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(54) POLYAMINES AND THEIR USE IN THERAPY

POLYAMINE UND IHRE THERAPEUTISCHE VERWENDUNG

POLYAMINES ET LEUR UTILISATION EN THERAPIE

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(73) Proprietor: Cellgate, Inc.
Redwood City, CA 94065 (US)

(72) Inventors:

- FRYDMAN, Benjamin
Madison, WI 53719 (US)
- MARTON, Laurence, J.
Madison, WI 53711 (US)
- REDDY, Venodhar, K.
Madison, WI 53717 (US)
- VALASINAS, Aldonia
Madison, WI 53719 (US)
- BLOKHIN, Andrei, V.
Madison, WI 53719 (US)
- BASU, Hirak, S.
Madison, WI 53717 (US)

(74) Representative: Roques, Sarah Elizabeth
J.A. Kemp & Co.
14 South Square
Gray's Inn
London WC1R 5JJ (GB)

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Remarks:

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Description

TECHNICAL FIELD

[0001] This invention relates to conformationally restricted polyamine analogs. This invention also relates to uses of these analogs in various medicinal applications, including suppressing cell proliferation and treating various diseases, including cancer.

BACKGROUND OF THE INVENTION

[0002] Natural polyamines, e.g., spermidine, norspermidine, homospermidine, 1,4-diaminobutane (putrescine), and spermine, are simple aliphatic amines produced in eukaryotic cells by a highly regulated metabolic apparatus. Polyamine levels and the activity of the polyamine biosynthetic apparatus tend to be high in dividing mammalian cells and low in quiescent cells. Populations of cells depleted of their polyamine content stop growing and may die. Janne et al. (1978) *A. Biochim. Biophys. Acta.* 473:241 and Pegg et al. (1982) *Am. J. Cell. Physiol.* 243:212-221. Polyamines are reviewed in Morgan (1998) *Methods. Mol. Biol.* 79:3-30.

[0003] Several lines of evidence indicate that polyamines, particularly spermidine, are required for cell proliferation: (i) they are found in greater amounts in growing than in non-growing tissues; (ii) prokaryotic and eukaryotic mutants deficient in polyamine biosynthesis are auxotrophic for polyamines; and (iii) inhibitors specific for polyamine biosynthesis also inhibit cell growth. Despite this evidence, the precise biological role of polyamines in cell proliferation is uncertain. It has been suggested that polyamines, by virtue of their charged nature under physiological conditions and their conformational flexibility, might serve to stabilize macromolecules, such as nucleic acids, by anion neutralization. Hafner et al. (1979) *J. Biol. Chem.* 254:12419; Pohjatipello et al. (1981) *Nature* 293:475; Mamont et al. (1978) *Biochem. Biophys. Res. Commun.* 81:58; Bloomfield et al. (1981) in *Polyamines in Biology and Medicine*, Morris et al., Eds., Dekker, New York, pp. 183-205.

[0004] A treatment approach has been devised based on the observation that increases in the polyamine pool suppress polyamine biosynthesis. Porter et al. (1988) in *Advances in Enzyme Regulation*, Pergamon Press, pp. 57-79. This approach attempts to identify polyamine analogs which down-regulate polyamine biosynthesis, but which do not perform the polyamine functions required for cell growth. BESPM, a N-bis(ethyl) analog of spermine, has served as a model compound for this strategy. BESPM rapidly suppresses polyamine biosynthetic enzymes, depletes natural polyamine pools, and inhibits cell growth *in vitro*. Porter et al. (1987) *Cancer Res.* 47:2821-2825. In addition, BESPM suppresses polyamine uptake (Byers et al. (1990) *J. Physiol.* 142:460-467; and Kramer et al. (1993) *J. Cell. Physiol.* 115:399-407), and thus minimizes the ability of tumor cells to meet their polyamine requirement by taking them up from their environment. BESPM and related analogs also induce the polyamine metabolizing enzyme spermidine/spermine N¹-acetyltransferase (SSAT) in certain human carcinoma cell lines.

[0005] BESPM and other polyamine analogs have been used, or proposed for use, in treating a large variety of diseases, including a number of different cancers. U.S. Patent No. 5,541,230 and WO 98/19624. Polyamine analogs demonstrated, for example, potent antitumor activity against several melanoma cell lines and tumors *in vitro* (Porter et al. (1991) *Cancer Res.* 51:3715-3720; Shappell et al. (1992) *Anticancer Res.* 12:1083-1090) and *in vivo* using tumors growing as xenografts in athymic mice (Bernacki et al. (1992) *Cancer Res.* 52:2424-2430; Porter et al. (1993) *Cancer Res.* 53:581-586). Potent antitumor activity of bis-ethyl spermine analogs has also been demonstrated for pancreatic cancer cell lines *in vitro* (Chang et al. (1992) *Cancer Chemother. Pharmacol.* 30:183-188) and *in vivo* (Chang et al. (1992) *Cancer Chemother. Pharmacol.* 30:179-182). Polyamine analogs have also been suggested for use in treating brain tumor therapy. Redgate et al. (1995) *J. Neurooncol.* 25:167-79. In addition to being useful against cancers of the brain, pancreas, and skin, polyamine analogs are also useful against cancers of the bladder, bone, breast, colon, digestive tract, lung and ovaries. Chang et al. (1993) *J. Urol.* 150:1293-7; Snyder et al. (1994) *Anticancer Res.* 14:347-56; Yuan et al. (1994) *Biochem. Pharmacol.* 47:1587-92; Davidson et al. (1993) *Cancer Res.* 53:2071-5; Berchtold et al. (1998) *J. Cell. Physiol.* 174:380-6; Porter et al. (1988) *Adv. Exp. Med. Biol.* 250:677-90; U.S. Patent Nos. 5,498,522 and 5,374,658. U.S. Patent No. 5,498,522 presents the use of spermidine/spermine N¹-acetyltransferase as a prognostic indicator of the efficacy of a polyamine analog against a malignant tumor.

[0006] Polyamine analogs have been used to treat cancer of the prostate. Mi et al. (1988) *Prostate* 34:51-60. Polyamines are produced in large amounts by the prostate gland and are abundant in the seminal fluid. Herr et al. (1984) *Cancer* 53:1294-8. Polyamine analogs such as BE-4444, BE-373, and BE-333 are particularly effective in inhibiting prostate xenograft tumors in nude mice. Zagaja et al. (1998) *Cancer Chem. Pharm.* 41:505-512; Jeffers et al. (1997) *Cancer Chem. Pharm.* 40:172-179; Feuerstein et al. (1991) *J. Cell. Biochem.* 46:37-47; and Marton et al. (1995) *Ann Rev. Pharm. Toxicol.* 35:55-91.

[0007] In addition to treating cancer, polyamines and their analogs have uses in treating a number of other diseases and in numerous other medicinal applications. Oxidized polyamines are believed to inhibit growth of parasites (Morgan

et al. (1983) *Adv.*

[0008] *Polyamine Res.* 4:169-174; Morgan et al. (1986) *Biochem. J.* 236:97-101; and U.S. Patent No. 4,935,449) and suppress infectivity of selected strains of bacteria and fungi (Bachrach et al. (1971) *J. Gen. Virol.* 13:415-22; Nishimura et al. (1971) *Biochim. Biophys. Acta* 247:153-6; and U.S. Patent No. 5,744,453). Polyamines such as spermine and polyamine analogs are also anti-viral and some are anti-insecticidal. Bachrach et al. (1972) *Appl. Microbiol.* 23:232-5; Bachrach et al. (1971) *J. Gen. Virol.* 11:1-9; U.S. Patent Nos. 5,021,409; 5,606,053; 5,608,061; 5,612,478; and 5,681,837. In addition, oxidized polyamines, such as spermine dialdehyde, for example, can be used in treatment of tissue grafts and other organs for transplantation. U.S. Patent No. 5,374,658. Polyamine analogs can also be used to treat neurodegenerative diseases and neurotrauma such as stroke. U.S. Patent Nos. 5,646,188 and 5,677,349. Polyamine analogs have also been reported to be useful as anti-psoratic agents, and in the treatment of epilepsy, Alzheimer's disease, and multiple sclerosis, as described in U.S. Patent No. 5,646,188. Polyamine analogs are also useful in treating and preventing restenosis. U.S. Patent No. 5,516,807. Polyamine analogs are also useful in treatment of gastric ulcers. Igarashi et al. (1990) *Biochem. Biophys. Res. Commun.* 172:715-20. In addition, polyamine derivatives including N-alkylthio polyamine derivatives, polyamine thiols, and polyamine phenols are useful as radioprotective agents for normal tissues during radiotherapy. U.S. Patent Nos. 5,217,964; 5,354,782; and 5,434,145.

[0009] Polyamines and their analogs can be administered alone or in conjunction with additional agents. For example, therapeutic polyamines can be administered along with 1,3-bis (2-chloroethyl)-1-nitrosourea. U.S. Patent No. 5,541,230. In treating cancer, polyamines can be co-administered with various cytotoxic agents, including antineoplastic vinca alkaloids, antibiotics, antimetabolites, and platinum coordination complexes. U.S. Patent No. 5,654,287.

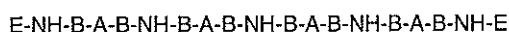
[0010] In addition to the various aforementioned medicinal uses, polyamines and polyamine analogs have a variety of industrial uses, including derivatization of silica U.S. Patent No. 5,763,388. Polyamines have also been used in conjunction with other clarification aids to treat wastewaters. U.S. Patent Nos. 5,413,719 and 5,707,532. The combination of aluminum chlorohydrate and a polyamine is an effective emulsion breaker for reverse (oil-in-water) emulsions, e.g. in a matrix comprising mostly oil as encountered in a crude oil desalter unit. U.S. Patent No. 5,607,574. Polyamines are also useful in deodorizing polysulfides. U.S. S.I.R. H1,633. Polyamines are also used in industrial dyes. U.S. Patent No. 5,672,202. Polyamines and hot water can also be used in manufacturing microcapsules. U.S. Patent No. 5,401,443. The antioxidative and metal-chelating effects of polyamines are reviewed in Lovaas (1997) *Adv. Pharmacol.* 38:119-149.

[0011] It would be advantageous to develop novel polyamine analogs for various uses, including disease treatment.

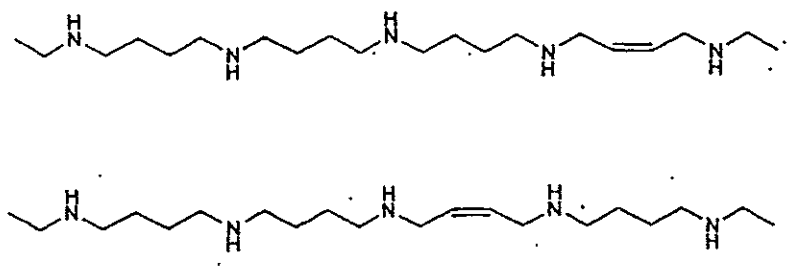
SUMMARY OF THE INVENTION

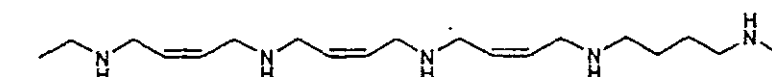
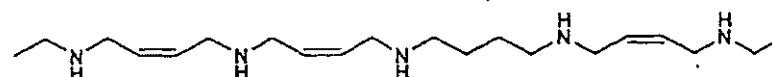
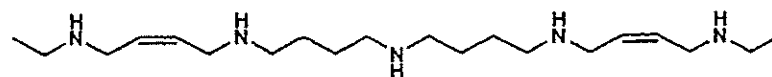
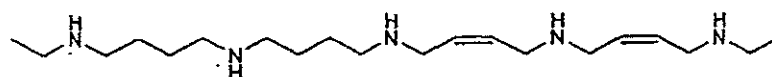
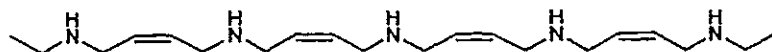
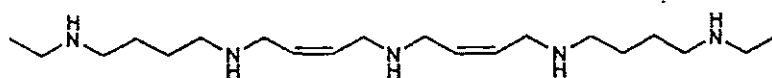
[0012] The invention provides novel polyamine analogs, compositions comprising a polyamine analog, and methods using the analogs and compositions. In one embodiment, the polyamine analog is conformationally restricted.

[0013] In another embodiment, the polyamine analog is selected from among compounds of the formula:

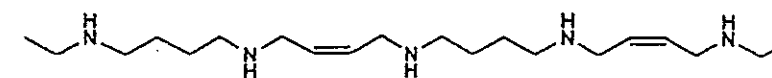


where A is independently selected from the group consisting of C₁-C₆ alkyl, C₂-C₆ alkenyl, C₂-C₆ alkynyl, C₃-C₆ cycloalkyl, C₃-C₆ aryl, and C₃-C₆ cycloalkenyl; B is independently selected from the group consisting of: a single bond, C₁-C₆ alkyl, and C₂-C₆ alkenyl; and E is independently selected from the group consisting of H, C₁-C₆ alkyl, C₂-C₆ alkenyl, C₂-C₆ alkynyl, C₃-C₆ cycloalkyl, C₃-C₆ aryl, and C₃-C₆ cycloalkenyl; with the proviso that either at least one A moiety is selected from the group consisting of C₂-C₆ alkenyl, C₂-C₆ alkynyl, C₃-C₆ cycloalkyl, C₃-C₆ aryl, and C₃-C₆ cycloalkenyl, or at least one B moiety is selected from the group consisting of C₂-C₆ alkenyl; and all salts and stereoisomers thereof. Specific embodiments of compounds of this type include



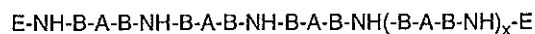


and

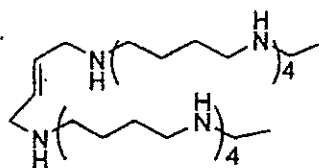


and all salts and stereoisomers thereof.

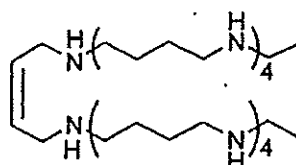
[0014] In another embodiment, the polyamine analog is selected from among the group of compounds of the formula:



wherein A is independently selected from the group consisting of C₈-C₆ alkyl, C₂-C₆ alkenyl, C₂-C₆ alkynyl, C₃-C₆ cycloalkyl, C₃-C₆ aryl, and C₃-C₆ cycloalkenyl; B is independently selected from the group consisting of a single bond, C₁-C₆ alkyl, and C₂-C₆ alkenyl; E is independently selected from the group consisting of H, C₁-C₆ alkyl, C₂-C₆ alkenyl, C₂-C₆ alkynyl, C₃-C₆ cycloalkyl, C₃-C₆ aryl, and C₃-C₆ cycloalkenyl; and x is an integer from 2 to 16; with the proviso that either at least one A moiety is selected from the group consisting of C₂-C₆ alkenyl, C₂-C₆ alkynyl, C₃-C₆ cycloalkyl, C₃-C₆ aryl, and C₃-C₆ cycloalkenyl, or at least one B moiety is selected from the group consisting of C₂-C₆ alkenyl; and all salts and stereoisomers thereof. Specific embodiments of compounds of this type include



and



and all salts and stereoisomers thereof.

[0015] The invention also provides methods of treating an indication comprising the step of administering to the individual an effective amount of a composition comprising a polyamine analog, preferably a conformationally restricted polyamine analog.

[0016] In one method, the indication is cancer. In various embodiments, the cancer affects cells of the bladder, blood, brain, breast, colon, digestive tract, lung, ovaries, pancreas, prostate gland, or skin. In other embodiments, the indication can also include, but is not limited to, Alzheimer's disease, epilepsy, multiple sclerosis, problems associated with tissue grafts and organ transplants, psoriasis, restenosis, stomach ulcers, or tissue overgrowth after surgery. In other embodiments, the indication is an infection or infestation of parasites, bacteria, fungi or insects. The polyamine analog is selected from the foregoing groups of compounds.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Fig. 1 is a graph depicting the *in vitro* effect of increasing concentrations of BE-4444 (○), SL-11121 (●), SL-11122 (□), SL-11123 (■), SL-11126 (Δ), SL-11127 (▲), SL-11128 (◇), SL-11129 (◆), SL-11130 (▽), SL-11133 (▼) on the survival of cultured human prostate cancer cells PC3.

ED₅₀ of BE-4444 = 0.6 μM, SL-11121 = 0.52 μM, SL-11122 >31.25 μM, SL-11123 >31.25 μM, SL-11126 = 0.2 μM, SL-11127 >31.25 μM, SL-11128 = 0.5 μM, SL-11129 = 1.7 μM, SL-11130 >31.25 μM, and SL-11133 >31.25 μM. Fig. 2 is a graph depicting the *in vitro* effect of increasing concentrations of BE-4444 (○), SL-11121 (●), SL-11122 (□), SL-11123 (■), SL-11126 (Δ), SL-11127 (▲), SL-11128 (◇), SL-11129 (◆), SL-11130 (▽), and SL-11133 (▼) on the survival of cultured human prostate cancer cells DU 145.

ED₅₀ of BE-4444 = 0.07 μM, SL-11121 = 0.08 μM, SL-11122 = 0.08 μM, SL-11123 = 0.51 μM, SL-11126 = 0.51 μM, SL-11127 = 0.22 μM, SL-11128 = 0.14 μM, SL-11129 = 0.32 μM, SL-11130 = 0.43 μM, and SL-11133 = 0.34 μM. Fig. 3 is a graph depicting the *in vitro* effect of increasing concentrations of BE-4444 (○), SL-11121 (●), SL-11122 (□), SL-11123 (■), SL-11126 (Δ), SL-11127 (▲), SL-11128 (◇), SL-11129 (◆), SL-11130 (▽), and SL-11133 (▼) on the survival of cultured human prostate cancer cells DUPRO.

ED₅₀ of BE-4444 = 0.2 μM, SL-11121 = 0.4 μM, SL-11122 = 0.56 μM, SL-11123 >31.25 μM, SL-11126 = 1.1 μM, SL-11127 = 1.3 μM, SL-11128 = 1.28 μM, SL-11129 >31.25 μM, SL-11130 >31.25 μM, and SL-11133 = 31.25 μM. Fig. 4 is a graph depicting the *in vitro* effect of increasing concentrations of BE-4444 (○), SL-11121 (●), SL-11122 (□), SL-11123 (■), SL-11126 (Δ), SL-11127 (▲), and SL-11128 (◇) on the survival of cultured human prostate cancer cells LNCAP.

ED₅₀ of BE-4444 = 0.14 μM, SL-11121 = 0.14 μM, SL-11126 = 0.55 μM and SL-11128 = 0.3 μM.

Fig. 5 is a graph depicting the *in vitro* effect of increasing concentrations of BE-4444 (○), SL-11121 (●), SL-11122 (□), SL-11123 (■), SL-11126 (Δ), SL-11127 (▲), and SL-11128 (◇) on the survival of cultured human colon cancer cells HT29.

ED₅₀ of BE-4444 = 0.5 μM, SL-11121 = 0.8 μM, SL-11122 = 0.8 μM, SL-11123 = 10.42 μM, SL-11126 = 1.5 μM,

SL-11127 = 2.91 μ M, and SL-11128 = 1.35 μ M.

Fig. 6 is a graph depicting the *in vitro* effect of increasing concentrations of BE-4444 (O), SL-11121 (*), SL-11122 (D), SL-11123 (■), and SL-11126 (Δ) on the survival of cultured human lung cancer cells A549.

ED₅₀ of BE-4444 >31.25 μ M, SL-11121 >31.25 μ M, SL-11122 >31.25 μ M, SL-11123 >31.25 μ M, and SL-11126 >31.25 μ M.

Fig. 7 is a graph depicting the *in vitro* effect of increasing concentrations of BE-4444 (O), SL-11121 (*), SL-11122 (□), SL-11123 (■), and SL-11126 (Δ) on the survival of cultured human breast cancer cells MCF7.

ED₅₀ of BE-4444 >31.25 μ M, SL-11121 = 17.0 μ M, SL-11122 >31.25 μ M, SL-11123 >31.25 μ M, and SL-11126 = 0.7 μ M.

Fig. 8 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11105 (*), SL-11124 (O), SL-11132 (■), and BE-333 (□) on the survival of cultured human prostate cancer cells PC3.

ED₅₀ of SL-11105 >31.25 μ M, SL-11124 >31.25 μ M, SL-11132 >31.25 μ M and BE-333 = 0.34 μ M.

Fig. 9 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11105 (*), SL-11124 (O), SL-11132 (■), and BE-333 (□) on the survival of cultured human prostate cancer cells DU145.

ED₅₀ of SL-11105 = 1.6 μ M, SL-11124 >31.25 μ M, SL-11132 = 0.015 μ M and BE-333 = 0.12 μ M.

Fig. 10 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11105 (*), SL-11124 (O), SL-11132 (■), and BE-333 (□) on the survival of cultured human prostate cancer cells DUPRO.

ED₅₀ of SL-11105 = 0.43 μ M, SL-11124 >31.25 μ M, SL-11132 >31.25 μ M and BE-333 = 0.9 μ M.

Fig. 11 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11105 (*), SL-11124 (O), and BE-333 (D) on the survival of cultured human colon cancer cells HT29.

ED₅₀ of SL-11105 = 25.2 μ M, SL-11124 >31.25 μ M, and BE-333 = 0.3 μ M.

Fig. 12 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11105 (*), SL-11124 (O), and BE-333 (D) on the survival of cultured human lung cancer cells A549.

ED₅₀ of SL-11105 = 0.43 μ M, SL-11124 >31.25 μ M, and BE-333 = 0.3 μ M.

Fig. 13 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11105 (*), SL-11124 (O), and BE-333 (□) on the survival of cultured human breast cancer cells MCF7.

ED₅₀ of SL-11105 >31.25 μ M, SL-11124 >31.25 μ M, and BE-333 = 3.7 μ M.

Fig. 14 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11105 (*) and BE-333 (□) on the survival of cultured human brain tumor cells U251 MG NCI.

ED₅₀ of SL-11105 = 25.9 μ M, and BE-333 = 0.23 μ M.

Fig. 15A is a graph depicting the *in vitro* effect of increasing concentrations of SL-11093 (*), SL-11098 (O), SL-11099 (■), SL-11100 (D), SL-11101 (▲), SL-11102 (Δ), and BE-444 (◆) on the survival of cultured human prostate cancer cells PC3.

ED₅₀ of SL-11093 = 1.6 μ M, SL-11098 = 1.4 μ M, SL-11099 = 2.5 μ M, SL-11100 = 4.7 μ M, SL-11101 = 7.7 μ M, SL-11102 >31.25 μ M and BE-444 = 0.7 μ M.

Fig. 15B is a graph depicting the *in vitro* effect of increasing concentrations of SL-11103 (*), SL-11104 (O), SL-11108 (■), SL-11114 (□), SL-11118 (▲), SL-11119 (Δ), and BE-444 (◆) on the survival of cultured human prostate cancer cells PC3.

ED₅₀ of SL-11103 >31.25 μ M, SL-11104 >31.25 μ M, SL-11108 = 2.2 μ M, SL-11114 = 0.7 μ M, SL-11118 = 1.65 μ M, SL-11119 >31.25 μ M and BE-444 = 0.7 μ M.

Fig. 16A is a graph depicting the *in vitro* effect of increasing concentrations of SL-11093 (*), SL-11098 (O), SL-11099 (■), SL-11100 (D), SL-11101 (▲), SL-11102 (Δ), and BE-444 (◆) on the survival of cultured human prostate cancer cells DU145.

ED₅₀ of SL-11093 = 0.016 μ M, SL-11098 = 0.02 μ M, SL-11099 = 0.014 μ M, SL-11100 = 0.021 μ M, SL-11101 = 0.22 μ M, SL-11102 = 0.03 μ M and BE-444 = 0.03 μ M.

Fig. 16B is a graph depicting the *in vitro* effect of increasing concentrations of SL-11103 (*), SL-11104 (O), SL-11108 (■), SL-11114 (□), SL-11118 (▲), SL-11119 (Δ), and BE-444 (◆) on the survival of cultured human prostate cancer cells DU145.

ED₅₀ of SL-11103 = 2.8 μ M, SL-11104 = 9.4 μ M, SL-11108 = 0.13 μ M, SL-11114 = 0.13 μ M, SL-11118 = 0.05 μ M, SL-11119 = 0.08 μ M and BE-444 = 0.03 μ M.

Fig. 17A is a graph depicting the *in vitro* effect of increasing concentrations of SL-11099 (■), SL-11100 (□), SL-11101 (▲), SL-11102 (Δ), and BE-444 (◆) on the survival of cultured human prostate cancer cells DUPRO.

ED₅₀ of SL-11099 = 0.08 μ M, SL-11100 = 0.3 μ M, SL-11101 = 0.85 μ M, SL-11102 = 0.15 μ M and BE-444 = 0.2 μ M.

Fig. 17B is a graph depicting the *in vitro* effect of increasing concentrations of SL-11108 (■), SL-11114 (□), SL-11118 (▲), SL-11119 (Δ), and BE-444 (◆) on the survival of cultured human prostate cancer cells DUPRO.

ED₅₀ of SL-11108 = 0.98 μ M, SL-11114 = 0.64 μ M, SL-11118 = 0.25 μ M, SL-11119 = 0.44 μ M and BE-444 = 0.2 μ M.

Fig. 18A is a graph depicting the *in vitro* effect of increasing concentrations of SL-11093 (*), SL-11098 (O), SL-11099 (■), SL-11100 (D), and BE-444 (◆) on the survival of cultured human prostate cancer cells LNCAP.

ED₅₀ of SL-11093 = 0.21 μ M, SL-11098 = 0.17 μ M, SL-11099 = 0.21 μ M, SL-11100 = 0.7 μ M, and BE-444 = 0.1 μ M.
Fig. 18B is a graph depicting the *in vitro* effect of increasing concentrations of SL-11108 (■), SL-11114 (D), SL-11118 (▲), and BE-444 (◆) on the survival of cultured human prostate cancer cells LNCAP.

ED₅₀ of SL-11108 = 7.7 μ M, SL-11114 = 3.0 μ M, SL-11118 = 0.21 μ M, and BE-444 = 0.1 μ M.

Fig. 19A is a graph depicting the *in vitro* effect of increasing concentrations of SL-11093 (●), SL-11098 (○), SL-11099 (■), SL-11100 (D), SL-11101 (▲), SL-11102 (Δ), and BE-444 (◆) on the survival of cultured human colon cancer cells HT29.

ED₅₀ of SL-11093 = 0.4 μ M, SL-11098 = 0.4 μ M, SL-11099 = 1.0 μ M, SL-11100 = 2.0 μ M, SL-11101 = 5.2 μ M, SL-11102 = 0.73 μ M and BE-444 = 0.93 μ M.

Fig. 19B is a graph depicting the *in vitro* effect of increasing concentrations of SL-11103 (●), SL-11104 (○), SL-11108 (■), SL-11114 (□), SL-11118 (▲), SL-11119 (Δ), and BE-444 (◆) on the survival of cultured human colon cancer cells HT29.

ED₅₀ of SL-11103 = 29.4 μ M, SL-11104 = 25.8 μ M, SL-11108 = 2.0 μ M, SL-11114 = 3.6 μ M, SL-11118 = 0.98 μ M, SL-11119 = 0.97 μ M and BE-444 = 0.93 μ M.

Fig. 20A is a graph depicting the *in vitro* effect of increasing concentrations of SL-11093 (●), SL-11098 (○), SL-11099 (■), SL-11100 (□), SL-11101 (▲), SL-11102 (Δ), and BE-444 (◆) on the survival of cultured human lung cancer cells A549.

ED₅₀ of SL-11093 = 0.26 μ M, SL-11098 = 0.29 μ M, SL-11099 = 0.51 μ M, SL-11100 = 0.65 μ M, SL-11101 = 2.2 μ M, SL-11102 = 0.15 μ M and BE-444 = 0.15 μ M.

Fig. 20B is a graph depicting the *in vitro* effect of increasing concentrations of SL-11103 (●), SL-11104 (○), SL-11108 (■), SL-11114 (□), SL-11118 (▲), and BE-444 (◆) on the survival of cultured human lung cancer cells A549.

ED₅₀ of SL-11103 = 12.4 μ M, SL-11104 >31.25 μ M, SL-11108 >31.25 μ M, SL-11114 >31.25 μ M, SL-11118 = 0.214 μ M and BE-444 = 0.15 μ M.

Fig. 21A is a graph depicting the *in vitro* effect of increasing concentrations of SL-11093 (●), SL-11098 (○), SL-11099 (■), SL-11100 (□), SL-11101 (▲), SL-11102 (Δ), and BE-444 (◆) on the survival of cultured human breast cancer cells MCF7.

ED₅₀ of SL-11093 = 0.66 μ M, SL-11098 >31.25 μ M, SL-11099 = 26.3 μ M, SL-11100 >31.25 μ M, SL-11101 >31.25 μ M, SL-11102 >31.25 μ M and BE-444 >31.25 μ M.

Fig. 21B is a graph depicting the *in vitro* effect of increasing concentrations of SL-11103 (●), SL-11104 (○), SL-11108 (■), and BE-444 (◆) on the survival of cultured human breast cancer cells MCF7.

ED₅₀ of SL-11103 >31.25 μ M, SL-11104 >31.25 μ M, SL-11108 >31.25 μ M, and BE-444 >31.25 μ M.

Fig. 22A is a graph depicting the *in vitro* effect of increasing concentrations of SL-11093 (●), SL-11098 (○), SL-11099 (■), SL-11100 (□), SL-11101 (▲), SL-11102 (Δ), and BE-444 (◆) on the survival of cultured human brain tumor cells U251 MG NCI.

ED₅₀ of SL-11093 = 0.07 μ M, SL-11098 = 0.1 μ M, SL-11099 = 0.11 μ M, SL-11100 = 0.22 μ M, SL-11101 = 1.7 μ M, SL-11102 = 0.15 μ M and BE-444 = 0.2 μ M.

Fig. 22B is a graph depicting the *in vitro* effect of increasing concentrations of SL-11103 (●), SL-11104 (○), SL-11108 (■), and BE-444 (◆) on the survival of cultured human brain tumor cells U251 MG NCI.

ED₅₀ of SL-11103 = 9.5 μ M, SL-11104 = 14.71 μ M, SL-11108 = 2.0 μ M, and BE-444 = 0.2 μ M.

Fig. 23 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11091 (●), SL-11094 (○), and BE-343 (■) on the survival of cultured human prostate cancer cells PC3.

ED₅₀ of SL-11091 >31.25 μ M, SL-11094 >31.25 μ M, and BE-343 = 0.24 μ M.

Fig. 24 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11091 (●), SL-11094 (○), and BE-343 (■) on the survival of cultured human prostate cancer cells DU 145.

ED₅₀ of SL-11091 = 4.33 μ M, SL-11094 = 15.4 μ M, and BE-343 = 0.044 μ M.

Fig. 25 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11091 (●), SL-11094 (○), and BE-343 (■) on the survival of cultured human colon cancer cells HT29.

ED₅₀ of SL-11091 >31.25 μ M, SL-11094 = 28.8 μ M, and BE-343 = 0.6 μ M.

Fig. 26 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11091 (●), SL-11094 (○), and BE-343 (■) on the survival of cultured human lung cancer cells A549.

ED₅₀ of SL-11091 >31.25 μ M, SL-11094 >31.25 μ M, and BE-343 = 0.2 μ M.

Fig. 27 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11091 (●), SL-11094 (○), and BE-343 (◆) on the survival of cultured human breast cancer cells MCF7.

ED₅₀ of SL-11091 >31.25 μ M, SL-11094 >31.25 μ M, and BE-343 = 0.5 μ M.

Fig. 28 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11091 (●), SL-11094 (○), and BE-343 (■) on the survival of cultured human brain tumor cells U251 MG NCI.

ED₅₀ of SL-11091 >31.25 μ M, SL-11094 >31.25 μ M, and BE-343 = 0.14 μ M.

Fig. 29 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11141 (●), SL-11144 (□), SL-11150

(■) on the survival of cultured human prostate cancer cells PC3.

ED₅₀ of SL-11141 > 31.25 μM, SL-11144 = 0.3 μM, and SL-11150 = 0.5 μM.

Fig. 30 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11141 (●), SL-11144 (□), SL-11150

(■) on the survival of cultured human prostate cancer cells DU145.

ED₅₀ of SL-11141 = 0.13 μM, SL-11144 = 0.1 μM, and SL-11150 = 0.11 μM.

Fig. 31 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11141 (●), SL-11144 (□), SL-11150

(■) on the survival of cultured human prostate cancer cells DUPRO.

ED₅₀ of SL-11141 = 0.71 μM, SL-11144 = 0.36 μM, and SL-11150 = 0.48 μM.

Fig. 32 is a graph depicting the *in vitro* effect of increasing concentrations of SL-11141 (●), SL-11144 (□), SL-11150

(■) on the survival of cultured human prostate cancer cells LNCAP.

ED₅₀ of SL-11141 = 0.07 μM, SL-11144 = 0.20 μM, and SL-11150 = 0.23 μM.

Fig. 33 illustrates synthetic methodology used to prepare the compounds of the invention.

Fig. 34 illustrates additional synthetic methodology used to prepare the compounds of the invention.

Fig. 35 illustrates additional synthetic methodology used to prepare the compounds of the invention.

Fig. 36 illustrates additional synthetic methodology used to prepare the compounds of the invention.

Fig. 37 illustrates additional synthetic methodology used to prepare the compounds of the invention.

Fig. 38 illustrates additional synthetic methodology used to prepare the compounds of the invention.

MODES FOR CARRYING OUT THE INVENTION

[0018] The present invention encompasses novel conformationally restricted polyamine analogs and compositions comprising these compounds. These analogs are useful as anti-proliferatives for suppressing cell proliferation. The analogs find use in treatment of various diseases, including use as anti-cancer agents in the treatment of various cancers. The analogs are also useful as anti-microbial agents. Novel polyamine analogs include the compounds shown in the synthetic schemes (Figures 33-38) and Table 1.

Definitions

[0019] By "polyamine analog" is meant an organic cation structurally similar but non-identical to polyamines such as spermine and/or spermidine and their precursor, diamine putrescine. By a "polyamine", a term well-understood in the art, is meant any of a group of aliphatic, straight-chain amines derived biosynthetically from amino acids; polyamines are reviewed in Marton et al. (1995) *Ann. Rev. Pharm. Toxicol.* 35:55-91. Polyamine analogs can be branched or unbranched. Polyamine analogs include, but are not limited to, BE-4444 [1,19-bis(ethylamino)-5,10,15-triazanonadecane]; BE-333 [N1,N11-diethylnorspermine; DENSPM; 1,11-bis(ethylamino)-4,8-diazaundecane; thermine; Warner-Parke-Davis]; BE-33 [N1,N7-bis(ethyl) norspermidine]; BE-34 [N1,N8-bis(ethyl) spermidine]; BE-44 [N1,N9-bis(ethyl) homospermidine]; BE-343 [N1,N12-bis(ethyl) spermine; diethylspermine-N1-N12; DESPM]; BE-373 [N,N'-bis(3-ethylamino) propyl]-1,7-heptane diamine, Merrell-Dow]; BE-444 [N1,N14-bis(ethyl) homospermine; diethylhomospermine-N1-N14]; BE-3443 [1,17-bis(ethylamino)-4,9,14-triazaheptadecane]; and BE-4334 [1,17-bis(ethylamino)-5,9,13-triazaheptadecane]; 1,12-Me₂-SPM [1,12-dimethylspermine]. Additional polyamine analogs are disclosed in International Patent Application WO 98/17624 and U.S. Patent No. 5,889,061. Various novel polyamine analogs are illustrated in the synthetic schemes in Figs. 33-38, and Table 1.

[0020] By "conformationally restricted" is meant that, in a polyamine analog, at least two amino groups in the molecule are locked or limited in spatial configuration relative to each other. The amino groups within the molecule may be primary, secondary, tertiary, or quaternary, and are preferably primary or secondary amino groups. The relative movement of two amino groups can be restricted, for example, by incorporation of a cyclic or unsaturated moiety between them (exemplified, but not limited to, a ring, such as a three-carbon ring, four-carbon ring, five-carbon ring, six-carbon ring, or a double or triple bond, such as a double or triple carbon bond). Groups restricting conformational flexibility by means of steric hindrance, yet structurally favorable to the anti-proliferative, anti-cancer, or anti-microbial effects, can also be used according to the invention. A "conformationally restricted" polyamine analog can comprise at least two amino groups which are conformationally restricted relative to each other, but can also further comprise amino groups which are not conformationally restricted relative to each other. Flexible molecules such as spermine and BE-444 can have a myriad of conformations and are therefore not conformationally restricted. Conformationally restricted polyamine analogs include, but are not limited to, the compounds listed in Table 1 and illustrated in Figures 33-38.

[0021] An "indication" includes any symptom or the like which points out a suitable remedy or treatment or which shows the presence of a disease or other unhealthful condition. As used herein, an "indication" also includes a "disease" itself, where a disease is a condition of an organ, part, structure or system of the body in which there is incorrect function resulting from the effect(s) of heredity, infection, diet and/or environment, and/or other causes. The indication can include cancer. By "cancer" is meant the abnormal presence of cells which exhibit relatively autonomous growth, so that they

exhibit an aberrant growth phenotype characterized by a significant loss of cell proliferation control. Cancerous cells can be benign or malignant. In various embodiments, the cancer affects cells of the bladder, blood, brain, breast, colon, digestive tract, lung, ovaries, pancreas, prostate gland, or skin. In other embodiments, the indication can also include, but is not limited to, Alzheimer's disease, epilepsy, multiple sclerosis, problems associated with tissue grafts and organ transplants, psoriasis, restenosis, stomach ulcers, or tissue overgrowth after surgery. In other embodiments, the indication is an infection or infestation of parasites, bacteria, fungi or insects.

[0022] An "individual" is a vertebrate, preferably a mammal, more preferably a human. Mammals include, but are not limited to, farm animals, sport animals, rodents, primates, and pets. Preferably, the individual is known or suspected to be afflicted by cancer or another disease treatable with a polyamine analog.

[0023] An "effective amount" or "therapeutic amount" is an amount sufficient to effect beneficial or desired clinical results. An effective amount can be administered in one or more administrations. For purposes of this invention, an effective amount of a polyamine analog is an amount that is sufficient to palliate, ameliorate, stabilize, reverse, slow or delay the progression of the disease state. A therapeutic amount of a polyamine of the present invention is an amount sufficient to inhibit proliferation of diseased cells. A polyamine analog is considered to be an effective anti-tumor or anti-cancer agent if it is effective against at least one type of cancer cell line, even if it is not effective against a different cell line.

[0024] As used herein, "treatment" is an approach for obtaining beneficial or desired clinical results. For purposes of this invention, beneficial or desired clinical results include, but are not limited to, alleviation of symptoms, diminishment of extent of disease, stabilization (i.e., not worsening) of state of disease, prevention of spread (i.e., metastasis) of disease, delay or slowing of disease progression, amelioration or palliation of the disease state, improvement in quality of enjoyment of life, and remission (whether partial or total), whether detectable or undetectable. "Treatment" can also mean prolonging survival as compared to expected survival if not receiving treatment.

[0025] "Palliating" a disease means that the extent and/or undesirable clinical manifestations of a disease state are lessened and/or time course of the progression is slowed or lengthened, as compared to not administering polyamine analogs of the present invention. Preferred polyamine analogs for methods of treating and palliating a disease include the compounds illustrated in Table 1.

Polyamine analogs of the present invention

[0026] Novel polyamine analogs can be first designed based on current knowledge of polyamines and their analogs. Without wishing to be bound by any particular theory explaining polyamine analog toxicity, the inventors suggest that relevant knowledge includes that related to polyamine interaction with DNA and ability to induce structural changes in nucleic acids. Feuerstein et al. (1991); Gosule et al. (1978) *J Mol. Biol.* 121:311-326; Behe et al. (1981) *Proc. Natl. Acad. Sci. USA* 78:1619-23; Jain et al. (1989) *Biochem.* 28:2360-2364; and Basu et al. (1990) *Biochem. J.* 269:329-334. Alternatively, a novel polyamine analog can be designed based on its likely ability to inhibit cell growth by suppressing natural polyamine synthesis or depleting the intracellular natural polyamine pool. Porter et al. (1988) in *Advances in Enzyme Regulation*, Pergamon Press, pp. 57-79. Preferably, the novel polyamine analog is conformationally restricted. In the next step, the polyamine analog is tested *in vitro* for efficacy in inhibiting proliferation of diseased cells, such as tumor cells. If the polyamine analog passes this test, it can then be tested in animals, such as nude mice with cancer xenografts. If the compound is found to be efficacious, testing can then proceed to human trials.

[0027] The present invention encompasses novel polyamine analogs, such as those shown in Figs. 33-38 and Table 1. Polyamine analogs of the present invention are conformationally restricted. Conformation is a determinant of the spatial arrangement of the pharmacophore or functional groups which interact with receptor binding sites. The latter prefer specific ligand conformations or a specific distribution of conformations. A flexible molecule such as spermine or BE-4444 can have a myriad of conformations. The conformer that binds to the macromolecule (e.g., DNA or RNA) may not necessarily be the one with the lowest energy as determined by spectroscopic methods or theoretically by molecular mechanics calculations. The binding energy of the polyamine binding to the nucleic acid may be overcome with formation of an unstable conformer. Conversely, in the presence of a conformationally rigid analog of a flexible molecule, the host macromolecule might change its overall conformation or the distances from one strand to the other. Hydrogen bonding is the main binding force of either spermine or spermidine associating with the helical region of a tRNA, and very likely also with DNA. Frydman et al. (1992) *Proc. Natl. Acad. Sci. USA* 89:9186-9191; and Fernandez et al. (1994) *Cell Mol. Biol.* 40: 933-944. The secondary amino groups present in the linear spermine analogs BE-343, BE-444, and BE-4444 are the groups most directly involved in the formation of the hydrogen bonds with the paired bases of tRNA. Therefore, these amino groups that usually flank the central four-carbon or three-carbon segment of the polyamine analog can be considered as the pharmacophore of the polyamine analog. When the nitrogens are separated by only a two-carbon segment they are not protonated at pH 7.4 and hence they do not form hydrogen bonds. If these amino groups are locked into various configurations by the incorporation of cyclic or unsaturated moieties into the polyamine analog molecule, a conformationally rigid analog is obtained. When such analogs bind to DNA or tRNA, they will very likely induce a change in the conformation of the nucleic acid strands or loops that may differ from the conformational changes

induced by the natural polyamines. A series of conformationally restricted analogs of *bis*-ethyl-spermine that exhibited cytotoxic activities are illustrated in Table 1 and described below.

Polyamine analogs and inhibition of cell growth

[0028] Polyamine analogs of the present invention are likely to be useful for treatment of a variety of diseases, including cancer, Alzheimer's disease, epilepsy, multiple sclerosis, problems associated with tissue grafts and organ transplants, psoriasis, restenosis, stomach ulcers, or tissue overgrowth after surgery, or an infection or infestation of parasites, bacteria, fungi or insects. In order to evaluate the efficacy of a particular novel polyamine for a particular medicinal application, the compounds can be first tested against appropriately chosen test cells *in vitro*. In a non-limiting example, polyamine analogs can be tested against tumor cells, for example, prostate tumor cells. On the basis of the unique nature of polyamine metabolism in the prostate gland, exemplary experiments can utilize cell lines capable of growing in culture as well as *in vivo* in athymic nude mice, such as LNCaP. Horoszewicz et al. (1983) *Cancer Res.* 43:1809-1818. Culturing and treatment of carcinoma cell lines, cell cycle and apoptosis determinations based on flow cytometry; enzyme assays including ODC, SAMDC and SSAT activities; and high pressure liquid chromatography detection and quantitation of natural polyamines and polyamine analogs are described in the art, for example, Mi et al. (1998) *Prostate* 34:51-60; Kramer et al. (1997) *Cancer Res.* 57:5521-27; and Kramer et al. (1995) *J Biol. Chem.* 270:2124-2132. Evaluations can also be made of the effects of the novel polyamine analog on cell growth and polyamine-related metabolism. Analysis begins with IC₅₀ determinations based on dose-response curves ranging from 0.1 to 1000 μ M performed at 72 hr. From these studies, conditions can be defined which produce about 50% growth inhibition and used to: (a) follow time-dependence of growth inhibition for up to 6 days, with particular attention to decreases in cell number, which may indicate drug-induced cell death; (b) characterize analog effects on cell cycle progression and apoptosis using flow cytometry (analysis to be performed on attached and detached cells); (c) examine analog effects on polyamine metabolic parameters, including the biosynthetic enzymes ODC, SAMDC, the catabolic enzyme SSAT and polyamine pools themselves. Analog effects can be normalized to intracellular concentrations (by HPLC analysis), which also provide an indication of their relative ability to penetrate cells. Marked differences in analog uptake can be further characterized by studying analog ability to utilize and regulate the polyamine transporter, as assessed by competition studies using radiolabeled spermidine, as previously described in Mi et al. (1998).

In vivo testing of polyamine analogs

[0029] Analogs found to have potent or mechanism-based anti-proliferative activity *in vitro* towards cultured carcinoma cells can be evaluated in *in vivo* model systems. The first goal is to determine the relative toxicity of the analogs in non-tumor-bearing animals, such as DBA/2 mice. Groups of three animals each can be injected intraperitoneally with increasing concentrations of a compound, beginning at, for example, 10 mg/kg. Toxicity as indicated by morbidity is closely monitored over the first 24 hr. A well-characterized polyamine analog, such as BE-333, can be used as an internal standard in these studies, since a data base has already been established regarding acute toxicity via a single dose treatment relative to chronic toxicity via a daily x 5 d schedule. Thus, in the case of new analogs, single dose toxicity relative to BE-333 is used to project the range of doses to be used on a daily x 5 d schedule.

[0030] After the highest tolerated dosage on a daily x 5 d schedule is deduced, antitumor activity is determined. Typically, tumors can be subcutaneously implanted into nude athymic mice by trocar and allowed to reach 100-200 mm³ before initiating treatment by intraperitoneal injection daily x 5 d. Most analogs can be given in a range between 10 and 200 mg/kg. Analogs can be evaluated at three treatment dosages with 10-15 animals per group (a minimum of three from each can be used for pharmacodynamic studies, described below). Mice can be monitored and weighed twice weekly to determine tumor size and toxicity. Tumor size is determined by multi-directional measurement from which volume in mm³ is calculated. Tumors can be followed until median tumor volume of each group reaches 1500 mm³ (i.e., 20% of body weight), at which time the animals can be sacrificed. Although the initial anti-tumor studies focuses on a daily x 5 d schedule, constant infusion can be performed via Alzet pump delivery for 5 days since this schedule dramatically improves the anti-tumor activity of BE-333 against A549 human large cell lung carcinoma. Sharma et al. (1997) *Clin. Cancer Res.* 3:1239-1244. In addition to assessing anti-tumor activity, free analog levels in tumor and normal tissues can be determined in test animals.

Methods of administration of polyamine analogs

[0031] The polyamine analogs of the present invention can be administered to an individual via any route known in the art, including, but not limited to, those disclosed herein. Preferably administration of the novel polyamine analogs is by intravenous routes. Other methods of administration include but are not limited to, oral, intrarterial, intratumoral, intramuscular, subcutaneous, intraperitoneal, gastrointestinal, and directly to a specific or affected organ. The novel

polyamine analogs described herein are administratable in the form of tablets, pills, powder mixtures, capsules, injectables, solutions, suppositories, emulsions, dispersions, food premixes, and in other suitable forms. Additional methods of administration are known in the art. The pharmaceutical dosage form which contains the compounds described herein is conveniently admixed with a non-toxic pharmaceutical organic carrier or a non-toxic pharmaceutical inorganic carrier.

Typical pharmaceutically-acceptable carriers include, for example, mannitol, urea, dextrans, lactose, potato and maize starches, magnesium stearate, talc, vegetable oils, polyalkylene glycols, ethyl cellulose, poly(vinylpyrrolidone), calcium carbonate, ethyl oleate, isopropyl myristate, benzyl benzoate, sodium carbonate, gelatin, potassium carbonate, silicic acid, and other conventionally employed acceptable carriers. The pharmaceutical dosage form can also contain non-toxic auxiliary substances such as emulsifying, preserving, or wetting agents, and the like. A suitable carrier is one which does not cause an intolerable side effect, but which allows the novel polyamine analogs to retain its pharmacological activity in the body. Formulations for parenteral and nonparenteral drug delivery are known in the art and are set forth in *Remington's Pharmaceutical Sciences*, 18th Edition, Mack Publishing (1990). Solid forms, such as tablets, capsules and powders, can be fabricated using conventional tableting and capsule-filling machinery, which is well known in the art. Solid dosage forms can contain any number of additional non-active ingredients known to the art, including excipients, lubricants, dessicants, binders, colorants, disintegrating agents, dry flow modifiers, preservatives, and the like. Liquid forms for ingestion can be formulated using known liquid carriers, including aqueous and non-aqueous carriers, suspensions, oil-in-water and/or water-in-oil emulsions, and the like. Liquid formulations can also contain any number of additional non-active ingredients, including colorants, fragrance, flavorings, viscosity modifiers, preservatives, stabilizers, and the like. For parenteral administration, novel polyamine analogs can be administered as injectable dosages of a solution or suspension of the compound in a physiologically acceptable diluent or sterile liquid carrier such as water or oil, with or without additional surfactants or adjuvants. An illustrative list of carrier oils would include animal and vegetable oils (peanut oil, soy bean oil), petroleum-derived oils (mineral oil), and synthetic oils. In general, for injectable unit doses, water, saline, aqueous dextrose and related sugar solutions, and ethanol and glycol solutions such as propylene glycol or polyethylene glycol are preferred liquid carriers. The pharmaceutical unit dosage chosen is preferably fabricated and administered to provide a final concentration of drug at the point of contact with the cancer cell of from 1 μ M to 10 mM. More preferred is a concentration of from 1 to 100 μ M. As with all pharmaceuticals, the optimal effective concentration of novel polyamine analogs will need to be determined empirically and will depend on the type and severity of the disease, route of administration, disease progression and health and mass or body area of the patient. Such determinations are within the skill of one in the art. Polyamine analogs can be administered as the sole active ingredient, or can be administered together, or in combination with another active ingredient, including, but not limited to, cytotoxic agents, antibiotics, antimetabolites, nitrosourea, vinca alkaloids, polypeptides, antibodies, cytokines, etc.

[0032] The following examples are provided to illustrate but not limit the invention.

EXAMPLES

Synthesis of conformationally-restricted polyamine analogs

a) Spermine and homospermine analogs containing a conformational restriction.

[0033] Scheme 2 exemplifies a N α , N $^{\omega}$ -bisethyl homospermine analog **7** containing a central *trans*-unsaturated bond. Amide **4** was prepared as described in Scheme 1 by alkylation of amide **1** with bromobutyronitrile to give **2**, followed by reduction of the nitrile to the amine **3** that was mesitylsulfonated to **4**. *Trans*-allylic diester **5** was used to alkylate amide **4** and the tetramide **6** was obtained. Deprotection gave the *trans*-tetramide **7** (Scheme 2).

[0034] Introduction of a triple bond in the butane segment of homospermine also reduces its mobility. This was achieved by starting with the butyne diester **8** and following the sequence of reactions outlined above (Scheme 3). Schemes 15-20 are further examples of the synthesis of polyamine spermine and homospermine analogs of this type.

b) Synthesis of pentamines with conformational restrictions.

[0035] Schemes 4-14 are outlines of the syntheses of conformationally restricted pentamines. Scheme 4 depicts the reaction of *cis*-1-chloro-4-phthalimido butene with amide **1** to give **11**. Hydrazinolysis of **11** gave **12** which was amidated to **13**. Reaction of the latter with 1,4-diodobutane gave **14**, while reaction with equimolar amounts of *cis*-1,4-dichlorobutene gave **15**.

[0036] Amide **4** was alkylated with either 4-chlorobutyronitrile to give **16** or with *cis*-1,4-dichlorobutene to give **19**. Nitrile **16** was reduced with hydrogen over Ni Raney to the amine **17** and the latter transformed in to the amide **18** (Scheme 5). Condensation of **18** with the chloroalkyl intermediate **15** gave the pentamide **20** that was deprotected to the pentamine **21** (Scheme 6). Condensation of **18** with the iodoalkyl derivative **14** gave **22** that was deprotected to the pentamine **23** (Scheme 7). Condensation of **18** and **19** gave pentamide **24** that was deprotected to the pentamine **25**

(Scheme 8). Using **14** as the alkylating agent, mesitylenesulfonamide was dialkylated to give **26**, and the latter deprotected to give **27** (Scheme 9). The analogous reaction carried out using **15** as alkylating agent, gave **28** and after deprotection led to the pentamine **29** (Scheme 10).

[0037] Alkylation of mesitylenesulfonamide with **19** gave the pentamide **30**, which was deprotected to **31** (Scheme 11). When **19** was used to alkylate an equimolar amount of mesitylenesulfonamide then **32** was obtained. Alkylation of **32** with **14** gave **33**, that was deprotected to give **34** (Scheme 12). When the chloroalkyl intermediate **15** was used to alkylate one equivalent of mesitylenesulfonamide, then the triamide **35** was obtained. Reaction of **35** with **14** gave **36** which was then deprotected to **37** (Scheme 13). Condensation of **35** and **19** gave the pentamide **38** that was deprotected to **39** (Scheme 14). The above mentioned Schemes describe the synthesis of *cis*-compounds. The same synthetic methodology can be used to obtain the *trans*-isomers, or *cis* and *trans* bonds in different segments within the same molecule.

C) Synthesis of oligoamines.

[0038] Scheme 22 describes the synthesis of a N-2 hydroxyethyl derivative of a pentamine such as **75**. Starting with **18**, alkylation with 4-bromobutyronitrile gave **70**. Reduction of the nitrile of **70** and mesitylenesulfonylation of the resulting amino group gave **71**. It was alkylated again with 4-bromobutyronitrile to give **72**, and again reduced and mesitylsulfonylated to give **73**. The latter was then alkylated with the benzyl ester of 2-bromoethanol to give **74**. Treatment with hydrobromic acid in acetic acid cleaved both the mesitylene sulfonyl protecting groups and the benzyl ether residue to give **75**.

[0039] Scheme 23 reports the synthesis of a *trans*-decamine **77** and of a *cis*-decamine **79**. Starting with the pentamide **73** (Scheme 22) and by reaction with *trans*-diester **5** (Scheme 2) the decamide **76** was prepared, which on deprotection gave **77** as a decahydrochloride. In an analogous manner, by condensation of **73** with the *cis*-1,4-dimesityleneoxy-2-butene, the decamide **78** was prepared, which on deprotection gave **79** as a decahydrochloride.

[0040] Scheme 24 outlines the synthesis of a N-2 hydroxyethyl *trans*-decamine **92** and a *cis*-2-hydroxyethyl decamine **95**. The procedure repeats almost all the procedures described in the foregoing schemes. The synthesis of **80** proceeded by alkylating BOC-mesitylenesulfonamide with the benzyl ester of 2-bromoethanol. Cleavage of the BOC protecting group leads to **81**, alkylation with 4-bromobutyronitrile then gave **82**, and after reduction of the nitrile group and reaction with mesitylene sulfonyl chloride the diamide **83** was obtained. Again, alkylation with 4-bromobutyronitrile led to **84**, reduction and mesitylsulfonylation gave **85**, alkylation of **85** gave **86**, reduction and mesitylsulfonylation gave **87**, and alkylation, reduction and mesitylsulfonylation performed on **87** gave **89**. Alkylation of **73** with *trans*-1,4-dibromo-2-butene gave **90**. Alkylation of **89** with **90** gave **91**, which after deprotection gave the *trans*- ω -hydroxy-decamine **92**. Alkylation of **73** with *cis*-1,4-dichloro-2-butene gave **93**. Alkylation of **89** with **93** gave **94**. Deprotection of **94** gave the *cis*- ω -hydroxy-decamine **95**, isomeric with **92**.

EXAMPLE 1

Synthesis Of Polyamine Compounds

[0041] Compound 2: NaH (80%, 1.08 g, 36 mmol) was added to a solution of amide **1** (6.81 g, 30 mmol) in DMF (50 ml) in an ice-water bath under N₂. The mixture was stirred for 1 h and a solution of 4-bromobutyronitrile (4.88 g, 33 mmol) in DMF (10 ml) was added in portions. The mixture was stirred over night at 75°C. The solvent was distilled off, the residue taken up in chloroform washed with a saturated solution of ammonium chloride, dried (Na₂SO₄) and evaporated. The residue was purified by flash chromatography on silica gel (hexane/ethyl acetate 3:1) to yield 8.0 g (90%) of **2** as a colorless oil. ¹H-NMR (CDCl₃) δ 1.05 (t, 3H), 1.90 (m, 2H), 2.30 (b, m, 5H), 2.60 (s, 6H), 3.20 (q, 2H), 3.35 (t, 2H), 6.95 (s, 2H); ¹³C-NMR (CDCl₃): δ 12.50, 20.61, 22.43, 23.60, 31.05, 36.12, 40.39, 43.78, 118.62, 131.79, 132.67, 139.71, 142.41. MS-EI (m/z) 294 (M⁺).

[0042] Compound 4: Nitrile **2** (7.8 g, 27 mmol) was dissolved in a mixture of ethanol (150 ml) and concentrated hydrochloric acid (1.5 ml). PtO₂ was added (700 mg) and the mixture was hydrogenated at 50 psi over night. The catalyst was filtered off and the solvent evaporated. The residue (78 g, 98%) was used in the next step without further purification. The free base gave ¹H-NMR (CDCl₃) δ 1.00 (t, 3H), 1.55 (m, 4H), 2.25 (s, 3H), 2.80 (t, 2H), 3.20 (m, 4H), 6.95 (s, 2H); ¹³C-NMR (CDCl₃): δ 12.54, 20.69, 22.53, 24.72, 27.65, 39.92, 40.29, 44.59, 131.71, 133.21, 139.82, 142.09. FAB-MS (m/z) 299 (M⁺+1). Mesitylenesulfonyl chloride (8.8 g; 40.5 mmol) in dioxane (30 ml) was added dropwise to a stirred mixture of compound **3** (7.8 g, 27 mmol) dissolved in dioxane (60 ml) and 50% KOH (30 ml) at 0°C. The reaction mixture was allowed to reach 20°C and then kept over night. An excess of water was added and the mixture was extracted with chloroform, dried (Na₂SO₄) and evaporated. The oily residue was crystallized from ethyl acetate/hexane yielding 4; 10.9 g (82%); mp 71.5-72°C. ¹H-NMR (CDCl₃) δ 1.00 (t, 3H), 1.10-1.54 (m, 4H), 2.30 (s, 6H), 2.55, 2.60 (s, 12H), 2.85 (q, 2H), 3.15 (m, 4H), 4.70 (t, 1H), 6.95, 7.00 (s, 4H); ¹³C-NMR (CDCl₃): δ 12.70, 20.92, 21.04, 22.73, 22.92, 24.58, 26.68,

40.04, 42.02, 44.42, 131.91, 133.31, 133.64, 138.99, 140.05, 142.15, 142.35. MS-FAB (m/z) 480 (M⁺).

[0043] Compound 5: (E)-2-Butene-1,4-diyl bis[mesitylenesulfonate] : (E)-2-Butene-1,4-diol (1.76 g, 20 mmol), and benzyltriethylammonium bromide (270 mg, 1 mmol) were dissolved in 30 ml of a 50% potassium hydroxide solution and 30 ml of dioxane. The mixture was stirred at 5°C and mesitylenesulfonyl chloride (8.72 g, 40 mmol) dissolved in 30 ml of dioxane was added dropwise. When the addition was over, stirring was continued for 1 h, water was then added, and the white precipitate was filtered and crystallized from chloroform-hexane to yield **5**; 7.0 g (77%); mp 119-120°C. ¹H-NMR (CDCl₃): δ 2.35 (s, 6H), 2.60 (s, 12H), 4.45 (d, 4H), 5.75 (b, 2H), 6.95 (s, 4H); ¹³C-NMR (CDCl₃): δ 20.96, 22.52, 67.96, 127.67, 131.69, 131.74, 139.79, 143.45. MS-EI (m/z), 452 (M⁺), 253, 200, 183. Anal. Calcd for C₂₂H₂₈O₆S₂: C, 58.40; H, 6.19. Found: C, 58.35; H, 6.22. **Compound 6** was synthesized from **5** according to a procedure described elsewhere (Reddy et al., *J. Med. Chem.* 41:4723 (1998)) in 56% yield. ¹H-NMR (CDCl₃): δ 0.95 (t, J=7.15 Hz, 6H, CH₃), 1.34 (m, 8H, CH₂), 2.29 (s, 12H, CH₃), 2.55 (s, 24H, CH₃), 3.09 (m, 12H, NCH₂), 3.72 (d, J=4.53 Hz, 4H, NCH₂), 5.48 (t, J=4.31 Hz, 2H, CH=CH), 6.92 (s, 4H, Ph), 6.93 (s, 4H, Ph); ¹³C-NMR (CDCl₃): δ 12.71, 20.90, 22.71, 22.76, 24.74, 40.04, 42.21, 44.56, 45.69, 128.45, 131.88, 132.02, 140.05, 140.16, 142.20, 142.58. MS-FAB (m/z) 1012.8 (M⁺, 100%), 828.7, 646.7, 561, 176.

[0044] Compound 7 was obtained from **6** as described elsewhere (Reddy et al., *J. Med. Chem.* 41:4723 (1998)) in 75% yield, mp >230°C. ¹H-NMR (D₂O): δ 1.26 (t, J=12.5 Hz, 6H, 2CH₃), 1.79 (m, 8H, CH₂), 3.12 (m, 12H, NCH₂), 3.80 (d, J=7.16 Hz, 4H, NCH₂), 6.10 (m, 2H, CH=CH); ¹³C-NMR (D₂O): δ 12.79, 25.10, 45.19, 48.53, 48.62, 50.36, 130.66. MS-MALDI (m/z): 285.3 (MH⁺, 100%).

[0045] Compound 8 was obtained from the commercially available butyne diol. Mesitylenesulfonyl chloride (19.5 g, 90 mmol) in dioxane (30 ml) was added dropwise to a stirred and cooled mixture of butyne diol (2.58 g, 30 mmol), 50% potassium hydroxide (30 ml) and triethylbenzyl ammonium bromide (405 mg, 1.5 mmol). Once the addition was over, the mixture was stirred at room temperature for an additional 3 h. An excess of water was added and the white precipitate was cooled over night, filtered off and dried.

[0046] Recrystallization from ethyl acetate/hexane afforded 8.6 g (63%) of **8**; mp 105-106°C. ¹H-NMR (CDCl₃): δ 2.30 (s, 6H), 2.60 (s, 12H), 4.50 (s, 4H), 6.95 (s, 4H); ¹³C-NMR (CDCl₃): δ 20.93, 22.48, 56.13, 80.41, 130.65, 131.67, 139.98, 143.67. MS-EI (m/z) 450 (M⁺).

[0047] Compound 9 was obtained following a procedure analogous to that described for **compound 42** (see below). From 450 mg (1 mmol) of diester **8** and 1.05 g (2.2 mmol) of diamide **4**, 570 mg (56%) of tetramide **9** was obtained. ¹H-NMR (CDCl₃): δ 0.90 (t, 6H), 1.30 (bs, 8H), 2.20 (s, 12H), 2.45 (s, 24H), 3.05 (m, 12H), 3.75 (s, 4H), 6.87 (s, 8H); ¹³C-NMR (CDCl₃): δ 12.70, 20.78, 22.68, 34.65, 39.97, 44.46, 44.99, 78.62, 131.85, 131.98, 132.34, 140.14, 142.13, 142.55. MS-FAB (m/z) 1010 (M⁺).

[0048] Compound 10 was obtained following a procedure analogous to that described for **compound 43** (see below). From 500 mg (0.49 mmol) of tetramide **9**, 160 mg (76%) of the tetrahydrochloride **25** was obtained; mp >280°C (decomp). ¹H-NMR (D₂O): δ 1.30 (t, 6H), 1.80 (b, 8H), 2.90-3.25 (m, 12H), 4.05 (s, 4H); ¹³C-NMR (D₂O): δ 13.39, 25.64, 39.26, 45.72, 49.00, 49.20, 81.20. MS-MALDI 283 (M⁺ + 1).

[0049] Compound 11: Mesitylenesulfonyl ethylamide **1** (3.1 g, 13.65 mmol) was dissolved in anhydrous DMF (30 ml) followed by the addition of NaH (85%, 0.423 g) in several portions. The mixture was stirred at room temperature for 1 h. N-(4-chloro-2-butenyl)-phthalimide (Aldrich, 3.06 g, 13 mmol) in 20 ml of DMF was added to the flask followed by stirring at 80°C over night. The mixture was cooled to room temperature, quenched with H₂O (10 ml), and the solution was evaporated to dryness in vacuo. The solid residue was partitioned between 25 ml H₂O and 25 CHCl₃. The aqueous layer was extracted with CHCl₃ (3 x 25 ml), the organic layers were washed with brine (35 ml), dried (MgSO₄), the solvent was evaporated to afford a gum which solidified upon trituration with hexane to give **11**. The ¹H-NMR and ¹³C-NMR spectra showed that **11** was pure enough to be used in the next step without further purification, yield 4.75 g. ¹H NMR (CDCl₃): δ 1.16 (t, J=7.11 Hz, 3H, CH₃), 2.29 (s, 3H, CH₃), 2.63 (s, 6H, 2CH₃), 3.29 (q, J=7.11 Hz, 2H, CH₂), 4.06 (d, J=5.24 Hz, 2H, NCH₂), 4.26 (d, J=5.72 Hz, 2H, NCH₂), 5.59 (m, 2H, CH=CH), 6.95 (s, 2H, Ph), 7.71 (m, 2H, Ph), 7.83 (m, 2H, Ph); ¹³C-NMR (CDCl₃): δ 13.06, 20.89, 22.72, 34.35, 40.68, 42.01, 123.27, 126.69, 129.47, 131.90, 134.00, 140.24.

[0050] Compound 12: Amide **11** (20 g, 46.95 mmol) was dissolved in methanol, hydrazine monohydrate (5 ml, 98.52 mmol) was added and the solution stirred at 55°C for 24 h. Initially it was a homogeneous solution; however, after several hours a white solid precipitated. The mixture was cooled to room temperature, 300 ml of conc. HCl were added slowly (exothermic reaction), and stirring at room temperature was continued for 12 h more. Methanol was evaporated, and the resulting solid was extracted with CHCl₃ (3 x 150 ml). The aqueous layer was neutralized with 50% NaOH, extracted again with CHCl₃ (3 x 100 ml), the combined organic layers were dried (MgSO₄); the solution was evaporated to afford a gum, which solidified under high vacuum to give **12**; yield 9.0 g (65%). The compound was purified by column chromatography using hexane, ethyl acetate (7:3) as eluent; mp 167-169°C. ¹H-NMR (CDCl₃): δ 1.0 (t, J=7.1 Hz, 3H, CH₃), 2.28 (s, 3H, CH₃), 2.56 (s, 6H, 2CH₃), 2.62 (br, NH₂), 3.12 (q, J=7.1 Hz, 2H, NCH₂), 3.73 (br, 2H, NCH₂), 3.94 (d, J=6.0 Hz, 2H, NCH₂), 5.80 (m, 2H, CH=CH), 6.92 (s, 2H, Ph); ¹³C-NMR (CDCl₃): δ 12.97, 20.93, 22.74, 36.43, 40.94, 42.08, 124.29, 131.89, 132.00, 132.62, 140.21, 142.67.

[0051] **Compound 13** was obtained from 12 as described for 4 in 96% yield. It was purified by column chromatography using hexane and ethyl acetate (4:1.5) as eluants; mp 98-99°C; ¹H-NMR (CDCl₃): δ 0.93 (t, J=5.85 Hz, 3H, CH₃), 2.23 (s, 3H, CH₃), 2.24 (s, 3H, CH₃), 2.50 (s, 6H, 2CH₃), 2.56 (s, 6H, 2CH₃), 3.06 (q, J=7.15 Hz, 2H, NCH₂), 3.48 (t, J=5.99 Hz, 2H, NCH₂), 3.68 (d, J=5.72 Hz, 2H, NCH₂), 4.58 (t, J=6.24 Hz, 1H, NH), 5.44 (m, 2H, CH=CH), 6.87 (s, 2H, Ph), 6.89 (s, 2H, Ph); ¹³C-NMR (CDCl₃): δ 12.80, 20.89, 22.64, 22.89, 39.01, 40.59, 41.41, 128.14, 128.46, 131.91, 131.96, 139.08, 140.19, 142.26, 142.54. MS-FAB (m/z) 479.2 (M⁺, 65%), 296.2, 279.1, 267.2, 183.1.

[0052] **Compound 15:** Amide 13 (4.79 g, 10 mmol) was dissolved in anhydrous DMF (40 ml) followed by addition of NaH (0.37 g) in several portions, the mixture stirred at room temperature for 2 h, cis-1,4-dichloro-2-butene (7.5 g, 60 mmol) in 10 ml DMF was added at once, and stirring was continued at 50°C over night. The mixture was cooled to room temperature, quenched with 10 ml H₂O, the solvents were evaporated, and the contents were partitioned between H₂O (50 ml) and CHCl₃ (50 ml). The aqueous layer was extracted with CHCl₃ (3 x 50 ml), the pooled organic layers were dried (MgSO₄), evaporated, and 15 was purified by column chromatography using hexane, ethyl acetate (8.5:1.5) as eluants; yield 5.5 g (97%), mp 106-108°C. ¹H-NMR (CDCl₃): δ 1.03 (t, J=7.33 Hz, 3H, CH₃), 2.30 (s, 6H, 2CH₃), 2.57 (s, 12H, 4CH₃), 3.17 (q, J=7.31 Hz, NCH₂), 3.71 (m, 4H, NCH₂), 3.81 (d, J=6.87 Hz, 2H, NCH₂), 3.95 (d, J=7.70 Hz, 2H, CHCl₂), 5.50 (m, 3H, CH=CH), 5.74 (m, 1H, CH=CH), 6.93 (s, 2H, Ph), 6.95 (s, 2H, Ph); ¹³C-NMR (CDCl₃): δ 12.91, 22.70, 22.74, 38.20, 40.45, 41.60, 42.11, 42.33, 128.17, 128.95, 129.34, 129.40, 131.94, 132.08, 140.23, 140.34, 142.91. MS-FAB (m/z) 566.7 (M⁺, 100%), 153.4, 96.3.

[0053] **Compound 14** was prepared from 13 and 1,4-diiodobutane as described above for 15. The product was purified by column chromatography using hexanes and ethyl acetate (4:1) as eluant; yield 79%. ¹H-NMR (CDCl₃): δ 1.04 (t, J=7.10 Hz, 3H, CH₃), 1.63 (m, 4H, CH₂), 2.30 (s, 6H, 2CH₃), 2.58 (s, 12H, 4CH₃), 3.04 (t, J=6.50 Hz, 2H, CH₂I), 3.16 (m, 4H, NCH₂), 3.78 (d, J=5.14 Hz, 4H, NCH₂), 5.55 (m, 2H, CH=CH), 6.94 (s, 2H, Ph), 6.95 (s, 2H, Ph); ¹³C-NMR (CDCl₃): δ 5.69, 12.92, 20.95, 22.72, 22.78, 28.25, 30.36, 40.47, 41.59, 42.11, 44.71, 128.34, 129.00, 131.94, 132.06, 132.60, 132.89, 140.15, 140.21, 142.50, 142.71.

[0054] **Compound 16** was prepared from 4 and 4-bromobutyronitrile as described above for Compound 2 in 94% yield. ¹H NMR(CDCl₃): δ 0.97 (t, J = 7.12Hz, 3H, CH₃), 1.40 (m, 4H, 2CH₂), 1.85 (Pent., m, 2H, CH₂), 2.27 (t, J = 7.17Hz, 2H CH₂CN), 2.30 (s, 6H, 2CH₃), 2.57 (s, 6H, 2CH₃), 2.58 (s, 6H, 2CH₃), 3.13 (m, 6H, NCH₂), 3.28 (t, J = 7.11Hz, 2H, NCH₂), 6.94 (s, 2H, Ph), 6.96 (s, 2H, Ph); ¹³C NMR (CDCl₃): δ 12.55, 14.54, 20.84, 22.64, 22.73, 23.65, 24.43, 24.57, 39.88, 44.31, 44.54, 45.58, 118.69, 131.84, 132.05, 132.73, 133.36, 139.94, 142.20, 142.71.

[0055] **Compound 17** was prepared from 16 as described above for Compound 3 in 93% yield.

¹H NMR(CDCl₃): δ 1.00 (t, J = 6.92Hz, 3H, CH₃), 1.40 (m, 10H, 4CH₂, NH₂), 2.29 (s, 6H, 2CH₃), 2.57 (b, 14H, 4CH₃, CH₂N), 3.13 (m, 8H, 4CH₂N), 6.93 (s, 4H, 2 Ph); ¹³C NMR (CDCl₃): 12.72, 20.90, 22.72, 22.78, 24.67, 24.80, 30.80, 40.02, 41.61, 44.56, 45.10, 45.38, 131.87, 140.04, 142.21, 142.28; MS-FAB(M/Z) 552.3(M⁺, 100%), 368.2, 299.1, 183.0, 154.0.

[0056] **Compound 18** was prepared from 17 as described above for Compound 4.

¹H NMR(CDCl₃): δ 0.96 (t, J = 7.13Hz, 3H, CH₃), 1.38 (m, 8H, 4CH₂), 2.29 (s, 9H, 3CH₃), 2.55 (s, 6H, 2CH₃), 2.56 (s, 6H, 2CH₃), 2.59 (s, 6H, 2CH₃), 2.80 (m, 2H, CH₂N), 3.10 (m, 8H, NCH₂), 4.67(t, J = 6.6Hz, 1H, NH), 6.93 (s, 6H, 3 Ph); ¹³C NMR(CDCl₃): δ 12.56, 20.87, 22.70, 22.74, 22.84, 24.40, 26.45, 24.67, 26.62, 39.87, 41.88, 44.45, 45.02, 45.09, 131.86, 131.90, 131.92, 133.12, 133.32, 133.68, 138.91, 139.97, 142.02, 142.21, 142.38; MS-FAB(M/Z): 756.9 (M + 23(Na), 100%) 572.8, 390.7, 333.6, 305.6

[0057] **Compound 19** was prepared from 4 and 1,4-dichloro-2-butene as described above for 15 in 99% yield. ¹H-NMR (CDCl₃): δ 1.01 (t, J=7.11 Hz, 3H, CH₃), 1.38 (m, 4H, CH₂), 2.29 (s, 3H), 2.30 (s, 3H), 2.57 (s, 6H), 2.61 (s, 6H), 3.11 (m, 4H, NCH₂), 3.16 (q, J=7.15 Hz, 2H, NCH₂), 3.81 (d, J=7.17 Hz, 2H, NCH₂), 3.98 (d, J=8.05 Hz, 2H, CH₂Cl), 5.51 (m, 1H, CH=CH), 5.77 (m, 1H, CH=CH), 6.93 (s, 2H, Ph), 6.95 (s, 2H, Ph); ¹³C-NMR (CDCl₃): δ 12.76, 20.91, 22.71, 22.76, 24.74, 38.12, 40.08, 41.85, 44.59, 45.54, 129.14, 129.25, 131.88, 132.02, 140.09, 140.19, 142.21, 142.61. MS-FAB (m/z) 569.3 (M⁺, 20%), 385.2, 240.1, 203.3, 183.0, 119 (100%).

[0058] **Compound 20** was prepared from 18 and 15 following the procedure described above for 15. It was purified by column chromatography using hexanes - ethyl acetate (7:3) as eluant (78% yield). ¹H-NMR (CDCl₃): δ 0.97 (t, J=7.10 Hz, 3H, CH₃), 0.99 (t, J=7.0 Hz, 3H, CH₃), 1.29 (m, 8H, CH₂), 2.29 (s, 15H, CH₃), 2.54, 2.55, 2.59 (s, 30H, CH₃), 3.06 (m, 12H, NCH₂), 3.65 (m, 8H, NCH₂), 5.48 (m, 4H, CH=CH), 6.92 (s, 10H, Ph); ¹³C-NMR (CDCl₃): δ 12.70, 12.83, 20.88, 20.91, 22.65, 22.68, 22.72, 22.74, 24.48, 24.72, 40.04, 40.47, 41.53, 42.07, 42.22, 42.34, 44.54, 44.96, 127.94, 128.27, 128.57, 129.20, 131.92, 132.05, 139.96, 140.00, 140.12, 140.16, 140.27, 142.19, 142.25, 142.47, 142.58, 142.87. MS-FAB (m/z) 1263.81 (M⁺, 100%), 1080.01, 898.11, 714.81, 563.

[0059] **Compound 21:** Pentamide 20 (0.93 g, 0.735 mmol) was dissolved in 20 ml anhydrous CH₂Cl₂, phenol (3.46 g, 36.77 mmol) was added, followed by HBr in acetic acid (30%, 17.62 ml) and the mixture was stirred over night at 25°C. Water (10 ml) was added to the flask, the aqueous layer was separated, the organic layer was extracted with 5 ml H₂O, and the combined aqueous layers were washed with CH₂Cl₂ (6 x 15 ml). Water was evaporated under vacuum to afford a solid which was dissolved in 1 ml 1N NaOH followed by 1 ml of 50% KOH. This solution was extracted with CHCl₃ (10 x 5 ml). The combined organic layers were dried (MgSO₄), CHCl₃ was evaporated, and the residue dissolved

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in anhydrous diethyl ether. Anhydrous HCl gas was passed into the solution while cooling at 0°C. A white solid precipitated which was filtered and washed with ether. It was 21 (84%). ¹H-NMR (D₂O): δ 1.29 (t, J=7.32 Hz, 3H, CH₃), 1.31 (t, J=7.24 Hz, 3H, CH₃), 1.79 (m, 8H, CH₂), 3.12 (m, 12H, NCH₂), 3.87 (m, 8H, NCH₂), 5.98 (m, 4H, CH=CH); ¹³C-NMR (D₂O):

δ 13.36, 13.46, 25.66, 25.77, 45.44, 45.74, 46.24, 46.41, 46.84, 49.09, 49.41, 49.70, 129.02, 129.16, 129.47, 129.66. MS-MALDI (m/z) 354.36 (MH⁺, 100%).

[0060] Compound 22 was prepared in 51% yield from **18** and **14** as described above for compound **15**. ¹H-NMR (CDCl₃): δ 0.97 (t, J=6.59 Hz, 3H, CH₃), 0.99 (t, J=7.02 Hz, 3H, CH₃), 1.29 (m, 12H, CH₂), 2.29 (s, 15H, CH₃), 2.55 (s), 2.56 (s), 2.57 (s), 3.10 (m, 16H, NCH₂), 3.70 (m, 4H, NCH₂), 5.47 (m, 2H, CH=CH), 6.93 (s, 10H, Ph); ¹³C-NMR (CDCl₃): δ 12.69, 12.83, 20.91, 22.69, 22.71, 22.76, 24.43, 24.70, 40.48, 41.11, 41.48, 44.50, 44.91, 128.13, 128.90, 131.88, -131.94, 132.01, 133.29, 139.95, 140.00, 140.15, 142.22, 142.29, 142.60. MS-FAB (m/z) 1265.91 (M⁺, 100%), 1082.01, 900.11, 716.91, 563.81.

[0061] Compound 23 was prepared from **22** in 79% yield as described above for **21**. ¹H-NMR (D₂O): δ 1.29 (t, J=7.29 Hz, 3H, CH₃), 1.30 (t, J=7.30 Hz, 3H, CH₃), 1.78 (m, 12H, CH₂), 3.12 (m, 16H, NCH₂), 3.83 (m, 4H, NCH₂), 5.96 (m, 2H, CH=CH); ¹³C-NMR (D₂O): δ 13.31, 13.42, 25.62, 25.75, 45.38, 45.71, 46.18, 46.76, 49.07, 49.32, 49.69, 129.11, 129.39. MS-MALDI (m/z) 356.38 (MH⁺, 100%).

[0062] Compound 24 was prepared from **18** (52% yield) as described. ¹H-NMR (CDCl₃): δ 0.95 (m, 6H, 2CH₃), 1.32 (m, 12H, CH₂), 2.29 (s, 15H, CH₃), 2.55 (s, 30H, CH₃), 3.06 (m, 16H, NCH₂), 3.70 (m, 4H, NCH₂), 5.47 (m, 2H, CH=CH), 6.92 (s, 10H, Ph); ¹³C-NMR (CDCl₃): δ 12.67, 20.90, 22.71, 22.76, 24.43, 24.68, 39.97, 42.08, 44.48, 44.90, 45.61, 128.28, 128.45, 131.87, 131.93, 132.01, 139.96, 140.00, 140.12, 142.21, 142.28, 142.58. MS-FAB (m/z) 1265.91 (M⁺, 100%), 1082.01, 900.11.

[0063] Compound 25 was prepared from **24** in 96% yield as described above for **21**. ¹H-NMR (D₂O): δ 1.28 (t, J=7.29 Hz, 6H, 2CH₃), 1.78 (m, 12H, CH₂), 3.09 (m, 16H, NCH₂), 3.84 (m, 4H, NCH₂), 5.96 (m, 2H, CH=CH); ¹³C-NMR (D₂O): δ 13.31, 25.61, 25.73, 45.70, 46.79, 49.05, 49.36, 49.65, 129.19. MS-MALDI (m/z) 356.4 (MH⁺).

[0064] Compound 26: A mixture of KOH (0.25 g), K₂CO₃ (0.25 g) and tetra-n-butyl-ammonium hydrogen bromide (0.05 g) were suspended in 15 ml benzene. Mesitylenesulfonylamide (0.199 g, 1 mmol) was added to the suspension and the mixture was heated to 50°C. Iodide **14** (1.98 g, 3 mmol) in 10 ml benzene was added to the flask, the mixture heated under reflux over night, then cooled to room temperature; the inorganic solids were filtered off and washed with benzene (2 x 20 ml). The combined organic layers were washed several times with water until the washings were neutral. The benzene was dried (MgSO₄) evaporated and the residue purified by column chromatography using hexanes and ethyl acetate (7.5:2.5) as eluant; 25% yield (0.948 g). ¹H-NMR (CDCl₃): δ 1.00 (t, J=7.18 Hz, 6H, CH₃), 1.28 (m, 8H, CH₂), 2.29 (s, 15H, CH₃), 2.53 (s), 2.55 (s), 2.57 (s), 3.03 (m, 8H, NCH₂), 3.12 (q, J=7.13 Hz, 4H, NCH₂), 3.70 (m, 8H, NCH₂), 5.47 (m, 4H, CH=CH), 6.93 (s, 10H, Ph); ¹³C-NMR (CDCl₃): δ 12.78, 20.85, 22.63, 22.69, 24.32, 24.58, 40.41, 41.43, 42.00, 44.76, 45.43, 128.08, 128.83, 131.88, 131.95, 132.77, 132.85, 133.23, 139.90, 140.04, 140.08, 142.22, 142.43, 142.53. MS-FAB (m/z) 1263.81 (M⁺, 100%), 1081, 898.11, 815.01, 561.81, 418.81.

[0065] Compound 27 was prepared from **26** in 57% yield as described above for **21**. ¹H-NMR (D₂O): δ 1.31 (t, J=7.31 Hz, 6H, CH₃), 1.78 (m, 8H, CH₂), 3.15 (m, 12H, NCH₂), 3.83 (m, 8H, NCH₂), 5.96 (m, 4H, CH=CH); ¹³C-NMR (CDCl₃): δ 13.43, 25.64, 25.76, 45.39, 46.19, 46.77, 49.35, 49.72, 129.11, 129.41. MS-MALDI (m/z) 354.3 (MH⁺, 100%). **Compound 28** was prepared from **15** and mesitylenesulfonylamide in 24% yield as described above for **26**; mp 57.7°C. ¹H-NMR (CDCl₃): δ 0.99 (t, J=7.09 Hz, 6H, CH₃), 2.29 (s, 15H, CH₃), 2.53 (s), 2.55 (s), 3.12 (q, J=7.09 Hz, 4H, NCH₂), 3.63 (m, 16H, NCH₂), 5.49 (m, 8H, CH=CH), 6.93 (s, 10H, Ph); ¹³C-NMR (CDCl₃): δ 12.85, 20.89, 20.92, 22.66, 40.47, 41.53, 42.19, 128.00, 128.47, 128.58, 129.11, 131.92, 132.05, 140.17, 140.30, 142.46, 142.87. MS-FAB (m/z) 1259.81 (M⁺, 60%), 1075.91, 894.01, 306.51, 153.4 (100%).

[0066] Compound 29 was prepared from **28** in 81% yield as described above for **21**. ¹H-NMR (D₂O): δ 1.31 (t, J=7.29 Hz, 6H, CH₃), 3.15 (q, J=7.31 Hz, 4H, NCH₂), 3.84 (m, 4H, NCH₂), 3.90 (m, 12H, NCH₂), 5.98 (m, 8H, CH=CH); ¹³C-NMR (D₂O): δ 13.42, 45.41, 46.22, 46.44, 129.07, 129.37, 129.42, 129.58. MS-MALDI (m/z) 350.31 (MH⁺).

[0067] Compound 30 was prepared from **19** in 25% yield as described above for **26**; mp 62.3°C. ¹H-NMR (CDCl₃): δ 0.95 (s, J=7.17 Hz, 6H, CH₃), 1.33 (m, 8H, CH₂), 2.29 (s, 15H, CH₃), 2.54 (s), 2.55 (s), 3.07 (m, 12H, NCH₂), 3.65 (m, 8H, NCH₂), 5.48 (m, 4H, CH=CH), 6.92 (s, 10H, Ph); ¹³C-NMR (CDCl₃): δ 12.69, 20.90, 22.69, 22.73, 24.70, 40.03, 42.13, 42.30, 44.53, 45.59, 128.11, 128.79, 131.87, 132.00, 140.02, 140.14, 140.28, 142.17, 142.58, 142.85. MS-FAB (m/z) 1263.81 (M⁺, 100%), 1080.01, 898.11, 714.01, 153.

[0068] Compound 31 was prepared from **30** in 87% yield as described above for **21**. ¹H-NMR (D₂O): δ 1.28 (t, J=7.32 Hz, 6H, CH₃), 1.79 (m, 8H, CH₂), 3.10 (m, 12H, NCH₂), 3.87 (m, 8H, NCH₂), 5.98 (m, 4H, CH=CH), ¹³C-NMR (D₂O): δ 12.70, 25.00, 25.13, 45.10, 45.81, 46.21, 48.44, 48.78, 128.44, 128.85. MS-MALDI (m/z) 354.3 (MH⁺).

[0069] Compound 32: Mesitylenesulfonylamide (1.47 g, 7.38 mmol) was dissolved in 50 ml anhydrous DMF, and NaH (85%, 0.3 g) was added to it under a nitrogen atmosphere. The mixture was stirred at room temperature and **19** (1.40

g, 2.46 mmol) in 25 ml DMF were added. Heating at 65°C continued over night. The mixture was cooled to room temperature, and 10 ml of H₂O were added. The solvents were evaporated and the solid residue was partitioned between 40 ml H₂O and 40 ml CHCl₃. The aqueous layer was extracted with CHCl₃ (2 x 30 ml), the combined organic layers were washed with H₂O (3 x 50 ml), dried (MgSO₄), and evaporated. The residue was purified by column chromatography using hexanes - ethyl acetate (7.5:2.5). 1.7 g (97%) of 32 as a white solid was obtained. ¹H-NMR (CDCl₃): δ 0.94 (t, J=7.10 Hz, 3H, CH₃), 1.30 (m, 4H, CH₂), 2.29 (s), 2.30 (s), 2.55 (s, 12H, CH₃), 2.65 (s, 6H, CH₃), 3.11 (m, 6H, NCH₂), 3.52 (m, 1H, NCH), 3.65 (m, 2H, NCH₂), 3.71 (m, 1H, NCH₂), 4.82 (br, 1H, NH), 5.47 (m, 2H, CH=CH), 6.93 (s, 4H, Ph), 6.96 (s, 2H, Ph); ¹³C-NMR (CDCl₃): δ 12.50, 20.91, 22.71, 22.76, 22.83, 22.91, 24.66, 38.98, 39.85, 42.15, 42.26, 44.50, 128.06, 128.51, 131.86, 131.91, 138.18, 140.00, 140.14, 140.28, 142.17, 142.65.

[0070] Compound 33 was prepared from 32 and 14 in 51 % yield as described above for 22. ¹H-NMR (CDCl₃): δ 0.99 (s, J=7.19 Hz, 6H, CH₃), 1.33 (m, 8H, CH₂), 2.29 (s, 15H, CH₃), 2.55 (s), 2.57 (s), 3.10 (m, 12H, NCH₂), 3.70 (m, 4H, NCH₂), 3.77 (m, 4H, NCH₂), 5.42 (m, 4H, CH=CH), 6.93 (s, 10H, Ph); ¹³C-NMR (CDCl₃): δ 12.70, 12.71, 20.89, 22.66, 22.72, 22.78, 22.81, 24.60, 26.53, 40.39, 41.37, 41.87, 42.20, 45.47, 128.26, 128.62, 131.78, 131.84, 131.86, 131.92, 132.77, 138.92, 139.96, 140.09, 140.17, 142.57, 142.63.

[0071] Compound 34 was prepared from 33 as described above for 21 in 40% yield.

[0072] Compound 35 was prepared from 15 in 94% yield as described above for 32.

[0073] Compound 36 was prepared from 35 and 14 in 82% yield as described above for 33. ¹H-NMR (CDCl₃): δ 0.99 (t, J=7.11 Hz, 6H, CH₃), 1.33 (m, 4H, CH₂), 2.29 (s, 15H, CH₃), 2.55 (s), 2.57 (s), 3.07 (m, 8H, NCH₂), 3.70 (m, 12H, NCH₂), 5.46 (m, 6H, CH=CH), 6.92 (s, 10H, Ph); ¹³C-NMR (CDCl₃): δ 12.69, 12.80, 20.84, 22.62, 22.68, 22.73, 22.77, 24.58, 26.55, 40.44, 41.51, 41.86, 42.04, 42.24, 45.49, 128.10, 128.25, 128.52, 128.62, 128.82, 131.89, 131.95, 132.79, 138.89, 140.07, 140.14, 140.23, 141.94, 142.44, 142.5-3, 142.82. MS-FAB (m/z) 1262.8 (M⁺, 75%), 1080.01, 896, 119 (100%).

[0074] Compound 37 was prepared from 36 in 65% yield as described above for 21. ¹H-NMR (D₂O): δ 1.31 (t, J=6.97 Hz, 6H, CH₃), 1.79 (m, 4H, CH₂); 3.12 (m, 8H, NCH₂), 3.83 (m, 12H, NCH₂), 5.96 (m, 6H, CH=CH); ¹³C-NMR (D₂O): δ 13.48, 25.69, 26.76, 41.67, 45.44, 46.24, 46.45, 46.80, 49.41, 129.00, 129.12, 129.45, 129.71. MS-MALDI (m/z) 352.3 (MH⁺).

[0075] Compound 38 was prepared from 35 and 19 in 89% yield as described. ¹H-NMR (CDCl₃): δ 0.95 (m, 6H, CH₃), 1.33 (m, 4H, CH₂), 2.29 (s, 15H, CH₃), 2.54 (s), 2.55 (s), 2.57 (s), 3.09 (m, 8H, NCH₂), 3.66 (m, 12H, NCH₂), 5.48 (m, 6H, CH=CH), 6.93 (s, 10H, Ph); ¹³C-NMR (CDCl₃): δ 12.51, 12.63, 20.84, 20.86, 22.63, 22.65, 22.84, 24.61, 38.92, 40.40, 41.40, 42.11, 42.18, 44.44, 45.48, 127.95, 128.07, 128.49, 128.62, 128.80, 131.76, 131.83, 131.85, 131.88, 132.01, 138.05, 139.01, 140.07, 140.13, 140.24, 142.15, 142.21, 142.87. MS-FAB (m/z) 1263.1 (M⁺, 90%), 1080.1, 896.01, 119 (100%).

[0076] Compound 39 was prepared from 38 in 54% yield as described above for 21; mp 270°C (dec.). ¹H-NMR (D₂O): δ 1.31 (m, 6H, CH₃), 1.80 (m, 4H, CH₂), 3.10 (m, 8H, NCH₂), 3.86 (m, 12H, NCH₂), 5.98 (m, 6H, CH=CH); ¹³C-NMR (D₂O): δ 13.30, 13.42, 25.58, 25.70, 45.69, 46.21, 46.43, 46.81, 49.02, 49.37, 129.00, 129.15, 129.37, 129.59. MS-MALDI (m/z): 352.343 (MH⁺).

[0077] Compound 42: NaH (80%, 132 mg, 4.4 mmol) was added to a solution of diamide 41 (1.98 g, 4.4 mmol) in DMF (10 ml). The mixture was stirred at 20°C for 30 minutes and a solution of the diester 40 (Reddy et al. (1998) J. Med Chem., 41:4723) (960 mg, 2 mmol) in DMF (10 ml) was added dropwise. The mixture was stirred at 75°C for 2 h, the solvent was distilled off, the residue was taken in chloroform, washed with a saturated solution of ammonium chloride, dried (Na₂SO₄) and evaporated to dryness. The crude oil was purified by column chromatography using hexane - ethyl acetate (8:2) as running solvent. 1.4 g (70%) was obtained as a glassy oil. ¹³C-NMR (CDCl₃): δ 20.58, 22.63, 22.80, 32.42, 33.86, 43.16, 45.42, 46.26, 132.75, 133.21, 139.82, 142.40. MS-FAB 984 (M⁺),

[0078] Compound 43: Phenol (1.86 g, 19.7 mmol) and 30% HBr in glacial acetic acid (35 ml) were added in that order to a solution of 42 (600 mg, 0.6 mmol) in CH₂Cl₂ (35 ml) at room temperature. The solution was stirred for 24 h, water (30 ml) was added, followed by extraction with methylene chloride (3 x 20 ml). The aqueous layer was evaporated under reduced pressure and the residue was taken up in 2N NaOH (2 ml) and then 50% KOH (2 ml) followed by extraction with chloroform (6 x 10 ml). After removal of chloroform, the residue was taken up in ethanol (15 ml) and acidified with concentrated hydrochloric acid (0.4 ml). The product 43 (230 mg, 93%) was recrystallized from aqueous ethanol; mp >270°C (decomp). ¹H-NMR (D₂O): δ 1.95 (m, 2H), 2.05-2.25 (m, 6H), 2.75 (s, 6H), 2.90 (b, 2H), 3.10-3.35 (m, 12H); ¹³C-NMR (D₂O): δ 25.21, 25.24, 35.60, 35.64, 47.41, 48.58, 50.87. MS-MALDI (m/z) 240 (M⁺ + 1).

[0079] Compound 47: NaH (80%, 132 mg, 4.4 mmol) was added to a solution of diamide 46 (1.98 g, 4.4 mmol) in DMF (10 ml). The mixture was stirred at 20°C for 30 min and a solution of the diester 8 (900 mg, 2 mmol) in DMF (10 ml) was added dropwise. The mixture was stirred at 75°C for 2 h. The solvent was distilled off, the residue was taken up in chloroform, washed with a saturated solution of ammonium chloride, dried (Na₂SO₄) and evaporated to dryness. The oily residue was crystallized from ethyl acetate/hexane 1.2 g (61%); mp 165-166°C. ¹H-NMR (CDCl₃): δ 1.08 (t, 3H), 1.75 (m 4H), 2.28 (s, 12H), 2.55 (bs, 24H), 3.10 (m, 12H), 3.98 (s, 4H), 6.95 (m, 8H); ¹³C-NMR (CDCl₃): δ 12.70, 20.86, 22.64, 25.14, 34.85, 40.22, 42.62, 43.37, 78.80, 131.99, 132.26, 133.21, 140.26, 142.28, 142.71. MS-FAB (m/z) 982 (M⁺).

[0080] Compound 48 was obtained as described for 47. From 1.2 g (1.22 mmol) of tetramide 47, 420 mg (86%) of the tetrahydrochloride 48 was obtained; mp >270°C (decomp). ¹H-NMR (D₂O): δ 1.29 (t, 6H), 2.13 (m, 4H), 3.14 (m, 12H), 4.06 (s, 4H); ¹³C-NMR (D₂O): δ 13.34, 25.52, 39.45, 45.90, 45.64, 46.71, 81.32. MS-MALDI (m/z) 255 (M⁺ + 1).

[0081] Compound 44 was obtained as described for 47. From 450 mg (1 mmol) of diester 8 and 994 mg (2.2 mmol) of diamide 41, 500 mg (52%) of the tetramide 44 was obtained and crystallized from ethyl acetate - hexane; mp 155-156°C.

[0082] Compound 45 was obtained as described for 43. From 500 mg (0.52 mmol) of tetramide 44, 160 mg (82%) of the tetrahydrochloride 45 was obtained; mp >270°C (decomp). ¹H-NMR (D₂O): δ 2.15 (m, 4H), 2.73 (s, 3H), 3.05-3.40 (m, 8H), 4.10 (s, 4H); ¹³C-NMR (D₂O): δ 25.59, 35.66, 45.90, 46.57, 48.61.

[0083] Compound 51 is a mixture of *cis/trans*-isomers. ¹H-NMR (D₂O): δ 1.15-2.10 (m, 7H), 2.90 (q, 1H), 3.30-3.80 (b, 2H); ¹³C-NMR (D₂O): δ 24.16, 24.97, 28.44, 30.42, 36.58, 37.14, 48.24, 52.27, 55.19, 57.45, 64.55, 67.26.

[0084] Compound 52: Mesitylenesulfonylchloride (6.5 g, 30 mmol) in dioxane (10 ml) was added dropwise to a stirred and cooled mixture of amine alcohol 51 (1.15 g, 10 mmol), triethylbenzyl ammonium bromide (135 mg, 0.5 mmol), 50% KOH (10 ml) and dioxane (10 ml). The reaction mixture was left over night at 20 °C with magnetic stirring. An excess of water was added, the solution was extracted with chloroform (3 x 30 ml), dried (Na₂SO₄) and evaporated to dryness. The oily residue was chromatographed on a silica-gel column using hexane:ethyl acetate (8:2) as eluants. Crystallization from ethyl acetate - hexane afforded 1.2 g (25%) of pure 52; mp 167-168°C. ¹H-NMR (CDCl₃): δ 1.35-1.90 (6H), 1.90-2.15 (m, 1H), 2.30, 2.35 (s, 6H), 2.65 (s, 12H), 3.20 (m, 1H), 3.70 (m, 1H), 3.90 (m, 1H), 5.15 (d, 1H), 6.90, 7.00 (s, 4H); ¹³C-NMR (CDCl₃): δ 20.73, 20.85, 22.15, 22.37, 22.70, 26.94, 32.75, 45.34, 56.09, 70.38, 130.22, 131.57, 133.98, 138.68, 139.64, 142.02, 143.10. MS-EI (m/z) 479 (M⁺), 280 (M⁺ - 199).

[0085] Compound 54: NaH (105 mg, 3.5 mmol) was added to a solution of compound 52 (1.7 g, 3.5 mmol) in DMF (10 ml). The mixture was stirred at 20°C for 30 min and a solution of compound 53 (1.34 g, 3.85 mmol) in DMF (5 ml) was added in small portions. The mixture was stirred at 75 °C for 2 h. The solvent was distilled off, the residue was taken up in chloroform, washed with a saturated solution of ammonium chloride, dried (Na₂SO₄) and evaporated. The oily residue was purified by column chromatography (hexane - ethyl acetate 8:2) which gave compound 54 (1.22 g, 47%). ¹H-NMR (CDCl₃): δ 1.98 (t, 3H), 1.20-2.05 (9H), 2.20 (s, 6H), 2.55, 2.65 (s, 12H), 2.70-3.55 (9H), 6.85 (s, 4H); ¹³C-NMR (CDCl₃): δ 12.49, 20.80, 21.64, 21.87, 22.88, 28.72, 33.16, 36.13, 39.96, 43.80, 47.95, 57.77, 61.26, 131.83, 132.94, 133.14, 138.82, 139.90, 142.07, 142.63. MS-FAB (m/z) 628 (M⁺+1), 546 (M⁺ - 81).

[0086] Compound 55 was obtained following the procedure described for compound 42. From 1.22 g (1.6 mmol) of bromoderivative 54 and 820 mg (1.76 mmol) of diamide 46, 1.26 g (77%) of tetramide 55 was obtained as a glassy oil. ¹H-NMR (CDCl₃): δ 0.80 (t, 6H), 1.20-1.75 (6H), 1.90 (m, 1H), 2.15 (s, 12H), 2.35-2.60 (s, 24H), 2.65-3.40 (15H), 6.85 (b, 8H); ¹³C-NMR (CDCl₃): δ 12.38, 20.71, 22.52, 22.66, 24.72, 27.55, 28.04, 39.19, 39.71, 41.02, 42.33, 42.62, 43.37, 48.81, 61.44, 131.76, 131.88, 133.10, 133.89, 138.66, 139.93, 142.17, 142.33, 142.57. MS-FAB (m/z) 1012 (M⁺), 828 (M⁺ - 184).

[0087] Compound 56 was obtained following the procedure described for compound 43. From 1.26 g (1.24 mmol) of tetramide 55, 300 mg (56%) of the tetrahydrochloride 56 was obtained; mp > 270°C (decomp). ¹H-NMR (D₂O): δ 1.35 (t, 6H), 1.60 (m, 1H), 1.80 (b, 3H), 2.1 (b, 6H), 2.50 (b, 1H), 3.20 (m, 13H), 3.45 (m, 2H); ¹³C-NMR (D₂O): δ 13.23, 25.48, 25.73, 25.79, 31.69, 31.99, 43.40, 45.91, 46.43, 46.71, 48.07, 53.20, 75.28. MS-MALDI (m/z) 285 (M⁺ + 1).

[0088] Compound 57: NaH (80%, 150 mg, 5 mmol) and NaBr (2.5 g, 25 mmol) were added to a solution of compound 52 (2.35 g, 4.9 mmol) in DMF (15 ml). The mixture was stirred at 20°C for 30 min and a solution of 1-bromoethane (2.2 g, 25 mmol) in DMF (10 ml) was added in small portions. The mixture was stirred at 90°C for 3 h. The solvent was distilled off, the residue taken up in chloroform, washed with a saturated solution of ammonium chloride, dried (Na₂SO₄) and evaporated. The product was purified by silica gel chromatography (hexane/ethyl acetate 9:1). The oily residue (1.5 g, 79%) crystallized on standing; mp 68-69°C. ¹H-NMR (CDCl₃): δ 1.10 (t, 3H), 1.30-2.10 (6H), 2.25 (b, 4H), 2.60 (s, 6H), 3.20 (m, 2H), 3.35 (m, 2H), 3.60 (m, 2H), 6.95 (s, 2H); ¹³C-NMR (CDCl₃): δ 16.35, 20.93, 21.79, 22.89, 29.32, 29.37, 36.54, 38.12, 44.13, 61.40, 131.99, 132.80, 140.20, 142.52. MS-FAB 389 (M⁺+1), 308 (M⁺ - 80).

[0089] Compound 59 was obtained following the procedure described for compound 42. From 700 mg (1.80 mmol) of compound 57 and 394 mg (0.9 mmol) of diamide 58, 400 mg (37%) of tetramide 59 were obtained. ¹H-NMR (CDCl₃): δ 0.90 (t, 6H), 1.25-1.80 (m, 8H), 1.80-2.10 (m, 8H), 2.15 (s, 12H), 2.40, 2.50 (s, 24H), 2.60-3.35 (m, 6H), 2.85, 2.90 (s, 8H); ¹³C-NMR (CDCl₃): δ 16.14, 20.85, 21.95, 21.99, 22.55, 25.49, 28.78, 28.88, 31.49, 37.87, 40.50, 40.83, 43.85, 44.06, 49.30, 61.42, 131.86, 131.96, 133.09, 133.40, 139.93, 139.98, 142.27, 142.40. MS-FAB (m/z) 1052 (M⁺), 891 (M⁺ - 184).

[0090] Compound 60 was obtained following the procedure described for compound 43. From 400 mg (0.38 mmol) of tetramide 59, 95 mg (53%) of the tetrahydrochloride derivative were obtained; mp >270°C (decomp.). ¹H-NMR (D₂O): δ 1.30 (t, 6H), 1.60 (m, 2H), 1.80 (m, 6H), 1.95-2.35 (6H), 2.45 (m, 2H), 3.20 (m, 10H), 3.40 (m, 4H); ¹³C-NMR (D₂O): δ 13.59, 25.34, 25.71, 31.75, 32.00, 43.34, 44.83, 48.02, 53.24, 64.52. MS-MALDI (m/z) 325 (M⁺ + 1).

[0091] Compound 62: Mesitylenesulfonylchloride (3.27 g, 15 mmol) in dioxane (20 ml) was added dropwise to a stirred solution of 61 (1.3 g, 10 mmol) in dioxane (20 ml) and 50% KOH (15 ml) at 0°C. When addition was completed, the mixture was left over night at 20°C. Excess water was added, the solution cooled and the precipitate filtered off.

Crystallization from ethylacetate - hexane gave compound **62** (2 g, 80%); mp 115-116°C. ¹H-NMR (CDCl₃): δ 2.35 (s, 3H), 2.55 (t, 2H), 2.65 (s, 6H), 3.25 (q, 2H), 5.15 (t, 1H), 7.0 (s, 2H); ¹³C-NMR (CDCl₃): δ 19.07, 20.82, 22.78, 3 8.3 7, 117.56, 132.07, 133.0, 138.99, 142.67. MS-EI (m/z) 252 (M⁺).

[0092] **Compound 63:** NaH (80%, 330 mg, 11 mmol) was added to a solution of compound **62** (2.52 g, 10 mmol) in DMF (20 ml) under N₂. The mixture was stirred for 30 min and a solution of compound **53** (3.82 g, 11 mmol) in DMF (10 ml) was added in small portions. The mixture was stirred at 70°C for 2h. The solvent was distilled off, the residue taken up in chloroform, washed with a saturated solution of ammonium chloride, dried (Na₂SO₄) and evaporated to dryness. The product was purified by silica-gel chromatography (hexane - ethyl acetate 8:2). The oily residue (3.0 g, 57%) crystallized on standing; mp 105-106°C. ¹H-NMR (CDCl₃): δ 1.00 (t, 3H), 1.75 (m, 2H), 2.35 (s, 6H), 2.60 (14H), 3.10 (m, 6H), 3.45 (t, 3H), 6.90, 6.95 (s, 4H); ¹³C-NMR (CDCl₃): δ 12.63, 16.94, 20.89, 22.67, 25.73, 40.27, 42.19, 42.51, 44.72, 117.36, 131.95, 132.22, 140.06, 140.34, 142.52, 143.33. MS-EI (m/z) 519 (M⁺), 429 (M⁺ - HCN).

[0093] **Compound 65:** The nitrile **63** (3.0 g, 5.7 mmol) was dissolved in a mixture of ethanol (150 ml) and concentrated hydrochloric acid (1.5 ml). PtO₂ was added (300 mg), the mixture was hydrogenated at 50 psi over night, the catalyst was filtered off and the solvent evaporated to afford an oily residue of compound **64**, which was used in the next step without further purification. Free base ¹H-NMR (CDCl₃): δ 1.00 (t, 3H), 1.55 (m, 2H), 1.75 (m, 2H), 2.30 (s, 6H), 2.55 (14 H), 2.90-3.30 (8H), 6.95 (s, 4H); ¹³C-NMR (CDCl₃): δ 12.64, 20.87, 22.69, 25.35, 30.93, 39.04, 40.12, 42.65, 43.11, 131.86, 133.10, 140.04, 142.43. MS-FAB (m/z) 524 (M⁺ + 1).

Mesitylenesulfonylchloride (1.86 g, 8.55 mmol) in dioxane (15 ml) was added dropwise to a stirred mixture of **64** (3.0 g, 5.7 mmol) dissolved in dioxane (30 ml) and 50% KOH (15 ml) at 0°C. The reaction mixture was allowed to reach room temperature and was kept for further 2 h. An excess of water was added and the mixture was extracted with chloroform, dried (Na₂SO₄) and evaporated to dryness. Purification was achieved by silica gel column chromatography using hexane - ethyl acetate (8:2) as eluant; 2.79 g (69%) of **65** were obtained. ¹H-NMR (CDCl₃): δ 0.95 (t, 3H), 1.60 (m, 4H), 2.30 (s, 9H), 2.50 (s, 12H), 2.65 (s, 6H), 2.85 (m, 2H), 3.05 (6H), 3.20 (t, 2H), 5.00 (t, 1H), 6.95 (6H); ¹³C-NMR (CDCl₃): δ 12.45, 20.81, 22.73, 25.23, 27.46, 39.19, 33.99, 42.49, 42.92, 43.17, 131.84, 133.05, 133.82, 138.80, 139.90, 141.92, 142.36, 142.64. MS-FAB (m/z) 705 (M⁺).

[0094] **Compound 66** was obtained following the procedure described for compound **42**. From 705 mg (1 mmol) of **65** and 426 mg (1.1 mmol) of **57**, 470 mg (46%) of tetramide **66** was obtained as a glassy product. ¹H-NMR (CDCl₃): δ 0.85-1.10 (t, 6H), 1.35-2.10 (m, 11H), 2.30 (s, 12H), 2.40-2.65 (m, 24H), 2.75-3.55 (m, 13H), 6.95 (m, 8H); ¹³C-NMR (CDCl₃): δ 12.64, 16.11, 20.91, 22.08, 22.75, 24.81, 25.09, 28.83, 29.07, 37.93, 40.08, 40.84, 42.50, 42.81, 43.11, 43.42, 49.11, 61.43. MS-FAB (m/z) 1013 (M⁺ + 1).

[0095] **Compound 67** was obtained following the procedure described for compound **43**. From 470 mg (0.46 mmol) of tetramide **66**, 142 mg (71%) of the tetrahydrochloride derivative was obtained; mp >250 °C (decomp). ¹H-NMR (D₂O): δ 1.30 (t, 6H), 1.60 (m, 1H), 1.85 (b, s, 3H), 2.15 (m, 6H), 2.45 (m, 1H), 3.15 (m, 13H), 3.45 (m, 2H); ¹³C-NMR (D₂O): δ 13.29, 13.57, 25.34, 25.44, 25.64, 31.68, 31.94, 43.27, 44.80, 45.86, 46.62, 47.42, 47.97, 53.19, 64.50. MS-MALDI 285 (M⁺ + 1), 286 (M⁺ + 2).

[0096] **Compound 68a:** 4-Cyanobenzaldehyde (Aldrich, 1.31 g, 10 mmol) was dissolved in 30 ml anhydrous MeOH followed by the addition of MgSO₄ (anhydrous, 1.5 g) and 1,4-diaminobutane (Aldrich, 0.44 g, 5 mmol) and the mixture was stirred under argon over night. The suspension was cooled in an ice bath and NaBH₄ (2.0 g) was added in portions and stirring continued for 2 h at 0°C. The methanol was evaporated under vacuum and the resulting solid was partitioned between 35 ml H₂O and 50 ml CHCl₃. Some of the solid was not soluble in either the H₂O or the CHCl₃ and was filtered off and the aqueous layer was extracted with CHCl₃ (2 x 25 ml). The pooled organic layers were dried (MgSO₄), evaporated and the solid was recrystallized from ethyl acetate - hexane, yield 1.1g (35%); mp 90.6-90.8°C. ¹H-NMR (CDCl₃): δ 1.43 (broad, 2H, NH), 1.55 (m, 4H, CH₂), 2.63 (m, 4H, NCH₂), 3.85 (s, 4H, benzylic CH₂), 7.44 (m, 4H, Ph), 7.60 (m, 4H, Ph); ¹³C-NMR (CDCl₃): δ 27.78, 49.28, 53.44, 110.65, 118.88, 128.52, 132.12, 146.21. MS (m/z) 318 (M⁺), 185, 145, 131, 116 (100%), 70.

[0097] **Compound 68b** was prepared from 4-cyano-benzaldehyde and 1,5-diaminopentane as described above for **68a**; 42% yield; mp 92.9-93.0°C. ¹H-NMR (CDCl₃): δ 1.40 (m, 4H, NH, CH₂), 1.50 (m, 4H, CH₂), 2.59 (m, 4H, NCH₂), 3.83 (s, 4H, benzylic CH₂), 7.45 (m, 4H, Ph), 7.59 (m, 4H, Ph); ¹³C-NMR (CDCl₃): δ 24.86, 29.87, 49.29, 53.40, 110.50, 118.85, 128.48, 132.04, 146.19. MS (m/z) 332 (M⁺), 216, 199, 145, 116 (100%), 84.

[0098] **Compound 68c** was prepared from 4-cyanobenzyldehyde and 1,6-diaminohexane as described above for **68a**; 45% yield; mp 95.6-95.8°C. ¹H-NMR (CDCl₃): δ 1.35 (m, 4H, CH₂), 1.50 (m, 6H, NH, CH₂), 2.60 (t, J=6.92 Hz, 4H, NCH₂), 3.84 (s, 4H, benzylic CH₂), 7.44 (m, 4H, Ph), 7.60 (m, 4H, Ph); ¹³C-NMR (CDCl₃): δ 27.17, 30.02, 49.42, 53.50, 110.65, 118.92, 128.55, 132.14, 146.27. MS (m/z) 346 (M⁺), 230, 213, 145, 116 (100%) 98.

[0099] **Compound 69a:** Dinitrile **68a** (0.75 g, 2.36 mmol) was dissolved in anhydrous THF, lithium bis(trimethylsilyl) amide (9.43 ml of a 1 m solution in THF) was added slowly under argon atmosphere. The mixture was stirred at room temperature for 2 h; then cooled in an ice bath, followed by the addition of 4 equivalents of 6N HCl in ether. A white solid precipitated immediately and was filtered after 12 h. The solid was recrystallized from ethanol-ether to afford 1.19 g of compound **69a** (93%). ¹H-NMR (D₂O): δ 1.87 (m, 4H, CH₂), 3.22 (m, 4H, CH₂N), 4.40 (s, 4H, benzylic CH₂), 7.74

(m, 4H, Ph), 7.91 (m, 4H, Ph); ^{13}C -NMR (DMSO- d_6): δ 22.68, 46.09, 49.28, 128.10, 128.47, 130.69, 138.15, 165.44. MS-ESI (m/z) 353.2 (M^+), 177.2 (100%).

[0100] Compound 69b was prepared from **68b** in 92% yield as described above for **69a**. ^1H -NMR (D_2O): δ 1.52 (m, 2H, CH_2), 1.80 (m, 4H, CH_2), 3.19 (m, 4H, NCH_2), 4.40 (s, 4H, benzylic CH_2), 7.75 (m, 4H, Ph), 7.91 (m, 4H, Ph); ^{13}C -NMR (DMSO- d_6): δ 24.90, 26.91, 48.96, 51.88, 130.29, 130.46, 132.43, 139.51, 167.52. MS-ESI (m/z) 367.2 (M^+), 350.2 (100%), 301.2.

[0101] Compound 69c was prepared from **68c** as described above for **69a** in 96% yield. ^1H -NMR (D_2O): δ 1.46 (m, 4H, CH_2), 1.78 (m, 4H, CH_2), 3.16 (m, 4H, NCH_2), 4.39 (s, 4H, benzylic CH_2), 7.74 (m, 4H, Ph), 7.91 (m, 4H, Ph); ^{13}C -NMR (DMSO- d_6): δ 25.24, 25.82, 46.73, 49.44, 128.35, 128.56, 130.81, 138.38, 165.58. MS-ESI (m/z) 381.2 (M^+), 191.2 (100%), 150, 116.

[0102] Compound 70: Triamide **18** (4.3 g, 5.8 mmol) was dissolved in 30 ml of DMF and 80% NaH (208 mg, 6.9 mmol) was added. The mixture was stirred under a N_2 atmosphere for 1 h and 1.12 g (7.5 mmol) of bromobutyronitrile dissolved in 3 ml of DMF were added all at once. The reaction mixture was heated for 3 h at 90°C . The solvent was distilled-off and the residue was dissolved in chloroform and washed twice with a saturated solution of ammonium chloride; dried (NaSO_4) and evaporated to dryness. Flash chromatography of the residue using hexane - ethyl acetate (6:4) as eluant gave the yellow oil **70** (3.7 g, 77%). ^1H -NMR (CDCl_3): δ 0.95 (t, 3H), 1.35 (m, 8H), 1.85 (m, 2H), 2.20 (t, 2H), 2.30 (s, 9H), 2.55 (s, 18H), 3.10 (m, 10H), 3.25 (t, 2H), 6.95 (s, 6H). MS-FA,B (m/z) 823 ($\text{M}^+ + \text{Na}$), 639, 457.

[0103] Compound 71: Nitrile **70** (3.7 g, 4.6 mmol) was dissolved in 20 ml of chloroform and 150 ml of ethanol were added. The mixture was reduced over 0.35 g of PtO_2 at 50 psi over night. The catalyst was filtered-off and the solvent evaporated to dryness. The oily residue was dried in vacuo for 2 h and dissolved in 50 ml of Cl_3CH and 12 ml 2N NaOH. The mixture was cooled in an icewater bath with efficient magnetic stirring and 1.50 g (6.9 mmol) of mesitylene chloride dissolved in 10 ml of chloroform were added all at once. After 2 h the organic layer was separated, washed twice with a saturated solution of ammonium chloride, dried (NaSO_4) and evaporated to dryness. Flash chromatography of the residue using hexane - ethyl acetate (7:3) as eluant provided the tetramide **71** as a colorless oil (3.3 g, 73% over two steps). ^1H -NMR (CDCl_3): δ 0.95 (t, 3H), 1.40 (m, 12H), 2.30 (s, 12H), 2.60 (s, 24H), 2.80 (b, 2H), 3.10 (m, 12H), 4.70 (b, 1H), 6.90 (s, 8H). MS-FAB (m/z) 1010 ($\text{M}^+ + 1 + \text{Na}$), 826, 643.

[0104] Compound 72: The tetramide **71** (6.28 g, 6.3 mmol) was dissolved in 40 ml of DMF and 80% NaH (230 mg, 7.6 mmol) was added. The mixture was stirred under a N_2 atmosphere for 1 h and 1.30 g (8.8 mmol) of bromobutyronitrile dissolved in 3 ml of DMF were added all at once. The reaction mixture was heated for 3h at 90°C , the solvent was distilled-off and the residue was extracted into chloroform and washed twice with a saturated solution of ammonium chloride; dried (NaSO_4) and evaporated to dryness. Flash chromatography of the residue with hexane - ethyl acetate (7:3) as eluant provided the nitrile **72** (5.0 g, 74%). ^1H -NMR (CDCl_3): δ 0.95 (t, 3H), 1.35 (m, 12H), 1.80 (m, 2H), 2.25 (t, 2H), 2.35 (s, 12H), 2.70 (s, 24H), 3.10 (m, 14H), 3.25 (t, 2H), 7.0 (s, 8H). MS-FAB (m/z) 1077 ($\text{M}^+ + 1 + \text{Na}$), 893, 711, 586.

[0105] Compound 73: Nitrile **72** (6.0 g, 5.6 mmol) was dissolved in 20 ml of chloroform and 150 ml of ethanol were added. The mixture was reduced over 600 mg of PtO_2 at 50 psi overnight. The catalyst was filtered-off and the solvent evaporated to dryness. The oily residue was dried in vacuo for 2 h and dissolved in 100 ml of chloroform and 15 ml 2N NaOH. The mixture was cooled in an icewater bath with efficient magnetic stirring, and 1.80 g (8.4 mmol) of mesitylene chloride dissolved in 10 ml of Cl_3CH was added all at once. After 2h the organic layer was separated, washed twice with a saturated solution of ammonium chloride, dried (Na_2SO_4) and evaporated to dryness. Flash chromatography of the residue using hexane - ethyl acetate (7:3) as eluant gave the pentamide **73** as a colorless oil (5.0 g, 71% over two steps). ^1H -NMR (CDCl_3): δ 0.95 (t, 3H), 1.35 (m, 16H), 2.30 (s, 15H), 2.55 (s, 30H), 2.75 (bs, 2H), 3.05 (m, 16H), 4.70 (b, 1H), 6.90 (s, 10H). MS-FAB (m/z) 1261 ($\text{M}^+ - 1 + \text{Na}$), 1077, 895.

[0106] Compound 74: Pentamide **73** (3.4 g, 2.7 mmol) was dissolved in 30 ml of DMF and 60% NaH (162 mg, 4.05 mmol) was added. The mixture was stirred under a N_2 atmosphere for 0.5 h and 2.3 g (10.8 mmol) of 2-bromoethanol benzylether dissolved in 3 ml of DMF were added all at once. The reaction mixture was heated for 2 h at 80°C , the solvent was distilled-off and the residue was dissolved in chloroform and washed twice with a saturated solution of ammonium chloride, dried (NaSO_4) and evaporated to dryness. Flash chromatography of the residue using hexane - ethyl acetate (7:3) as eluant provided the product **74** (2.6 g, 70%). ^1H -NMR (CDCl_3): δ 0.95 (t, 3H), 1.30 (m, 16H), 2.30 (s, 15H), 2.50 (s, 30H), 2.90-3.20 (m, 18H), 3.25 (t, 2H), 2.35 (t, 2H), 4.35 (s, 2H), 6.95 (s, 10H), 7.20-7.35 (m, 5H). ^{13}C NMR (CDCl_3): δ 12.65, 20.84, 22.67, 22.71, 24.41, 24.66, 39.97, 44.48, 44.88, 46.59, 68.01, 72.95, 127.46, 127.57, 128.25, 131.83, 131.89, 133.28, 139.88, 139.95, 140.04, 142.16, 142.23. MS-FAB (m/z) 1394 ($\text{M}^+ - 2 + \text{Na}$) 1030.

[0107] Compound 75: Pentamide **74** (1.2 g, 0.87 mmol) was dissolved in 12 ml of methylene chloride followed by the addition of 30% HBr/acetic acid (16 ml) and phenol (3.0 g, 32 mmol). The mixture was stirred at room temperature overnight, water (16 ml) was added, followed by extraction with methylene chloride (3 x 10 ml). The aqueous layer was evaporated in vacuo. The residue was dissolved in 2N NaOH (4 ml) and 50% KOH (4 ml) followed by extraction with chloroform (4 x 10 ml). After removal of the solvent the residue was dissolved in ethanol (20 ml) and acidified with concentrated hydrochloric acid (0.5 ml). The white precipitate (**75**) was recrystallized from aqueous ethanol (440 mg, 90%); mp above 270°C (decomp). ^1H -NMR (D_2O): δ 1.30 (t, 3H), 1.75 (b, 16H), 2.90-3.30 (m, 20H), 2.85 (t, 2H). ^{13}C

NMR (D₂O): δ 13.29, 25.48, 25.59, 45.70, 49.04, 49.49, 49.67, 51.88, 59.39. MS-MALDI (m/z) 374 (M⁺ + 1).

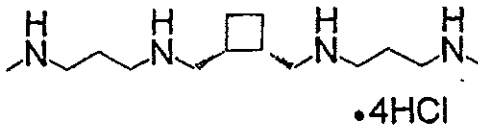
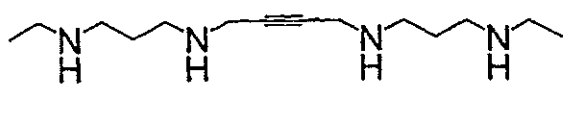
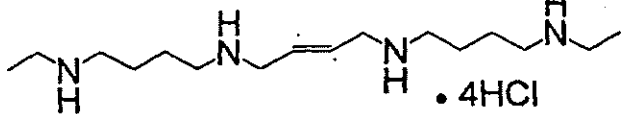
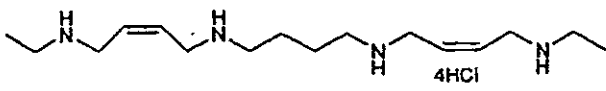
[0108] **Compound 76:** Pentamide **73** (850 mg, 0.68 mmol) was dissolved in DMF (15 ml) and 80% NaH (30 mg, 1 mmol) was added. The mixture was stirred under a N₂ atmosphere at room temperature for 0.5 h and 137 mg (0.30 mmol) of **73** dissolved in 5 ml of DMF were slowly added. The reaction mixture was heated for 2 h at 80°C, the solvent was distilled-off and the residue was dissolved in chloroform and washed twice with a saturated solution of ammonium chloride, dried (NaSO₄) and evaporated to dryness. Flash chromatography of the residue using hexane - ethyl acetate - methanol (6:4:0.1) as eluant afforded the product **76** (590 mg, 77%). ¹H-NMR (CDCl₃): δ 0.95 (t, 6H), 1.15-1.40 (m, 32H), 2.30 (s, 30H), 2.55 (s, 60H), 2.90-3.25 (m, 36H), 3.60 (d, 4H), 5.40 (t, 2H), 6.95 (s, 20H); MS-FAB 2553 (M⁺ + Na).

[0109] **Compound 77** was obtained following the procedure described for compound **75**. From 650 mg (0.25 mmol) of decamide **76**, 225 mg (81%) of decahydrochloride **77** was obtained; mp > 270°C (decomp). ¹H-NMR (D₂O): δ 1.30 (t, 6H), 1.75 (b, 32H), 3.10 (b, 36H), 3.75 (b, 4H), 6.05 (b, 2H); ¹³C NMR (D₂O): δ 13.28, 25.57, 45.66, 49.00, 49.13, 49.64, 50.86, 131.15. MS-ESI 711 (M⁺ + 1).

[0110] **Compound 78** was obtained following the procedure described for compound **76**. From 850 mg of **73**, 360 mg (47%) of decamide **78** were obtained. ¹H-NMR (CDCl₃): δ 0.95 (t, 6H), 1.15-1.45 (m, 32H), 2.30 (s, 30H), 2.55 (s, 60H), 2.90-3.20 (b, 36H), 3.65 (d, 4H), 5.40 (t, 2H), 6.90 (s, 20H). MS-FAB (m/z) 2553 (M⁺ + Na).

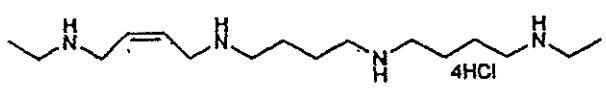
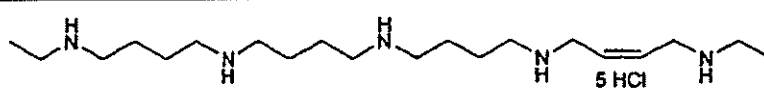
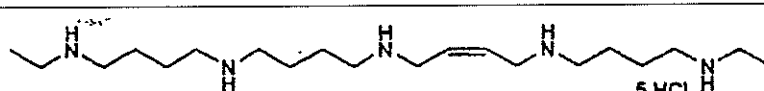
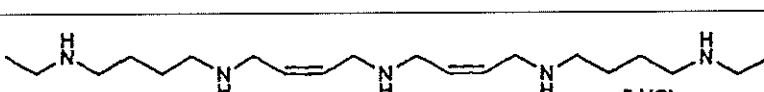
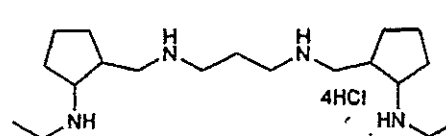
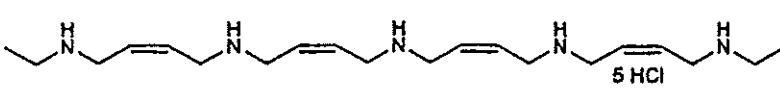
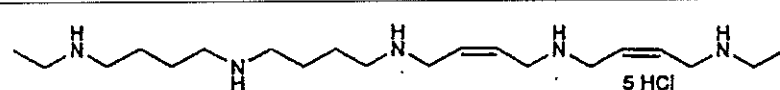
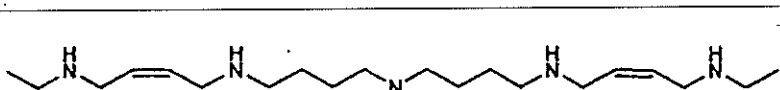
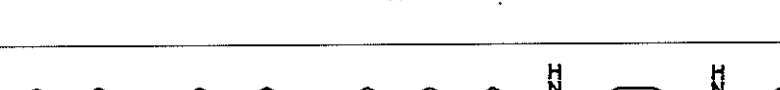
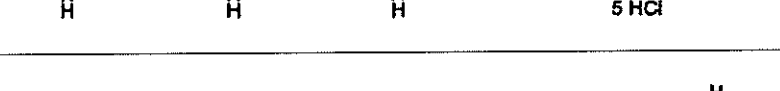
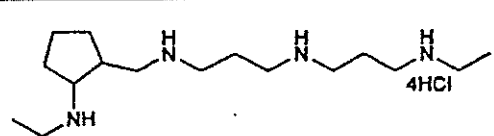
[0111] **Compound 79** was obtained following the procedure described for compound **75**. From 330 mg (0.13 mmol) of decamide **78**, 127 mg (90%) of decahydrochloride **79** was obtained; mp > 270°C (decomp). ¹H-NMR (D₂O): δ 1.30 (t, 6H), 1.80 (b, s, 32H), 3.10 (b, 36H), 3.85 (d, 4H), 6.0 (t, 2H). ¹³C NMR (D₂O): δ 13.31, 25.59, 45.71, 46.83, 49.05, 49.39, 49.69, 129.21. MS-ESI (m/z) 512 (M⁺ + 2).

Table I. Polyamine analogs

Compound	Structure
SL-11090	 •4HCl
SL-11091	 •4HCl
SL-11092	 •4HCl
SL-11101	 •4HCl
SL-11103	 •4HCl
SL-11114	 4HCl

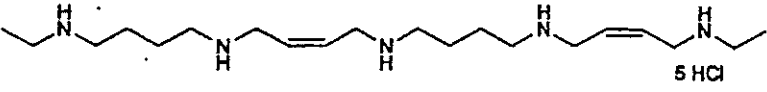
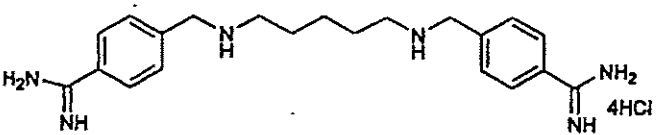
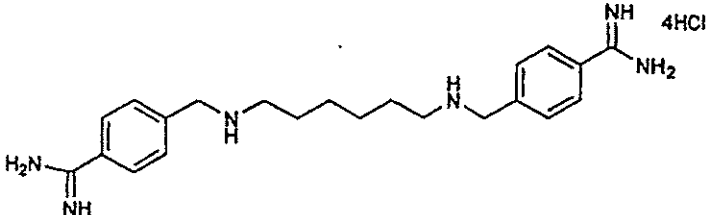
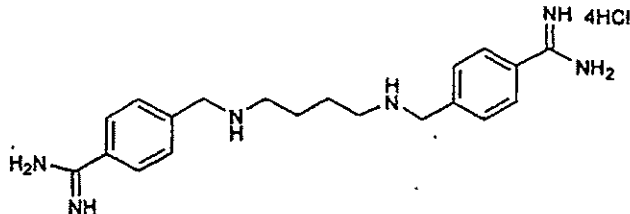
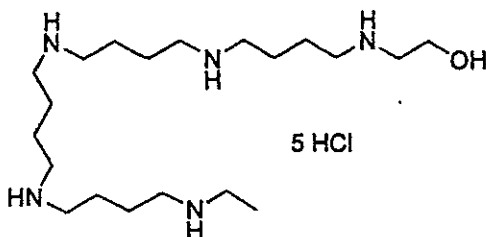
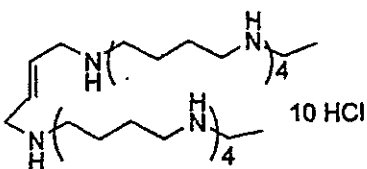
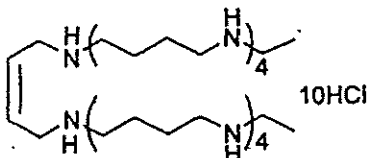
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(continued)

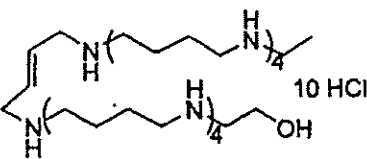
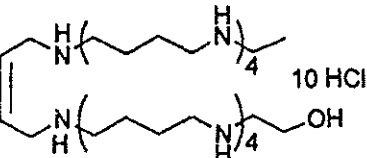
Compound	Structure
SL-11118	 4HCl
SL-11121	 5 HCl
SL-11122	 5 HCl
SL-11123	 5 HCl
SL-11124	 4HCl
SL-11126	 5 HCl
SL-11127	 5 HCl
SL-11128	 5 HCl
SL-11129	 5 HCl
SL-11130	 5 HCl
SL-11132	 4HCl

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(continued)

Compound	Structure
SL-11133	 5 HCl
SL-11134	 4 HCl
SL-11136	 4 HCl
SL-11137	 4 HCl
SL-11141	 5 HCl
SL-11144	 10 HCl
SL-11150	 10 HCl

(continued)

Compound	Structure
SL-11201	
SL-11202	

EXAMPLE 2***In vitro* testing of the efficacy of novel polyamine analogs against tumor cell lines**

[0112] These experiments are designed to evaluate the newly synthesized compounds described above against cultured human carcinoma cell lines for their effects on cell growth, cell-cycle regulation and polyamine regulatory responses. Additional methods for testing compounds are described in U.S. Patent No. 5,889,061.

[0113] As shown in Table 2 and Figs. 1-32, several novel conformationally restricted polyamine analogs were tested for anti-proliferative properties against cancer cells. Table 2 illustrates the concentration in μM of the various novel polyamine analogs needed for 50% growth inhibition (ID_{50}) values for human cancer cell lines LNCaP, PC-3, DuPro (all three human prostate cancer cell lines), HT-29 (colon cancer cell line), A549 (lung cancer cell line), MCF7 (breast cancer cell line), and U251 MG-NCI (brain cancer cell line). Figs. 1-32 show a representative plot of the effects of some of these novel analogs on the growth of human tumor cell lines, as determined by MTT (methyl thiazol tetrazolium) assay; known anti-proliferative polyamine analogs BE-333, BE-343, BE-444, and BE-4444 were used for comparative purposes.

Cell Lines and Media

[0114] Human breast cancer cell line MCF7 was grown in Richter's Improved Modified Eagle's Medium supplemented with 10% fetal bovine serum (FBS) and 2.2 g/L sodium bicarbonate. Human brain tumor cell line U251 MG-NCI was grown in Dulbecco's Modified Eagle's Medium supplemented with 10% FBS. Human lung cancer cell line A549 was grown in Ham's F-12K medium (Cellgro, Mediatech, Inc., VA), supplemented with 10% FBS and 2 mM L-glutamine. Human colon cancer cell line HT29 was cultured in McCoy's 5A medium (Gibco, BRL, Gaithersburg, MD) supplemented with 10% FBS. Human prostate cancer cell lines PC-3, LNCaP and DuPro were grown in RPMI 1640 Medium (Cellgro, Mediatech, Inc., VA) supplemented with 10% FBS. Another human prostate cancer cell line DU145 was grown in Dulbecco's Modified Eagle's Medium (Gibco, BRL, Gaithersburg, MD) supplemented with 5% FBS. The A549, MCF7, PC3, LNCaP and DuPro cell lines were cultured in 100 units/mL penicillin and 100 $\mu\text{g/mL}$ streptomycin. HT29 and U251MG cell lines were grown in 50 $\mu\text{g/mL}$ gentamycin (Gibco, BRL, Gaithersburg, MD). DU145 cell line was maintained in 1% antibiotic-antimycotic solution (Sigma, St. Louis, MO). The cell cultures were maintained at 37°C in 5% CO_2 /95% humidified air. DuPro cells were obtained from M. Eileen Dolan, University of Chicago. All other cells are available from the American Type Culture Collection, Rockville, MD.

MTT assay

[0115] A conventional MTT assay was used to evaluate percent cell survival. Exponentially growing monolayer cells were plated in 96-well plates at a density of 500 cells per well and allowed to grow for 24 hours. Serial dilutions of the drugs were added to the wells. Six days after drug treatment, 25 μL of MTT solution (5 mg/ml) was added to each well and incubated for 4 hours at 37°C. Then 100 μL of lysis buffer (20% sodium dodecyl sulfate, 50% DMF, and 0.8% acetic acid, pH 4.7) was added to each well and incubated for an additional 22 hours. A microplate reader ("EMAX"-brand, Molecular Devices, Sunnyvale, Calif.) set at 570 nm was used to determine the optical density of the cultures. Results

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are expressed as a ratio of the optical density in drug-treated wells to the optical density in wells treated with vehicle only.

TABLE 2

	PC-3	DU-145	DUPRO	HT-29	A549	MCF7	U251M G
BE-4444	0.54	0.07	0.2	0.8	0.4	>31.25	NT
SL-11029	24.5	0.32	NT	>31.25	>31.25	>31.25	>31.25
SL-11090	>31.25	>31.25	NT	>31.25	>31.25	>31.25	>31.25
SL-11091	>31.25	1.33	NT	>31.25	>31.25	>31.25	>31.25
SL-11092	>31.25	1.7	NT	>31.25	>31.25	>31.25	>31.25
SL-11093	14.3	0.01	0.06	0.40	0.26	0.66	NT
SL-11094	>31.25	12.6	NT	28.8	>31.25	>31.25	>31.25
SL-11098	1.4	0.018	0.08	0.40	0.51	>31.25	0.10
SL-11099	2.5	0.014	0.08	1.00	0.65	26.3	0.11
SL-11100	4.7	0.021	0.29	2.00	2.20	>31.25	0.22
SL-11101	7.7	0.218	0.85	5.20	0.15	>31.25	1.70
SL-11102	>31.25	0.027	0.15	0.73	12.40	>31.25	0.15
SL-11103	>31.25	2.8	NT	29.4	>31.25	>31.25	9.50
SL-11104	>31.25	9.4	NT	25.8	0.43	>31.25	14.71
SL-11105	>31.25	1.6	>31.25	25.2	>31.25	>31.25	25.9
SL-11108	2.2	0.13	0.98	2.00	>31.25	>31.25	2.00
SL-11114	0.70	0.135	0.64	3.6	>31.25	NT	NT
SL-11118	1.65	0.05	0.25	0.98	0.21	NT	NT
SL-11119	>31.25	0.08	0.44	0.97	NT	NT	NT
SL-11121	0.52	0.08	0.40	0.80	>31.25	17.0	NT
SL-11122	>31.25	0.80	0.56	0.80	>31.25	>31.25	NT
SL-11123	>31.25	0.51	>31.25	10.42	>31.25	>31.25	NT
SL-11124	>31.25	>31.25	>31.25	>31.25	>31.25	>31.25	NT
SL-11126	0.20	0.51	1.10	1.50	>31.25	0.70	NT
SL-11127	>31.25	0.22	1.3	2.91	NT	NT	NT
SL-11128	0.50	0.14	1.25	1.35	NT	NT	NT
SL-11129	1.70	0.32	NT	NT	NT	NT	NT
SL-11130	>31.25	0.43	NT	NT	NT	NT	NT
NT indicates not tested.							

EXAMPLE 3

In vivo testing of anti-tumor activity of polyamine analogs

[0116] Analogs found to have potent or mechanism-based anti-proliferative activity *in vitro* towards cultured carcinoma cells are evaluated in *in vivo* model systems. The first goal is to determine the relative toxicity of the analogs in non-tumor-bearing animals, such as DBA/2 mice. Groups of three animals each are injected intraperitoneally with increasing concentrations of an analog, beginning at 10 mg/kg. Toxicity, as indicated by morbidity, is closely monitored over the first 24 hr. A well-characterized polyamine analog, such as BE-333, is used as an internal standard in these studies, since a data base has already been established regarding acute toxicity via a single dose treatment relative to chronic

toxicity via a daily x 5 d schedule. Thus, in the case of new analogs, single dose toxicity relative to BE-333 is used to project the range of doses to be used on a daily x 5 d schedule.

[0117] After the highest tolerated dosage on a daily x 5. d schedule is deduced, antitumor activity is determined. Tumors are subcutaneously implanted into nude athymic mice by trocar and allowed to reach 100-200 mm³ before initiating treatment by intraperitoneal injection daily x 5 d. Analogs are given in a range between 10 and 200 mg/kg. Analogs are evaluated at three treatment dosages with 10-15 animals per group (a minimum of three from each are used for pharmacodynamic studies, described below). Mice are monitored and weighed twice weekly to determine tumor size and toxicity. Tumor size is determined by multi-directional measurement from which volume in mm³ is calculated. Tumors are followed until median tumor volume of each group reaches 1500 mm³ (i.e., 20% of body weight), at which time the animals are sacrificed. Although the initial anti-tumor studies focused on a daily x 5 d schedule, constant infusion is performed via Alzet pump delivery for 5 days since this schedule dramatically improves the anti-tumor activity of BE-333 against A549 human large cell lung carcinoma. Sharma et al. (1997) *Clin. Cancer Res.* 3:1239-1244. In addition to assessing anti-tumor activity, free analog levels in tumor and normal tissues are determined in test animals.

Claims

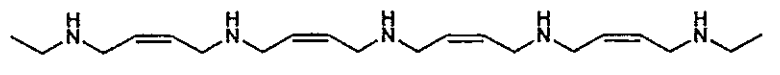
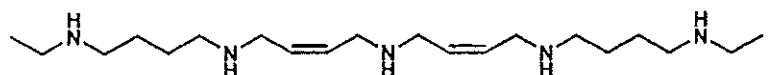
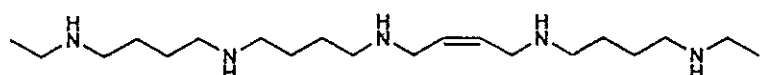
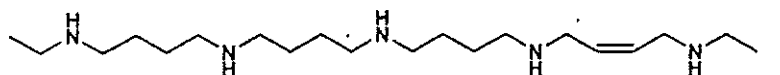
1. A conformationally restricted polyamine analog of the formula:

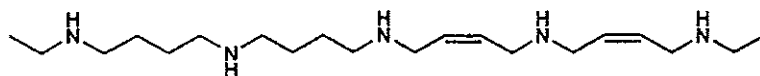


wherein each A is independently selected from the group consisting of: C₁-C₆ alkyl, C₂-C₆ allenyl, C₂-C₆ alkynyl, C₃-C₆ cycloalkyl, C₃-C₆ aryl, and C₃-C₆ cycloalkenyl; each B is independently selected from the group consisting of: a single bond, C₁-C₆ alkyl, and C₂-C₆ alkenyl;

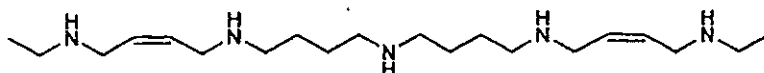
and each E is independently selected from the group consisting of H, C₁-C₆ alkyl, C₂-C₆ alkenyl, C₂-C₆ alkynyl, C₃-C₆ cycloalkyl, C₃-C₆ aryl, and C₃-C₆ cycloalkenyl; with the proviso that either at least one A moiety is selected from the group consisting of C₂-C₆ alkenyl, C₂-C₆ alkynyl, C₃-C₆ cycloalkyl, C₃-C₆ aryl, and C₃-C₆ cycloalkenyl, or at least one B moiety is selected from the group consisting of C₂-C₆ alkenyl; and any salt or stereoisomer thereof.

2. A conformationally restricted polyamine analog according to claim 1, selected from the group consisting of

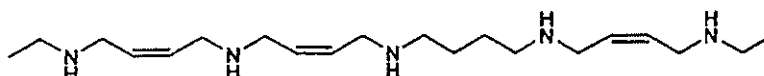




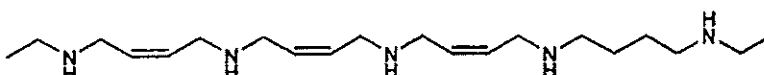
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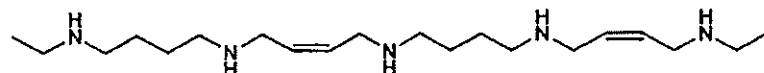
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20

25

and

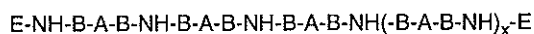


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and any salt or stereoisomer thereof.

3. A conformationally restricted polyamine analog of the formula:



40

wherein each A is independently selected from the group consisting of: C₁-C₆ alkyl, C₂-C₆ alkenyl, C₂-C₆ alkynyl, C₃-C₆ cycloalkyl, C₃-C₆ aryl, and C₃-C₆ cycloalkenyl; each B is independently selected from the group consisting of: a single bond, C₁-C₆ alkyl, and C₂-C₆ alkenyl;

45

each E is independently selected from the group consisting of H, C₁-C₆ alkyl, C₂-C₆ alkenyl, C₂-C₆ alkynyl, C₃-C₆ cycloalkyl, C₃-C₆ aryl, and C₃-C₆ cycloalkenyl; and x is an integer from 2 to 16;

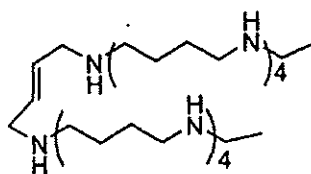
with the proviso that either at least one A moiety is selected from the group consisting of C₂-C₆ alkenyl, C₂-C₆ alkynyl, C₃-C₆ cycloalkyl, C₃-C₆ aryl, and C₃-C₆ cycloalkenyl, or at least one B moiety is selected from the group consisting of C₂-C₆ alkenyl;

50

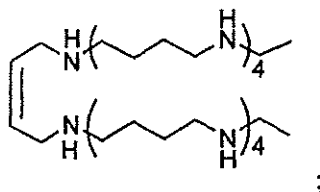
and any salt or stereoisomer thereof.

4. A conformationally restricted polyamine analog according to claim 3, selected from the group consisting of:

55



and

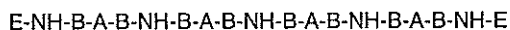


and any salt or stereoisomer thereof.

5. The polyamine analog of any one of the preceding claims, further comprising a pharmaceutically acceptable excipient.
6. A polyamine analog of any one of claims 1 to 4 for use in a method of treatment of the human or animal body.
7. Use of a polyamine analog of any one of claims 1 to 4, for the manufacture of a medicament for the treatment of cancer.
8. The use of claim 7, wherein the cancer affects cells of the bladder, blood, brain, breast, colon, digestive tract, lung, ovaries, pancreas, prostate gland, or skin.
9. Use of a polyamine analog of any one of claims 1 to 4, for the manufacture of a medicament for the treatment of Alzheimer's disease, epilepsy, multiple sclerosis, problems associated with tissue grafts and organ transplants, psoriasis, restenosis, stomach ulcers, or tissue overgrowth after surgery, or an infection or infestation of parasites, bacteria, fungi or insects.
10. Use of a polyamine analog of any one of claims 1 to 4 for the manufacture of a medicament for suppressing cell growth in an individual.

Patentansprüche

1. Konformationell eingeschränktes Polyamin-Analogon der Formel:



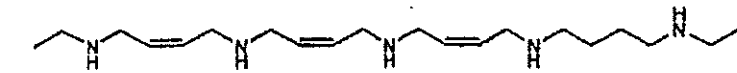
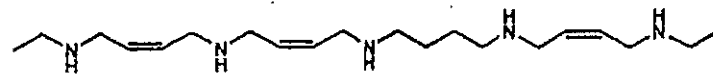
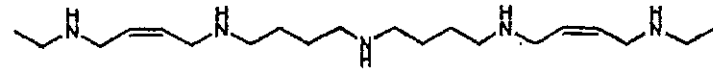
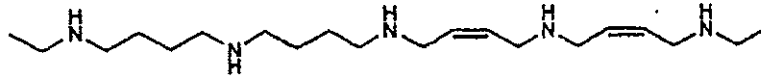
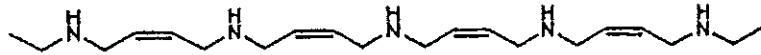
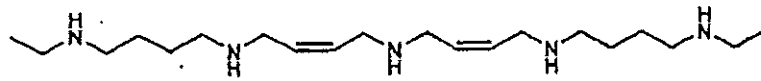
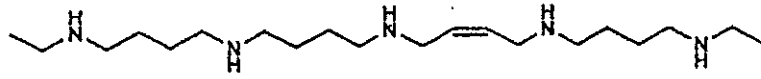
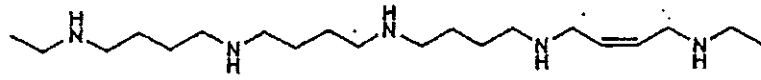
worin jedes A unabhängig ausgewählt ist aus der Gruppe, bestehend aus: C_1-C_6 -Alkyl, C_2-C_6 -Alkenyl, C_2-C_6 -Alkynyl, C_3-C_6 -Cycloalkyl, C_3-C_6 -Aryl und C_3-C_6 -Cycloalkenyl;

jedes B unabhängig ausgewählt ist aus der Gruppe, bestehend aus: einer Einzelbindung, C_1-C_6 -Alkyl und C_2-C_6 -Alkenyl;

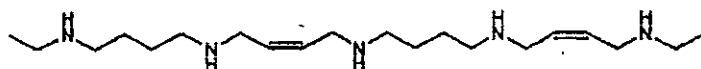
und jedes E unabhängig ausgewählt ist aus der Gruppe, bestehend aus H, C_1-C_6 -Alkyl, C_2-C_6 -Alkenyl, C_2-C_6 -Alkynyl, C_3-C_6 -Cycloalkyl, C_3-C_6 -Aryl und C_3-C_6 -Cycloalkenyl;

unter der Voraussetzung, dass entweder mindestens eine A-Komponente ausgewählt ist aus der Gruppe, bestehend aus C_2-C_6 -Alkenyl, C_2-C_6 -Alkynyl, C_3-C_6 -Cycloalkyl, C_3-C_6 -Aryl und C_3-C_6 -Cycloalkenyl, oder mindestens eine B-Komponente ausgewählt ist aus der Gruppe, bestehend aus C_2-C_6 -Alkenyl; und jegliches Salz oder Stereoisomer davon.

2. Konformationell eingeschränktes Polyamin-Analogon nach Anspruch 1, ausgewählt aus der Gruppe, bestehend aus

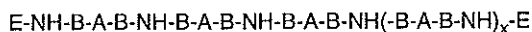


und



und jegliches Salz oder Stereoisomer davon.

3. Konformationell eingeschränktes Polyamin-Analogon der Formel:



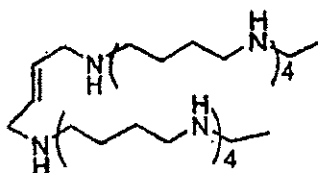
worin jedes A unabhängig ausgewählt ist aus der Gruppe, bestehend aus: C₁-C₆-Alkyl, C₂-C₆-Alkenyl, C₂-C₆-Alkynyl, C₃-C₆-Cycloalkyl, C₃-C₆-Aryl und C₃-C₆-Cycloalkenyl;

jedes B unabhängig ausgewählt ist aus der Gruppe, bestehend aus: einer Einzelbindung, C₁-C₆-Alkyl und C₂-C₆-Alkyl;

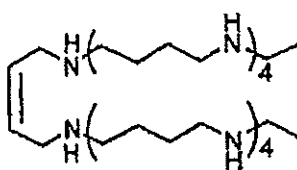
und jedes E unabhängig ausgewählt ist aus der Gruppe, bestehend aus H, C₁-C₆-Alkyl, C₂-C₆-Alkenyl, C₂-C₆-Alkynyl, C₂-C₆-Cycloalkyl, C₂-C₆-Aryl und C₂-C₆-Cycloalkenyl; und x eine ganze Zahl von 2 bis 16 ist;

unter der Voraussetzung, dass entweder mindestens eine A-Komponente ausgewählt ist aus der Gruppe, bestehend aus C₂-C₆-Alkenyl, C₂-C₆-Alkynyl, C₃-C₆-Cycloalkyl, C₃-C₆-Aryl und C₃-C₆-Cycloalkenyl, oder mindestens eine B-Komponente ausgewählt ist aus der Gruppe, bestehend aus C₂-C₆-Alkenyl;

4. Konformationell eingeschränktes Polyamin-Analogon nach Anspruch 3, ausgewählt aus der Gruppe, bestehend aus:



und



und jegliches Salz oder Stereoisomer davon.

5. Polyamin-Analogon nach einem der vorangehenden Ansprüche, außerdem umfassend einen pharmazeutisch akzeptablen Exzipienten.

6. Polyamin-Analogon nach einem der Ansprüche 1 bis 4 zur Verwendung bei einer Methode zur Behandlung des menschlichen oder tierischen Körpers.

7. Verwendung eines Polyamin-Analogons nach einem der Ansprüche 1 bis 4, für die Herstellung eines Medikaments für die Behandlung von Krebs.

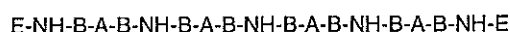
8. Verwendung nach Anspruch 7, wobei der Krebs Zellen der Blase, Blut, Gehirn, Brust, Darm, Verdauungstrakt,

Lunge, Eierstöcke, Bauchspeicheldrüse, Prostata-drüse oder Haut befällt.

9. Verwendung eines Polyamin-Analogons nach einem der Ansprüche 1 bis 4, für die Herstellung eines Medikaments zur Behandlung von Alzheimer-Krankheit, Epilepsie, Multiple Sklerose, Probleme in Verbindung mit Gewebetran-splantaten und Organtransplantaten, Psoriasis, Restenose, Magengeschwüren oder Gewebewucherung nach einer Operation, oder einer Infektion oder Befall mit Parasiten, Bakterien, Pilzen oder Insekten.
10. Verwendung eines Polyamin-Analogons nach einem der Ansprüche 1 bis 4, für die Herstellung eines Medikaments zur Unterdrückung des Zellwachstums in einem Individuum.

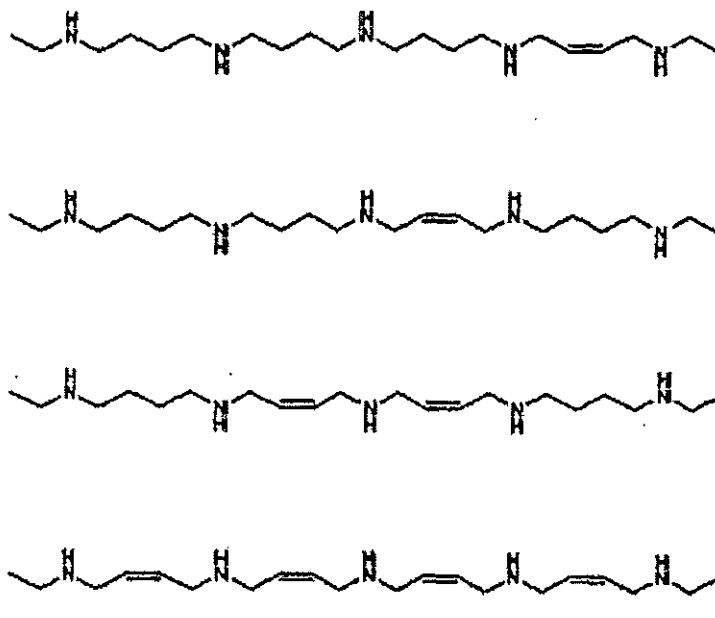
Revendications

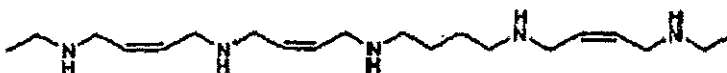
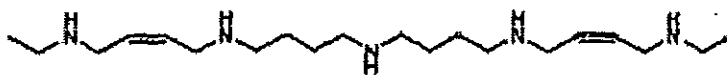
1. Analogue de polyamine à restriction conformationnelle de formule :



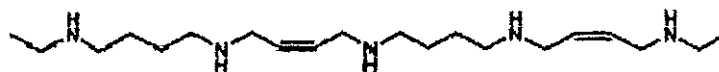
où chaque A est indépendamment choisi dans le groupe consistant en : un groupe alkyle en C₁ à C₆, alcényle en C₂ à C₆, alcynyle en C₂ à C₆, cycloalkyle en C₃ à C₆, aryle en C₃ à C₆ et cycloalcényle en C₃ à C₆; chaque B est indépendamment choisi dans le groupe consistant en : une simple liaison, un groupe alkyle en C₁ à C₆ et alcényle en C₂ à C₆; et chaque E est indépendamment choisi dans le groupe consistant en H, un groupe alkyle en C₁ à C₆, alcényle en C₂ à C₆, alcynyle en C₂ à C₆, cycloalkyle en C₃ à C₆, aryle en C₃ à C₆ et cycloalcényle en C₃ à C₆; à condition que, soit au moins un résidu A soit choisie dans le groupe consistant en un groupe alcényle en C₂ à C₆, alcynyle en C₂ à C₆, cycloalkyle en C₃ à C₆, aryle en C₃ à C₆ et cycloalcényle en C₃ à C₆, soit au moins un résidu B soit choisie dans le groupe consistant en un groupe alcényle en C₂ à C₆; et tout sel ou stéréoisomère de ceux-ci.

2. Analogue de polyamine à restriction conformationnelle selon la revendication 1, choisi dans le groupe consistant en :



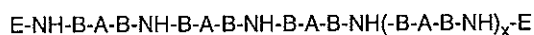


et



et tout sel ou stéréoisomère de ceux-ci.

3. Analogue de polyamine à restriction conformationnelle de formule :



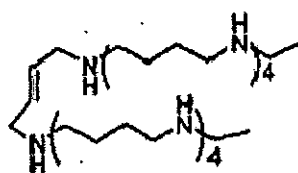
où chaque A est indépendamment choisi dans le groupe consistant en : un groupe alkyle en C₁ à C₆, alcényle en C₂ à C₆, alcynyle en C₂ à C₆, cycloalkyle en C₃ à C₆, aryle en C₃ à C₆ et cycloalcényle en C₃ à C₆; chaque B est indépendamment choisi dans le groupe consistant en : une simple liaison, un groupe alkyle en C₁ à C₆ et alcényle en C₂ à C₆ ;

et chaque E est indépendamment choisi dans le groupe consistant en H, un groupe alkyle en C₁ à C₆, alcényle en C₂ à C₆, alcynyle en C₂ à C₆, cycloalkyle en C₃ à C₆, aryle en C₃ à C₆ et cycloalcényle en C₃ à C₆ ; et x est un nombre entier allant de 2 à 16 ;

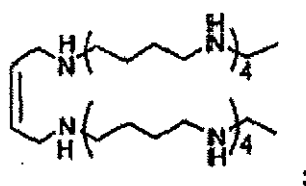
à condition que, soit au moins un résidu A soit choisie dans le groupe consistant en un groupe alcényle en C₂ à C₆, alcynyle en C₂ à C₆, cycloalkyle en C₃ à C₆, aryle en C₃ à C₆ et cycloalcényle en C₃ à C₆, soit au moins un résidu B soit choisie dans le groupe consistant en un groupe alcényle en C₂ à C₆ ;

et tout sel ou stéréoisomère de ceux-ci.

4. Analogue de polyamine à restriction conformationnelle selon la revendication 3, choisi dans le groupe consistant en :

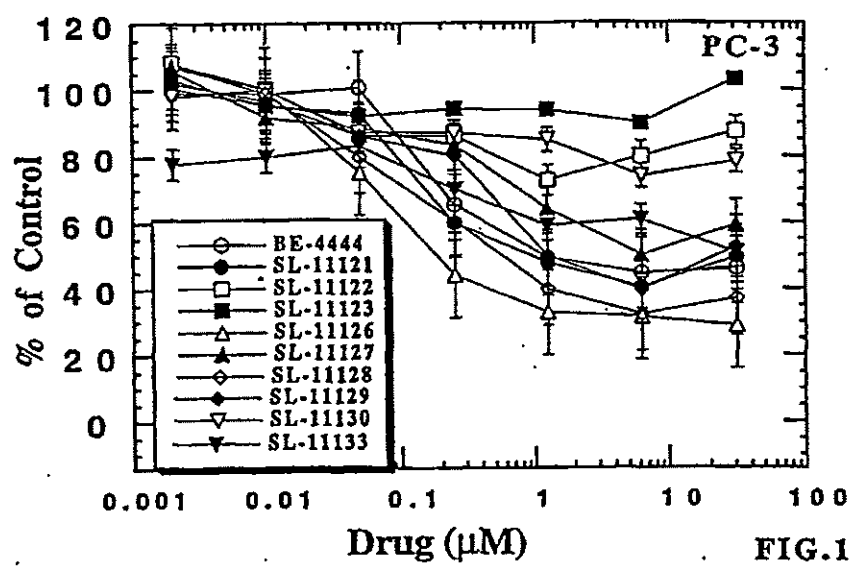


et



et tout sel ou stéréoisomère de ceux-ci.

5. Analogue de polyamine à restriction conformationnelle selon l'une quelconque des revendications précédentes, comprenant en outre un excipient pharmaceutiquement acceptable.
6. Analogue de polyamine selon l'une quelconque des revendications 1 à 4, pour une utilisation dans un procédé de traitement d'un corps humain ou animal.
7. Utilisation d'un analogue de polyamine selon l'une quelconque des revendications 1 à 4, pour la fabrication d'un médicament pour le traitement du cancer.
8. Utilisation selon la revendication 7, où le cancer affecte des cellules de la vessie, du sang, du cerveau, des seins, du côlon, du tube digestif, des poumons, des ovaires, du pancréas, de la prostate ou de la peau.
9. Utilisation d'un analogue de polyamine selon l'une quelconque des revendications 1 à 4, pour la fabrication d'un médicament destiné au traitement de la maladie d'Alzheimer, l'épilepsie, la sclérose en plaques, les problèmes associés aux greffes de tissus et aux transplantations d'organes, le psoriasis, la resténose, les ulcères d'estomac, ou une prolifération de tissus après une intervention chirurgicale, ou une infection ou une infestation de parasites, de bactéries, de champignons ou d'insectes.
10. Utilisation d'un analogue de polyamine selon l'une quelconque des revendications 1 à 4, pour la fabrication d'un médicament destiné à supprimer la croissance de cellules chez un individu.



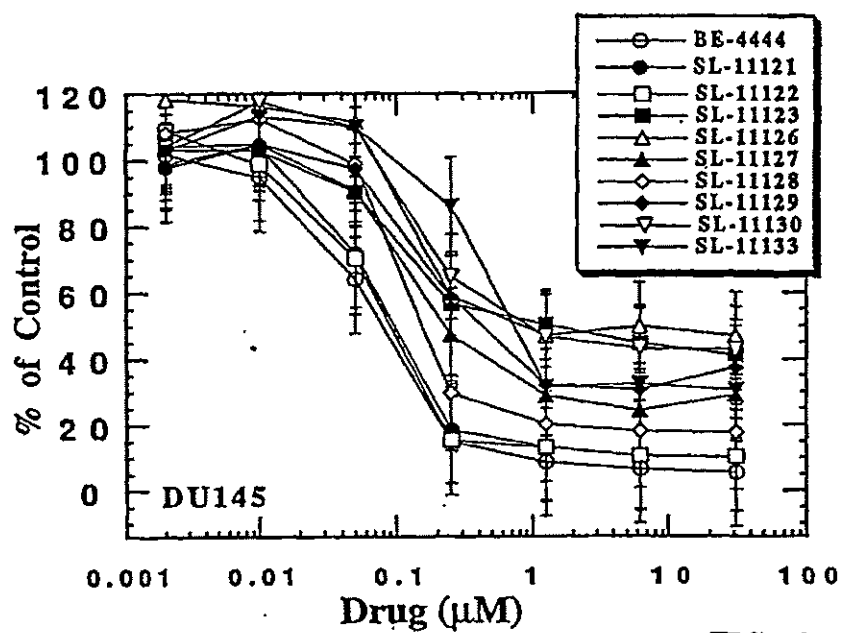
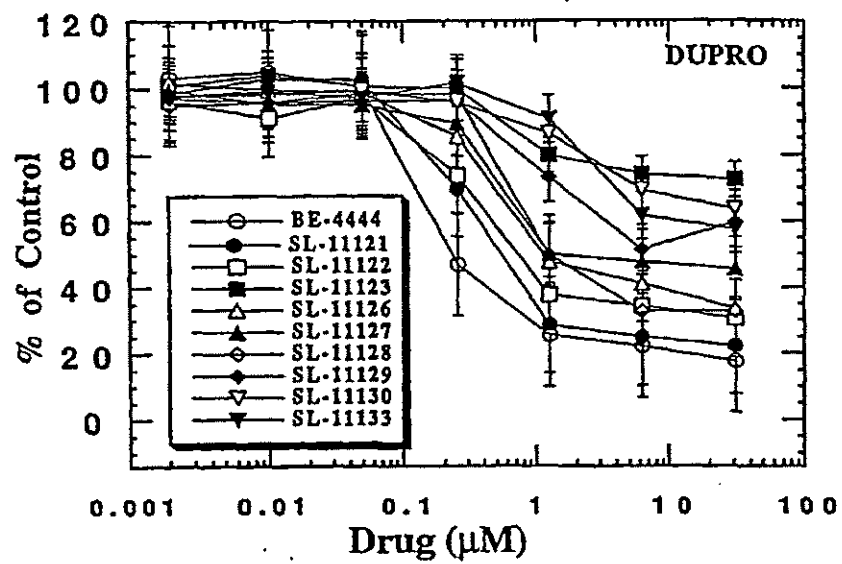


FIG. 2



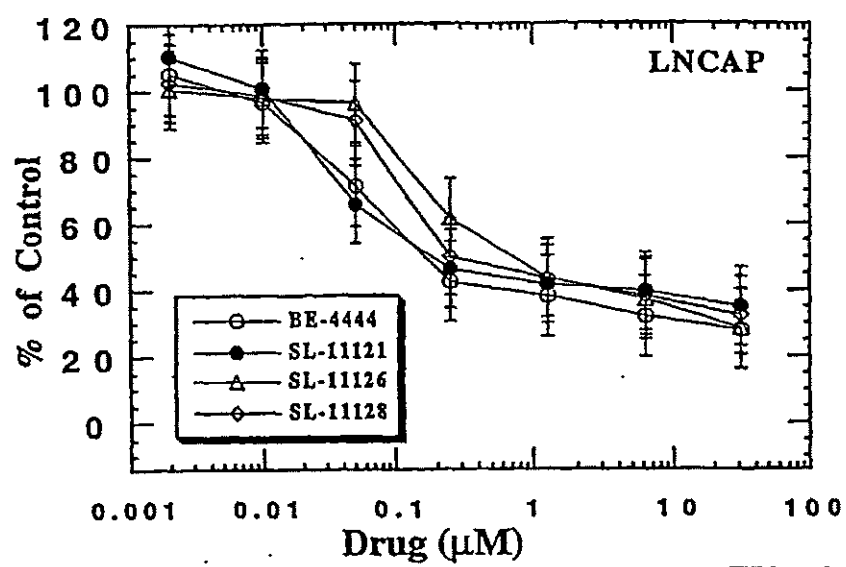
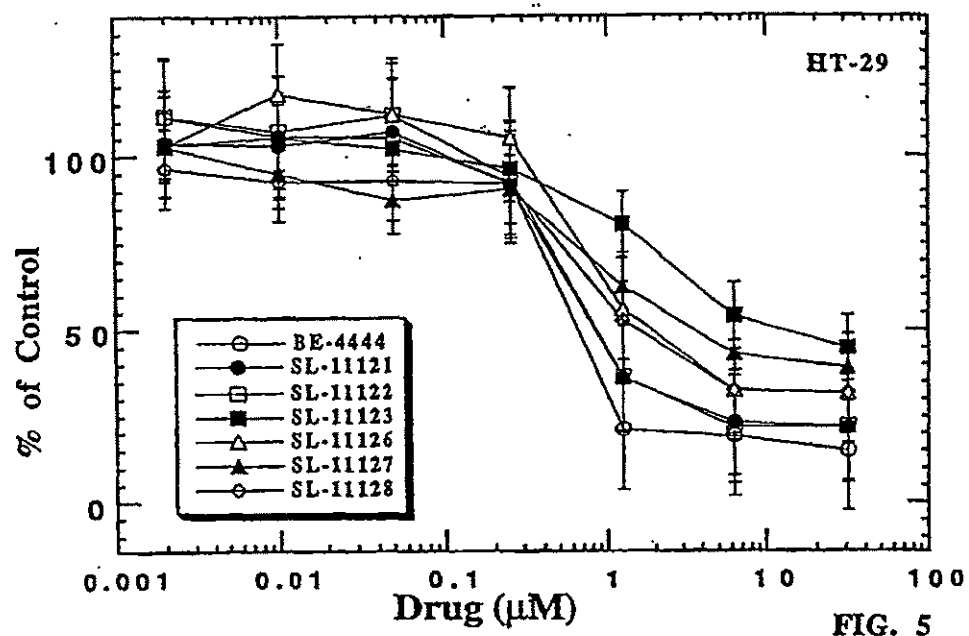


FIG. 4



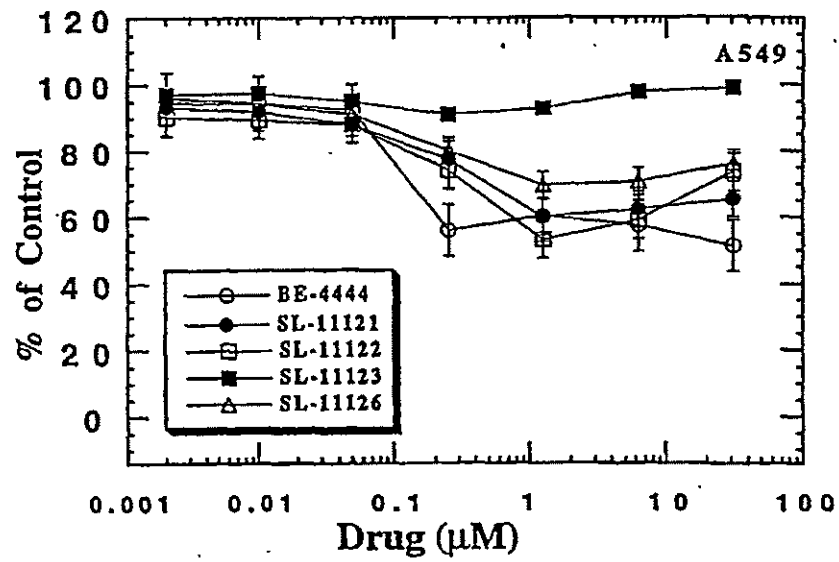


FIG. 6

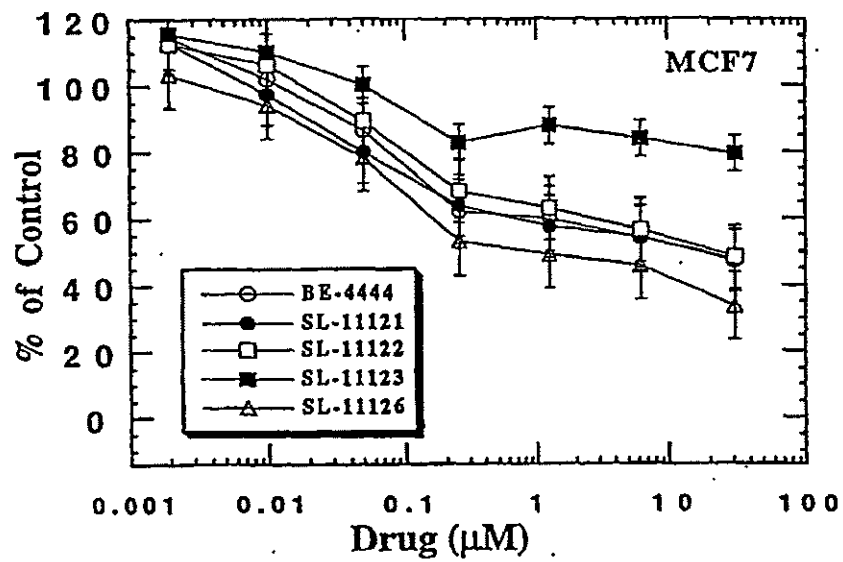


FIG. 7

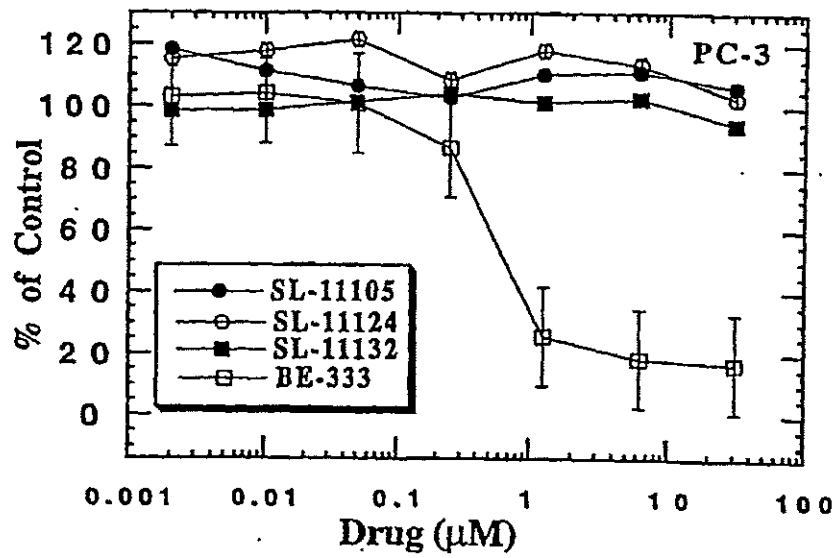


FIG. 8

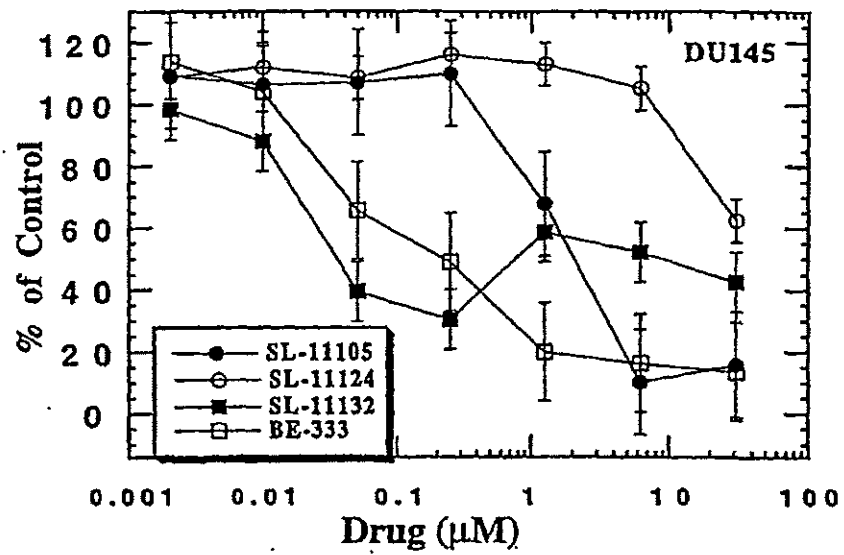


FIG. 9

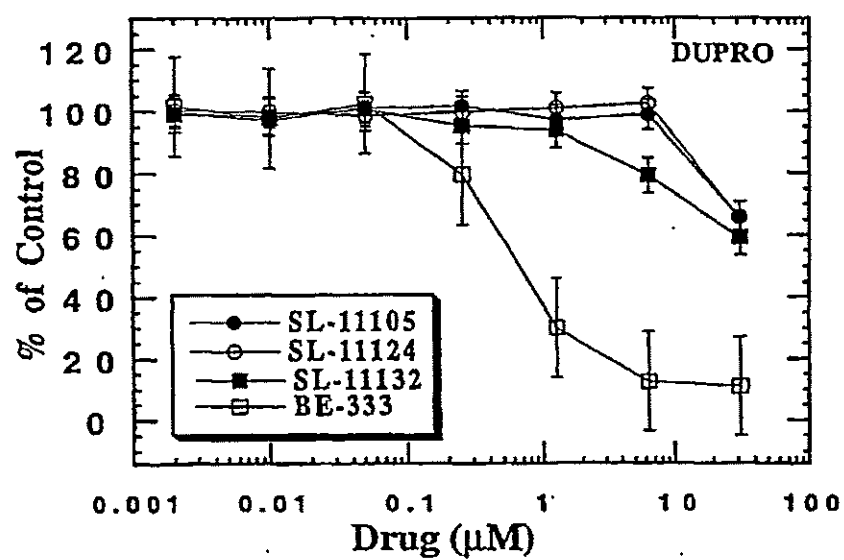


FIG. 10

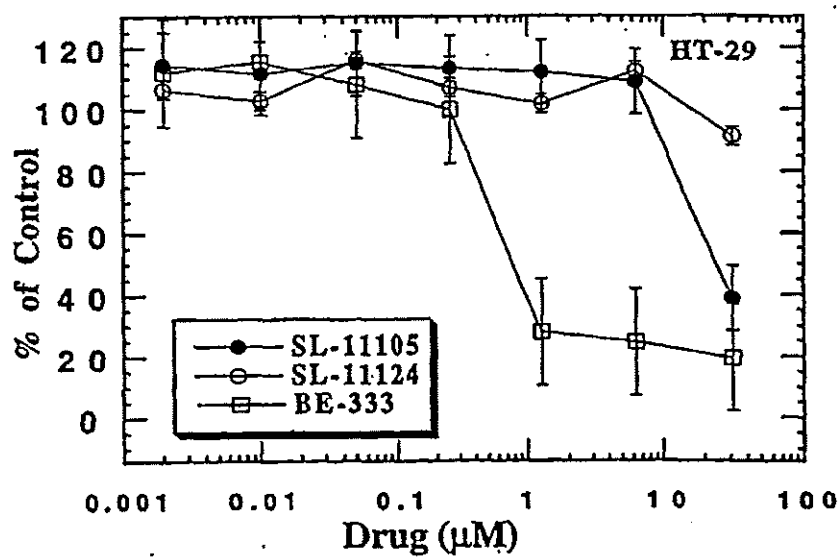


FIG. 11

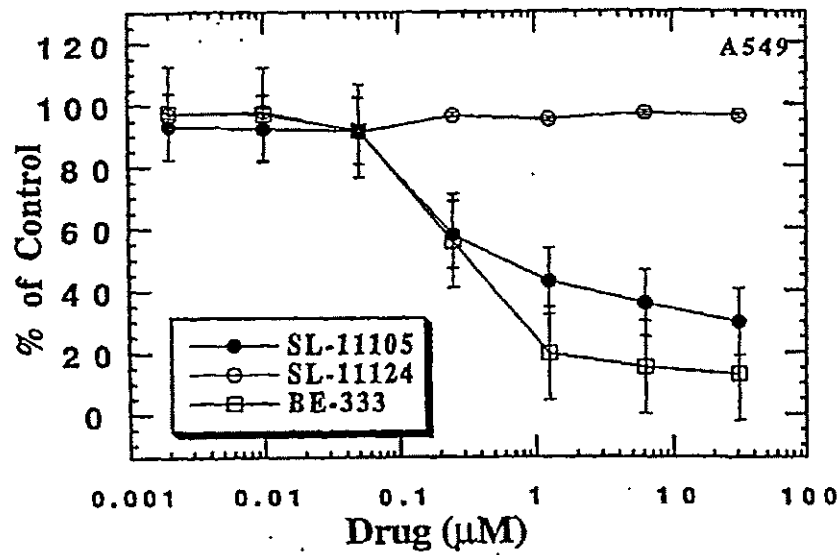


FIG. 12

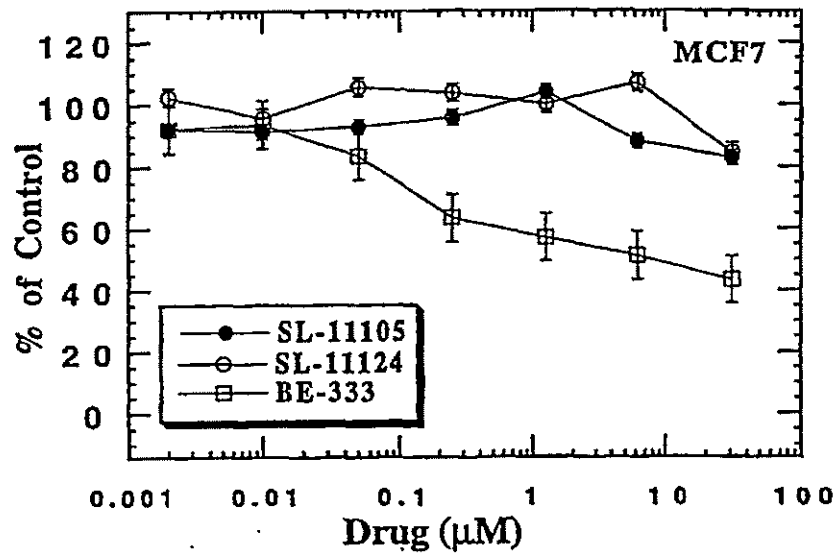


FIG. 13

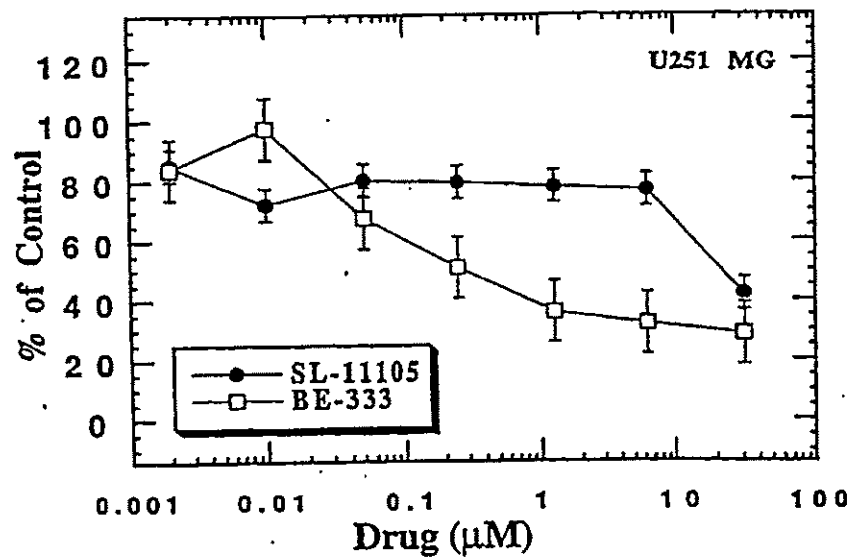


FIG. 14

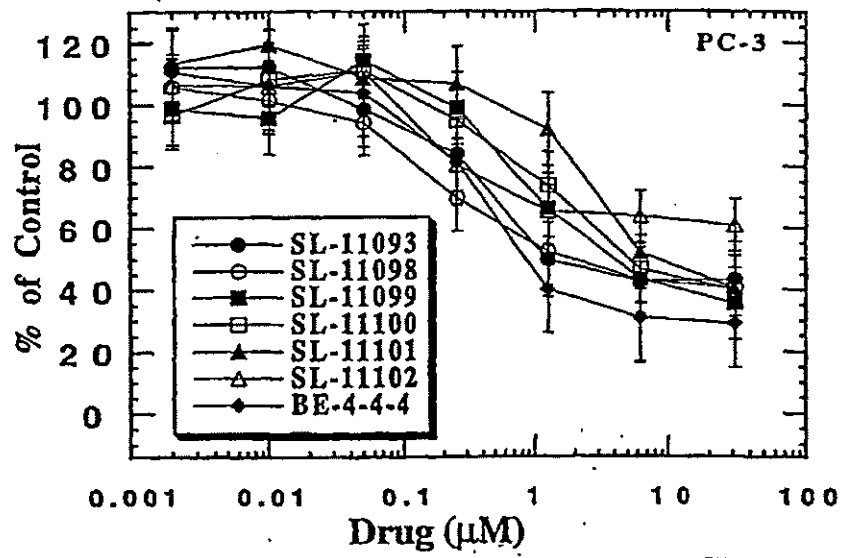


FIG. 15A

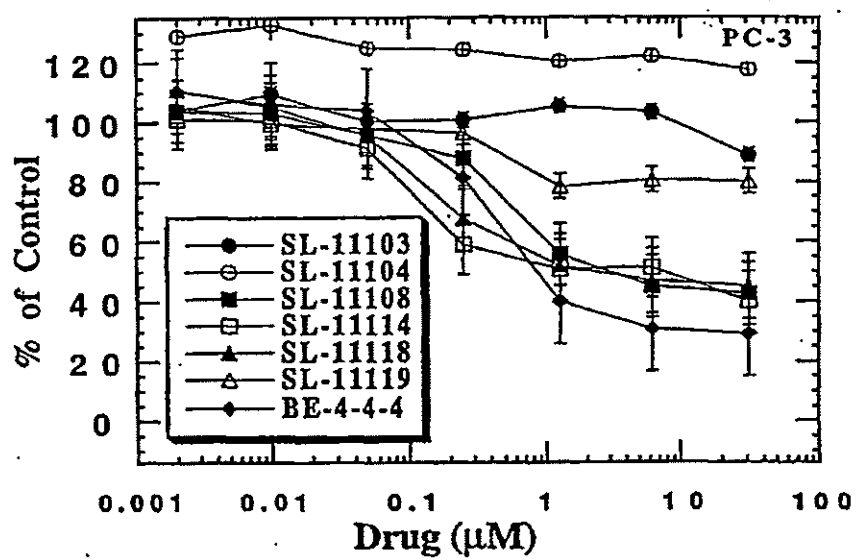


FIG. 15B

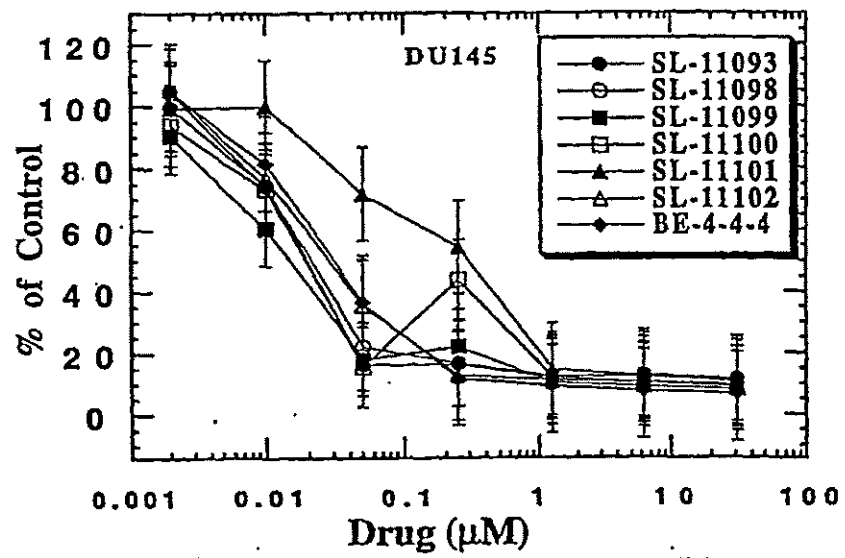


FIG. 16 A.

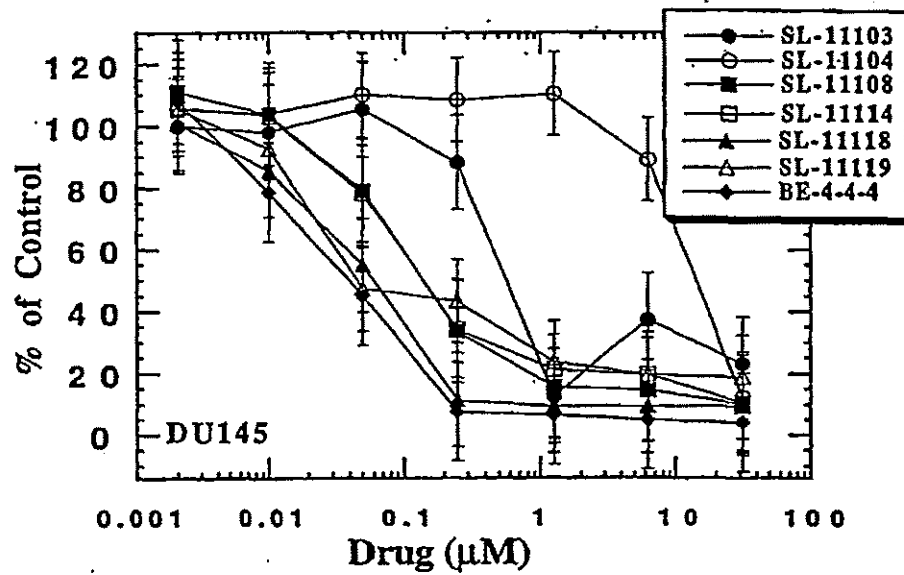


FIG. 16 B

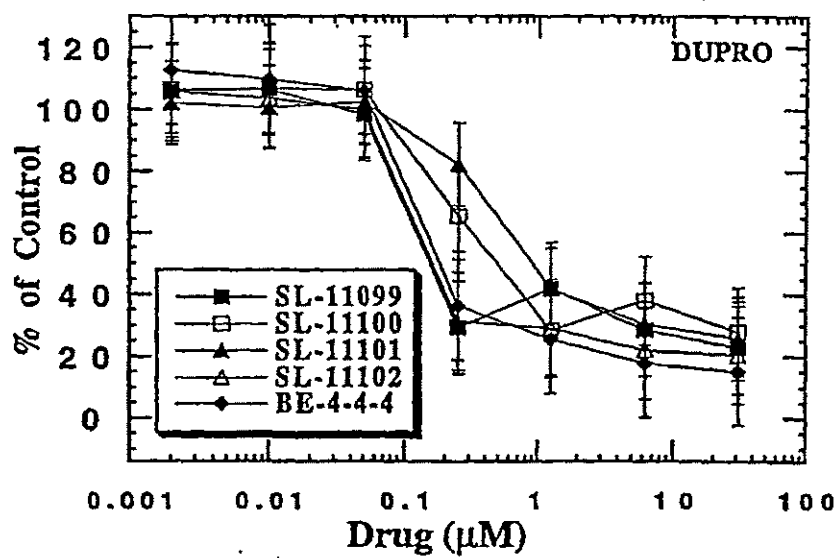


FIG. 17 A

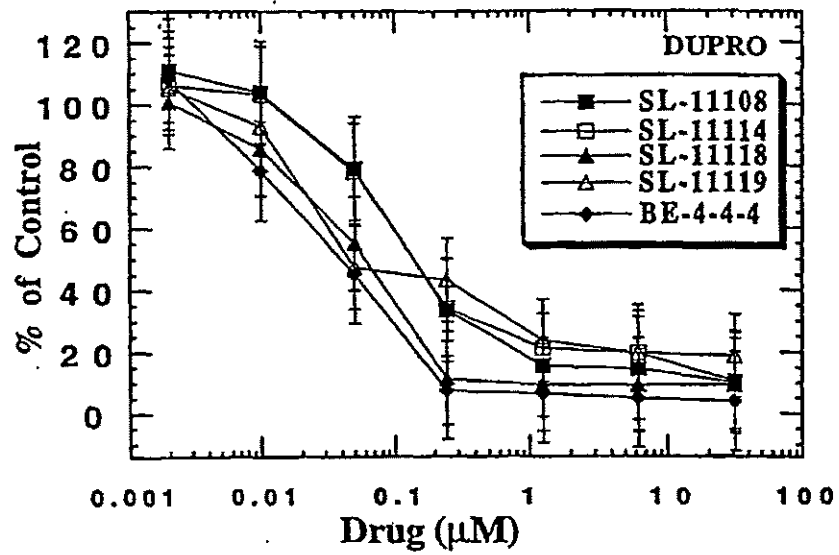


FIG. 17 B

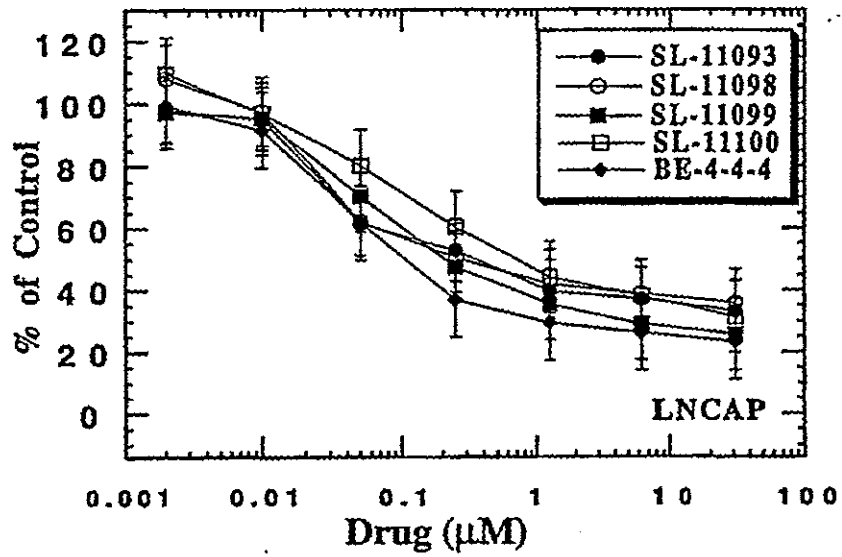


FIG. 18 A

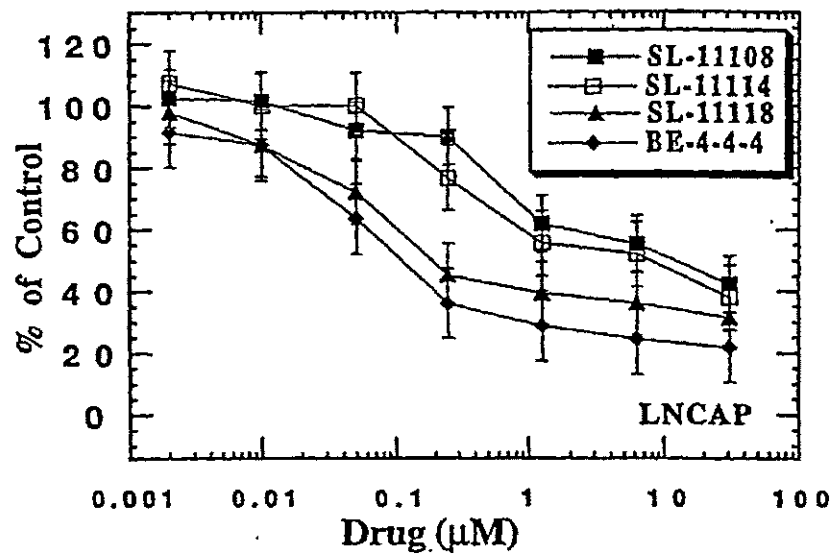
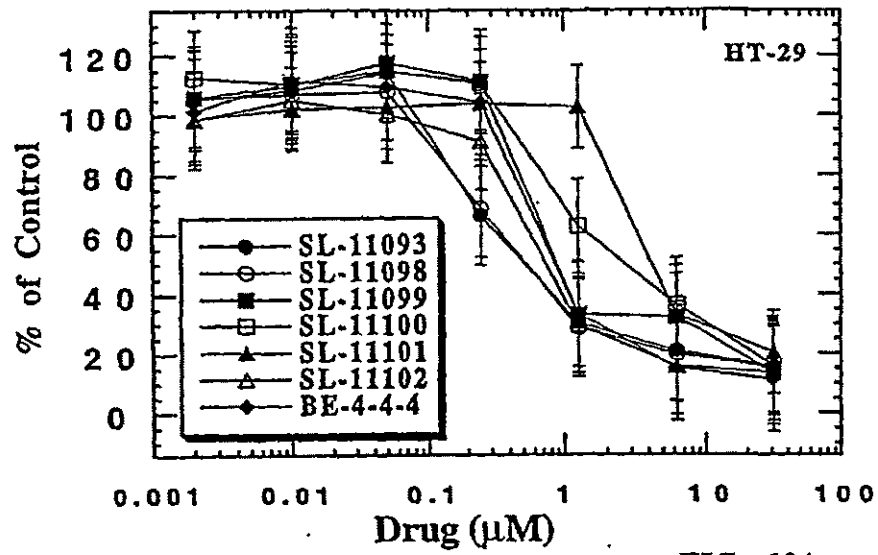


FIG. 18 B



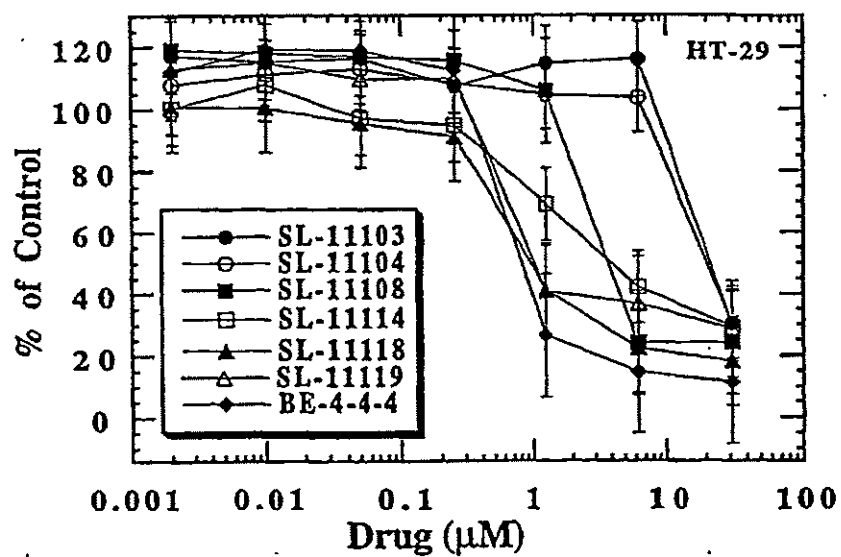
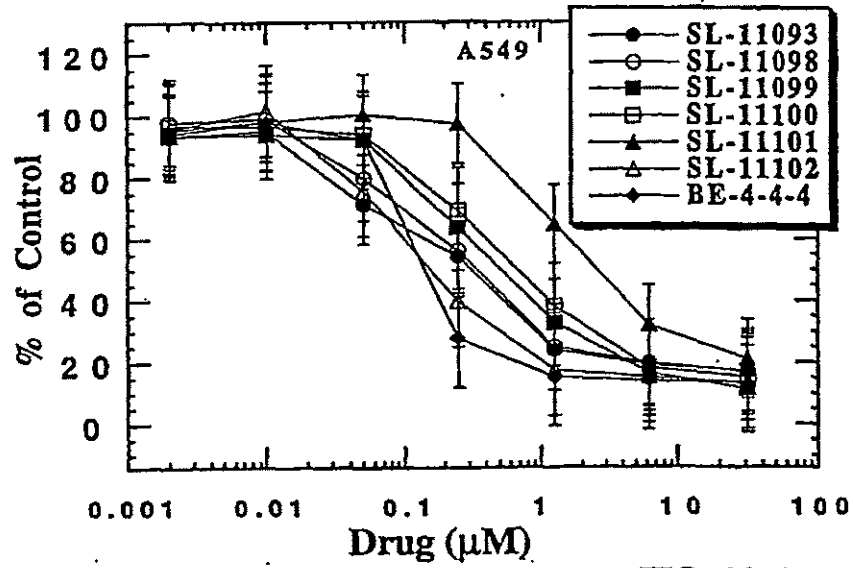


FIG. 19B



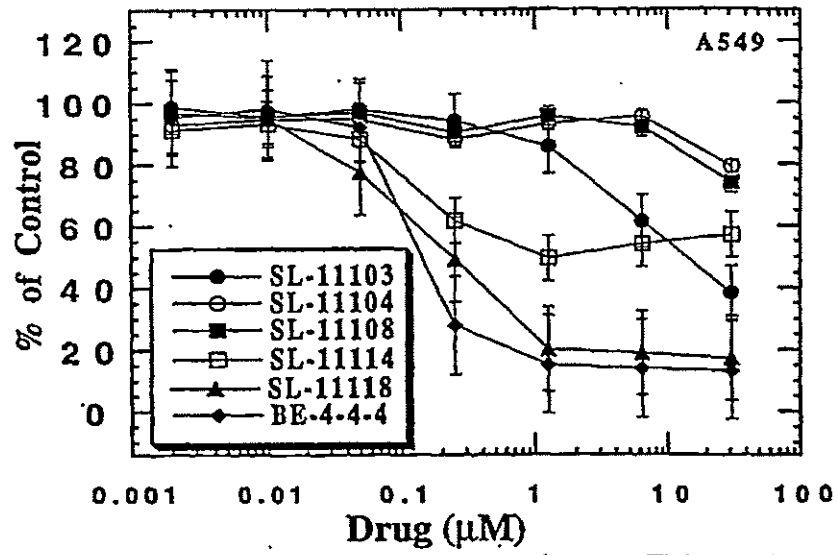


FIG. 20 B

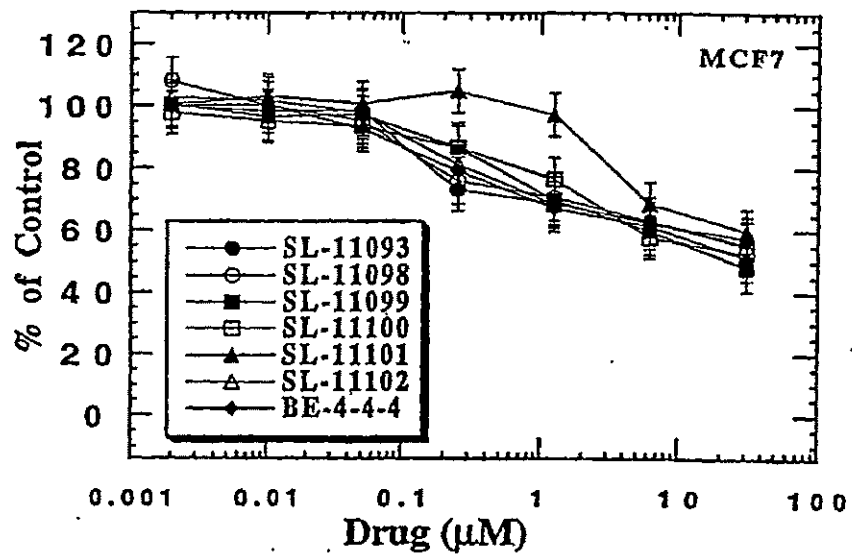


FIG. 21 A

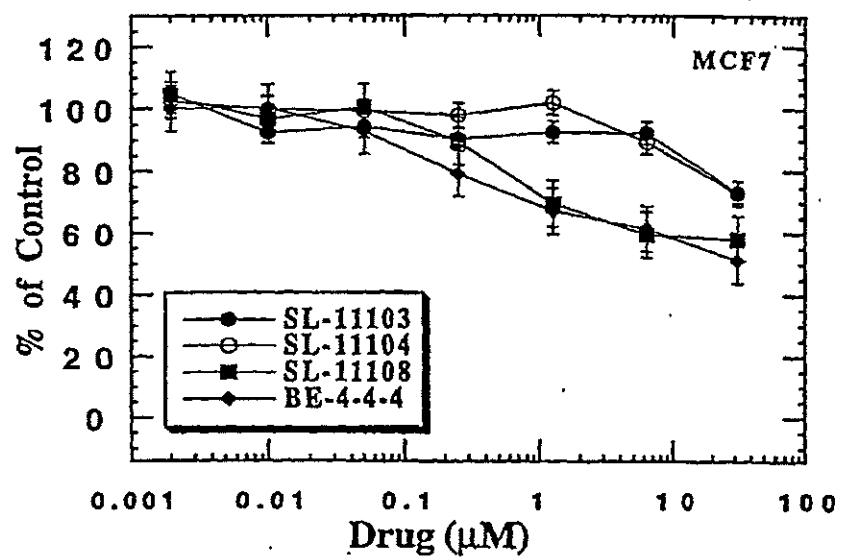


FIG. 21 B

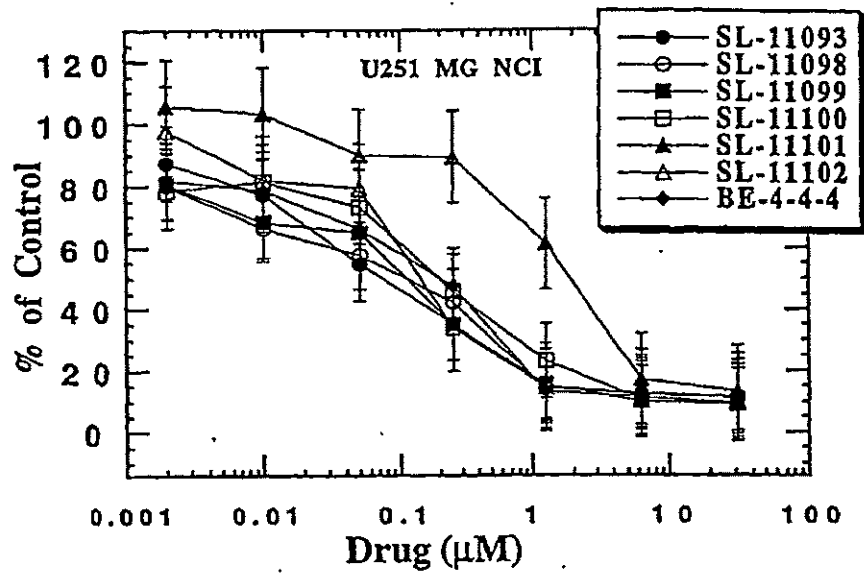


FIG. 22 A

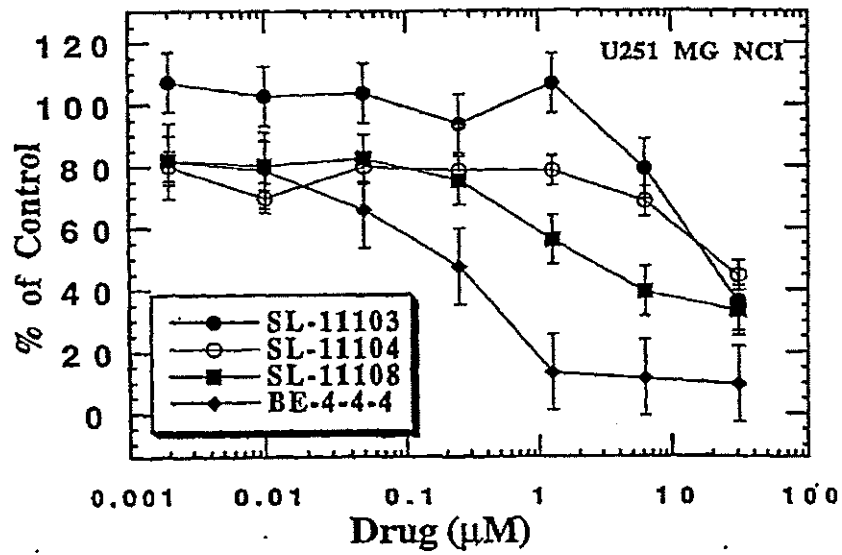


FIG. 22 B

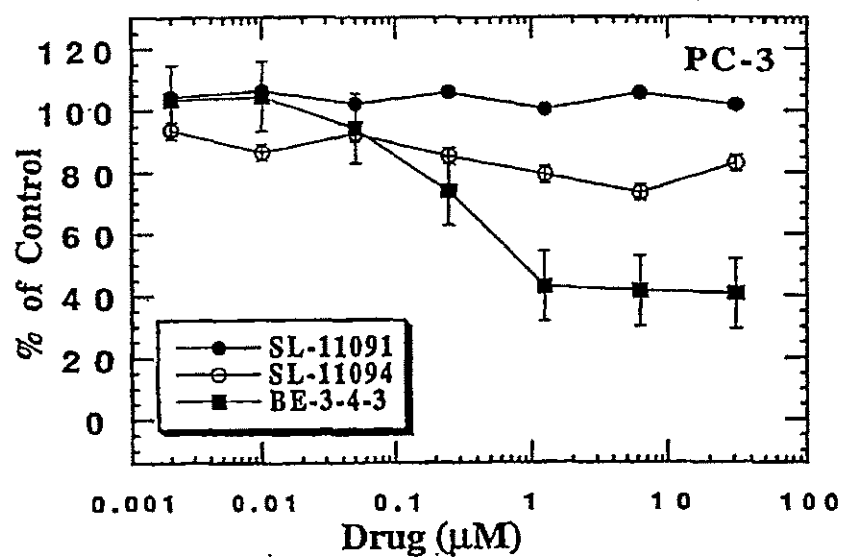


FIG. 23

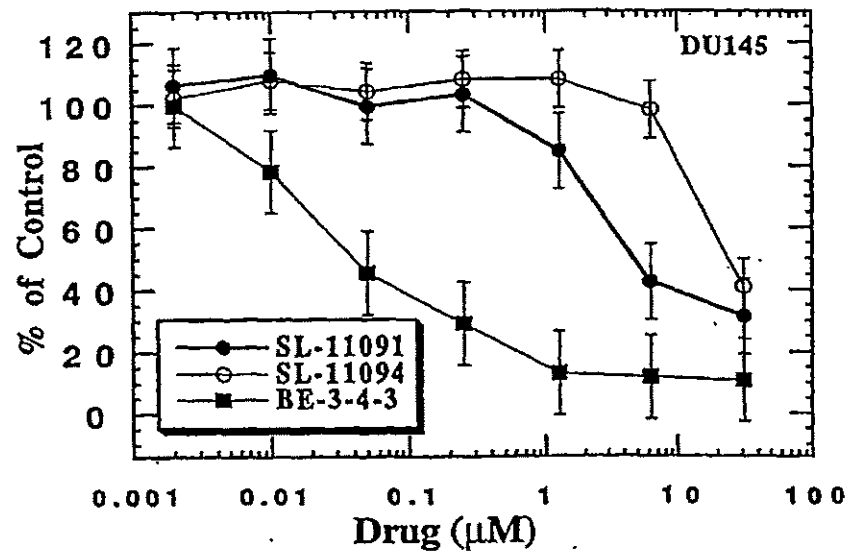


FIG. 24

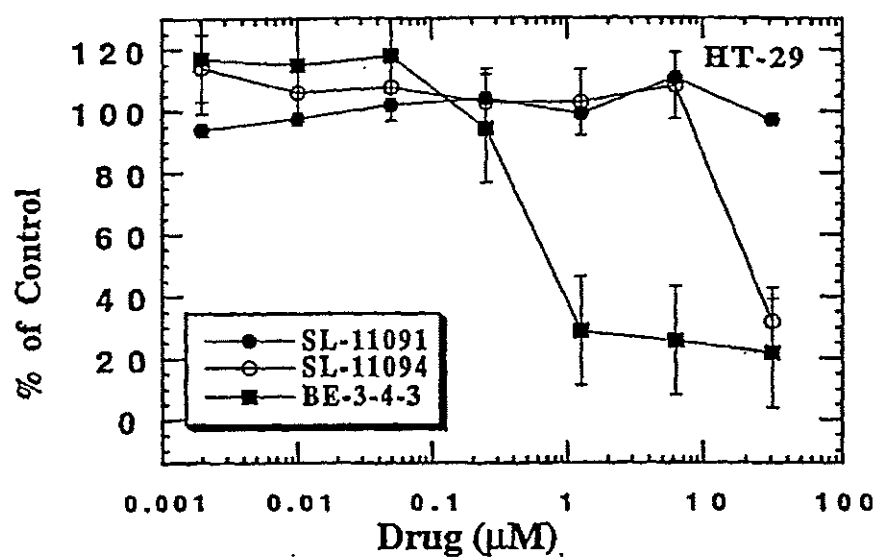


FIG. 25

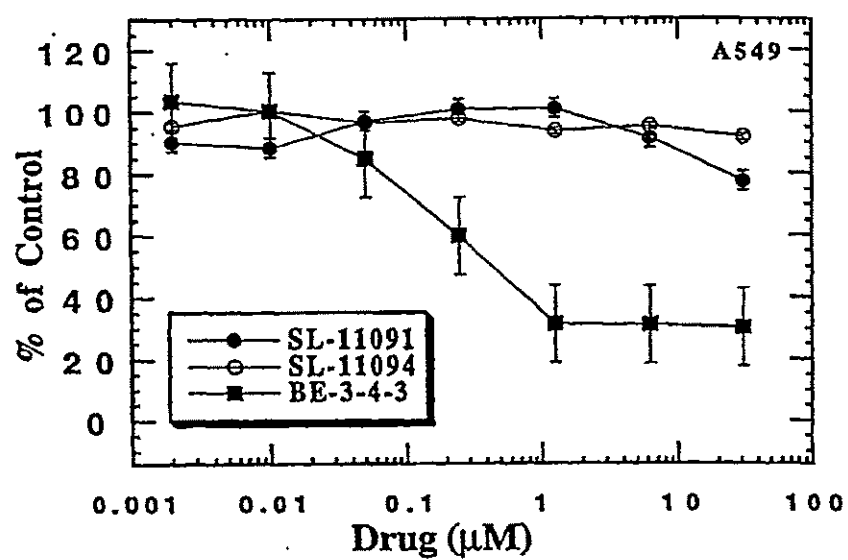


FIG. 26

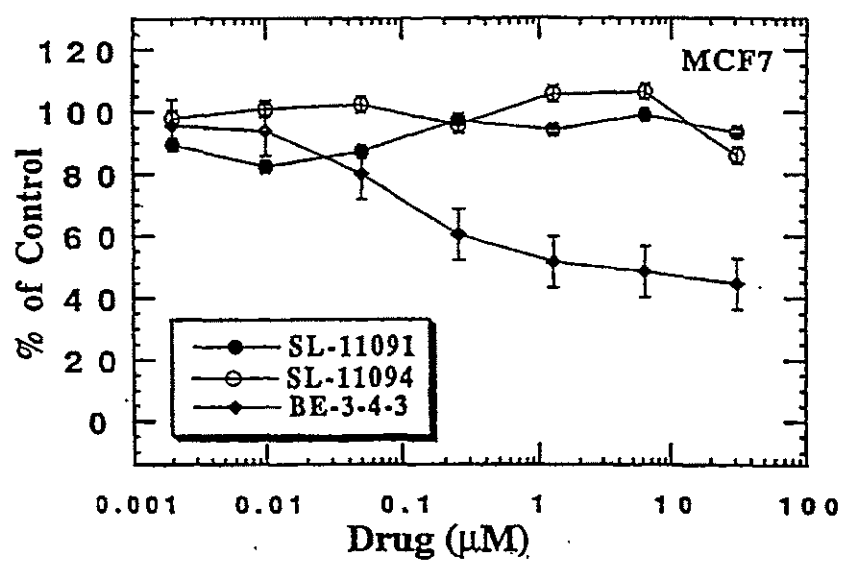


FIG. 27

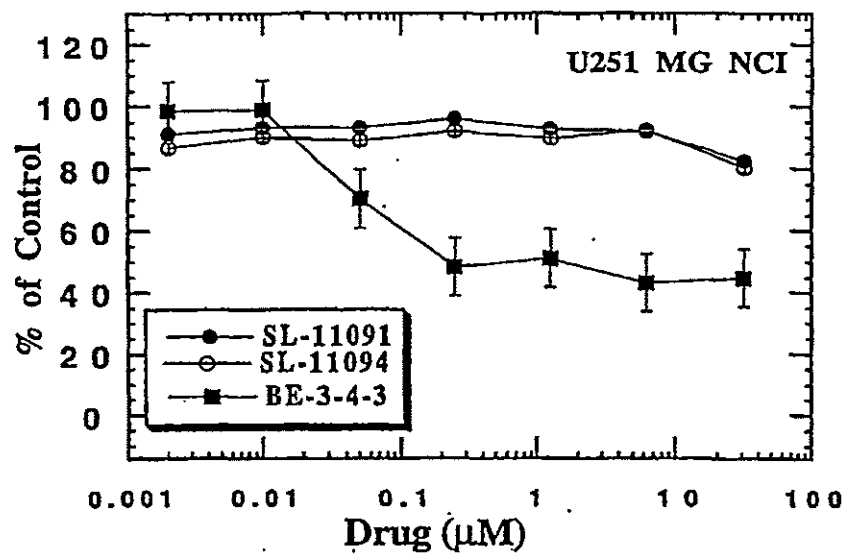
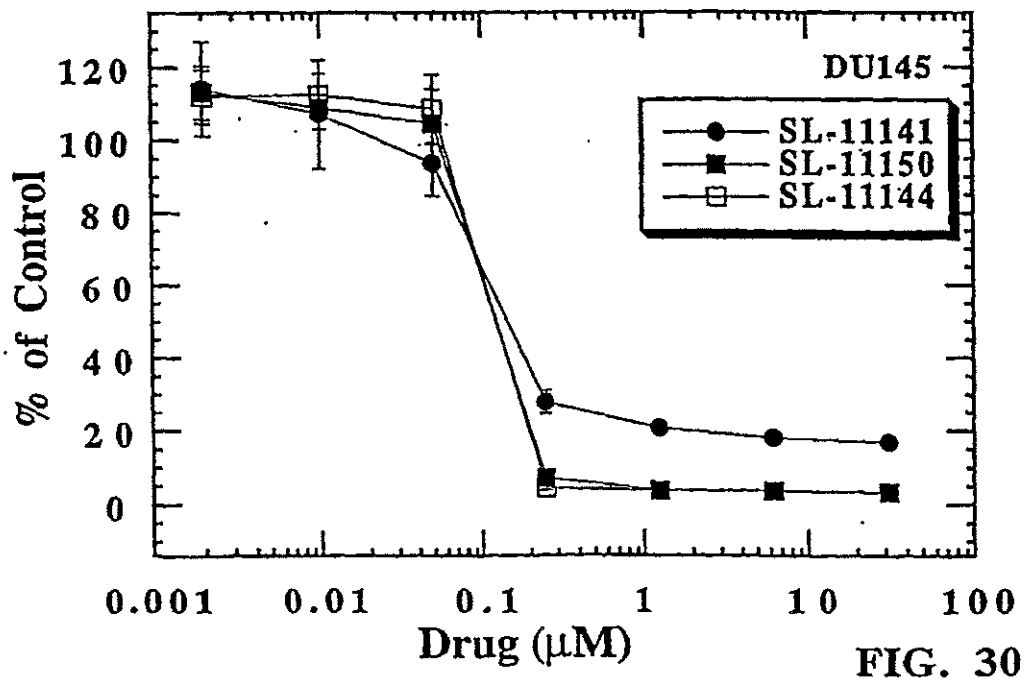
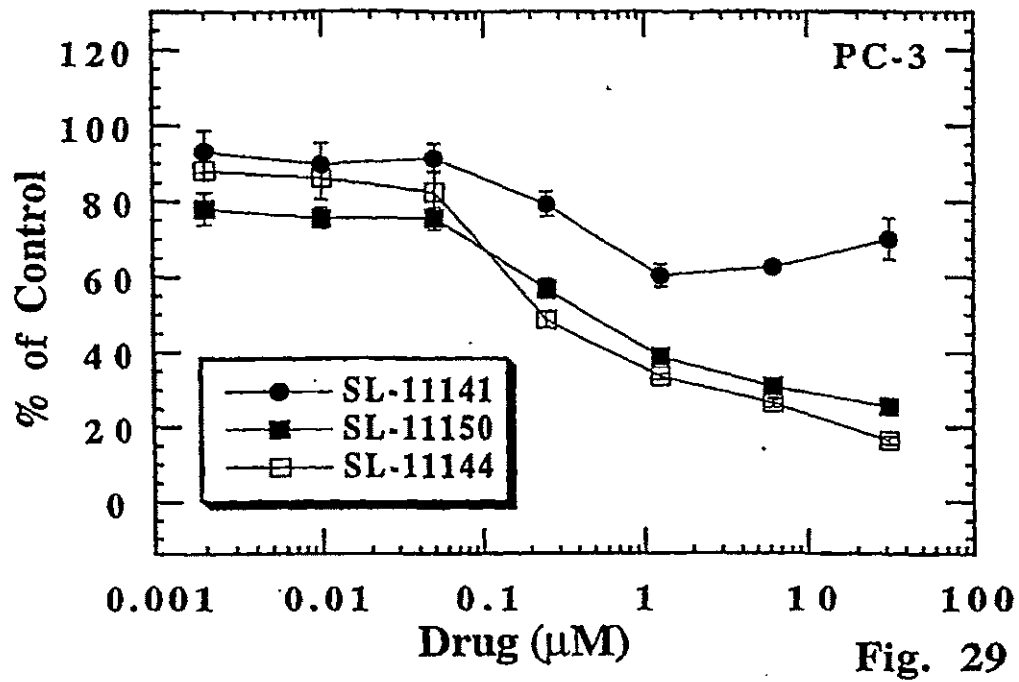


FIG. 28



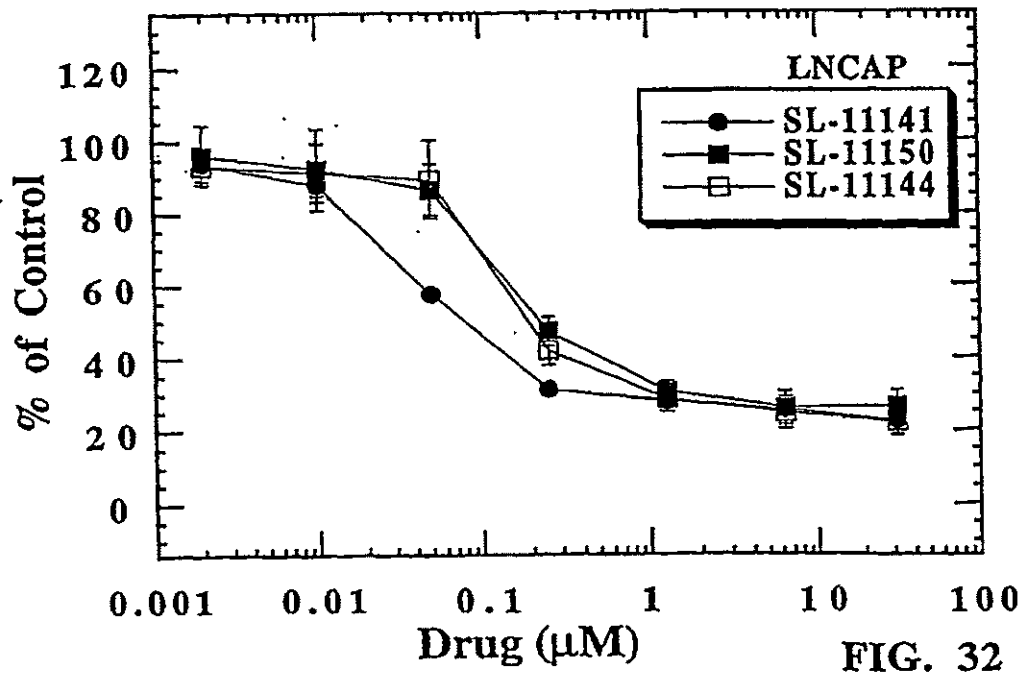
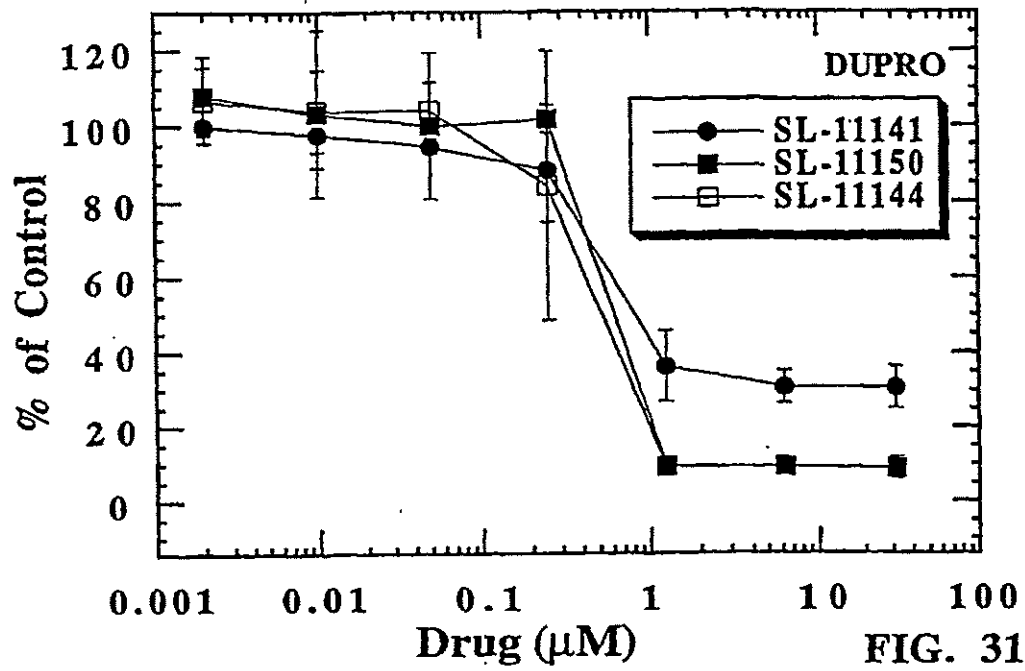


Figure 33

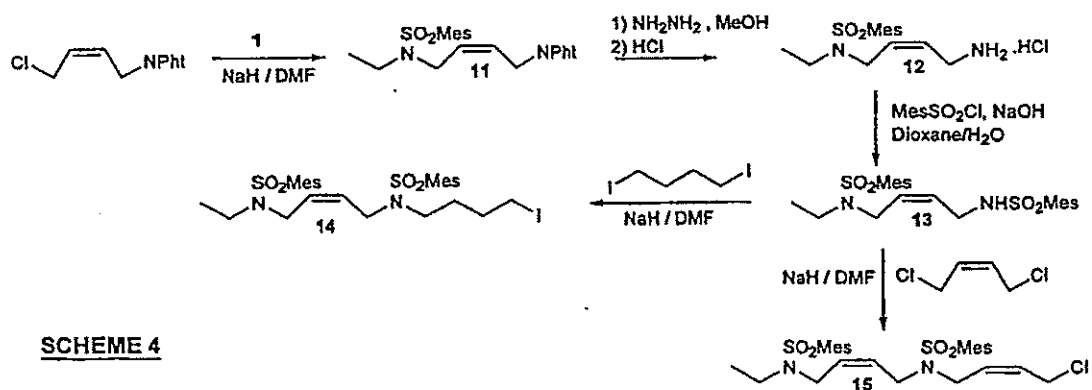
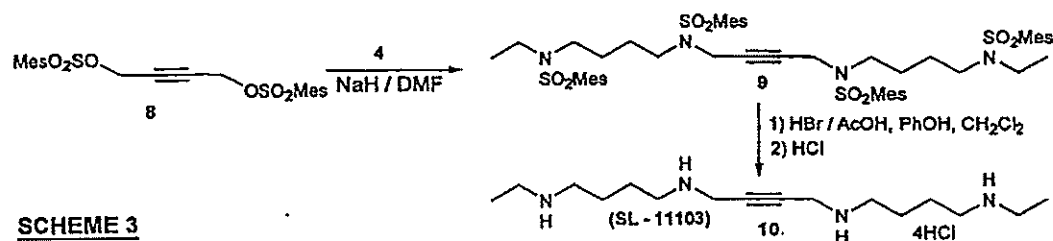
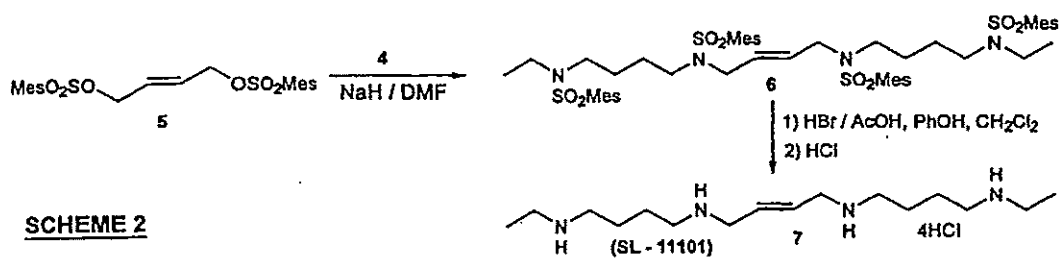
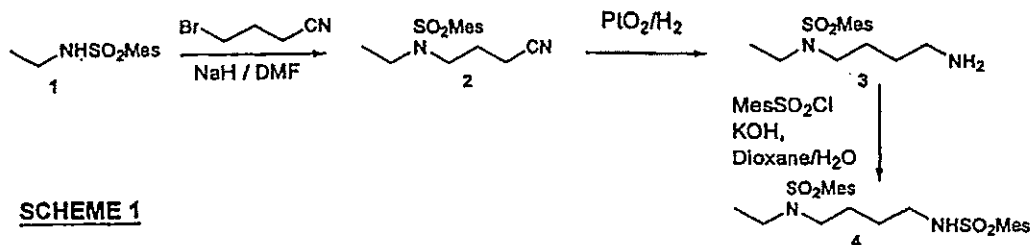


Figure 34

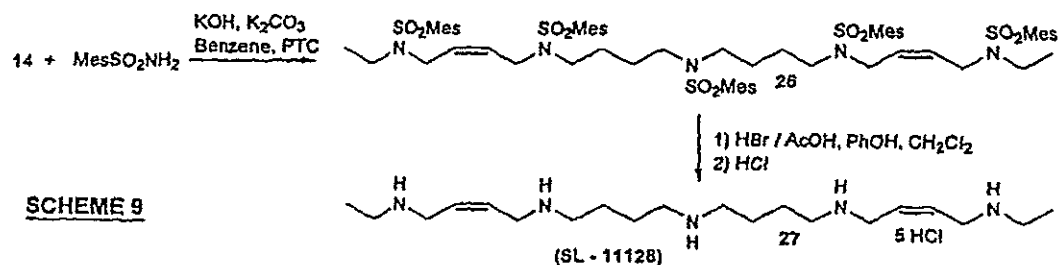
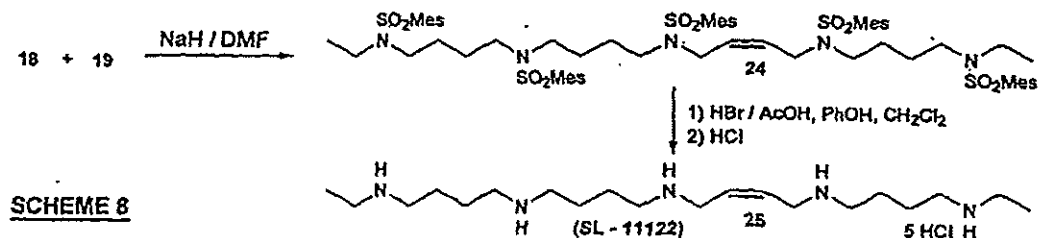
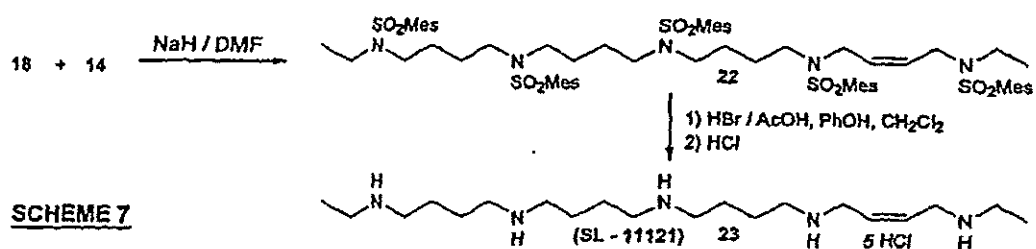
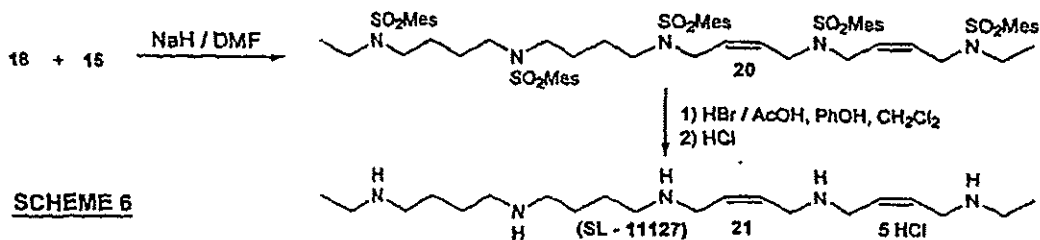
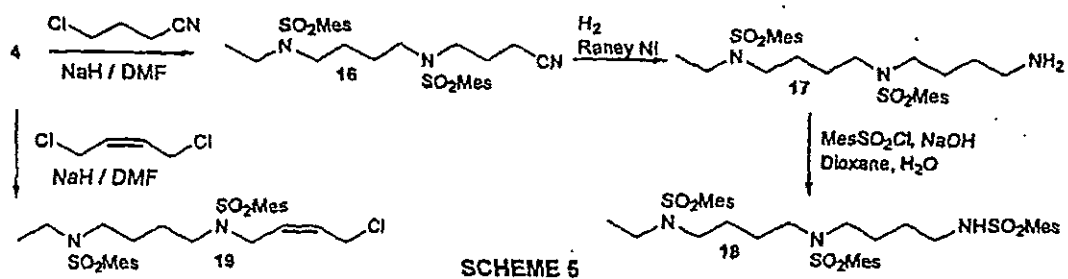


Figure 35

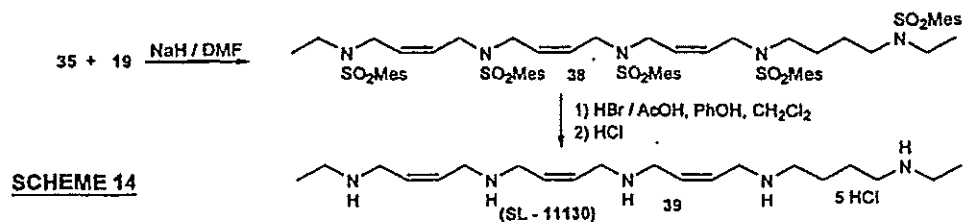
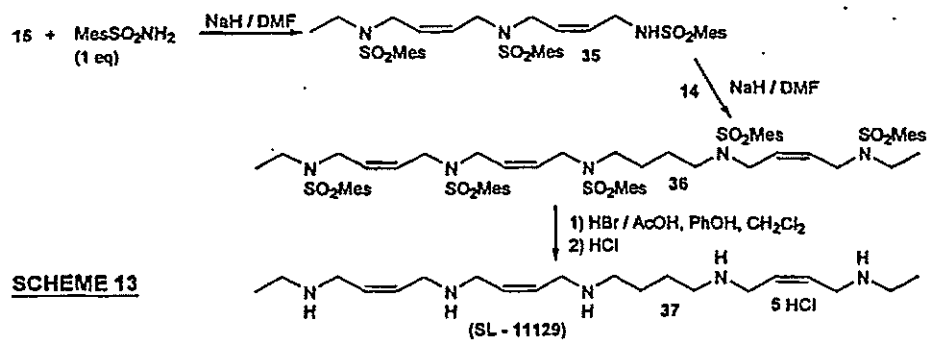
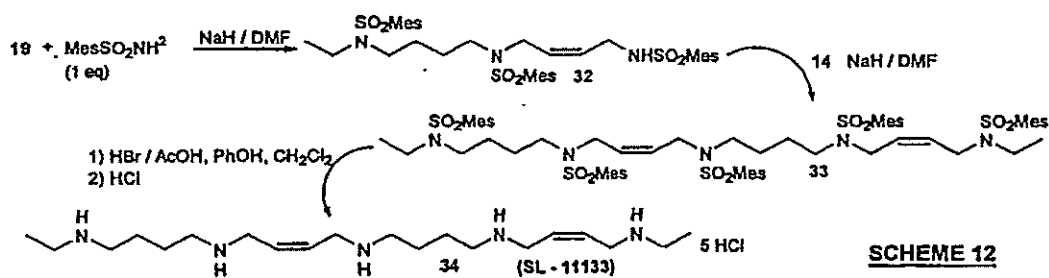
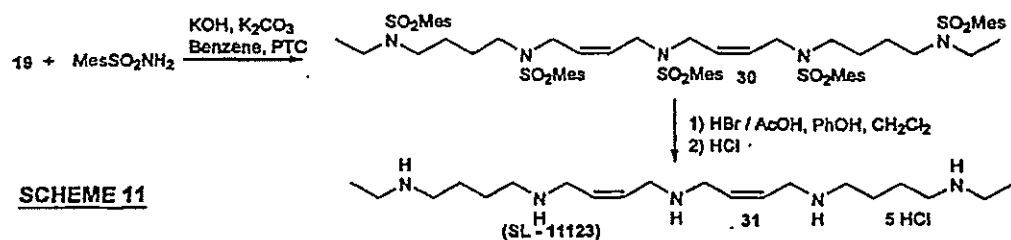
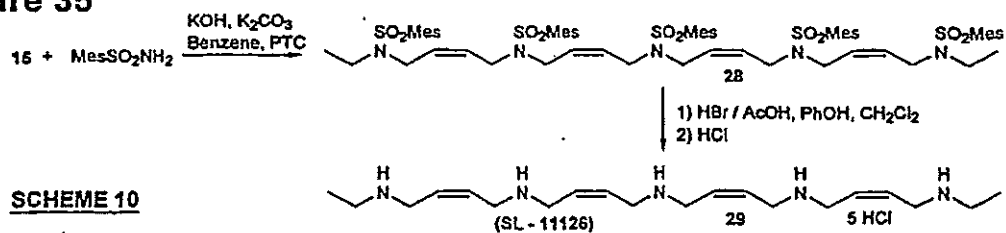


Figure 36

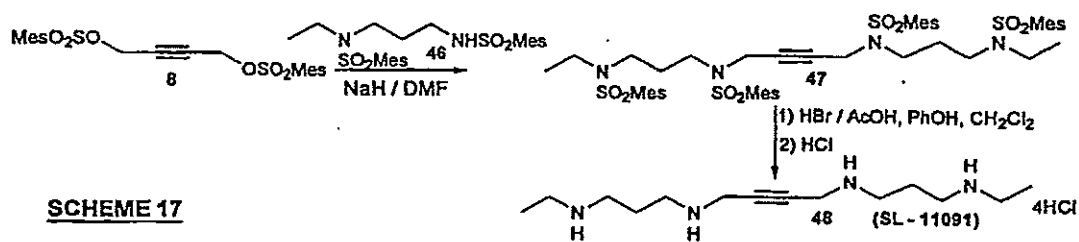
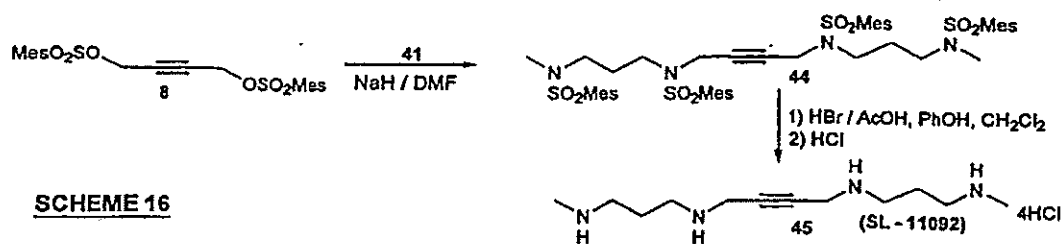
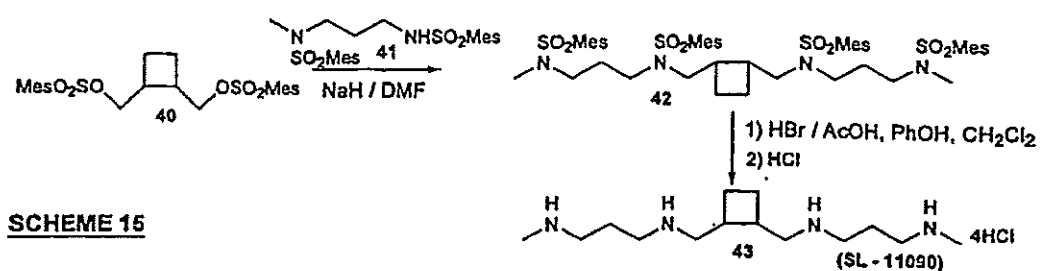


Figure 37

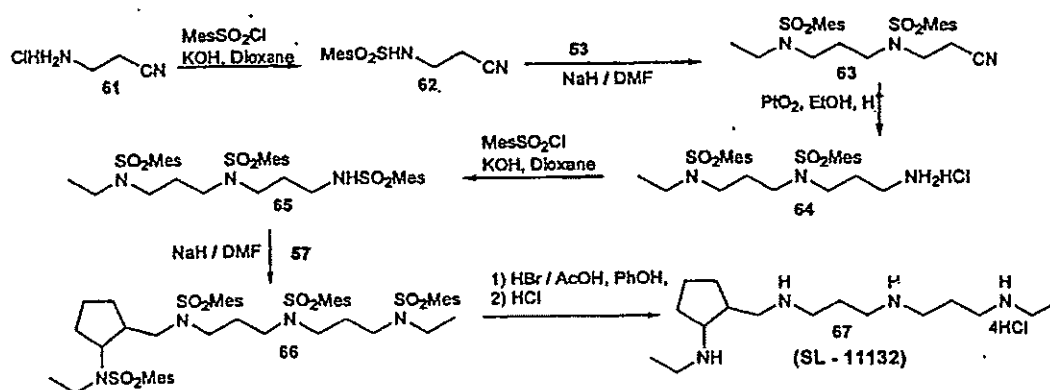
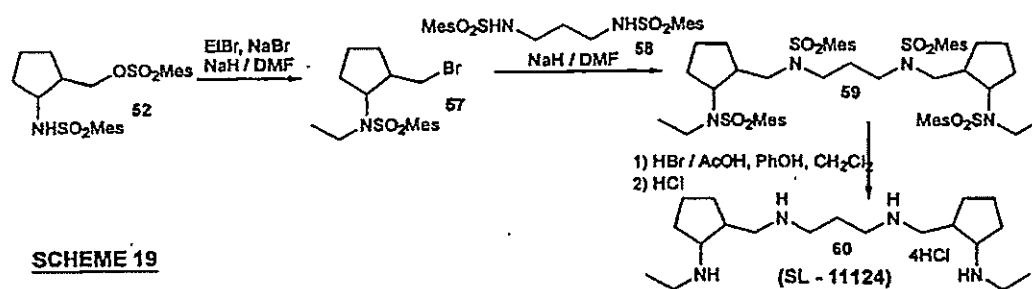
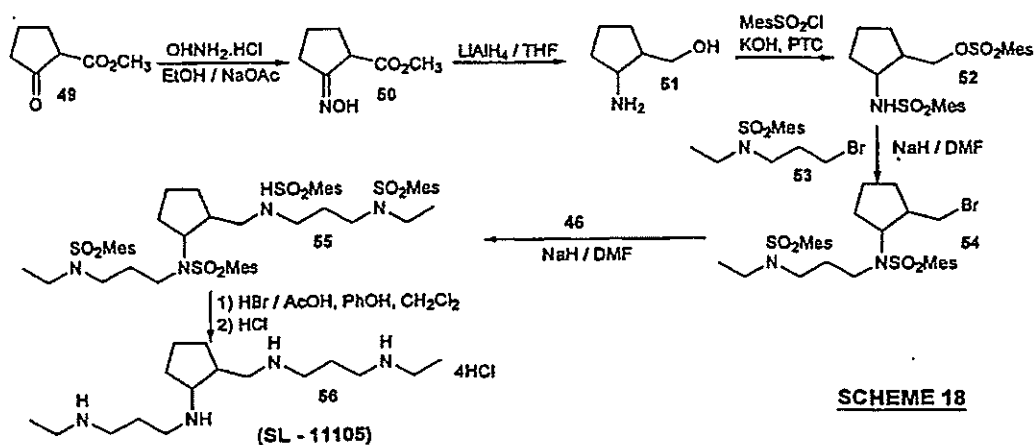
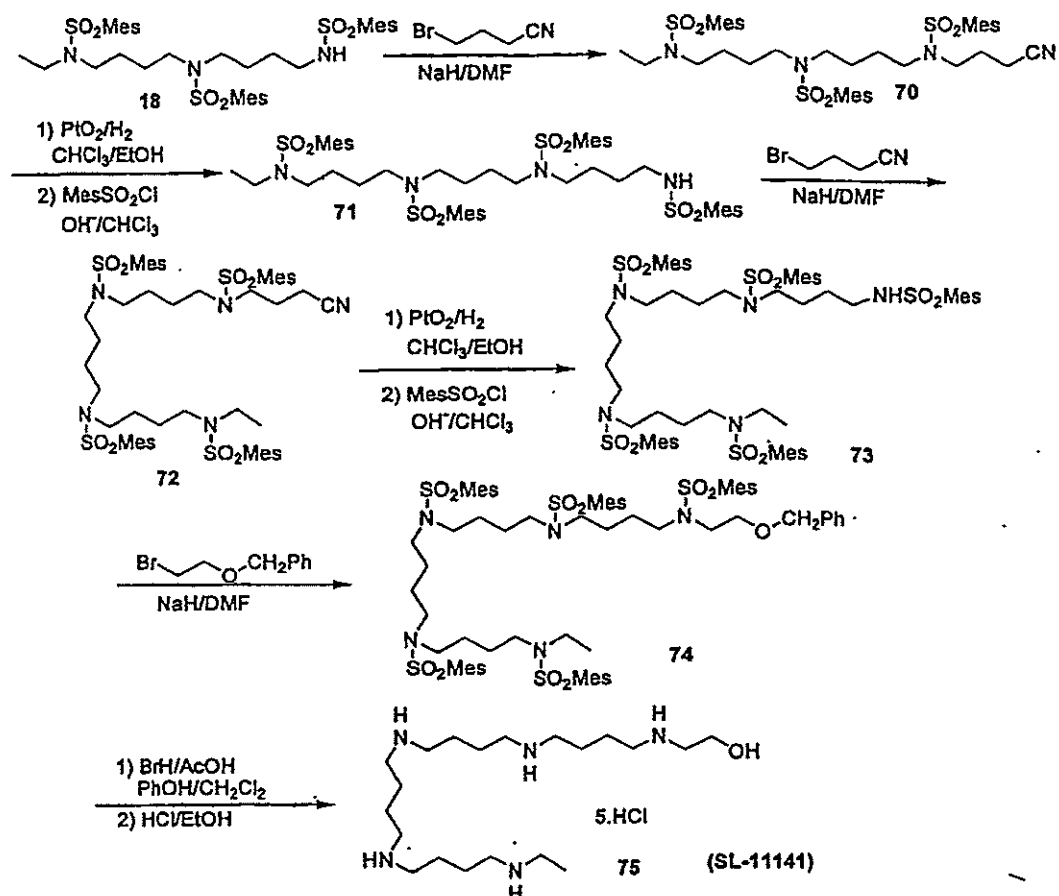


Figure ~~39~~ 30

SCHEME 22



SCHEME 23

