



(86) Date de dépôt PCT/PCT Filing Date: 1996/07/12
(87) Date publication PCT/PCT Publication Date: 1997/02/13
(45) Date de délivrance/Issue Date: 2007/01/09
(85) Entrée phase nationale/National Entry: 1998/01/21
(86) N° demande PCT/PCT Application No.: NO 1996/000179
(87) N° publication PCT/PCT Publication No.: 1997/005154
(30) Priorité/Priority: 1995/07/25 (GB9515279.9)

(51) Cl.Int./Int.Cl. *C07H 19/09* (2006.01),
A61K 31/70 (2006.01), *C07H 19/06* (2006.01)

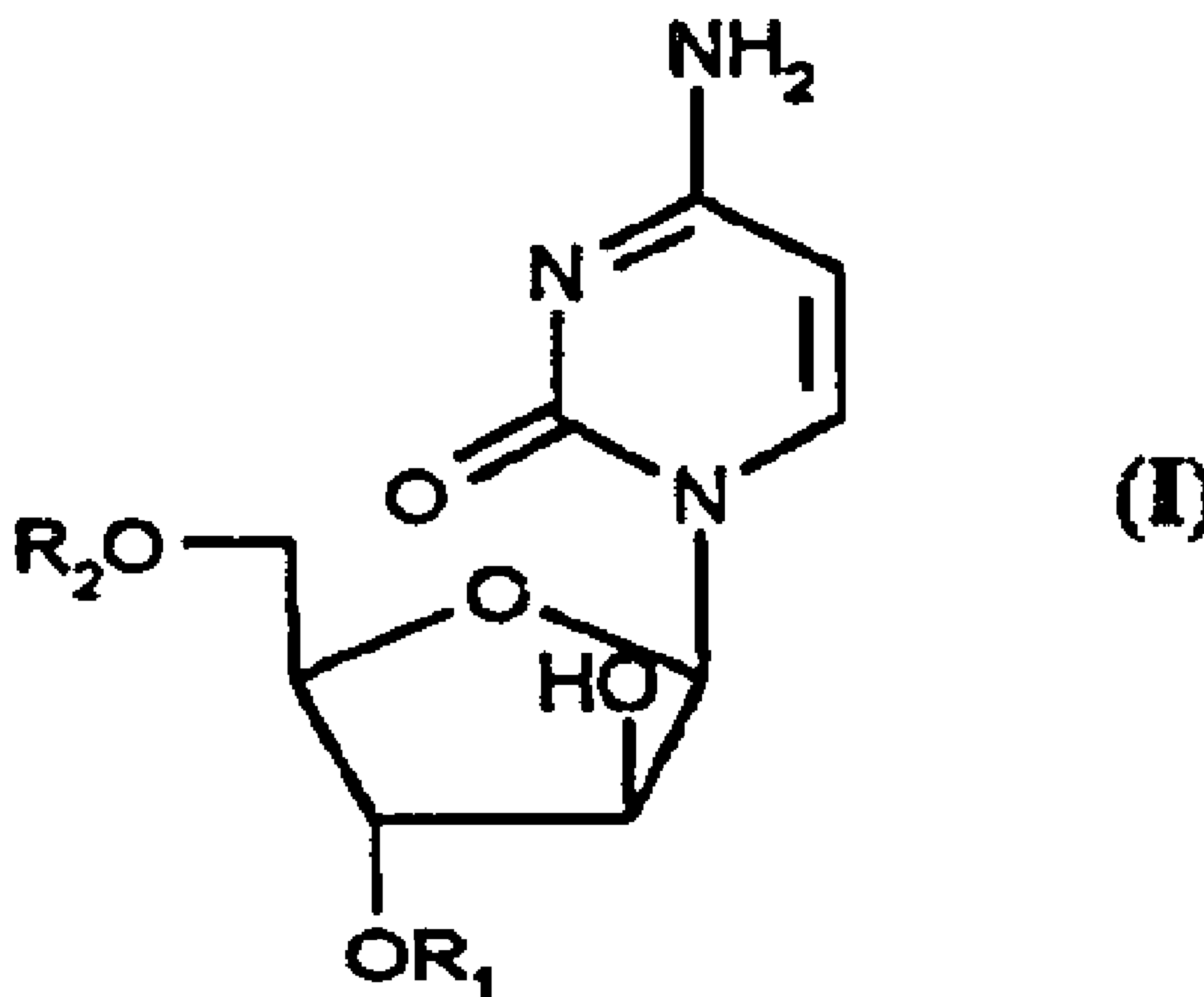
(72) Inventeurs/Inventors:
MYHREN, FINN, NO;
BORRETZEN, BERNT, NO;
DALEN, ARE, NO;
STOKKE, KJELL TORGEIR, NO

(73) Propriétaire/Owner:
CONPHARMA AS, NO

(74) Agent: FETHERSTONHAUGH & CO.

(54) Titre : AGENTS THERAPEUTIQUES AMELIORES

(54) Title: IMPROVED THERAPEUTIC AGENTS



(57) Abrégé/Abstract:

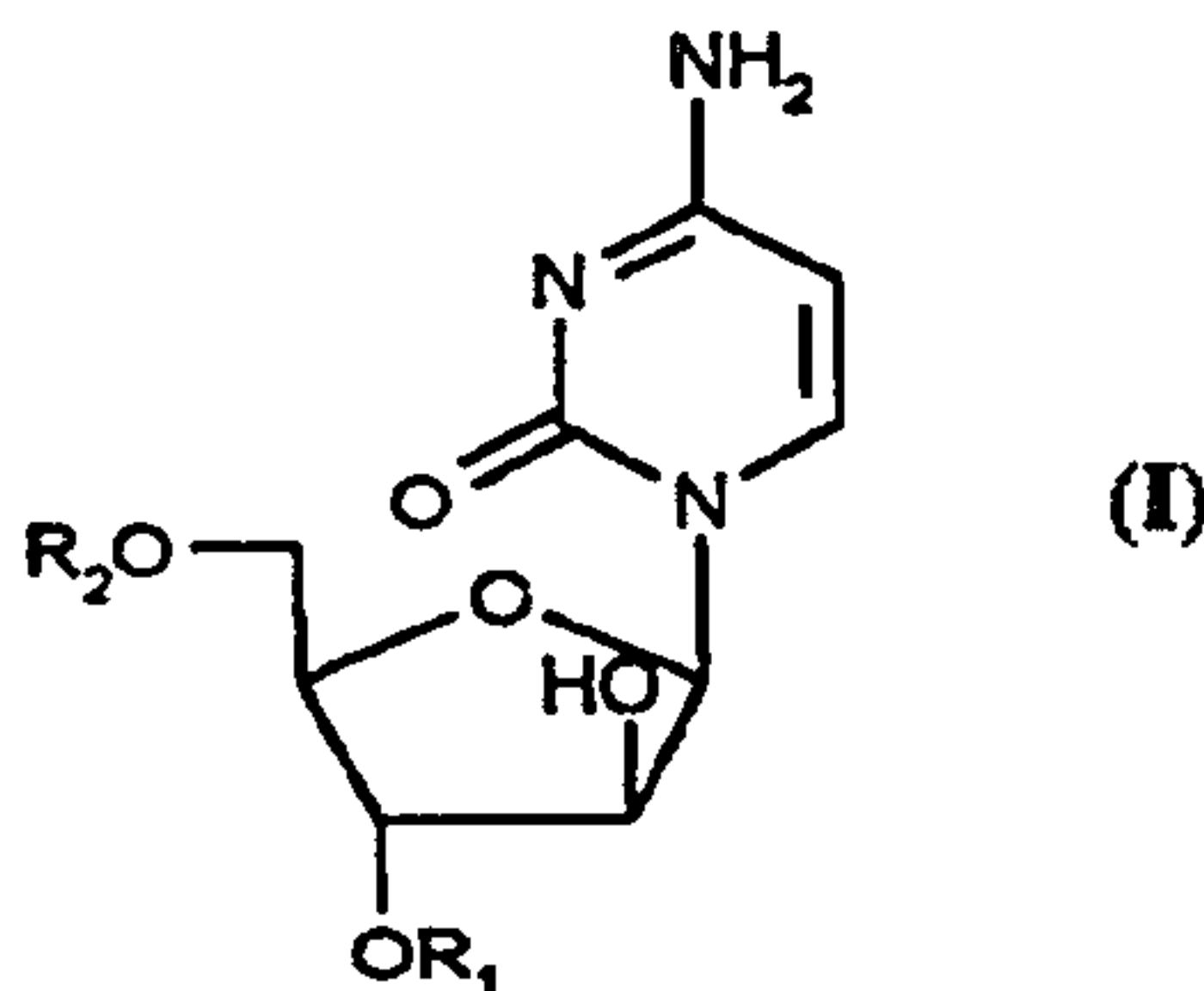
This invention relates to new nucleoside derivatives of formula (I); wherein R_1 and R_2 are independently selected from hydrogen, elaidoyl, oleoyl, stearoyl, eicosenoyl (cis or trans) and eicosanoyl, with the provisos that R_1 and R_2 cannot both be hydrogen, oleoyl or stearoyl, R_1 cannot be hydrogen when R_2 is oleoyl or stearoyl, and R_2 cannot be hydrogen when R_1 is elaidoyl, oleoyl or stearoyl. Further, the invention relates to the use of the nucleoside derivatives of formula (I) wherein R_1 and R_2 are independently selected from hydrogen, and C_{18} - and C_{20} -saturated and mono-unsaturated acyl groups, with the provisos that R_1 and R_2 cannot both be hydrogen, in the manufacture of a pharmaceutical preparation for the treatment of tumours.

PCTWORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : C07H 19/06	A1	(11) International Publication Number: WO 97/05154 (43) International Publication Date: 13 February 1997 (13.02.97)
(21) International Application Number: PCT/NO96/00179 (22) International Filing Date: 12 July 1996 (12.07.96) (30) Priority Data: 9515279.9 25 July 1995 (25.07.95) GB (71) Applicant (for all designated States except US): NORSK HYDRO A.S [NO/NO]; N-0240 Oslo (NO). (72) Inventors; and (75) Inventors/Applicants (for US only): MYHREN, Finn [NO/NO]; Leirkuppgt. 7, N-3915 Porsgrunn (NO). BØRRETZEN, Bernt [NO/NO]; Granlia 3, N-3940 Heistad (NO). DALEN, Are [NO/NO]; Nordahl Brunsvei 7, N-7015 Trondheim (NO). STOKKE, Kjell, Torgeir [NO/NO]; Kampheimveien 6B, N-0685 Oslo (NO). (74) Agent: LILLEGRAVEN, Rita; Norsk Hydro a.s, N-0240 Oslo (NO).		(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published With international search report. With amended claims.

(54) Title: IMPROVED THERAPEUTIC AGENTS



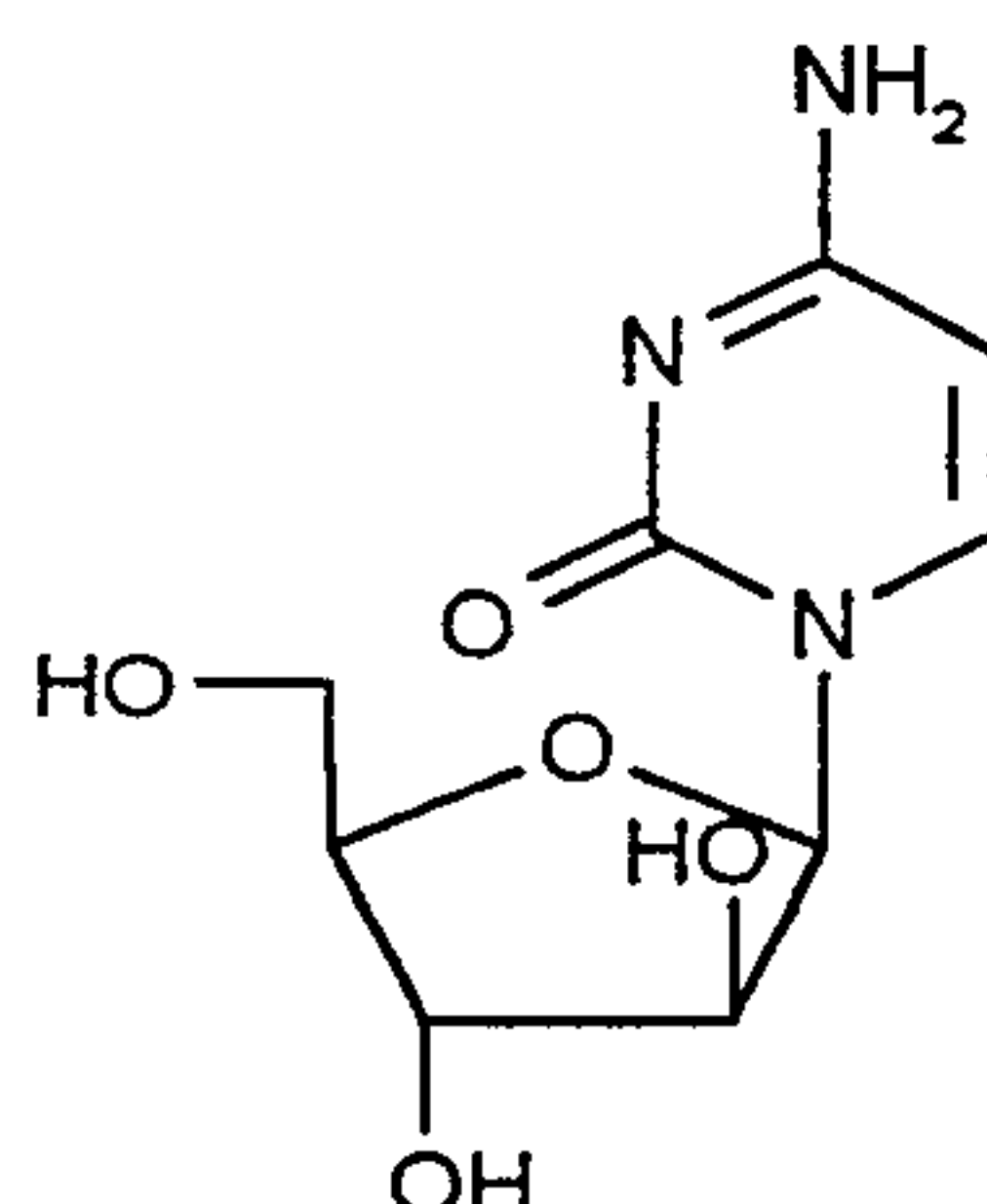
(57) Abstract

This invention relates to new nucleoside derivatives of formula (I); wherein R_1 and R_2 are independently selected from hydrogen, elaidoyl, oleoyl, stearoyl, eicosenoyl (cis or trans) and eicosanoyl, with the provisos that R_1 and R_2 cannot both be hydrogen, oleoyl or stearoyl, R_1 cannot be hydrogen when R_2 is oleoyl or stearoyl, and R_2 cannot be hydrogen when R_1 is elaidoyl, oleoyl or stearoyl. Further, the invention relates to the use of the nucleoside derivatives of formula (I) wherein R_1 and R_2 are independently selected from hydrogen, and C_{18} - and C_{20} -saturated and mono-unsaturated acyl groups, with the provisos that R_1 and R_2 cannot both be hydrogen, in the manufacture of a pharmaceutical preparation for the treatment of tumours.

"IMPROVED THERAPEUTIC AGENTS"

This invention relates to certain nucleoside derivatives which have been found to have valuable properties for the treatment of tumours.

The nucleoside derivatives are esters of 1- β -D-arabinofuranosylcytosine (Ara-C) of formula A:



(A)

Ara-C is also sometimes known as cytosar.

Ara-C has long been known as a chemotherapeutic agent in the treatment of acute myelogenous leukaemia but has limited efficiency against solid tumours (Fre et al., Cancer Res. 29 (1969), 1325-1332; Davis et al., Oncology, 29 (1974), 190-200; Cullinan et al., Cancer Treat. Rep. 61 (1977), 1725-1726). However, even in the treatment of leukaemia Ara-C has found only limited use due to its very short biological half-life and its high toxicity.

With a view to overcoming these difficulties, a number of workers have prepared and tested pro-drug derivatives of Ara-C. For example, Hamamura et al. investigated 3'-acyl and 3',5'-diacyl derivatives of Ara-C (J. Med. Chem. 19 (1976) No. 5, 667-674). These workers prepared and tested numerous Ara-C derivatives with saturated or unsaturated ester groups containing from 2 to 22 carbon atoms, and they found that many of the

compounds showed a higher activity against L1210 Leukaemia in mice than the parent nucleoside alone.

The work by Hamamura et al., and others, on pro-drug analogues of Ara-C was reviewed by Hadfield et al. in *Advances in Pharmacology and Chemotherapy*, 20, 1984, pages 21-67. In discussing 5'-esters of Ara-C, these authors conclude (page 27):

"...though many of these agents appear to function as very efficient depot forms of ara-C in mice, the analogous action in man has not been demonstrated."

Although work has continued on pro-drugs based on Ara-C, including 3'- and 5'-acyl derivatives (see, for instance, Rubas et al. in *Int. J. Cancer*, 37, 1986, pages 149-154 who tested liposomal formulations of, inter alia, 5'-oleyl-Ara-C against L1210 Leukaemia and Melanoma B16) to date no such drugs have become available to the clinician.

The mode of action of Ara-C relies on its enzymatic recognition as a 2'-deoxy-riboside and subsequent phosphorylation to a nucleoside triphosphate which competes with the normal CTP for incorporation into DNA. The 2'-hydroxyl group causes steric hindrance to rotation of the pyrimidine base around the nucleosidic bond. The bases of polyarabinonucleotides cannot stack normally, as do the bases of polydeoxynucleotides. Ara-C inhibits DNA repair and DNA synthesis both by slowing down chain elongation and movement of newly replicated DNA through the matrix-bound replication apparatus. The mechanism of action of Ara-C results in an "unbalanced growth" in dividing cells. Ara-C acts in the S-phase of the cell cycle. For continuous inhibition of the DNA synthesis and finally cell death, it is crucial that Ara-C is present at a sufficiently high concentration during at least one cell cycle.

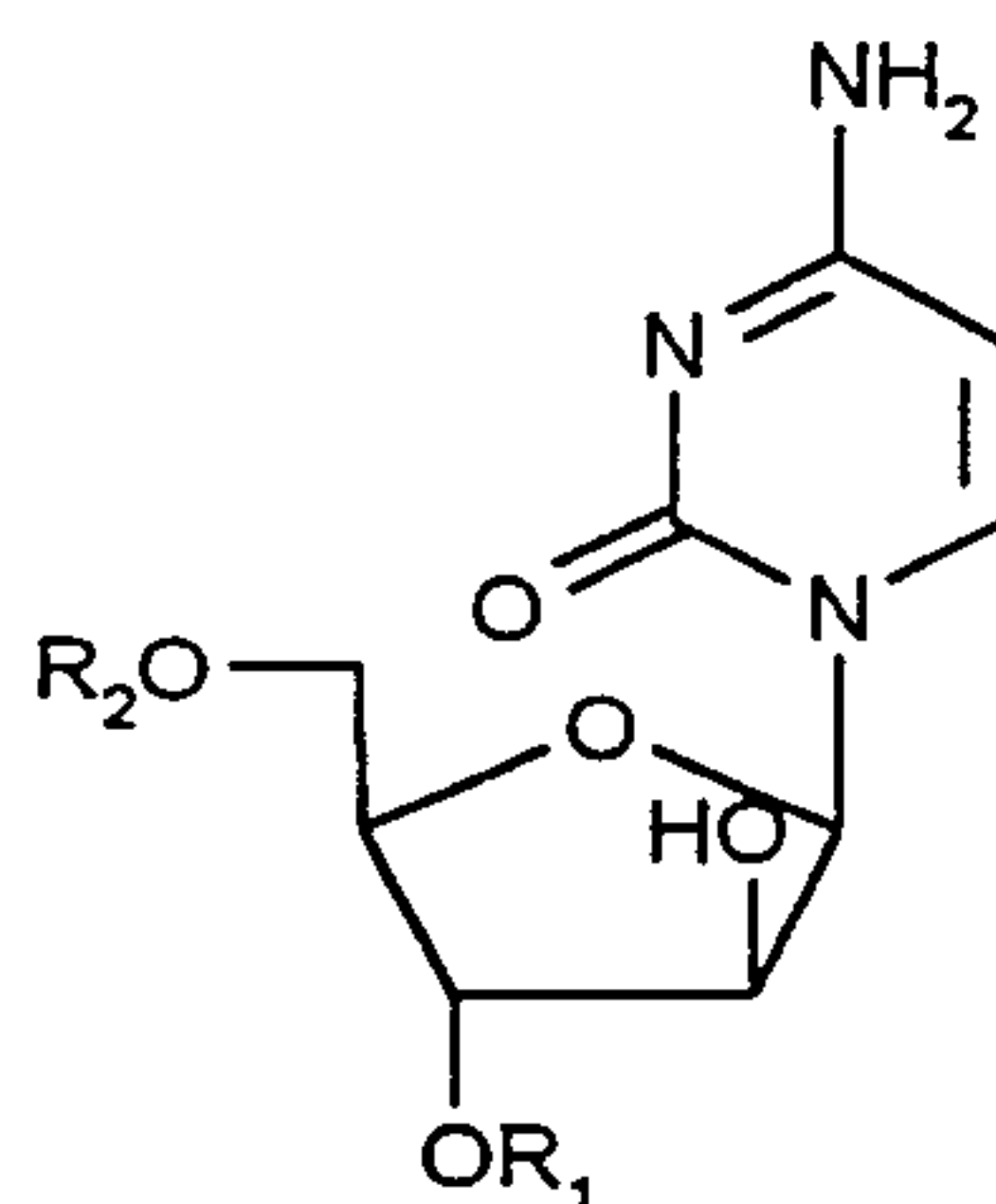
A main reason why Ara-C is not used in the treatment of solid tumours is again the rapid clearance of the active drug from cancer cells and plasma. It is apparently not possible to achieve significant intracellular levels of drug in the neoplastic tissue, even though the tumour in question is sensitive to Ara-C in-vitro. The surprisingly prolonged half life and altered tissue distribution of the products of this invention will be of great importance for the therapeutic effect of these products.

We have found, as shown in figure 7, 8 and 9, that 3'- and 5'-O-esters of Ara-C and certain saturated and unsaturated fatty acids unexpectedly exhibit good activity against different tumours in contrast to Ara-C itself and also other mono- and di-esters.

It is felt by the present inventors that the test model which is commonly used (injection of leukaemia cells into the abdominal cavity of mice and treated i.p.) is more comparable to an in vitro model than to an actual clinical situation and may have served to hide the particularly valuable properties of the selected Ara-C esters used in the present invention, as will be described below.

More specifically, the 3'- and 5'-O-esters which are used according to the present invention are those which are derived from C_{18} or C_{20} saturated and monounsaturated fatty acids.

Thus, the esters used according to the present invention may be represented by the formula I:



(I)

wherein R_1 and R_2 are independently selected from hydrogen, and C_{18} - and C_{20} -saturated and mono-unsaturated acyl groups, with the provisos that R_1 and R_2 cannot both be hydrogen.

The double bond of the mono-unsaturated acyl groups may be in either the cis or the trans configuration, although the therapeutic effect may differ depending on which configuration is used.

The position of the double bond in the mono-unsaturated acyl groups also seems to affect the activity. Currently, we prefer to use esters having their unsaturation in the ω -9 position. (In the ω -system of nomenclature, the position (ω) of the double bond of a monounsaturated fatty acid is counted from the terminal methyl group, so that, for example, eicosenoic acid ($C_{20}:1$ ω -9) has 20 carbon atoms in the chain and the single double bond is formed between carbon atoms 9 and 10 counting from the methyl end of the chain). Thus, we prefer to use Ara-C esters derived from oleic acid ($C_{18}:1$, ω -9, cis) elaidic acid ($C_{18}:1$, ω -9, trans) and eicosenoic acid ($C_{20}:1$, ω -9, cis) and ($C_{20}:1$, ω -9, trans) and stearic acid ($C_{18}:0$) and eicosanoic acid ($C_{20}:0$).

Both 3'-O- and 5'-O-monoesters and 3', 5'-O-diester can be used in the treatment of different tumours in accordance with the present invention, but in general the 5'-O-monoesters are preferred. The 3',5'-O-diester are expected to be useful in those cases where lipophilic properties are of advantage, e.g. absorption or uptake in lipid tissues.

The compounds of formula (I) wherein R_1 and R_2 are independently selected from hydrogen, elaidoyl, oleoyl, stearoyl, eicosenoyl (cis or trans) and eicosanoyl, with the provisos that R_1 and R_2 cannot both be hydrogen, oleoyl or stearoyl, R_1 cannot be hydrogen when R_2 is oleoyl or stearoyl, and R_2 cannot be hydrogen when R_1 is elaidoyl, oleoyl or stearoyl, are new compounds not previously reported in the prior art.

More specifically these new compounds of formula (I) are defined in the below Table A wherein R_1 and R_2 are as given:

Table A

R_1	R_2
hydrogen	elaidoyl
hydrogen	eicosenoyl (cis)
hydrogen	eicosenoyl (trans)
eicosenoyl (cis)	hydrogen
eicosenoyl (trans)	hydrogen

R_1	R_2
eicosenoyl (cis)	eicosenoyl (cis)
eicosenoyl (trans)	eicosenoyl (trans)
eicosenoyl (cis)	eicosenoyl (trans)
eicosenoyl (trans)	eicosenoyl (cis)
eicosenoyl (cis)	elaidoyl
eicosenoyl (trans)	elaidoyl
elaidoyl	eicosenoyl (cis)
elaidoyl	eicosenoyl (trans)
eicosenoyl (cis)	oleoyl
eicosenoyl (trans)	oleoyl
oleoyl	eicosenoyl (cis)
oleoyl	eicosenoyl (trans)
eicosanoyl	eicosanoyl
eicosanoyl	stearoyl
stearoyl	eicosanoyl
elaidoyl	stearoyl
eicosenoyl (cis)	stearoyl
eicosenoyl (trans)	stearoyl
elaidoyl	eicosanoyl
eicosenoyl (cis)	eicosanoyl
eicosenoyl (trans)	eicosanoyl
stearoyl	oleoyl
oleoyl	stearoyl

A limiting factor for the use of Ara-C is its degradation by cytidine deaminase and deoxycytidine-monophosphate (dCMP) deaminase to inactive metabolites. We have surprisingly found that the monoesters of this invention are poor substrates for these

deactivating enzymes. This difference could imply that these ester-derivatives are more suited than Ara-C itself for systemic or local treatment of malignant tumours, especially malignant tumours in the RES and CNS.

This is clearly demonstrated in the leukaemia brain-metastasis model described in figure 10, 11 and 12 and especially with the more aggressive B-cell lymphoma shown in figure 11 where Ara-C itself is void of activity.

In the clinical treatment of myelogenous leukaemia, the rapid deactivation of Ara-C is compensated by continuous infusion over 5-7 days to establish a reasonably stable therapeutic active plasma level of Ara-C. We have shown that following intravenous administration of equimolar amounts of radio labelled Ara-C and Ara-C-5'-elaidic ester to rats, a beneficial change in the metabolism rate and excretion profile is achieved. As can be seen from table 1 and figure 20, the administration of Ara-C-5'-elaidic ester gives both a higher initial whole blood and plasma concentration and a slower conversion to Ara-U. The deamination to Ara-U from Ara-C of the esters of this invention, here exemplified by administration as the elaidate is observed as significantly slower, and when the plasma levels of both Ara-C and Ara-U is below the assay limit of detection at 48 h when administered as pure Ara-C, the two compounds can still be quantified at 72h following administration of Ara-C-5'-elaidate. As can be seen from table 2, the total excreted amount of Ara-U (AUC, 0-72h) is the same for both administered compounds. In a clinical situation these results are reflected in a broader time window of therapeutic active concentration of Ara-C in the blood. In the in-vivo leukaemia model described in figure 13, Ara-C and the 5'-elaidic ester are compared, and similar anti-cancer effects achieved with Ara-C are demonstrated with administration of 1/20 of the molar dose of the ester.

If a similar toxicity profile that is seen in the clinic with Ara-C is observed with the ester derivatives, the improvement in therapeutic index should be of the same order (x 20) of magnitude as the dose/effect improvement.

Of major importance in the treatment of leukaemia's and other diseases confined to the reticulo endothelial system (RES) is of course the time window of active drug plasma concentration, but a localisation of the active compound in RES tissues (defined as liver,

spleen, lymph, lung, intestine wall and free phagocytotic cells present in for example. bone marrow and whole blood) will be of great importance as well. We have observed (figure 21 and table 1) that by intravenous administration of equimolar amounts of Ara-C and Ara-C-5'-elaidic ester, the concentration of active drug in RES tissues is significantly higher, and persists with a broader time window when dosing the ester derivative. The pattern of distribution and metabolism is investigated in greater detail and results from the liver is given in figure 19. A therapeutic significant Ara-C level is sustained for at least 72h after dosing the ester derivative. This can enable treatment of original liver cancer or liver metastases of colo-rectal, breast, melanoma or other forms of cancer. The treatment can stand as mono-therapy, or as paliative/adjuvant treatment in combination with surgery, radiation or other chemotherapy.

There is also observed increased concentrations of Ara-C in other tissues, and this combined with a smaller volume of distribution may open for therapy with Ara-C esters in cancer forms not normally associated with Ara-C treatment.

Moreover we unexpectedly found that the esters of this invention (figure 15) stimulated to a large degree the activation of NFkappaB whilst Ara-C gave no stimulation. The stimulation is a biological effect not normally seen with therapeutic chemicals, and in particular not with conventional cytostatics. This could suggest that the Ara-C esters of this invention have a stimulating effect on certain immune factors which again could explain the astonishing improvement in anti-cancer effect. This could be of significant importance in the treatment of neoplastic diseases involving immunocompetent cells such as leukaemia's and lymphomas.

The development of resistant cancer cells is a severe problem in the current chemotherapy of cancer. We have found (figure 7-9) that the Ara-C derivatives of this invention show the same effect against Cis-platin resistant cells (NH1K 3025/DDP) and MDR resistant cells (A549) as against the corresponding non resistant cell lines. This, we believe, is because the derivatives are not substrates for the cellular drug-efflux mechanisms, such as the "gp 120 MDR pump", responsible for the phenomenon seen as multi drug resistance.

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The C₁₈ and C₂₀ mono- and di-esters of Ara-C can be used according to the present invention in the treatment of a number of neoplastic tumours. We have found an especially promising effect on brain tumours such as glioma, and
5 metastasis from other tumours such as sarcomas, carcinomas, as well as leukaemia. Currently, glioma are treated by surgery, radiation therapy and cytostatica, e.g. N,N-cis(2-chloroethyl)-N-nitroso-urea (BCNU). However, the prognosis by these treatments is very poor.

10 Useful effects with the Ara-C esters of the present invention have also been found in metastatic tumours, such as carcinoma, sarcomas, leukaemia and melanomas.

The invention also provides: compositions of the
15 known and novel compounds (I); use of the known and novel compounds (I) as well as the compositions thereof for: preparing a pharmaceutical preparation/medicament for the treatment of solid tumours or lymphomas, or for the treatment of solid tumours or lymphomas; and a commercial
20 package comprising a known or novel compound (I), or a composition thereof and instructions associated therewith for the treatment of solid tumours or lymphomas.

The scope of the invention and its essential and preferred features are as defined in the attached claims.

25 Biological effects

Micellar formulation

A 1 mg/ml micellar formulation is prepared by the 1:1 (w/w) mixing of Ara-C ester (in DMSO) and lecithin (in ethanol) in sterile water.

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Clonogenic agarose assay¹

A biopsy was taken from the patient and placed immediately in a growth medium. Tumour tissue was desegregated mechanically, and living cells were selected, the chemotherapeutic test substance was added, BCNU (in water) and Ara-C and Ara-C esters (in micelles), and the cells were cultivated in a soft agarose medium. Twenty-four hours before termination of the cultures (7 days) ³H Thymidin was added. The activity of the test substance is thus quantified as cpm in a scintillation counter.

⁽¹⁾G. Unsgaard et al., Acta Neurochir (Wien) (1988) 91:60-66.

Figure 1

The results here are obtained with a glioblastoma taken from a patient. The same response pattern is found in 8 other glioblastoma biopsies. The graph shows the in vitro

comparison of Ara-C and its 3'-elaidyl ester and 5'-elaidyl ester. The results are given as % of the untreated control. A count of 50% (CD_{50}) is taken as promising regarding use in therapy of this actual cancer line. What is worth nothing here is the $10^{1.5}$ higher concentration of Ara-C needed to obtain CD_{50} as compared with elaidyl esters.

Figure 2

Shows the results obtained with the same glioblastoma as Figure 1. The graph compares radiation therapy and chemotherapy (BCNU). A radiation dose greater than 10 Gray (Gy) needed to obtain CD_{50} is in no sense practical in therapy. Comparing Figures 1 and 2, the concentration needed of BCNU to obtain CD_{50} is about 10 times higher than what is needed with the Ara-C esters, but reasonably comparable to Ara-C alone.

Figure 3

These results are obtained with a biopsy taken from a brain metastasis of a melanoma. The difference here between Ara-C and the 3'- and 5'-elaidyl esters is not as pronounced as with the glioma, but is still of the order of 10 times higher.

Figure 4

This shows the activity of BCNU on the melanoma cell line. Compared to the Ara-C esters the BCNU is here needed in more than 1×10^2 higher concentration to give CD_{50} .

Figure 5

This graph shows results with brain metastasis of a carcinoma (lung). These cancer cells are more resistant to chemotherapy, but the difference between Ara-C and Ara-C esters are still present.

Figure 6

These results with BCNU treatment of brain metastasis of a carcinoma (lung) which are presented here are similar to what has already been demonstrated with the other cell lines.

Regarding the different cell types investigated, there seems to be an explicit difference in activity between the Ara-C esters, Ara-C alone and BCNU. A potentiation of 1×10^2 is very

promising for a therapy situation. The findings indicate that the 5' esters are somewhat more potent than the 3' esters.

Cell inactivation - colony forming ability

Cell inactivation measured by means of loss of ability to form colonies was determined for several compounds. Cells used were of the established human cell lines of cancer cervix *in situ* origin, NHIK 3025, NHIK 3025/DDP, a cis-DDP-resistant variant of the same or A549 cells (human lung carcinoma). The cells were exposed to the test compound for 4 up till 24 hours. Test compounds were administered as micellar solution. Number of colonies were counted after about 12 days of incubation.

Figure 7

The graph shows the in vitro comparison of the test compounds Ara-C, Ara-C-5'-elaidyl ester, Ara-C-5'-stearyl ester, Ara-C-5'-eicosen ester and Ara-C-5'-petroseline ester. The results are given as the dose needed to reduce cell survival with 90% relative to untreated control. As seen from the graph, substantial higher inactivation of NHIK 3025 cells is observed following exposure to the esters compared to Ara-C itself. The dose modifying factor at the 10% survival level is in the range of 3 to 5 for the Ara-C-esters compared to Ara-C, which means that a 3 to 5 times higher dose is required of Ara-C to obtain similar reduced colony forming ability as that observed for the esters.

Figure 8

The results here are obtained with 4 h treatment of NHIK 3025/DDP cells. Enhanced effect of Ara-C-5'-elaidate ester compared to effect of Ara-C is observed similar to the effect enhancement observed in NHIK 3025 cells. Enhanced effect does not depend on resistance to cis-DDP.

Figure 9

The graph shows the in vitro results using A549 cells (human lung carcinoma cells) colony forming ability to compare the test compounds Ara-C, Ara-C-5'-elaidyl ester, Ara-C-5'-stearyl ester, Ara-C-5'-eicosen ester and Ara-C-5'-petroseline ester. The cells were exposed for 24 hours. The highest inactivation is observed for Ara-C-5'-stearyl ester, but enhanced effect is also observed for the elaidyl and petroseline esters.

Raji human B-lymphoma cells - leptomeningal carcinomatosis model in nude rats

The model used is a tumour model in nude rats for leptomeningal growth of tumours. 1×10^6 cells of the B-cell tumour line Raji were injected into the spinal fluid through cisterna magna (c.m.) of 4 - 5 weeks old nude rats. The animals develop neurological symptoms after 12 - 14 days if untreated. Anaesthetised animals were treated intracerebrally with a 40 μ l injection into cisterna magna with 3 or 4 bolus injections. Treatment was started 1 day after cell inoculation. Test compounds were Ara-C-5'-elaidyl ester (in micelles) and Ara-C. Ara-C was administered both at maximal tolerable dose (MTD) and at an equimolar dose to Ara-C-5'-elaidyl ester. Control animals (treated with NaCl) or empty liposomes (micelles without Ara-C esters) developed symptoms from the central nervous system after approximately 14 days.

Figure 10

3 bolus injections with Ara-C-elaidate on day 1, 2 and 4 increased the symptom free latency period by 135% as compared to Ara-C, with mean day of death delayed from day 13 till day 30.5, as seen in fig. 10. One rat survived for more than 70 days, and was considered to be cured. No tumours were visible at necropsy on day 76. This increase in disease-free survival is superior to results obtained with other therapeutic alternatives tested in comparable models for different types of human tumours.

Figure 11

Survival curves from an additional experiment with nude rats inoculated with Raji cells in the brain, treated with 4 bolus doses is shown in this figure. One daily bolus dose on day 1, 2, 3 and 4 were administered into cisterna magna. As in the previous experiment, no effects were observed for Ara-C, neither at maximal tolerable dose of Ara-C (MTD) nor at a dose equimolar to Ara-C-elaidate. The results for the group given Ara-C-elaidate were even more astonishing than in the previous experiment. 3 out of 5 rats were still alive and symptom-free at day 70. They were considered to be cured. This is most promising. 5/6 control rats died on day 13. The 6th control rat had no backflow of spinal fluid into the syringe following injection of tumour cells and no neurological symptoms after 70 days. According to normal procedure this animal is left out of the results.

Molt 4 human lymphoma cells - leptomeningal carcinomatosis model in nude rats

The model used is a tumour model in nude rats for leptomeningal growth of tumours. 10^6 cells of the T-cell tumour line Molt 4 were injected into the spinal fluid through cisterna magna (c.m.) of 4 - 5 weeks old nude rats. The animals develop neurological symptoms after 20 -22 days if untreated. Anaesthetised animals were treated intracerebrally with a 40 μ l injection into cisterna magna with 4 bolus injections. Treatment was started 1 day after cell inoculation. Test compounds were Ara-C-5'-elaidyl ester (in micelles) and Ara-C. Ara-C was administered both at maximal tolerable dose (MTD) and at an equimolar dose to Ara-C-5'-elaidyl ester. Control animals (treated with NaCl) developed symptoms from the central nervous system after approximately 20 days.

Figure 12

Survival as a function of time for rats injected in the brain with Molt 4 lymphoma cells, treated 4x in cisterna magna is shown in figure 12. In this initial experiment, onset of death was delayed for the animals receiving Ara-C-elaidate compared to animals receiving Ara-C or control. The number of animals per group were: Control (7), Ara-C-elaidate (3) and Ara-C (5).

Leukaemia model using Raji human B-lymphoma cells

SCID mice were injected intravenously with 1×10^6 Raji human B-lymphoma cells. The mice were treated on days 7, 9, 11, 13 and 15 following injection of the tumour cells with either 20 mg/kg/day of Ara-C-elaidate or 200mg/kg/day of Ara-C or control. Animals develop paralysis of the hind legs as a result of the tumour growth. Mean day of death for the animals treated with the different treatments are shown in figure 13.

Figure 13

Mean survival of SCID mice injected with Raji human B-lymphoma cells intravenously, treated intravenously with one injection on each of the days 7,9,11,13 and 15 with either Ara-C-elaidate, Ara-C or Control is shown in this figure. The doses were 20mg/kg of Ara-C-elaidate and 200 mg/kg for Ara-C. On an equimolar basis, a 20 times reduced dose of Ara-C-elaidate compared to the Ara-C dose increased mean survival compared to control and Ara-C treated animals. The number of animals in each group were 7.

Figure 14

Mean survival of SCID mice injected with Raji human B-lymphoma cells intravenously, treated intraperitoneally with once daily injection days 7 - 11 with either Ara-C-elaidate, Ara-C or Control is shown in this figure. The mean survival time is greatly prolonged for the Ara-C-elaidate when treatment is repeated daily instead of every other day.

Activation of the cellular transcription factor NFkappaB

Human SW480 colon adenocarcinoma cells stably transfected with a CMV promotor/enhancer containing the gene for β -galactosidase were used. Activation of the transcription factor NFkappaB results in enhanced amount of the enzyme β -galactosidase in cytoplasm. The amount of β -galactosidase is quantified using optical density at 570 nm as parameter. The SW380 cells were incubated 2 - 3 days before exposure to the test compound for 4 h. The cells were washed and prepared, and optical density recorded for the different compounds.

Figure 15

No β -galactosidase activity was measured following exposure to Ara-C, whilst a substantial increase in β -galactosidase activity was observed as an increase in optical density at 570 nm following exposure to Ara-C-elaidate. This indicates that a surprisingly high induction of the transcriptional activator protein NFkappaB is obtained with Ara-C-elaidate. NFkappaB is involved in gene control of a range of immune factors, and this activation by Ara-C-elaidate could explain the improved anticancer effects observed for Ara-C-elaidate. One would expect a stimulation of certain immune cells by Ara-C-elaidate, which could be of special interest in the treatment of leukaemia and lymphomas.

The anti-tumour activity of Ara-C-elaidate versus Ara-C against the murine TLX/5 lymphoma.

CBA mice weighing 20 - 25 g were inoculated subcutaneously inguinally with 1×10^5 TLX/5 tumour cells day 0. Ara-C-elaidate or Ara-C were administered intraperitoneally on days 3,4,5,6 and 7. Doses were in the range 6.25 - 50 mg/kg/day. There were 5 mice per treatment per group and 10 tumour-bearing controls. Activity was assessed in terms of increase in life span (ILS) versus controls.

Figure 16

TLX/5 lymphoma tumour bearing mice and their % increase in lifespan (median of 5 per group) following treatment with Ara-C-elaidate or Ara-C, i.p treatment for 5 days is shown in this figure. Ara-C was only active at the dose 25 mg/kg, whilst Ara-C-elaidate was active at the doses 12.5 mg/kg and 25 mg/kg. Maximum increase in lifespan was 47.2% compared to 32.7% for Ara-C.

The anti-tumour activity of Ara-C-elaidate versus Ara-C in SCID mice inoculated intraperitoneally with hemangiosarcoma cells.

SCID mice were inoculated intraperitoneally with PV/2b/35 hemangiosarcoma cells. Mice were treated 5 days per week with 25 mg/kg/day of either Ara-C-elaidate prepared in micelles, Ara-C-elaidate dissolved in DMSO, Ara-C dissolved in PBS. Controls were empty micelles, DMSO or PBS respectively. The animals were not treated during weekends. Survival was the endpoint of the study.

Figure 17

Survival of SCID mice inoculated intraperitoneally with PV/2b/35 hemangiosarcoma cells. Survival was greatly enhanced for animals treated with Ara-C-elaidate. The enhanced survival compared to control was observed both for Ara-C-elaidate prepared in micelles and for Ara-C-elaidate dissolved in DMSO.

Figure 18

The results presented here are from a study of the 5'-Ara-C elaidyl ester in a glioblastoma tumour grown in nude mice. A glioblastoma cell line U-118 (Uppsala) tissue culture was injected subcutaneously in nude mice. A small part (2 x 2 mm) of growing tumour was transferred to new mice. The subcutaneous tumours show a somewhat different growth rate in the various animals, but at the size of 4-6 mm, an injection with a 10 mg/ml micellar solution of the Ara-C ester was given intratumourally. Depending on the actual tumour size, the animals received the same relative amount of test substance. The control was given saline water. The growth rate was recorded as relative tumour volume (RTV). The control tumour follows a quite normal growth pattern typical to this cancer type. What is noted is the complete stop in tumour growth of the treated animals. Further, the animals showed no signs of toxic side effects, which in the case of Ara-C are

damage to bone marrow with the development of anaemia or haemorrhages, nor was there noted any sign of CNS disturbance.

Comparative pharmacokinetic, distribution, metabolism and excretion of ^{14}C -Ara-C-elaidate and ^{14}C -Ara-C administered intravenously to male rats

^{14}C -Ara-C-elaidate (in micelles) or ^{14}C -Ara-C were administered intravenously to male rats at equimolar doses, 5 mg/kg for ^{14}C -Ara-C-elaidate and 2.4 mg/kg for ^{14}C -Ara-C. Plasma concentrations of total radioactivity and of the metabolites were determined at different timepoints. Tissue concentrations of total radioactivity were determined from a range of tissues at different timepoints up to 120 hours following injection. Liver tissues were extracted and metabolite concentrations were determined up to 72 hours post injection. Tissue distribution of Ara-C-elaidate was significantly altered compared to the distribution of Ara-C. Maximal concentrations in most tissues were notably higher and occurred at later timepoints following ^{14}C -Ara-C-elaidate administration, especially in whole-blood/plasma, spleen, liver and lungs. Maximal concentrations in muscle, salivary glands, skin and urinary bladder were lower. The proportion of the dose in whole-blood at 0.08 hours after ^{14}C -Ara-C-elaidate administration was estimated to be 64.7%, notably higher than the proportion present in the systemic circulation at this time after ^{14}C -Ara-C administration (7.76 %). Excretion via the renal system was much slower for the elaidate than the Ara-C itself. Elimination from tissues were much slower for ^{14}C -Ara-C-elaidate compared to elimination from tissues when ^{14}C -Ara-C was administered.

Table 1

Maximal concentrations of radioactivity (expressed as μg equivalents/g) following administration of equimolar doses of ^{14}C -Ara-C-elaidate or ^{14}C -Ara-C with corresponding timepoint for maximal concentration. As seen in the table, maximal concentrations occurred in different tissues and at different timepoints for the two compounds.

Table 1

Tissue	¹⁴ C-Ara-C-elaidate (t _{max} hours)	¹⁴ C-Ara-C (t _{max} hours)
spleen	175.2 (0.25)	2.406 (0.08)
plasma	55.60 (0.08)	3.058 (0.08)
whole-blood	47.32 (0.08)	2.707 (0.08)
liver	42.37 (1 hour)	2.526 (0.08)
blood cells	34.37 (0.08)	2.201 (0.08)
lung	28.97 (0.08)	2.144 (0.08)
vena cava	17.29 (0.08)	1.887 (0.25)
bone marrow	13.29 (1 hour)	1.950 (0.08)
heart	10.15 (0.08)	1.916 (0.25)
kidney	9.108 (0.08)	7.752 (0.08)
prostate	9.014 (4 hours)	2.810 (0.25)
pituitary	8.359 (0.08)	0.931 (0.08)
aorta	7.795 (0.08)	2.213 (0.08)
urinary bladder	6.421 (4 hours)	13.07 (1 hour)
adrenal glands	5.229 (0.08)	1.764 (0.08)
salivary glands	2.366 (0.25)	2.505 (0.08)
lacrimal glands	4.438 (4 hours)	2.460 (0.08)
lymph nodes	2.831 (1 hour)	2.222 (0.08)
skin	1.793 (0.25)	2.189 (0.08)
muscle	1.990 (0.25)	2.158 (0.08)
pancreas	2.817 (0.08)	2.148 (0.08)
thymus	2.090 (0.25)	2.054 (0.08)
brain	1.408 (0.08)	0.233 (1 hour)

Table 2

Excretion of radioactivity (% of dose) after intravenous administration of ^{14}C -Ara-C-eladiate (5 mg/kg) or ^{14}C -Ara-C (2.4 mg/kg) to male rats. Rate of excretion of radioactivity in urine is slower for ^{14}C -Ara-C-eladiate than for ^{14}C -Ara-C.

Table 2

Sample/time (hours)	^{14}C -Ara-C-eladiate	^{14}C -Ara-C
0 - 6	59.1 ± 3.7	85.3 ± 3.1
6 - 24	34.1 ± 2.5	8.8 ± 1.9
24 - 48	2.7 ± 0.8	0.5 ± 0.3
48 - 72	0.5 ± 0.1	$0.2 \pm <0.1$
72 - 96	0.2 ± 0.1	0.2 ± 0.1
96 - 120	$0.1 \pm <0.1$	0.1 ± 0.1

Figure 19

Liver concentration of Ara-C-eladiate (P-Ara-C-el) and the metabolites Ara-C (P-Ara-C) and Ara-U (P-Ara-U) are plotted as a function of time following injection of ^{14}C -Ara-C-eladiate in figure 15 as well as the concentration of Ara-C (Ara-C) and the metabolite Ara-U (Ara-U) as a function of time following injection of ^{14}C -Ara-C itself. Injection of Ara-C-eladiate gave rise to substantially increased and prolonged exposure of rat-liver to both Ara-C-eladiate and Ara-C, with no detection of Ara-U up to 24 hours. This was in strong contrast to the liver concentration of Ara-C after administration of Ara-C as such. Liver concentration of Ara-C diminished to non-detectable levels after 4 hours, with the metabolite Ara-U present at all timepoints.

Figure 20

Plasma levels of Ara-C-eladiate and the metabolites Ara-C and Ara-U following intravenous administration of ^{14}C -Ara-C-eladiate is shown as a function of time as well as plasma levels of Ara-C and the metabolite Ara-U following intravenous administration of ^{14}C -Ara-C as a function of time. Ara-C-eladiate administration give rise to prolonged plasma level of Ara-C, with detectable levels up to 72 hours in plasma following administration compared to 24 hours following Ara-C administration. Metabolism of Ara-C

to Ara-U is less extensive, and starts later in animals which have received Ara-C-elaidate.

Figure 21

Tissue concentration of total radioactivity is plotted as a function of time following intravenous administration of either ^{14}C -Ara-C-elaidate (P) or ^{14}C -Ara-C. The tissues shown in the graph are liver, spleen, lung, bone and bone marrow. Concentration of radioactivity following injection of ^{14}C -Ara-C-elaidate is higher at all timepoints up to 120 hours for all the corresponding tissues.

The Ara-C esters of the present invention may be formulated with conventional carriers and excipients for administration.

As the most promising regime for the treatment of gliomas and other solid brain tumours, we currently envisage local deposition of the active compounds at the site of the tumour to be attacked. For this purpose, the active compounds may preferably be presented as a lecithin micellar formulation. For example, the preferred treatment of brain metastasis will be by administration of a formulation of the Ara-C ester into the spinal fluid or into the tumour area by means of a dosing pump or similar device.

The Ara-C esters of the present invention may also be administrated systemically, either enterally or parenterally.

For enteral administration, the active compounds of the present invention may be presented as, e.g. soft or hard gelatine capsules, tablets, granules, grains or powders, drags, syrups, suspensions or solutions.

When administrated parenterally, preparations of Ara-C esters as injection or infusion solutions, suspensions or emulsions are suitable.

The preparation can contain inert or pharmacodynamically active additives, as well known to those skilled in the formulation arts. For instance, tablets or granulates can contain a series of binding agents, filler materials, emulsifying agents, carrier substances

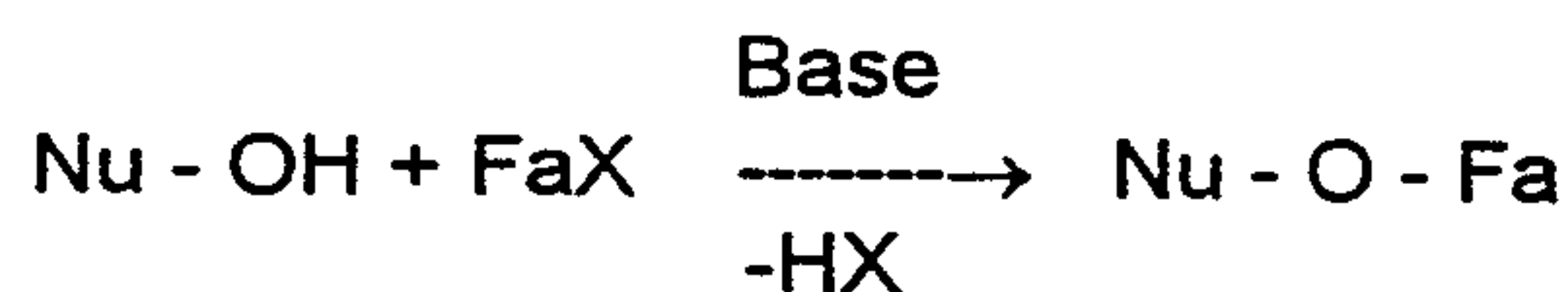
or dilutes. Liquid preparations may be present, for example, in the form of a sterile solution. Capsules can contain a filler material or thickening agent in addition to the active ingredient. Furthermore, flavour-improving additives as well as the substances usually used as preserving, stabilising, moisture-retaining and emulsifying agents, salts for varying the osmotic pressure, buffers and other additives may also be present.

The dosage in which the preparations according to this invention are administered will vary according to the mode of use and route of use, as well as to the requirements of the patient. In general a daily dosage for a systemic therapy for an adult average patient will be about 0.1-150 mg/kg body weight/day, preferably 1-50 mg/kg/day. For topical administration, an ointment, for instance, can contain from 0.1-10% by weight of the pharmaceutical formulation, especially 0.5-5% by weight.

I desired the pharmaceutical preparation containing the Ara-C esters can contain an antioxidant, e.g. tocopherol, N-methyl-tocopheramine, butylated hydroxyanisole, ascorbic acid or butylated hydroxytoluene.

Combination therapies, i.e. in which the administration of an Ara-C ester of this invention is carried out in conjunction with other therapies, e.g. surgery, radiation treatment and chemotherapy, are also contemplated. For example, the preferred treatment of brain tumours seems likely to be a combination of surgery and treatment with an Ara-C ester of this invention by systemic or local administration.

The esters of Ara-C used according to the invention may generally be prepared according to the following reaction equation:



wherein Nu-OH stands for Ara-C, O is oxygen at 3' and /or 5' position of the sugar moiety of Ara-C, Fa is an acyl group of a saturated or monounsaturated C₁₈ or C₂₀ fatty acid, and X may be Cl, Br or OR' wherein R' is Fa, COCH₃, COEt or COCF₃.

Thus, the reaction proceeds by acylation of the nucleoside. This is accomplished by the use of suitable reactive derivatives of fatty acids, especially acid halides or acid anhydrides. When an acid halide such as an acid chloride is used, a tertiary amine catalyst, such as triethylamine, N,N-dimethylaniline, pyridine or N,N-dimethylaminopyridine is added to the reaction mixture to bind the liberated hydrohalic acid. The reactions are preferably carried out in an unreactive solvent such as N,N-dimethylformamide or a halogenated hydrocarbon, such as dichloromethane. If desired any of the above mentioned tertiary amine catalysts may be used as solvent, taking care that a suitable excess is present. The reaction should preferably be kept between 5°C and 25°C. After a period of 24 to 60 hours, the reaction will be essentially completed. The progress of the reaction can be followed using thin layer chromatography (TLC) and appropriate solvent systems. When the reaction is completed as determined by TLC, the product is extracted with an organic solvent and purified by chromatography and/or recrystallization from an appropriate solvent system. As more than one hydroxyl group and also an amino group are present in Ara-C, a mixture of acylated compounds will be produced. The individual mono- and di-O-esters required may be separated by, for instance, chromatography, crystallisation, supercritical extraction etc.

When it is desired to prepare a diester compound of formula I, in which R_1 and R_2 are the same acyl group, it is preferred to employ the above method using the appropriate acyl chloride in excess.

In order to prepare a diester compound of formula I, in which R_1 and R_2 are different, it is preferred to first prepare either the 3'- or 5'-monoester and then react the monoester with the proper acyl chloride.

This will be exemplified by the following working examples.

Example 15'-O-(Elaidoyl) 1- β -D-arabinofuranosyl-cytosine.^{1,2}

To a suspension of Ara-C·HCl (1.007g, 3.6×10^{-3} mol) in 15 ml dimethylacetamide (DMA) was added a solution of Elaidoyl chloride (1.26g, 4.2×10^{-3} mol) in 5 ml DMA, and the mixture was stirred at 30°C for 22 h. The solvent was evaporated at high vacuum and the residue was treated with hot ethyl acetate and filtered. The crude product was treated with 2 M NaHCO₃ aq., filtered off and purified on a column of silica gel with methanol (5 30%) in chloroform as the eluent system. Homogenous fractions were recrystallized to give 1.31g (72%) of the title compound as a white solid (mp. 133-134°C). ¹H NMR (DMSO-d₆, 300 MHz) δ : 7.58(1H, d, H-6), 7.18(2H, br.d, NH₂), 6.20(1H, d, H-5), 5.77(1H, d, H-1'), 5.65(2H, m, OH-2' and OH-3'), 5.47(2H, m, CH=CH), 4.43(1H, m, H-5'₁), 4.30(1H, m, H-5'₂), 4.1-4.0(3H, m, H-2', H-3' and H-4'), 2.45(2H, t, CH₂-COO), 2.05(4H, m, CH₂-C=), 1.63(2H, m, CH₂-C-COO), 1.35(20H, m, CH₂), 0.97(3H, t, CH₃).

¹³C NMR (DMSO-d₆, 75 MHz) δ : 172.8(COO), 165.59(C4-N), 155.05(C=O 2), 142.86(C-6), 130.11(CH=CH), 92.54(C-5), 86.23(C-1'), 81.86(C-4'), 76.83(C-3'), 74.35(C-2'), 63.77(C-5'), 33.46, 31.95, 31.30, 29.03, 28.97, 28.85, 28.73, 28.52, 28.43, 28.36, 24.48 and 22.12(CH₂), 13.97(CH₃).

Example 23'-O-(Elaidoyl) 1- β -D-arabinofuranosyl-cytosine.^{2,3}

A mixture of 2-hydroxyisobutyric acid (1.15g, 12×10^{-3} mol) and elaidoyl chloride (3.10g, 10×10^{-3} mol) was stirred at 50°C for 1 h. Thionyl chloride (1.5 ml, 21×10^{-3} mol) was added and stirring was continued for 2 h. The reaction mixture was kept by 50°C at reduced pressure (40 mmHg) for 14 h. The formed 2-elaidoyloxy-2-methylpropanoyl chloride was used without any further purification, and suspended in 13 ml anhydrous acetonitrile. Cytidine (0.608 g, 2.5×10^{-3} mol) was added, and the reaction mixture was stirred at 60°C

for 24 h. The solvent was evaporated off, and the residue treated with ether. The crude product was stirred in 40 ml pyridine-methanol 1:1 at 80°C for 20 h, whereafter it was evaporated to dryness and the product purified on a column of silica gel. Homogenous fractions were recrystallized to give 0.446g (35%) of the title compound as a white solid (mp. 164-166°C).

¹H NMR (DMSO-d₆, 300 MHz) δ: 7.71(1H, d, H-6), 7.2(2H, br.d, NH₂), 6.1(1H, d, H-5), 5.88(1H, d, H-1'), 5.81(1H, d, OH-2'), 5.45(2H, m, CH=CH), 5.18(1H, m, OH-5'), 5.06(1H, dd, H-3'), 4.18(1H, m, H-2'), 4.01(1H, m, H-4'), 3.75(2H, m, H-5'), 2.47(2H, t, CH₂-COO), 2.06(4H, m, CH₂-C=), 1.65(2H, m, CH₂-C-COO), 1.35(20H, m, CH₂), 0.97(3H, t, CH₃).

¹³C NMR (DMSO-d₆, 75 MHz) δ: 172.15(COO), 165.67(C4-N), 154.95(C=O), 142.72(C-6), 130.11 and 130.08(CH=CH), 92.59(C-5), 86.24(C-1'), 82.75(C-4'), 78.72(C-3'), 72.29(C-2'), 61.15(C-5'), 33.43, 31.97, 31.30, 29.03, 28.99, 28.85, 28.73, 28.53, 28.41, 28.36, 24.40, 22.12(CH₂), 13.97(CH₃).

Example 3

5'-O-(*cis*-11-eicosenoyl)1-β-D-arabinofuranosyl-cytosine.

To a suspension of Ara-C-HCl (0.87g, 3.1 x 10⁻³ mol) in 30 ml N,N-dimethylformamide was added a solution of *cis*-11-eicosenoyl chloride (1.06g, 3.22 x 10⁻³ mol) in 30 ml DMA, and the reaction mixture was stirred at 25°C for 24 h. The solvents was evaporated at high vacuum and the residue was dissolved in 60 ml boiling ethanol to which was added 20 ml water and 20 ml saturated NaHCO₃ solution. The crude product was filtered off at room temperature and dissolved in 100 ml boiling ethanol (60% in water). The crude product was recrystallized from ethylacetate to give 1.1g (66%) of the title compound as a white solid.

¹H NMR (DMSO-d₆, 300 MHz) δ: 7.45(1H, d, H-6), 7.1(2H, br.d, NH₂), 6.08(1H, d, H-1'), 5.65(1H, d, H-5), 5.55(2H, m, OH-2' and OH-3'), 5.32(2H, m, CH=CH), 4.25(1H, m, H-5'), 4.15(1H, m, H-5'), 4.0-3.85(3H, m, H-2', H-3', H-4'), 2.33(2H, t, CH₂-COO), 1.95(4H, m, CH₂-C=), 1.5(2H, m, CH₂-C-COO), 1.25(24H, m, CH₂), 0.85(3H, t, CH₃).

^{13}C NMR (DMSO- d_6 , 75 MHz) δ : 172.79(COO), 165.59(C-4), 155.08(C=O 2), 142.78(C-6), 129.60(CH=CH), 92.52(C-5), 86.21(C-1'), 81.82(C-4'), 76.75(C-3'), 74.25(C-2'), 63.76(C-5'), 33.41, 31.30, 29.11, 28.85, 28.72, 28.60, 28.42, 26.57, 24.46, 22.11 (CH_2), 13.94(CH_3).

Ref.:

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2. E. K. Hamamura *et al.*, J. Med. Chem. 19 (1976) 667
3. E. K. Hamamura *et al.*, J. Med. Chem. 19 (1976) 654

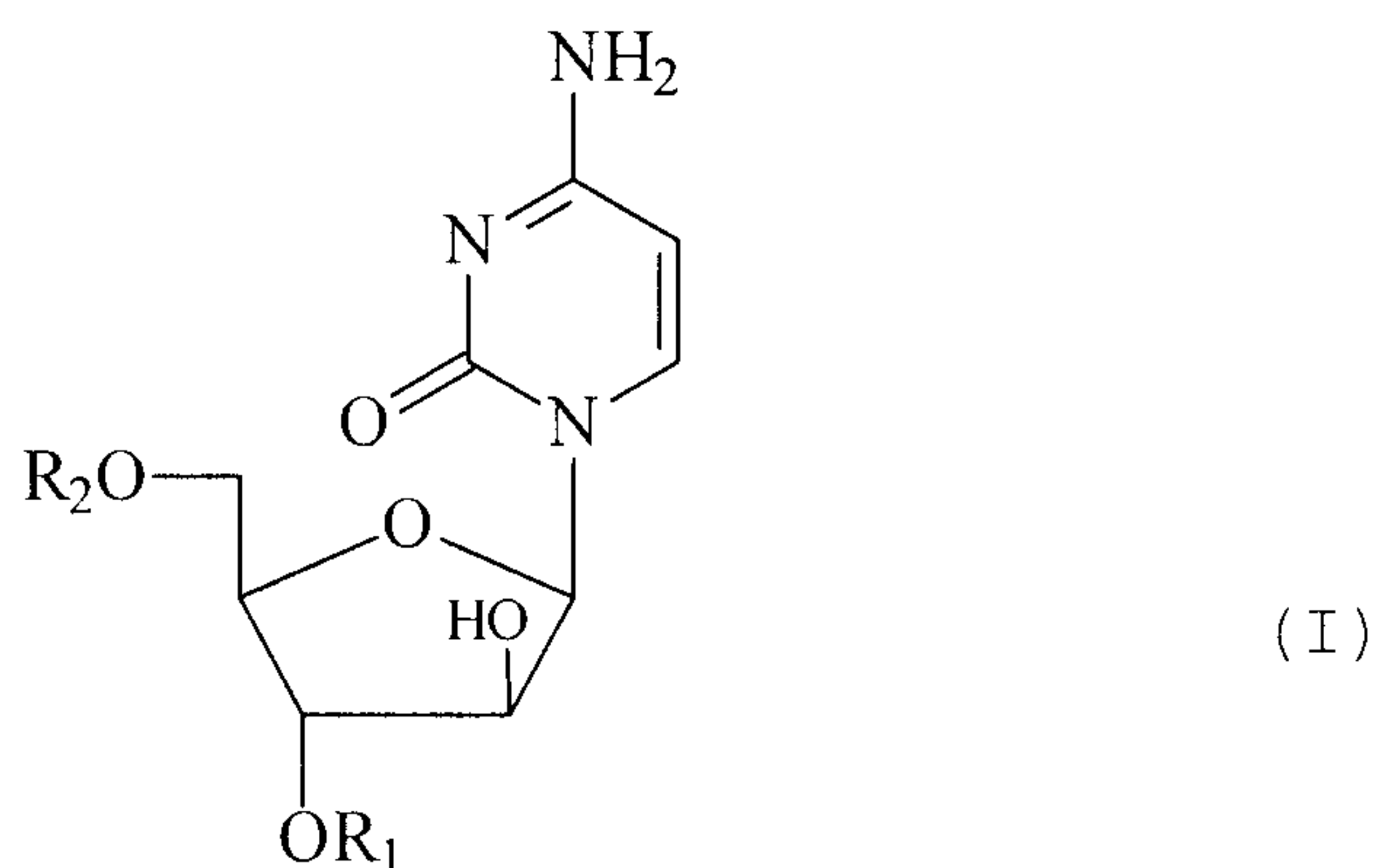
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CLAIMS:

1. The use of an Ara-C derivative of formula (I) in the manufacture of a pharmaceutical preparation for the treatment of solid tumours or lymphomas:

5



10 wherein R_1 and R_2 are independently selected from hydrogen and C_{18} - and C_{20} -saturated or monounsaturated acyl groups, with the proviso that R_1 and R_2 cannot both be hydrogen.

2. The use according to claim 1, in which R_1 and R_2 are selected from hydrogen and saturated or ω -9
15 monounsaturated C_{18} - and C_{20} -acyl groups.

3. The use according to claim 2, in which R_1 is hydrogen.

4. The use according to claim 3, in which R_2 is an elaidoyl or eicosenoyl (cis or trans) group.

20 5. The use according to any one of claims 1 to 4, in the manufacture of a pharmaceutical preparation for local treatment of solid tumours or lymphomas.

6. The use according to any one of claims 1 to 4, in the manufacture of a pharmaceutical preparation for systemic
25 treatment of solid tumours or lymphomas.

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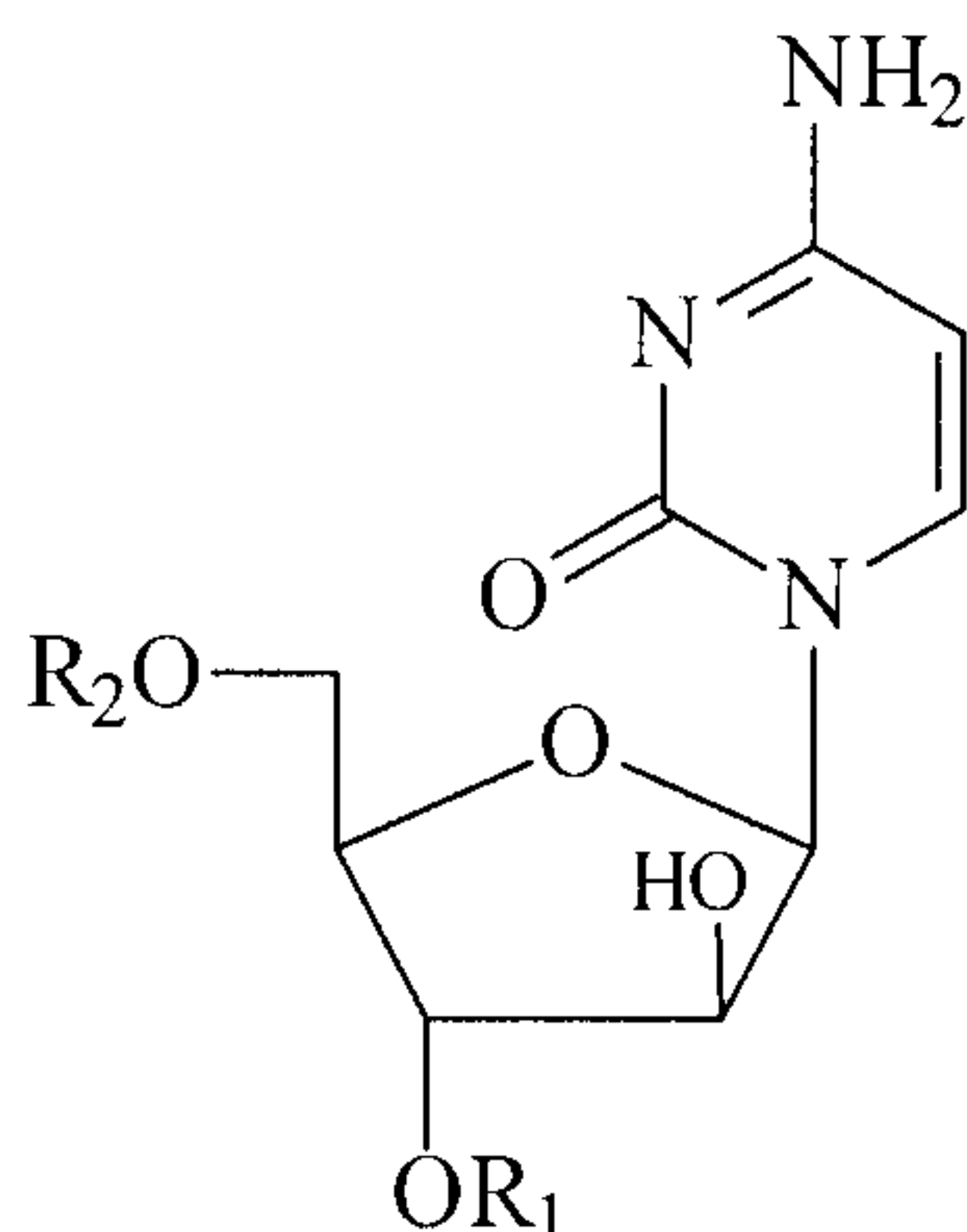
7. The use according to any one of claims 1 to 6 in the manufacture of a pharmaceutical preparation for the treatment of solid tumours or lymphomas in the reticulo endothelial system (RES).

5 8. The use according to any one of claims 1 to 6, in the manufacture of a pharmaceutical preparation for the treatment of solid tumours or lymphomas in the central nerve system (CNS).

9. The use according to any one of claims 1 to 8, in
10 the manufacture of a pharmaceutical preparation for the treatment of metastatic tumours.

10. An Ara-C derivative of formula (I):

15



(I)

wherein R_1 and R_2 are independently selected from hydrogen, elaidoyl, oleoyl, stearoyl, eicosenoyl (cis or trans) and
20 eicosanoyl, with the provisos that R_1 and R_2 cannot both be hydrogen, oleoyl, elaidoyl, stearoyl or eicosanoyl, R_1 cannot be hydrogen when R_2 is oleoyl or stearoyl, and R_2 cannot be hydrogen when R_1 is elaidoyl, oleoyl, stearoyl or eicosanoyl.

11. A pharmaceutical composition, comprising an Ara-C
25 derivative of formula (I), as defined in claim 10 and a pharmaceutically acceptable carrier or excipient therefor.

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12. The use of an Ara-C derivative as defined in any one of claims 1 to 4, for the treatment defined in any one of claims 1 and 5 to 9.

13. An Ara-C derivative as defined in any one of
5 claims 1 to 4, for the treatment defined in any one of claims 1 and 5 to 9.

14. An Ara-C derivative as defined in any one of claims 1 to 4, for the manufacture of a pharmaceutical preparation for the treatment defined in any one of claims 1
10 and 5 to 9.

15. A pharmaceutical composition comprising an Ara-C derivative as defined in any one of claims 1 to 4, and a pharmaceutically acceptable carrier or excipient therefor, for the treatment defined in any one of claims 1 and 5 to 9.

15 16. The use of a pharmaceutical composition comprising an Ara-C derivative as defined in any one of claims 1 to 4, and a pharmaceutically acceptable carrier or excipient therefor, for the treatment defined in any one of claims 1 and 5 to 9.

20 17. A commercial package comprising an Ara-C derivative as defined in any one of claims 1 to 4, or a composition as defined in claim 15, and associated therewith instructions for the use thereof in the treatment defined in any one of claims 1 and 5 to 9.

25 18. The use of an Ara-C derivative as defined in claim 10, or a composition as defined in claim 11, for the treatment defined in any one of claims 1 and 5 to 9.

19. The use of an Ara-C derivative as defined in claim 10, or a composition as defined in claim 11, for the

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manufacture of a medicament for the treatment defined in any one of claims 1 and 5 to 9.

20. An Ara-C derivative as defined in claim 10, or a composition as defined in claim 11, for the treatment
5 defined in any one of claims 1 and 5 to 9.

21. An Ara-C derivative as defined in claim 10, or a composition as defined in claim 11, for the manufacture of a medicament for the treatment defined in any one of claims 1 and 5 to 9.

10 22. A commercial package comprising an Ara-C derivative as defined in claim 10, or a composition as defined in claim 11, and associated therewith instructions for the use thereof in the treatment defined in any one of claims 1 and 5 to 9.

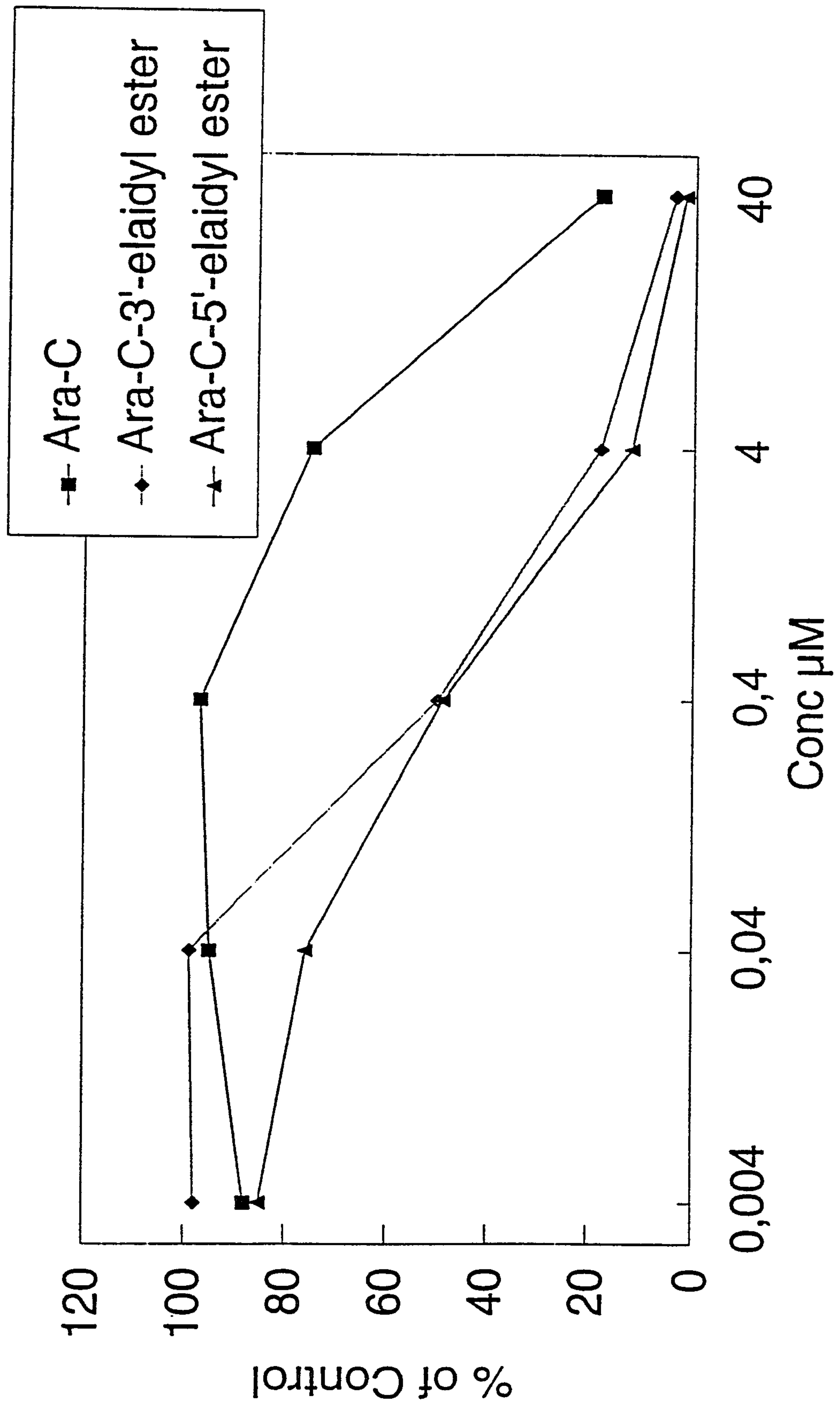
FETHERSTONHAUGH & CO.

OTTAWA, CANADA

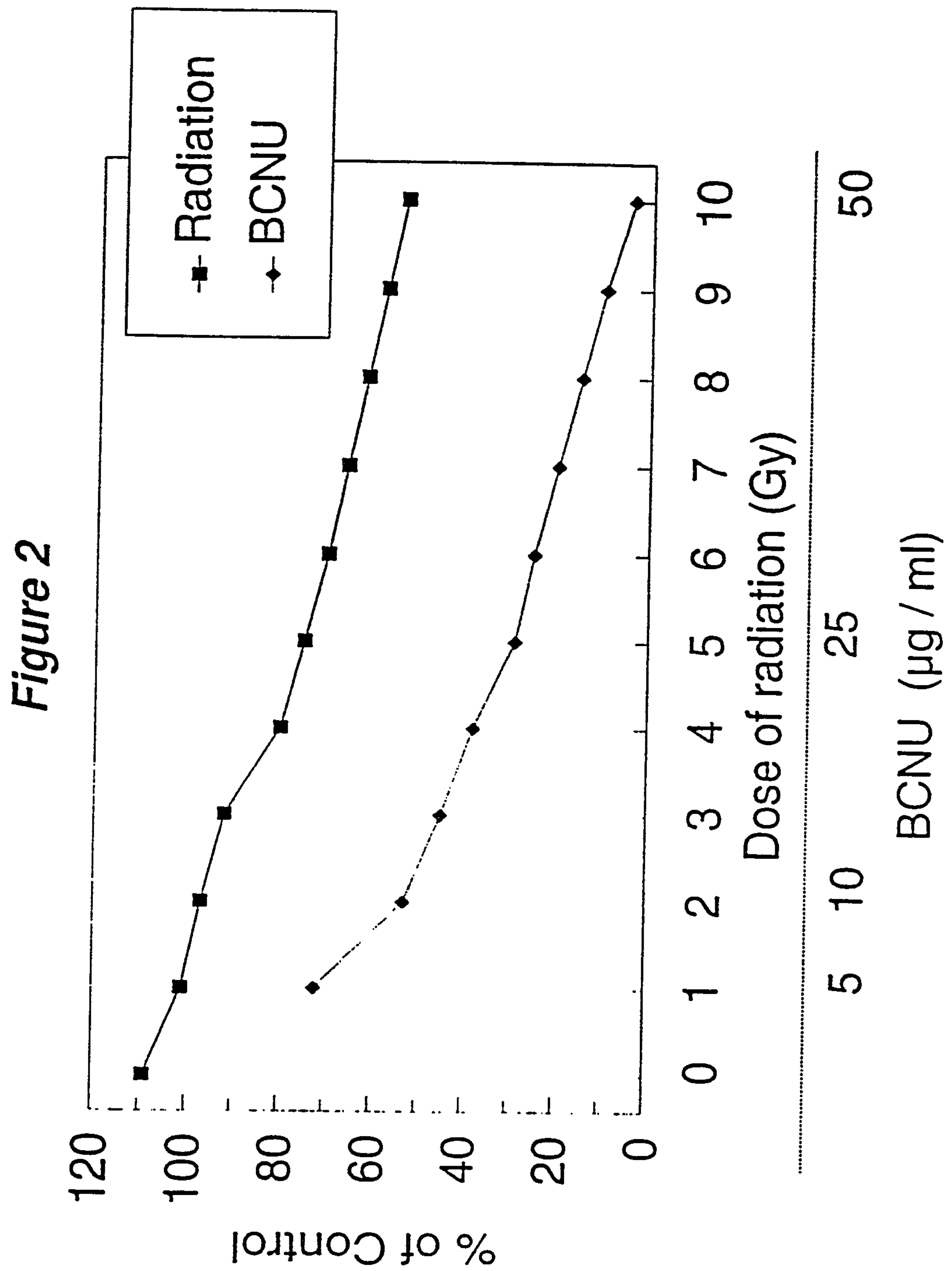
PATENT AGENTS

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Figure 1

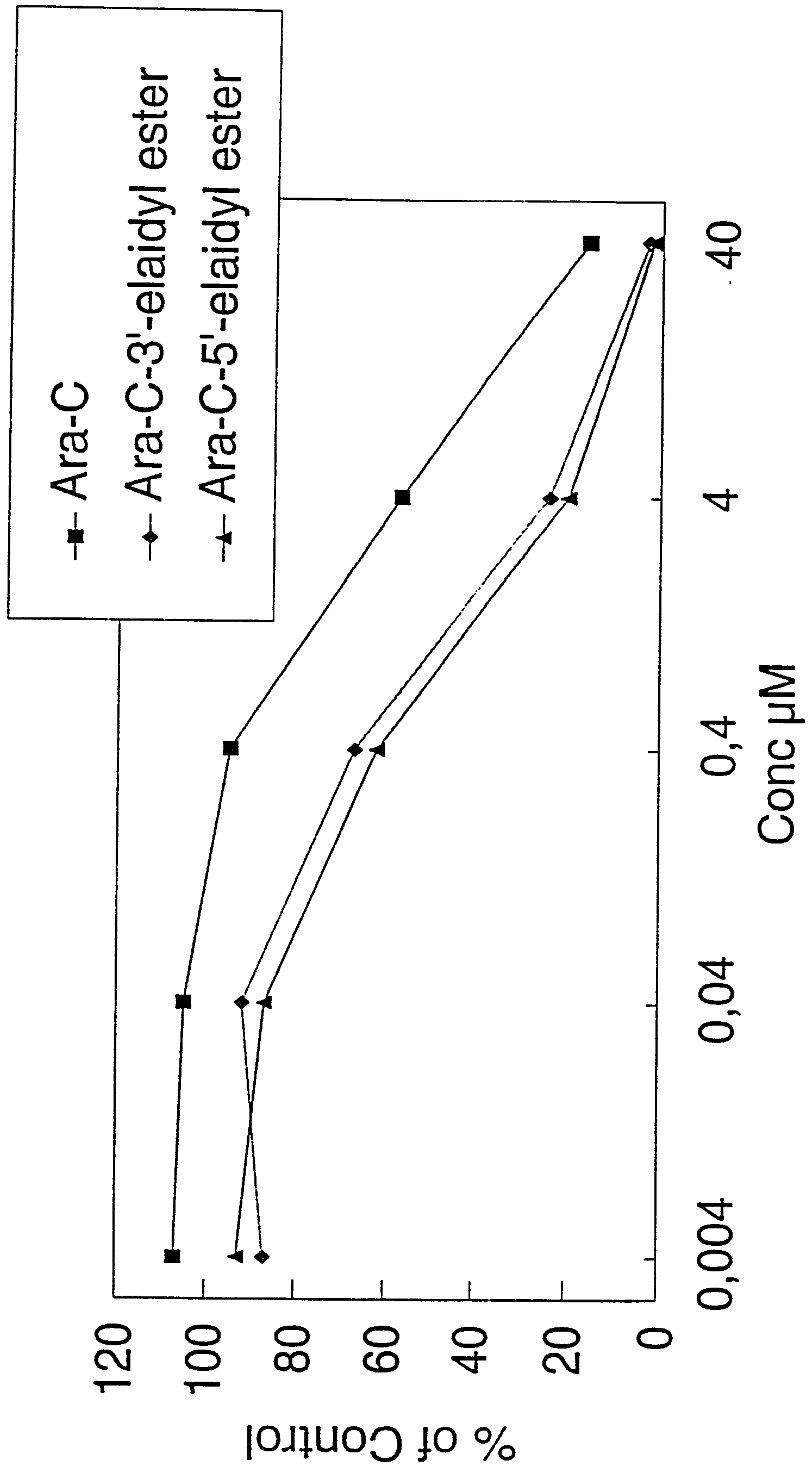


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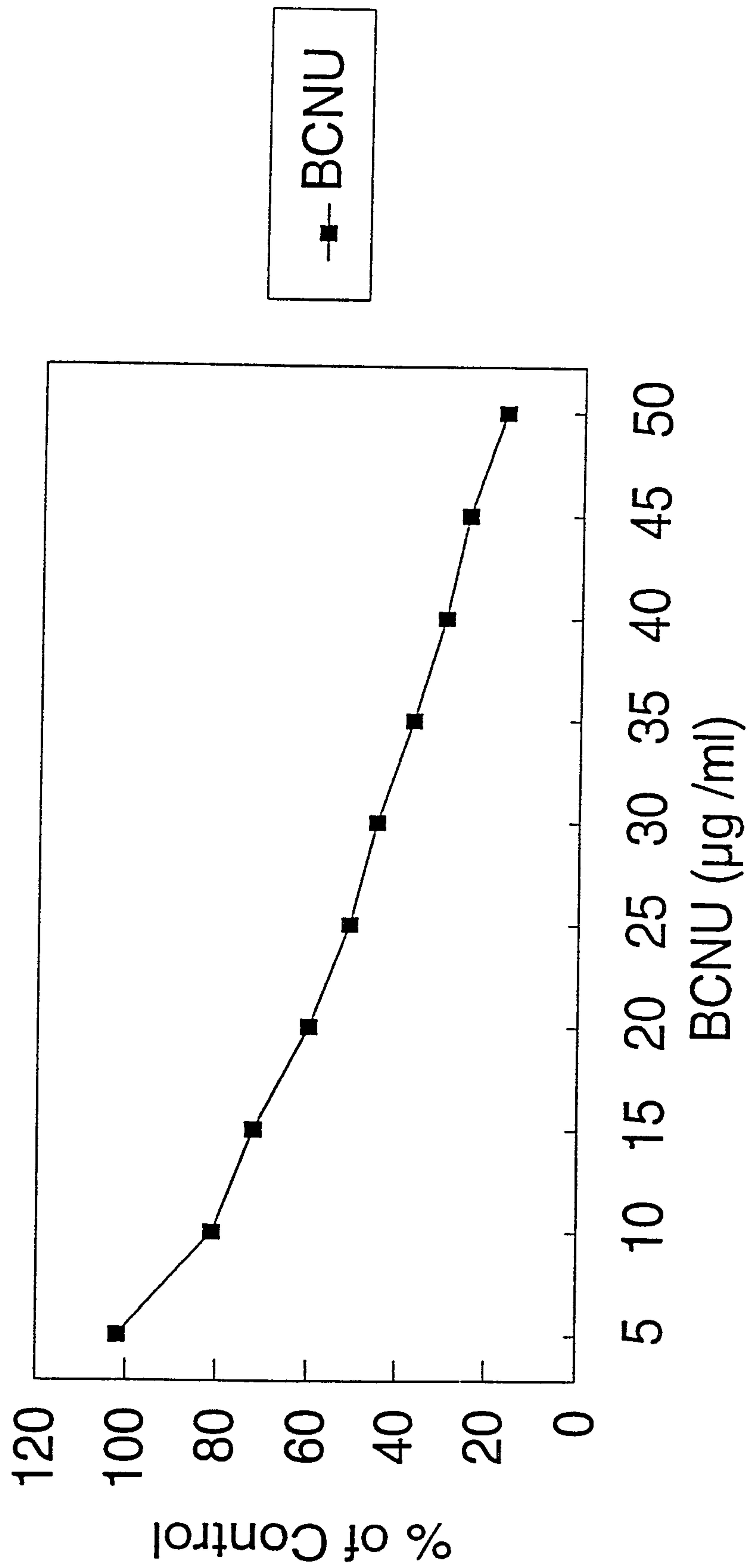


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Figure 3

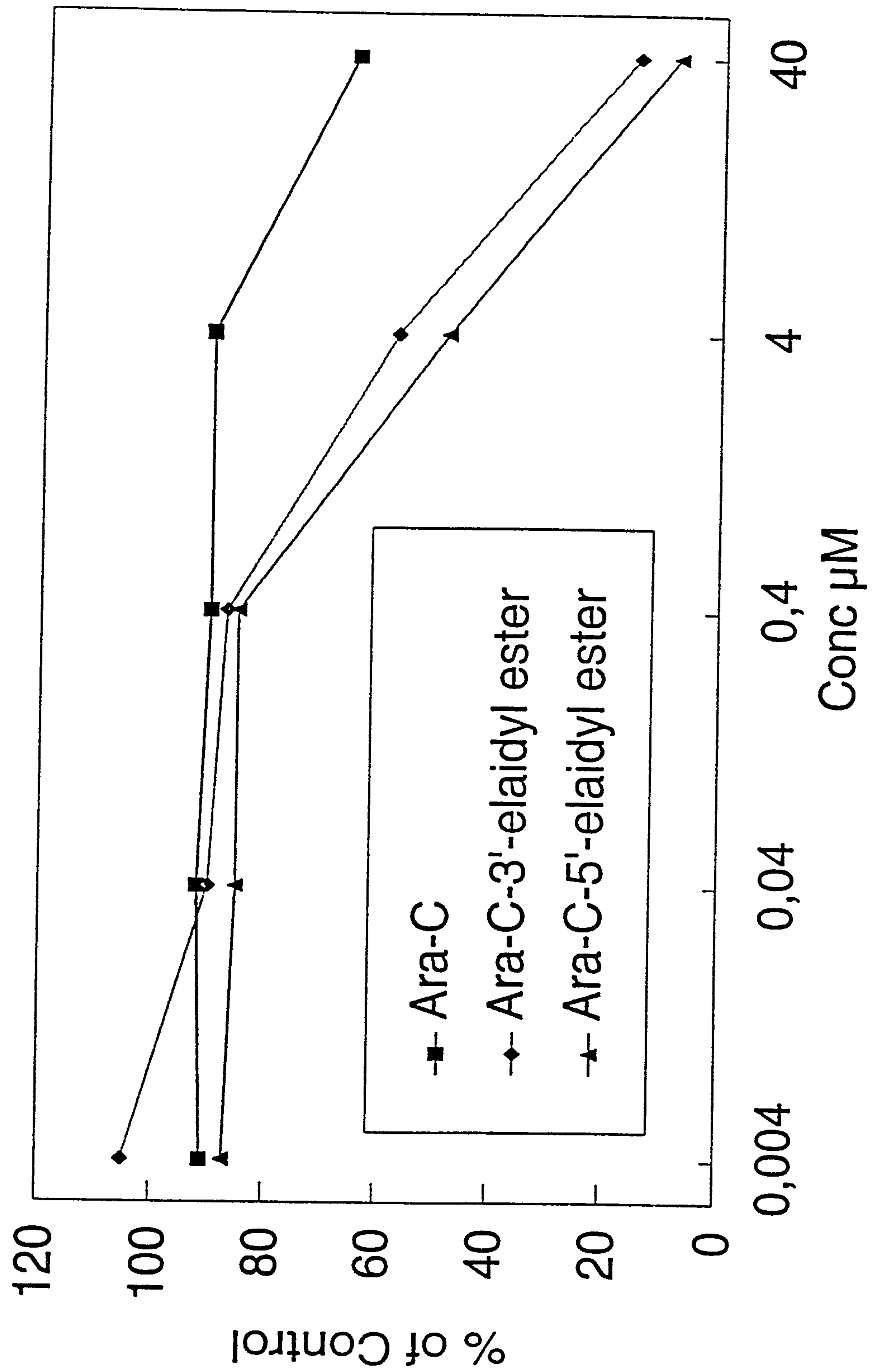


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Figure 4

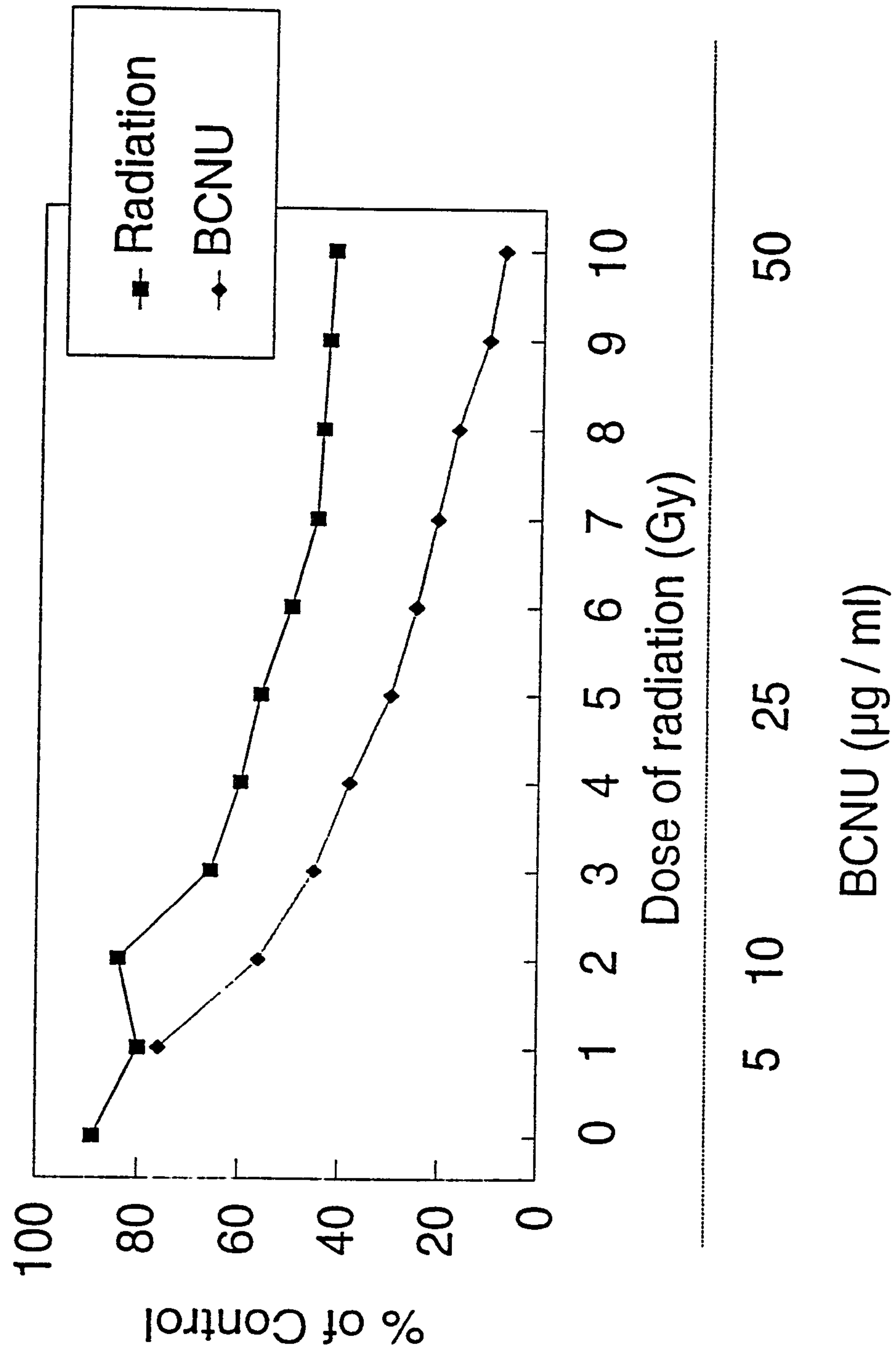
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Figure 5



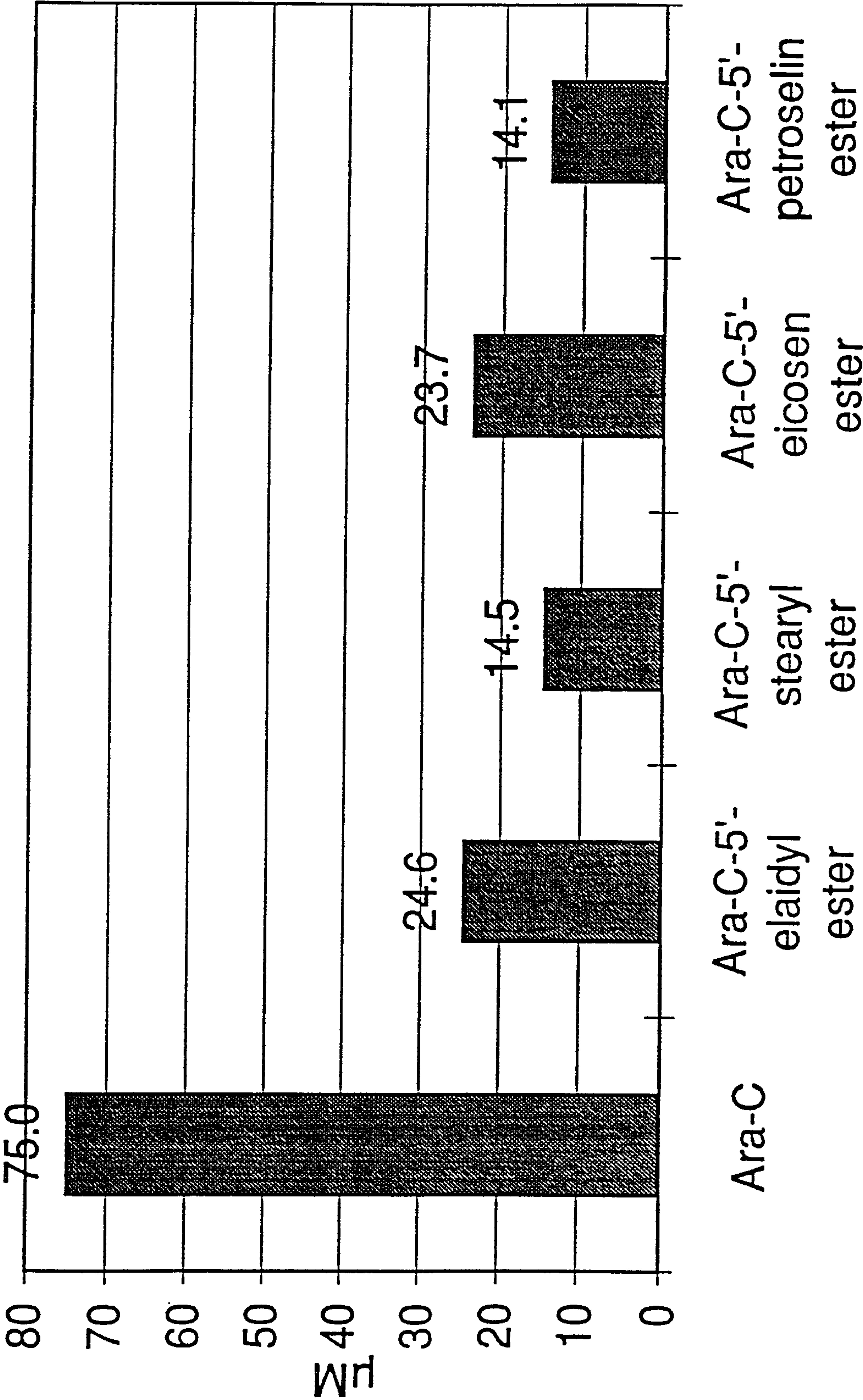
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Figure 6



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Figure 7



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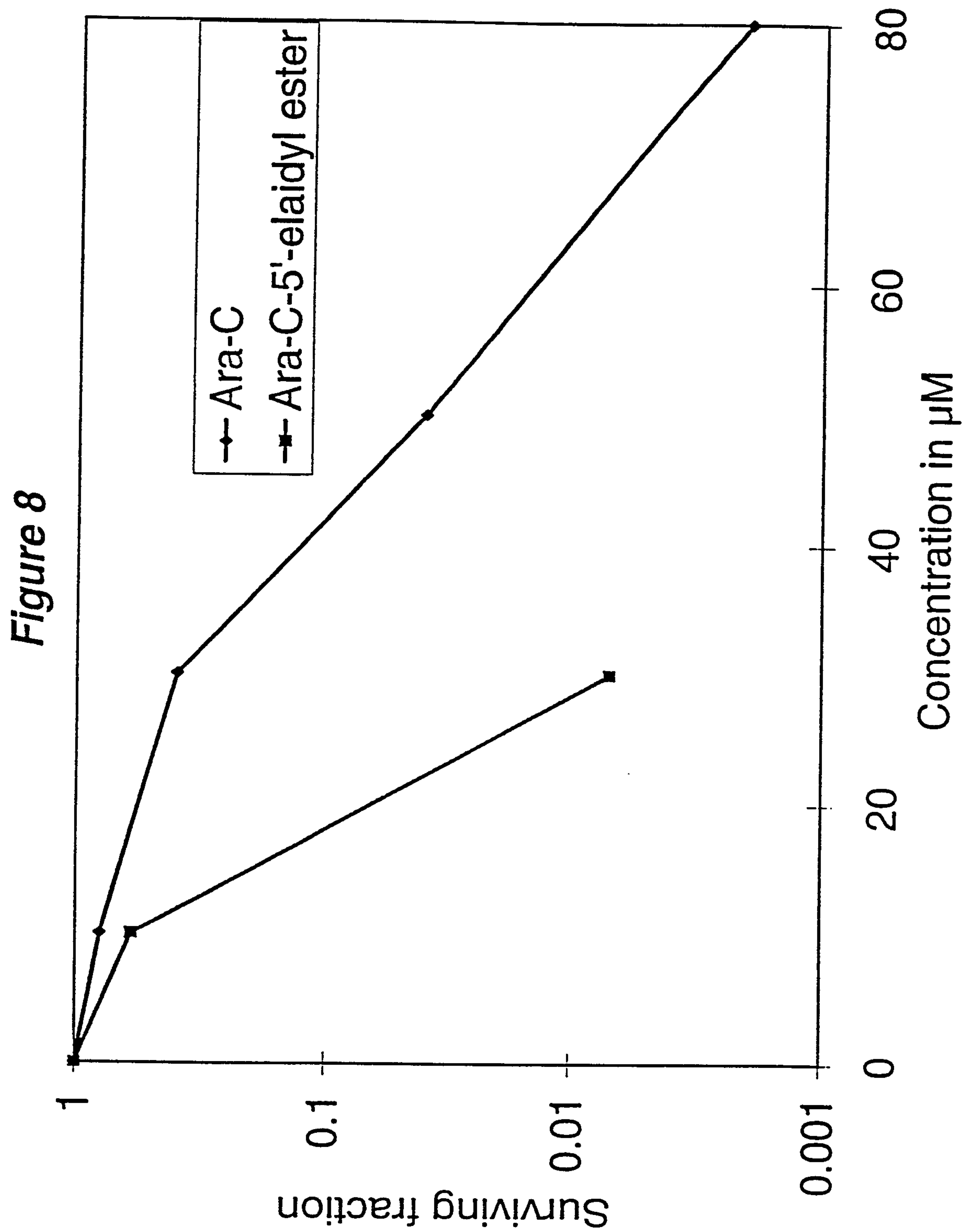


Figure 9

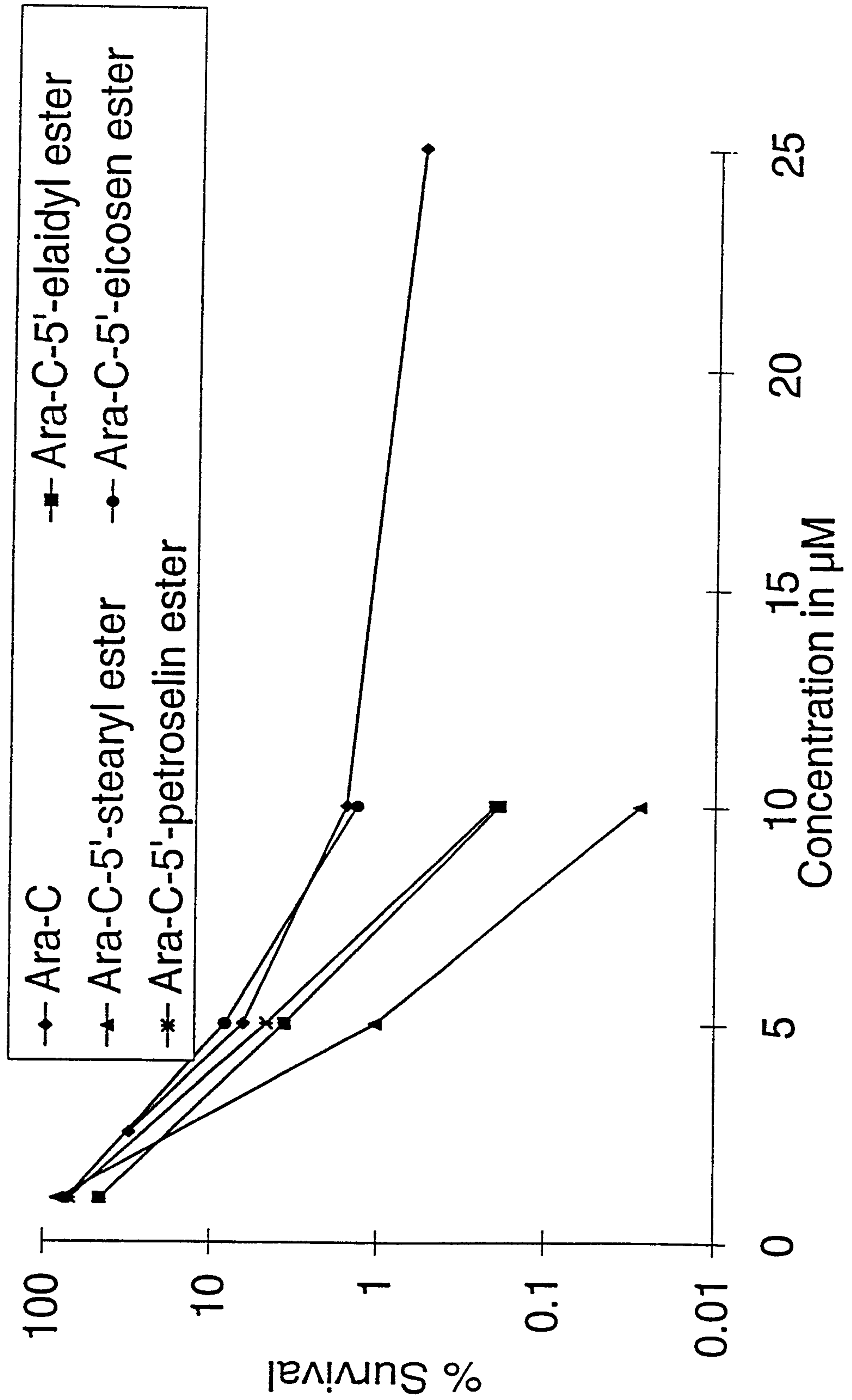


Figure 10

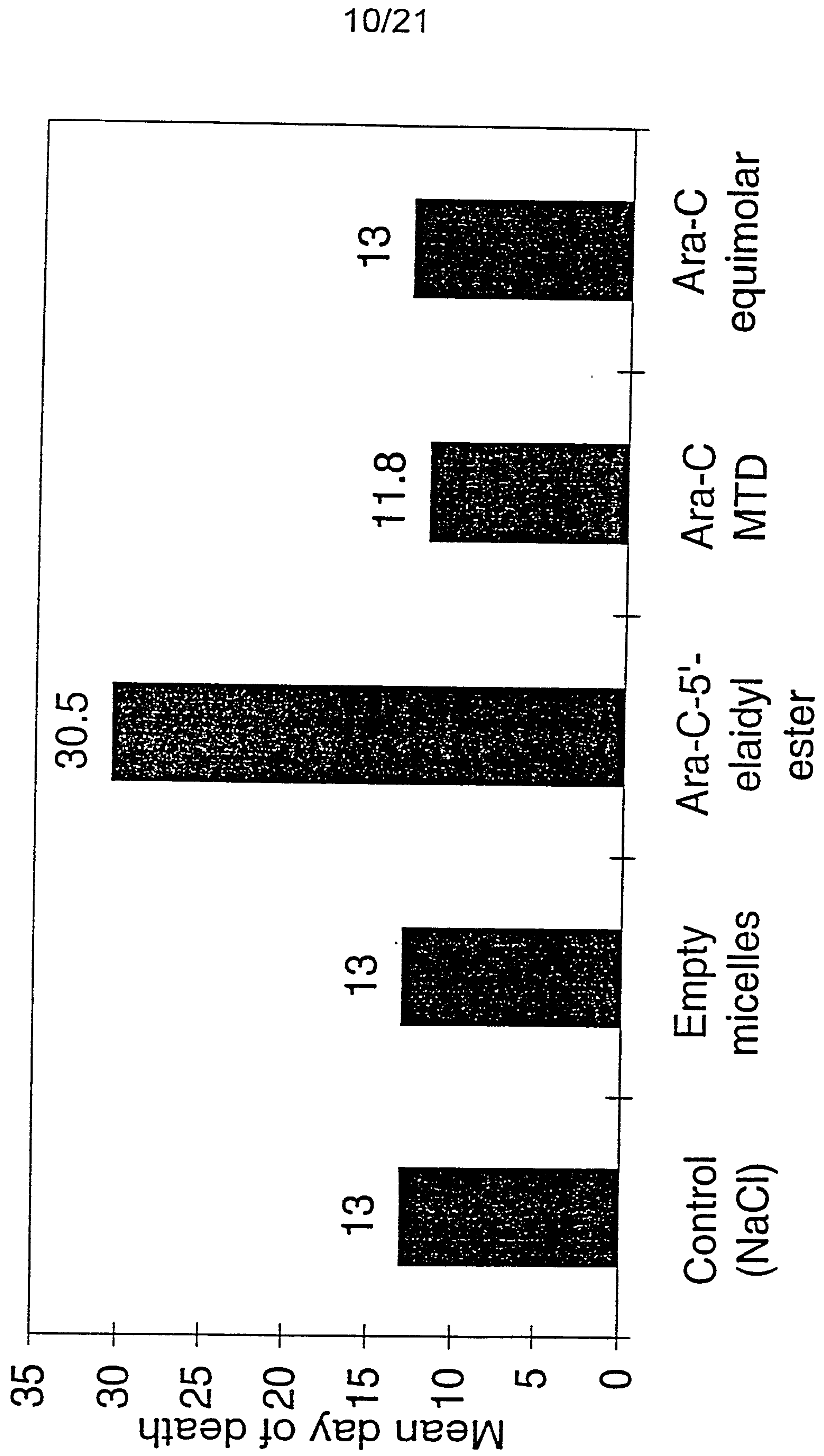


Figure 11

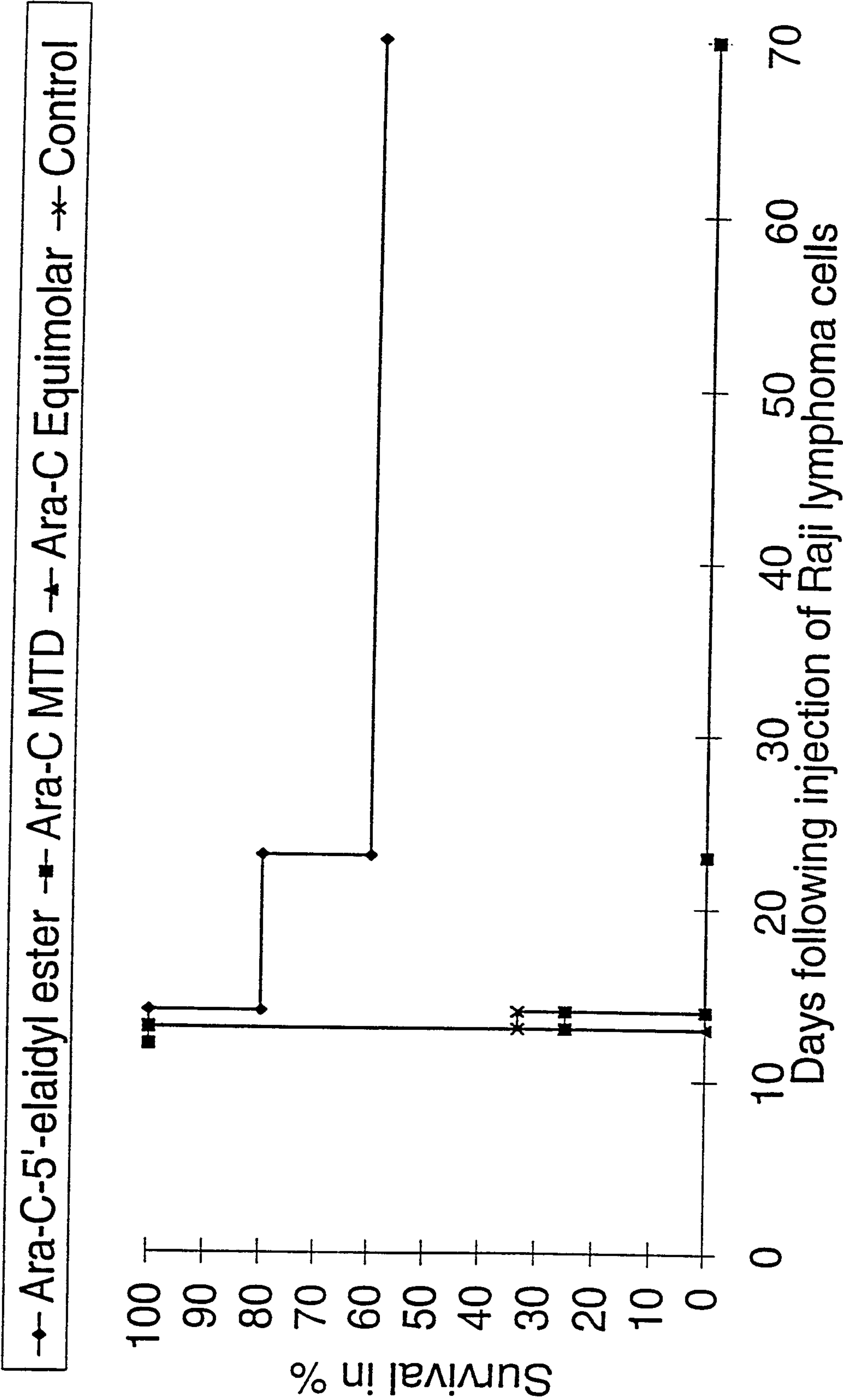
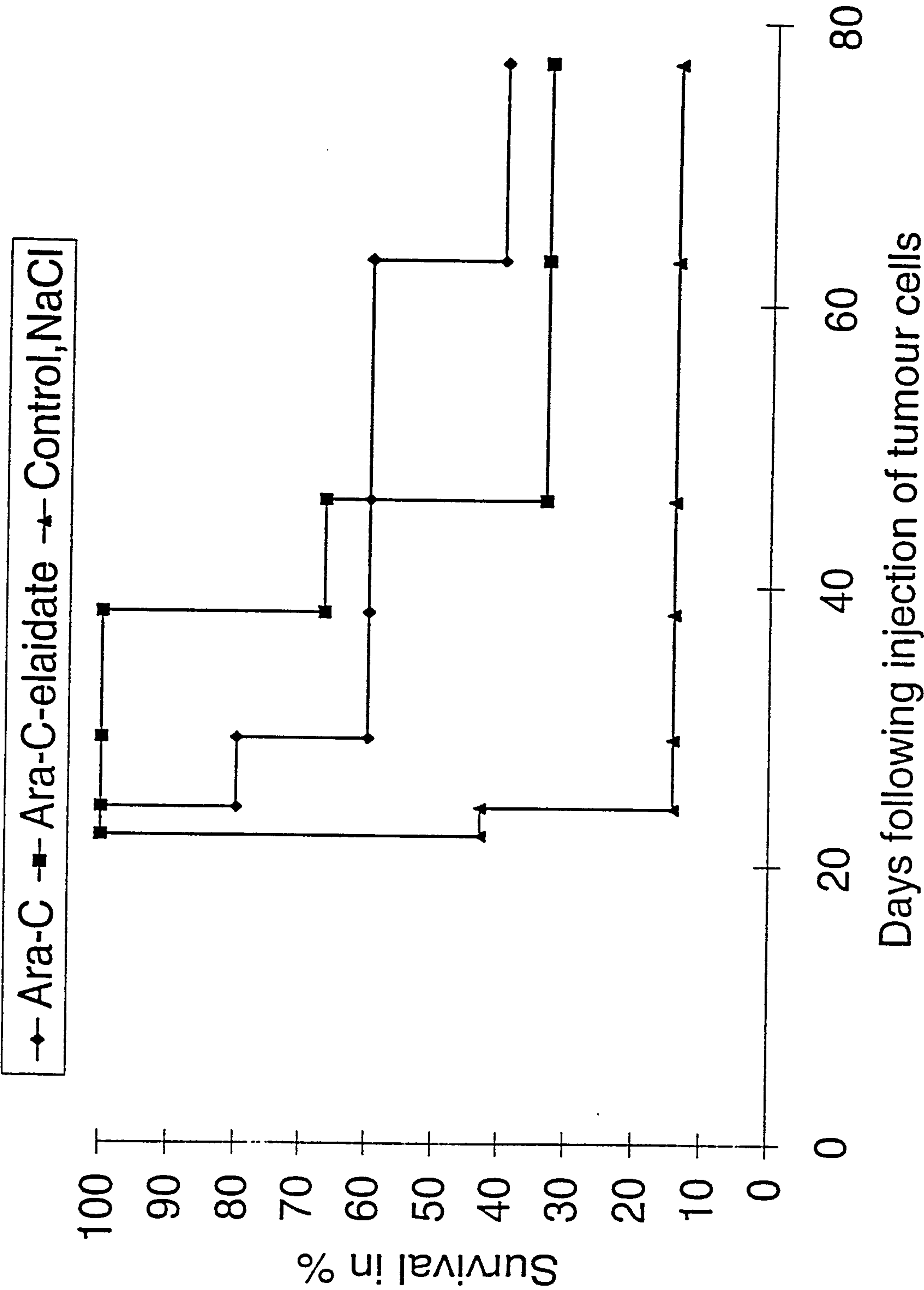


Figure 12



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Figure 13

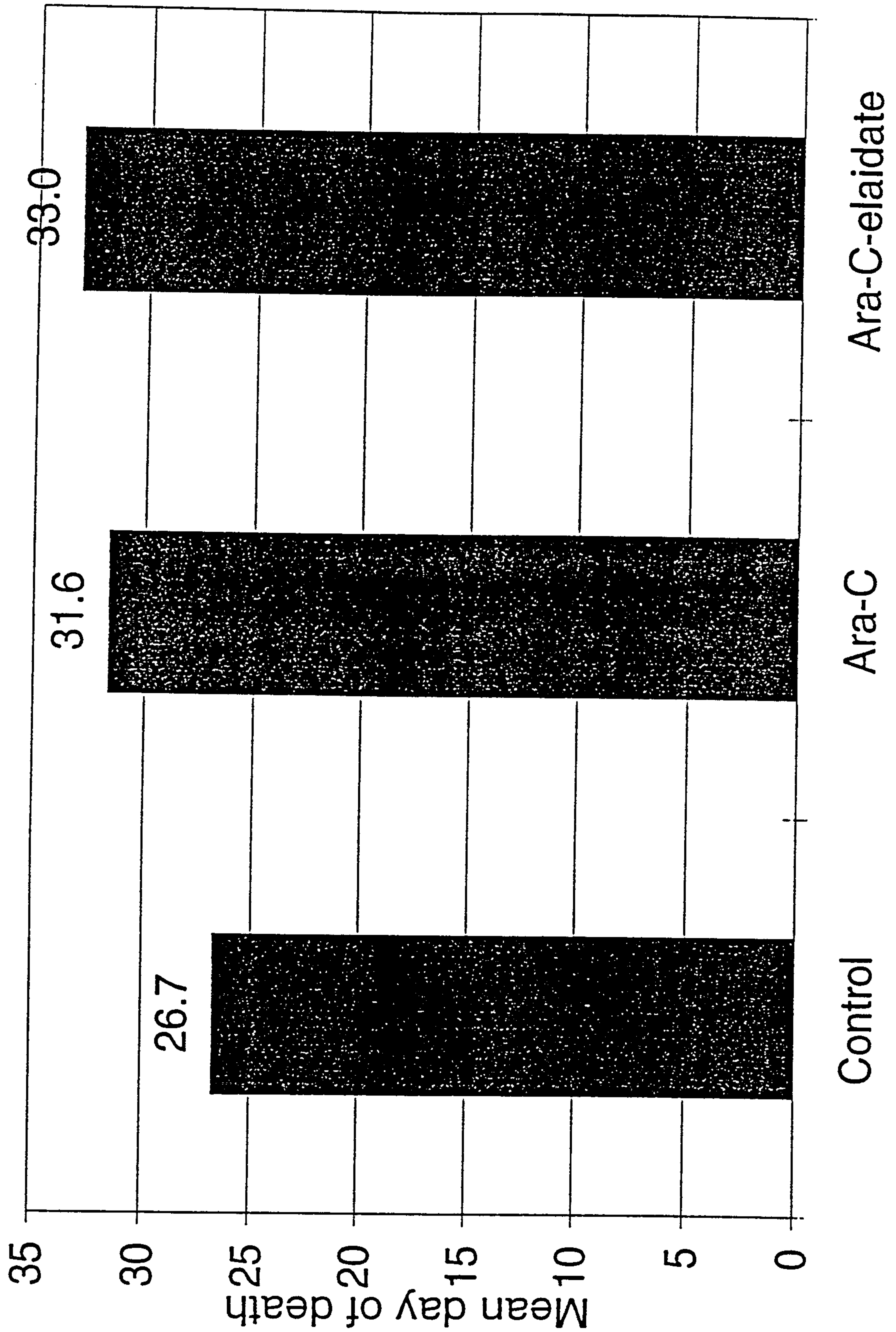
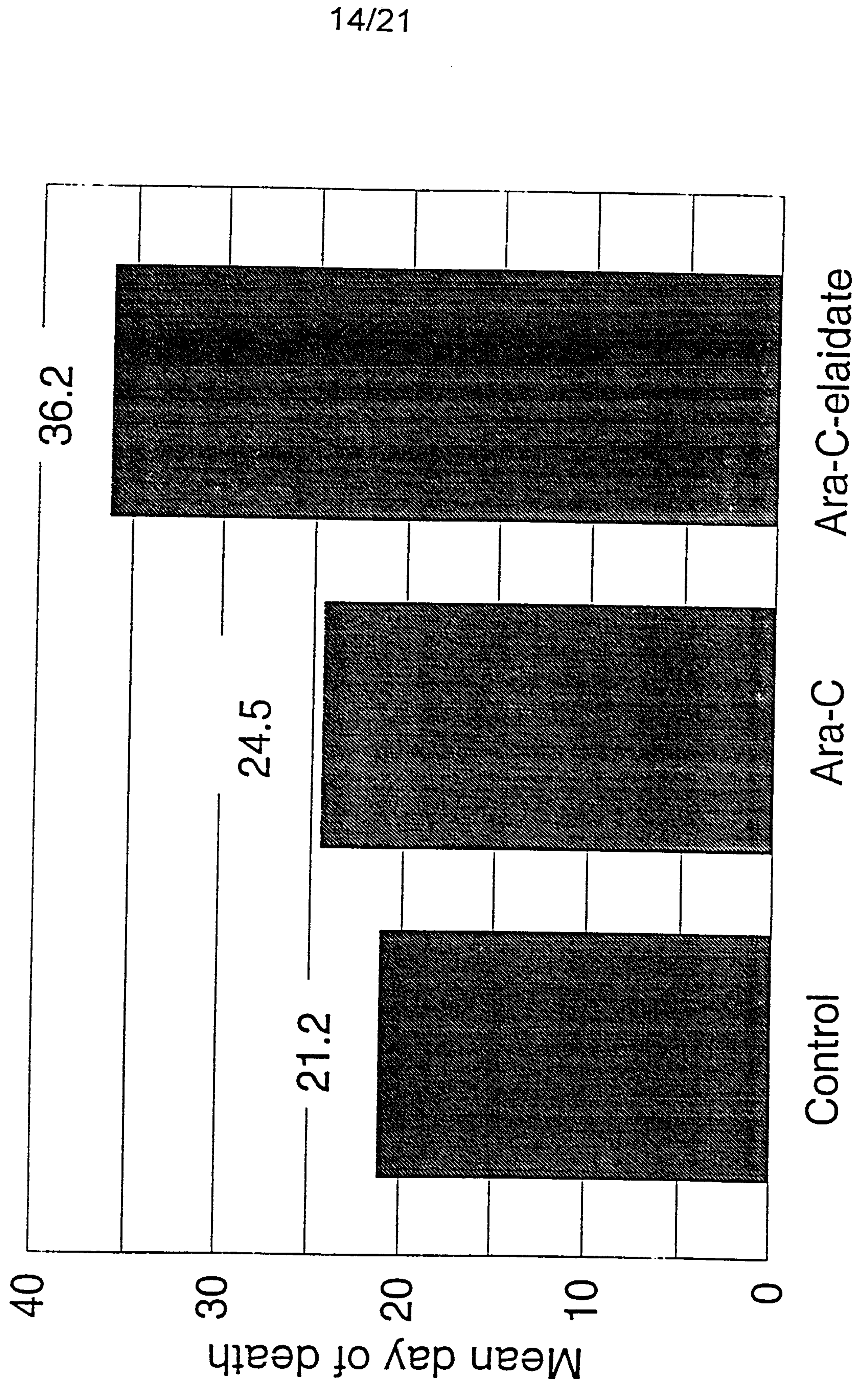
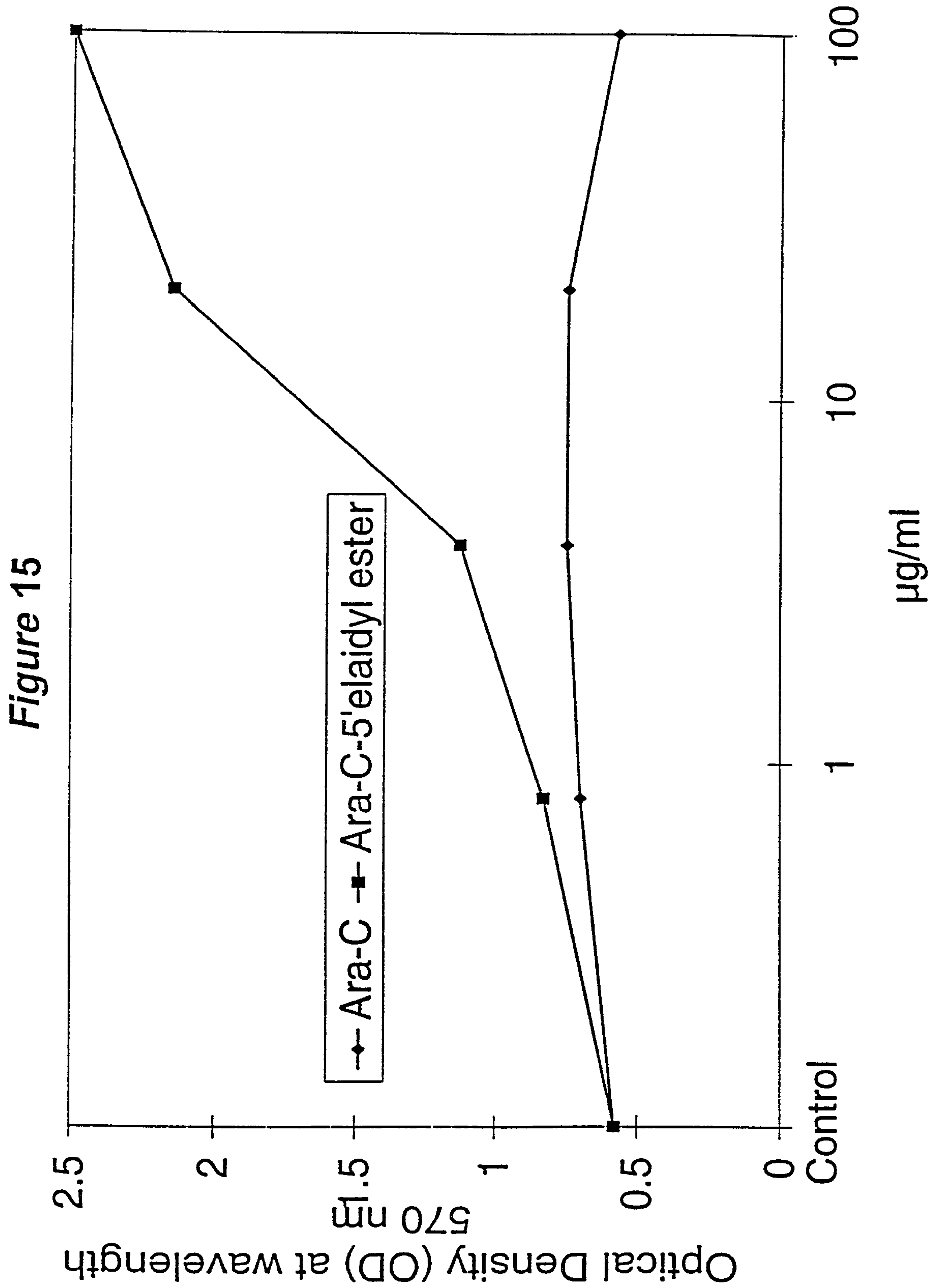


Figure 14

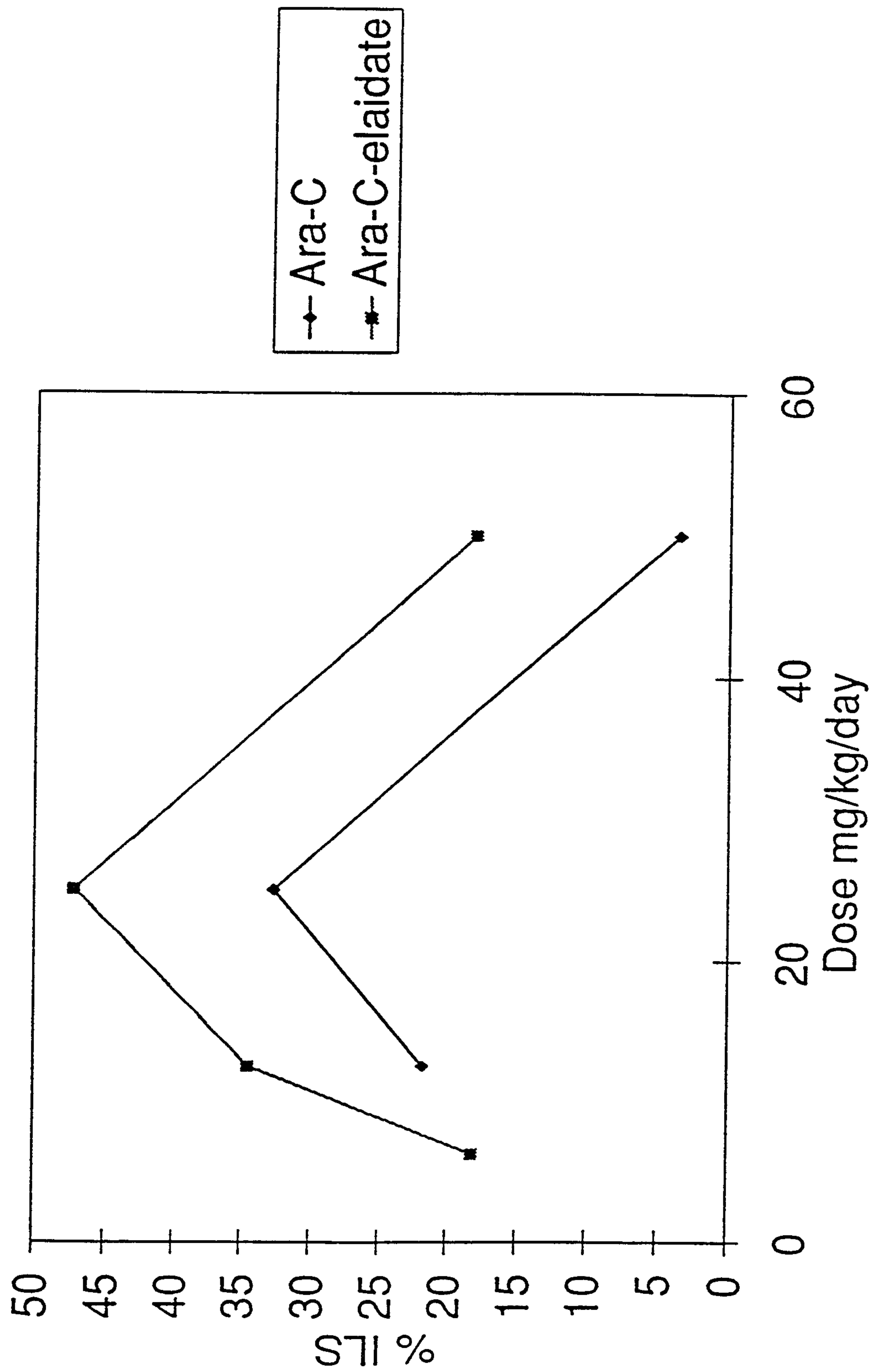


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FIGURE 16



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Figure 17

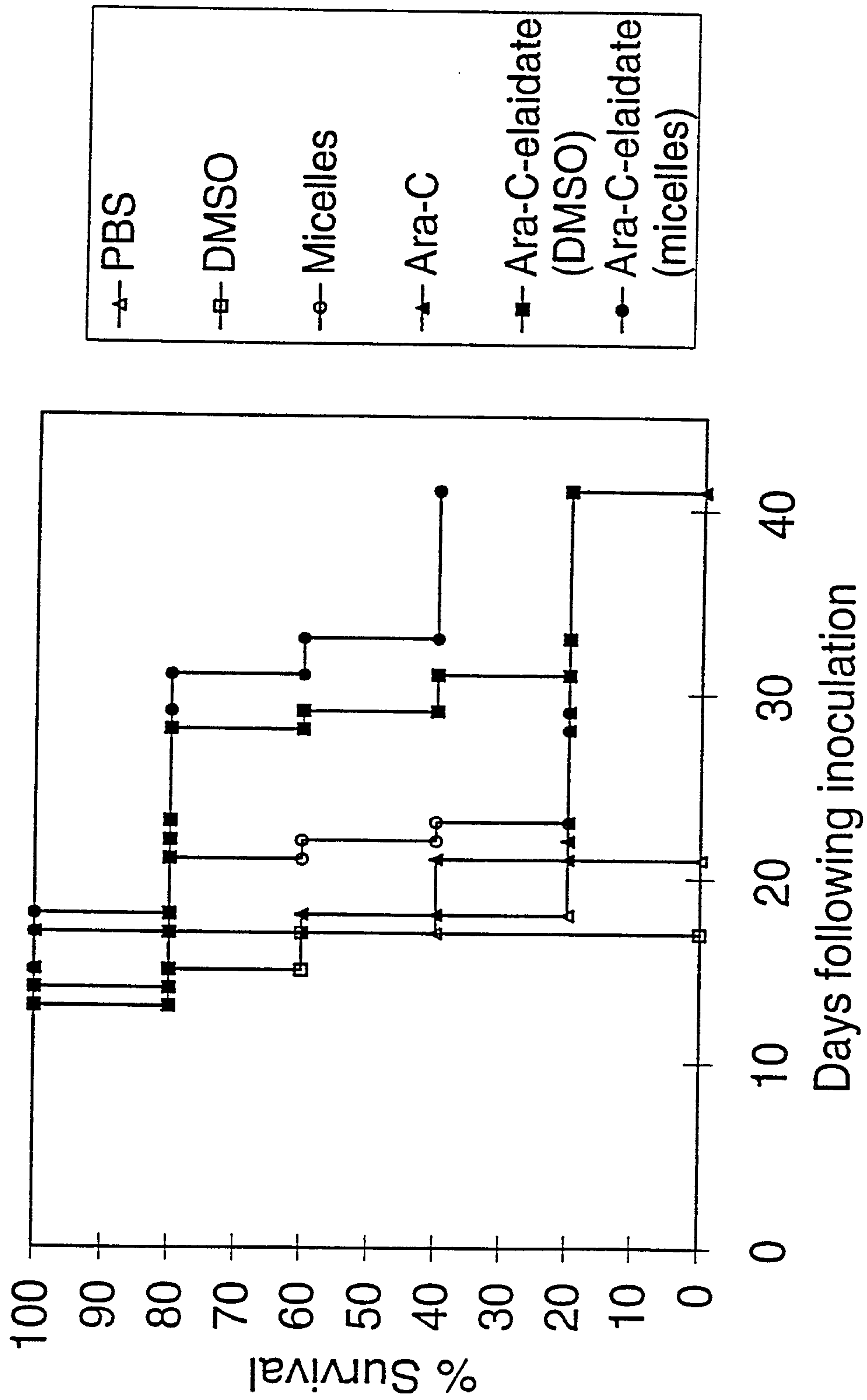
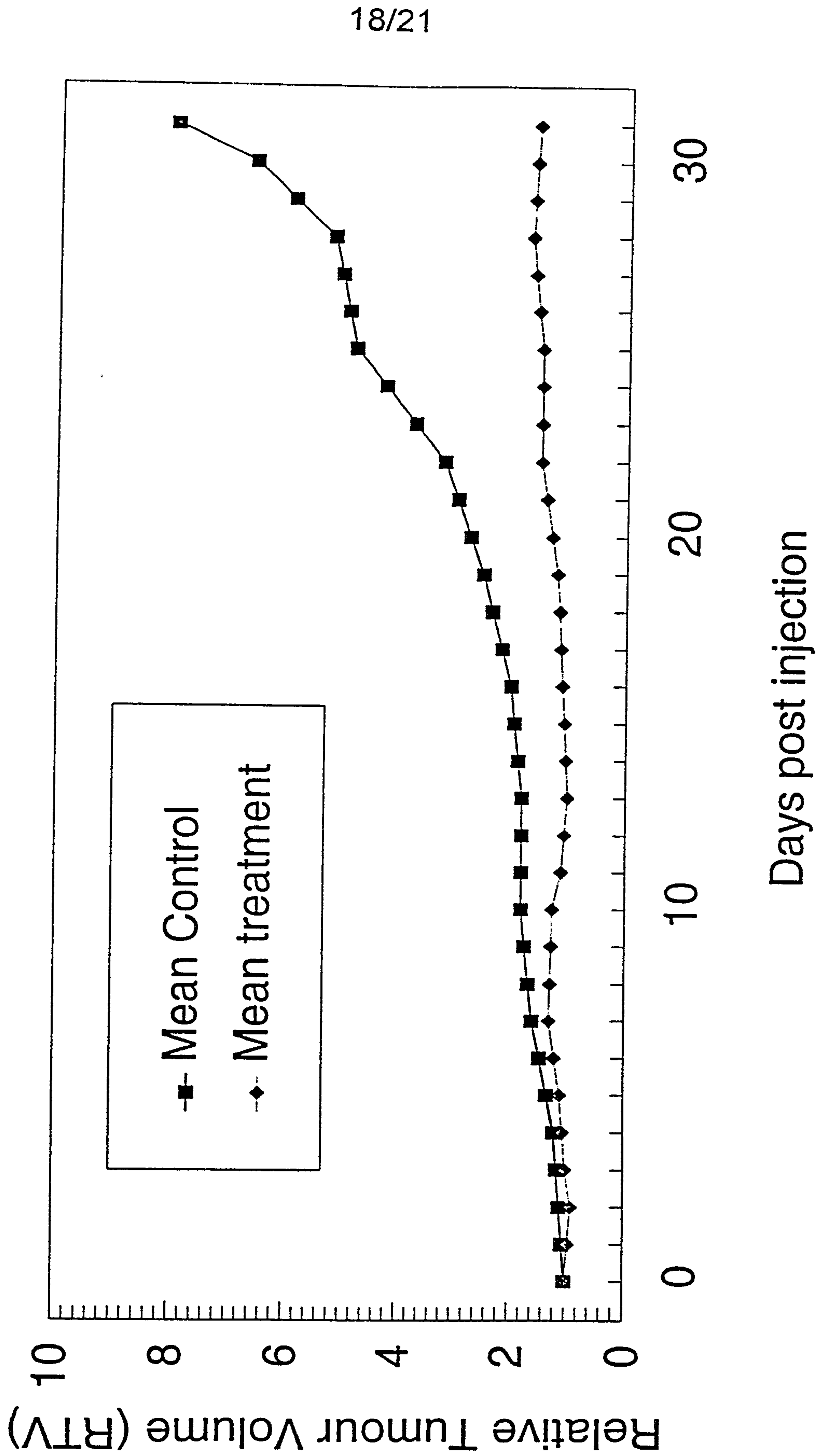
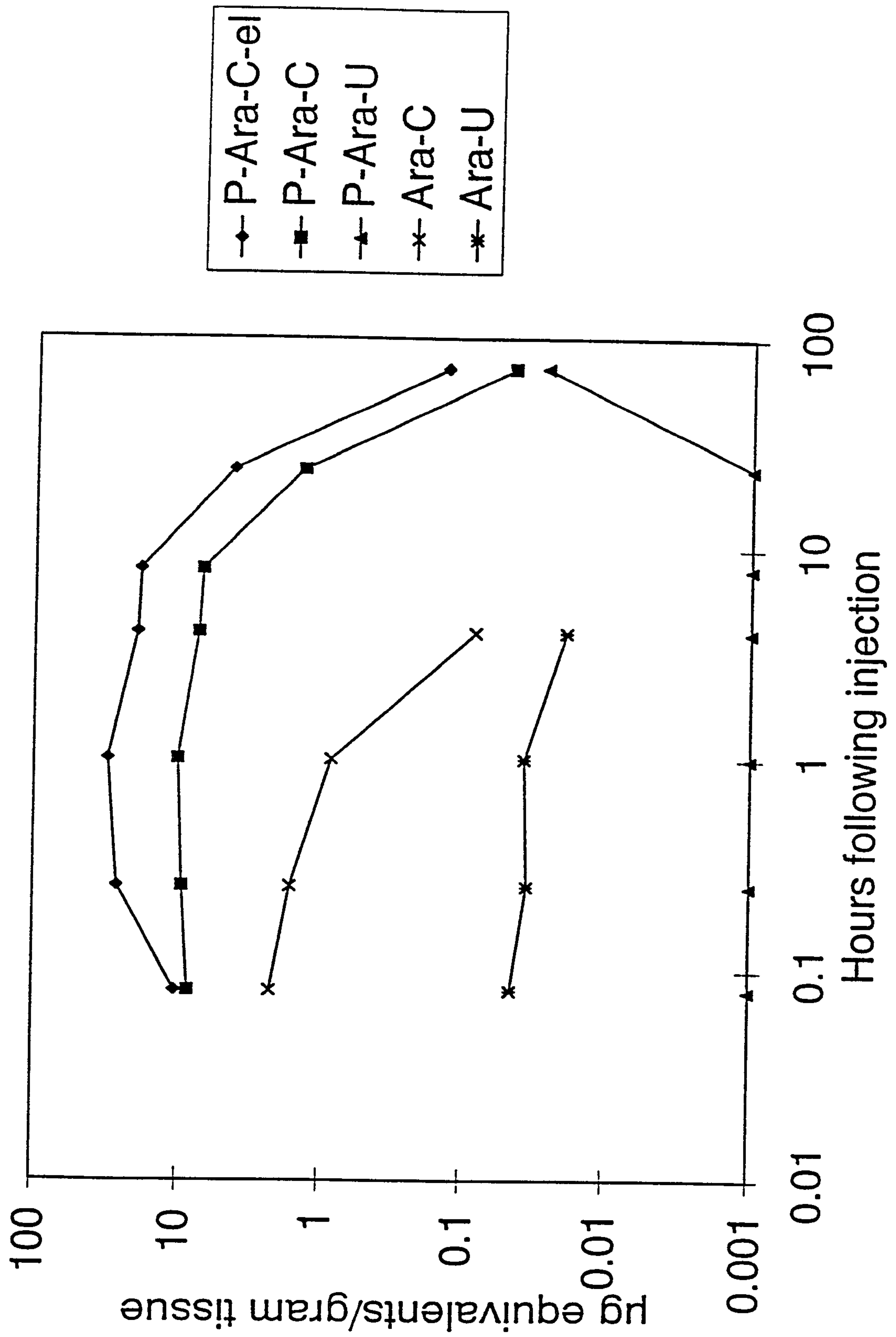


Figure 18



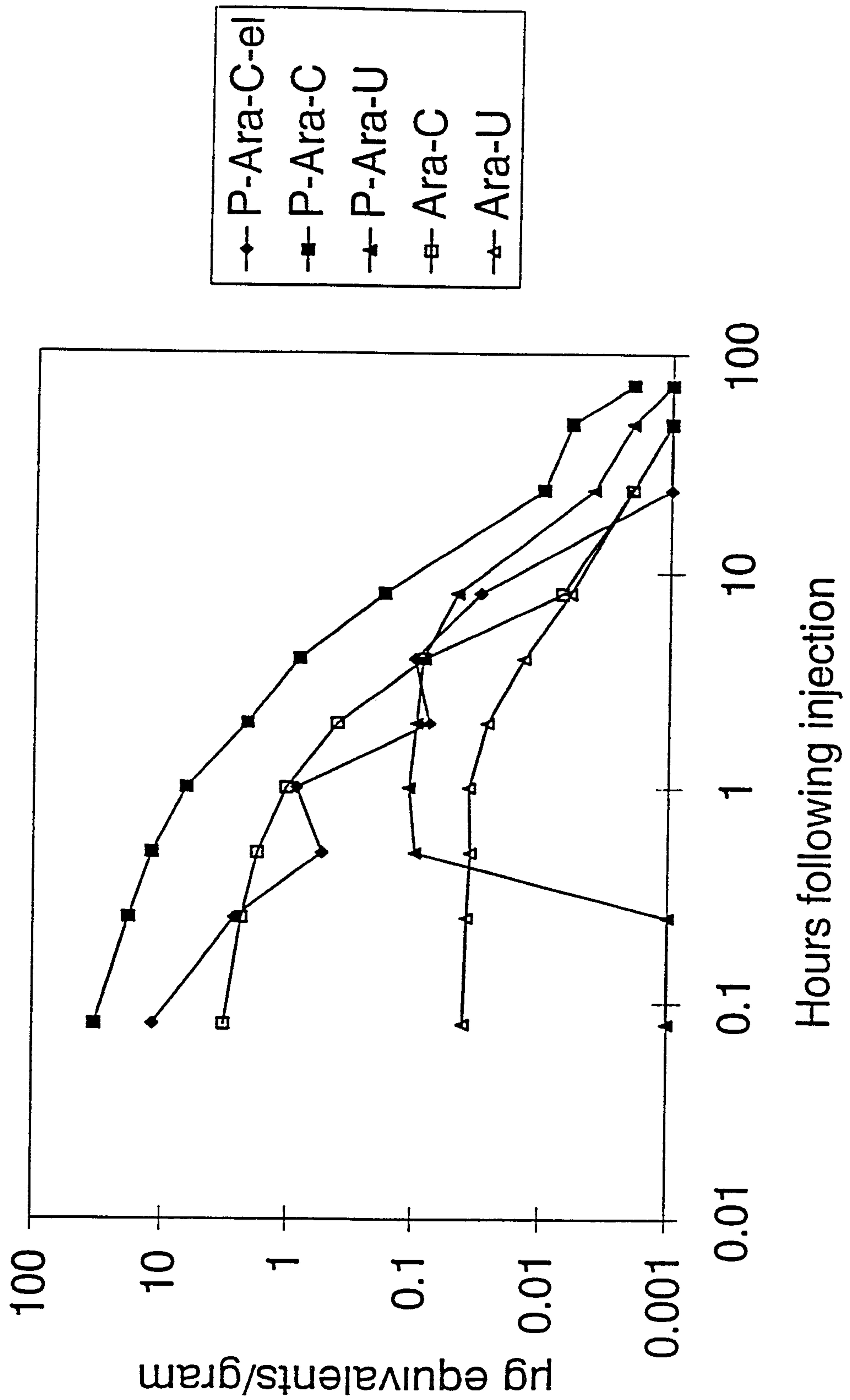
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Figure 19



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Figure 20



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