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Enzyme derivatives for use in the treatment of venous thrombosis compositions containing them and their preparation

This invention relates to enzyme derivatives for use in the treatment of venous thrombosis.

Venous thrombosis is the formation from the constituents of the blood of a solid mass or plug in a vein. Such plugs or thrombi may be dislodged in whole or part and may move to another vascular site; when this occurs the thrombus or its fragment is referred to as an embolus. Collectively the states associated with thrombi and emboli are referred to as thromboembolic diseases or disorders, and when viewed together they represent a leading cause of serious illness and death in the Western world.

Currently there are two classes of therapeutic agents proposed for the treatment of venous thrombosis, these are anti-coagulants and thrombolytics. At present anti-coagulants are the most commonly used therapeutic agents; the most widely employed being heparin (generally recognised as most effective) and dihydroxycoumarin (warfarin). The principal disadvantage of anti-coagulant agents is that they have no direct lytic action on the clot and therefore they have little usefulness in the treatment of an acute thrombotic condition. Secondly because they depress the clotting system, a complication inherent in the use of such agents is uncontrollable bleeding, which is recognised as a significant hazard.

Thrombolytic agents suggested to date for use in the treatment of venous thrombosis fall into two classes. Firstly there are proteolytic enzymes which are able to lyse fibrin directly. Secondly there are enzymic activators which activate the lytic pathway in the body liberating plasmin which lyses the clot. Examples of proteolytic enzymes which have been suggested for use as thrombolytic agents include brinase, papain, ochrase, trypsin and plasmin. However these enzymes are extremely toxic because intravenous administration can lead to uncontrolled proteolytic degradation *in vivo*. For example plasmin degrades fibrinogen and other clotting factors causing a bleeding syndrome. Moreover such agents may cause plasminogen depletion thereby creating a thrombotic state. For these reasons enzymes of this type are rarely used as therapeutic agents.

The two agents generally recognised as most useful for thrombolytic therapy are streptokinase and urokinase. These are activators and operate by converting plasminogen to plasmin. Streptokinase is a secretory product of haemolytic streptococci, and can be produced cheaply in large quantities. Urokinase is available only in very small quantities and is extremely expensive. Although both agents are able to resolve large clots even in deep veins the intense fibrinolytic state which they cause tends to induce bleeding which is again a significant hazard. Consequently the use is strictly limited to patients having a serious thrombotic blockage in a major vein or with pulmonary embolism. Moreover since activators stimulate the natural lytic system their systemic administration can result in plasminogen depletion thus predisposing a patient to a thrombotic state if treatment is prolonged. To some extent this effect may be overcome by the use of streptokinase-plasminogen combinations. This compromise does not present an adequate solution to the problem of therapeutic fibrinolysis since systemic formation of plasmin by such combination tends to swamp the clotting/lytic pathway control mechanisms. Moreover these combinations do nothing to overcome the problems of uncontrollable bleeding.

We have now discovered that it is possble to overcome most of the disadvantages of known thrombolytic agents by making use of certain enzymes which can be reversibly deactivated. It is recognised that some enzymes such as plasmin or streptokinase/plasminogen activator complex display some selectivity for fibrin particularly *in vivo*. Although the full structural requirements and characteristics of such enzymes have not been determined, we have devised a test by which enzymes having specificity for fibrin *in vivo* may be recognised. Hereafter enzymes which are positive in this test will be referred to as "*in vivo* fibrinolytic enzymes".

We have found that derivatives of these enzymes can be made in which the catalytic activity is masked while the affinity for fibrin remains unaffected, but which will hydrolyse in aqueous media to liberate the active enzyme.

The test used to determine *in vivo* fibrinolytic activity of an enzyme is performed by forming a radio actively labelled clot in the inferior vena cava in a test rabbit. The agent under test is introduced into the bloodstream at a point where it must pass through the heart to ensure that the agent will be thoroughly mixed with venous blood. Non-specific lytic enzymes attack blood proteins and cause death before any lysis of the clot is observed. Enzymes which have a degree of specificity for fibrin lyse the clot at a dose lower than the lethal dose. The occurrence of lysis is demonstrated by the liberation of radio active fragments into the bloodstream.

By the term "*in vivo* fibrinolytic enzyme" used in this specification, we mean an enzyme which, when systemically administered in not more than five hours to a rabbit with a radioactively labelled clot localised in its inferior vena cava, will raise the blood radioactivity level to at least twice that of the background level in six hours from beginning the administration, without causing death of the animal.

One specific way of carrying out this test is as follows:

A New Zealand white rabbit (2.5—3.5 kg) is anaesthetised and three cannulas are inserted into the anterior facial vein (referred to as cannula 1 in this description), the left carotid artery (referred to as cannula 2) and the left external iliac vein (referred to as cannula 3). A laparotomy is then performed

upon the rabbit to expose the inferior vena cava near its junction with the left renal vein. A section of the inferior vena cava is isolated by closing a ligature near that point and placing a clamp on the inferior vena cava at a point further towards its junction with the left external iliac vein. A radio-labelled clot is induced by injecting 50 μl of a mixture made up of radio-iodinated human fibrinogen (100 μl) and rabbit thromboplastin (150 μl) into the isolated portion of the vein. The quantity of 50 μl is determined arbitrarily, and represents an amount between the minimum quantity which can be measured accurately and the maximum quantity which can be injected without excessive disturbance of physiological conditions within the isolated vein portion. It is essential for the purposes of measuring any radio-activity released into the bloodstream that the amount of radio-activity injected into the vein should be not less than 0.25 μC_i and an amount in the range 0.25 to 1.0 μC_i is generally convenient. A clot swab is placed over the injecting needle at its point of entry into the exterior wall of the inferior vena cava as the injection is made so as to absorb any seepage from the injection site and any unclotted radio-activity. A second 50 μl portion or blank of the fibrinogen-thromboplastin mixture is transferred to a counting vial and its level of γ-radiation is estimated either by liquid scintillation counting or by direct γ-counting using a sodium iodide crystal technique. The blank gives a measure of the radio-activity injected into the animal. The first clot swab is kept in place long enough to collect all initial seepage (5 minutes is generally sufficient) and replaced by a second clot swab. The first swab is transferred to a counting vial, and the level of γ-radiation is measured. The cannula 3 is advanced as far as the aforementioned clamp and 10 minutes following the injection of the fibrinogen-thromboplastin mixture, heparin solution (0.5 ml 500 μ/ml) is administered via cannula 3. The purpose of the heparin injection is to limit the extent of clotting in order to prevent the incorporation of significant amounts of unlabelled endogenous rabbit fibrin into the test clot. The reason for this is that if significant amounts of unlabelled material were incorporated into the clot lysis might go undetected since unlabelled lysis products would be released into the bloodstream. This error would be significant if for example the radio-labelled clot were encapsulated in unlabelled material.

The ligature is partially opened so that the inferior vena cava is constricted to between 40% and 60% of its normal diameter. Constriction is required in order to prevent dislodgement of the clot. The clamp is removed. Heparin solution (1.0 ml, 500 μ ml) is administered via cannula 2 to anti-coagulate the animal and to prevent the formation of clots in addition to that required for the purpose of the experiment. A check is then made for any bleeding which if persistent, is stopped by application of a thrombin-impregnated swab. A blood sample (1.8 ml) is withdrawn via cannula 2 fifteen minutes following the injection of radio-active material and anti-coagulated by adding trisodium citrate buffer (0.2 ml 3.8% w/v). The diluted blood sample (P_o) is assayed for γ-radiation by liquid scintillation counting or direct γ-counting using a sodium iodide crystal method. This gives a measure of radio-activity in the bloodstream. The clot is then washed by infusion of saline (4.0 ml, 0.2 ml min^{-1}) via cannula 3 to wash out any exogenous radio-active material into the circulation and to assist in preventing clot extension by washing away any thrombogenic agents. A second blood sample (P_{10}) is withdrawn into citrate buffer as above and counted as previously described ten minutes after P_o. This count is made to check that no additional radio-activity has been washed into the bloodstream, thereby giving an indication of the stability of the clot.

Twenty minutes after P_o has been taken, the saline infusion is stopped, a further blood sample is taken (time t=o) and the infusion of the test enzyme started. The amount of radiation from the t=o blood sample is a measure of background radiation.

A dose of enzyme is administered by systemic infusion and 2 ml blood samples are taken every 30 minutes for 6 hours following the beginning of the infusion. Each sample is assayed for radio-activity by direct γ-counting using a sodium iodide crystal method or liquid scintillation counting, and the free plasmin activity are measured *ex vivo*.

The dose to be administered to the test animal to achieve a positive result is determined by trial and error until activity is observed without causing death. As a guide to the dose to be employed a dose of human plasmin in the range 1×10^{-7} to 5×10^{-6} mol of active catalytic sites per kg of test animal give a positive result in the test; similarly a dose of streptokinase/plasminogen activator complex is positive in the range 1×10^{-10} to 1×10^{-8} mol/kg. Accordingly, the proteolytic active site concentration is determined, if unknown, either by chromogenic or fluorogenic titration or by determining the molecular weight and specific activity of an analytically pure specimen of the enzyme.

A dose is selected arbitrarily similar to the ranges indicated above. 20% of the selected dose is administered at the onset of the experiment and the remainder is administered over 2 hours. If no activity is observed the experiment is repeated with increasing doses until activity is observed or until toxicity limits the experiment. The period of the infusion may be increased up to 5 hours.

In one aspect of the invention, therefore, there is provided a pharmaceutical composition which comprises a pharmaceutically acceptable carrier together with an *in vivo* fibrinolytic enzyme, having a catalytic site essential for fibrinolytic activity, and wherein the catalytic site is blocked by a group which is removable by hydrolysis at a rate such that the pseudo-first order rate constant for hydrolysis is in the range 10^{-6} sec^{-1} to 10^{-3} sec^{-1} in isotonic aqueous media at pH 7.4 at 37°C.

Examples of enzymes which are suitable for use in this invention are urokinase; streptokinase-

plasminogen activator complex; vascular activator, particularly human vascular activator and plasmins particularly mammalian plasmins, e.g. ovine, porcine, bovine, equine, simian and human plasmin.

Preferred enzymes for use in this invention are human plasmin and the streptokinase/human plasminogen activator complex. We have found that it is particularly advantageous to form a blocked derivative, especially an acyl derivative, of a mixture of human plasmin and streptokinase/human plasminogen activator complex. This mixture is conveniently prepared by activating human plasminogen by means of streptokinase in a conventional manner, and not removing all the activator complex.

We have found that the blocked enzymes employed in the compositions of this invention have the following advantages over the use of the corresponding free enzymes:

a) they are more efficacious than the free enzyme;

b) they are longer lasting in terms of their biological activity;

c) they can be administered as single, often large, intravenous doses because of their relatively low toxicity, whereas in current therapy, enzymes, activators or activator complexes must be given by continual intravenous infusion over periods of several hours or days.

Enzymes such as plasmins may be prepared by known methods as disclosed for example in B. A. K. Chibber et al., Methods in Enzymol., Vol 34 p 424—432.; K. C. Robbins and K. Summaria, Methods in Enzymol., Vol. 45 p 257—273. Alternatively plasminogen may be isolated by methods disclosed in British Patents No. 1013507, 1066467, 1078141 and 1096953 which may then be converted by standard methods to plasmin.

Human vasoular activator may be isolated by the method of D. S. Pepper *et al.* Progress in Chem. Fibrinolysis and Thrombolysis, 1978, 3., 91—98. Raven Press New York. Streptokinase-plasminogen activator complex is described by D. K. McClintock and P. H. Bell, Bio chem: Biophys Res. Comm. 43, 694—702, 1971. Urokinase may be isolated from human urine as described by T. Macaig et al. Methods in Enzymol Vol. 34 p 451—459 and G. H. Barlow Methods in Enzymol Vol. 45 p 239—245 Academic Press.

The essential feature of the blocking group for the catalytic site is that it should be removable by hydrolysis at a rate where the pseudo-first order rate constant for hydrolysis is not less than 10^{-6} sec^{-1} and not greater than 10^{-3} sec^{-1}. Preferably the rate constant should be in the range 10^{-5} to 10^{-3} sec^{-1}.

Derivatives having a pseudo-first order rate constant of greater than 10^{-3} sec^{-1} liberate unacceptably high levels of free enzyme before attaching to fibrin. Derivatives having pseudo-first order rate constants of less than 10^{-6} sec^{-1} liberate enzyme too slowly to be of any clinical use.

The compositions in accordance with this invention may be used as either prophylactic or therapeutic agent. For the purposes of prophylaxis a derivative having a slow rate of hydrolysis and therefore long half life is preferred. Such derivatives suitable for this purpose have pseudo-first order rate constants for hydrolysis in the range 5×10^{-5} to 10^{-5} sec^{-1} and half life of 3.5 to 16 hours. For therapeutic purposes a more rapidly hydrolysing derivative is preferred i.e. one having a pseudo-first order rate constant for hydrolysis in the range 5×10^{-4} to 7×10^{-5} sec^{-1} which corresponds to an approximate half life of 30 minutes to 2 hours.

The pseudo-first order rate constant is determined by hydrolysing the enzyme derivative under physiological conditions i.e. in isotonic aqueous media at pH 7.4 and at 37°C. At regular intervals aliquots are withdrawn and incubated with a chromogenic or fluorogenic protease substrate such as S-2251 (*H-D*-Val-Leu-Lys-p-nitroanilide 2HCl) and the rate of conversion of the substrate measured.

The hydrolysis is followed until such time as the rate of conversion of substrate reaches a maximum. The rate constant k is then calculated by plotting:

$$\log_e\left(1-\frac{A_t}{A_{max}}\right) \text{ against } t$$

where A_{max} the maximum rate at which an aliquot converts substrate and A_t is the rate at which an aliquot converts substrate at time t.

The precise identity of the blocking group used in the derivatives of this invention depends to a degree on the nature of the enzyme selected and the use to which the derivative will be put.

In the case of plasmin and the streptokinase/plasminogen activator, for example, the catalytic site essential for proteolytic activity includes a serine residue having a free hydroxyl moiety. The catalytic site of the enzyme is conveniently blocked by acyl groups such as benzoyl, substituted benzoyl, acryloyl or substituted acryloyl groups. The pseudo-first order rate constant for hydrolysis of any particular substituted benzoyl enzyme derivative can be estimated on the basis of the Hammett σ value of any substituent once the pseudo-first order rate constant of two or more substituted benzoyl derivatives have been measured provided that there is no special interaction between a particular substituent and the enzyme.

It generally recognised that Hammett values for meta and para substituents (σ_m and σ_p) give an acceptable prediction of hydrolysis rates. Moreover σ_m and σ_p values may be summed with reasonable accuracy to calculate kinetic properties of other substituted benzoyl groups bearing more than one

substituent. Hammett values for ortho substituents (σ_o) cannot be summed with the same reliability as σ_m and σ_p values because of steric effects. However, when the ortho substituent is small and therefore produces a negligible steric effect i.e. in the case of fluorine, methyl and methoxy, then the σ_o value may within generally accepted degrees of error be used alone or summed with σ_m and/or σ_p values to calculate reaction rates.

Subject to these limitations, a substituted benzoyl group in which the phenyl ring bears one or more substituents, particularly meta and/or para substituents where the sum of the Hammett σ values is in the range 0.1 to −1.1. may be used in accordance with this invention to block human plasmin. A substituted benzoyl group in which the phenyl ring bears one or more substituents particularly meta and/or para substituents such that the sum of the Hammett σ values is in the range −0.9 to +0.3 may be used in accordance with this invention to block the catalytic site of porcine plasmin.

Suitable benzoyl and substituted benzoyl groups include benzoyl, optionally substituted with halogen, C_{1-6} alkyl C_{1-6} alkoxy, C_{1-6} alkanoyloxy, C_{1-6} alkanoylamino (RCONH—). Examples include, benzoyl, p-fluorobenzoyl, o-, m-, or p-toluoyl, o-, m-, or p-methoxybenzoyl (i.e. anisoyl), o-, m-, or p-ethoxybenzoyl, 2,4-dimethoxybenzoyl, 3,4-dimethylbenzoyl, 4-butylbenzoyl, 3-methyl-4-methoxybenzoyl, o-acetoxybenzoyl (i.e. acetylsalicyloyl) and p-acetamidobenzoyl. A further aromatic group is naphthoyl.

An exception to this general rule is where the benzoyl group contains a basic moiety such as amino, dimethylamino and guanidino. The rate of hydrolysis of such derivatives is up to ten times less rapid than the calculated value.

Examples of such derivatives are p-guanidinobenzoyl human and porcine plasmin.

Another series of acyl groups which may be used to block human and porcine plasmins in accordance with the invention are acryloyl and substituted acryloyl, in particular cinnamoyl and substituted cinnamoyl groups bearing one or more substituents particularly meta and/or para substituents in which the sum of the Hammett σ values is in the range −1.0 to +0.15 subject to the limitations above.

Suitable substituted acryloyl groups C_{1-6} alkylacryloyl, furyl-acryloyl, cinnamoyl, C_{1-6} alkyl-cinnamoyl. Specific examples include 3,3-dimethylacryloyl, 3-(2-furyl)acryloyl, cinnamoyl, and p-methylcinnamoyl.

The compositions according to this invention are formulated in accordance with routine procedures as pharmaceutical compositions adapted for intravenous administration to human beings.

Typically compositions for intravenous administration are solutions of the sterile derivative in sterile isotonic aqueous buffer. Where necessary the composition may also include a solubilizing agent to keep the derivative in solution and a local anaesthetic such as lignocaine to ease pain at the site of injection. Generally, the enzyme derivative will be supplied in unit dosage form for example as a dry powder or water free concentrate in a hermetically sealed container such as an ampoule or sachette indicating the quantity of enzyme in activity units, as well as an indication of the time within which the free enzyme will be liberated. Where the derivative is to be administered by infusion, the derivative will be dispensed with an infusion bottle containing sterile pharmaceutical grade "Water for Injection". Where the derivative is to be administered by injection the derivative is dispensed with an ampoule of sterile water for injection. The injectable or infusable composition will be made up by mixing the ingredients prior to administration.

The quantity of material administered will depend upon the amount of fibrinolysis required and the speed with which it is required, the seriousness of the thromboembolic condition and the position and size of the clot. For example a patient with a pulmonory embolism or a large life threatening ascending ileo-femoral thrombus will require administration of a bolus of rapidly acting material. On the other hand where it is desired to prevent the formation of post-operative thrombi, a small quantity of slow acting material will be required. The precise dose to be employed and mode of administration must *per force* in view of the nature of the complaint be decided according to the circumstances by the physician supervising treatment. However, in general, a patient being treated for a medium size thrombus will generally receive a daily dose of from 1 to 20 mg kg^{-1} of body weight either by injection in up to eight doses or by infusion.

A number of derivatives which may be used in the compositions of this invention are known. These appear below together with a literature reference reporting their preparation:

1. p-Guanidinobenzoyl human plasmin, T. Chase and E. Shaw, Biochem., 8, No. 5, 2212—2224, 1969;
2. p-Guanidinobenzoyl streptokinase-plasminogen activator complex, D. K. McClintock and P. H. Bell, Biochem. Biophys. Res. Comm., 43, 694—702, 1971.

In the past these two derivatives have been found during active-site titrations of the above enzymes. The isolation and characterisation of these derivatives has never been reported. Moreover it has never previously been recognised that these enzyme derivatives are useful as fibrinolytic agents.

Accordingly, in a further aspect the invention provides an isolated derivative of an *in vivo* fibrinolytic enzyme, having a catalytic site essential for fibrinolytic activity, and wherein the catalytic site is blocked by a group which is removable by hydrolysis such that the pseudo-first order rate

constant for hydrolysis of the derivative is in the range 10^{-6} sec^{-1} to 10^{-3} sec^{-1} in isotonic aqueous media at pH 7.4 at 37°C.

In yet a further aspect the invention provides a derivative of an *in vivo* fibrinolytic enzyme, having a catalytic site essential for fibrinolytic activity, and wherein the catalytic site is blocked by a group which is removable by hydrolysis such that the pseudo-first order rate constant for hydrolysis of the derivative is in the range 10^{-6} sec^{-1} to 10^{-3} sec^{-1} in isotonic aqueous media at pH 7.4 at 37°C with the exception of:—

(1) p-guanidinobenzoyl human plasmin.

(2) p-guanidinobenzoyl streptokinase-plasminogen activator complex.

The derivatives of this invention may be prepared in two ways, i.e. by direct or inverse blocking. The direct blocking method involves reacting the enzyme with an agent:—

AB

in which A is a group which is selective for the catalytic site essential for fibrinolytic activity and which is capable of transferring from the group B to the catalytic site and B is a leaving group which facilitates the attachment of the enzyme by A; and thereafter optionally isolating the enzyme derivative so formed.

Agents which operate in this way are known. One example is p-nitrophenyl p'guanidinobenzoate. The guanidinobenzoyl moiety becomes selectively situated adjacent the catalytic site and its attachment is assisted by the p-nitrophenyl leaving group. The inverse blocking method involves the use of an agent

EF

where E is a locating group which locates the agent in the catalytic site and F is a group which is capable of transferring from the locating group to the catalytic site, and thereafter optionally isolating the derivative so formed.

Examples of the group E, when the enzyme to be blocked is plasmin or streptokinase/plasminogen activator include p-amidinophenyl and p-acetamidinophenyl or structurally similar substituted phenyl groups containing a positively charged moiety in the meta or para position.

Examples of inverse blocking agents are:— p-amidinophenyl p'fluorobenzoate, p-amidinophenyl p'-toluate, p-amidinophenyl p'anisate, p-amidinophenyl benzoate, p-amidinophenyl cinnamate, p-amidinophenyl p'-methylcinnamate, p-amidinophenyl 3-(2-furyl)-acrylate, p-amidinophenyl 2-naphthoate, p-amidinophenyl 3,3-dimethylacrylate, p-amidinophenyl 4-butyl benzoate, p-amidinophenyl 2,4-dimethoxybenzoate, p-amidinophenyl acetylsalicylate, p-amidinophenyl 4-ethoxybenzoate, p-acetamidinophenyl p'-anisate, p-amidinophenyl o-toluate, p-amidinophenyl o-anisate, p-amidinophenyl 3,4-dimethylbenzoate, p-amidinophenyl 3-methyl-4-methoxy benzoate, and p-amidinophenyl 4-acetamidobenzoate.

The direct and inverse blocking reactions are carried out in aqueous media at a pH range which is not detrimental to the enzyme, blocking agent or product, e.g. between pH 4 and 8 and preferably at a pH in the range 5.0 to 7.5.

The reaction is generally carried out using equi-molar equivalents of enzyme and blocking agent, but excess of blocking agent may be employed. It is also preferred to carry out the reaction in dilute solution, i.e. less than 10^{-3} molar with respect to enzyme and less than 10^{-2} molar with respect to blocking agent. Generally the reaction will not be carried out in a solution where the concentration of enzyme or blocking agent is less than 10^{-7} molar.

The blocking reaction should be carried out at moderate temperatures, i.e. room temperature or below, and more particularly less than 10°C but greater than the freezing point of the reaction medium.

The time for which the reaction is allowed to proceed depends upon the blocking reagent employed, the temperature at which the reaction is carried out and the enzyme selected for blocking. The optimum time period for any particular circumstances may be selected by following the decrease in enzymic activity by incubating aliquots with a chromogenic or fluorogenic substrate.

After the reaction is complete the derivative is purified by standard methods such as dialysis, affinity chromatography, and ultra filtration, and thereafter recovered by standard methods such as freeze drying from aqueous media. Where necessary the material may be adapted for example by sterilization for intravenous administration to human beings.

The inverse blocking agents:—

EF

where E is p-amidinophenoxy and F is an acyl group may be prepared by acylating p-hydroxybenzamidine or a salt thereof with an acylating derivative:—

FX

wherein F is as previously defined and X is hydroxyl or an activated acylating derivative thereof, optionally in the presence of a catalyst.

Examples of activated acylating derivatives include the acyl chloride or bromide. These derivatives may be prepared by standard methods.

Suitable catalysts for this process include tertiary organic bases such as pyridine and coupling agents such as dicyclohexylcarbodimide.

The acylation reaction is generally carried out in a polar organic solvent which is inert to the reagents and product. Examples of suitable solvents include N,N-dimethylformamide and dimethylsulphoxide. Alternatively where the catalyst is a liquid as in the case of pyridine then the reaction may be carried out in the absence of solvent.

The reaction is generally carried out at moderate temperatures i.e. less than 70°C and generally less than 40°C; ambient temperature is most convenient.

The time for the reaction to proceed to completion depends upon the specific reagents employed, the solvent and the temperature at which the reaction is performed. This may be determined by following the reaction for examle by thin layer chromatography.

When the reaction is complete, the product is recovered and purified by standard methods.

The following examples illustrate the invention.

Examples 1—7 illustrate the preparation of inverse blocking agents.

Example 1

Benzoic acid p-amidinophenyl ester. HCl

p-Hydroxybenzamidine . HCl (0.172 g) was dissolved in dry pyridine (1.0 ml) and a solution of benzoyl chloride (0.141 g) in pyridine (1.0 ml) added dropwise. The mixture was stirred for 1 hour at ambient temperature and allowed to stand for 4 days also at ambient temperature. The material was evaporated to near dryness, triturated with dry diethyl ether and the solid recrystallised from 2-propanol/diethyl ether 2:1 v/v (c. 3 ml). Yield 0.223 g. M.P. 160°C.

N.M.R. δ (Dimethylsulphoxide d^6): 9.65. Doublet. 4*H*. Exchangeable with D_2O. Amidine H.: about 8.0. Multiplet. 9*H*. Phenyl and amidinophenyl. The compounds of Examples 2 to 10 were prepared in similar manner to the method described in Example 1.

Example 2

Trans-cinnamic acid p-amidinophenyl ester . HCl

M.P. 192°C.

N.M.R. δ (Dimethylsulphoxide d^6): 9.55 Doublet 4*H*. Exchangeable with D_2O. Amidine H.: 7.95. Multiplet. 6*H*. Amidinophenyl and acryloyl H.: 7.10. Multiplet 5H. Phenyl H.: 6.96. Doublet (J: 16 Hz) 1*H*. Acryloyl H.

Example 3

p-Anisic acid p'-amidinophenyl ester . HCl

Recrystallised from 2-propanol. M.P. 225°C.

N.M.R. δ (Dimethylsulphoxide d^6): 9.50. Doublet. 4*H*. Amidinophenyl H.: 7.38. Quartet. (J: 9 Hz) 4*H*. p-Anisoyl H.: 3.90. Singlet 3*H*. Methoxy H.

Example 4

3,3 Dimethacrylic acid p-amidinophenyl ester hydrochloride

Recrystallised from water. M.P. 173°C.

N.M.R. δ (Dimethylsulphoxide d^6). 9.50 doublet 4*H* exchangeable with D_2O, amidine H; 7.95 and 7.37 quartet (J=9 Hz) 4*H*, amidinophenyl H; 5.96 broad doublet (J=1 Hz) *1H*, acryloyl H; 2.09 singlet *3H*, methyl H; 1.90 singlet *3H* methyl H.

Example 5

4-Butyl benzoic acid p-amidinophenyl ester hydrochloride

Recrystallised from isopropanol/water. (1:4 v/v). M.P. 190°C.

N.M.R. δ (Dimethylsulphoxide d^6). 9.55 broad doublet *4H* exchangeable with D_2O, amidine H. 7.6 to 8.1 overlapping quartets *8H* amidinophenyl+benzoyl H. 1.30 singlet *9H* t-butyl H.

Example 6

2,4-Dimethoxybenzoic acid p-amidinophenyl ester hydrochloride

Recrystallised from methanol, M.P. 213—4°C.

N.M.R. δ (Dimethylsulphoxide d^6): 9.48 doublet *4H* exchangeable with D_2O, amidine H; 8.01 and 7.50 AA'BB' quartet (J: 8 Hz) *4H*, amidinophenyl H; 8.03 and 6.75 multiplet 3H, 2,4 substituted phenyl H; 3.90 singlet *6H*, 2x methoxy H.

Example 7

Acetyl salicyclic acid p-amidinophenyl ester hydrochloride

Recrystallised from isopropanol, M.P. 109—111°C.

N.M.R. δ (Dimethylsulphoxide d^6): 9.62 broad doublet *4H* exchangeable with D_2O, amidine H; 8.12 and 7.55 AA'BB' quartet (J: 9 Hz) *4H*, amidinophenyl H; 2.26 singlet *3H*, acetyl H.

Example 8
4-Ethoxybenzoic acid p-amidinophenyl ester hydrochloride
Recrystallised from isopropanol, M.P. 211—2°C.
N.M.R. δ (Dimethylsulphoxide d^6): 9.60 broad doublet *4H* exchangeable with D_2O amidine H; 8.10 and 7.56 AA'BB' quartet (J: 9 Hz) *4H*, amidinophenyl H; 8.13 and 7.15 AA'BB' quartet (J: 9 Hz) *4H*, 4-ethoxyphenyl H; 4.19 quartet 2H, $—OCH_2CH_3$; 9.38 triplet *3H*, $—OCH_2CH_3$.

Example 9
O-toluic acid p-amidinophenyl ester hydrochloride
Twice recrystallised from isopropanol/diethyl ether. M.P. 157—9°C.
N.M.R. δ (Dimethylsulphoxide d^6): broad doublet *4H* exchangeable with D_2O, amidine H; 8.20 and 7.62 AA'BB' quartet *4H*, amidinophenyl H; 7.3—8.2 multiplet *4H*, 2-methylphenyl H; 2.11 singlet 3H, methyl H.

Example 10
(a) 2-(4-Hydroxyphenyl) acetamidine hydrochloride
p-Hydroxybenzyl cyanide (5.0 g) was dissolved in absolute ethanol (50 ml) and the solution saturated with dry HCl gas over 4 hours at ambient temperature. After standing at 4°C for 72 hours, dry diethyl ether (200 ml) and light petroleum (100 ml) were added and white crystals were deposited over 2 hours. The solid was isolated by filtration and reacted immediately with saturated ethanolic ammonia (300 ml) for 3 hours at ambient temperature. The reaction mixture was evaporated to dryness on a steam bath and the residue recrystallised from ethanol. Yield 4.36 g M.P. 248°C (dec.).
N.M.R. δ (Dimethylsulphoxide d^6) 9.0—9.8 envelope *5H* exchangeable with D_2O, amidine H, hydroxyl H. 6.85+7.37 AA'BB' quartet *4H* (J: 9 Hz) phenyl H; 3.70 singlet *2H* benzyl H.

(b) p-(Formamidino methyl) phenyl ester of 4-methoxy benzoic acid
Recrystallised from isopropanol/diethyl ether. M.P. 174—6°C.
N.M.R. δ (Dimethylsulphoxide d^6): 9.42 broad doublet *4H* exchangeable with D_2O, amidine H; 8.15 and 6.29 AA'BB' quartet (J: 8 Hz) *4H*, 4-methoxyphenyl H; 7.69 and 7.13 AA'BB' quartet (J: 8 Hz) *4H*, amidinophenyl H; 3.90 singlet *3H*, methoxy H.

Example 11
p-Toluic acid p'amidinophenyl ester . HCl
p-Hydroxybenzamidine HCl (1.72 g) and p-toluic acid (1.36 g) were dissolved in a mixture of dry pyridine (5.0 ml) and dimethylsulphoxide (10.0 ml) and stirred with *N,N* dicyclohexyl carbodiimide (2.1 g) for 72 hours at ambient temperature. The product was filtered and the filtrate precipitated with dry diethyl ether (200 ml). The resulting oil crystallised after precipitation and was recrystallised from 2-propanol/1,4 dioxane 1:1 v/v. M.P. 164°C.
N.M.R. δ (Dimethylsulphoxide d^6): 9.6 broad doublet exchangeable with D_2O. *4H*. Amidine H. : 8.15 Quartet (J: c. 4 Hz) *4H*. Amidinophenyl H.: 7.60 quartet (J: c. 9 Hz) *4H*. Benzoyl H.: 2.44 Singlet *3H*. Methyl H. The compounds of Examples 12 to 18 were prepared by the method described in Example 11.

Example 12
p-Fluorobenzoic acid p'amidinophenyl ester perchlorate
Ether-precipitated oil recrystallised from 5% w/v perchloric acid (10 ml). M.P. 180°C (decomp.).
N.M.R. δ (Dimethylsulphoxide d^6): 9.3 Doublet *4H*. exchangeable with D_2O. Amidine H.: 8.25 quartet (J: c. 5 Hz) *5H*. 3,5 H in benzoyl.: 7.8 Overlapping quartets *6H*. Amidinophenyl H and 2.6 H in benzoyl.

Example 13
3-(2-Furyl) acrylic acid p-amidinophenyl ester perchlorate
Coupling performed in pyridine. Filtrate evaporated to near dryness and residue recrystallised from dilute perchloric acid. Off-white plates M.P. 157°C.
N.M.R. δ (Dimethylsulphoxide d^6): 9.35 doublet exchangeable with D_2O *4H* amidine H.: 7.7 quartet (J: c. 8 Hz) *4H*. Amidinophenyl H.: 7.9 doublet (J: c. 3 Hz) *1H* 5-furyl H.: 7.85/7.40 doublet (J: 20 Hz) *1H*. 2-Acryloyl H.: 7.10 doublet (J: c. 3 Hz) *1H*. 3-Furyl H.: 6.70 multiplet. *1H* 4-Furyl H.: 6.44 doublet (J: 15 Hz) *1H* 3-acryloyl H.

Example 14
p-Methyl-trans-cinnamic acid p-amidinophenyl ester perchlorate
Isolated as for 3-(2-furyl) acrylic acid ester. M.P. 155°C.
N.M.R. δ (Dimethylsulphoxide d^6): 9.15 doublet exchangeable with D_2O. *4H*. Amidine H.: 7.2—8.2 Multiplet 9H. Amidinophenyl and phenyl H.: 6.82 doublet (J: 16 Hz) *1H* 2-acryloyl H.: 6.44 doublet (J: 16 Hz) *1H*. Acryloyl H.: 2.42 doublet (J: 2 Hz) 3H. Methyl H.

Example 15

O-Anisic acid p-amidinophenyl ester hydrochloride

Recrystallised from isopropanol. M.P. 149°C.

N.M.R. δ (Dimethylsulphoxide d^6) 9.50 broad singlet *4H* exchangeable with D_2O, amidine H; 7.50 and 7.95 irregular multiplet *5H*, amidinophenyl H and 2-H; 7.0—7.5 multiplet *3H* 3,4,5 benzoyl H; 3.86 singlet 3*H* methoxy H.

Example 16

3,4 Dimethyl benzoic acid p-amidinophenyl ester hydrochloride

Recrystallised from isopropanol/brine M.P. 107°C.

N.M.R. δ (Dimethylsulphoxide d^6) 9.56 broad singlet *4H* exchangeable with D_2O, amidine H; 7.50—7.95 irregular triplets *7H* amidinophenyl and benzoyl H. 2.30 singlet *6H* methyl H.

Example 17

3,Methyl-4-methoxy benzoic acid p-amidinophenyl ester hydrochloride

Recrystallised from isopropanol/2N HCl (10:1 v/v). M.P. 210°C.

N.M.R. δ (Dimethylsulphoxide d^6). 9.54 doublet *4H* exchangeable with D_2O, amidine H. 8.07 irregular doublet *4H*. 2-H+6-H benzoyl, 2H, 6H amidinophenyl; 7.60 doublet (J=9 Hz) *2H*, 3H, 5H amidinophenyl; 7.22 doublet (J=9 Hz) *1H 5H* benzoyl; 3.92 singlet *3H* methoxyl H; 2.26 singlet *3H* methyl H.

Example 18

4-Acetamidobenzoic acid p-amidinophenyl ester hydrochloride

Recrystallised from isopropanol/water 1:2 v/v. M.P. 257°C.

N.M.R. δ (Dimethylsulphoxide d^6) 10.62 singlet *1H* exchangeable with D_2O, amidine H. 7.90 AA'BB' quartet *4H* overlapping 7.50—7.9 AA'BB' quartet *4H*, benzoyl and amidinophenyl H. 2.09 singlet *3H*, acetyl H.

Example 19

Isolated freeze-dried p-anisoyl human plasmin

Human plasmin (0.15 micromoles) in 20% v/v glycerol/0.9% w/v saline solution (4.2 ml) was treated with 50 microlitres of a 0.1 M solution of p-amidinophenyl p'anisate (prepared as in Example 3 above) in dimethylsulphoxide at 22°C. After 7.5 minutes a further 50 microlitres of acylating agent were added. The product was dialysed for 2 hours against 2 litres of the above glycerol/saline mixture and then added to a mixture of *L*-lysine-sepharose 4B (Pharmacia Fine Chemicals, 23 grams wet weight) and 0.1 M Triethanolamine Hydrochloride buffer pH 7.0 (20 ml). The mixture was incubated for 10 minutes at 4°C, and then filtered the gel being washed with 100 ml of the above buffer. The gel was then mixed with a solution of ε-aminocaproic acid 0.2 M in the above buffer and incubated at 4°C for 10 minutes. After filtration and washing with another 55 ml of the ε-aminocaproic acid solution, the filtrate was dialysed against two changes of 50 mM ammonium bicarbonate buffer pH 7.0 (5 litres) at 4°C for two hours. The final retentate was mixed with Dextran T 70 (Pharmacia) and freeze-dried. 1.98 g of a white solid resulted. This inactivated material could be reactivated quantitatively to free plasmin in approximately two hours under the conditions specified for deacylation.

The acylating agents of Examples 1, 2 and 4 to 18 were also reacted with human plasmin by the method of Example 19 to give the corresponding blocked plasmin. With the acylating agent of Example 10, it is preferable to use a higher concentration of the acylating agent or allow the reaction to proceed a longer time to ensure complete reaction. The deacylation rates of the latter compounds are given in table 1 below.

Example 20

Freeze-dried p-guanidinobenzoyl human plasmin

Human plasmin (8.45 nanomoles) in 20% v/v glycerol (1.0 ml) was treated twice with 10 microlitres of 0.1 M p-nitrophenyl p'guanidinobenzoate in dimethylsulphoxide for 10 minutes at 0°C. The solution was adjusted to pH 6.0 with dilute hydrochloric acid and dialysed for 2 hours against 2 litres of 10 mM ammonium bicarbonate buffer pH 7.0. *L*-Lysine . HCl (100 milligrams) was added and the mixture freeze dried. A pale yellow solid (93.5 milligrams) was isolated which could be hydrolysed to active plasmin.

Example 21

Preparation of a solution of trans-cinnamoyl porcine plasmin

Porcine plasmin (1.73 micromoles) in 10% v/v glycerol 0.9% w/v saline solution (26 ml) was treated with p-amidinophenyl transcinnamate (3.02 miligrams) suspended in 0.9% w/v saline (1 ml) by stirring for 20 minutes at 4°C. The mixture was then frozen at −20°C and stored at this temperature overnight. After thawing, the mixture was dialysed in the above glycerol/saline mixture (2 litres) at 4°C

for 2 hours. The product was stored at 0°C until used. The derivative had less than 0.5% of the activity of the original enzyme and could be reactivated in two hours under deacylation conditions.

Example 22

Preparation of a solution of p-anisoyl streptokinase-human plasminogen activator complex

Streptokinase (5×10^4 units, A. B. Kabi, Stockholm, Sweden) in 0.9% w/v saline solution 10.5 ml) was mixed with lys-human plasminogen (0.025 ml 4.9 nanomoles). The mixture was incubated at 25°C for 40 minutes and then diluted with 0.1 M trishydroxymethylaminomethan hydrochloride, 0.9% w/v saline 20% v/v glycerol pH 7.4 (2.0 ml). This solution was treated with 3 lots of 0.1 mM (final concentration) p-amidinophenyl p'anisate (prepared as a stock solution 0.1 M in dimethylsulphoxide) for 3 five minute periods at 25°C. The acylated enzyme was mixed with a 33% wet wt/vol suspension of L-lysine sepharose 4B (2.5 ml) for 10 minutes at 0°C. The suspension was filtered under suction and washed with the above Tris/glycerol/saline buffer (100 ml) at 4°C. The gel was re-suspended in the tris/glycerol/saline buffer (5 ml) containing, in addition, 0.1 M—aminocaproic acid. After 10 minutes at 0°C, the suspension of gel was clarified by centrifugation for 2 minutes at 1000 g and the supernatant (4 ml) dialysed against the tris/glycerol/saline buffer (2.0 l) at 4°C for 2 hours. The resulting solution of acyl-activator complex could be regenerated to free enzyme at 37°C with a pseudo-first order rate constant of 2.7×10^{-4} sec^{-1}.

Example 23

Preparation of a solution of 3-methyl p-anisoyl streptokinase-human plasminogen activator complex

This material was prepared in the same way as described in Example 22 except that the acylation was performed with 2 lots of 0.2 mM (final concentration) of 3-methyl p-anisic acid p-amidinophenyl ester in 2 periods of 15 minutes at 25°C, followed by 1 hour at 0°C. The pseudo-first order deacylation rate constant was 1×10^{-4} sec^{-1}.

Example 24

Preparation of a mixture of p-anisoyl human plasmin and p-anisoyl streptokinase-human plasminogen activator complex

Lys-human plasminogen (216 mg, 2.56 micromoles dissolved to concentration of 6.8 mg/ml in 0.1 M trishydroxymethylaminomethane hydrochloride, 0.9% w/v saline, 20% v/v glycerol pH 7.4 was treated with streptokinase (A. B. Kabi, Sweden 1.2×10^4 units, approximately 2.67 nanomoles). The mixture was incubated at 25°C for 1 hour and brought to 33% v/v glycerol. This solution (9.0 ml) was acylated with 2 lots of 0.1 mM (final concentration) p-amidinophenyl p-anisate in 2 periods of 15 minutes at 25°C and then dialysed for 1 hour against 2 litres of the above buffer. The resulting solution showed less than 1% of the original plasmin activity and was in a form suitable for use in the rabbit test system.

Example 25

Stoichiometric reaction of (^{3}H-methoxy)-p-amidinophenyl p'anisate with human and porcine plasmins

(a) Human plasmin

Solutions of human plasmin (2.67×10^{-5} M, 0.2 ml 5.34 nanomoles) were reacted with 2 lots of a 20 mM solution of tritiated p-amidinophenyl p-anisate (specific radioactivity: 22.8 mC/m mole) in two 7.5 minute periods at 25°C. After addition of 10% w/v trichloracetic acid in acetone (1.8 ml), the protein was precipitated and isolated by centrifugation at 1500 g for 3 minutes. The protein pellet was washed with two lots of acid/acetone (2 ml) and dissolved in 2 N sodium hydroxide solution (1.0 ml). Liquid scintillation counting of this solution showed a mean 0.130 μ Ci associated with protein, corresponding to 5.73 nanomoles of anisic acid.

(b) Porcine plasmin

A similar experiment using a solution of pig plasmin (5.29×10^{-5} M 10.54 nanomoles used) gave a mean radiochemical analysis for anisic acid of 9.58 nanomoles.

Example 26

Freeze-dried p-anisoyl streptokinase-human plasminogen activator complex

Streptokinase (9×10^4 units) in 0.9% w/v saline solution (0.9 ml) was mixed with lys-human plasminogen (0.075 ml 14.9 nanomoles). The mixture was incubated at 25°C for 30 minutes and then diluted with 0.1 M trishydroxymethylaminomethane hydrochloride pH 7.4 (4.0 ml). This solution was treated with 3 lots of 0.1 mM (final concentration) p-amidinophenyl p-anisate (prepared as a stock solution 10 mM in dimethylsulphoxide) for 3 five minute periods at 25°C. The acylated enzyme was mixed wtih a 33% wet wt/vol suspension of L-lysine Sepharose 4B (5.0 ml) for 10 minutes at 0°C. The suspension was filtered under suction and washed with the above TrisHCl buffer (200 ml) at 4°C. The gel was re-suspended in 0.1 M-aminocaproic acid, 50 mM TrisHCl pH 7.4 (5.0 ml) and then filtered, washing with 3 five ml lots of the same buffer. The combined eluate was dialysed against 2 litres of 5% w/v Mannitol in TrisHCl buffer (5.0 mM) pH 7.4 for 2 hours at 4°C and then freeze-dried to a white

powder. (0.560 g). This material had less than 5% of the original enzyme activity and could be regenerated in aqueous media at 37°C.

Hydrolysis data

The pseudo-first order rate constants (K) for enzyme derivatives prepared from the acylating agents described in Examples 1 to 18 are given in table 1 below.

TABLE 1
Deacylation rates of active site serine substituted plasmins pH 7.4, 37°C

Acyl group	Human plasmin K $sec^{-1} \times 10^4$	Porcine plasmin K $sec^{-1} \times 10^4$
p-Fluorobenzoyl	—	3.30
Benzoyl	5.20	1.90
p-Toluoyl	2.30	0.74
p-Anisoyl	1.10	0.33
Trans-cinnamoyl	—	4.20
p-Methyl-t-cinnamoyl	—	2.92
3-(2-Furyl) acryloyl	1.33	1.50
p-Guanidinobenzoyl	0.41	0.21
N-methyl-p-guanidinobenzoyl	2.0	—
O-Anisoyl	1.82	—
p-Acetamidobenzoyl	2.70	—
Acetylsalicycloyl	4.70	—
3,3 Dimethylacryloyl	0.69	—
3,4 Dimethylbenzoyl	0.55	—
3 Methyl 4-methoxybenzoyl	0.70	—
O-Toloyl	1.71	—
p-Ethoxybenzoyl	1.10	—
2,4 Dimethoxybenzoyl	1.10	—

Claims

1. A pharmaceutical composition which comprises a pharmaceutically acceptable carrier together with an *in vivo* fibrinolytic enzyme, having a catalytic site essential for fibrinolytic activity, such as urokinase, streptokinase-plasminogen activator complex, vascular activator and mammalian plasmin, and wherein the catalytic site of the enzyme is blocked by a group which is removable by hydrolysis at a rate such that the pseudo-first order rate constant for hydrolysis is in the range 10^{-6} sec^{-1} to 10^{-3} sec^{-1} in isotonic aqueous media at pH 7.4 at 37°C.

2. A composition as claimed in claim 1 wherein the enzyme is human plasmin.

3. A composition as claimed in claim 1 wherein the enzyme is streptokinase/human plasminogen activator complex.

4. A composition as claimed in claim 1 wherein the enzyme is a mixture of human plasmin and streptokinase/human plasminogen activator complex.

5. A composition as claimed in any one of claims 1 to 4 wherein the group which is removable by hydrolysis is an acyl group.

6. A composition as claimed in claim 5 wherein the acyl group is a benzoyl, substituted benzoyl, acryloyl or substituted acryloyl group.

7. A composition as claimed in claim 6 wherein the acyl group is a benzoyl group or a substituted benzoyl group having one or more meta and/or para substituents wherein the sum of the Hammett σ_m and σ_p values is in the range +0.1 to −1.1.

8. A composition as claimed in claim 6 wherein the acyl group is benzoyl, optionally substituted with halogen, C_{1-6} alkyl, C_{1-6} alkoxy, C_{1-6} alkanoyloxy, C_{1-6} alkanoylamino, amino or p-guanidino.

9. A composition as claimed in claim 6 wherein the acyl group is acryloyl, optionally substituted with C_{1-6} alkyl, furyl, phenyl or C_{1-6} alkylphenyl.

10. An isolated derivative of an *in vivo* fibrinolytic enzyme as defined in claim 1.

11. A derivative of an *in vivo* fibrinolytic enzyme as defined in claim 1, with the exception of:
(i) p-guanidinobenzoyl human plasmin,
(ii) p-guanidinobenzoyl streptokinase-plasminogen activator complex.

12. A derivative as claimed in claim 10 or 11 wherein the enzyme is human plasmin.

13. A derivative as claimed in claim 10 or 11 wherein the enzyme is streptokinase/human plasminogen activator complex.

14. A derivative as claimed in claim 10 or 11 wherein the enzyme is a mixture of human plasmin and streptokinase/human plasminogen activator complex.

15. A derivative as claimed in any one of claims 10 to 14 wherein the group which is removable by hydrolysis is an acyl group.

16. A derivative as claimed in claim 15 wherein the acyl group is a benzoyl, substituted benzoyl, acryloyl or substituted acryloyl group.

17. A derivative as claimed in 16 wherein the acyl group is a benzoyl group or a substituted benzoyl group having one or more meta and/or para substituents wherein the sum of the Hammett σ_m or σ_p values is in the range +0.1 to −1.1.

18. A derivative as claimed in claim 16 wherein the acyl group is benzoyl, optionally substituted with halogen, C_{1-6} alkyl, C_{1-6} alkoxy, C_{1-6} alkanoyloxy, C_{1-6} alkanoylamino, amino or p-guanidino.

19. A derivative as claimed in claim 16 wherein the acyl group is acryloyl, optionally substituted with C_{1-6} alkyl, furyl, phenyl or C_{1-6} alkyl phenyl.

20. A derivative according to claim 10 or 11, which is p-anisoyl human plasmin.

21. A derivative according to claim 10 or 11, which is p-anisoyl streptokinase human plasminogen activator complex.

22. A derivative according to claim 10 or 11, which is a mixture of p-anisoyl human plasmin and p-anisoyl streptokinase human plasminogen activator complex.

23. A process for preparing a derivative of an *in vivo* fibrinolytic enzyme as claimed in claim 11 which process comprises reacting an *in vivo* fibrinolytic enzyme as defined in claim 1 with a blocking agent:

AB

wherein A is a group which is selective for the catalytic site essential for fibrinolytic activity and which is capable of transferring from the group B to the catalytic site and B is a group which facilitates the attachment of A to the enzyme.

24. A process as claimed in claim 23 wherein the agent AB is p-nitrophenyl p-guanidinobenzoate.

25. A process for preparing a derivative of an *in vivo* fibrinolytic enzyme as claimed in claim 11 which process comprises reacting an *in vivo* fibrinolytic enzyme as defined in claim 1 with a compound:

EF

wherein E is a locating group which is selective for the catalytic site and F is a group which is capable of transferring from the locating group to the active site.

26. A process as claimed in claim 25 wherein E is a benzoyl or substituted benzoyl group.

27. A process as claimed in claim 25 wherein E is p-amidinophenyl or p-acetamidinophenyl.

28. A pharmaceutical composition according to any one of claims 1 to 9 or a derivative according to any one of claims 10 to 22, for use in the treatment of venous thrombosis.

Revendications

1. Composition pharmaceutique renfermant un excipient pharmaceutiquement acceptable conjointement à une enzyme fibrinolytique in vivo présentant un site catalytique essentiel à l'activité fibrinolytique, telle que l'urokinase, un complexe activateur streptokinase-plasminogène, un activateur vasculaire et de la plasmine de mammifère, et dans laquelle le site catalytique de l'enzyme est bloqué par un groupe qui peut être éliminé par hydrolyse à une vitesse telle que la constante de vitesse de pseudo-premier ordre pour l'hydrolyse soit comprise dans une gamme allant de 10^{-6} sec^{-1} à 10^{-3} sec^{-1} dans des milieux aqueux isotoniques à un pH de 7,4 à 37°C.

2. Composition suivant la revendication 1, dans laquelle l'enzyme est de la plasmine humaine.

3. Composition suivant la revendication 1, dans laquelle l'enzyme est un complexe activateur streptokinase/plasminogène humain.

4. Composition suivant la revendication 1, dans laquelle l'enzyme est un mélange de plasmine humaine et de complexe activateur streptokinase/plasminogène humain.

5. Composition suivant l'une quelconque des revendications 1 à 4, dans laquelle le groupe qui peut être éliminé par hydrolyse est un groupe acyle.

6. Composition suivant la revendication 5, dans laquelle le groupe acyle est un groupe benozyle, benzoyle substitué, acryloyle ou acryloyle substitué.

7. Composition suivant la revendication 6, dans laquelle le groupe acyle est un groupe benzoyle ou benzoyle substitué comportant un ou plusieurs substituants en méta et/ou para, la somme des valeurs σ_m et σ_p de Hammett étant comprise entre +0,1 et −1,1.

8. Composition suivant la revendication 6, dans laquelle le groupe acyle est un groupe benzoyle éventuellement substitué par un halogène, alcoyle en C_{1-6}, alcoxy en C_{1-6}, alcanoyloxy en C_{1-6}, alcanoylamino en C_{1-6}, amino ou p-guanidino.

9. Composition suivant la revendication 6, dans laquelle le groupe acyle est un groupe acryloyle facultativement substitué par un alcoyle en C_{1-6}, furyle, phényle ou alcoyl (C_{1-6}) phényle.

10. Dérivé isolé d'une enzyme fibrinolytique in vivo telle que définie dans la revendication 1.

11. Dérivé d'une enzyme fibrinolytique in vivo telle que définie dans la revendication 1 à l'exception de:

(i) plasmine humaine à groupe p-guanidinobenzoyle;

(ii) complexe activateur streptokinase-plasminogène à groupe p-guanidinobenzoyle.

12. Dérivé suivant la revendication 10 ou 11, dans lequel l'enzyme est de la plasmine humaine.

13. Dérivé suivant la revendication 10 ou 11, dans lequel l'enzyme est un complexe activateur streptokinase-plasminogène humain.

14. Dérivé suivant la revendication 10 ou 11, dans lequel l'enzyme est un mélange de plasmine humaine et de complexe activateur streptokinase/plasminogène humain.

15. Dérivé suivant l'une quelconque des revendications 10 à 14, dans lequel le groupe qui peut être éliminé par hydrolyse est un groupe acyle.

16. Dérivé suivant la revendication 15, dans lequel le groupe acyle est un groupe benzoyle, benzoyle substitué, acryloyle ou acryloyle substitué.

17. Dérivé suivant la revendication 16, dans lequel le groupe acyle est un groupe benzoyle ou un groupe benzoyle substitué comportant un ou plusieurs substituants en méta et/ou para, la somme des valeurs σ_m ou σ_p de Hammett étant comprise dans une gamme allant de +0,1 à −1,1.

18. Dérivé suivant la revendication 16, dans lequle le groupe acyle est un groupe benzoyle facultativement substitué par un halogène, alcoyl en C_{1-6}, alcoxy en C_{1-6}, alcanoyloxy en C_{1-6}, alcanoylamino en C_{1-6}, amino ou p-guanidino.

19. Dérivé suivant la revendication 16, dans lequel le groupe acyle est le groupe acryloyle, facultativement substitué par un alcoyle en C_{1-6}, furyle, phényle ou alcoyl(C_{1-6})phényle.

20. Dérivé suivant la revendication 10 ou 11, constitué par de la plasmine humaine à groupe p-anisoyle.

21. Dérivé suivant la revendication 10 ou 11, constitué par un complexe activateur streptokinase/plasminogène humain à groupe p-anisoyle.

22. Dérivé suivant la revendication 10 ou 11, constitué par un mélange de plasmine humaine à groupe p-anisoyle et de complexe activateur streptokinase/plasminogène humain à groupe p-anisoyle.

23. Procédé pour la préparation d'un dérivé d'une enzyme fibrinolytique in vivo suivant la revendication 11, ce procédé consistant à faire réagir une enzyme fibrinolytique in vivo telle que définie dans la revendication 1 avec un agent de blocage:

AB

dans lequel A est un groupe qui est sélectif vis-à-vis du site catalytique essentiel à l'activité fibrinolytique et qui est capable de subir un transfert du groupe B au site catalytique, et B est un groupe qui facilite la fixation de A sur l'enzyme.

24. Procédé suivant la revendication 23, caractérisé en ce que l'agent AB est du p-guanidinobenzoate de p-nitrophényle.

25. Procédé pour la préparation d'un dérivé d'une enzyme fibrinolytique in vivo telle que définie dans la revendication 11, ce procédé consistant à faire réagir une enzyme fibrinolytique in vivo telle que définie dans la revendication 1 avec un composé:

EF

dans lequel E est un groupe de positionnement qui est sélectif vis-à-vis du site catalytique et F est un groupe capable de subir un transfert du groupe de positionnement au site actif.

26. Procédé suivant la revendication 25, caractérisé en ce que E est un groupe benzoyle ou benzoyle substitué.

27. Procédé suivant la revendication 25, caractérisé en ce que E est un groupe amidinophényle ou p-acétamidinophényle.

28. Composition pharmaceutique suivant l'une quelconque des revendications 1 à 9 ou dérivé suivant l'une quelconque des revendications 10 à 22, destiné à être utilisé dans le traitement de la thrombose veineuse.

Patentansprüche

1. Eine pharmazeutische Zusammensetzung, welche einen pharmakologisch annehmbaren Träger zusammen mit einem *in vivo* fibrinolytisch wirksamen Enzym umfaßt, welches eine für die fibrinolytische Aktivität ausschlaggebende katalytisch wirksame Stelle aufweist, wie Urokinase, Streptokinase-Plasminogenaktivatorkomplex, Vaskuläraktivator und Säugetierplasmin, und wobei die katalytisch wirksame Stelle des Enzyms durch eine mittels Hydrolyse entfernbare Gruppe blockiert ist, derart, daß die Reaktionskonstante für die Hydrolyse von pseudo-erster Ordnung ist und in einem isotonischen wäßrigen Medium bei einem pH-Wert von 7,4 bei 37°C einen Wert im Bereich von 10^{-6} sec^{-1} bis 10^{-3} sec^{-1} hat.

2. Eine Zusammensetzung wie in Anspruch 1 beansprucht, in welcher das Enzym menschliches Plasmin ist.

3. Eine Zusammensetzung wie in Anspruch 1 beansprucht, in welcher das Enzym Streptokinase/Humanplasminogenaktivatorkomplex ist.

4. Eine Zusammensetzung wie in Anspruch 1 beansprucht, in welcher das Enzym eine Mischung aus menschlichem Plasmin und Streptokinase/Humanplasminogenaktivatorkomplex ist.

5. Eine Zusammensetzung wie in irgendeinem der Ansprüche 1 bis 4 beansprucht, in welcher die durch Hydrolyse entfernbare Gruppe eine Acylgruppe ist.

6. Eine Zusammensetzung wie in Anspruch 5, beansprucht, in welcher die Acylgruppe eine Benzoyl-, substituierte Benzoyl, Acryloyl- oder substituierte Acryloylgruppe ist.

7. Eine Zusammensetzung wie in Anspruch 6 beansprucht, in welcher die Acylgruppe eine Benzoylgruppe oder eine substituierte Benzoylgruppe mist 1 oder mehreren Substituenten in meta- und/oder para-Stellung ist, wobei die Summe der Werte σ_m und σ_p nach Hammett im Bereich von +0,1 bis −1,1 liegt.

8. Eine Zusammensetzung wie in Anspruch 6 beansprucht, in welcher die Acylgruppe die Benzoylgruppe ist, welche gegebenenfalls mit Halogen, C_{1-6}-Alkyl, C_{1-6}-Alkoxy, C_{1-6}-Alkanoyloxy, C_{1-6}-Alkanoylamino, Amino oder p-Guanidino substituiert ist.

9. Eine Zusammensetzung wie in Anspruch 6 beansprucht, in welcher die Acylgruppe die Acryloylgruppe ist, welche gegebenenfalls mit C_{1-6}-Alkyl, Furyl, Phenyl oder C_{1-6}-Alkylphenyl substituiert ist.

10. Ein isoliertes Derivat eines *in vivo* fibrinolytisch wirksamen Enzyms wie in Anspruch 1 definiert.

11. Ein Derivat eines *in vivo* fibrinolytisch wirksamen Enzyms wie in Anspruch 1 definiert, mit Ausnahme von:

(i) p-Guanidinobenzoyl-Humanplasmin,

(ii) p-Guanidinobenzoyl-Streptokinase-Plasminogenaktivatorkomplex.

12. Ein Derivat wie in Anspruch 10 oder 11 beansprucht, wobei das Enzym menschliches Plasmin ist.

13. Ein Derivat wie in Anspruch 10 oder 11 beansprucht, wobei das Enzym Streptokinase/Humanplasminogenaktivatorkomplex ist.

14. Ein Derivat wie in Anspruch 10 oder 11 beansprucht, wobei das Enzym eine Mischung aus menschlichem Plasmin und Streptokinase/Humanplasminogenaktivatorkomplex ist.

15. Ein Derivat wie in irgendeinem der Ansprüche 10 bis 14 beansprucht, wobei die durch Hydrolyse entfernbare Gruppe eine Acylgruppe ist.

16. Ein Derivat wie in Anspruch 15 beansprucht, wobei die Acylgruppe eine Benzoyl-, substituierte Benzoyl-, Acryloyl- oder substituierte Acryloylgruppe ist.

17. Ein Derivat wie in Anspruch 16 beansprucht, wobei die Acylgruppe eine Benzoylgruppe oder eine substituierte Benzoylgruppe mit 1 oder mehreren Substituenten in meta- und/oder para-Stellung ist, wobei die Summe der Werte σ_m und σ_p nach Hammett im Bereich von +0,1 bis −1,1 liegt.

18. Ein Derivat wie in Anspruch 16 beansprucht, wobei die Acylgruppe die Benzoylgruppe ist, welche gegebenenfalls mit Halogen, C_{1-6}-Alkyl, C_{1-6}-Alkoxy, C_{1-6}-Alkanoyloxy, C_{1-6}-Alkanoylamino, Amino oder p-Guanidino substituiert ist.

19. Ein Derivat wie in Anspruch 16 beansprucht, wobei die Acylgruppe die Acryloylgruppe ist, welche gegebenenfalls mit C_{1-6}-Alkyl, Furyl, Phenyl oder C_{1-6}-Alkylphenyl substituiert ist.

20. Ein Derivat gemäß Anspruch 10 oder 11, welches p-Anisoyl-Humanplasmin ist.

21. Ein Derivat gemäß Anspruch 10 oder 11, welches p-Anisoyl-Streptokinase/Humanplasminogenaktivatorkomplex ist.

22. Ein Derivat gemäß Anspruch 10 oder 11, welches eine Mischung aus p-Anisoyl-Humanplasmin und p-Anisoyl-Streptokinase/Humanplasminogenaktivatorkomplex ist.

23. Ein Verfahren zur Herstellung eines Derivates eines *in vivo* fibrinolytisch wirksamen Enzyms wie in Anspruch 11 beansprucht, welches Verfahren die Reaktion eines *in vivo* fibrinolytisch wirksamen Enzyms wie in Anspruch 1 definiert mit einem Blockierungsmittel:

AB

umfaßt, wobei A eine Gruppe bedeutet, welche selektiv für die für die fibrinolytische Aktivität ausschlaggebende katalytisch wirksame Stelle ist und welche befähigt ist, von der Gruppe B auf die katalytisch wirksame Stelle überzugehen, und B eine Gruppe bedeutet, welche das Anhaften von A an das Enzym erleichtert.

24. Ein Verfahren wie in Anspruch 23 beansprucht, wobei das Mittel AB p-Nitrophenyl-p'-guanidinobenzoat ist.

25. Ein Verfahren zur Herstellung eines Derivates eines *in vivo* fibrinolytisch wirksamen Enzyms, wie in Anspruch 11 beansprucht, welches Verfahren die Reaktion eines *in vivo* fibrinolytisch wirksamen Enzyms wie in Anspruch 1 definiert mit einer Verbindung

EF

umfaßt, wobei E eine lokalisierende Gruppe ist, welche selektiv für die katalytisch wirksame Stelle ist, und F eine Gruppe mit der Befähigung des Überganges von der lokalisierenden Gruppe auf die katalytisch wirksame Stelle bedeutet.

26. Ein Verfahren wie in Anspruch 25 beansprucht, wobei E eine Benzoyl- oder substituierte Benzoylgruppe ist.

27. Ein Verfahren wie in Anspruch 25 beansprucht, wobei E p-Amidinophenyl oder p-Acetamidinophenyl ist.

28. Eine pharmazeutische Zusammensetzung gemäß irgendeinem der Ansprüche 1 bis 9 oder ein Derivat gemäß irgendeinem der Ansprüche 10 bis 22 zur Anwendung bei der Behandlung von venöser Thrombose.

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(54) Enzymderivate für den Gebrauch bei der Behandlung von Venenthrombosen und sie enthaltende Arzneimittel
Enzyme derivatives for use in the treatment of venous thrombosis, compositions containing them and their preparation
Dérivés d'enzymes utilisés dans le traitement de thromboses veineuses, compositions les contenant et leur préparations

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