Enzo® Life Sciences

SPIN TRAPS & SPIN PROBES

High Purity & Stable Spin Traps

- Highest purity spin traps for *in vitro* and *in vivo* applications
- All products are quality tested by ESR spectroscopy
- No additional purification is required

DEPMPO

[5-(Diethoxyphosphoryl)-5-methyl-1-pyrroline-N-oxide]

ALX-430-093-M050	50 mg
ALX-430-093-M500	500 mg

PURITY: ≥99%. Most efficient spin trap for the *in vitro* and *in vivo* detection of O-, N-, S- and C-centered free radicals. Has a longer life-time than DMPO (Prod. No. ALX-430-090). Can distinguish between superoxide-dependent and independent mechanisms that lead to the hydroxyl radical. Less lipophilic (Kp=0.16) than DIPPMPO (Prod. No. ALX-430-119).

LIT: 5-(Diethoxyphosphoryl)-5-methyl-1-pyrroline N-oxide: a new efficient phosphorylated nitrone for the in vitro and in vivo spin trapping of oxygen-centered radicals: C. Frejaville, et al.; J. Med. Chem. **38,** 258 (1995) ▪ Quantitative measurement of superoxide generation and oxygen consumption from leukocytes using electron paramagnetic resonance spectroscopy: V. Roubaud, et al.; Anal. Biochem. **257,** 210 (1998) ▪ **For a comprehensive bibliography please visit our website.**

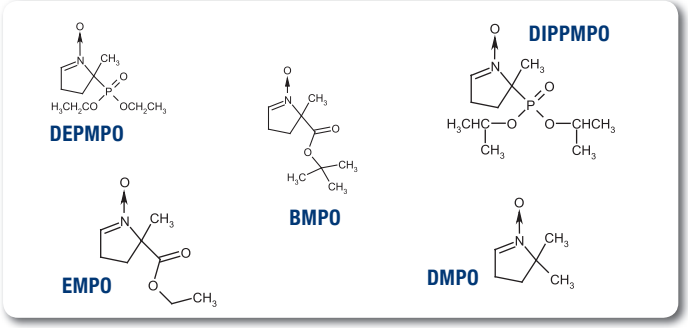
BMPO (high purity)

[5-tert-Butoxycarbonyl-5-methyl-1-pyrroline-N-oxide]

ALX-430-141-M010	10 mg
ALX-430-141-M050	50 mg

PURITY: ≥99%. Nitrone spin trap for the specific *in vivo* or *in vitro* detection of short-lived superoxide, hydroxyl and thiyl radicals. Forms distinguishable adducts which can be measured by EPR spectroscopy. Unlike with DMPO, the superoxide adduct does not decay into a hydroxyl adduct and it has a much longer half-life ($t_{1/2}$=23min). Low paramagnetic impurities.

LIT: Synthesis and biochemical applications of a solid cyclic nitrone spin trap: a relatively superior trap for detecting superoxide anions and glutathiyl radicals: H. Zhao, et al.; Free Radic. Biol. Med. **31,** 599 (2001) ▪ Spin traps: in vitro toxicity and stability of radical adducts: N. Khan, et al.; Free Radic. Biol. Med. **34,** 1473 (2003) ▪ **For a comprehensive bibliography please visit our website.**



DIPPMPO

[5-(Diisopropoxyphosphoryl)-5-methyl-1-pyrroline-N-oxide; 2-Diisopropylphosphono-2-methyl-3,4-dihydro-2H-pyrrole-1-oxide]

ALX-430-119-M050	50 mg
ALX-430-119-M500	500 mg

PURITY: ≥99%. Beside DEPMPO (Prod. No. ALX-430-093), most efficient spin trap for the *in vitro* and *in vivo* detection of O-, N-, S-, and C-centered free radicals. Has a longer life-time than DMPO (Prod. No. ALX-430-090). More lipophilic (Kp=2.1) than DEPMPO.

LIT: 5-(Diisopropoxyphosphoryl)-5-methyl-1-pyrroline-N-oxide, DIPPMPO, a crystalline analog of the nitrone DEPMPO: synthesis and spin trapping properties: F. Chalier & P. Tordo; J. C. S. Perkin Trans. II **2002,** 2110 ▪ **For a comprehensive bibliography please visit our website.**

DMPO (high purity)

[5,5-Dimethyl-1-pyrroline-N-oxide]

ALX-430-090-M500	500 mg
ALX-430-090-G001	1 g

PURITY: ≥99%. Low paramagnetic impurities. Cell permeable hydrophilic spin trap for both *in vivo* and *in vitro* studies of superoxide, O-, C-, S- and N- centered free radicals.

LIT: The spin trapping of superoxide and hydroxyl free radicals with DMPO (5,5-dimethylpyrroline-N-oxide): more about iron: G. R. Buettner; Free Radic. Res. Comm. **19** Suppl 1, S79 (1993) ▪ **For a comprehensive bibliography please visit our website.**

EMPO

[2-Ethoxycarbonyl-2-methyl-3,4-dihydro-2H-pyrrole-1-oxide]

ALX-430-098-M010	10 mg
ALX-430-098-M050	50 mg

PURITY: ≥95%. Beside DEPMPO (Prod. No. ALX-430-093), most efficient spin trap for the *in vitro* and *in vivo* detection of O-, N-, S-, and C-centered free radicals. Has a longer life-time than DMPO (Prod. No. ALX-430-090).

LIT: 2-ethoxycarbonyl-2-methyl-3,4-dihydro-2H-pyrrole-1-oxide: evaluation of the spin trapping properties: G. Olive, et al.; Free Radic. Biol. Med. **28,** 403 (2000) ▪ Detection of superoxide anion using an isotopically labeled nitrone spin trap: potential biological applications: H. Zhang, et al.; FEBS Lett. **473,** 58 (2000) ▪ **For a comprehensive bibliography please visit our website.**

Cyclic Hydroxylamine Spin Probes

Spin trapping is widely used for unambiguous detection of free radicals, such as superoxide radical. Unfortunately, EPR detection of the $O_2^{\bullet-}$ radicals in biological systems is limited by slow kinetics of $O_2^{\bullet-}$ spin trapping (~55 M-1s-1) and biodegradation of the radical adducts (reduction to EPR silent hydroxylamines and oxidation to secondary nitrones) [1]. It has been previously shown that PP-H is an effective scavenger of the $O_2^{\bullet-}$ [2], rapidly reacts with $O_2^{\bullet-}$ to form stable nitroxides with a much longer half-life than $O_2^{\bullet-}$ radical adducts. This is a distinct advantage of cyclic hydroxylamines over nitrone spin traps, which form relatively stable $O_2^{\bullet-}$ adducts in cell-free systems [3], but these adducts rapidly degrade in biological samples [4]. Cyclic hydroxylamines react with $O_2^{\bullet-}$ 100 times faster (~104 M-1s-1) than spin traps, which allow cyclic hydroxylamines to compete with cellular antioxidants and react with intracellular $O_2^{\bullet-}$. The lack of specificity of cyclic hydroxylamines can be overcome by use of superoxide dismutases or inhibitors of $O_2^{\bullet-}$ production by NADPH oxidase, uncoupled eNOS (NOS III), xanthine oxidase, apocynin, L-NAME, and oxypurinol [5-7]. Cationic, anionic and neutral spin probes with various lipophilicity and cell permeability allow site-specific $O_2^{\bullet-}$ detection with higher sensitivity than nitrone spin traps.

LIT: [1] Inhibition of radical adduct reduction and reoxidation of the corresponding hydroxylamines in in vivo spin trapping of carbon tetrachloride-derived radicals: M. Sentjurc & R. P. Mason; Free Radic. Biol. Med. **13,** 151 (1992) ▪ **[2]** Noninvasive diagnostic tool for inflammation-induced oxidative stress using electron spin resonance spectroscopy and an extracellular cyclic hydroxylamine: S. I. Dikalov, et al.; Arch. Biochem. Biophys. **402,** 218 (2002) ▪ **[3]** Detection and characterization of the product of hydroethidine and intracellular superoxide by HPLC and limitations of fluorescence: H. Zhao, et al.; PNAS **102,** 5727 (2005) ▪ **[4]** Oxygen radical generation and enzymatic properties of mitochondria in hypoxia/reoxygenation: K. Zwicker, et al.; Arzneimittelforschung **48,** 629 (1998) ▪ **[5]** Interactions of peroxynitrite with uric acid in the presence of ascorbate and thiols: implications for uncoupling endothelial nitric oxide synthase: N. Kuzkaya, et al.; Biochem. Pharmacol. **70,** 343 (2005) ▪ **[6]** C242T CYBA polymorphism of the NADPH oxidase is associated with reduced respiratory burst in human neutrophils: K. E. Wyche, et al.; Hypertension **43,** 1246 (2004) ▪ **[7]** Regulation of xanthine oxidoreductase protein expression by hydrogen peroxide and calcium: J. S. McNally, et al.; Arterioscler. Thromb. Vasc. Biol. **25,** 1623 (2005)

CAT1-H . HCl

ALX-430-131-M010	10 mg
ALX-430-131-M050	50 mg
ALX-430-131-M250	250 mg

Cyclic hydroxylamine spin probe for *in vivo*, intraperitoneal and intravenous injections. Lifetime of more than 4 hours in blood plasma, in cells and tissue. Allows quantitative measurements of extracellular $O_2^{\bullet-}$ and quantification of intracellular $O_2^{\bullet-}$ in cells and tissue samples and *in vivo* $O_2^{\bullet-}$ detection.

LIT: Role of extracellular superoxide dismutase in hypertension: M. C. Gongora, et al.; Hypertension **48,** 473 (2006)

CM-H . HCl

ALX-430-117-M010	10 mg
ALX-430-117-M050	50 mg
ALX-430-117-M250	250 mg

Analog of CP-H (Prod. No. ALX-430-078) with higher cell permeability and 3-fold better reactivity with superoxide. Has been used to study intracellular production of superoxide radicals in plasma, endothelial cells and isolated hearts.

LIT: Detection of superoxide with new cyclic hydroxylamine CMH in plasma, cells and isolated heart: B. Fink & S. Dikalov; Free Radic. Biol. Med. **33,** S366 (2002) ▪ Oscillatory shear stress stimulates endothelial production of O2- from p47phox-dependent NAD(P)H oxidases, leading to monocyte adhesion: J. Hwang, et al.; J. Biol. Chem. **278,** 47291 (2003) ▪ **For a comprehensive bibliography please visit our website.**

CP-H . HCl

ALX-430-078-M010	10 mg
ALX-430-078-M050	50 mg
ALX-430-078-M250	250 mg

Effective, cell permeable and non-toxic spin trap for the detection of superoxide radical and peroxynitrite, both *in vitro* and *in vivo*. Resistant to reduction by vitamin C and thiols.

LIT: Spin trapping of superoxide radicals and peroxynitrite by 1-hydroxy-3- carboxy-pyrrolidine and 1-hydroxy-2,2,6, 6-tetramethyl-4-oxo-piperidine and the stability of corresponding nitroxyl radicals towards biological reductants: S. Dikalov, et al.; BBRC **231,** 701 (1997) ▪ Quantification of superoxide radicals and peroxynitrite in vascular cells using oxidation of sterically hindered hydroxylamines and electron spin resonance: S. Dikalov, et al.; Nitric Oxide **1,** 423 (1997) ▪ **For a comprehensive bibliography please visit our website.**

PP-H . HCl

ALX-430-080-M010	10 mg
ALX-430-080-M050	50 mg

Effective, non-cell permeable and non-toxic analog of CP-H, for the detection of superoxide radical. Resistant against reduction of vitamin C. For the cell permeable analog see CP-H (Prod. No. ALX-430-078).

LIT: Detection of superoxide radicals and peroxynitrite by 1-hydroxy-4- phosphonooxy-2,2,6,6-tetramethylpiperidine: quantification of extracellular superoxide radicals formation: S. Dikalov, et al.; BBRC **248,** 211 (1998) ▪ A new approach for extracellular spin trapping of nitroglycerin-induced superoxide radicals both in vitro and in vivo: B. Fink, et al.; Free Radic. Biol. Med. **28,** 121 (2000) ▪ Noninvasive diagnostic tool for inflammation-induced oxidative stress using electron spin resonance spectroscopy and an extracellular cyclic hydroxylamine: S. I. Dikalov, et al.; Arch. Biochem. Biophys. **402,** 218 (2002)

TM-H . HCl

ALX-430-132-M010	10 mg
ALX-430-132-M050	50 mg
ALX-430-132-M250	250 mg

Cyclic hydroxylamine spin probe for *in vivo*, intraperitoneal and intravenous injections. Lifetime of more than 4 hours in blood plasma, in cells and tissue. Allows quantitative measurements of extracellular $O_2^{\bullet-}$ and quantification of intracellular $O_2^{\bullet-}$ in cells and tissue samples and *in vivo* $O_2^{\bullet-}$ detection.

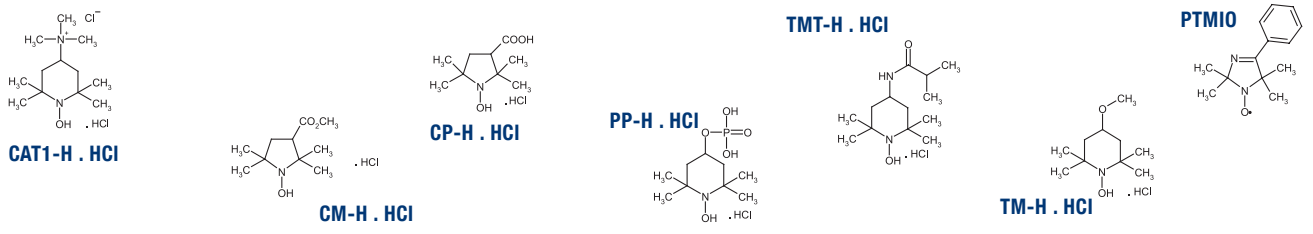
TMT-H . HCl

ALX-430-133-M010	10 mg
ALX-430-133-M050	50 mg
ALX-430-133-M250	250 mg

Cyclic hydroxylamine spin probe for *in vivo*, intraperitoneal and intravenous injections. Lifetime of more than 4 hours in blood plasma, in cells and tissue. Allows quantitative measurements of extracellular $O_2^{\bullet-}$ and quantification of intracellular $O_2^{\bullet-}$ in cells and tissue samples and *in vivo* detection.

PTMIO

ALX-430-145-M050	50 mg
ALX-430-145-M250	250 mg
ALX-430-145-G001	1 g



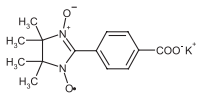
Nitric Oxide Spin-trapping Reagents

Carboxy-PTIO . K

[2-(4-Carboxyphenyl)-4,4,5,5-tetramethylimidazoline-1-oxyl-3-oxide . potassium salt]

ALX-430-001-M010	10 mg
ALX-430-001-M050	50 mg
ALX-430-001-M250	250 mg

Water soluble and stable nitric oxide radical scavenger that shows in chemical and biological systems antagonistic action against the free nitric oxide radical ($NO^{\bullet}$). Reacts with nitric oxide in a stoichometric manner.



LIT: Improved detection of nitric oxide radical (NO.) production in an activated macrophage culture with a radical scavenger, carboxy PTIO and Griess reagent: F. Amano & T. Noda; FEBS Lett. **368,** 425 (1995) ▪ Nitric oxide activation of guanylyl cyclase in cells revisited: B. Roy & J. Garthwaite; PNAS **103,** 12185 (2006) ▪ **For a comprehensive bibliography please visit our website.**

Diethyldithiocarbamic acid . Na . $3H_2O$ (high purity)

[DETC; Diethyldithiocarbamate]

ALX-400-003-G005	5 g
ALX-400-003-G025	25 g

Nitric oxide spin-trapping reagent. Thiol and iron chelator. Inhibits induction of macrophage nitric oxide synthase. Has been shown to be an inhibitor of the nuclear transcription factor κB (NF-κB).

LIT: On-line detection of nitric oxide formation in liquid aqueous phase by electron paramagnetic resonance spectroscopy: P. Mordvintcev, et al.; Anal. Biochem. **199,** 142 (1991) ▪ Dithiocarbamates as potent inhibitors of nuclear factor kappa B activation in intact cells: R. Schreck, et al.; J. Exp. Med. **175,** 1181 (1992) ▪ Diethyldithiocarbamate inhibits induction of macrophage NO synthase: A. Mülsch, et al.; FEBS Lett. **321,** 215 (1993) ▪ **For a comprehensive bibliography please visit our website.**

MGD . Na . H_2O

[N-(Dithiocarbamoyl)-N-methyl-D-glucamine]

ALX-400-014-M050	50 mg
ALX-400-014-M250	250 mg

Together with $FeSO_4$ MGD is a useful component for the formation of the MGD_2-Fe^{2+}complex, which is an excellent nitric oxide (NO) spin-trapping reagent. The MGD_2-Fe^{2+}complex is quite unstable, especially in the presence of dissolved oxygen. Thus, the complex should be used immediately after being made. Acidic conditions should be avoided because dithiocarbamate tends to decompose forming toxic carbon disulfide.

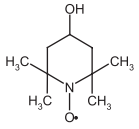
LIT: Sodium N-methyl-D-glucamine dithiocarbamate and cadmium intoxication: L. A. Shinobu, et al.; Acta Pharmacol. Toxicol. **54,** 189 (1984) ▪ In vivo spin trapping of nitric oxide in mice: A. Komarov, et al.; BBRC **195,** 1191 (1993) ▪ Spin trapping of nitric oxide produced in vivo in septic-shock mice: C. S. Lei & A. M. Komarov; FEBS Lett. **345,** 120 (1994) ▪ **For a comprehensive bibliography please visit our website.**

Antioxidant Spin Probe – A Key Standard Compound

TEMPOL

ALX-430-081-M250	250 mg
ALX-430-081-M500	500 mg
ALX-430-081-G001	1 g

Free radical scavenger useful for both *in vivo* and *in vitro* experiments.



LIT: Measurement of intracellular oxygen concentration using the spin label TEMPOL: P. D. Morse, 2nd & H. M. Swartz; Magn. Reson. Med. **2,** 114 (1985) ▪ Tempol, a stable free radical, is a novel murine radiation protector: S. M. Hahn, et al.; Cancer Res. **52,** 1750 (1992) ▪ **For a comprehensive bibliography please visit our website.**

Other Spin Traps & Spin Probes

CDMIO . K

ALX-430-089-M010	10 mg
ALX-430-089-M050	50 mg

DMPIO

ALX-430-088-M010	10 mg
ALX-430-088-M050	50 mg

MCPIO

ALX-430-083-M010	10 mg
ALX-430-083-M050	50 mg

POBN (high purity)

ALX-430-091-M500	500 mg
ALX-430-091-G001	1 g

PTIO

ALX-430-007-M025	25 mg
ALX-430-007-M100	100 mg

TEMPONE

ALX-430-079-M250	250 mg
ALX-430-079-M500	500 mg
ALX-430-079-G001	1 g

TEMPONE-H . HCl

ALX-430-071-M010	10 mg
ALX-430-071-M050	50 mg
ALX-430-071-M250	250 mg

TMIO

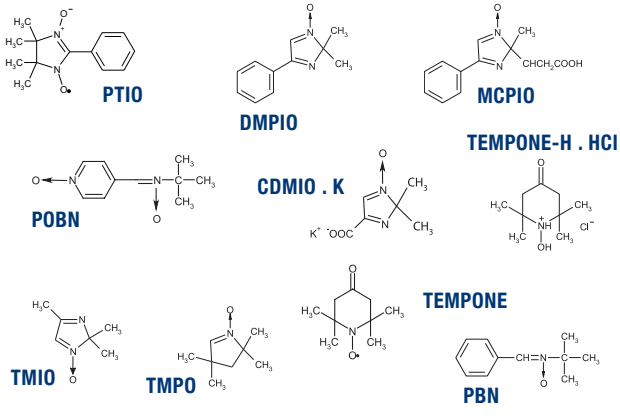
ALX-430-073-M050	50 mg
ALX-430-073-M250	250 mg
ALX-430-073-G001	1 g

TMPO

ALX-430-084-M100	100 mg
ALX-430-084-M500	500 mg

PBN [N-t-Butyl-α-phenylnitrone]

ALX-430-082-G001	1 g



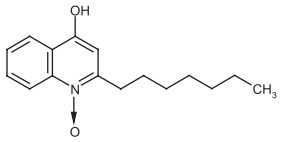
HQNO

[2-n-Heptyl-4-hydroxyquinoline N-oxide]

ALX-430-130-M010 10 mg

ALX-430-130-M050 50 mg

Naturally occurring antagonist of dihydrostreptomycin. Potent inhibitor of the respiratory chain binding to the mitochondrial cytochrome b protein. Inhibits NADH oxidase (NADH) and Na^+-dependent NADH-quinone reductase (NQR). Used in the investigation of the enzymatic pathways of elemental sulfur and thiosulfate disproportionation. Synthetic.



LIT: Inhibition of cytochrome system of heart muscle and of Staphylococcus aureus by 2-heptyl-4-hydroxyquinoline-N-oxide, an antagonist of dihydrostreptomycin: J. W. Lightbown & F. L. Jackson; Biochem. J. **58,** 15 (1954) ▪ Structure of a naturally occurring antagonist of dihydrostreptomycin: J. W. Cornforth & A. T. James; Biochem. J. **63,** 124 (1956) ▪ Binding of HQNO to beef-heart sub-mitochondrial particles: G. Van Ark & J. A. Berden; Biochim. Biophys. Acta **459,** 119 (1977) ▪ Inhibitor studies of a new antibiotic, korormicin, 2-n-heptyl-4-hydroxyquinoline N-oxide and Ag+ toward the Na^+-translocating NADH-quinone reductase from the marine Vibrio alginolyticus: Y. Nakayama, et al.; Biol. Pharm. Bull. **22,** 1064 (1999) ▪ FTIR spectroscopic evidence for the involvement of an acidic residue in quinone binding in cytochrome bd from Escherichia coli: J. Zhang, et al.; Biochemistry **41,** 4612 (2002) ▪ A stable isotope dilution assay for the quantification of the Pseudomonas quinolone signal in Pseudomonas aeruginosa cultures: F. Lepine, et al.; Biochim. Biophys. Acta **1622,** 36 (2003) ▪ **For a comprehensive bibliography please visit our website.**

HIGHLIGHT

Efficient Cysteine-specific Spin Labeling Compound

MTSSL

[(1-Oxyl-2,2,5,5-tetramethylpyrroline-3-methyl) methanethiosulfonate]

ALX-430-134-M010 10 mg

ALX-430-134-M050 50 mg

Highly reactive thiol-specific spin label. Has been used to label cysteine residues in proteins (site-directed labeling, SDS-labeling). Allows protein structure and protein dynamics determination as well as the study of protein-protein and protein-oligonucleotide interactions.

LIT: A novel reversible thiol-specific spin label: papain active site labeling and inhibition: L. J. Berliner, et al.; Anal. Biochem. **119,** 450 (1982) ▪ Pressure-induced thermostabilization of glutamate dehydrogenase from the hyperthermophile Pyrococcus furiosus: M. M. Sun, et al.; Protein Sci. **8,** 1056 (1999) ▪ Inter- and intra-molecular distances determined by EPR spectroscopy and site-directed spin labeling reveal protein-protein and protein-oligonucleotide interaction: H.J. Steinhoff; Biol. Chem. **385,** 913 (2004) ▪ Spontaneous refolding of the pore-forming Colicin A toxin upon membrane association as studied by X-band and W-band high-field electron paramagnetic resonance spectroscopy: A. Savitski, et al.; J. Phys. Chem. B **108,** 9541 (2004) ▪ Calcium structural transition of human cardiac troponin C in reconstituted muscle fibres as studied by site-directed spin labelling: M. Nakamura, et al.; J. Mol. Biol. **348,** 127 (2005) ▪ **For a comprehensive bibliography please visit our website.**

Fluorinated Spin Probe

FDMPO

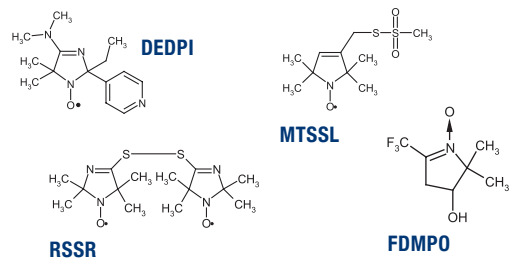
[4-Hydroxy-5,5-dimethyl-2-trifluoromethylpyrroline-1-oxide]

ALX-430-135-M010 10 mg

ALX-430-135-M050 50 mg

A fluorinated spin trap which allows 19F-NMR detection of free radical reactions. Greatly improved signal-to-noise ratio when compared to the 31P-sensitivity of the phosphorus-containing spin trap DEPMPO (Prod. No. ALX-430-093).

LIT: NMR spin trapping: detection of free radical reactions with a new fluorinated DMPO analog: V. V. Khramtsov, et al.; Free Radic. Biol. Med. **30,** 1099 (2001)



pH-sensitive Spin Probes

DEDPI

[4-(Dimethylamino)-2-ethyl-5,5-dimethyl-2-pyridine-4-yl-2,5-dihydro-1H-imidazol-1-oxyl]

ALX-430-120-M010 10 mg

ALX-430-120-M050 50 mg

pH-sensitive nitroxide for *in vivo* studies. The presence of two ionizable groups in the side-chains extends the range of pH sensitivity. The relatively high solubility in water and broad range of pH-sensitivity makes the probe particularly suitable for pH monitoring in stomach using non-invasive low-field EPR techniques.

LIT: Grignard reagent addition to 5-alkylamino-4H-imidazole 3-oxides: synthesis of new pH-sensitive spin probes : T. G. Shevelev, et al.; Synthesis **2003,** 871 ▪ Synthesis of the tetraethyl substituted pH-sensitive nitroxides of imidazole series with enhanced stability towards reduction: I. A. Kirilyuk, et al.; Org. Biomol. Chem. **2,** 1025 (2004) ▪ In vitro and in vivo measurement of pH and thiols by EPR-based techniques: V. V. Khramtsov, et al.; Antioxid. Redox Signal. **6,** 667 (2004) ▪ Nitroxides with two pK values--useful spin probes for pH monitoring within a broad range: I. A. Kirilyuk, et al.; Org. Biomol. Chem. **3,** 1269 (2005) ▪ Real-time monitoring of drug-induced changes in the stomach acidity of living rats using improved pH-sensitive nitroxides and low-field EPR techniques: D. I. Potapenko, et al.; J. Magn. Reson. **182,** 1 (2006)

Biradical Spin Label
For Monitoring of Intracellular Redox States of Thiols

RSSR

[bis-(2,2,5,5-Tetramethyl-3-imidazoline-1-oxyl-4-yl) disulfide, biradical]

ALX-430-102-M010 10 mg

ALX-430-102-M025 25 mg

ALX-430-102-M050 50 mg

Cell permeable supersensitive spin label (detection limit varies from 10nM to 100nM) for quick detection of reduced thiols using ESR. Allows following the reactions of sulfhydryl groups with RSSR to form thiol spin label adducts, for the monitoring of intracellular redox states of glutathione and other thiols.

LIT: Quantitative determination of SH groups in low- and high-molecular-weight compounds by an electron spin resonance method: V. V. Khramtsov, et al.; Anal. Biochem. **182,** 58 (1989) ▪ Quantitative determination of thiol groups in low and high molecular weight compounds by electron paramagnetic resonance: L. M. Weiner; Meth. Enzymol. **251,** 87 (1995) ▪ Quantitative determination and reversible modification of thiols using imidazolidine biradical disulfide label: V. V. Khramtsov, et al.; J. Biochem. Biophys. Methods **35,** 115 (1997) ▪ Use of imidazoline nitroxides in studies of chemical reactions. ESR measurements of the concentration and reactivity of protons, thiols and nitric oxide.: V. V. Khramtsov & L. B. Volodarsky; Spin labeling. The next Millennium. **145,** 109 (1998) ▪ Unique in vivo applications of spin traps: L. J. Berliner, et al.; Free Radic. Biol. Med. **30,** 489 (2001) ▪ In vitro and in vivo measurement of pH and thiols by EPR-based techniques: V. V. Khramtsov, et al.; Antioxid. Redox. Signal. **6,** 667 (2004)

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