the main chain) degradation means changes in chemical structure and is accompanied also by crosslinking.
2. Usually degradation results in the loss of, or deterioration in, useful properties of the material. However in the case of **biodegradation**, it can provide desirable properties, i.e., biodegradable polymers change into environmentally acceptable substances by biological activity (see Definition 3.1).
3. See Definition 16 in [5].

### 1.14 polymer functionalization

Introduction of chemical groups into polymer molecules to exert specific chemical, physical, biological, pharmacological, or other functions.

### 1.15 polymer reaction

A chemical reaction in which at least one of the reactants is a high-molar-mass substance.

### 1.16 polymer-supported reaction

A chemical reaction in which at least one reactant or a catalyst is chemically bound to a polymer.

#### *Notes*

1. The easy separation of low-molar-mass reactants or products from polymer-supported species is a great advantage of polymer-supported reactions.
2. Typical examples of polymer-supported reactions are: (a) reactions performed by use of polymer-supported catalysts, (b) solid-phase peptide synthesis, in which intermediate peptide molecules are chemically bonded to beads of a suitable polymer support.

### 1.17 protection of a reactive group

Temporary transformation of a reactive group in a polymer into a group that does not react under conditions where the non-protected group reacts.

*Note*

For example, **trimethylsilylation** is a typical way to protect reactive functional groups such as hydroxy or amino groups against e.g. anionic polymerization.

### **1.18 radiation reaction**

A chemical reaction that is induced by ionizing radiation with  $\gamma$ -ray, X-ray, electron, or other high-energy beams.

*Notes*

1. Typical polymer reactions induced by irradiation are chain scission and crosslinking.
2. **Photochemical reaction** (see Definition **1.13**) can be referred to as radiation reaction.

### **1.19 reactive blending**

A mixing process that is accompanied by chemical reaction(s) of components of a polymer mixture.

*Notes*

1. Examples of reactive blending are: (a) blending accompanied by formation of a polymer-polymer complex, (b) formation of block or graft copolymers by a combination of radicals formed by mechanochemical scission of polymers during blending.
2. Reactive blending may also be carried out as a **reactive extrusion moulding** or **reaction injection moulding (RIM)**.

### **1.20 sol-gel process**

A process through which a polymer network is formed by a gradual conversion of monomer(s), liquid or in solution, into a polymeric sol, to a gel, and in most cases finally to a dry network. (see Definitions 1.9, 2.11 in [10] and 1.58 in [2])

*Notes*

1. An inorganic polymer, e.g. silica-gel or organic-inorganic hybrid, can be prepared by the sol-gel process (see [10]).
2. When the sol-gel process proceeds inside micelles, microgel particles are formed.



3. A sol is a system of colloidal particles dispersed in a liquid.
4. A gel is a polymer network swollen in a liquid.

### **1.21 surface grafting**

A process in which a polymer surface is chemically modified by a grafting reaction or by the generation of active sites that can lead to the initiation of a graft polymerization.

#### *Note*

Peroxidation, ozonolysis, high-energy irradiation, and plasma etching are methods of generating active sites on a polymer surface.

### **1.22 vulcanization**

Chemical crosslinking of high-molar-mass linear or branched polymers to give a polymer network.

#### *Notes*

1. The polymer network formed often displays rubberlike elasticity. However, a high concentration of crosslinking reactions can lead to rigid materials.
2. A classic example of vulcanization is the crosslinking of *cis*-polyisoprene through sulfide bridges in the thermal treatment of natural rubber with sulfur or a sulfur-containing compound.

## **2. POLYMER REACTANTS AND REACTIVE POLYMERIC MATERIALS**

### **2.1 chelating polymer**

A polymer containing ligand groups capable of forming chelates through two or more coordinative bonds with a metal ion (see [7], p. 68).

#### *Note*

Chelating polymers mostly act as ion-exchange polymers specific to ions that form chelates with chelating ligands of the polymer.

### **2.2 ion-exchange polymer**

A polymer that has ionic groups (anionic or cationic) and is able to exchange counterions (cations or anions) with the ionic components of a solution (see [7], p. 208).

*Notes*

1. An ion-exchange polymer in ionized form may also be referred to as a **polyanion** or a **polycation**.
2. Synthetic ion-exchange organic polymers are often network polyelectrolytes.
3. A membrane having ion-exchange groups is called an **ion-exchange membrane**.
4. The term "ion-exchange resin" is strongly discouraged.

### 2.3 living polymer

A polymer with stable polymerization-active sites formed by a chain polymerization in which irreversible chain transfer and chain termination are absent (see Definition 3.21 in [2], and Definition 60 in [4]).

### 2.4 macromonomer

A polymer or oligomer whose molecules each have a polymerizable functional group, often at the end, that enables it to act as a monomer. After polymerization, the groups are part of the main chain of the final polymer.

*Notes*

1. Homopolymerization or copolymerization of a macromonomer yields comb or graft polymers.
2. See Definition 1.9 in [2] and Definition 61 in [4].
3. Macromonomers are also sometimes referred to as macromers<sup>®</sup>. The use of the term "macromer"<sup>®</sup> is strongly discouraged.

### 2.5 polymer catalyst

A polymer that exhibits catalytic activity.

*Notes*

1. Various synthetic polymer catalysts can mimic enzymes.
2. Poly(4-vinylpyridine) in the basic form and sulfonated polystyrene in the acid form are examples of polymers that can act as catalysts in some base- and acid-catalysed reactions, respectively.

## 2.6 polymer-metal complex

A complex comprising a metal and one or more polymeric ligands.

## 2.7 polymer phase-transfer catalyst

A polymer that acts as a phase-transfer catalyst and thereby causes a significant enhancement of the rate of a reaction between two reactants located in neighboring phases owing to the extraction of one of the reactants across the interface to the other phase where the reaction takes place.

### *Note*

Polymer phase-transfer catalysts in the form of beads are often referred to as **triphase catalysts** because such catalysts form the third phase of the reaction system.

## 2.8 polymer-supported catalyst

A catalyst system comprising a polymer support in which catalytically active species are immobilized through chemical bonds or weak interactions such as hydrogen bonds or donor-acceptor interactions.

### *Notes*

1. Polymer-supported catalysts are often based on network polymers in the bead form, which are easy to separate from reaction media and can be used repeatedly.
2. Examples of polymer-supported catalysts are: (a) a polymer-metal complex that can coordinate reactants, (b) colloidal palladium dispersed in a swollen network polymer that can act as a hydrogenation catalyst. **Polymer-supported enzymes** are also polymer-supported catalysts.

## 2.9 polymer reactant polymer reagent polymer-supported reagent

A reactant (reagent) that is or is attached to a high-molar-mass linear polymer or a network.

### *Note*

The attachment may be by chemical bonds, by weak interactions such as hydrogen bonds, or simply by inclusion.

## **2.10 prepolymer**

A polymer or oligomer capable of entering, via reactive groups, into further polymerization; the reactive species thereby contributes more than one monomeric unit to at least one chain of the final polymer.

### *Note*

See Definition 2.37 in [2].

## **2.11 reactive polymer**

A polymer having reactive functional groups that can be transformed under the conditions required for a given reaction or application.

## **2.12 redox polymer electron-exchange polymer oxidation-reduction polymer**

A polymer containing groups that can be reversibly reduced or oxidized.

### *Notes*

1. Reversible redox reaction can take place in a polymer main-chain as in the case of polyaniline and quinone/hydroquinone polymers, or on side groups, as in the case of a polymer carrying ferrocene side-groups.
2. See [7] p. 346.

## **2.13 resin**

A soft solid or highly viscous substance, usually containing prepolymers with reactive groups.

### *Notes*

1. This term was used historically because of its analogy with a natural resin (rosin) and was once used in a broad sense to designate any polymer that is a basic material for plastics, organic coatings, or laquers. However, recently it has become used in more narrow senses to refer to prepolymers of thermosets (thermosetting polymers) and some soft network polymers, especially those in bead form (see note 3).

2. It is sometimes used not only for prepolymers of thermosets but also for cured thermosets, e.g., epoxy resin, phenolic resin. The use of the term for cured thermosets is strongly discouraged.

3. The use of the term "resin" to describe the polymer beads used in solid-phase synthesis and as polymer supports, catalysts, reagents, and scavengers is also discouraged.

#### **2.14 telechelic polymer telechelic oligomer**

A prepolymer capable of entering into further polymerization via its reactive end-groups (see Definition 1.11 in [2]).

#### **2.15 thermosetting polymer**

A prepolymer in a soft solid or viscous state that changes irreversibly into an infusible, insoluble polymer network by heating (curing).

##### *Note*

The product of curing a thermosetting polymer is called a **thermoset**.

### **3. FUNCTIONAL POLYMERIC MATERIALS**

#### **3.1 biodegradable polymer**

A polymer susceptible to degradation (see Definition 16 in [5]) by biological activity, with the degradation accompanied by a lowering of its molar mass.

#### **3.2 conducting polymer**

A polymer that exhibits electric conductivity similar to that of metals or solutions of electrolytes (see [7], p. 84).

##### *Notes*

1. The electric conductivity of a conjugated polymer is markedly increased by doping it with an electron donor or acceptor, as in the case of polyacetylene doped with iodine.

2. A polymer showing a substantial increase in electric conductivity upon irradiation with ultraviolet or visible light is called a **photoconductive polymer**, an example is poly(*N*-vinylcarbazole).
3. A polymer that shows electric conductivity due to the transport of ionic species is called an **ion-conducting polymer**, an example is sulfonated polyaniline. When the transported ionic species is a proton as, e.g., in the case of fuel cells, it is called a **proton-conducting polymer**.
4. A polymer that shows electric semiconductivity is called a **semiconducting polymer**.
5. Electric conductance of a non-conducting polymer can be achieved by dispersing conducting particles (e.g., metal, carbon black) in the polymer. The resulting materials are referred to as **conducting polymer composites** or **solid polymer-electrolyte composites**.

### 3.3 electroluminescent polymer

A polymeric material that shows luminescence when an electric current passes through it such that charge carriers can combine at luminescent sites to give rise to electronically excited states of luminescent groups or molecules.

#### *Note*

Electroluminescent polymers are often made by incorporating luminescent groups or dyes into conducting polymers.

### 3.4 ferroelectric polymer

A polymer in which spontaneous polarization (see [7], p. 153) arises when individual dipoles become arranged in parallel by electric fields.

#### *Note*

Poly(vinylidene fluoride) subjected to a corona discharge is an example of a ferroelectric polymer.

### 3.5 ferromagnetic polymer

A polymer that has unpaired electron spins aligned in parallel or that can easily be so aligned and thus exhibits magnetic properties (see [7], p. 242).

### 3.6 functional polymer

- (a) A polymer that bears specified chemical groups  
or

(b) a polymer that has specified physical, chemical, biological, pharmacological, or other uses.

*Note*

Examples of functions of functional polymers under definition (b) are catalytic activity, selective binding of particular species, capture and transport of electric charge carriers or energy, conversion of light to charge carriers and vice versa, transport of drugs to a particular organ in which the drug is released.

### 3.7 impact-modified polymer

A polymeric material whose impact resistance and toughness have been increased by the incorporation of microphase domains of a rubbery material.

*Note*

An example is the incorporation of soft polybutadiene domains into glassy polystyrene to produce high-impact polystyrene.

### 3.8 liquid-crystalline polymer

A polymer that can exhibit one or more liquid state(s) with one- or two-dimensional long-range orientational order over a certain range of temperatures either in the melt (**thermotropic liquid-crystalline polymer**) or in solution (**lyotropic liquid-crystalline polymer**).

*Note*

See Definition 6.1 in [11].

### 3.9 macroporous polymer

A solid or soft polymer that includes a large number of macropores (50 nm - 1  $\mu\text{m}$  in diameter) that persist in solvents and in the dry state.

*Notes*

1. Typical macroporous polymers are network polymers in bead form. However, linear polymers can also be prepared in the form of macroporous polymer beads.
2. Macroporous polymers swell only a little in solvents.
3. Macroporous polymers are used, e.g., as precursors for ion-exchange polymers, as adsorbents, as supports for catalysts or reagents and as stationary phases in size-exclusion-chromatography columns.

4. Porous polymers with pore dimeters from ca. 2 to 50 nm are called **mesoporous polymers**.

### 3.10 non-linear-optical polymer

A polymer that exhibits dielectric polarization induced by electromagnetic radiation, the magnitude of the polarization not being proportional to the applied electromagnetic field (see [7], p. 275).

#### *Notes*

1. An example of a non-linear-optical effects is the generation of higher harmonics of the incident light wave.
2. A polymer that exhibits a non-linear-optical effect due to anisotropic electric susceptibilities when subjected to electric field together with light irradiation is called an **electro-optical polymer**. **Photorefractive polymers** exhibit a non-linear-optical effect by combining photoconductivity and electro-optical effects.

### 3.11 optically-active polymer

A polymer capable of rotating the polarization plane of a transmitted beam of plane-polarized light (see [7], p. 282).

#### *Note*

The optical activity originates from the presence of chiral elements in a polymer such as chiral centers or chiral axes due to long-range conformational order in a polymer (helicity) (see [7], p. 182).

### 3.12 photoelastic polymer

A polymer that exhibits reversible stress birefringence.

### 3.13 photoluminescent polymer

A polymer that emits fluorescence or phosphorescence after photo-excitation to a higher electronic state.

### 3.14 photosensitive polymer



A polymer that responds to ultraviolet or visible light by exhibiting a change in its molecular shape (**photoresponsive polymer**), a change in its constitution (**photoreactive polymer**), or a reversible change in colour (**photochromic polymer**).

### 3.15 piezoelectric polymer

- (a) A polymer that exhibits a change in dielectric properties on application of pressure or
- (b) a polymer that shows a change in its dimensions when subjected to an electric field.

### 3.16 polyelectrolyte

A polymer bearing ionizable or ionic groups on a significant fraction of its constitutional repeating units (see Definition 2.38 in [2]).

#### *Notes*

1. A polymer bearing both anionic and cationic groups is called an **amphoteric polyelectrolyte**.
2. A polymer bearing acid or basic groups is called a **polymer acid** or a **polymer base**, respectively.
3. A polymer acid or a polymer base can be used as a matrix for ion-conducting polymers.

### 3.17 polymer sorbent

A polymer that adsorbs or absorbs a certain substance or certain substances from a liquid or a gas.

#### *Note*

A polymer sorbent may be a **polymer adsorbent** or a **polymer absorbent**. The former acts by surface adsorption and the latter by bulk absorption.

### 3.18 polymer compatibilizer

A polymeric additive that, when added to a blend of immiscible polymers, modifies their interfaces and stabilizes the blend (see Definition 1.37 in [9]).

#### *Note*

Typical polymer compatibilizers are block or graft copolymers.

### **3.19 polymer drug**

A polymer that contains either chemically bonded drug molecules or pharmacologically active moieties.

#### *Note*

A polymer drug is usually used to provide targeted drug delivery to an organ and controlled release of an active drug at the target organ.

### **3.20 polymer gel**

A covalent or physical polymer network swollen in a liquid (see Definition 1.58 in [2]).

### **3.21 polymer membrane**

A thin layer of polymeric material that acts as a barrier permitting mass transport of selected species.

### **3.22 polymer solvent**

A polymer that acts like a solvent for low-molar-mass compounds.

#### *Note*

An example of polymer solvents is poly(oxyethylene); it can dissolve various inorganic salts by complexation.

### **3.23 polymer support**

A polymer to which a reagent or catalyst is chemically bonded, immobilized, dispersed, or associated.

#### *Notes*

1. A polymer support is usually a network polymer.
2. A polymer support is also usually prepared in bead form by suspension polymerization.

3. The location of active sites introduced into a polymer support depends on the type of polymer support. In **swollen gel beads** the active sites are distributed uniformly throughout the beads, whereas in **macroporous beads** they are predominantly on the internal surfaces of the macropores.

### 3.24 polymer surfactant

A polymer that lowers the interfacial tension of the material in which it is dissolved (see [7], p. 409).

### 3.25 resist polymer

A polymeric material that, when irradiated, undergoes a profound change in solubility in a given solvent or is ablated.

#### *Notes*

1. A resist polymer under irradiation either forms patterns directly or undergoes chemical reactions leading to pattern formation after subsequent processing.
2. A resist material that is optimized for use with ultraviolet or visible light, an electron beam, an ion beam, or X-rays is called a **photoresist**, **electron-beam resist**, **ion-beam resist**, or **X-ray resist**, respectively.
3. In a **positive-tone resist**, also called a **positive resist**, the material in the irradiated area not covered by a mask is removed, resulting in an image with a pattern identical with that on the mask. In a **negative-tone resist**, also called a **negative resist**, the non-irradiated area is subsequently removed, resulting in an image with a pattern that is the complement of that on the mask.

### 3.26 shape-memory polymer

A polymer that has been subjected to a plastic deformation and resumes its original shape when heated above its glass-transition or melting temperature.

#### *Note*

Crystalline *trans*-polyisoprene is an example of a shape-memory polymer.

### 3.27 superabsorbent polymer

A polymer that can absorb and retain extremely large amounts of a liquid relative to its own weight.

*Notes*

1. The liquid absorbed can be water or an organic liquid.
2. The swelling ratio of a superabsorbent polymer can reach of the order of 1000:1.
3. Superabsorbent polymers for water are frequently polyelectrolytes.

IUPAC Provisional Recommendations

## REFERENCES

1. *Compendium of Macromolecular Nomenclature* (“Purple Book”), prepared for publication by W. V. Metanovski, Blackwell Sci. Publ., Oxford, 1991, Chapter 1; IUPAC. Basic Definitions of Terms Relating to Polymers (1974), *Pure Appl. Chem.*, **40**, 477-491 (1974).
2. Glossary of Basic Terms in Polymer Science (IUPAC Recommendations 1996), *Pure Appl. Chem.*, **68**, 2287-2311 (1996).
3. Basic Classification and Definitions of Polymerization Reactions (IUPAC Recommendations 1994), *Pure Appl. Chem.*, **66**, 2483-2486 (1994).
4. Terminology on Kinetics and Thermodynamics of Polymerization (IUPAC Recommendations in preparation).
5. Definitions of Terms Relating to Degradation, Aging, and Related Chemical Transformations of Polymers (IUPAC Recommendations 1996), *Pure Appl. Phys.*, **68**, 2313-2323 (1996).
6. Nomenclature for Organic Chemical Transformations (IUPAC Recommendations 1989), *Pure Appl. Chem.*, **61**, 725-768 (1989).
7. *Compendium of Chemical Terminology* (“Gold Book”) 2nd ed., compiled by A. D. McNaught, A. Wilkinson, Blackwell Sci. Publ., Oxford 1997.
8. Glossary of Polymer Chemical and Topological Class Names (IUPAC Recommendations, in preparation).
9. Definitions of Terms Relating to Polymer Blends and Multi-Phase Polymeric Materials (IUPAC Recommendations, in preparation).
10. Glossary of Terms Relating to the Structure of Inorganic and Polymeric Gels, Networks, Inorganic Polymeric Materials and the Processing Thereof (IUPAC Recommendations, in preparation).
11. Definitions of Basic Terms Relating to Low-Molar-Mass and Polymer Liquid-Crystals (IUPAC Recommendations 2001), *Pure Appl. Chem.*, **73**, 845-895 (2001).

## ALPHABETICAL INDEX OF TERMS

<i>Term</i>	<i>Definition number</i>	<i>Term</i>	<i>Definition number</i>
$\alpha$ -scission	1.8	living polymer	2.3
$\beta$ -scission	1.8	lyotropic liquid-crystalline polymer	3.8
amphoteric polyelectrolyte	3.16	macromonomer	2.4
biodegradable polymer	3.1	macroporous bead	3.23
biodegradation	1.13	macroporous polymer	3.9
chelating polymer	2.1	main-chain scission	1.8
chemical amplification	1.1	mechanochemical reaction	1.9
chemical modification	1.2	mechanochemical scission	1.8
conducting polymer	3.2	mesoporous polymer	3.9
conducting polymer composite	3.2	negative resist	3.25
crosslinking	1.3	negative-tone resist	3.25
curing	1.4	non-linear-optical polymer	3.10
depolymerization	1.5	optically-active polymer	3.11
EB curing	1.4	oxidation-reduction polymer	2.12
electro-optical polymer	3.10	oxidative scission	1.8
electroluminescent polymer	3.3	photo-acid generator	1.1
electron-beam resist	3.25	photo-base generator	1.1
electron-exchange polymer	2.12	photo-curing	1.4
ferroelectric polymer	3.4	photochemical reaction	1.10, 1.18
ferromagnetic polymer	3.5	photochemical scission	1.8
functional polymer	3.6	photochromic polymer	3.14
grafting	1.6	photoconductive polymer	3.2
hydrolytic scission	1.8	photoelastic polymer	3.12
impact-modified polymer	3.7	photoluminescent polymer	3.13
interchange reaction	1.7	photopolymerization	1.10
ion-beam resist	3.25	photoreactive polymer	3.14
ion-conducting polymer	3.2	photorefractive polymer	3.10
ion-exchange membrane	2.2	photoresist	3.25
ion-exchange polymer	2.2	photoresponsive polymer	3.14
liquid-crystalline polymer	3.8	photosensitive polymer	3.14

<i>Term</i>	<i>Definition number</i>	<i>Term</i>	<i>Definition number</i>
piezoelectric polymer	3.15	prepolymer	2.10
polyanion	2.2	protection of a reactive group	1.17
polycation	2.2	proton-conducting polymer	3.2
polyelectrolyte	3.16	radiation reaction	1.18
polymer absorbent	3.17	reaction injection moulding (RIM)	1.19
polymer acid	3.16	reactive blending	1.19
polymer adsorbent	3.17	reactive extrusion moulding	1.19
polymer base	3.16	reactive polymer	2.11
polymer catalyst	2.5	redox polymer	2.12
polymer compatibilizer	3.18	resin	2.13
polymer complex formation	1.11	resist polymer	3.25
polymer complexation	1.11	semiconducting polymer	3.2
polymer cyclization	1.12	shape-memory polymer	3.26
polymer degradation	1.13	sol-gel process	1.20
polymer drug	3.19	solid polymer-electrolyte composite	3.2
polymer functionalization	1.14	superabsorbent polymer	3.27
polymer gel	3.2	surface grafting	1.21
polymer membrane	3.21	swollen gel bead	3.23
polymer phase-transfer catalyst	2.7	telechelic oligomer	2.14
polymer reactant	2.9	telechelic polymer	2.14
polymer reaction	1.15	thermal curing	1.4
polymer reagent	2.9	thermal scission	1.8
polymer solvent	3.22	thermoset	2.15
polymer sorbent	3.17	thermosetting polymer	2.15
polymer support	3.23	thermotropic liquid-crystalline polymer	3.8
polymer surfactant	3.24	transesterification	1.7
polymer-metal complex	2.6	trimethylsilylation	1.17
polymer-supported catalyst	2.8	triphase catalyst	2.7
polymer-supported enzyme	2.8	vulcanization	1.22
polymer-supported reaction	1.16	X-ray resist	3.2
polymer-supported reagent	2.9		
positive resist	3.25		
positive-tone resist	3.25		