Polysciences, Inc.
Chemistry beyond the ordinary

PolyFacts

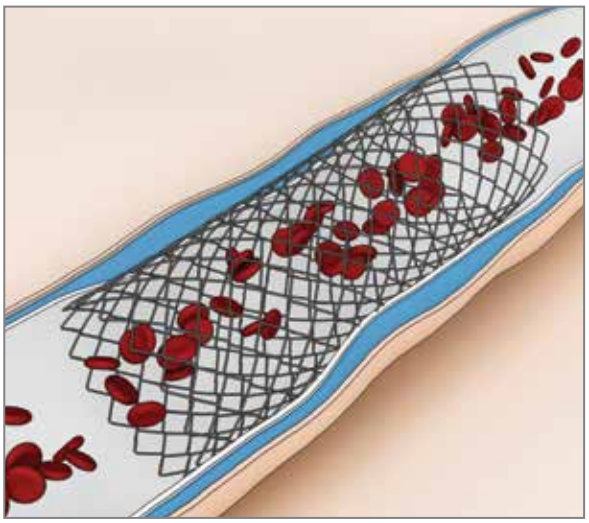
News | Views | Insights

Monomers & Polymers

Vol. 9 | No. 2

Biodegradable Polymers

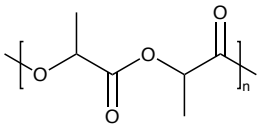
Polysciences offers a range of biodegradable polymers for evaluation and product development. Biodegradable polymers are engineered to undergo controlled degradation over time, which makes them uniquely useful for medical applications. The ability to degrade inside the body eliminates the need for implant removal surgeries, and creates opportunities for new drug delivery systems.



The exploration of biodegradable polymers in life sciences and pharmaceuticals has grown rapidly. The biodegradability of these polymers make them ideal for many applications, including drug encapsulation & delivery, sutures, tissue engineering, surgical plates and dental devices. Polysciences' biodegradable polymers are based on polyethylene glycol (PEG), polylactic acid (PLA), polycaprolactone (PCL) and polyglycolide (PGA) chemistries.

Polysciences' polymers are offered for research purposes only, and are not intended for use in or on humans as a drug or device.

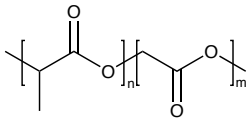
Poly(L-lactic acid) Polymers



Lactic acid is a chiral molecule, having both (L) and (D) forms. The family of lactic acid polymers includes pure poly-L-lactic acid, pure poly-D-lactic acid and poly-D,L-lactic acid. L-lactic acid polymers are commonly used for cast and extruded biomedical devices because they degrade into naturally occurring stereoisomers that can be excreted. The rate of degradation is inversely related to the polymer's molecular weight. These poly(L-lactic acid) polymers have a crystallinity of approximately 70%.

Cat. #	Description
18580	Poly(l-lactic acid) [MW ~1,600 - 2,400]
06529	Poly(l-lactic acid) [MW 40-70 K]
18402	Poly(l-lactic acid) [MW ~80,000 - 100,000]
18582	Poly(l-lactic acid) [MW ~325,000 - 460,000]
21512	Poly(l-lactic acid) [MW ~700,000]
18599	Poly(l-lactic acid) Molecular Weight Kit

Poly(D,L-Lactide-co-Glycolide) Polymers



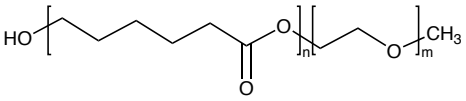
The ratio of lactide to glycolide in poly(D,L-lactide-co-glycolide) (PLGA) copolymers define their crystallinity, and thus their degradation times. Generally, as the ratio of glycolide increases, the copolymer degrades more quickly. Copolymers are available in PLA:PGA ratios ranging from 50:50 to 90:10. All conformations are soluble in MDC, THF, ethyl acetate and acetone.

Cat. #	Description
23986	Poly(dl-lactide/glycolide) [50:50] MW ~12,000-16,000
23987	Poly(dl-lactide/glycolide) [50:50] MW ~150,000
19247	Poly(dl-lactide/glycolide) [70:30]
25107	Poly(d,l-lactide-co-glycolide), [75:25]
19077	Poly(dl-lactide/glycolide) [80:20]
23989	Poly(dl-lactide/glycolide) [85:15]
19076	Poly(dl-lactide/glycolide) [90:10]

continued on page 2

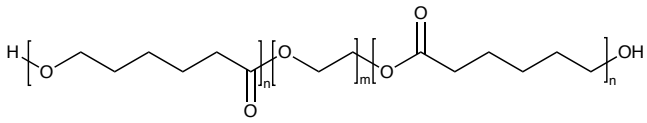
Polycaprolactone-Polyethylene Glycol Diblock & Triblock Polymers

Polycaprolactone is among the leading candidates for biodegradable polymers due to its numerous FDA approved medical uses. Polycapralactone is a biodegradable polyester, however, converting it into a diblock (A-B) or triblock (A-B-A) copolymer with polyethylene glycol leads to improved physiological compatibility and controlled biodegradation rates. The PEG terminal groups are blocked as methyl ethers, but the caprolactone end groups are hydroxyl, thus suitable for functionalization. Low molecular weight PEG and PCL blocks are tolerated by the human body and can be excreted. Such amphiphilic block copolymers can be used to form polymersomes that contain active compounds.[1,2]



Diblock Polymers

Cat. #	Description
25010	PCL(1,000)-b-PEG(1,000), Diblock Polymer
25011	PCL(1,000)-b-PEG(2,000), Diblock Polymer
25012	PCL(1,000)-b-PEG(5,000), Diblock Polymer
25022	PCL(5,000)-b-PEG(1,000), Diblock Polymer
25023	PCL(5,000)-b-PEG(2,000), Diblock Polymer
25024	PCL(5,000)-b-PEG(5,000), Diblock Polymer

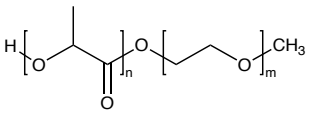


Triblock Polymers

Cat. #	Description
25013	PCL(1,000)-b-PEG(10,000)-b-PCL(1,000), Triblock Polymer
25014	PCL(5,000)-b-PEG(1,000)-b-PCL(5,000), Triblock Polymer
25015	PCL(5,000)-b-PEG(2,000)-b-PCL(5,000), Triblock Polymer
25016	PCL(5,000)-b-PEG(5,000)-b-PCL(5,000), Triblock Polymer
25019	PCL(1,000)-b-PEG(1,000)-b-PCL(1,000), Triblock Polymer
25020	PCL(1,000)-b-PEG(2,000)-b-PCL(1,000), Triblock Polymer
25021	PCL(1,000)-b-PEG(6,000)-b-PCL(1,000), Triblock Polymer
25025	PCL(5,000)-b-PEG(10,000)-b-PCL(5,000), Triblock Polymer

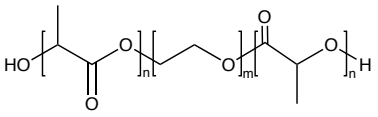
Polylactic acid-Polyethylene Glycol Diblock & Triblock Polymers

Copolymerization of PLA into diblock or triblock copolymers with ethylene glycol increases hydrophilicity and flexibility. Due to their biocompatibility and resistance to immunological recognition, these PLA-PEG copolymers are being researched for use in drug delivery devices.[3] When prepared as nanoparticles, PLA-PEG copolymers can provide enhanced drug efficacy and reduced toxicity.[4] The degradation products can enter the tricarboxylic cycle or be eliminated by the kidney. PLA-PEG copolymers are insoluble in water, but degrade by hydrolytic attack on their ester bonds.



Diblock Polymers

Cat. #	Description
24375	PEG(350)-b-PLA(300), Diblock Polymer
24378	PEG(1,000)-b-PLA(750), Diblock Polymer
24381	PEG(1,000)-b-PLA(5,000), Diblock Polymer
24386	PEG(5,000)-b-PLA(1,000), Diblock Polymer
24389	PEG(5,000)-b-PLA(5,000), Diblock Polymer
25017	PEG(10,000)-b-PLA(5,000), Diblock Polymer
25018	PEG(5,000)-b-PLA(10,000), Diblock Polymer



Triblock Polymers

Cat. #	Description
24500	PLA(1,000)-b-PEG(1,000)-b-PLA(1,000), Triblock Polymer
24501	PLA(2,000)-b-PEG(1,000)-b-PLA(2,000), Triblock Polymer
24502	PLA(5,000)-b-PEG(1,000)-b-PLA(5,000), Triblock Polymer
24503	PLA(1,000)-b-PEG(4,000)-b-PLA(1,000), Triblock Polymer
24509	PLA(1,000)-b-PEG(10,000)-b-PLA(1,000), Triblock Polymer
25026	PLA(5,000)-b-PEG(10,000)-b-PLA(5,000), Triblock Polymer
25027	PLA(10,000)-b-PEG(10,000)-b-PLA(10,000), Triblock Polymer

Polysciences' PLA-PEG / PCL-PEG diblock and triblock copolymers are available with a range of block molecular weights. Additionally, Polysciences offers custom synthesis services for other compositions and block molecular weights.

1. Ahmed F, Discher, DE. Self-porating polymersomes of PEG-PLA and PEG-PCL: hydrolysis-triggered controlled release vesicles. Journal of Controlled Release. 2004; 96(1): 37-53.

2. Petersen MA, Yin L, Kokkoli E, Hillmyer M. Synthesis and characterization of reactive PEO–PMCL polymersomes. Polymer Chemistry. 2010; 1: 1281-1290.

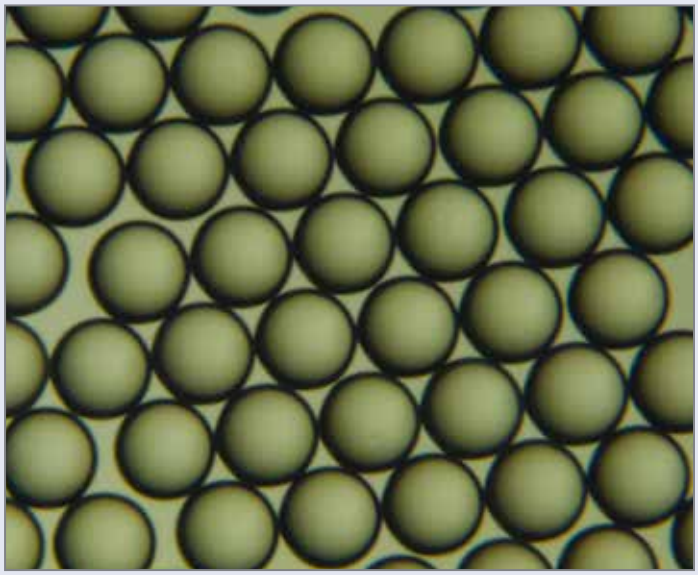
3.Takami T, Murakami Y. Development of PEG-PLA/PLGA microparticles for pulmonary drug delivery prepared by a novel emulsification technique assisted with amphiphilic block copolymers. Colloids and Surfaces B: Biointerfaces. 2011; 87(2): 433-8.

4. Xiao RZ, Zeng ZW, Zhou GL, Wang JJ, Li FZ, Wang AM. Recent advances in PEG-PLA block copolymer nanoparticles. International Journal of Nanomedicine. 2010; 5: 1057-65.

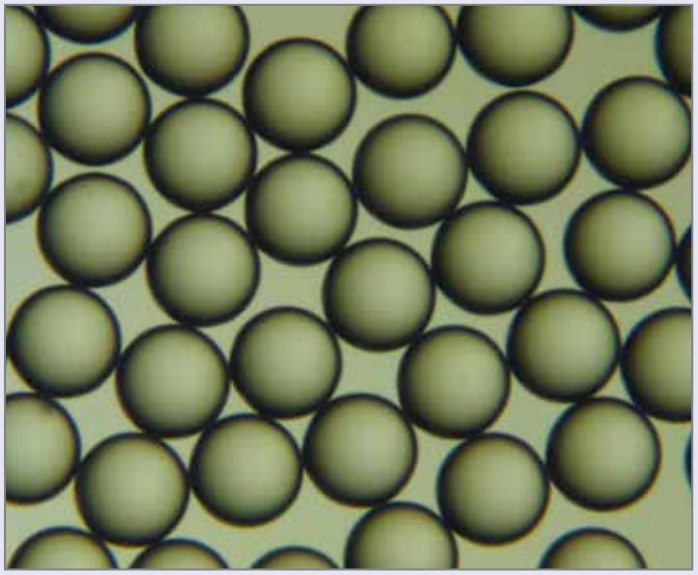
Biodegradable Poly(Lactic-co-Glycolic) Acid (PLGA) Uniform Microspheres

Poly(Lactic-co-Glycolic) acid (PLGA) is a common biodegradable polymer that has been utilized in a diverse set of medical applications. Polysciences' PLGA Microspheres are monodisperse, and can be used as a drug encapsulant[5], a scaffold for implants and bone grafts[6], and for medical device coatings.[7] They can also be used to generate specific features on biosensor surfaces and within imaging phantoms, and provide controlled particle size for instrument calibration and particle size assays. Compositions may be engineered to achieve desired degradation profiles, and sizes can be tailored to fit specific applications. Though the biodegradation rate will be dependent on the conditions of the usage environment (pH, temperature, etc.), the microspheres are expected to fully degrade over a period of 2-4 months. Degradation occurs due to hydrolysis of ester linkages, and is associated with a loss of molecular weight and mass, as well as morphological alterations such as surface erosion and changes in geometry.

Since Polysciences' Microspheres are inherently hydrophobic, a small amount of surfactant or a few seconds in an ultrasonic bath may aid in forming aqueous suspensions. Catalog items are available with lactic:glycolic acid ratios of 50:50 and 75:25, with diameters of 75, 100 and 120 µm. Custom sizes and compositions can also be synthesized. Lyophilized microspheres should be stored at 4-8° C and protected from moisture. For best stability, handle microspheres under nitrogen or another inert gas.



50:50 75µm 10X



75:25 75µm 10X

Cat. #	Description
25401	50:50 LA/GA, 75µm
25402	50:50 LA/GA, 100µm
25403	50:50 LA/GA, 120µm

Cat. #	Description
25398	75:25 LA/GA, 75µm
25399	75:25 LA/GA, 100µm
25400	75:25 LA/GA, 120µm

5. Makadia HK, Siegel SJ. Poly Lactic-co-Glycolic Acid (PLGA) as Biodegradable Controlled Drug Delivery Carrier. Polymers. 2011; 3(3), 1377-1397.

6. Habraken WJ, Wolke JG, Mikos AG, Jansen JA. PLGA microsphere/calcium phosphate cement composites for tissue engineering: in vitro release and degradation characteristics. Journal of Biomaterials Science, Polymer Edition. 2008; 19(9): 1171-88.

7. Wang Y, Vaddiraju S, Qiang L, Xu X, Papadimitrakopoulos F, Burgess DJ. Effect of dexamethasone-loaded poly(lactic-co-glycolic acid) microsphere/poly(vinyl alcohol) hydrogel composite coatings on the basic characteristics of implantable glucose sensors. Journal of Diabetes Science and Technology. 2012; 6(6): 1445-53.

EVA Polymers for Medical Devices

Polyethylene-co-vinyl acetate (PEVA) has many desirable characteristics that make it ideal for medical applications. PEVA polymers possess favorable tensile strength, barrier properties and optical transparency that make them ideal for controlled release[8] and implant applications.[9] Polysciences' PEVA polymers do not contain additives and are highly purified, exhibiting low polydispersity indices and residual monomer and solvent levels of <100 ppm. The polymers can be processed using a variety of methods including spin coating, casting, molding and extrusion.

Polysciences offers PEVA polymers in stock quantities or through custom synthesis. Our two gallon reactor is capable of pressures as high as 3000 psi, and can be used for emulsion or solution polymerizations. Polymer properties, such as molecular weight and monomer ratios, can be customized to meet requested values. The reactor suite is under GLP conditions. Material can be transferred to ISO Class 8 cGMP Clean Rooms for processing.

- Synthesis of materials with VA weight ratios of 20-90% & with molecular weights ranging from ~25,000 to ~300,000
- Synthesis of additive-free polymers
- Synthesis with other monomers (MAA, MMA, etc.)

Interested in our custom synthesis capabilities?
Call 1.800.523.2575 or visit www.polysciences.com/customform

Cat. #	Description
25356	Polyethylene-co-vinyl acetate 70:30 (wt) MW 55,000
25357	Polyethylene-co-vinyl acetate 70:30 (wt) MW 60,000
25358	Polyethylene-co-vinyl acetate 70:30 (wt) MW 65,000
25359	Polyethylene-co-vinyl acetate 70:30 (wt) MW 75,000

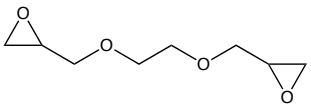
Pressure Reactor

8. Kenawy el-R, Bowlin GL, Mansfield K, Layman J, Simpson DG, Sanders EH, Wnek GE. Release of tetracycline hydrochloride from electrospun poly(ethylene-co-vinylacetate), poly(lactic acid), and a blend. Journal of Controlled Release. 2002; 81(1-2): 57-64.

9. Zhang C, Easteal A, Edmonds N, Liang G, Razzak M, Leech W. In Vitro and Mechanism Study of Poly(ethylene-co-vinyl acetate)- Based Implant for Sustained Release of Vitamin B12. Macromolecular Research. 2010; 18(7): 653-659.

Featured Building Blocks

Ethylene Glycol Diglycidyl Ether

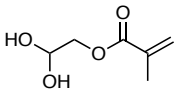


Ethylene glycol diglycidyl ether (EGDE) is commonly used for cross linking polymers that contain amine, hydroxyl or carboxyl groups. EGDE is a water miscible epoxy monomer with dual functionality that makes it attractive for a wide range of applications. EGDE and its corresponding polymers have been identified as useful materials for microelectrode biosensor preparation[10], medical device polymer crosslinking[11], membrane surface modification[12] and hydrogel crosslinking.[13]

When polymerized, EGDE can be used to immobilize proteins on biosensors that are highly sensitive and give response times on the order of seconds, which is sufficient for *in vivo* observation of biological processes. In medical devices, EGDE can be used as a crosslinker for biocompatible polymers. It has been recently identified as a surface modifier for membranes, in both biological and industrial applications, that reduces fouling and the effort required for cleaning.

Cat. #	Description
01479	Ethylene glycol diglycidyl ether (Quetol 651)

Glycerol Monomethacrylate

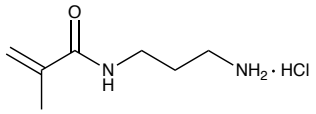


Glycerol Monomethacrylate (GMMA) is a hydrophilic biocompatible monomer that is often used in hydrogel preparation. Hydrophilic monomers are known for their utility in ocular applications, but they are also being investigated for use in tissue engineering and as a steric stabilizer in latex synthesis.[14] GMMA containing polymers can be used to form low adsorption "stealth" polymers[15] and can provide cell adhesion modulation on cell culture substrates.[16] The non-toxic, anti-fouling properties of the GMMA monomer make it an interesting candidate for polymer systems that are intended for medical/biological use.

GMMA readily accommodates reactions with many organic and inorganic compounds and can contribute properties of hydrophilicity, high crosslinking density, flexibility and oxygen permeability when polymerized. GMMA is available in 25g quantities and must be stored below -20° C.

Cat. #	Description
04180	Glycerol monomethacrylate, mixture of isomers

N-(3-Aminopropyl)methacrylamide hydrochloride, >98%



The increase in the use of implantable medical devices has caused great interest in synthetic materials that minimize the body's defensive reactions. Negative reactions to medical devices that are in contact with blood can include inflammatory reactions and thrombus formation. One approach to combating the rejection of artificial materials is to coat the implantable device with a material that is biocompatible.

N-(3-Aminopropyl)methacrylamide hydrochloride is a biocompatible monomer that can be used to make polymers for implantable medical device coatings.[17] It can be combined with other monomers/polymers, such as AMPS, to provide slip properties and to minimize thrombus formation. In addition, by providing primary amine groups, the polymer facilitates the addition of bioreactive agents, such as antibiotics, antimicrobials or anticoagulants to a secondary coating layer.[18] This multi-coat system allows for the controlled release of bioactive agents inside the body. Polysciences' N-(3-Aminopropyl)methacrylamide hydrochloride is greater than 98% pure and is available in 5g quantities. ***Please call for bulk manufacturing inquiries.***

Cat. #	Description
21200	N-(3-Aminopropyl)methacrylamide hydrochloride, >98%

10. Vasylieva N, Barnych B, Meiller A, Maucler C, Pollegioni L, Lin JS, Barbier D, Marinesco S. Covalent enzyme immobilization by poly(ethylene glycol) diglycidyl ether (PEGDE) for microelectrode biosensor preparation. Biosensors and Bioelectronics. 2011; 26(10): 3993-4000.

11. Chen M, Mi F, Liao Z, Sung H. Chitosan: Its Applications in Drug-Eluting Devices Advances in Polymer Science. 2011; 243: 185-230.

12. Van Wagner E, Sagle A, Sharma M, La Y, Freeman B. Surface modification of commercial polyamide desalination membranes using poly(ethylene glycol) diglycidyl ether to enhance membrane fouling resistance. Journal of Membrane Science. 2011; 367(1-2): 273-287.

13. Concheiro A, Alvarez-Lorenzo C. Chemically cross-linked and grafted cyclodextrin hydrogels: from nanostructures to drug-eluting medical devices. Advanced Drug Delivery Reviews. 2013; 65(9): 1188-203.

14. Thompson KL, Armes SP, York DW, Burdis JA. Synthesis of Sterically-Stabilized Latexes Using Well Defined Poly(glycerol monomethacrylate) Macromonomers. Macromolecules. 2010; 43(5): 2169-2177.

15. Robert-Nicoud G, Evans R, Vo C, Cadmanc C, Tirelli N. Synthesis, self-assembly and (absence of) protein interactions of poly(glycerol methacrylate)–silicone macro-amphiphiles. Polymer Chemistry. 2013; 4: 3458-3470.

16. Patrucco E, Ouasti S, Vo CD, De Leonardis P, Pollicino A, Armes SP, Scandola M, Tirelli N. Surface-initiated ATRP modification of tissue culture substrates: poly(glycerol monomethacrylate) as an antifouling surface. Biomacromolecules. 2009; 10(11): 3130-40.

17. Andrade-Vivero P, Fernandez-Gabriel E, Alvarez-Lorenzo C, Concheiro A. Improving the loading and release of NSAIDs from pHEMA hydrogels by copolymerization with functionalized monomers. Journal of Pharmaceutical Sciences. 2007; 96(4): 802-13.

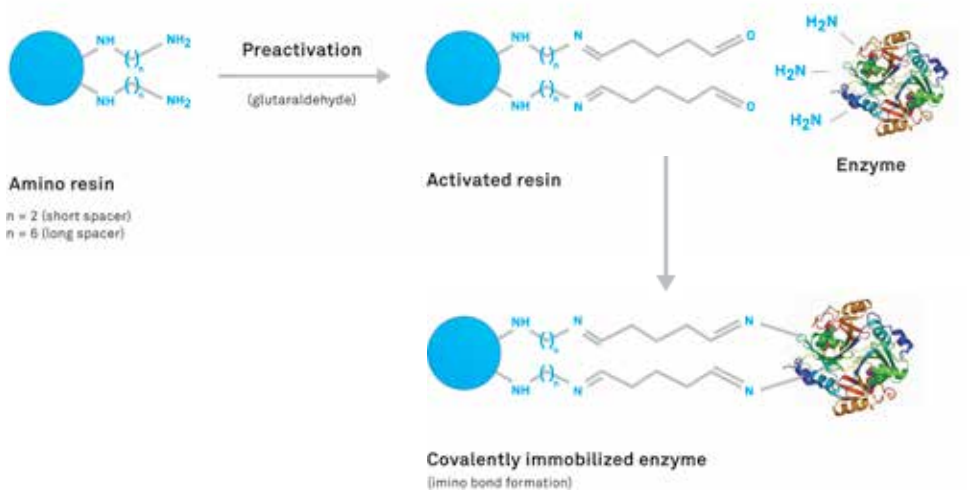
18. Sobczak M, Dębek C, Olędzka E, Kozłowski, R. Polymeric Systems of Antimicrobial Peptides—Strategies and Potential Applications. Molecules. 2013; 18(11): 14122-14137.

Enzyme Carrier Resins (ECR) - Purolite®

Enzyme Carrier Resins attach to enzymes and hold them in place throughout the intended catalyzed reaction. Immobilized enzymes are powerful tools to optimize processes in both operative and economic terms. Immobilized enzymes can be easily separated from reaction products and can be reused. Ease of separation increases the simplicity and efficiency of enzyme reactions, while the reusability of the enzyme decreases the costs of downstream processing. Polysciences' Enzyme Carrier Resins are based on amine functionalized, epoxy functionalized and adsorption technologies. Resins are available in F or M grade, which refers to particle size ranges of 150-300 µm and 300-700 µm respectively, and with different porosities and spacer lengths.

Amine Functionalized Resins

Amine functionalized resins can be pre-activated by glutaraldehyde and then used in the covalent immobilization of enzymes. The reaction of the aldehyde groups with enzyme amino groups quickly forms Schiff bases, which give stable multipoint covalent binding. The linkage can be made more stable through reduction with borohydrides.

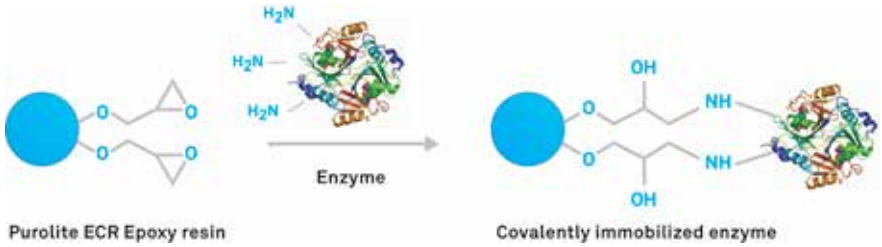


Cat. #	Description
50257	ECR8310F, Amino C2 Methacrylate ECR
50258	ECR8310M, Amino C2 Methacrylate ECR
50259	ECR8319F, Amino C2 Methacrylate ECR
50260	ECR8319M, Amino C2 Methacrylate ECR

Cat. #	Description
50261	ECR8405F, Amino C6 Methacrylate ECR
50262	ECR8405M, Amino C6 Methacrylate ECR
50263	ECR8417F, Amino C6 Methacrylate ECR
50264	ECR8417M, Amino C6 Methacrylate ECR

Epoxy Functionalized Resins

Epoxy Functionalized Resins allow multipoint covalent binding between the enzyme and resin, making them excellent Enzyme Carrier Resins. The high mechanical stability of Epoxy-Functionalized Resins allows the immobilized enzymes to be used in a stirred tank or bed reactor.



Cat. #	Description
50251	ECR4204F, Epoxy Methacrylate/Styrene ECR
50252	ECR4204M, Epoxy Methacrylate/Styrene ECR
50253	ECR8205F, Epoxy Methacrylate ECR

Cat. #	Description
50254	ECR8205M, Epoxy Methacrylate ECR
50255	ECR8214F, Epoxy Methacrylate ECR
50256	ECR8214M, Epoxy Methacrylate ECR

Resins for Enzyme Adsorption

Enzymes can also be immobilized by physical adsorption of enzyme protein onto the surface of water-insoluble carriers. This method is very gentle and causes little or no conformational change of the enzyme or destruction of its active center. Adsorption is particularly suitable for applications in organic solvents or hydrophobic media such as oils. Usually no reagents are required for adsorption, which is a major advantage over other methods.

Cat. #	Description
50245	ECR1090F, Macroporous Styrene ECR
50246	ECR1090M, Macroporous Styrene ECR
50247	ECR1091F, Macroporous Styrene ECR
50248	ECR1091M, Macroporous Styrene ECR

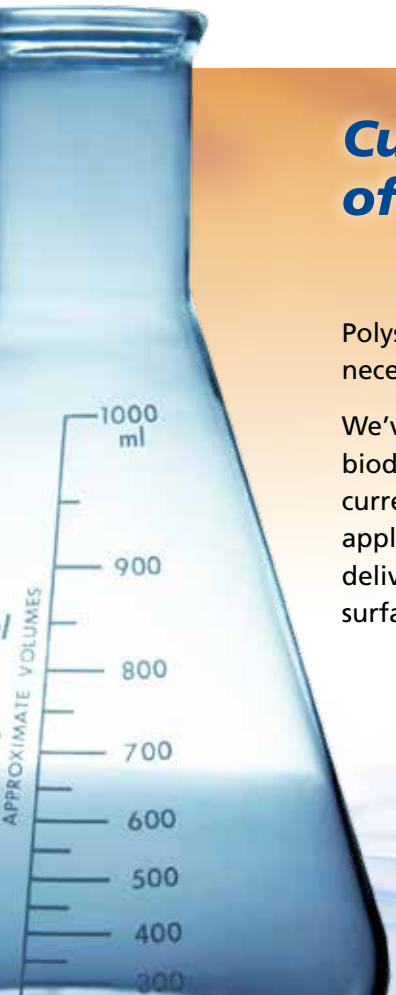
Cat. #	Description
50265	ECR8804F, Octadecyl Methacrylate ECR
50266	ECR8804M, Octadecyl Methacrylate ECR
50267	ECR8806F, Octadecyl Methacrylate ECR
50268	ECR8806M, Octadecyl Methacrylate ECR

Enzyme Carrier Resin Kits

Enzyme Carrier Resins are also available in kits that feature multiple products. For kit component details, please visit: polysciences.com/ecrkits

Cat. #	Description
50269	PolyLink Amine Linker Kit - F50
50270	PolyLink Epoxy Linker Kit - F50
50271	PolyLink Enzyme Adsorption Kit - F50
50272	PolyLink Lipase Linker Kit - F50

Cat. #	Description
50273	PolyLink Enzyme Linker Kit - F50
50275	PolyLink Amine Linker Kit with Columns and Reagents for Enzyme Immobilization
50279	PolyLink Epoxy Linker Kit with Columns and Reagents for Enzyme Immobilization



Custom Synthesis & Development Services of Biomaterials for Life Sciences Applications

your partner for collaborative innovation

Polysciences, Inc. delivers high-quality custom synthesis and contract manufacturing services necessary to accelerate your research and development programs.

We've partnered with innovative companies both large and small in the development of biodegradable polymers and microparticles for medical device and drug delivery applications. We currently develop and manufacture novel monomers and polymers under c-GMP for a range of applications including cardiovascular: device coatings and biodegradable microspheres for drug delivery, ophthalmic: specialty monomers, polymeric coatings and additives, bioassay systems: surface active microparticles and hydrogel polymers.

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