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(54) Titre : DETECTION DE NO PAR UTILISATION DE LA PRODUCTION DE GUANYLYLE CYCLASE ET DE cGMP COMME SYSTEME DE LECTURE

(54) Title: DETECTION OF NO BY USING GUANYLYL CYCLASE AND cGMP PRODUCTION AS A READOUT SYSTEM

(57) Abrégé/Abstract:
A method for measuring nitric oxide synthase activity, characterized in the method comprises; (a) providing a solution comprising a nitric oxide synthase and a suitable substrate under conditions which allow synthesis of nitric oxide; (b) adding guanylyl cyclase and GTP under conditions which allow synthesis of cGMP; (c) measuring cGMP.

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(54) Title: DETECTION OF NO BY USING GUANYLYL CYCLASE AND CGMP PRODUCTION AS A READOUT SYSTEM

(57) Abstract: A method for measuring nitric oxide synthase activity, characterized in the method comprises; (a) providing a solution comprising a nitric oxide synthase and a suitable substrate under conditions which allow synthesis of nitric oxide; (b) adding guanylyl cyclase and GTP under conditions which allow synthesis of cGMP; (c) measuring cGMP.

Detection of NO by using guanylyl cyclase and cGMP production as a readout system

Introduction

The L-arginine-nitric oxide pathway is involved in a large variety of physiological processes (Mayer; B. et al., 1997; Vallance, P. et al., 2002; Wendy, K. et al., 2001), like for example the regulation of blood pressure, platelet aggregation or host defence against pathogens. Nitric oxide (NO) can be for example produced by nitric oxide synthase (NOS) representing a group of enzymes existing as three different isoforms of NOS: eNOS, nNOS and iNOS (Janssens, S.P. et al., 1992; Marsden, P.A. et al., 1992; Nakane, M. et al., 1993; Geller, D.A. et al., 1993; Sherman, P.A. et al. 1993; Charles, I.G. et al., 1993; Maier, R. et al., 1994; Chartrain, N.A. et al., 1994).

To influence diseases which are associated with NOS activity (e.g. chronic obstructive pulmonary disease (COPD), arteriosclerosis, wound-heeling) modulation of NOS activity is wanted. Therefore, there exists a need for substances which can modulate NOS activity. Subsequently, there is a need for e.g. an ultra high throughput compatible assay which is sensitive enough to determine whether a substance can modulated NOS activity.

In the following the known reaction of NOS with Arginine in presence of NADPH, FAD, FMN and biopterin resulting in Citrulline and No and $NADP^+$ is given (Griffith, O.W. et al, 1995; Mayer, B. et al.; 1995; Stuehr, D.J. et al., 1991; Klatt, P. et al.,1993; Feldmann, P.L. et al, 1993; Marletta, M.A., et al., 1994; Pufahl, R.A. et al., 1993; Clement, B. et al., 1993;):

$$\text{Arginine} + \text{NOS} \xrightarrow[\text{NADPH, FAD, FMN, biopterin}]{} \text{Citrulline} + \text{NO} + NADP^+$$

To verify whether NOS activity indeed has been altered it is essential to measure NOS activity. To measure the activity of a NOS enzyme it is necessary to detect arginine consumption, citrulline production or NO generation.

Currently, only assay systems which are not compatible to miniaturized high through put screening systems are known. Only radioactive systems for measuring arginine or citrulline are available. To make matters worse, said systems are only meaningful at high doses of arginine or citrulline and therewith respective miniaturising is not successfully possible.

Other systems are not usable for a screening campaign since a substance to be tested interacts unspecifically with substances of the system (Powell D.and Williams D., 2002).

Since NO is only stable for a few seconds it is not regarded as a suitable read-out. Commercially available NO detection systems have been failed as a suitable readout technique in high throughput screening (Misko T.P. et al. 1993).

For a high throughput compatible NOS activity assay for a drug screening campaign it is necessary to have a sensitive and miniaturizable assay format.

Description Of The Invention

Until now nitric oxide (NO) was regarded as a not suitable readout since it is only stable for a few seconds. The present invention provides for a method for detecting NO which is surprisingly accessible to a new detection method of the present invention.

The guanylyl cyclase is a physiological target for NO. Guanylyl cyclase becomes activated by NO several hundred fold. In the presence of GTP a said activated guanylyl cyclase catalyses the generation of cGMP. Therewith, NO causes the generation of cGMP. As disclosed in the present invention said signal transduction can be surprisingly used in an inverse direction to detect NO quantitatively.

We have established a high throughput compatible assay format for the detection of Nitric oxide synthase (NOS) activity employing guanylyl cyclase and cGMP as an amplification and readout system for the detection of NO. Our assay setup is as

follows: recombinantly expressed NOS enzyme, purified NOS enzyme from a natural source or working with a cell based assay system containing NOS is used to generate NO. Adding soluble guanylyl cyclase to the system leads to an increased activation of the guanylyl cyclase enzyme. This results in the generation of cyclic GMP which is then detected using a cGMP detection system. As a cGMP detection system e.g. commercially available detection systems can be used.

This detection system for NO is quite sensitive since the activation of the guanylyl cyclase results in an cGMP increase. One activated guanylyl cyclase can generate several cGMP molecules therefore we have an amplification effect and can overcome the sensitivity issue.

The present invention provides therewith a technical basis for a long felt need: An assay for determining whether a substance can modulate NOS activity. Therewith the invention also provides for a high throughput screening (HTS) compatible NOS activity assay for a drug screening campaign.

Nitric oxide synthase (NOS) according to the present invention is any enzyme which is selected from a group consisting of: i-NOS (inducible NO synthase, II) e-NOS (endothelial NO synthase, III), and n-NOS (neuronal NO synthase, I)

Nitric oxide synthase (NOS) activity according to the present invention is an activity which catalyzes the formation of NO by converting arginine to citrulline with the concomitant release of NO. NOS activity according to the present invention includes any further conversion of any other substrate resulting in the generation of NO.

A substrate according to the invention is every substance which can be transformed by NOS in any other substance as long as NO is produced. A preferred substance of the invention is arginine.

A substance to be tested to be a modulator of NOS according to the invention is any small chemical molecule, peptide, or antibody.

A modulator according to the invention is either an inhibitor of the invention or an activator of the invention.

An inhibitor of the nitric oxide synthase activity according to the present invention is identifiable by an reduced level of cGMP in a method according to the invention which can be measured in the solution to which the substance to be tested (in step (c)) was added.

An activator of the nitric oxide synthase activity according to the present invention is identifiable by an enhanced level of cGMP in a method according to the invention which can be measured in the solution to which the substance to be tested (in step (c)) was added.

A method according to the invention is, characterized in that the method comprises:
- providing a solution comprising NO;
- adding guanylyl cyclase and guanosin triphosphate (GTP) under conditions which allow synthesis of cyclic guanosin monophosphate (cGMP);
- measuring cGMP. Measuring according to the invention is any suitable detecting method which is useful of determining cGMP quantitatively. A preferred method for measuring cGMP according to the invention uses an antibody which is capable of binding to cGMP.

Said method can be used to detect NO in solution.

Said method can additionally be used in a high throughput screening. Therefore, the present invention provides for a method for detection of nitric oxide (NO)) in an high throughput (HTS) format characterized in that the above mentioned method is performed. Said method can be performed by using a plate having at least 96 wells, more preferred is the use of a 384 well plate or a 1536 well plate. Also preferred is the use of a chip as reaction and/or readout platform.

Accordingly, one aspect of the invention relates to a method for measuring nitric oxide synthase activity, which is suitable for high throughput screening, the method comprising: (a) providing a solution comprising a nitric oxide synthase and a substrate for nitric oxide synthase under conditions which allow synthesis of nitric oxide; (b) adding guanylyl cyclase and GTP under conditions which allow synthesis of cGMP; and (c) measuring cGMP by using an antibody that binds to cGMP; wherein the cGMP measured in (c) indicates the amount of nitric oxide synthesized in (a).

In another aspect, the invention relates to a method which is suitable for high throughput screening, for determining whether a substance is a modulator of nitric oxide synthase activity, comprising: (a) providing a first solution comprising a nitric oxide synthase and a substrate for nitric oxide synthase under conditions which allow synthesis of nitric oxide; (b) providing a second solution comprising a nitric oxide synthase and a substrate for nitric oxide synthase under conditions which allow synthesis of nitric oxide; (c) adding a substance to be tested to the first or the second solution; (d) adding guanylyl cyclase and GTP under conditions which allow synthesis of cGMP to the first and the second solution; (e) measuring cGMP in the first and the second solution by using an antibody that binds to cGMP; and (f) comparing cGMP levels of the first and the second solution, wherein a modulator of a nitric oxide synthase activity is identified by different levels of cGMP.

In another aspect, the invention relates to a method which is suitable for high throughput screening for detection of nitric oxide (NO), the method comprising: (a) providing a solution in which NO is to be detected; (b) adding guanylyl cyclase and guanosine triphosphate (GTP) under conditions which allow synthesis of cyclic guanosine monophosphate (cGMP); and (c) detecting cGMP by using an antibody that binds to cGMP; wherein detection of cGMP in (c) indicates that NO was present in the solution.

In another aspect, the invention relates to a kit comprising: (a) guanylyl cyclase, (b) GTP, (c) an antibody that binds to cGMP, and (d) instructions for using the kit for determining whether a substance is a modulator of NOS activity.

In another aspect, the invention relates to a kit comprising: (a) guanylyl cyclase, (b) GTP, (c) an antibody that binds to cGMP, and (d) instructions for using the kit for measuring nitric oxide synthase (NOS) activity.

In another aspect, the invention relates to a kit comprising: (a) guanylyl cyclase, (b) GTP, (c) an antibody that binds to cGMP, and (d) instructions for using the kit for detection of nitric oxide (NO).

In one embodiment the present invention provides for a method for measuring nitric oxide synthase activity, characterized in that the method comprises:

(a) providing a solution comprising a nitric oxide synthase and a suitable substrate under conditions which allow synthesis of nitric oxide;

(b) adding guanylyl cyclase and GTP under conditions which allow synthesis of cGMP;

(c) measuring cGMP.

Measuring cGMP according to the invention is any suitable detecting method which is useful of determining cGMP quantitatively. A preferred method for measuring cGMP according to the invention uses an antibody which is capable of binding to cGMP.

Said method can be used in a high throughput screening. Therefore, the present invention provides for a method for measuring nitric oxide synthase (NOS) activity in an high throughput (HTS) format characterized in that the above mentioned method is performed. Said method can be performed by using a plate having at least 96 wells, more preferred is the use of a 384 well plate or a 1536 well plate. Also preferred is the use of a chip as reaction and/or readout platform.

In a further embodiment the present invention provides for a method for determining whether a substance is modulator of nitric oxide synthase activity according to the invention, characterized in that the method comprises:

(a) providing a first solution comprising a nitric oxide synthase and a suitable substrate under conditions which allow synthesis of nitric oxide;

(b) providing a second solution comprising a nitric oxide synthase and a suitable substrate under conditions which allow synthesis of nitric oxide;

(c) adding a substance to be tested to the first or the second solution;

(d) adding guanylyl cyclase and GTP under conditions which allow synthesis of cGMP to the first and the second solution;

(e) measuring cGMP in the first and the second solution;

(f) comparing cGMP levels of the first and the second solution, wherein a modulator of a nitric oxide synthase activity is identified by different levels of cGMP.

Measuring cGMP according to the invention is any suitable detecting method which is useful of determining cGMP quantitatively. A preferred method for measuring

cGMP according to the invention uses an antibody which is capable of binding to cGMP.

Said method can be used in a high throughput screening. Therefore the present invention provides for a method for determining whether a substance is modulator of nitric oxide synthase (NOS) activity in an high throughput (HTS) format characterized in that the above mentioned method is performed. Said method can be performed by using a plate having at least 96 wells, more preferred is the use of a 384 well plate or a 1536 well plate. Also preferred is the use of a chip as reaction and/or readout platform.

In a further embodiment all above mentioned methods of to the invention additionally comprise superoxid dismutase (SOD) which can be added together with guanylyl cyclase and GTP.

All methods of the present invention can be used in a high throughput screening assays.

The present invention also provides for a kit for determining whether a substance is a modulator - i.e. an activator or an inhibitor – of NOS activity comprising: guanylyl cyclase, GTP and a system for detection of cGMP. Said system is any suitable detecting method which is useful of determining cGMP quantitatively. A preferred method for measuring cGMP according to the invention uses an antibody which is capable of binding to cGMP.

In a more preferred embodiment said kit of the invention further comprises Superoxide dismutase (SOD).

In a most preferred embodiment said kit of the invention further comprises nitric oxid synthase (NOS) which is selected from a group consisting of: i-NOS, e-NOS, and n-NOS. This kit can additionally comprise Superoxide dismutase (SOD).

In a further embodiment the present invention also provides for a kit for measuring nitric oxide synthase (NOS) activity comprising: guanylyl cyclase, GTP and a system for detection of cGMP. Said system is any suitable detecting method which is useful of determining cGMP quantitatively. A preferred method for measuring cGMP according to the invention uses an antibody which is capable of binding to cGMP.

In a more preferred embodiment said kit of the invention further comprises Superoxide dismutase (SOD).

In a most preferred embodiment said kit of the invention further comprises nitric oxid synthase (NOS) which is selected from a group consisting of: i-NOS, e-NOS, and n-NOS. This kit can additionally comprise Superoxide dismutase (SOD).

The present invention additionally provides for a further kit for detection of nitric oxid (NO) comprising: guanylyl cyclase, GTP and a system for detection of cGMP. Said system is any suitable detecting method which is useful of determining cGMP quantitatively. A preferred method for measuring cGMP according to the invention uses an antibody which is capable of binding to cGMP.

In a more preferred embodiment said kit of the invention further comprises Superoxide dismutase (SOD).

The following Examples are meant to illustrate the present invention, however, shall not be construed as limitation. However, the Examples describe most preferred embodiments of the invention.

Examples:

Example 1: Assay description

Detection of NOS activity by using the activation of soluble guanylyl cyclase, an enzyme which is well known for years (Gerzer R., et al. 1981; Zabel U.,et al., 1998; Hoenicka, M.et al., 1999; Lee, Y.C. et al., 2000; Kosarikov, D.N. et al.; 2001). NO produced by the different NOS enzymes can activate soluble guanylyl cyclase and also its membrane standing counterpart. In said type of assays recombinantly expressed NOS, a cell-lysate containing NOS as well as NOS purified from a natural source can be used (Janssens, S.P. et al., 1992; Marsden, P.A. et al., 1992; Nakane, M. et al., 1993; Geller, D.A. et al., 1993; Sherman, P.A. et al. 1993; Charles, I.G. et al., 1993; Maier, R. et al., 1994; Chartrain, N.A. et al., 1994).

Here we describe a non radioactive HTS compatible assay format which can be used to detect the NO produced by the NOS activity via activation of guanylyl cyclase and subsequent detection of the produced cGMP using the AlphaScreen technology in a mix and measure mode.

Arginine as a substrate is converted by each of the three different NOS enzymes respectively, into citrulline. During this process NO is also produced. Therefore NO detection can be used to monitor directly the activity NOS enzymes. It is known that NO can directly stimulate the soluble guanylyl cyclase. This activation leads to an increase in cGMP production by the activated guanylyl cyclase. The produced cGMP can be detected and quantified. A variety of different technologies can be employed for the detection and quantification of the newly produced cGMP. This technologies can be e.g. based on HTRF (Claret E.J., et al. , 2004) or radioactivity (Perkin Elmer: Flashplate cyclic cGMP [^{125}I]-assay product no: SMP002J001PK) or like it is shown here based on the AlphaScreen technology. Using the Alphascreen cGMP competition assay a biotinylated cGMP is used to generate a fluorescence signal. The biotinylated cGMP is binding to the AlphaScreen donor bead via streptavidin and is binding to the AlphaScreen acceptor bead via an anti-cGMP specific antibody bound to the bead surface. If cGMP is freshly produced by the stimulated guanylyl cyclase it is competing with the binding to the anti-cGMP antibody. Therefore, the

standard fluorescence signal is getting reduced by freshly produced cGMP, which is not biotinylated.

Example 2: Standard operating procedure for performing a mix and measure HTS compatible NOS activity assay.

Method

In 384-well plates, 3 µl of a test compound diluted in distilled water (final concentration of compounds 5 µg/ml; DMSO 1%) is mixed with 3 µl enzyme mix dissolved in assay buffer (i-NOS final 2 -10 µg/ml or e-NOS final 2-10 µg/ml or n-NOS final 2-10 µg/ml, sGC final 1:800 000 – given amounts of respective NOS enzymes are based on total concentration of cell culture supernatant employed (insect cell recombinant expression system)). After an incubation time of 30 minutes 3µl substrate mix dissolved in assay buffer (GTP final 100µM, Arginine final 3µM, NADPH final 500µM, for n-NOS 1 µM Ca^{2+} and 1 µM Calmodulin is necessary) is added. After another incubation time of 90 minutes the reaction is stopped with 10 µl acceptor and donor bead–antibody mix dissolved in stop/detection buffer (final concentration of each bead-type 15 µg/ml; antibody final 1:15000).
After an overnight incubation, the assay is measured using e.g. an Alphaquest reader (Perkin Elmer), which is measuring fluorescence at 520-620 nm.

Assay buffer:	25mM Tris pH 7.4, 3mM $MgCl_2$, 3mM DTT, 0.05% BSA, 3µM BH_4, 1µM FAD, 1µM FMN, 10µM 4-{[3', 4'-(Methylenedioxy) benzyl]amino}-6- methoxyquinazoline
Stop / detection buffer:	50mM Tris, 50mM EDTA pH 7.4, 0.10% BSA, 0.10% Tween-20*

Each assay microtiter plate contains wells with vehicle control instead of compound (1% DMSO in water) as reference for non-inhibited enzyme activity (100% CTL; high values) and wells with 100µM AMT as reference for inhibited enzyme activity (0% CTL; low values).

*Trade-mark

Each assay micro-titer plate contains a cGMP standard curve (1, 10, 100, 1000, 3000, 10000, 100000, 1000000 pM/l) in duplicate used as reference to calculate the amount of cGMP produced in every well.

The analysis of the data is performed by the calculation of the percentage of cGMP in the presence of the test compound compared to cGMP generated from the positive control:

(cGMP(sample) – cGMP (low value)) x 100/ (cGMP (high value) – cGMP (low value))

An inhibitor of the enzyme activity will give values between 100% Ctl (no inhibition) and 0% Ctl (complete inhibition).

Materials used are well known in the art, however, in the following respective suppliers are given: The 384 low volume plates were purchased from Greiner (white; cat.-no. 784075).The AlphaScreen IgG Detection Kit (cat.-no. 6760617) and the biotinylated cGMP were bought from Perkin Elmer. The anti-cGMP antibody (cat.-no. 970161) is from Merck Biosciences. The different NOS enzymes i-NOS (cat.-no. 201-069), e-NOS (cat.-no. 201-070) and n-NOS (cat.-no. 201-068), sGC (cat.-no. 201-177) and the L-Arginine (cat.-no. 101-004) were from Alexis. The NADPH (cat.-no. N-6005) and the GTP (cat.-no. G-5884) were purchased from Sigma. All other materials were of highest grade commercially available.

Example 3: Standard operating procedure for performing a mix and measure HTS compatible NOS activity assay optimized by adding a further enzyme to the reaction mixture the Superoxide dismutase (SOD)

In the following a further variant of the assay of the invention is disclosed in which an enzyme has been added to the reaction mixture. The Superoxide dismutase (SOD) (Keele Jr. B. B. et al.,1970; Beckman J. S. et al., 1990) increases the sensitivity of the assay system and therefore reduces the amount of NOS enzyme needed for performing the assay.

Method

In the 384-well plates, 3 µl of the test compounds diluted in distilled water (final concentration of compounds 5 µg/ml; DMSO 1%) is mixed with 3 µl enzyme mix dissolved in assay buffer (i-NOS final 2µg/ml, e-NOS 5 µg/ml, n-NOs 0.4 µg/ml, SOD final 300nM, sGC final 1:800 000 – given amounts of respective NOS enzymes are based on total concentration of cell culture supernatant employed (insect cell recombinant expression system)). After an incubation time of 30 minutes 3µl substrate mix dissolved in assay buffer (GTP final 100µM, Arginine final 3µM, NADPH final 500µM, for nNOS 1 µM Ca^{2+} and 1 µM Calmodulin is necessary) is added. After another incubation time of 90 minutes the reaction is stopped with 10 µl acceptor and donor bead–antibody mix dissolved in stop/detection buffer (final concentration of each bead-type 15 µg/ml; antibody final 1:15000).

After an overnight incubation, the assay is measured using e.g. an Alphaquest (as outlined in Example 2).

Assay buffer:	25mM Tris pH 7.4, 3mM $MgCl_2$, 3mM DTT, 0.05% BSA, 3µM BH_4, 1µM FAD, 1µM FMN, 10µM 4-{[3', 4'-(Methylenedioxy) benzyl]amino}-6- methoxyquinazoline
Stop / detection buffer:	50mM Tris, 50mM EDTA pH 7.4, 0.10% BSA, 0.10% Tween-20

Each assay microtiter plate contains wells with vehicle control instead of compound (1% DMSO in water) as reference for non-inhibited enzyme activity (100% CTL; high values) and wells with 100µM AMT as reference for inhibited enzyme activity (0% CTL; low values).

Each assay microtiter plate contains a cGMP standard curve (1, 10, 100, 1000, 3000, 10000, 100000, 1000000 pM/l) in duplicate used as reference to calculate the amount of cGMP produced in every well.

The analysis of the data is performed by the calculation of the percentage of cGMP in the presence of the test compound compared to cGMP generated from the positive control.

(cGMP(sample) – cGMP (low value)) x 100/ (cGMP (high value) – cGMP (low value))

An inhibitor of the enzyme activity will give values between 100% Ctl (no inhibition) and 0% Ctl (complete inhibition).

Example 4: Stimulation of soluble guanylyl cyclase and subsequent cGMP detection:

The principle mechanism of the stimulation of the soluble guanylyl cyclase can be shown by using a NO donor compound like for example DEA NONOate or others like DETA NONOate, DPTA NONOate, GEA 5024 or GEA 3162 (Drago R.S. & Paulik F.E., 1960; Drago R.S. & B.R. Karstetter B.R. 1961; Maragos, C.M. et al, 1991; Wink D.A., et al. 1991; Hrabie, et al. 1993; Robak, et al., 1992; Moilanen, E. et al. 1993; Corell, T. et al. 1994; Karup, G. et al. 1994; Malo-Ranta, U. et al. 1994; Ma H.T. et al. 1999). These type of compounds produce NO which can stimulate the soluble guanylyl cyclase which leads to a cGMP production. Figure 1 shows the cGMP production after stimulating the soluble guanylyl cyclase with DEA NONOate in a dose dependent manner. For detection of cGMP an AlphaScreen competition assay was used.

Example 5: Inhibition of different NOS enzymes using standard inhibitors:

Table 1 summarises the results obtained by employing the assay described above and testing standard NOS inhibitors.

enzyme	**AMT [µM]**	**ODQ [µM]**	**L-NMMA [µM]**	**1400W [µM]**	**L-NIL [µM]**
iNOS	1.3×10^{-8}	7.7×10^{-7}	3.2×10^{-6}	9.7×10^{-7}	2.2×10^{-6}
eNOS	9.9×10^{-8}	5.8×10^{-7}	2.3×10^{-6}	2.0×10^{-4}	2.7×10^{-5}
nNOS	3.1×10^{-8}	9.0×10^{-7}	7.9×10^{-6}	1.5×10^{-5}	2.8×10^{-4}

In Table 1 is given: IC50 [µM] determination of different compounds for the different NOS enzymes.

Above mentioned NOS inhibitors are state of the art as depicted below:

AMT: Nakane, M. et al., 1995; Tracey, W.R. et al., 1995; Rairigh, R.L. et al.1998; Briones, A-M. et al., 1999;

ODQ: Boulton, C. L. et al., 1995; Brunner, F. et al.,1995; Garthwaite, J et al., 1995; Moro, M.A. et al., 1996; Schrammel, A. et al., 1996; Southam, E. et al., 1996; Abi-Gerges, N. et al., 1997; Olson, L.J, et al., 1997; Sobey C.G. & Faraci F.M. 1997; Hwang, T.L. et al., 1998; R. Motterlini, et al., 2000;

L-NMMA: Sakuma,I. et al., 1988; Rees, D.D. et al., 1989;

1400W: Garvey, E.P et al., 1997; Thomsen, L.L. et al., 1997; Laszlo F. & Whittle B.J.R, 1997; Gumpricht, E. et al., 2002;

L-NIL: Moore, W.M. et al., 1994.

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Description of Figure 1: Dose response curve for cGMP production

Figure 1 shows a Dose response testing of the synthetic NO donor DEA NONOate on the stimulation of soluble guanylyl cyclase and detection of the subsequent cGMP production of guanylyl cyclase by employing the AlphaScreen cGMP competition assay outlined in Example 4.

CLAIMS:

1. A method for measuring nitric oxide synthase activity, which is suitable for high throughput screening, the method comprising:

(a) providing a solution comprising a nitric oxide synthase and a substrate for nitric oxide synthase under conditions which allow synthesis of nitric oxide;

(b) adding guanylyl cyclase and GTP under conditions which allow synthesis of cGMP; and

(c) measuring cGMP by using an antibody that binds to cGMP;

wherein the cGMP measured in (c) indicates the amount of nitric oxide synthesized in (a).

2. A method which is suitable for high throughput screening, for determining whether a substance is a modulator of nitric oxide synthase activity, comprising:

(a) providing a first solution comprising a nitric oxide synthase and a substrate for nitric oxide synthase under conditions which allow synthesis of nitric oxide;

(b) providing a second solution comprising a nitric oxide synthase and a substrate for nitric oxide synthase under conditions which allow synthesis of nitric oxide;

(c) adding a substance to be tested to the first or the second solution;

(d) adding guanylyl cyclase and GTP under conditions which allow synthesis of cGMP to the first and the second solution;

(e) measuring cGMP in the first and the second solution by using an antibody that binds to cGMP; and

(f) comparing cGMP levels of the first and the second solution, wherein a modulator of a nitric oxide synthase activity is identified by different levels of cGMP.

3. The method according to claim 2, in which the modulator is an inhibitor of the nitric oxide synthase activity, wherein the inhibitor is identified by a reduced level of cGMP which can be measured in the solution to which the substance in step (c) was added.

4. The method according to claim 2 in which the modulator is an activator of the nitric oxide synthase activity, wherein the activator is identified by an enhanced level of cGMP which can be measured in the solution to which the substance in step (c) was added.

5. The method according to claim 1, 2, 3 or 4 in which the substrate is arginine.

6. The method according to claim 1, 2, 3, 4 or 5 in which the nitric oxide synthase is selected from the group consisting of: i-NOS, e-NOS, and n-NOS.

7. The method according to claim 1, 2, 3, 4, 5, or 6 wherein superoxide dismutase is added together with guanylyl cyclase and GTP.

8. The method according to claim 1, 2, 3, 4, 5, 6 or 7, in high throughput (HTS) format.

9. The method according to claim 8 in which a plate having at least 96 wells is used.

10. The method according to claim 9 in which a 384 well plate or a 1536 well plate is used.

11. The method according to claim 8, 9 or 10 in which a chip is used as reaction and/or readout platform.

12. A method which is suitable for high throughput screening for detection of nitric oxide (NO), the method comprising:

(a) providing a solution in which NO is to be detected;

(b) adding guanylyl cyclase and guanosine triphosphate (GTP) under conditions which allow synthesis of cyclic guanosine monophosphate (cGMP); and

(c) detecting cGMP by using an antibody that binds to cGMP;

wherein detection of cGMP in (c) indicates that NO was present in the solution.

13. The method according to claim 12, in high throughput (HTS) format.

14. The method according to claim 13 in which a plate having at least 96 wells is used.

15. The method according to claim 13 in which a 384 well plate or a 1536 well plate is used.

16. The method according to claim 12, 13, 14 or 15 in which a chip is used as reaction and/or readout platform.

17. Use of the method according to claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 or 16, for high throughput screening.

18. A kit comprising:

(a) guanylyl cyclase,

(b) GTP,

(c) an antibody that binds to cGMP, and

(d) instructions for using the kit for determining whether a substance is a modulator of NOS activity.

19. The kit according to claim 18 which additionally comprises a nitric oxide synthase (NOS) selected from the group consisting of: i-NOS, e-NOS, and n-NOS.

20. The kit according to claim 18 or 19 comprising additionally superoxide dismutase.

21. A kit comprising:

(a) guanylyl cyclase,

(b) GTP,

(c) an antibody that binds to cGMP, and

(d) instructions for using the kit for measuring nitric oxide synthase (NOS) activity.

22. The kit according to claim 21 which additionally comprises a nitric oxide synthase (NOS) selected from the group consisting of: i-NOS, e-NOS, and n-NOS.

23. The kit according to claim 21 or 22 comprising additionally superoxide dismutase.

24. A kit comprising:

(a) guanylyl cyclase,

(b) GTP,

(c) an antibody that binds to cGMP, and

(d) instructions for using the kit for detection of nitric oxide (NO).

25. The kit according to claim 24 comprising additionally superoxide dismutase.

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PATENT AGENTS

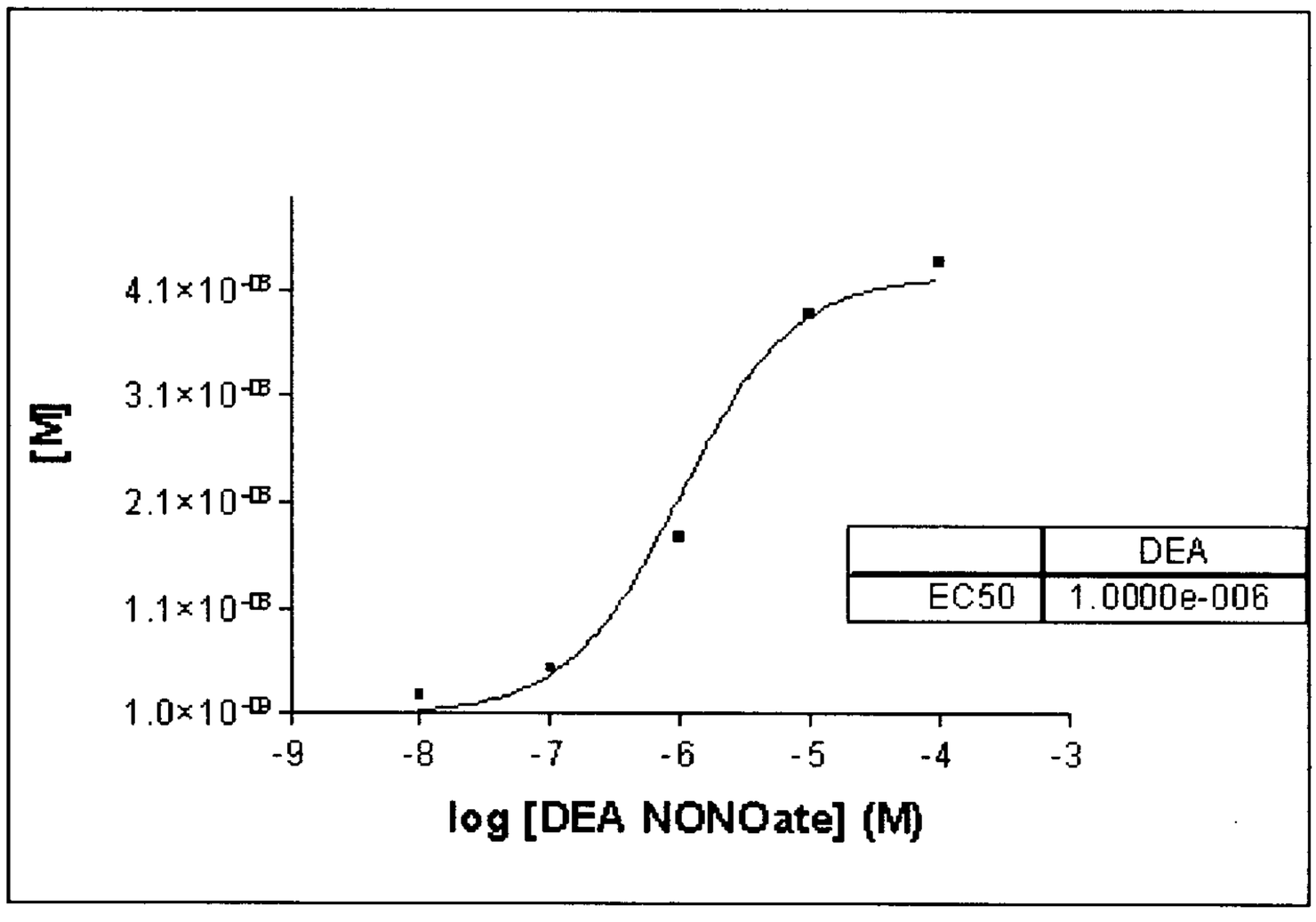

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Figure 1